The NIST Cybersecurity of Industrial Control Systems Testbed

Keith A. Stouffer
Manufacturing Engineering Laboratory
National Institute of Standards and Technology

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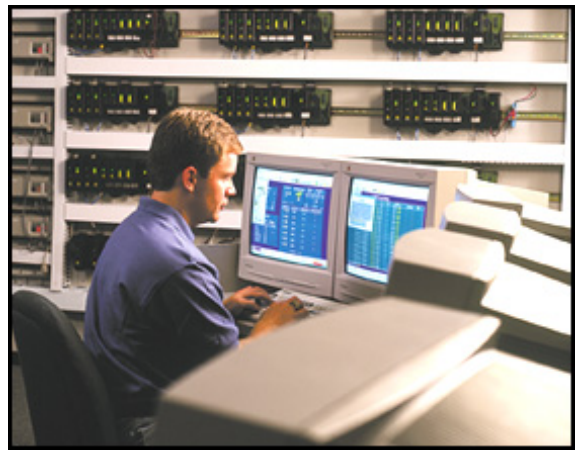
National Institute of Standards and Technology

NIST's mission is to develop and promote measurement, standards, and technology to enhance productivity, facilitate trade, and improve the quality of life.

- 3,000 employees
- 1,600 guest researchers
- $820 million annual budget
- NIST Laboratories -- National measurement standards
- Advanced Technology Program -- $640 million current R&D partnerships with industry
- Manufacturing Extension Partnership -- 400 centers nationwide to help small manufacturers
- Baldrige National Quality Award

Motivation: Critical Infrastructure Protection

- The (US) National Plan for Information Systems Protection and other reports cite industrial control systems as critical points of vulnerability in America's utilities and industrial infrastructure...



Electric power — Water — Oil & Gas
Chemicals — Pharmaceuticals
Mining, Minerals & Metals
Pulp & Paper — Food & Beverage
Consumer Products
Discrete Manufacturing
(automotive, aerospace, durable goods)

Risks

- Loss of Life, Endangerment of Public Health and Safety
- Social Disruption
- Loss of Production/Generation/Distribution
- Harm to Personnel and Equipment
- Environmental Damage
- Compromising of Proprietary Information
- Threat of Liability

Control System Characteristics

- Time critical
- Designed to maximize performance, reliability, flexibility, safety
- In past, typically physically isolated and based on proprietary hardware, communications
- Security has not been a significant consideration

Increased Connectivity = Increased Vulnerabilities

- Enterprise Integration
  - Across Functions and Departments
  - Across Sites/Facilities
- Remote/Web Access of Equipment and Control Information
- Open/COTS Systems
- Factory Floor Ethernet
- Strategic Partnering
- Mergers and Acquisitions
- Wireless Communications

…Which Could Be Exploited By:

- Communications or processing denial of service
- Spoofing of sensor readings or control commands
- Modification of control programs
- Interfering with safety system operation
- Changing/disabling process parameters/limits

Process Control Security Challenges

- Real time constraints - IT security technology can impact timing, inhibit performance
- Balancing of cost, performance, reliability, flexibility, safety, security requirements
- Difficulty of specifying requirements and testing capabilities of complex systems in operational environments
- Security expertise and domain expertise required

CIP Program Summary

- **Long-term Objective:** Integrate security engineering into the industrial automation life cycle, including design, implementation, configuration, maintenance and decommissioning
- **Outcome:** Reduced likelihood of successful cyberattack on the nation's critical infrastructure
- **NIST Role:** Working with industry to develop standards and test methods for validation and conformance

Process Control Security Requirements Forum (PCSRF)

Immediate Goal:

Increase the security of industrial process control systems through the definition and application of a common set of information security requirements for these systems.

Based on NIST and NSA work to develop the *Common Criteria for IT Security Evaluation*

Process Control Security Requirements Forum

PCSRF Representation

- EPRI (Electric Power Research Institute)
- Texaco, BP
- Georgia-Pacific
- Association of Metropolitan Water Agencies
- American Chemistry Council
- Open Group
- ISA
- National Security Agency
- Department of Energy/Sandia, PNNL
- National Center for Manufacturing Sciences (NCMS)
- Honeywell, Rockwell
- NIST (Manufacturing Engineering, Electrical and Electronics Engineering, and Information Technology Laboratories)

