UNITED STATES
NAVAL ACADEMY
Annapolis

Lessons Learned when building a Maritime Systems Security Laboratory Testbench

Brien Croteau, USNA, Cyber Science

DefCon 31- ICS Village, 12 Aug 2023

Link to these slides:
https://github.com/brienc23/Defcon31_workshop_materials

My Background

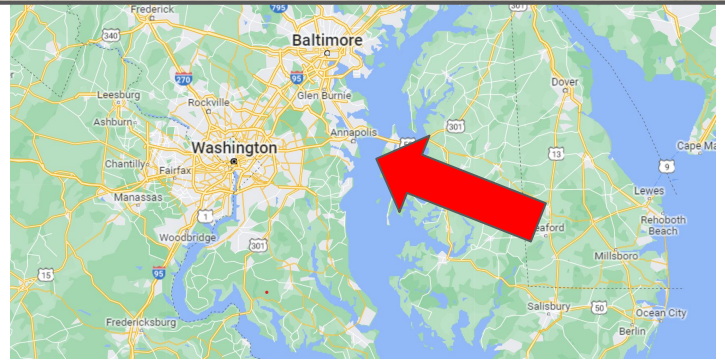
Disclaimer: All my opinions, not those of the US Gov, US Navy, or USNA

24-year Active Duty Naval Officer, EE Ph.D.
Assistant Professor, USNA Cyber Science Department
Military Deputy for the Dean of Math and Science

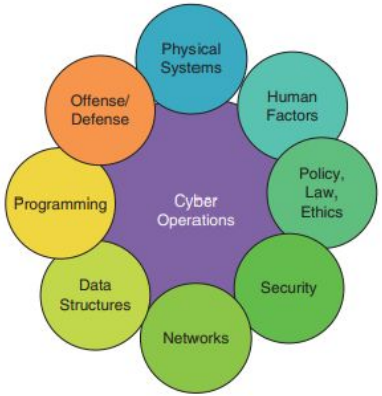
Research in Cyber-Physical Systems (CPS) Security: Detection of malicious sensors using side-channel power analysis, Alternate actuation paths, Actuation limits, Industrial Control Systems (ICS) security, Maritime Hull, Mechanical, & Electrical (HM&E) security

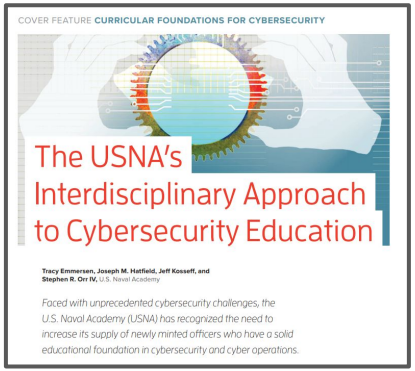
About the U. S. Naval Academy

- Located in Annapolis, MD
- One of Five Federal Military Academies
  - feeding the U. S. Navy and Marine Corps
- Approx. 4500 students and 600 Faculty
  - 300 civilian, 300 military
- 26 Majors
  - 65% graduates must be STEM majors



Cyber Operations: Interdisciplinary Major

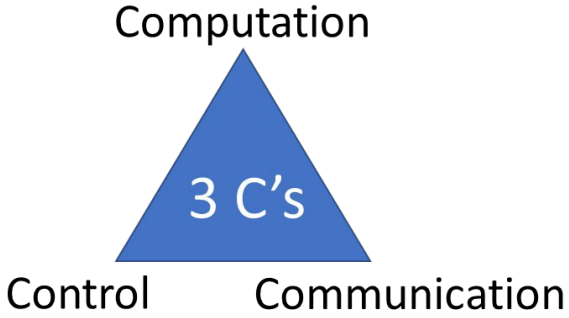




https://ieeexplore.ieee.org/abstract/document/8677342

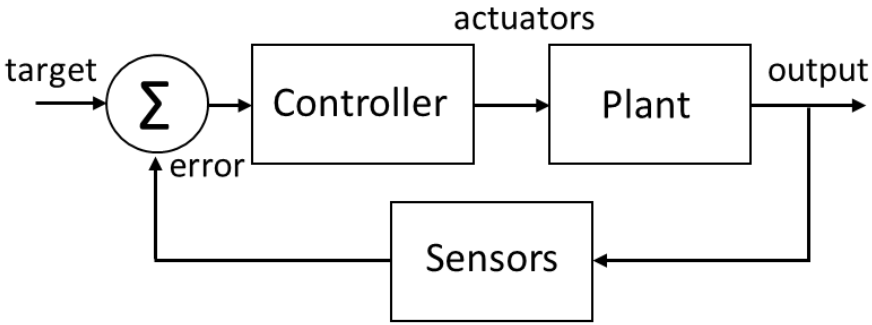
What do I mean by CPS?

