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Warfare Innovation Continuum (WIC) Workshop:

Resurrecting War Plan Blue

September 2020

After Action Report

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for
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NAVAL POSTGRADUATE SCHOOL

Released 9 November 2020

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ACKNOWLEDGMENTS

Thank you to all those who made this workshop a success:

— To our embedded design facilitators Ms. Ann Gallenson, Mr. John Hawley, Mr. Garth Jensen, Ms. Marianna Jones, Mr. Steve Koepenick, Dr. Matt Largent, Col Todd Lyons USMC (ret), Mr. David Mortimore, CAPT Tony Nelipovich USNR, Mr. Dave Newborn, Mr. Stephen O'Grady, Dr. Carl Oros, Col Randy Pugh USMC, Dr. Don Thieme, Ms. Kristen Tsolis, Mr. Brett Vaughan, and LCDR Kristen Wheeler USN (ret). All your work and expertise were absolutely reflected in the outstanding outcomes.

— To our panelists, mentors and observers for sharing their time and expertise with the participants to better prepare them for their work.

— To all the participants for your willingness to join us on the NPS Virtual Campus to help shape the future of our Navy.

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EXECUTIVE SUMMARY

This Naval Warfare Studies Institute (NWSI), Consortium for Robotics and Unmanned Systems Education and Research (CRUSER), and Consortium for Intelligent Systems Education and Research (CISER) sponsored Warfare Innovation Continuum (WIC) workshop was held 21-24 September 2020 on the 'Virtual Campus' of the Naval Postgraduate School (NPS). The three-and-a-half-day experience allowed NPS students focused interaction with faculty, staff, fleet officers, and guest engineers from Navy labs, system commands and industry.

The September 2020 workshop "Resurrecting War Plan Blue" tasked participants to apply emerging technologies to shape the way we fight in a 2035 global conflict. Concept generation teams were given a design challenge: *How might emerging technologies; concepts; joint, combined and coalition forces contribute to enhancing the resiliency of naval forces, logistics, and support facilities in an extended campaign against a peer adversary? How do we best prepare for war in the era of competition and robotics warfare?* Following panel discussions and presentations from leading technical experts, the teams and their embedded facilitators had seven hours of scheduled concept generation time to meet that challenge, and presented their best concepts on the final morning of the workshop.

The "Resurrecting War Plan Blue" WIC Workshop included 157 registered participants in the roles of concept generation team members, facilitators, panelists, mentors, and observers – the full participant pool included representatives from 72 different organizations. Half of the workshop participants were NPS students drawn from curricula across the NPS campus. Panelists and featured speakers included Dr. Pate-Cornell from Stanford University, Ms. Rana Foroohar from the Financial Times, and Dr. P.W. Singer from the New America Foundation think tank. For this workshop, the final team roster also included participants from The Johns Hopkins University (JHU) Applied Physics Lab, the Naval War College (NWC), Raytheon, and Lockheed Martin. Fleet commands and warfare centers represented were the Naval Information Warfare Command (NIWC) Atlantic and Pacific, Naval Undersea Warfare Center (NUWC) Newport and Keyport, Naval Surface Warfare Center (NSWC) Carderock, and the Office of Naval Research (ONR). The entire incoming cohort of students from Temasek Defence Systems Institute (TDSI) in Singapore who start their NPS Systems Engineering program in Fall 2020 also participated, along with a student from Israel, a member of the Romania Navy, and a student currently enrolled at the Columbian Naval Academy.