Requirements Development Steps

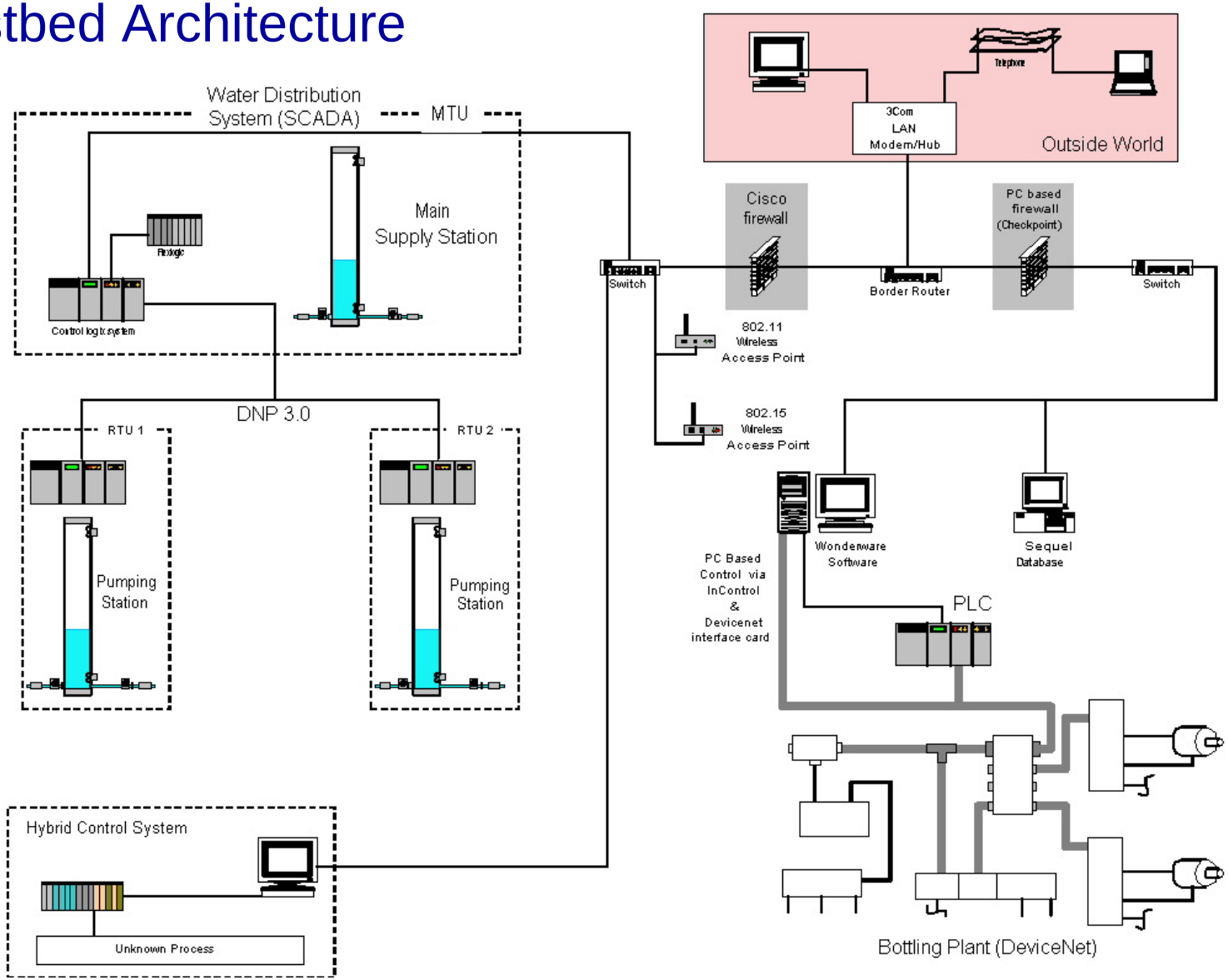
- Analyze industrial control system architectures, including analysis of threats and vulnerabilities
- Partition the system architecture for the purpose of requirements definition
- Develop information security requirements for a subset of the overall system
  - Target Definition, Security Environment, Security Objectives, Security Functional and Assurance Requirements
  - Express in procurement language accessible to process control community
- Translate information security requirements into Protection Profile(s)
- Establish testbed to develop test methods and demonstration capability

⇨ *Sector-specific workshops, cosponsored with industry organizations (NCMS, EPRI, AWWA, AGA, ACC) will be key information sources*

