



INSTITUTE FOR DEFENSE ANALYSES

**Challenges and Recommendations: Operational Cyber  
Testing of Hull, Mechanical, and Electrical (HM&E) /  
Industrial Control Systems (ICS)**

Dr. Mark R. Herrera, Project Leader

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## Executive Summary

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This test and evaluation concept proposes IDA’s general evaluation approach for assessing the cybersecurity posture of Hull, Mechanical, and Electrical (HM&E) systems aboard U.S. Navy platforms. HM&E systems, also described as Industrial Control Systems (ICS), allow operators and maintainers to control critical ship functions. For the purposes of this test concept, we will use the terms HM&E and ICS interchangeably.

DOT&E guidance states that “test agencies must continue to use all available tools and resources to assess these [HM&E/ICS] systems.” However, to date, no Navy platform on DOT&E oversight has included on-ship testing of HM&E/ICS as part of cyber operational testing for several reasons: (1) the Navy’s Operational Test and Evaluation Force (OPTEVFOR) has lacked tools and expertise in HM&E/ICS-specific technologies and (2) system owners are concerned that testing of HM&E/ICS networks could cause unforeseen disruption or damage to critical systems.

To overcome these challenges, this test concept outlines an integrated methodology using passive data collection techniques, engineering-based risk assessments, laboratory-

based demonstrations, and focused on-ship operational testing to help DOT&E assess these critically important but so far unassessed systems.

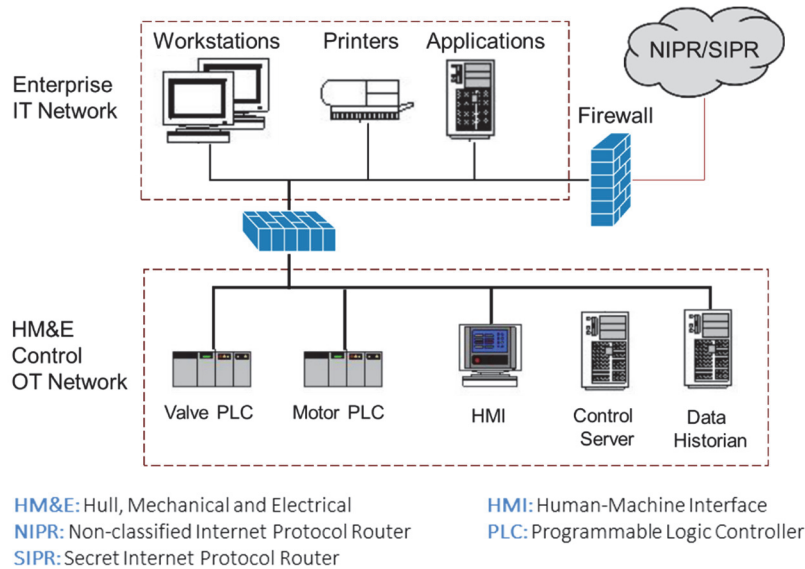
### A. System Description

HM&E/ICS networks allow a computer network to physically monitor, interact, and control physical processes. In the context of shipboard Navy systems, common examples include:

- Electrical power and distribution
- Steering propulsion
- Damage control
- Heating, ventilation, and air conditioning
- Auxiliary functions (e.g. degaussing)

Similar types of hardware and software are also found in large-scale industrial processes. Field-level devices, such as programmable logical controllers or remote terminal units serve as the interface between the computer and physical control

systems (e.g. switches, relays, valves). A notional HM&E/ICS network and its segmented interface with the rest of a ship's systems is shown in Figure 1.

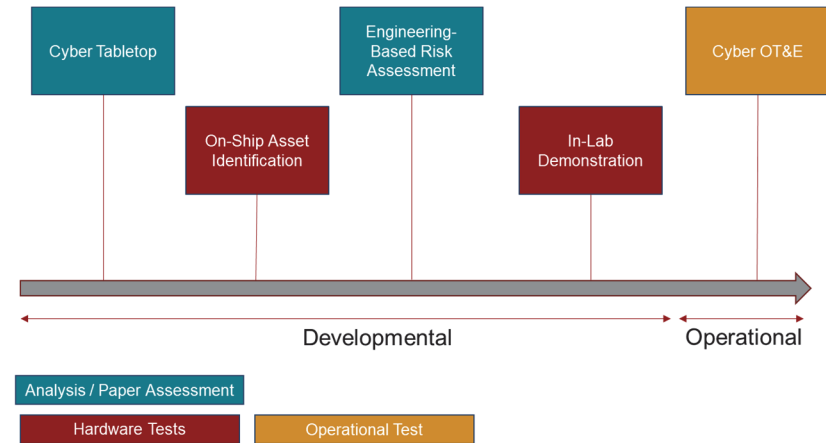


**Figure 1. A Notional Diagram of an HM&E/ICS Control Network and Its Segmentation from the Rest of a Ship's Computing Infrastructure**

## B. Evaluation Approach

We propose an integrated test strategy that leverages developmental testing and other testing activities to form an analytic basis for a cybersecurity assessment. We propose the use of passive data collection techniques, engineering-based risk

assessments, laboratory-based demonstrations, and focused, on-ship operational testing. A notional timeline demonstrating how these various events may fit together is shown in Figure 2.



