FY 22-23

Naval Warfare Studies Institute

WARFARE INNOVATION CONTINUUM

"Future Hybrid Force" Executive Summary Report

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Where Science Meets the Art of Warfare

Naval Warfare Studies Institute

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1 Overview

The NPS Naval Warfare Studies Institute's (NWSI) Warfare Innovation Continuum (WIC) is a series of cross-campus educational and research activities synchronized with a central theme of interest to the United States Navy. Its purpose is to expose NPS faculty and students to emerging naval challenges and opportunities to catalyze relevant warfighting education and research across campus. NPS Naval Warfare Studies Institute Warfare Innovation Continuum leverages classroom projects, theses, the NPS Naval Research Program and other research initiatives in advancing naval concepts, assessing new technologies, and developing tactics while enhancing our officer- scholars' educational experience and sharpening their combat skills. The WIC covers the coordinated research efforts of various cross-campus events including regularly scheduled classes, workshops, Capstone Projects, and individual theses research (see Figure 1).

The over-arching WIC construct facilitates a synergistic concept development method which results in innovative ideas produced at the beginning of the continuum to be further developed as the timeline progresses. For example, some of the technical proposals and concepts proposed at the beginning of the timeline will be taken to prototyping and experimentation in the Consortium for Robotics and Unmanned Systems Education and Research (CRUSER'S) Innovation Thread. This report provides an executive summary of the FY22-23 Naval Studies Institute Warfare Innovation Continuum titled "Future Hybrid Force". The broad focus of this NWSI WIC efforts is to explore emerging technologies and opportunities which may contribute to the future naval force design.

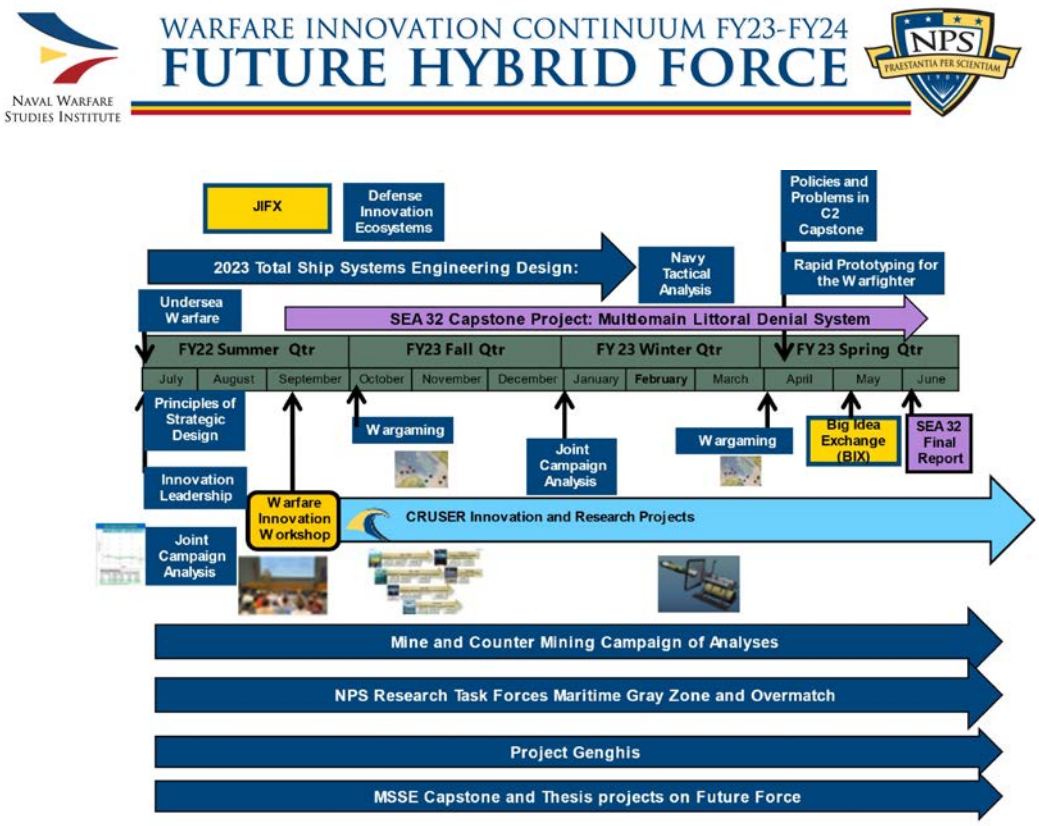


Figure 1. *Timeline of courses and events included in the FY22-23 Warfare Innovation Continuum "Future Hybrid Force".*

2 WIC FY21-22 Project Descriptions

The following pages provide short abstracts, descriptions and results of each completed activity FY22-23 Warfare Innovation Continuum ***"Future Hybrid Force***". If you would like additional information, or full reports on any section, please contact Jane Barreto at jfbarret@nps.edu

2.1 Summer 2022 Joint Campaign Analysis:

The summer Joint Campaign Analysis course composed of 31 officers from various services and allied countries used the Warfare Innovation Continuum scenario "Global War 2045" to explore the following issues:

- Countering PLAN submarine and PLAAF forces' incursion in the Philippine Sea to protect U.S. Sea lines of communications
- Criticality of the Panama Canal and alternative sea logistic lines
- Feasibility and effectiveness of a multi-domain manned-unmanned littoral denial system for Taiwan strait employment
- Alternatives for delivery and sustainment of mine fields

Major Findings:

- Establishing two barriers to PLAN submarine incursion using SSNs and mines along the first island chain, and P-8s further to the east into the Philippine Sea, with surface ships used for close logistic ship protection, provide the highest value in convoy protection.
- Loss or reduced operations through the Panama Canal will result in from 8 to 26-day delay in shifting ships from the east coast to COMPACFLT AoR. Depending on individual ship fuel reserve percentage, at least two refueling at sea events is required for alternate routes not using the Panama Canal, despite port fueling opportunities. This has impact on concepts for shifting forces and Combat Logistic Force design. Network analysis demonstrated that if an adversary wanted to slow U.S. logistics world-wide, the primary target will be the Panama Canal. Follow on targets include the Suez Canal and Cape of Good Hope ports.
- Shore based anti-ship missile systems integrated with an unmanned ISR system in the Taiwan strait was the primary kinetic capability to reduce PLA troop and sustainment levels crossing the Taiwan strait.
- Using a T-AKE to transit mines into the AOR, then ORCA XLUVV for final mine field placement and sustainment is recommend using current technologies to create offensive and protective minefields.
  If covertness is not desired, MDUSV provides a strong alternative to ORCA.

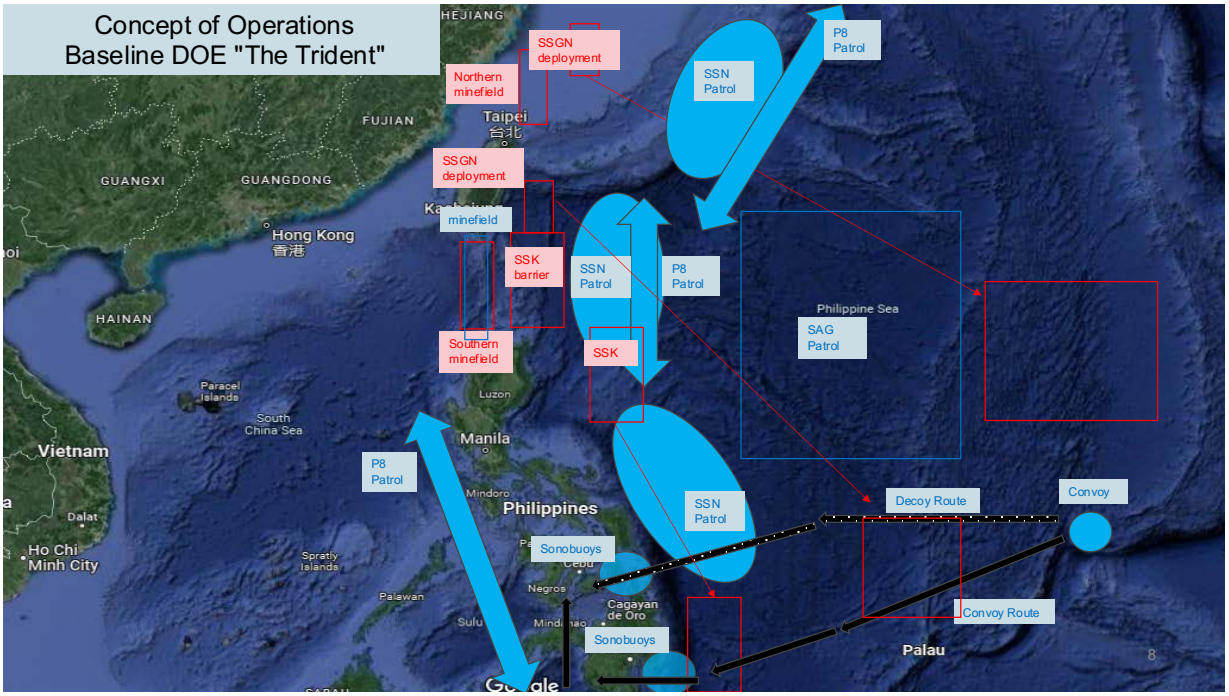


***Figure 2**: Illustrative Course of Action to deny PLAN and PLAAF access to Philippine Sea*

Specific quantitative results are CUI and may be requested by e-mail Prof. Jeff Kline at jekline@nps.edu

2.2 Summer 2022 Warfare Innovation Continuum Workshop:

This Naval Warfare Studies Institute (NWSI) and Consortium for Robotics and Unmanned Systems Education and Research (CRUSER)–sponsored Warfare Innovation Continuum (WIC) workshop was held September 19–22, 2022 concurrently on both the Monterey campus and the "Virtual Campus" of the Naval Postgraduate School (NPS) via the ZoomGov online collaboration platform. The three-and-a-half- day experience provided facilitated focused interaction for NPS students, faculty from across the NPS campus, fleet officers, and guest engineers from Navy labs, warfare centers, system commands, and industry. The September 2022 workshop "Future Hybrid Force" tasked participants to apply emerging technologies to shape the way we might fight in a 2045 global conflict depicted in the fictional scenario "Global War 2045." With the design challenge "How might the convergence of emerging technologies offer new operational concepts and force designs to create a more effective and resilient naval, joint, and coalition force across the spectrum of conflict and in all domains?" seven facilitated concept generation teams used tools of warfighter-centered design to develop full concepts of operations and employment to meet key missions in a potential future battlespace. The seven teams composed of NPS students, civilian engineers, and researchers with diverse perspectives addressed challenges in contested littoral warfare, integrated and joint fires, integrated deterrence, contested logistics, and cloud computing at the tactical edge. Three of these teams worked remotely. Two U.S. only teams worked on the NPS campus in Monterey in classified spaces on C5ISRT, undersea and mine warfare challenges. To provide context for the variety of challenges, four Discovery Panels included speakers from across NPS, the warfare centers, and industry – many of them leaders in their fields. Equal in significance to the concept outcomes was the opportunity to build and grow networks between NPS students and faculty, warfare center personnel, and industry engineers.