Participants were asked to propose both physical designs and concepts of operation for notional future systems' employment in a plausible real-world scenario with the intent of advancing robotic and autonomous systems concepts. From all the concepts generated during the ideation phase, each team selected concepts to present in their final briefs. NWSI leadership reviewed all the proposed concepts and selected ideas with potential operational merit that aligned with available resources for further research and development. All concepts are described fully in this report, but in summary these concepts include:

- ***Distributed Autonomous Logistics:*** *repurpose existing commercial systems during wartime*

- ***AI for Port Operations:*** *integrate AI into forward port operations*
- ***Project Shell Game:*** *dynamic sea bases to keep adversaries guessing at location and function of forward bases*
- ***Resilient Infrastructure:*** *high speed internet utility, "ruggedize" utilities for resilience, agile manufacturing, spare production capacity, re-shore with automation*
- ***(Camo) Green New Deal:*** *whole-of-society approach to leverage elements of social investment programs and repurpose them in the event of war*
- ***Robotics and Autonomy for MILDEC:*** *(details restricted) separate report available upon request through secure channels*
- ***Sensor Network System of Systems:*** *full overarching concept of wide area autonomous sense, track, and interdiction platforms*
- ***Networked Citizenry:*** *incentivize skill generation and usage of networked citizenry and general population*
- ***Tailored Industry Liaison Teams (TILTs):*** *groups to support rapid mobilization through quick reorganization of private assets*

Selected concepts will inform research and exploration across the NPS campus over the next 18 months, and will enable NPS students and faculty to work with stakeholders across the Department of Defense (DoD), academia, and industry to develop solutions for the future. This sort of applied approach ensures that NPS provides defense-focused graduate education, including classified studies and interdisciplinary research, to advance the operational effectiveness, technological leadership and warfighting advantage of the Naval service.

I. BACKGROUND

Sponsored by and the Naval Warfare Studies Institute (NWSI), the Consortium for Robotics and Unmanned Systems (CRUSER), and the Consortium for Intelligent Systems Education and Research (CISER), this Warfare Innovation Continuum (WIC) workshop was held on the Naval Postgraduate School (NPS) 'Virtual Campus' during NPS Thesis & Research Week, 21-24 September 2020. Tasked with developing concepts of operations (CONOPS) in a near future global scenario with simultaneous conflicts on several distinct fronts, participants generated and proposed technologies to support their CONOPS to increase national resiliency to sustain a prolonged war.

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*To be prepared for war is one of the most effectual means of preserving peace – **U.S. President George Washington** in his first State of the Union address to Congress in 1790*

A. ORIGINS

Innovation and concept generation are key drivers for NWSI, CRUSER and other NPS research efforts, and these workshops are a central element of the overall strategic plan for the CRUSER program. The first NPS Innovation Seminar supported the Chief of Naval Operations (CNO)-sponsored Leveraging the Undersea Environment war game in February 2009. Since that time, workshops have been requested by various sponsors to address self-propelled semi-submersibles, maritime irregular challenges, undersea weapons concepts and unmanned systems concepts generation. Participants in these workshops have included junior officers from NPS and the fleet; early career engineers from industry, U.S. Department of Defense (DoD) laboratories, and other Federal agencies; and officers from allied nations.

Beyond producing concepts of interest, these workshops are designed to maximize relationship building to strengthen the CRUSER community in the future. During Enrichment Week in September of 2012, the Navy Warfare Development Command (NWDC) and CRUSER sponsored a concept generation workshop that was focused on advancing the Design for Undersea Warfare.[1] The March 2013 workshop, Undersea Superiority 2050, took a more focused look at the undersea domain aspects of the September 2012 workshop outcomes. The September 2013 workshop looked at distributed surface and air forces, and was the first workshop as part of the Warfare Innovation Continuum (WIC). The September 2014 workshop explored operations in contested littoral environments. The September 2015 workshop was designed to explore the concept of electromagnetic maneuver warfare, and tasked participants with employing unmanned systems in cross domain operations. Based on Fleet interest, the September 2016 workshop focused on developing autonomy to strengthen Naval power in response to CNO Richardson's release of the Design for Maintaining Maritime Superiority focusing document in January 2016. The September 2017 workshop "Distributed Maritime Operations" tasked participants to apply emerging

[1] *Design for Undersea Warfare Update One*, November 2012: http://www.public.navy.mil/subfor/hq/PDF/Undersea%20Warfare.pdf

technologies within a near future conflict in an urban littoral environment, and the 2018 workshop "Cross Domain Operations" looked at integration of assets. The September 2019 workshop "Logistics in Contested Environments" asked teams to focus on how to maintain forces in a sustained conflict. In addition to supplying topics for further NPS research, past WIC Workshops provided information and concept ideas to NWDC and the Marine Corps Warfighting Lab (MCWL).