**Figure 2. A Notional Timeline Showing Possible Data Sources and How They Relate to Developmental and Operational Testing**

### 1. Passive Data Collection/Enumeration

To develop an accurate representation of the HM&E/ICS network as deployed on a ship (rather than as designed or delivered), IDA recommends the use of passive data collection techniques to increase visibility and asset identification. These methods include:

- Review of configuration files taken from on-ship network infrastructure to verify hardware and access controls

- Physical inspection of on-ship HM&E/ICS systems to discover essential, non-networked components
- Passive collection / traffic sniffing using existing network infrastructure or defensive appliances to observe operational network traffic

Environmental enumeration is essential not only for ensuring the accuracy of any cybersecurity assessment, but also for allowing system owners to develop an adequate cyber defense.

## **2. Engineering-Based Risk Assessments**

Once an accurate representation of a ship's onboard HM&E/ICS networks have been developed, IDA recommends that the test and evaluation community (including developmental testers, operational testers, and program office personnel) develop an engineering-based risk assessment to help characterize risk to critical HM&E/ICS components. These assessments can help identify:

- The potential access points into the HM&E/ICS environment
- The kinds of malicious activity that can be detected
- The critical components and key failure modes that an adversary could try to exploit

- The range of tools available to system users and maintainers to detect potential compromise

These risk assessments are also useful for focusing and scoping laboratory and on-ship testing. Optimally, the output of such an assessment is a detailed, formal report that describes the potential attack surface and risks, as well as the mitigation measures a system owner might employ to lower risk to critical systems.

## **3. Demonstrations in Controlled, Laboratory Environments**

For ground engineering assessments and the validation of potential, high-risk attack vectors against an HM&E/ICS, we recommend the development of HM&E/ICS-specific tools and their application in controlled, laboratory environments. For example, OPTEVFOR is already developing a non-internet protocol (non-IP) cybersecurity suite focused on HM&E/ICS to support future operational testing.

Because of the potential for damage from active testing (e.g. transmitting commands/signals to HM&E/ICS networks), IDA recommends first applying these tools in controlled, laboratory environments to minimize risk against deployed Navy platforms. In addition, successful testing with these tools in laboratory environments may increase stakeholder confidence in the safe and effective application of these tools to shipboard systems.

While it might not be feasible to verify, validate, and accredit laboratory-based demonstrations for every program of record on DOT&E oversight, it may be possible to select types of HM&E/ICS implementations that are common across Navy platforms as potential subjects of laboratory testing.

#### **4. On-ship Operational Testing to Determine Accessibility of HM&E/ICS Components and Demonstrate High-Confidence Attack Vectors**

Regardless of whether a system or platform is the subject of a laboratory-based test event, all programs on DOT&E oversight should probe how accessible HM&E/ICS components are from starting postures elsewhere on a system's computing network. At a minimum, operational testing should be able to provide information on:

- The presence of appropriate access controls between HM&E/ICS systems and the rest of the ship/platform
- Whether shipboard operators are trained and equipped to identify cyber compromise on HM&E/ICS networks
- Whether support activities (e.g. Naval Surface Warfare Centers) have response procedures to support triage of critical HM&E/ICS components

Additionally, for systems that have undergone controlled, laboratory-based testing, testers can conduct focused

demonstrations against specific elements of an HM&E/ICS aboard ship, with the technical support of system subject matter experts.

### **C. Recommendations**

We recommend that DOT&E consider the following immediate and long-term courses of action to support the adequate assessment of these critical shipboard systems:

#### **1. Immediate**

- Require the consistent conduct of engineering-based risk assessments (and delivery of formal reports) as part of the cyber assessment for Navy platforms.
- Require that all on-ship operational tests assess interface between HM&E/ICS systems and the rest of a ship's computing environment.
- Continue to encourage OPTEVFOR's development of active, non-IP, HM&E/ICS-specific test tools and the use of passive collection methods on HM&E/ICS systems.
- After HM&E/ICS tools and tactics have been proved out in laboratory environments, advocate for their inclusion in select operational cyber assessments.

## **2. Long-Term**

- Advocate for the funding, development, and use of land-based test sites for families of HM&E/ICS systems (e.g. power distribution, steering control).
- Encourage system owners to conduct passive data collection on-ship to improve their ability to defend these critical components and support land-based test sites and engineering-based risk assessments.





# **Challenges and Recommendations: Operational Cyber Testing of Hull, Mechanical, and Electrical (HM&E) / Industrial Control Systems (ICS)**

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15 February 2022

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## Background

Provide background on the current state and challenges of testing Hull, Mechanical, and Electrical (HM&E) / Industrial Control Systems (ICS) on Navy platforms.