Generated in only twelve hours of work time, from the concepts presented on the final morning of the workshop the following were selected as concepts of interest:

Key takeaways surfaced in discussion following the final presentations included:

Allies & Partners – coordinated coalition operations are essential for future success, and these relationships need nurturing now to ensure we work together effectively by 2045.

Operational Energy – available and durable energy supply is a challenge to be addressed early and often.

TEAM	CONCEPT	DESCRIPTION
TEAM C5ISRT		*Classified – available upon request through appropriate channels.*
TEAM CLOUD	**SCUBA**	Support for cloud-based architecture to extend service range to the warfighter through an ad hoc mesh network using a variety of assets and digital technology.
TEAM DETER	**CIFID**	Climate initiatives for integrated deterrence that include Blue Initiatives for Regional Unity (BIRU) and the "Blue Economy" Development Fund.
TEAM FIRES	**AARP**	Autonomous attack and reconnaissance platform.
TEAM LITTORAL	**Project PROJECT**	Mobile observation and sensing quick unmanned ISR and targeting object (MOSQUITO) and littoral attachment device (LAD) as a hybrid force to inform littoral placement, and disposable ad-hoc networks (DANets) for coalition operations.
TEAM LOGISTICS	**The Continuum**	Estimate bulk energy needs, identify storage locations, engage key stakeholders, finalize planning and design, execute pilot program, exercise ops, and "fight the fight" leveraging underwater bladders and concealed shore-based facilities.
TEAM USW		*Classified – available upon request through appropriate channels.*

Reliable & Robust Comms – secure networks for coalition communications are key for all future operations, as is secure data sharing within a coalition.

All the concepts provided by the teams are included in a final report that was distributed to NPS own researchers and NWSI stakeholders and is archived in the NPS Dudley Knox Library. This report is intended to inform and influence NPS capstone classes, research topics, experimentation, the NPS Systems Engineering and Analysis project, wargaming, prototyping and theses included in the Warfare Innovation Continuum "Future Hybrid Force." We hope these presentations and the conversations they inspired will carry on well after the workshop experience.

2.3 Summer 2022 Capstone: Multi-Mission Resource Allocation – Decision Aid Leveraging Artificial Intelligence

Advisors: Dr. Bonnie Johnson and Mr. Scot Miller
Student capstone team: Kelly Tesch, Tara Sprinkle, Christopher Ghigliotti
Students graduated in September 2022
Research Sponsor: Naval Research Program, NPS-22-N305
Topic Sponsor: Bill Treadway, OPNAV N2/N6

This Systems Engineering (SE) capstone project explored the potential for emerging data analytic methods artificial intelligence (AI), machine learning (ML), game theory, and wargaming) to aid future mission planners in performing multi-mission resource allocation (MMRA). Many military platforms are inherently multi-mission—they execute a variety of missions simultaneously. Ships, submarines, and aircraft support multiple missions across domains, such as air and missile defense, anti-submarine warfare, strike operations, fires in support of ground operations, and intelligence, surveillance, and reconnaissance. Scheduling and positioning of these multi-mission platforms are problematic since one warfare area commander desires one position and schedule, while another may have a completely different approach. Commanders struggle to decide and adjudicate these conflicts, because there is plenty of uncertainty about the enemy and the environment (Johnson, 2022). Additionally, the complexity of warfare is continuing to advance, yet naval forces only have a set number of warfare resources to execute multi-missions. The project focused on a MMRA process involving AI-enabled systems for real-time wargaming and analysis that generate recommended tactical courses of action (COAs) at operational "decision points" when dynamic replanning is required. The team studied three multi-mission scenarios: convoy protection, aviation operations, and a carrier strike group.

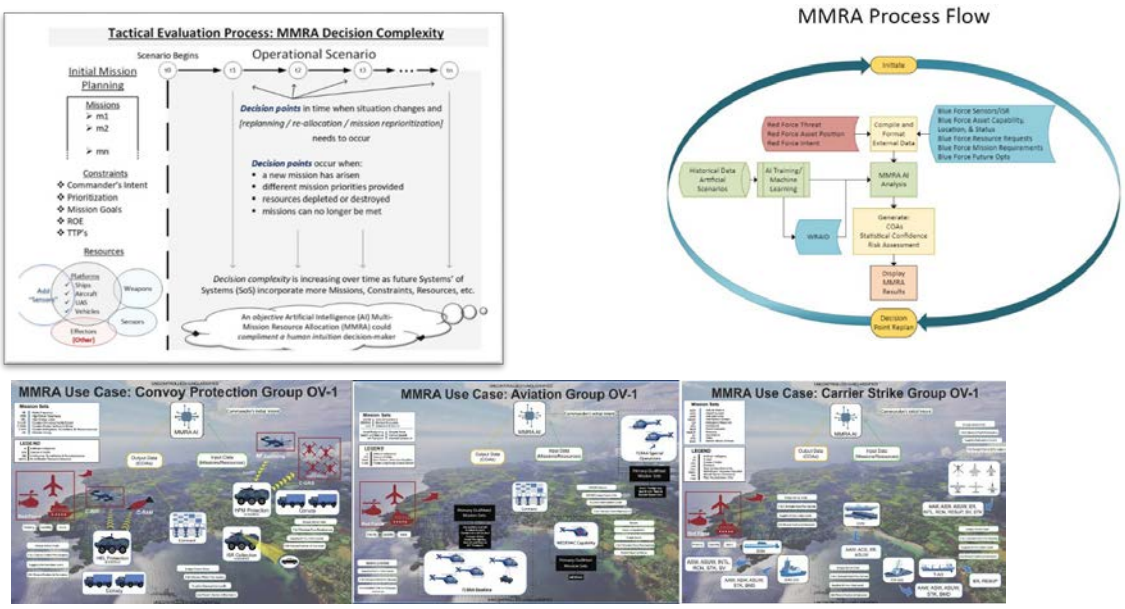


Figure 3. *Multi-Mission Resource Allocation*

2.4 Summer FY22 Capstone: Detecting Cyber Attacks on Naval Ships using Energy Monitoring Data

Advisors: Dr. Bonnie Johnson and Mr. John M. Green
Student capstone team: LCDR Shannon Zoch, USN, Mursleen Mumtaz, Richard Tawney, Christopher Ray
Students graduated in September 2022
Research Sponsor: DASN-Operational Energy, Jim Caley

An increase in network connectivity for control systems within Naval infrastructures has led to further vulnerabilities against cyber intrusions. The continuous evolution of advanced cyber threats requires novel solutions for timely indications and warnings of anomalies occurring in the system. The Navy has recognized the need for an energy monitoring capability to identify potential cyber threats that can impact industrial control system (ICS) mechanisms and sensors in ships and naval facilities. This project is studying energy usage patterns of life and characterizing potential cyber threats to gain an understanding of the problem. Analysis of energy usage data from previous studies and modern ICS implementations may provide the basis for patterns of life characterization that can support cyber-attack detection. The capstone teams are identifying cyber vulnerabilities in ship ICS and exploring detection and warning capabilities through the analysis of energy usage monitoring data.

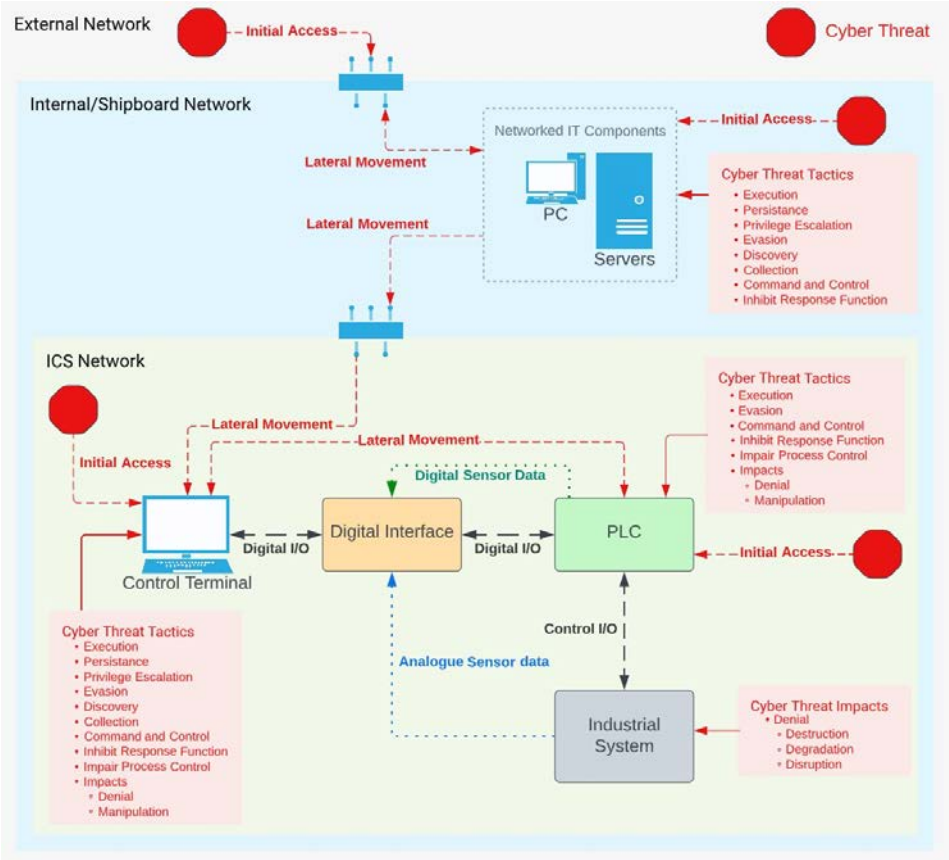


***Figure 4**. External Network and Internal/Shipboard Network*

2.5 Summer 2022 Capstone: Blockchain at the Tactical Edge

Advisors: Dr. Bonnie Johnson, Mr. John M. Green, and Mr. Tony Kendall
Student capstone team: Gregory Dogum, Kristin Jones Maia, Michele Meszaros, Jonathan Novoa, and Rene Villarreal
Students graduated in September 2022
Research Sponsor: ONR Project Neptune