Cyber-Physical Systems



Other Monikers:

- OT = Operational Technology
- ICS = Industrial Control Systems
- Industry 4.0, IIoT
- SCADA



Why should you care about this?

threatpost | Cloud Security / Malware / Vulnerabilities / InfoSec Insider

Researcher: Not Hard for a Hacker to Capsize a Ship at Sea

Mashable TECH SCIENCE SOCIAL GOOD

Remotely hacking ships shouldn't be this easy, and yet ...

UNITED STATES COAST GUARD
U.S. Department of Homeland Security

MARINE SAFETY ALERT
Inspections and Compliance Directorate

July 8, 2019
Washington, D.C.

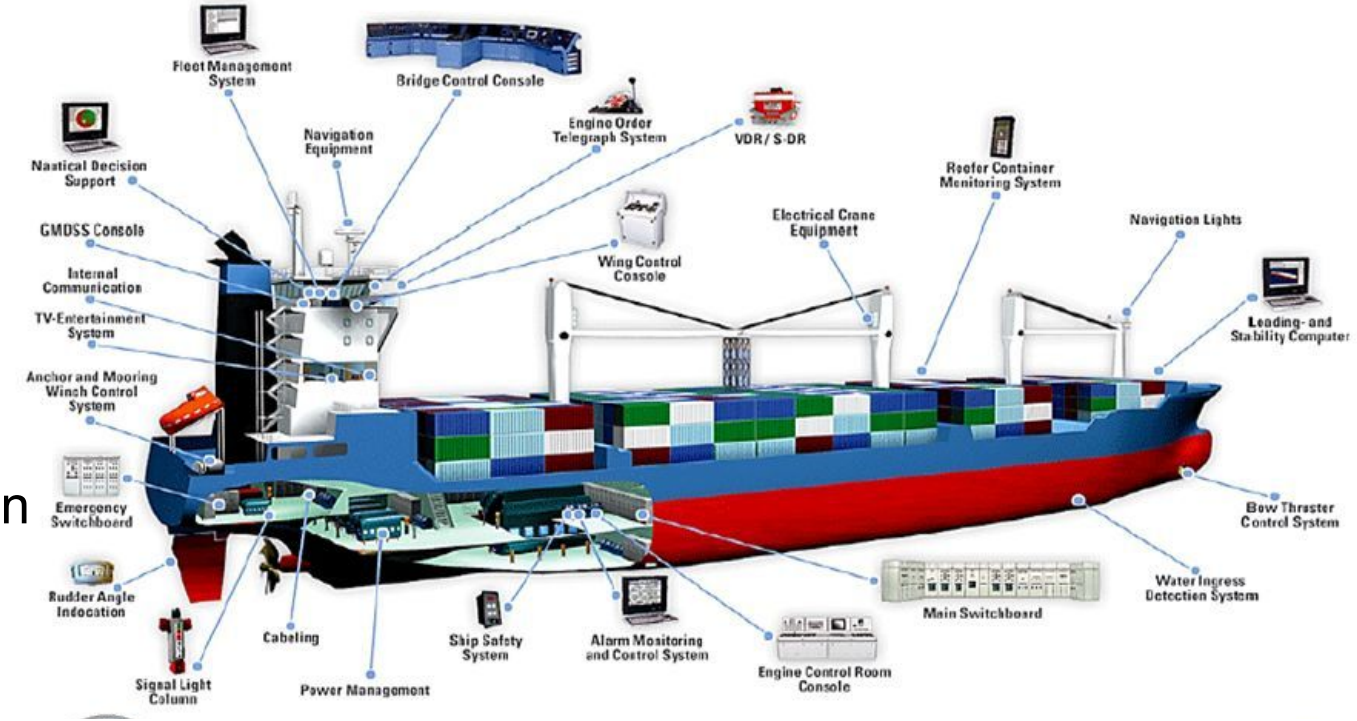
Safety Alert 06-19

Cyber Incident Exposes Potential Vulnerabilities Onboard Commercial Vessels

These were <u>not</u> caused by cyber attacks, but show the devastating potential consequences

Maritime Systems Overview

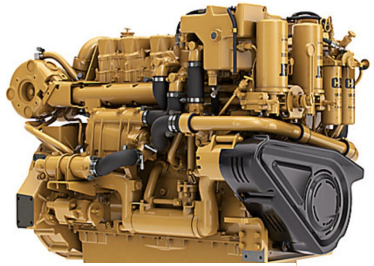
- Propulsion
- Electrical
- Auxiliary
  - Fresh Water
  - Sea Water
- Bridge
  - Navigation
  - Communication
  - Sensors