## Purpose

Provide recommendations on how DOT&E can advocate for near-term inclusion of HM&E/ICS in future cyber assessments

# Background – What is an ICS?

Industrial control system (ICS) is a general term that encompasses several types of control systems, including:

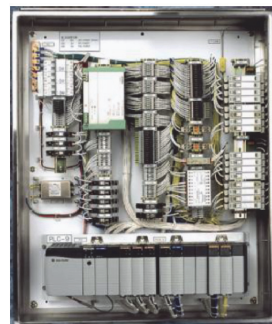
- Architectures
  - Supervisory Control and Data Acquisition (SCADA)
  - Distributed Control Systems (DCS)
- Field Components
  - Programmable Logic Controllers (PLC)
  - Remote Terminal Units (RTUs)

... often found in the industrial sectors and critical infrastructures.  
(NIST 800-82)



PLC

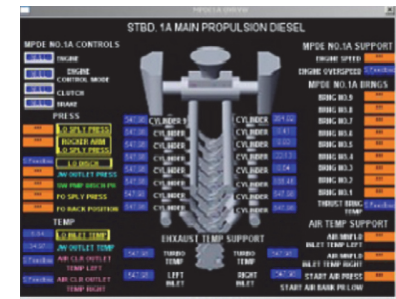
HMI: Human Machine Interface



RTU

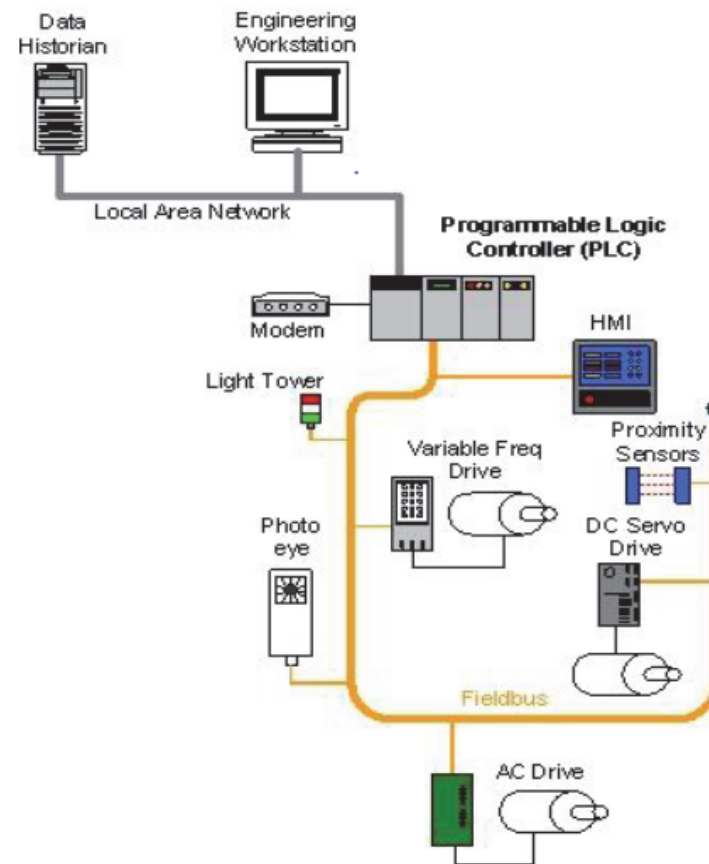


HMI  
Station



Physical  
Process

# ICS components allow computer networks to monitor, interact, and control *physical processes*.



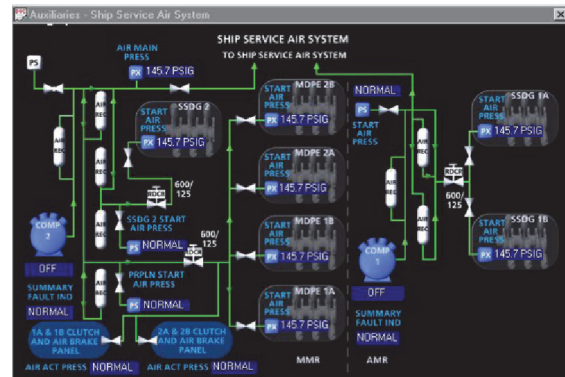
If there's a valve connected to a computer, there's likely a PLC acting as the interface between the computer and the physical world.