This capstone project evaluated the use of blockchain technology to address several challenges with increasing amounts of disparate sensor data and an information-rich landscape that can quickly overwhelm effective decision-making processes. The team explored how blockchain can be used in a variety of defense applications to verify users, validate sensor data fed into artificial intelligence models, limit access to data, and provide an audit trail across the data life cycle. The team developed a conceptual design for implementing blockchain for tactical data, artificial intelligence, and machine learning applications; identified challenges and limitations involved in implementing blockchain for the tactical domain; described the benefits of blockchain for these various applications; and evaluated this project's findings to propose future research into a wider set of blockchain applications. The team did this through the development of three use cases. One use case demonstrated the use of blockchain at the tactical edge in a "data light" information environment. The second use case explored the use of blockchain in securing medical information in electronic health records. The third use case studied blockchain's application in the use of multiple sensors collecting data for chemical weapons defense to support measurement and signature intelligence analysis using artificial intelligence and machine learning.

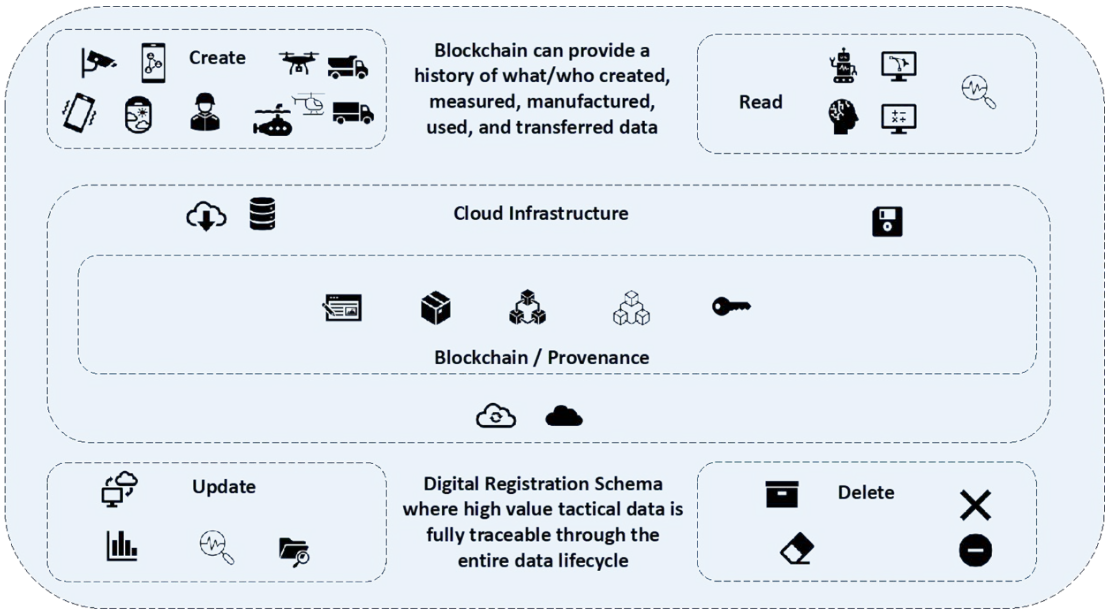
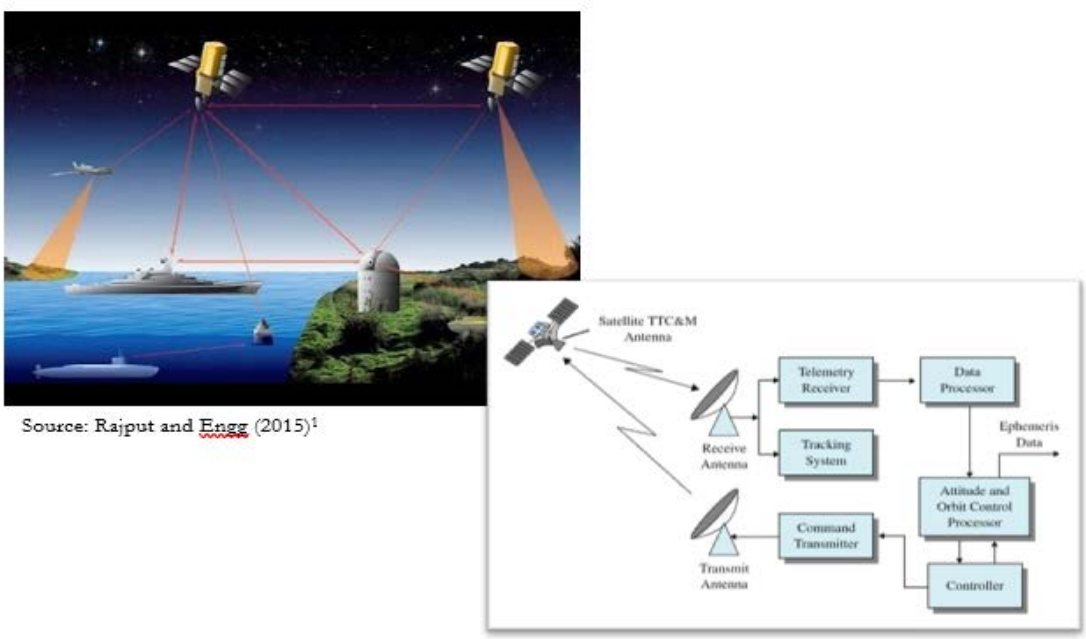


Figure 5. *Blockchain for Tactical Edge*

2.6 Summer 2022 Capstone: Maritime Over-the-Horizon Laser Communications using Space-Based Relays

Advisors: Dr. Bonnie Johnson and Mr. John M. Green
Thesis student: LT Frank Conenna, USN
Student graduated in September 2022
Research Sponsor: ONR, Mr. Peter Morrison

This thesis studied an over-the-horizon (OTH) maritime communication free-space optics (FSO) concept using lasers and space-based relays. This thesis applied a system engineering analysis approach to study stakeholder needs, identify requirements, and develop a conceptual design of the FSO concept. Three concept of operation scenarios were developed to illustrate (1) land-to-maritime, (2) maritime-to-land, and (3) maritime-to-maritime communication transmission. The three conceptual FSO communication capability scenarios were modeled using the behavioral modeling tool, Monterey Phoenix (MP). The MP models could be varied to represent nominal or clear atmospheric conditions and off-nominal or poor atmospheric conditions (e.g., precipitation, thermal turbulence, absorption, and scattering). The thesis analyzed expected, unexpected, and emergent behavior using the MP model. The results yielded event traces characterized by transmission time, success data, and behavior expectation data. The MP model analysis produced a pattern of unexpected or emergent behavior that would interfere with successful communication transmission may arise from laser system failures, ship movement, or operator issues. The study results indicated that the FSO OTH communication system could transmit communication quickly and with high data rates, but only during nominal or fair atmospheric conditions.



Source: Rajput and Engg (2015)[1]

Source: Ippolito (2013, 43)[2]

[1] Rajput and Engg. 2015. "Free Space Optical." Presentation for Hansaba College of Engineering and Technology, Siddhpur India. https://electrocircuit4u.blogspot.com/search/label/Free%20Space%20Optical%20Communication
[2] Ippolito, Louis J. 2017. *Satellite Communications Systems Engineering: Atmospheric Effects on Satellite Link Design and Performance*, 2nd edition. Chichester, West Sussex, UK: John Wiley & Sons Inc.

Figure 6. *Conceptual design for laser and space-based relay system*

2.7 Summer 2022 Capstone: Space-Based Power Beaming for Naval Applications

Advisors: Dr. Bonnie Johnson and Mr. John M. Green
Thesis student: Mr. John P. Pagel
Student graduated in September 2022
Research Sponsor: ONR, Mr. Peter Morrison

Power beaming is a technology that will significantly transform mobilized operations for the military by providing power on-demand to line-of-sight forces, autonomous or otherwise. The current modus operandi requires the delivery of energy by transport, which is burdensome, costly, and dangerous depending on the threats. Power beaming applications for the military include powering autonomous air, ground, and sea vehicles, offboard countermeasures, unattended ground and sea sensors, supporting explosive ordnance disposal, and providing wireless power in space (Jaffe 2021).

There are still numerous challenges facing the speedy maturation of space-based power beaming technology. Technical barriers include the large collection area in space required to harvest the sun's energy, research required for solar wind effects, material rigidity, and strength limits, as well as lifetime and serviceability uncertainty. There are economic challenges with investments required in the billions for further development and transition to operations, and even energy cost uncertainty related to both space solar and alternatives. Legal/political challenges include formal spectrum allocation to reduce electromagnetic interference risk, as well as the safety versus perception of safety paradox. Operational challenges range from potential incompatibility with site receiver requirements, more mature alternatives, the long development timeline, possible emergence of mobile nuclear, and susceptibility to disruption by hostile actors or space weather.