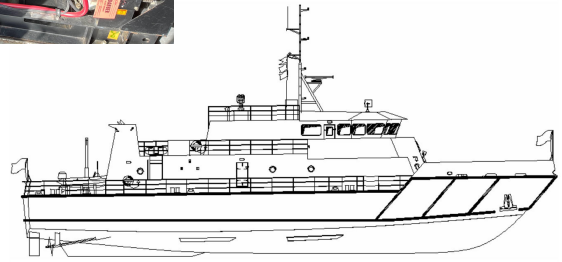


USNA Yard Patrol vessels (YP703)

- Builder: C&G Boat Works Inc. (YP703-2010 to YP708-2014)
- Propulsion: 2x715 bhp (2x448kw) Cat C-18 diesel engines at 2,100 RPM
- Electrical: 2x CAT Diesel Generators 480V, 99 KW, 3-phase AC
- Length: Overall: 119 feet (36.3 meters)
- Beam: 27.9 feet (8.51 meters)
- Displacement: 227.6 Metric Tonnes (223.9 long tons)
- Draft: 7.5 feet (2.27 meters)
- Speed: 12.6 knots (23.3 kilometers per hour)

Used for local ship-handling training operations and summer cruises on the eastern seaboard

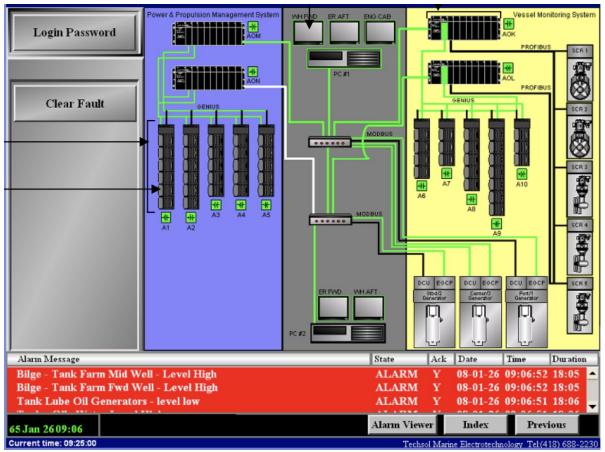


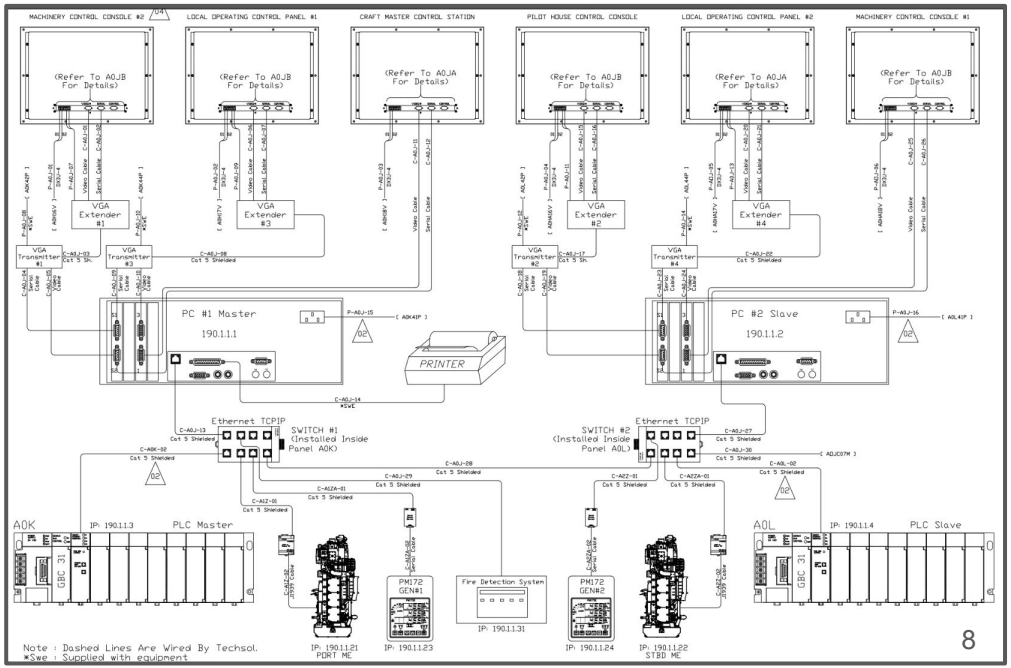


MAX II Alarms and Monitoring System on the YP703 class

GE Fanuc based custom install

- 2x PC to drive 6x touchscreen Human Machine Interface (HMI)
- 2x Programmable Logic Controllers (PLCs)
- Dual redundant IP/serial communications
- Interfaces with:
  - Engines
  - Generators
  - Tanks
  - Fire Detection