HMI: Human Machine Interface  
AC: Alternating Current  
DC: Direct Current

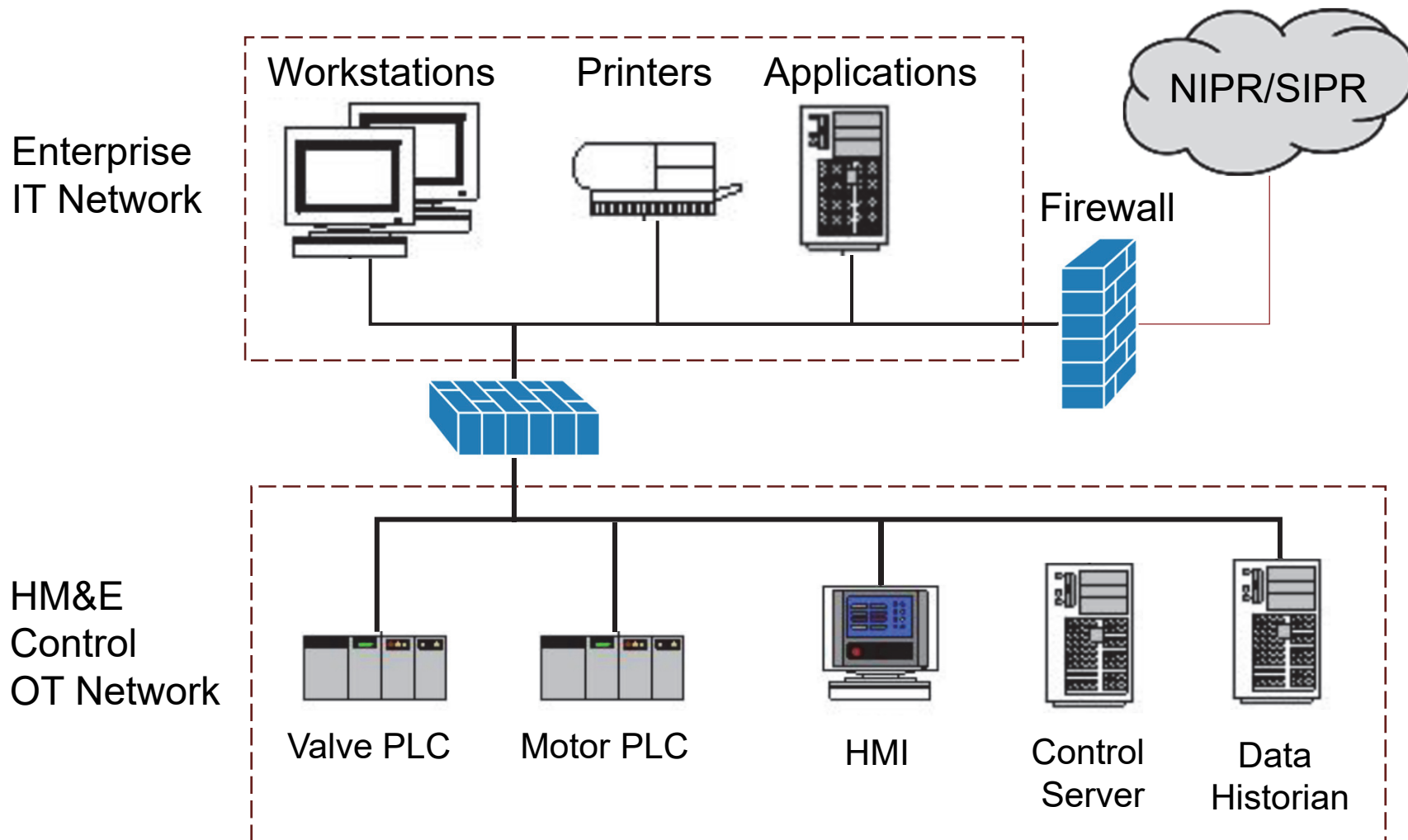
# In the shipboard context, these components are typically part of **Hull, Mechanical, and Electrical (HM&E) Systems**.

- Electrical power and distribution
- Steering propulsion
- Damage control
- Heating, ventilation, and air conditioning
- Auxiliaries (e.g. degaussing)

For the purposes of this briefing, we'll use the terms HM&E and ICS as interchangeable catchalls



# Networks are traditionally separated into Information Technology (IT) and Operational Technology (OT)



HM&E: Hull, Mechanical and Electrical  
NIPR: Non-classified Internet Protocol Router  
SIPR: Secret Internet Protocol Router

HMI: Human-Machine Interface  
PLC: Programmable Logic Controller

# What's the current state of ICS testing in the Navy OT&E community?

DOT&E guidance states that “test agencies must continue to use all available tools and resources to assess these [ICS] systems.”

--DOT&E Memorandum. Cybersecurity Operational Test and Evaluation Priorities and Improvements. 27JUL2016

Additionally, DOT&E has also invested in the development of safe test and evaluation techniques for ICS.

--DOT&E Memorandum. Cybersecurity Operational Test and Evaluation Priorities and Improvements. 27JUL2016

However, to date, no Navy platform on DOT&E oversight has included on-ship testing of ICS as part of cyber operational testing.

# What has hampered testing of ICS networks of systems on DOT&E oversight?

In the past, system owners and test teams have resisted the inclusion of ICS systems as part of cyber operational testing for a number of reasons.\*

- ICS protocols have traditionally been serial/non-IP and are outside of the current expertise and toolsets of operational test teams.
- Concerns that ICS testing can cause unforeseen disruption or damage to critical systems.
  - DOT&E guidance has expressed the necessity for caution in testing ICS components due to the risk of damage.
  - Testing of ICS systems in private industry has demonstrated that these kinds of systems can be too sensitive for common red-team tools like active scanning.

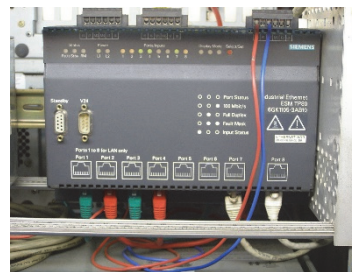
# ICS implementations depend less and less on legacy serial/non-IP protocols.

- The distinction between the IT networks and OT networks is vanishing as legacy serial interfaces get replaced by enterprise-like TCP/IP hardware.\*
- Modern ICS protocols run as layers on TCP/IP networks—allowing network owners to use the same kind of infrastructure.

Serial



Industrial Ethernet



- BUT: Even if an ICS uses the types of networks that red teams are familiar with, there is still risk due to the potential of damage to the underlying system.
- AND: An assessment should involve more than just finding vulnerabilities.

ICS: Industrial Control Systems

IT: Information Technology

OT: Operational Technology

TCP/IP: Transmission Control Protocol/Internet Protocol

\* M. Keene. <https://www.sans.org/blog/the-risks-of-an-it-versus-ot-paradigm/>

# Actively testing ICS components is still a higher risk activity than traditional IT cyber testing

- A failure in a critical safety system or physical process can lead to costly downtime or even unsafe conditions.
- Even scanning tools that vendors claim are “ICS specific” or “use native ICS protocols” can lead to unforeseen circumstances/situations.
  - Often, the challenge in testing ICS is not the lack of a tool (though having one helps): **Creating reproducible, safe effects on an ICS typically requires a detailed understanding of the physical process the ICS is managing.**
- Ultimately, finding vulnerabilities/exposures in an ICS system (e.g. using ICS test tools) is only one part of a holistic approach to evaluating a system.