This thesis developed concepts for space-based power beaming systems that will collect solar power and direct/transmit this energy for military applications. This thesis developed requirements and a conceptual design for a space-based power beaming system and studied the challenges involved in developing and implementing a future system.

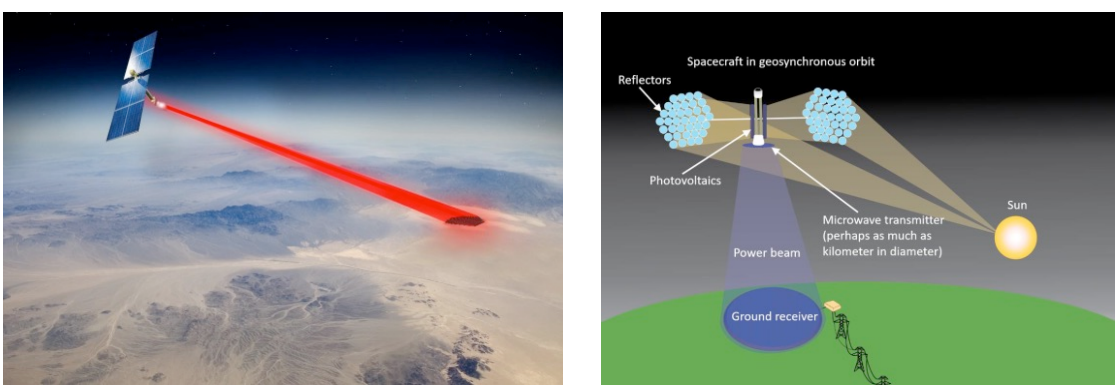


Figure 7. *Space-Based Powerbeaming for Naval Applications*

[1] Jaffe, Paul. 2019. *Opportunities and Challenges for Space Solar for Remote Installations*. Naval Research Laboratory Report, NRL/MR/8243-19-9813.

2.8 Summer 2022 Capstone: Fleet Commander and Combatant Command Planning Aid Leveraging Artificial Intelligence

Advisors: Dr. Bonnie Johnson and Mr. Scot Miller
Thesis student: Bryan Lee
Student graduated in September 2022
Research Sponsor: Naval Research Program, NPS-22-N157
Topic Sponsor: Bill Treadway, OPNAV N2/N6

The rapid pace, volume and velocity of information, overlapping missions, the level of uncertainty, and the severity of decision consequences at the strategic and operational levels creates a highly complex decision space for Fleet commanders and Combatant Commands (COCOMs). With ever-growing adversarial threats from advances in technology and weapon proliferation, stresses the need for our Joint Forces and Naval Fleets to maintain decision superiority and ensure the alignment of military operations with national strategies. Current military planning at the strategic and operational levels is largely accomplished manually with the aid of a mix of modeling and simulation systems that are narrowly focused on specific missions. The Chairman of the Joint Chiefs of Staff (CJCS) Guide 3130 for Adaptive Planning and Execution (APEX) Overview and Policy Framework (Gilday 2019)[1] highlights the joint need and requirement for automated decision aids to support the planning process. This thesis envisions a Strategic and Operational Decision Aid (SODA) system as a system that can produce plans that "balance strategic and operational ends, ways, and means with understood assumptions at acceptable risk in pursuit of policy objectives" (Gilday 2019). This thesis developed requirements and a conceptual design for an automated AI-enabled SODA system that generates recommended courses of actions (COA) and plans for Fleet Commanders and Combatant Commands.

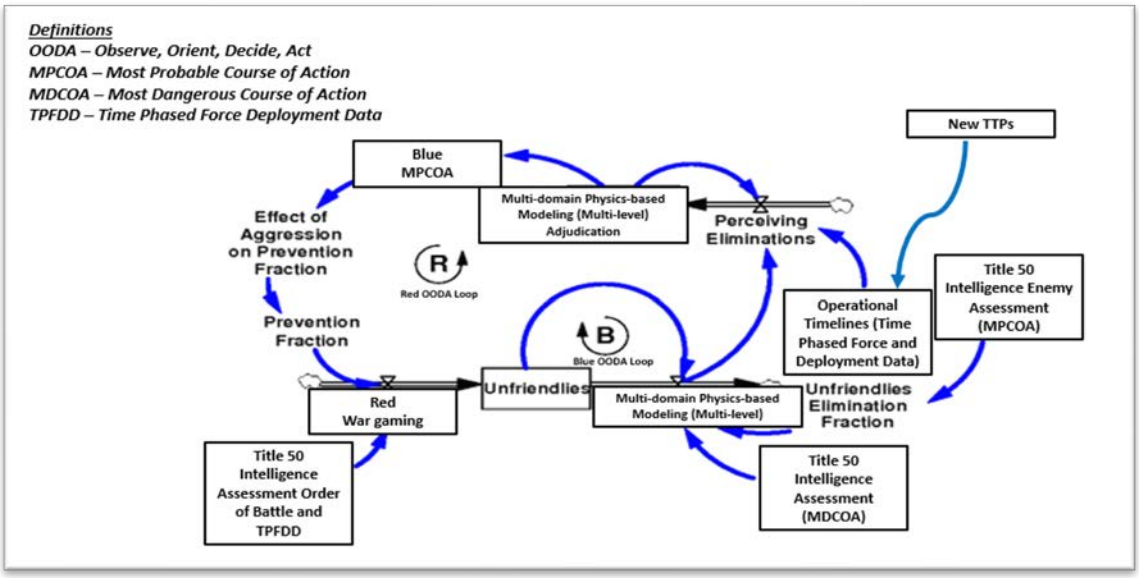


Figure 8. *Adaptive Planning and Execution Overview*

[1] Gilday, Michael. Adaptive Planning and Execution Overview and Policy Framework. *Chairman of the Joint Chiefs of Staff Guide 3130.* March 5, 2019. https://www.jcs.mil/

2.9 Summer 2022 Capstone: Naval Net-Zero 2050

Advisors: Dr. Bonnie Johnson and Ms. Kristen Fletcher
Student capstone team: CPT John Hohng, USA, CPT Erik Forsgren, USA, CPT Brian Jernigan, USA, CPT Justin Strait, USA, CPT Joseph Lucas, USA, CPT Steven Moore, USA
Team graduated in December 2022
Research Sponsor: Naval Research Program, NPS-22-N258
Topic Sponsor: Cayle Bradley

The U.S. Navy has set a goal of achieving net-zero greenhouse gas emissions by 2050. As part of reaching this goal, the U.S. Navy has established a key initiative to forecast future energy consumption based on past and expected future naval operations, along with analyzing alternative fuel pathways. This capstone project supported the U.S. Navy's initiative by developing a phased approach for analyzing fuel alternative options as net-zero pathways. The team developed an analytical tool, the Fuel Decision Support Tool (FDST), based on systems engineering analytical approaches. The team used the phased approach and FDST tool to study historical, current, and expected future naval fuel consumption, gas emissions, and fuel alternatives for two specific platforms: DDG-51 and F/A-18. The analysis results indicate that alternative fuel pathways exist that are feasible for existing naval platforms and can provide a foundation for future platforms. The phased approach and FDST provide acquisition decision authorities and leaders with an approach to study additional net-zero pathways.

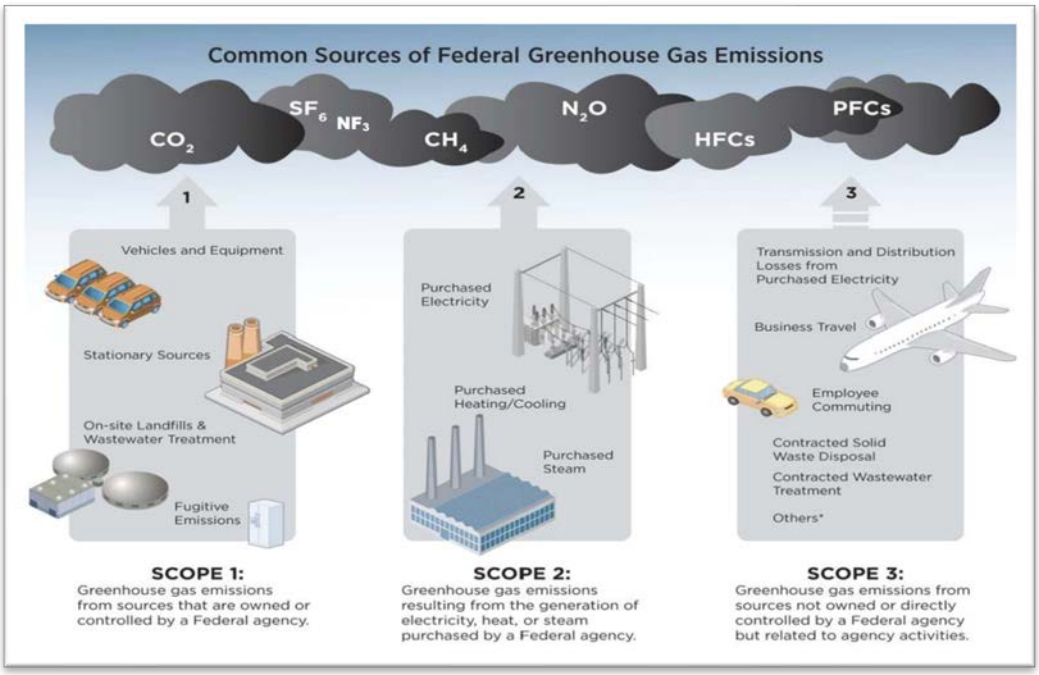


***Figure 9**. Common Source of Federal Greenhouse Gas Emissions*

[1] Council on Environmental Quality. 2016. Federal Greenhouse Gas Accounting and Report Guidance. www.sustainability.gov

2.10 Summer 2022 Capstone: Vehicle-Mounted High Energy Laser for Marine Corps Expeditionary Operations

Advisors: Dr. Bonnie Johnson, Dr. Joseph Blau, Mr. Erik Johnson
Student capstone team: Terry Dang, Samantha Hazard, Joshua McDonald, Aaron Huott
Team graduated in December 2022
Research Sponsor: ONR, Mr. Peter Morrison

Unmanned aerial systems (UAS) are becoming primary threats of concern that adversaries may use against U.S. warfighters and warfare assets. UAS technologies are rapidly advancing in capability and are easy to manufacture and operate. The potential use of UAS as threats has led to the critical need for counter-unmanned aerial systems (C-UAS) solutions. This project studied the use of laser weapons technologies as a C-UAS solution. The Office of Naval Research (ONR) and the US Marine Corps (USMC) are investing in an initiative that mounts a high energy laser (HEL) weapon system onto a tactical vehicle for C-UAS operations. The intent is for the HEL to support USMC expeditionary forces in their mission to provide ground-based air defense (GBAD) against UAS threats. This project used modeling and simulation to conduct a parametric study of C-UAS performance of a HEL system mounted on a tactical vehicle. The team varied parameters within the model to represent different HEL power levels, different atmospheric conditions, and different UAS threat scenarios. The team found that greater HEL power levels offered significant C-UAS performance gains, especially to overcome poor atmospheric conditions, longer ranges to the threats, greater numbers of threats, and larger threat UAVs with more substantial materials.