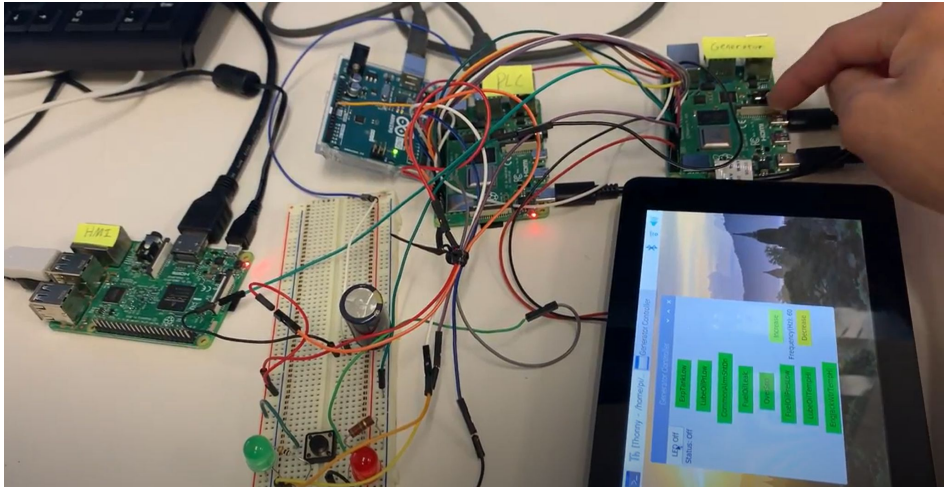


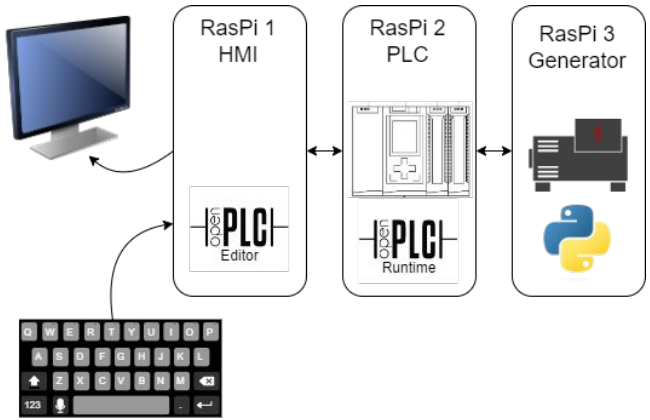
5 min [demo video]

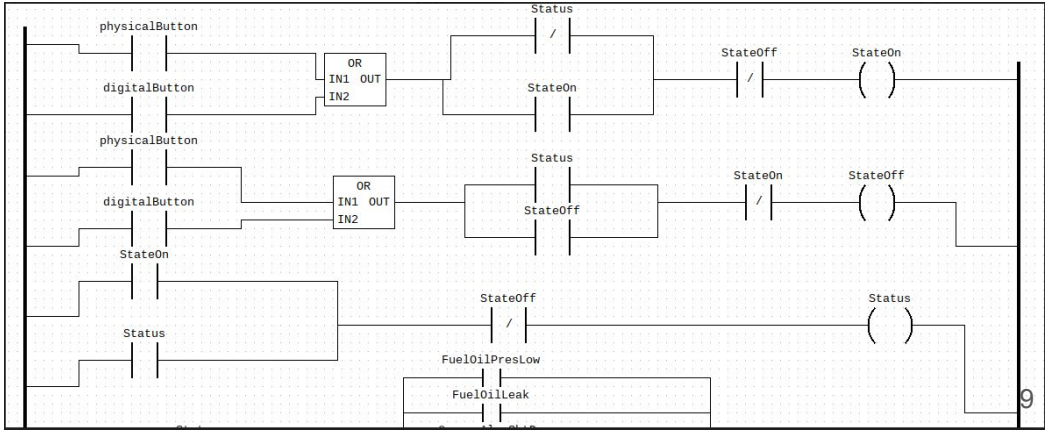
v1.0 Proof of Concept

3x Ras Pi: HMI, PLC, "Generator"

- OpenPLC v1.0
- 8 discrete faults
- 1 "analog" frequency
- toggle on/off status







MICS Course Offering

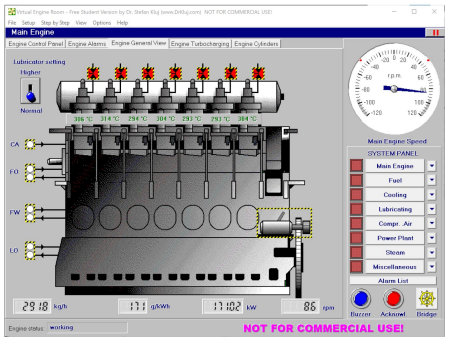
Spring 2023, SY486K Maritime Industrial Control Systems Cybersecurity