**It's not enough to test if an adversary can get in.**

**What happens *when* they do get in, and *how do systems and users respond?***

**Proposal: An integrated (developmental  
+ operational) assessment of ICS  
systems, using data from operational  
testing and other sources.**

# We propose an integrated approach to assessing cyber posture of ICS systems, using data from operational testing and other sources

- Use *passive* techniques to collect on-ship data as part of program office enumeration activities.
- Require **engineering risk assessments** that characterize the risk to ICS systems.
- Advocate for general “demonstrations” of HM&E systems in **controlled laboratory environments** to ensure that these risk assessments are grounded in reality.
- Dedicate **operational testing** events to probe the interface between traditional shipboard IT systems and ICS components, and potentially targeted, vetted actions against an ICS system.

# Passive techniques to increase visibility and asset identification on ship

In order for system defenders to protect an ICS, they need to know what is in their environment!

- Not just *as designed* but also *as deployed*.

The test and evaluation community could encourage program offices to identify assets in their ICS networks using non-disruptive techniques:

## Review of configuration files

- Router/hardware
- Verify access controls

## Physical Inspection

- Important for non-networked components

## Passive Collection/Traffic Sniffing

- Use framework of existing defensive appliances (e.g. SPAN ports)

Environment enumeration is useful for an assessment and necessary for cyber defense!

# Engineering-Based Risk Assessments to describe the potential effects of ICS compromise

The combined test and evaluation community (DT/OT/program office) along with contractor subject matter experts could develop engineering risks assessments of these ICS subsystems:

- Identify potential access points into the ICS environment from the platform.
- Identify the kinds of malicious activity the system can actually detect.
  - How would these data overlay with known threat actors?
- Identify critical components and key failure modes that an adversary could potentially try to cause.
- Develop potential attack paths that could cause those failure modes.
- Determine what tools are available to system users and maintainers to postulate potential compromise.

Consider leveraging one of the existing frameworks to scope these questions: e.g. MITRE ATT&CK Framework for ICS.

# Example: What do known threats do, and can the system detect that kind of behavior?

The MITRE ATT&CK Framework for ICS is useful in characterizing the tools and techniques of world ICS threats.



The image displays the MITRE ATT&CK Framework for ICS matrix. At the top, there are 14 circular icons representing different threat groups: AL, Ch, Co, Dy, EL, Hx, Ka, Ma, Pi, Ra, St, Ta, Va, Wa, and Xt (XENOTIME). Below these icons is a table with 12 columns representing attack phases and 14 rows representing specific attack techniques. The columns are: INITIAL ACCESS, EXECUTION, PERSISTENCE, PRIVILEGE ESCALATION, EVASION, DISCOVERY, LATERAL MOVEMENT, COLLECTION, COMMAND AND CONTROL, INHIBIT RESPONSE FUNCTION, IMPAIR PROCESS CONTROL, and IMPACT. The rows list various attack techniques such as Data Historian Compromise, Drive-by Compromise, Engineering Workstation Compromise, Exploit Public-Facing Application, Exploitation of Remote Services, External Remote Services, Internet Accessible Device, Remote Services, Replication Through Removable Media, Rogue Master, Spearphishing Attachment, Supply Chain Compromise, and Wireless Compromise. Each cell in the table contains a specific technique or action, and the final column lists the potential impact of each attack.