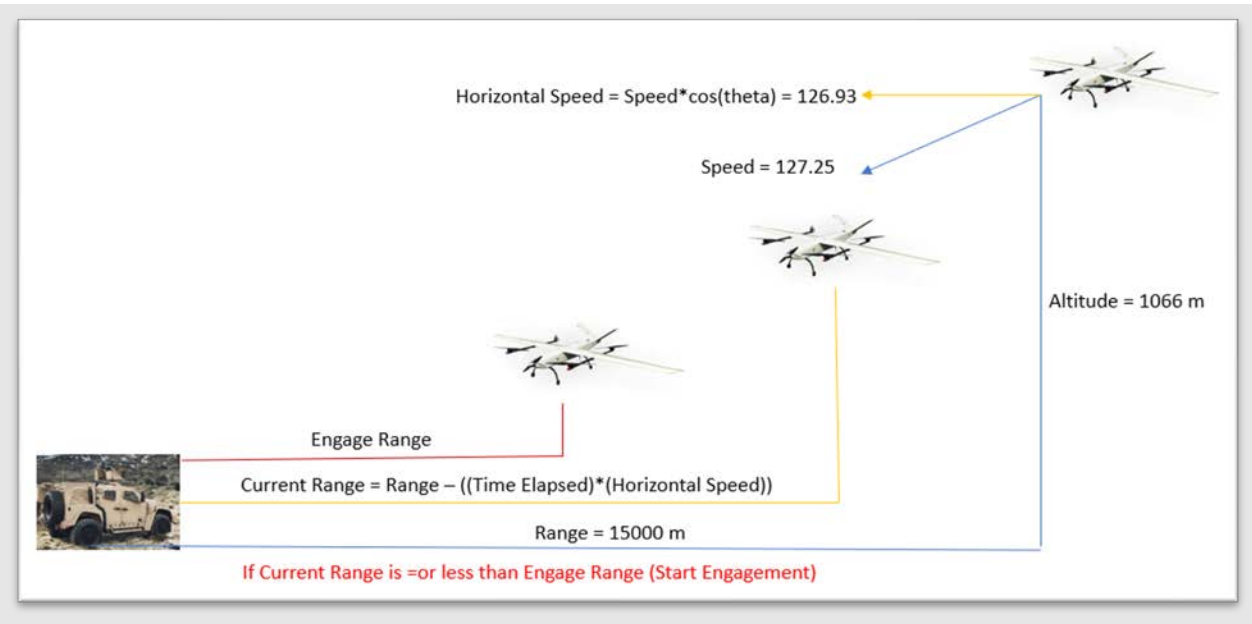


Figure 10. *Horizontal Speed and Range*

2.11 Summer 2022 Capstone: Analysis of Strategies for the Prevention and Mitigation of Impacts to Unmanned Aerial Systems from High Power Microwave Weapon Front Door Entry

Advisors: Dr. Bonnie Johnson, Dr. Joseph Blau, Mr. Erik Johnson, Dr. John M. Green
Student capstone team: Jamie Donais, Sarah Brown, Joshua Denney, Kory Hughs, Andrew Kurdziel
Team graduated in March 2022
Research Sponsor: ONR, Mr. Peter Morrison

High power microwave (HPM) weapons pose a significant risk to US naval unmanned aerial vehicles (UAVs) due to their speed of delivery and ability to impact a broad area resulting in degradation or damage to sensitive electronic components that are critical to UAV operations. The objective of this study was to assess the potential effectiveness of strategic and material solutions for countering HPM weapon effects during naval UAV operations. As a precursor to the solution analyses, an investigation was conducted of HPM weapon capabilities and ranges, as well as corresponding naval UAV front door entry vulnerabilities to the HPM weapon threat. Subsequently, both quantitative and qualitative analysis was conducted on UAV Groups 2-5 to assess the material and non-material solution space for countering HPM weapons; for Group 5 UAVs only, quantitative analysis was also conducted via dynamic modelling in order to assess variable strategic solutions for countering HPM weapons during UAV field operations. Results of the dynamic modelling effort indicated that strategic mitigation strategies would be effective non-material solutions for mitigating the threat of HPM weaponry, specifically leader-follower and combat spread approaches; material solution analysis conducted via Pugh matrix analysis indicated that the use of RF limiters would be worth considering, but their effectiveness is dependent on specific mission and program needs.

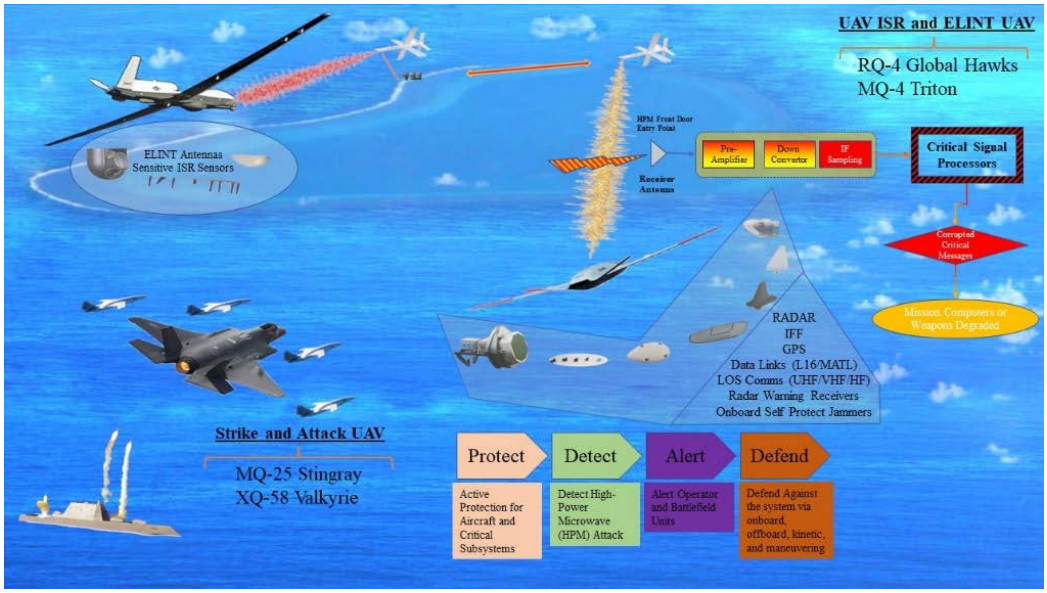


***Figure 11**. UAV ISR and FLINT UAW*

2.12 Fall FY23 Total Ship Systems Engineering (TSSE) Design Program

Background

The Chief of Naval Operations' NAVPLAN 2022 includes the outline for Force Design 2045. While nuclear-powered aircraft carriers and ballistic missile submarines continue to serve as key elements of the future force, this long-term strategic vision includes more than 350 manned ships and 150 large, unmanned vessels, of which amphibious assault, combat logistics, and auxiliary vessels figure prominently. Additionally, a mix of traditional maritime patrol aircraft, helicopters, and fighter jets, such as the F-35, is specified to be supplemented by evolving unmanned aircraft, and other small, unmanned platforms capable of increasing sensing resilience, persistence, and coverage for this more distributed hybrid force.

Recent developments in the East threaten energy security within the European continent and throughout the world. The Fleet is not immune to this threat as transit time to shore-based maintenance, refueling, and rearming facilities reduces the overall time on station thus taking the warfighting assets away from their duties within the theatre of war. Persistent, distributed, agile, and independent operations will be required to check the aggressors' advances in future conflicts and crises as we head toward 2045.

Project

The 2022 NPS Total Ship Systems Engineering (TSSE) project focuses on the design of an aircraft-carrying vessel that will make, store and supply hydrogen fuel products derived from the U.S. Naval Research Laboratory's patented process to produce synthetic fuel from seawater. The carbon dioxide and hydrogen gas recovered from the seawater are further converted to hydrocarbons and their derivatives are utilized as the primary fuel source for the ships, their manned aircraft, and unmanned aerial vehicles within the group; see Figure 1. The form factor and other key characteristics of the primary vessel are based on the design requirements meeting various mission sets that were specified by the stakeholders.

Solution

This year's team of multidisciplinary engineering students proposes the Edison-Class Hydrogen Tanker Carrier (CVT 1) as depicted in Figure 2. The ship concept design is of an energy-independent aircraft-carrying vessel capable of producing, storing, and transferring hydrogen-based fuel to sustain extended operations in support of the Distributed Maritime Operations concept. Delivering combat readiness, persistent surveillance, and energy needs for its group, Edison enables expanded distributed maritime operations in 2045.

