Shipyard 4.0 Security & Resiliency

Using Digital Twin and Data-Driven technology for increasing the Security & Resiliency of Shipyard 4.0 Processes

ELECOMP Capstone Design Project 2025-2026

Sponsoring Company:

Rite-Solutions
One Corporate Place
Middletown, RI. 02842
https://www.rite-solutions.com

Company Overview:

Rite-Solutions is an award-winning Veteran-Owned Small Business (VOSB) headquartered in Middletown, Rhode Island, established since April 2000. We have a stable and deep corporate history in Rhode Island, with over 380 employees with core competencies including systems engineering, software development, information technology, and cyber engineering. The stability of our business is demonstrated by both our longevity and business backlog. We have achieved both state and national recognition; one of our founders, Joe Marino, is an active member of the RI Science and Technology Advisory Council, along with other trusted Rhode Island business and academic leaders.

Rite-Solutions is known for innovation and dedication to the information and decision-making needs of our government and commercial customers, as well as our commitment to providing our customers what we are known for, namely The Information Advantage®. We have significant US Navy prime contracts in both warfare systems and business systems development and sustainment, as well as in Information Technology infrastructure support and cyber protection. In research and development efforts, we demonstrate a proclivity for our own inventive solutions but also for finding and working with non-traditional partners, including

academia and small commercial businesses, whose technologies we adapt to national research objectives in practical and meaningful ways that lead to productization.

Our corporate culture is a major part of our drive to both attract and retain people who make a difference. We take pride in our ethos of the F.E.W. (Friends Enjoying Work). Our ownership and management team work to create an open, creative, and stimulating environment. Our founders embraced the servant-leader concept from company inception, and it continues to guide our management team and approach. We recognize great ideas can and do come from anyone, not just the C-suite and thus facilitate ideation across the workforce in an engaging format. This approach to business nurtures the employer/employee relationship and moves our teams to a model where anyone who wants to can be part of the company's growth and contribute to our success. We have won numerous awards. Each year since 2021, we have been awarded the **Providence Business News "best place to work"** among large organizations (> 150 employees) and received extensive media coverage and academic interest about our culture, including as the subject of case studies by Harvard University and Stanford University, in employee motivation and idea generation techniques. In 2022 and 2023, we had a national organization – Great Places to Work - conduct a survey where our employees could anonymously rate Rite-Solutions. The results were astounding – **96% of our employees say Rite-Solutions is a great place to work** as compared to 57% at a typical U.S. based company.

Technical Directors:

Anissa Elias
Software Research Engineer
aelias@rite-solutions.com / anissa_elias@uri.edu
https://www.linkedin.com/anissaelias

Stephen Eacuello
Software Research Engineer
seacuello@rite-solutions.com / seacuello@uri.edu

Alex Moulton
Software/Systems Engineer
amoulton@rite-solutions.com

Thomas Santos
Chief Solutions Architect
tsantos@rite-solutions.com

Project Motivation:

Today, the U.S. constructs less than 1% of commercial ships globally, reflecting a significant shift in shipbuilding dominance. On April 9th, 2025, an Executive Order "Restoring America's Maritime Dominance" was signed, highlighting America's current lag in shipbuilding processes and technological advancements. This executive order emphasizes revitalizing the U.S. shipyard capacity and workforce through substantial federal investments and encourages maritime-focused companies to actively participate in this effort.

Located in Middletown, RI, Rite-Solutions has a distinct geographical advantage due to its proximity to major naval shipyards such as Quonset Point, Portsmouth, and Groton. This strategic position enables Rite-Solutions to actively invest in regional initiatives aimed at revitalizing commercial and naval shipbuilding security infrastructure.

A crucial aspect of revitalizing America's shipbuilding capabilities involves incorporating technological advancements, such as automation, AI, and data analytics, into shipbuilding

processes. Implementing these technologies has been shown to improve manufacturing efficiency by 30-50%. However, this increased reliance on technology also introduces heightened security concerns related to the physical infrastructure, manufacturing processes, and communication between devices.

Vulnerabilities within the supply chain, infrastructure, and communication were specifically highlighted as a significant national security concern. For instance, cited within the executive order, 90% of shipyard cranes used in the U.S. are sourced from the People's Republic of China (PRC), while domestic production accounts for less than 10%. As a security-focused company, Rite-Solutions is highly interested and well-positioned to lead vulnerability analysis research in shipyard operations, supply chain practices, and infrastructure resilience. Such efforts will directly contribute to America's mission in regaining global dominance in shipbuilding.