| INITIAL ACCESS                      | EXECUTION                 | PERSISTENCE            | PRIVILEGE ESCALATION                  | EVASION                   | DISCOVERY                           | LATERAL MOVEMENT                | COLLECTION                         | COMMAND AND CONTROL                 | INHIBIT RESPONSE FUNCTION     | IMPAIR PROCESS CONTROL       | IMPACT                           |
|-------------------------------------|---------------------------|------------------------|---------------------------------------|---------------------------|-------------------------------------|---------------------------------|------------------------------------|-------------------------------------|-------------------------------|------------------------------|----------------------------------|
| Data Historian Compromise           | Change Operating Mode     | Modify Program         | Exploitation for Privilege Escalation | Change Operating Mode     | Network Connection Enumeration      | Default Credentials             | Automated Collection               | Commonly Used Port                  | Activate Firmware Update Mode | Brute Force I/O              | Damage to Property               |
| Drive-by Compromise                 | Command-Line Interface    | Module Firmware        | Hooking                               | Exploitation for Evasion  | Network Sniffing                    | Exploitation of Remote Services | Data from Information Repositories | Connection Proxy                    | Alarm Suppression             | Modify Parameter             | Denial of Control                |
| Engineering Workstation Compromise  | Execution through API     | Project File Infection |                                       | Indicator Removal on Host | Remote System Discovery             | Lateral Tool Transfer           | Detect Operating Mode              | Standard Application Layer Protocol | Block Command Message         | Module Firmware              | Denial of View                   |
| Exploit Public-Facing Application   | Graphical User Interface  | System Firmware        |                                       | Masquerading              | Remote System Information Discovery | Program Download                | I/O Image                          |                                     | Block Reporting Message       | Spoof Reporting Message      | Loss of Availability             |
| Exploitation of Remote Services     | Hooking                   | Valid Accounts         |                                       | Rootkit                   | Wireless Sniffing                   | Remote Services                 | Man in the Middle                  |                                     | Block Serial COM              | Unauthorized Command Message | Loss of Control                  |
| External Remote Services            | Modify Controller Tasking |                        |                                       | Spoof Reporting Message   |                                     | Valid Accounts                  | Monitor Process State              |                                     | Data Destruction              |                              | Loss of Productivity and Revenue |
| Internet Accessible Device          | Native API                |                        |                                       |                           |                                     |                                 | Point & Tag Identification         |                                     | Denial of Service             |                              | Loss of Protection               |
| Remote Services                     | Scripting                 |                        |                                       |                           |                                     |                                 | Program Upload                     |                                     | Device Restart/Shutdown       |                              | Loss of Safety                   |
| Replication Through Removable Media | User Execution            |                        |                                       |                           |                                     |                                 | Screen Capture                     |                                     | Manipulate I/O Image          |                              | Loss of View                     |
| Rogue Master                        |                           |                        |                                       |                           |                                     |                                 | Wireless Sniffing                  |                                     | Modify Alarm Settings         |                              | Manipulation of Control          |
| Spearphishing Attachment            |                           |                        |                                       |                           |                                     |                                 |                                    |                                     | Rootkit                       |                              | Manipulation of View             |
| Supply Chain Compromise             |                           |                        |                                       |                           |                                     |                                 |                                    |                                     | Service Stop                  |                              | Theft of Operational Information |
| Wireless Compromise                 |                           |                        |                                       |                           |                                     |                                 |                                    |                                     | System Firmware               |                              |                                  |

Source: <https://www.dragos.com/mitre-attack-for-ics/>

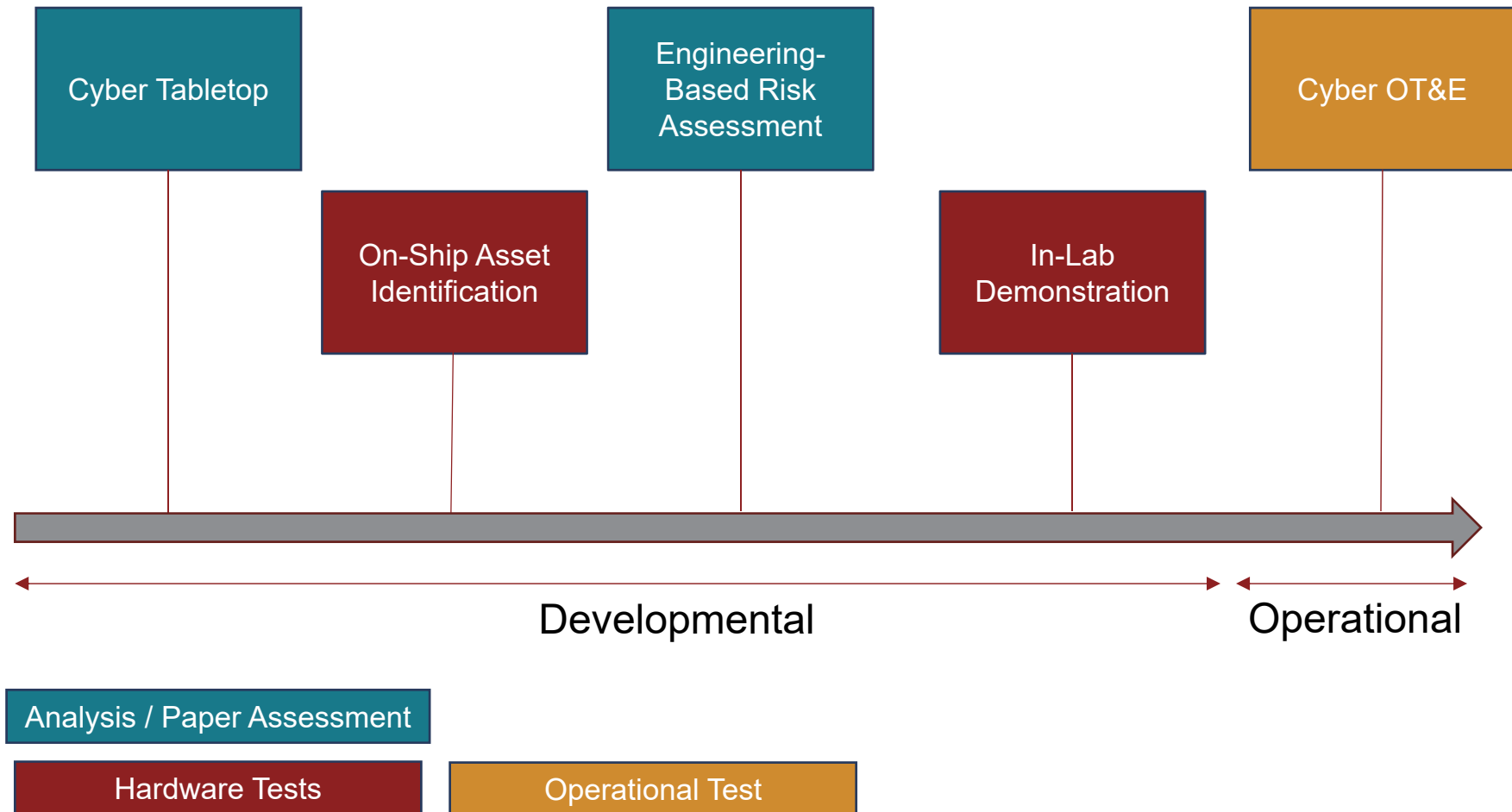
# Advocate demonstrations in a controlled, laboratory environment