Primary characteristics include a 42,000 displacement, 825 ft length overall, 90 ft maximum beam, 28 ft design draft, and 34 knots top speed. While powering the battle group is its primary mission, with a crew of approximately 800 officers and enlisted plus 300 additional air detachment personnel, the CVT 1 has the ability to support the Intelligence, Surveillance, and Reconnaissance mission and provide limited staging, maintenance, and repair of manned and unmanned air assets as a secondary mission set.

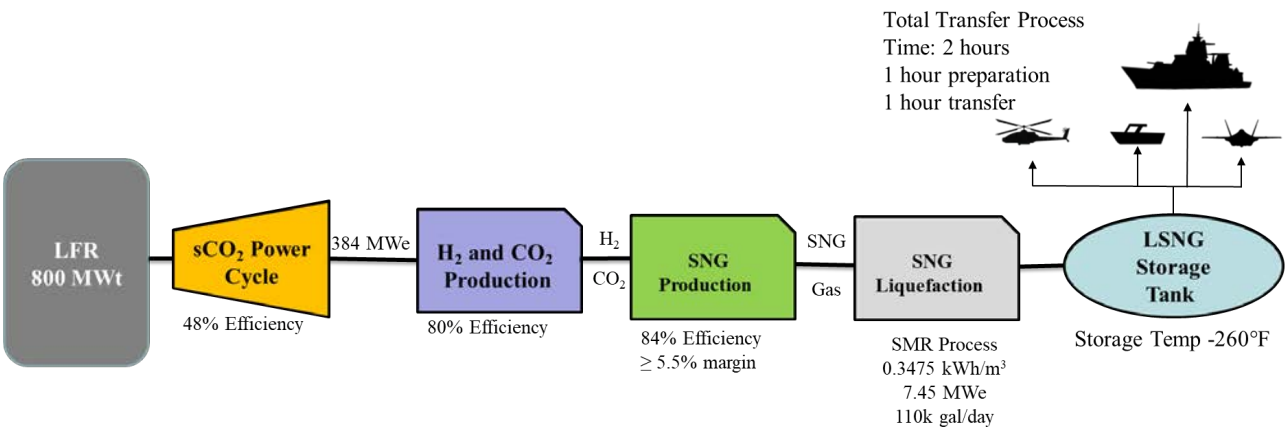


Figure 12. *LSNG Fuel Production and Transfer Process (Refuel) Concept*

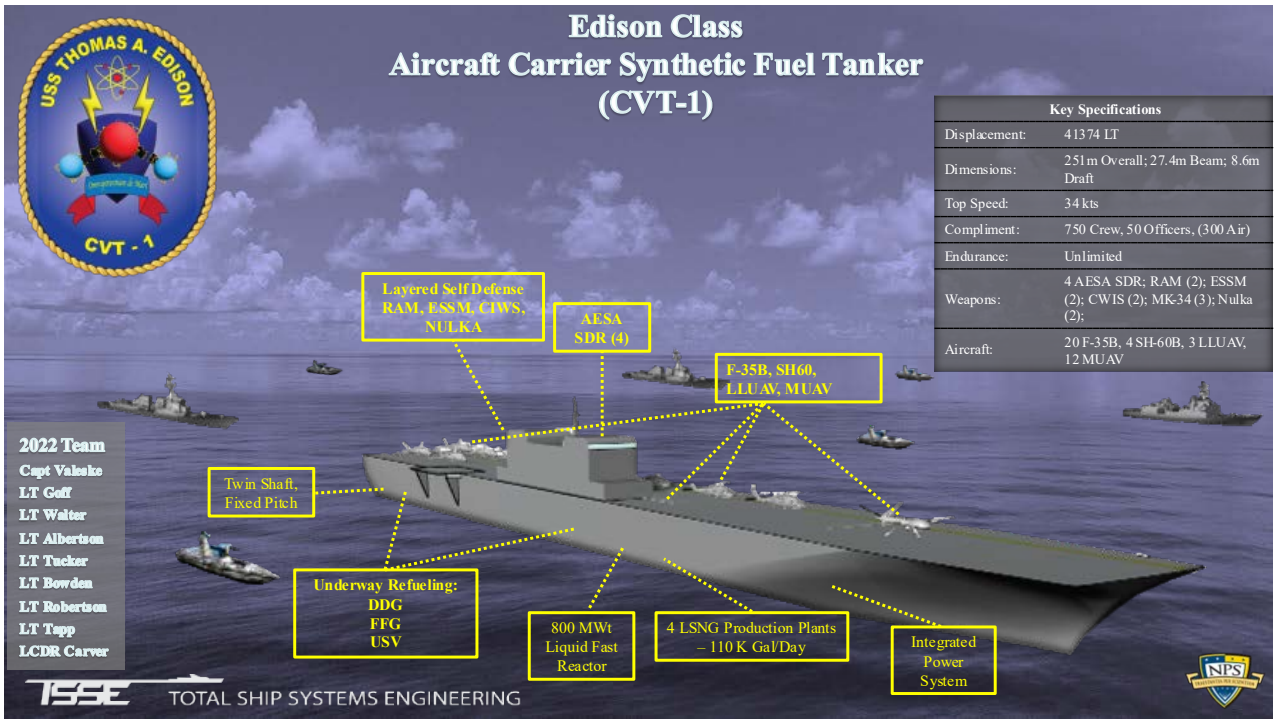


Figure 13. *EDISON-Class Hydrogen Tanker Carrier (CVT 1)*

Further information for this project may be requested via the project team at jmdidosz@nps.edu or papoulias@nps.edu.

2.13 Fall FY23 Wargaming Class

Wargames played during the Fall FY2022 OA4604 Wargaming Applications class included six sponsored wargames conducted during Wargaming Week. Summaries of the sponsored wargame activities follow:

Wargame "Low Probability Detect-Intercept" (CUI) - The wargame participants investigated how operators utilize Low Probability of Detection/Interception (LPD/I) communications in a contested, wartime environment.

Wargame "MARSCO SSR" (CUI) - The wargame participants examined how relationships with allies and partners allow Marine Special Operations Command (MARSOC) to achieve effects through Strategic Shaping and Reconnaissance (SSR) activities.

Wargame "Operation Moonraker" - Sponsor U.S. Navl Forces South (CUI) - The wargame participants analyzed the criticality of the Panama Canal when looking at best sea routes to swing U.S. Naval Forces from one theater to another in times of conflict.

Wargame "Examination of Intra-Theater Fuel Supply Chain Gaps and Vulnerabilities in support of Distributed Maritime Operations" (CUI) - The wargame participants examined the regional and strategic impacts of the refuel kill chain's ability to meet operational demands generated from force protection to and persistent effects in INDO-PACOM theater.

Final war game reports are restricted distribution. Request a specific report from Dr. Jeff Appleget at jaappleg@nps.edu.

2.14 Winter 2023 Joint Campaign Analysis: "Global War 2045" Scenario

1. (U) Purpose: To summarize highlights from the NPS Winter Joint Campaign Analysis three-week campaign studies in the "Global War 2045" scenario.
2. (U) To contribute to the current NPS Warfare Innovation Continuum "Future Hybrid Force 2045" the winter Joint Campaign Analysis class conducted ten quantitative three-week campaign studies on various topics related to the continuum's Global War 2045 scenario which aligns China, Russia, and North Korea against the U.S. and allies in conflicts in the Western Pacific, Baltic, and Mediterranean. Several of these studies' topics will be further explored in the Spring 2023 NWSI spring wargaming efforts.
3. (U) Select quantitative highlights are summarized below:

   a. (CUI) To support JWC research at NPS: Most promising deterrence measures to demonstrate risk to China's force-able takeover of Taiwan in the metrics of Chinese shipping lost, Chinese land forces landed, Chinese tons delivered across the strait, Chinese casualties and Taiwanese casualties:

Figure 14. *Satellite, Cameras, Electric motor Engagement Tactics*

i. (CUI) Provide Taiwan with "Ukrainian style" swarm attack USVs
ii. (CUI) Provide Taiwan with many portable air defense capabilities (MANPADs) to reduce Chinese offensive power from the air
iii. (CUI) Provide Taiwan with additional shore-based ASCMs and near-shore mines
iv. (CUI) U.S. measures include posturing U.S. bomber fleet forward with additional anti-ship weapons, posturing CVW forward (not necessarily the CVN) to increase tactical air over Taiwan and straits, and purchase many missile boats for U.S. and/or Taiwan employment: Concurs with recent CSIS study (2023)[i]

b. (CUI) The GBASM basing capacity on islands in the Luzon Strait is sufficient to provide credible sea denial capability pending logistic pre-positioning and resilient comms. Captain Ryan Helm modified his thesis research in autonomous geospatial analysis to find helo landings sites to instead locate over two thousand suitable GBASM sites on the Luzon strait islands of Calayan and Itbaya.

c. (CUI) For quick logistics fleet augmentation to increase delivery in a contested logistics environment, purchasing the U.S. Army's LCU's can increase tonnage delivered and logistics fleet resiliency. (Provided to OPNAV N4 staff)

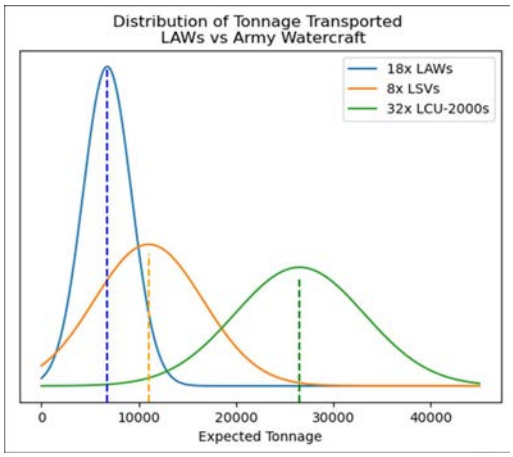


Figure 15. *Distribution of Tonnage Transported LAWs vs Army Watercraft*

d. (CUI) Scheduled for briefing to MARSOC staff: Special force measurable contributions in competition phase which impact warfighting advantage if conflict occurs are pre-positioning strategic sensors to increase actionable I&W and terminal target designation for air-launched anti-ship weapons in a comms denied environment by employing Group 2 UAVs on Taiwan.