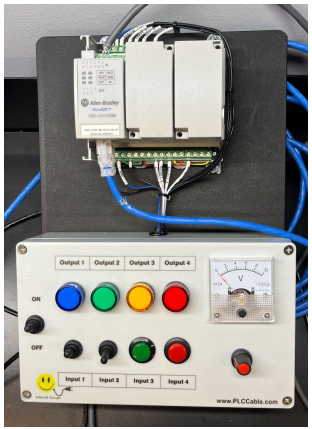
Three-credit technical elective

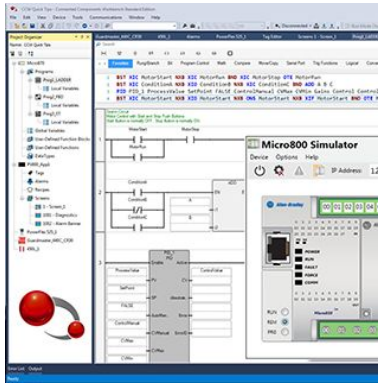
Lectures, Labs, Student Presentations, and YP Project

Topics included: Maritime Systems, PLC, Ladder Logic, Modbus, CIP, Attacking ICS

https://github.com/brienc23/MICS_Course_Materials





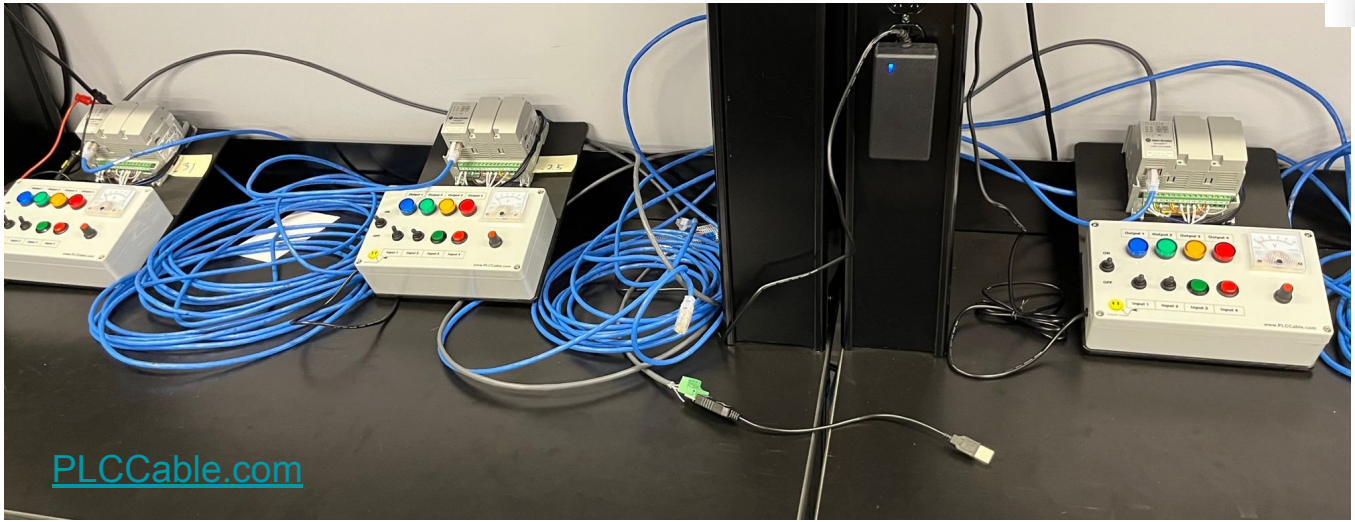


v2.0 Classroom Trainers

Allen-Bradley (AB) micro820 PLC based

Individual Ladder Logic Programming

Modbus Communication (RS-232, RS-485, and TCP)



Rockwell Automation

Connected Components Workbench™ Software

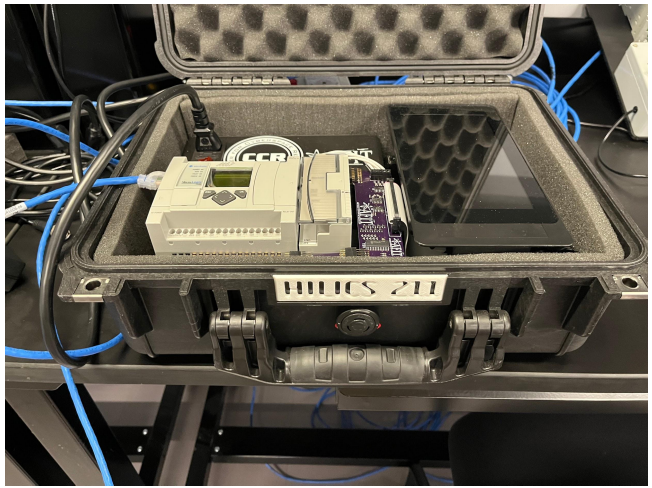
v2.5 Hardware-in-the-Loop ICS (HILICS)