- To ground the engineering analyses in reality, DOT&E could work with program offices and DTE&A to stand up demonstration events for the kinds of attacks developed in the engineering analysis.
- One demonstration could cover multiple programs of record, since there may be commonalities between the implementations of their ICS solutions.
- Working closely with system owners and process engineers, develop and deploy ICS attacks to prove out attack threads in the engineering risk assessment.
- It might not be feasible to verify, validate, and accredit a lab based event for each program of record.
  - But it is also likely not feasible to conduct this level of testing for every program on ship, due to safety constraints and the intensive nature required to develop controlled ICS attacks.

# Operational tests to determine accessibility of ICS components

- Regardless of whether a system conducts a laboratory-based test event, all programs should include probing how accessible ICS components are from traditional IT systems.
  - Are ICS networks adequately separated from the rest of the ship?
  - What parts of the ICS are routable from the non-ICS enclave?
  - Are there appropriate access controls in place to prevent intrusion?
  - Are shipboard operators trained and equipped to identify cyber compromise on ICS networks, and do they have an appropriate incident response plan?
  - If the ship outsources this work to a support activity (e.g. Navy Surface Warfare Center), what are that entities response procedures?
- The answers to these questions can directly translate into recommendations to increase the robustness of HM&E systems.
- OPTEVFOR has also sponsored NSWC-Philadelphia to develop ICS specific test tools to support their assessments.
  - After their application and testing in a controlled lab environment, these tools could potentially be used on ship against high interest components, with the *technical support of system subject matter experts*.

**These combined activities provide an integrated, executable timeline to assess ICS components**



# IDA Recommendations that DOT&E consider the following courses of action

## Immediate

- Require the consistent conduct of Engineering Risk Assessments (and delivery of formal reports) as part of the cyber assessment for Navy platforms.
- Require that all on-ship operational tests assess interface between HM&E systems and the rest of a ship's computing environment.
- Continue to encourage OPTEVFOR's development of active, non-IP HM&E specific test tools and the use of passive collection methods on HM&E systems.
- After HM&E tools and tactics have been proved out in laboratory environments, advocate for their inclusion in select operational cyber assessments.

## Long-Term

- Advocate for the funding, development, and use of land-based test sites for particular families of HM&E systems (e.g. power distribution, steering control).
- Encourage system owners to conduct passive data collection on-ship to improve their ability to defend these critical components and support land-based test sites and engineering risk assessments.

# Conclusions

- The challenges of testing ICS components continue to hamper the test community's ability to assess the cyber survivability of these subcomponents.
- An opportunity exists not only to leverage non-OT data for DOT&E assessments, but to encourage system owners to increase their visibility into their ICS systems.
  - “You can’t defend what you don’t know.”
- Operational testing will still play an important part in determining how connected these ICS systems are to the rest of the ship, and whether system operators have the tools and procedures in place to identify and respond to cyber intrusion.

# Backup

# ICS Cyber Test Data Elements – Find Vulnerabilities and Exposures

| How should the OTA and red team collect vulnerability and exposure data for each attack volume component? |                                  |                      |                 |                                                            |                               |                                                  |                     |
|-----------------------------------------------------------------------------------------------------------|----------------------------------|----------------------|-----------------|------------------------------------------------------------|-------------------------------|--------------------------------------------------|---------------------|
| ICS Component                                                                                             |                                  |                      |                 |                                                            |                               |                                                  |                     |
| Primary Collection Method Venue                                                                           | Component of ICS to interrogate  |                      |                 |                                                            |                               |                                                  |                     |
|                                                                                                           | Devices at the Interface of ICS  |                      |                 |                                                            | Operational and Control Units |                                                  | Process/Field Units |
| Data to Obtain                                                                                            | Edge Switches                    | Remote Access Server | Other DMZ Hosts | Data Historian Mirror                                      | HMI                           | Data Historian                                   | PLCs/RTUs           |
| Enumeration of Known (Hardware) Vulnerabilities                                                           | Deliberate Network Scanning      |                      |                 | Deliberate Passive Network Sniffing / Configuration Review |                               | Deliberate Dedicated ICS Tool + Passive Sniffing |                     |
| Enumeration of Software Flaws/Data Flows                                                                  | Deliberate Network Scanning      |                      |                 | Deliberate Passive Network Sniffing / Configuration Review |                               | Deliberate Dedicated ICS Tool + Passive Sniffing |                     |
| Hardware and Software Configuration                                                                       | Inferential Configuration Review |                      |                 | Deliberate Passive Network Sniffing / Configuration Review |                               | Inferential Configuration Review                 |                     |

|                              |                   |
|------------------------------|-------------------|
| Analysis or Paper Assessment | Other Test Events |
| DT or IT Test Events         | Operational Tests |