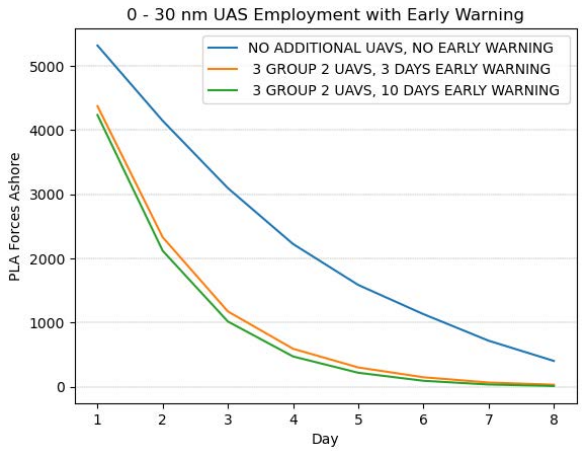


Figure 16. *UAS Employment with Early Warning*

e. (U) Two teams analyzed various options for the covert laying and reseeding of Hammerhead minefields in various locations in the South and East China sea. XLUUV (ORCA) and SSNs were sufficient to covertly lay a field, but time/distance/speed/capacity challenged XLUUV (ORCA) to sufficiently reseed and maintain fields unless forward operating bases are used. Other options explored included SWIG and LMACC, both with greater speed and capacity to reseed, but exposed to higher risk. Results delivered to Mine Warfare Chair

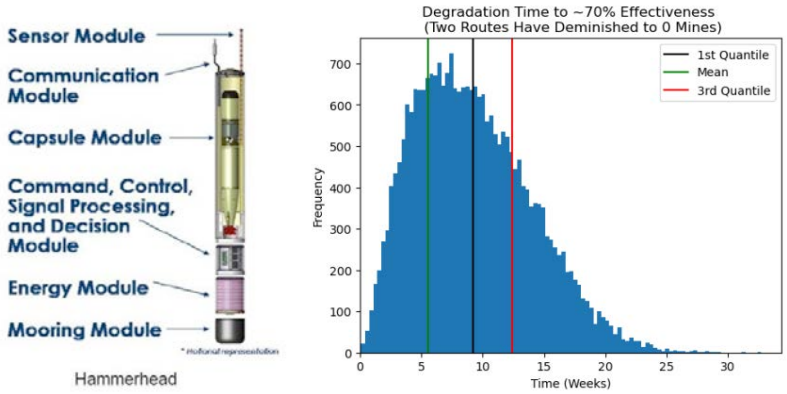


Figure 17. *Reseeding of Hammerhead minefields*

f. (CUI) Current capacity limitations make area ASW challenging to prevent PLAN SSKs/SSNs from infiltrating and attacking sea lines of communication across the Philippine Sea. Current forces will require robust convoy escort and deception operations, particularly against a "surge" of 25 submarines or more.

Figure 18. *Concept of Operations*

[1] Cancian, Mark, Cancian Matthew, Heginbotham, Eric. *"The First Battle of the Next War: Wargaming a Chinese Invasion of Taiwan"*. Center for Strategic and International Studies, January 2023.

Further information about this report may be requested by e-mailing jekline@nps.edu

2.15 Spring FY23 Systems Engineering Analysis Cohort 32: Multi-domain, Manned-Unmanned Littoral Denial System.

Lead by the officers in the Systems Engineering Analysis program, eighteen officers from various curricula conducted a nine-month engineering design study to propose a multi-domain, manned-unmanned littoral denial system.

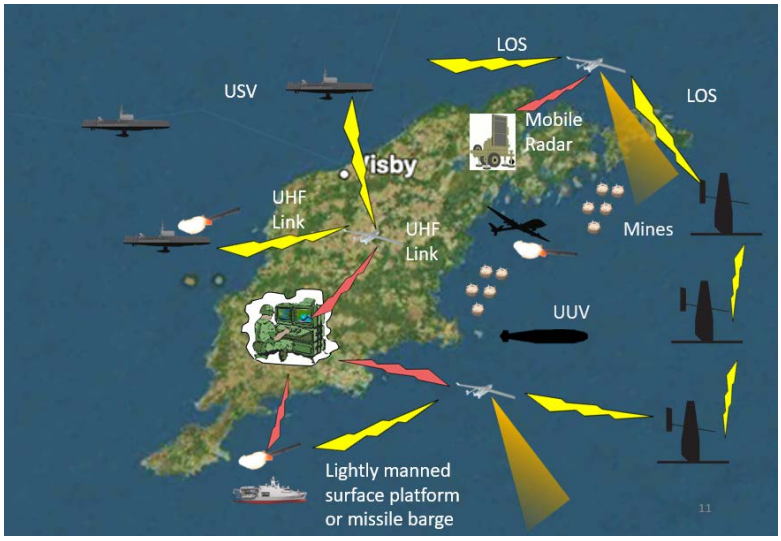


Figure 19. *Lightly manned surface platform or missile barge*

The final study details a systems engineering approach to design a manned-unmanned, multi-domain, littoral denial system of systems, projected over the next decade. Mission context scenarios were created to provide diverse system operating environments, enabling a flexible system architecture to address a variety of threats in near-peer competition. With efforts to employ cost-effective and attritable unmanned components, open-source platform reviews were conducted to determine performance parameters, cost, and technical readiness levels, ultimately influencing the eligibility and appropriateness of these platforms for system integration. This evaluation led to a value system design for each candidate platform, providing quantitative analysis for its potential contribution to our system functions as they pertain to each mission scenario. An optimization program under cost constraints was then utilized to yield ideal platform combinations while meeting all functional requirements. Each architecture that resulted from the optimization program was then subjected to a combat model to verify its effectiveness, and then compared to conventional littoral denial constructs. Analysis and comparison of each system architecture yielded relevant insights for the project sponsor at OPNAV N9I (Director of Warfare Integration). Each scenario-dependent system of systems yielded improvements in certain functional evaluations, while also while also producing degradations in other functional areas. Final report and briefing are available upon request from Dr. Fotis Papoulias (papaoulias@nps.edu), Dr. Jefferson Huang (Jefferson.huang@nps.edu), or Professor of Practice Jeff Kline (jekline@nps.edu)

2.16 Spring FY23 Wargame Class

Wargame "Intra-Theater Fuel Supply Chain" in Support of Distributed Maritime Operations - Sponsor OPNAV N4 - Examine the regional and strategic impacts of the refueling kill chain's ability to meet operational demands generated from force protection and persistent effects in the INDO-PACOM theater.

Wargame "MARSOC Wargame Spring 2023" - The wargame participant analyzed how MARSOC could assess possible COMPOPS and missions for Marine Raider Detachments (MRDs) that are executing Strategic Shaping and Reconnaissance (SSR) during competing in INDOPACOM in the 2027 timeframe.

Final war game reports are restricted distribution. Request a specific report from Dr. Jeff Appleget at jaappleg@nps.edu.

2.17 Spring FY23 Naval Tactical Analysis Class

The spring 2023 Naval Tactical Analysis course composed of 5 officers conducted a convoy protection study using the "Second Battle of the Philippine Sea" scenario. The officers were asked to assess and quantify the value of integrating unmanned systems into the convoy protection.

Major Findings:

- Using traditional convoy operations with our current logistics fleet composition, and counter-targeting methods with unmanned system operational level decoys (LUSV), convoy ops were successful (no hits) about 2/3rds the transits across the campaign. The remaining convoys received one or more hits, with 2/3rds being missile attacks and 1/3 torpedo attacks.
- Decoy groups were killed about 1/3 of their trips.
- Use of TRITON surface/subsurface unmanned system in coordination with submarines in barrier operations resulted in a 50% increase in probability of detection a transiting SSK

***Figure 20**. TRITON Surface/Subsurface unmanned system assessed in undersea barrier operations.*

Specific quantitative results are CUI and may be requested by e-mailing jekline@nps.edu

2.18 Spring FY23 Joint Campaign Analysis Class

The spring 2023 Joint Campaign Analysis asynchronous course composed of 19 uniformed officers and civilian government employees used the "Second battle of the Philippine Sea" scenario to assess various logistic fleet designs for resilience across a contested logistics campaign. Four courses of action were assessed: Convoy operations with our current logistics fleet; convoy operations with our current logistics fleet augmented by decoy groups; distributed logistics (independent steaming) with our current logistics fleet; and distributed logistics with a new logistics fleet of more numerous, but small logistics ships.

Major Findings:

- Conducting distributed logistics with a logistics fleet composed of smaller, more numerous logistics ships resulting in **4 times** the tonnage delivered over the campaign than with the current logistics ships and convoying.
- Use of decoy logistic ships had more effect on increasing tonnage delivered when the U.S. was using escorted convoys with traditional logistic ships (about 45% more) and least effect on the numerous distributed small ship concept (about 1% more). This was a result of the decoys being "lost in the crowd" with the distributed logistics concept. Per the first observation, however, the distributed logistic concept with smaller more numerous ships delivered much more logistics across the campaign.