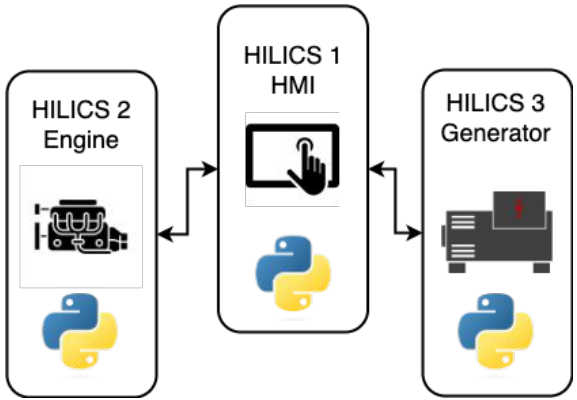
On loan from Air Force Institute of Technology (AFIT)
AB microLogix 1100+RasPi
Students made a 3-node network replicating a portion of the YP703 system:

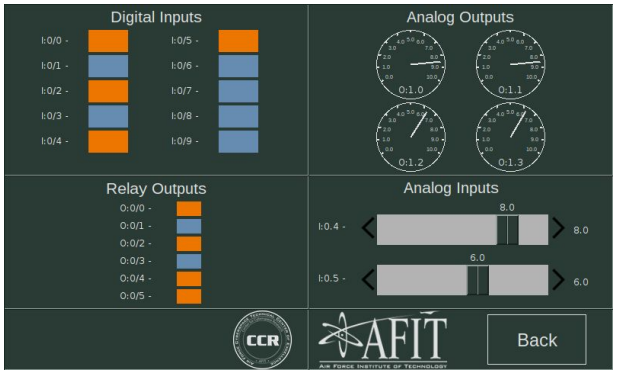
- 1x HMI
- 1x Diesel Engine
- 1x Generator

Captured their work in an Interface Control Document

https://github.com/sdunlap-afit/hilics







[Future] v3.0 Modular PLC Laboratory

Siemens S7-1215C PLCs + ktp700 Basic HMI
Envision a reconfigurable PLC centric lab that can emulate different applications

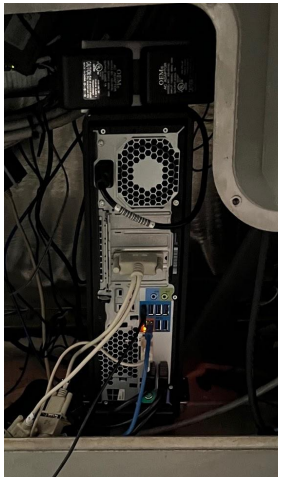
- Naval Vessel
- Factory Floor
- Water Treatment
- Building Automation