**OTA:** Operational Test Agency  
**DMZ:** Demilitarized Zone  
**HMI:** Human-Machine Interface  
**PLC:** Programmable Logic Controller

**ICS:** Industrial Control System  
**RTU:** Remote Terminal Unit

# ICS Cyber Test Data Elements – Characterize Potential Mission Effects

| To what extent can mission effects be induced by attacks from each family, given an adversary's starting posture? |                        |                                                                            |                                  |
|-------------------------------------------------------------------------------------------------------------------|------------------------|----------------------------------------------------------------------------|----------------------------------|
| Data Collected During Adversarial Cyber Attacks                                                                   |                        | Cyber Attacker Seeking to Conduct Fire from Predetermined Starting Posture |                                  |
| Mission Effect Objectives                                                                                         | Attack Family          | Authenticated Access                                                       | Unauthenticated Access           |
| Exploit Initial Access on ICS to attack IT Network                                                                | <i>Confidentiality</i> | N/A                                                                        | N/A                              |
|                                                                                                                   | <b>Integrity</b>       | <b>Inferential</b>                                                         | <b>Inferential</b>               |
|                                                                                                                   | <i>Availability</i>    | N/A                                                                        | N/A                              |
| Exfiltration Operational Process Information                                                                      | <b>Confidentiality</b> | Deliberate (on-ship)                                                       | Deliberate (on-ship)             |
|                                                                                                                   | <i>Integrity</i>       | N/A                                                                        | N/A                              |
|                                                                                                                   | <i>Availability</i>    | N/A                                                                        | N/A                              |
| Deny/Alter Operators View of Physical Process                                                                     | <i>Confidentiality</i> | N/A                                                                        | N/A                              |
|                                                                                                                   | <b>Integrity</b>       | <b>Deliberate (on-ship)</b>                                                | <b>Deliberate (on-ship)</b>      |
|                                                                                                                   | <b>Availability</b>    | <b>Deliberate (on-ship)</b>                                                | <b>Deliberate (on-ship)</b>      |
| Deny Availability of Physical Process (e.g. Shutdown Physical Process)                                            | <i>Confidentiality</i> | N/A                                                                        | N/A                              |
|                                                                                                                   | <b>Integrity</b>       | <b>Deliberate (in-lab)</b>                                                 | <b>Deliberate (in-lab)</b>       |
|                                                                                                                   | <b>Availability</b>    | <b>Deliberate (in-lab)</b>                                                 | <b>Deliberate (in-lab)</b>       |
| Intentionally Cause a Loss of Safety (e.g. Interfere with Safety Control System)                                  | <i>Confidentiality</i> | N/A                                                                        | N/A                              |
|                                                                                                                   | <b>Integrity</b>       | <b>Inferential (by analysis)</b>                                           | <b>Inferential (by analysis)</b> |
|                                                                                                                   | <i>Availability</i>    | N/A                                                                        | N/A                              |

# ICS Cyber Test Data Elements – Defensive Actions

| How do ICS defenders and operators deal with cyber effects and subsequent mission effects?               |                            |              |                                                                         |                                      |                         |                           |
|----------------------------------------------------------------------------------------------------------|----------------------------|--------------|-------------------------------------------------------------------------|--------------------------------------|-------------------------|---------------------------|
| Data Collected During Defensive Actions<br>(Potentially in laboratory setting due to safety constraints) |                            |              | Defensive Capabilities                                                  |                                      |                         |                           |
|                                                                                                          |                            |              | Inherited Defenses (Host Platform)                                      |                                      | Inherent Defenses (ICS) |                           |
|                                                                                                          |                            |              | Cyber<br>(CSSP)                                                         | Non-cyber<br>(Fire Control Operator) | Cyber                   | Non-cyber<br>(Maintainer) |
| Detections                                                                                               | Authenticated Access       | Native Tool  | Inferential<br><br>Based on observations from platform/host CVPA and AA |                                      | No Role                 | Opportunistic             |
|                                                                                                          |                            | Foreign Tool |                                                                         |                                      |                         | Opportunistic             |
|                                                                                                          | Unauthenticated Access     | Native Tool  |                                                                         |                                      |                         | Deliberate                |
|                                                                                                          |                            | Foreign Tool |                                                                         |                                      |                         | Deliberate                |
| Responses                                                                                                | Treat                      |              | Inferential<br><br>Based on observations from platform/host CVPA and AA |                                      | No Role                 | Deliberate                |
|                                                                                                          | Tolerate                   |              |                                                                         |                                      |                         | Deliberate                |
|                                                                                                          | Terminate                  |              |                                                                         |                                      |                         | Opportunistic             |
|                                                                                                          | Transfer                   |              |                                                                         |                                      |                         | No Role                   |
| Recovery Actions                                                                                         | Reboot ICS                 |              | No Role                                                                 |                                      | No Role                 | Deliberate                |
|                                                                                                          | Revert to Known Good State |              |                                                                         |                                      |                         | Opportunistic             |
|                                                                                                          | Other Actions              |              |                                                                         |                                      | Inferential             | Inferential               |

**AA:** Adversarial Assessment  
**CEC:** Cooperative Engagement Capability

**CSSP:** Cybersecurity Service Provider  
**CVPA:** Cooperative Vulnerability and Penetration Assessment



## REPORT DOCUMENTATION PAGE

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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                    |                                                                             |                                            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|-----------------------------------------------------------------------------|--------------------------------------------|
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