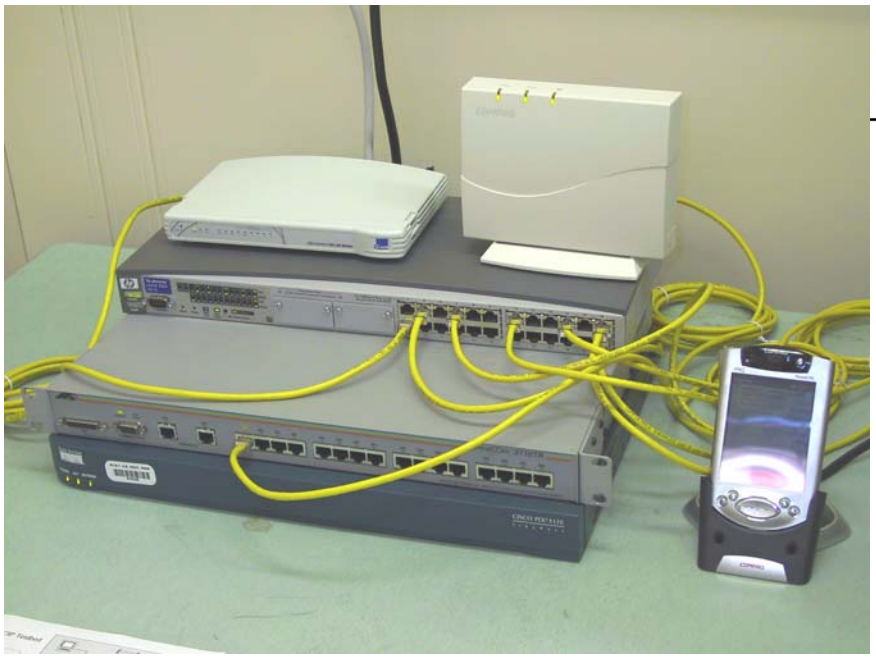
Process Control Security Testbed

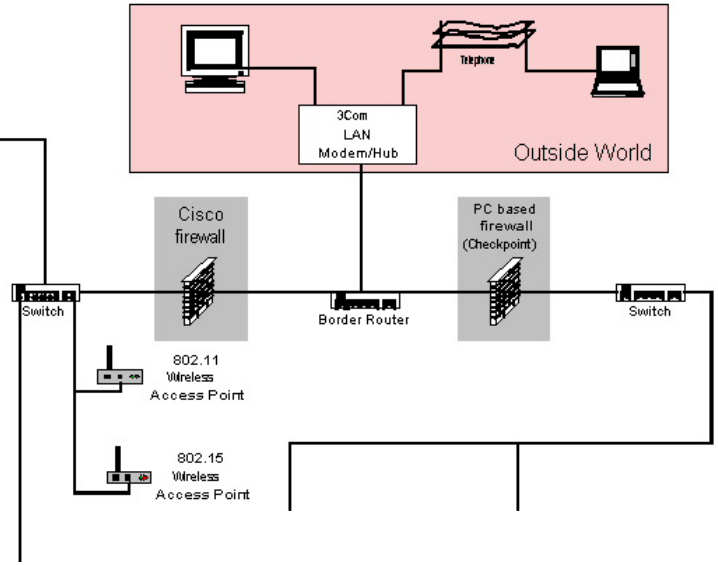
- Provides an industrial setting in which to
  - validate standards for process control security
  - develop performance- and conformance test methods
- Targeted outcomes:
  - development and dissemination of best practices for process control security
  - security standards for acquisition, development, and retrofit of industrial control systems