UlrichAAB CC3.0, https://commons.wikimedia.org/wiki/File:Simatic_S7-1200.JPG

[Future] v4.0 Actual YP Hardware in the Loop

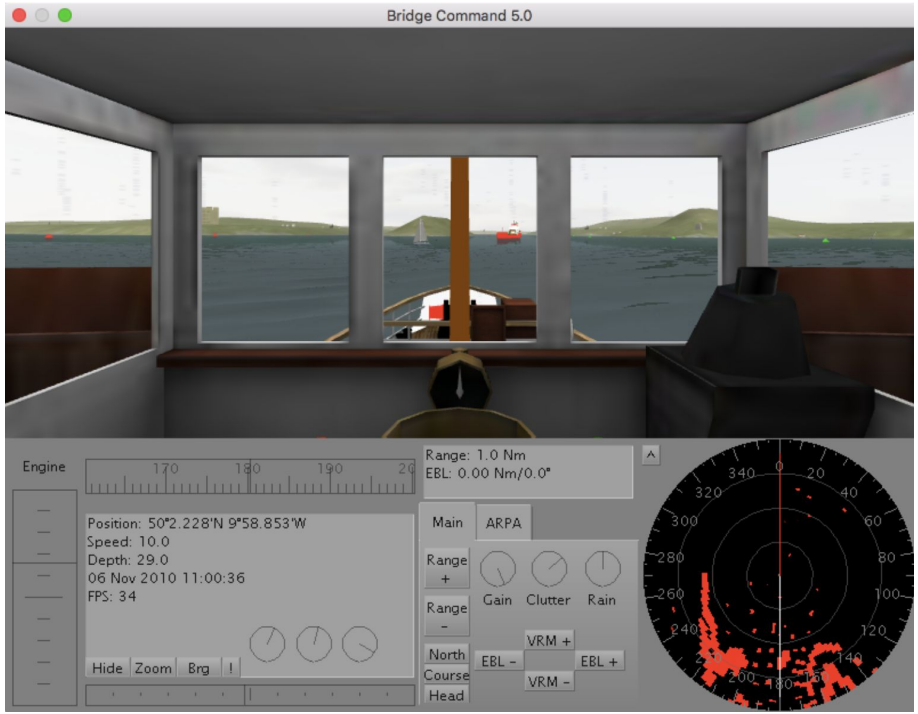
GE Fanuc PLC hardware from YPs + PC

Computer endpoints and networks allow a wider range of students to interact



[Future] v5.0 Bridge and Simulated Motion Integration

https://www.bridgecommand.co.uk/



Research platform to work on defense on advanced cyber attacks on ships

https://github.com/osrf/vrx

GAZEBO ROS

Conclusion

Shared the journey that I have begun on iterating towards a more comprehensive and realistic training and research environment.

I look forward to hearing your **questions** and and suggestions you might have about ideas moving forward.

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https://github.com/brienc23/Defcon31_workshop_materials

Brien Croteau, USNA, croteau@usna.edu

5 min demo video

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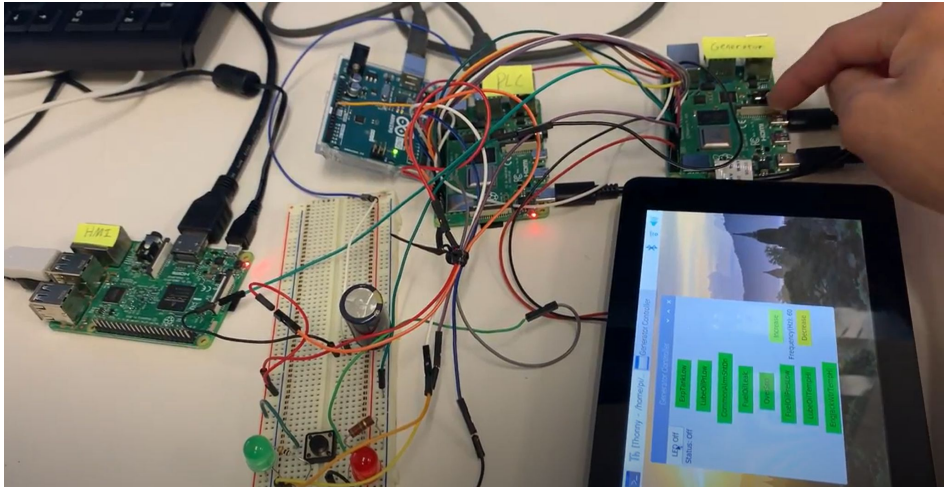
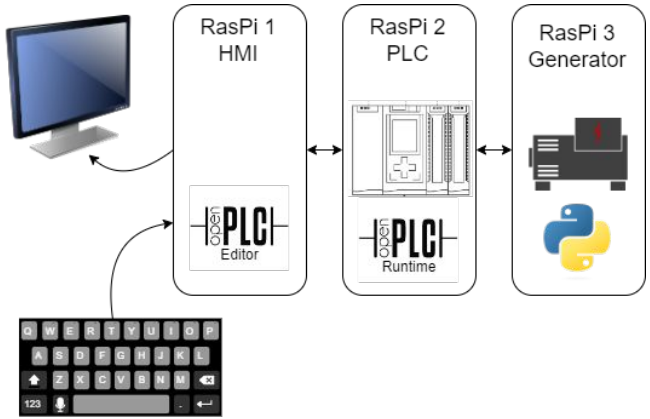
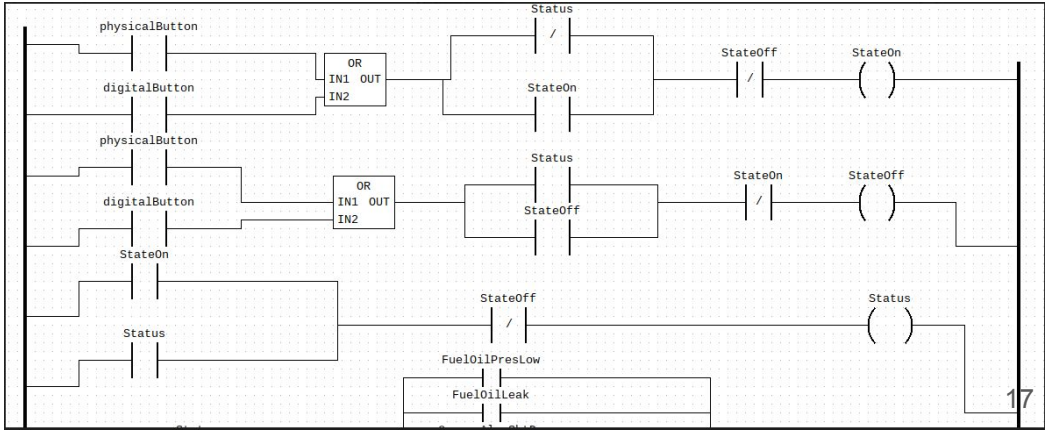
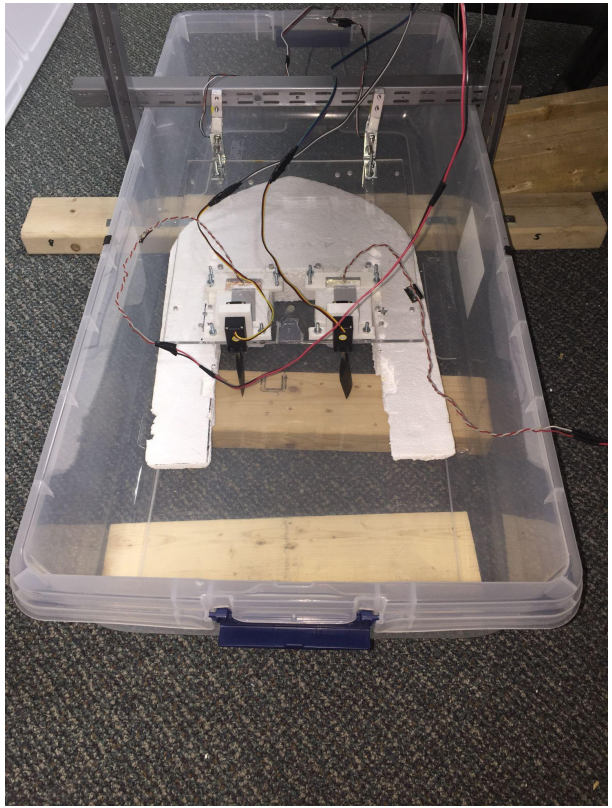