By leveraging this unique geographic position, aligning with growing national momentum, and addressing security needs and concerns, this capstone project has the potential to have a long-lasting impact at an exceptional time. Additionally, the project will equip the future workforce with essential skills and insight focused on security and vulnerability analysis of large-scale processes.

Anticipated Best Outcome:

The Anticipated Best Outcome (ABO) involves collaborating with two Industrial Systems Engineering capstone designers to plan, design, and construct a multi-part project. The first component is the creation of a **physical testbed** composed of components commonly found in shipyards. This testbed will support simulation and vulnerability analysis within the broader context of Shipyard 4.0, particularly supply chain and manufacturing cell frameworks.

In addition to the simulation testbed, the ABO also includes the development of a **digital twin** of the system to enable enhanced security monitoring and anomaly detection within a simulated environment. An **operator-centric dashboard** will also be designed to increase situational awareness in the event of a cyberattack.

Lastly, kill chain implementation and vulnerability analysis will take place to evaluate potential threats and inform future efforts focused on increasing security, mitigation, and response strategies.

Project Details:

This project is a joint multi-disciplinary initiative between the Industrial Systems Engineering (ISE) Capstone and the ELECOMP Capstone. It involves collaboration between two ISE designers and four ELECOMP designers to complete this project. Each set of designers will have separate and discipline-specific tasks that will allow them to reach their ABO.

This project will be executed in three phases:

Phase 1: Research and Tool Decision
In this initial phase, ELECOMP and ISE designers will collaborate to build a comprehensive understanding of the project concept. Designers are expected to familiarize themselves with key foundational topics essential for achieving the ABO, including: **kill chain implementation**, **vulnerability analysis**, **Shipyard 4.0**, **Digital Twin systems in manufacturing**, and **operator Dashboards in manufacturing**.

In the second part of this phase, designers will work together with their Technical Directors to choose the best software and tools to use. Tool decisions will be made for the testbed, digital twin, and operator dashboard. Designers will use standard evaluation methods like the Pugh matrix to present their findings and justify their selection before transitioning to the implementation phase.

Phase 1 - Hardware/Electrical Tasks:

- Conduct in-depth research on the proposed process and relevant system components
- Gain a deeper understanding of Shipyard operations and kill chain analysis within the project's context
- Identify and select hardware components and tools required to design and build the physical testbed

Phase 1 - Firmware/Software/Computer Tasks:

- Conduct in-depth research on relevant processes and software components
- Study digital twin technologies applicable to manufacturing systems
- Determine best digital twin tool to use based on proposed system (i.e. Simio, MATLAB, inductive, etc.)
- Explore existing operator dashboard designs used in manufacturing environments
- Make decisions on what software to use for creating the operator dashboard

Phase 2: Building the Physical Testbed, Digital Twin, and Dashboard
In phase 2, the focus shifts to building the three primary components of the system: the physical testbed, the digital twin, and the operator dashboard.

Physical Testbed: The testbed will be constructed following Figure 1. It will focus on four key components commonly found in shipyard manufacturing environments: a **CNC milling machine**, a **conveyor belt system**, **a robotic pick and place system**, and a variety of **sensing devices**. All components are readily available, and prior work on the testbed provides a solid foundation. This subtask will be led by one ELE and one ISE student.

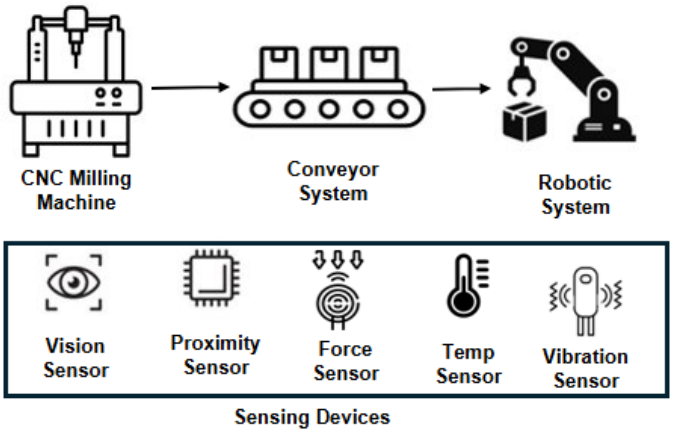

Figure 1

Digital Twin: A digital twin system will be developed concurrently to model the behavior of the physical system. Each component shown in Figure 1 will also be modeled in the digital twin system. There will be two main components to the digital twin: a **3D virtual model** for real-time synchronized representation, and a **simulation environment** for modeling operations. This subtask will be led by one ELE and one ISE student.