Process Control Security Testbed Architecture



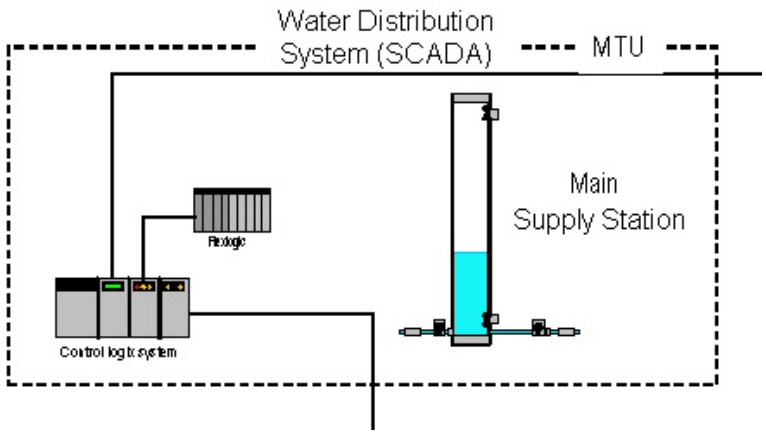
Network Hardware

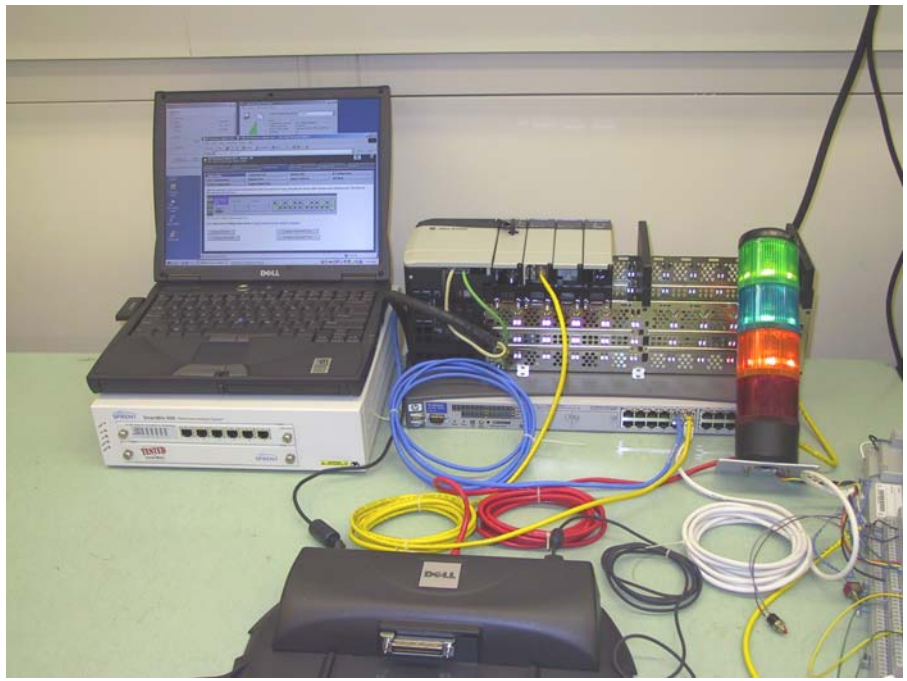




- Hardware firewall
- Ethernet switch
- Dial-up modem/4 -port hub
- 802.11a,b wireless access point
- Handheld PC