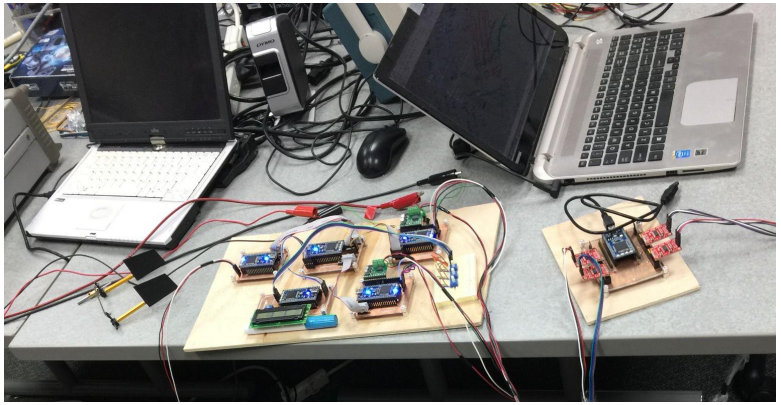


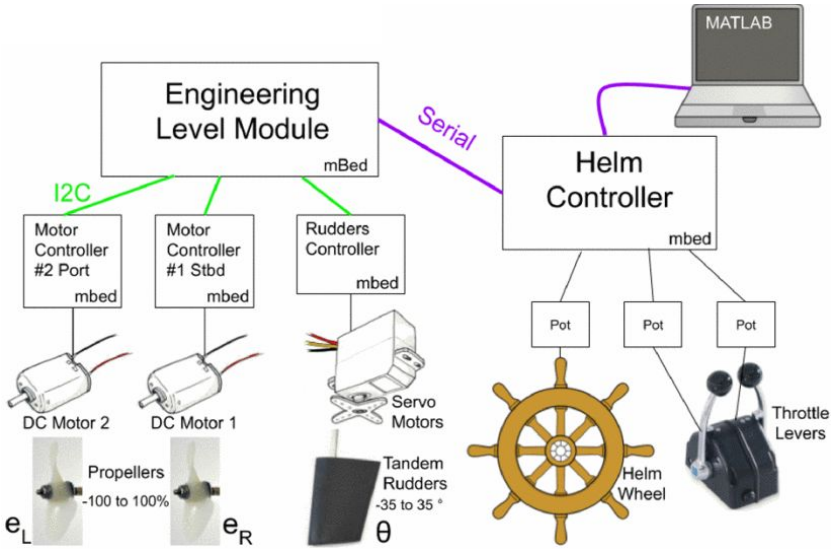


Other Maritime Testbenches

v0.1 UMBC Ship System Testbed







2019 R Week Paper

[Alternative Actuation Paths for Ship Applications in the Presence of Cyber-Attacks]