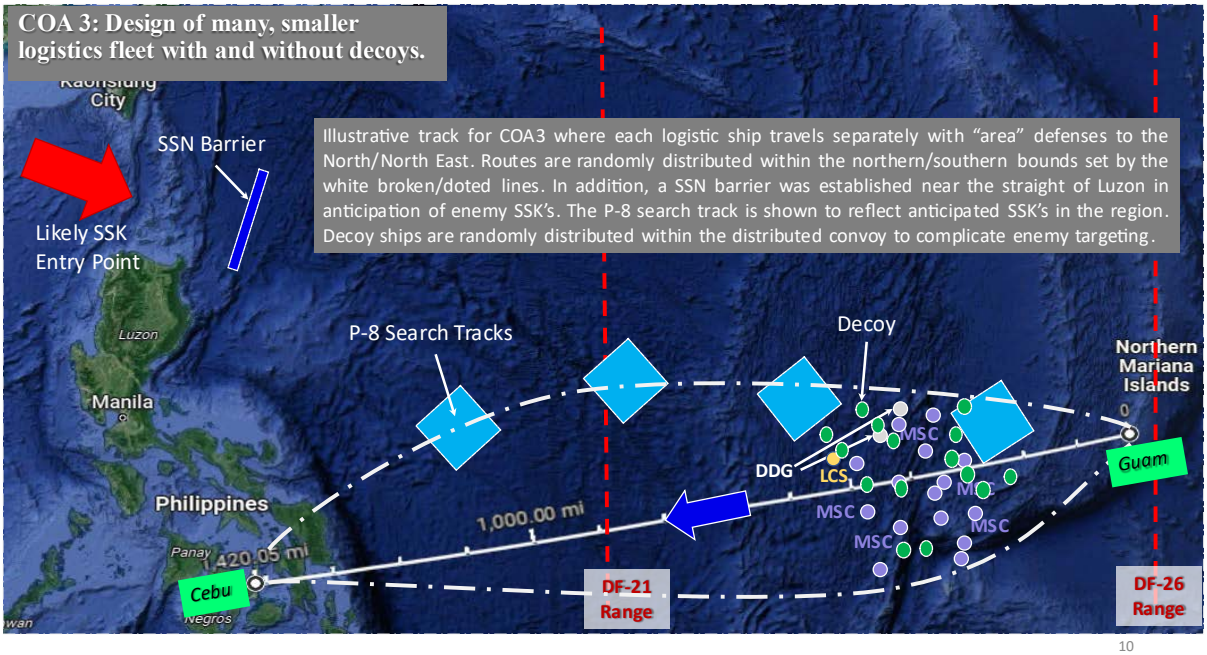


***Figure 21**: Illustrative concept for using smaller, but more numerous logistics ships*

For additional information contact Prof. Jeff Kline jekline@nps.edu

3 THE WAY AHEAD - SUMMARY

This Executive Summary provides a brief look the WIC events supported by over 300 participants involving inter-disciplinary research on creating asymmetric warfighting advantages. All of these events were previously scheduled and would have occurred regardless of the Warfare Innovation Continuum implementation. However, the WIC provided the over-arching focus and coordination toward a CNO's stated line of effort. In addition, it gave a real world practical maritime problem for faculty and students to focus their academic efforts. This on-going work provided a focused bank of research and concept development for all participants to draw from. Covering topics ranging from joint campaign analysis through wargaming to systems engineering analysis, the synergy was evident when the SEA 31 students began their culminating Capstone Project, armed with the research and analysis of over 300 preceding WIC participants.

The FY23-24 Warfare Innovation Continuum began in July 2022 and is entitled "Integrated Naval Campaigning". Several topics areas have been identified. The Systems Engineering Analysis cohort 33 will construct designs for a new mobile mine capability; the Total Ship Systems Engineering course work will create a new ship design for surface tender (afloat expeditionary maintenance forward); and the Warfare Innovation Continuum Workshop will focus on technologies and unmanned systems to which may be included in a future hybrid force to support integrated naval campaigning.

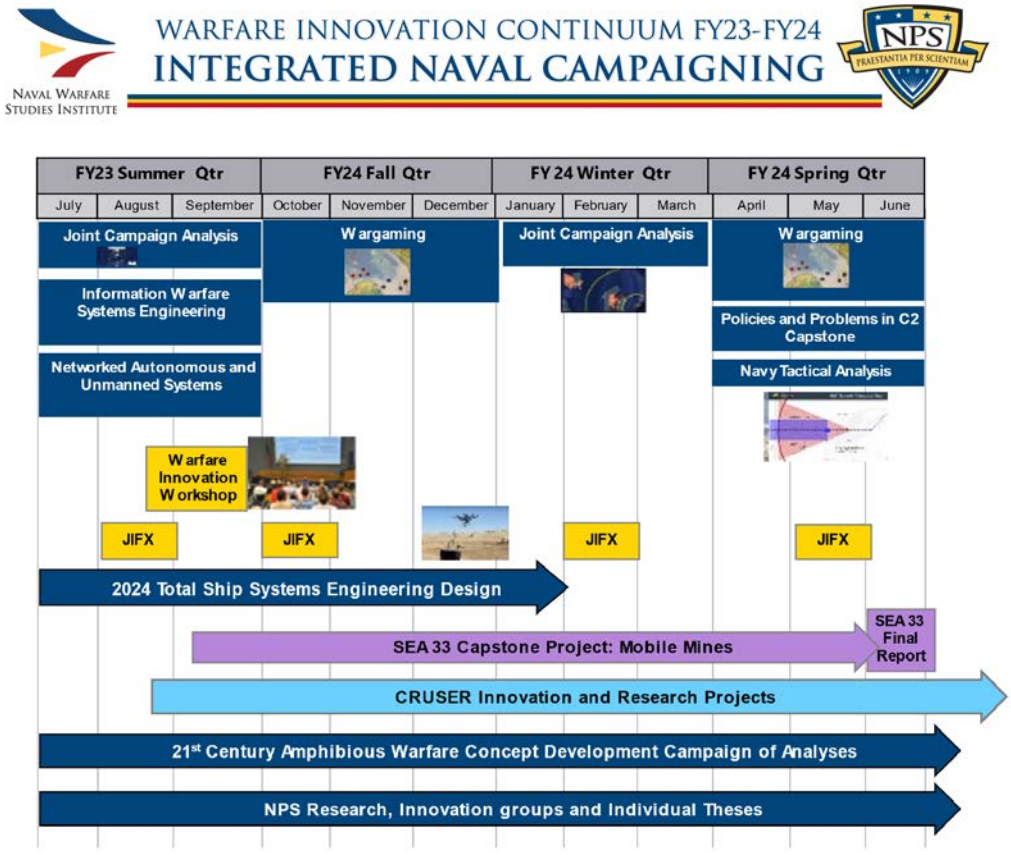
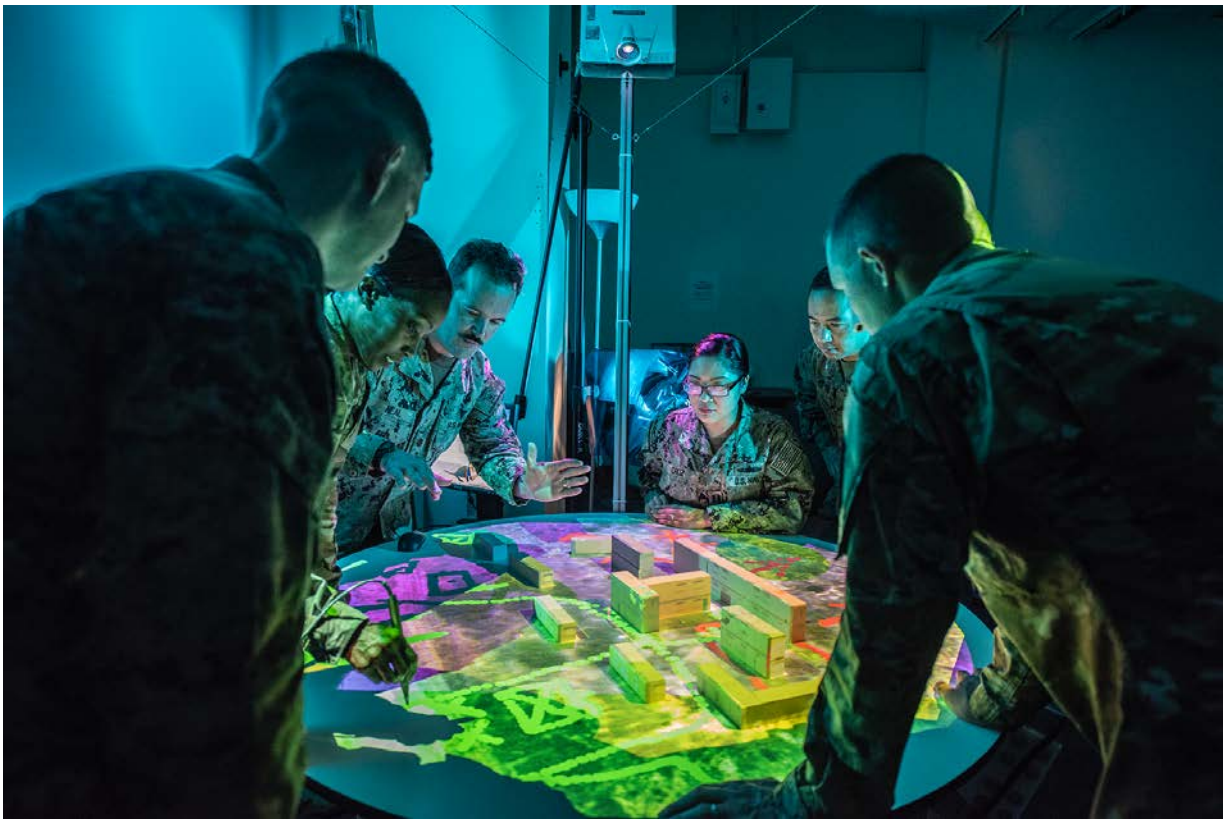


***Figure 22**. The FY23-FY24 NPS NWSI Warfare Innovation Continuum "Integrated Naval Campaigning"*

Since its inception in 2012, the Warfare Innovation Continuum initiative has involved over 4,000 NPS students, faculty and researchers, and other DoD affiliated personnel. Participation is expected to continue and expand in future iterations. The exposure of navy mission requirements, innovative techniques, and emerging technologies to address mission challenges to this many junior officers is just one positive outcome of the effort.

[i] Cancian, Mark, Cancian Matthew, Heginbotham, Eric. *"The First Battle of the Next War: Wargaming a Chinese Invasion of Taiwan"*. Center for Strategic and International Studies, January 2023.



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