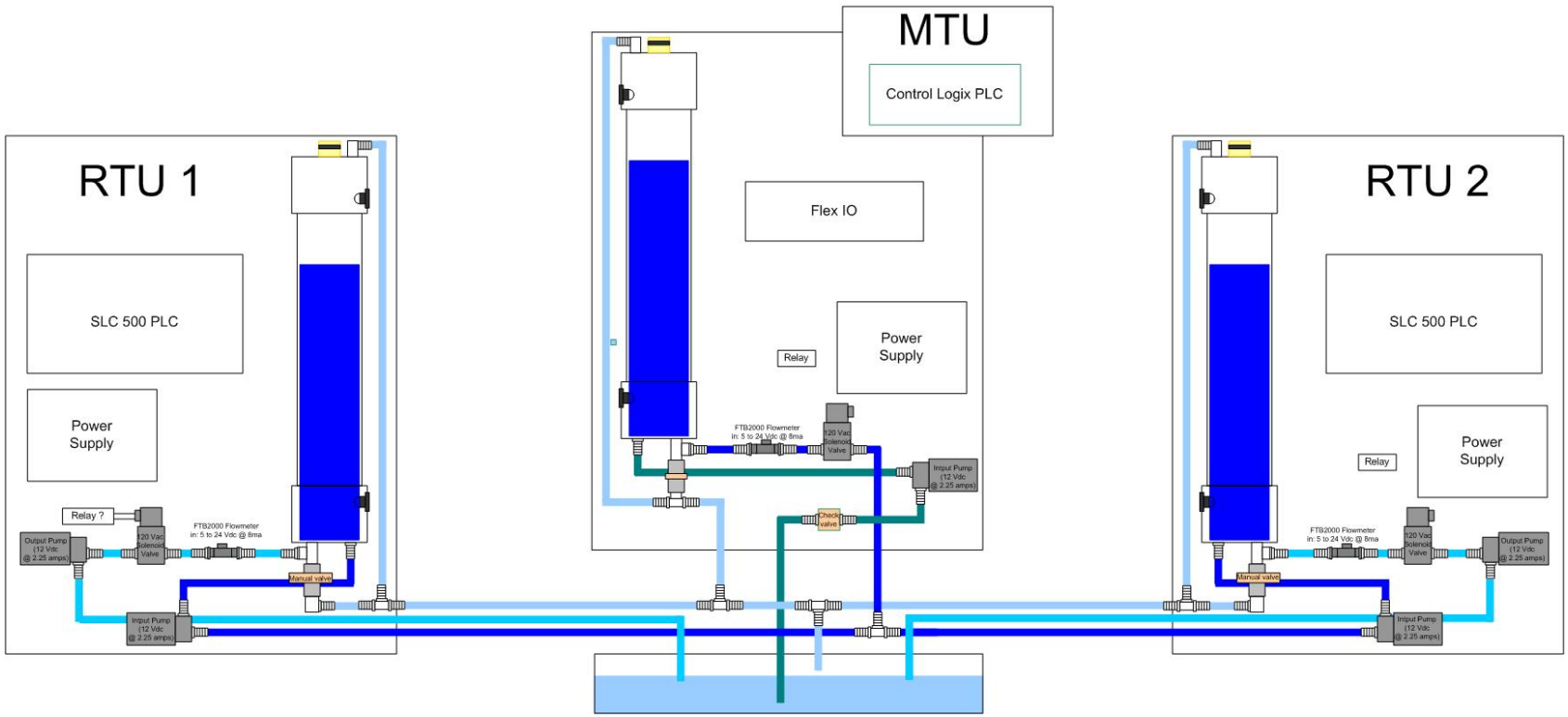
Water Distribution MTU





- Master Terminal Unit (MTU) for water distribution simulation
  - Programmable logic controller (PLC)
  - EtherNet/IP, DeviceNet and DNP 3.0 protocols

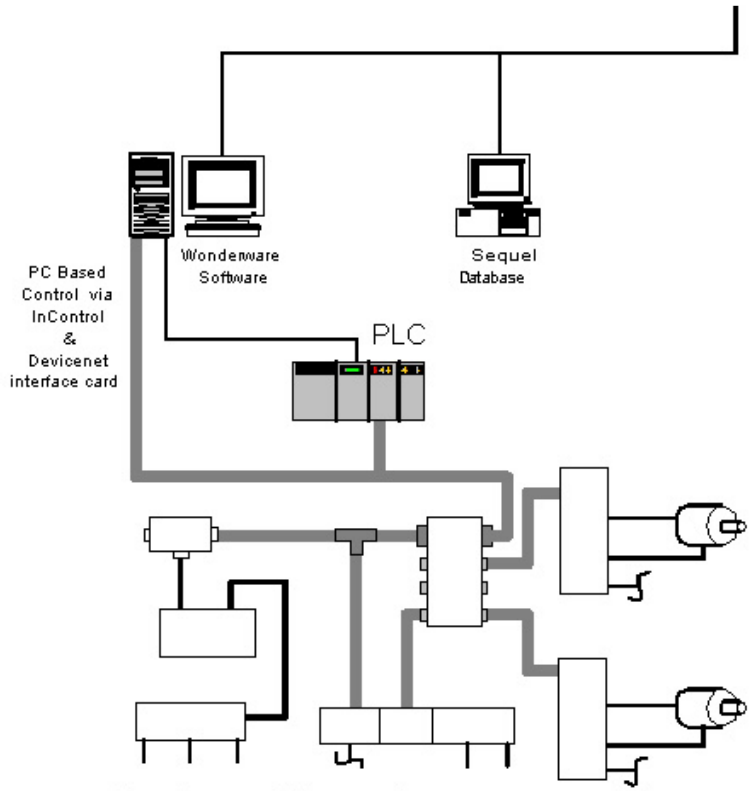
Water Distribution SCADA System



Bottling Plant PLC

- Bottling plant simulation:
  - drive motors
  - proximity switches
  - rejection actuators
  - bottle counters

- DeviceNet I/O network
- Two PLC options:
  - PC-based software
  - dedicated hardware
- SQL database for data logging



Latency and Jitter Measurement

- Effects of adding crypto-modules to existing network
- Critical parameter can be jitter of data in control loops
- How to measure with typical network traffic, crypto-modes, and communications noise
- Two protocols – Ethernet and Serial (TCP/IP and RS232)

Latency Testbed

- Three Computers used to simulate MTU, RTU and network
- Ethernet or serial communications modes

Summary

- Process control automation is heavily used in critical infrastructure
- Lack of security + increased connectivity = significant vulnerabilities; major health and safety risks
- Traditional IT security solutions don’t address real-time, embedded nature of devices and controllers
- Users and vendors are teaming to develop standards and products to address the needs
- NIST’s role is in standards validation, conformance- and performance test development

Questions?

More information:

www.isd.mel.nist.gov/projects/processcontrol
or
www.niap.nist.gov
click *Forums ⇨ Process Control*