Operator Dashboard: An operator dashboard will be developed with the intent of increasing situational awareness of the physical system and accurately showing system behavior. This dashboard will have four main components: a **data processing pipeline**, an **interactable map** of the system, a **data visualization** panel, and an alert & monitoring panel. This subtask will be led by one ELE and one ISE student.

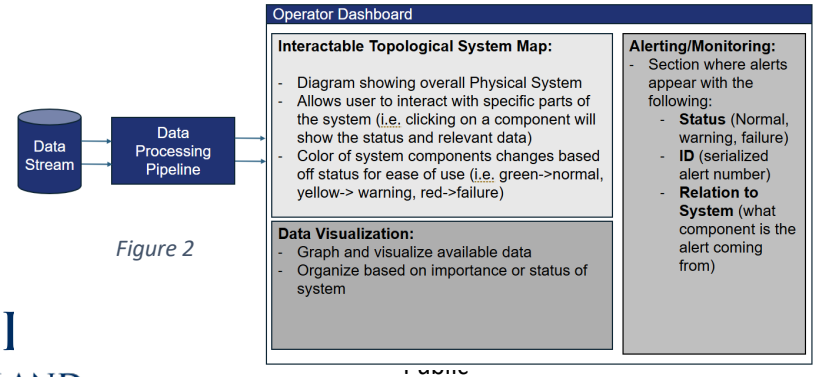

Figure 2

Phase 2: Hardware/Electrical Tasks:

- Select, install, and calibrate all sensing devices (vision systems, proximity sensors, temperature, vibration, force sensors)
- Design and implement sensor interface circuits and signal conditioning
- Develop embedded systems for real-time data acquisition using microcontrollers/industrial computers
- Create custom PCBs for sensor integration where needed

Phase 2: Firmware/Software/Computer Tasks:

- Create a 3D virtual representation of each component found in the physical system using a digital twin development tool
- Develop a simulation environment for system-level
- Design an adaptable data processing pipeline that can be applied to data streams from both the physical system and digital twin
- Create an operator dashboard that includes all features detailed in the figure above

Phase 3: Kill Chain and Vulnerability Analysis

In the final phase, all designers will work collaboratively to develop and implement between at one and three kill chain scenarios (depending on timeline constraints). The designers will administer the attack(s) on the physical and simulated system to demonstrate potential cascading failures, setting up grounds for future research in security maintenance and guardrails. This will allow the designers to complete vulnerability analysis.

Phase 3: Hardware/Electrical Tasks:

- Design and implement a hardware-based attack scenario that targets and exploits vulnerabilities in the **physical system**
- Execute the selected attack scenario
- Assess and document the cascading effects resulting from the attack

Phase 3: Firmware/Software/Computer Tasks:

- Design a simulated attack targeting and exploiting vulnerabilities in the **digital twin system**
- Design a simulated attack targeting and exploiting vulnerabilities in the **dashboard system**
- Administer the selected attack(s) scenario(s)
- Analyze and document the cascading effects and system response

Composition of Team:

3 Electrical Engineers & 1 Computer Engineer

Skills Required:

Electrical Engineering Skills Required:

- MATLAB/Simulink
- Electronics
- Arduino or any microcontroller programming
- Python (minimum experience)
- Basic understanding of **networking protocols** and the **OSI model**
- Basic understanding of **cybersecurity techniques**

Computer Engineering Skills Required:

- Python
- JavaScript
- HTML/CSS
- Basic understanding of some **cybersecurity techniques**
- Basic understanding of **networking protocols** and the **OSI model**
- Basic data analysis
- Basic AI/ML experience

Anticipated Best Outcome's Impact on the Company's Business and Economic Impact

Rite-Solutions is an early adopter of emerging technologies aligned with evolving government and commercial needs. Currently, there is no open-source simulation-based testbed for vulnerability analysis in Shipyard processes. The unavailability of such a platform poses a significant barrier to research and internal innovation, particularly in a time when national momentum is focused on securing a modernizing Shipyard industry.

By creating a simulation intentionally created for kill chain modeling and vulnerability analysis, this project addresses a critical gap. It has the potential to accelerate innovation, stimulate internal interest, and enable broader exchange of ideas across the security of manufacturing.

Broader Implications of the Best Outcome on the Company's Industry:

The White House executive order, widely explored in the project motivation section, not only called for the building of commercial ships to regain global dominance but also called for workforce development, technological advancements, and a huge emphasis on increasing the security and resiliency of the overall process from supply chain to end-product. This Capstone project is a step forward in aiding the research and development around this widely critical topic. Providing a simulation platform can propel research forward in Rite-Solutions and URI in this ever-growing field.