The September 2020 Workshop "Resurrecting War Plan Blue" tasked participants to consider a conflict scenario in the year 2035 requiring the U.S. to quickly mobilize forces and assets in response to a rapidly deteriorating global security environment.[2] The intent was to explore technologies and policies to undertake now to increase the nation's resiliency for an extended conflict.

B. PLANNING AND EXECUTION

Planning for this workshop began in earnest several months in advance of the event. NWSI and CRUSER concept generation workshops are scheduled during the week between the end of classes and graduation in September or March each academic year to maximize the utility of NPS student time. NPS Thesis & Research Week, formerly Enrichment Week – a week without regularly scheduled classes – is intended to allow all NPS students to participate in an activity to further their intellectual growth in specialized areas of study. These concept generation workshops are an ideal fit for this mission.

The year 2020 has brought us many challenges – not the least of which is a global pandemic which forced all resident work on the NPS campus in Monterey to be pushed to a remote environment. In mid-March 2020 all NPS staff were put into a mandatory telework environment, and with the exception of specialized lab work NPS faculty adjusted to teach all scheduled courses in a remote distance learning format. Although we were initially hopeful that we might hold the September workshop in a hybrid format, it became clear by late June 2020 that in the interest of public health the workshop should be scheduled on the NPS 'Virtual Campus' using a combination of remote learning tools. For this workshop we decided to use the NPS instance of Microsoft (MS) Teams for all the plenary session and for concept generation team breakout rooms. The NPS distance learning platform Sakai supported all materials for the workshop which allowed for participants to review materials in advance, and reference materials throughout the workshop as well as retrieve results once posted. The NPS Field Experimentation team supported the workshop both through offering personnel to serve as tech facilitators, but also through the purchase of seven memberships to the digital collaboration tool MURAL[3] for concept generation work in a remote environment. One team of select NPS students were able to gather in person and use Post-its and Sharpies to work the design challenge at the classified level. This team followed strict pandemic cleaning and contact tracing protocols.

1. Workshop Participants

Workshop participants were recruited from across the full NWSI and CRUSER communities to include NPS, DoD commands, academia and industry. A concerted effort was made to solicit representatives from all naval warfare domains, as well as from the full range of armed services on campus.

[2] The full scenario is included as Appendix B on page 71 of this full workshop report.
[3] MURAL is a digital workspace for visual collaboration (https://www.mural.co/)

This September 2020 WIC workshop included 157 registered participants in the roles of concept generation team members, facilitators, panelists, mentors, and observers – the full participant pool included representatives from 72 different organizations. Half of the workshop participants were NPS students drawn from curricula across the NPS campus. Panelists and featured speakers included Dr. Pate-Cornell from Stanford University, Ms. Rana Foroohar from the Financial Times, and Dr. P.W. Singer from the New America Foundation think tank. For this workshop, the final team roster also included participants from The Johns Hopkins University (JHU) Applied Physics Lab, the Naval War College (NWC), Raytheon, and Lockheed Martin. Fleet commands and warfare centers represented were the Naval Information Warfare Command (NIWC) Atlantic and Pacific, Naval Undersea Warfare Center (NUWC) Newport and Keyport, Naval Surface Warfare Center (NSWC) Carderock, and the Office of Naval Research (ONR). The entire incoming cohort of students from Temasek Defence Systems Institute (TDSI) in Singapore who start their NPS Systems Engineering program in Fall 2020 also participated, along with a student from Israel, a member of the Romania Navy, and a student currently enrolled at the Columbian Naval Academy.

Figure 1. A concept generation team presenting their ideas on the NPS 'Virtual Campus' (24 September 2020).

The six concept generation teams were organized to maximize diversity of participant experience. The NPS 'Virtual Campus' environment on Microsoft Teams allowed each concept generation team to work through the design challenge with their facilitators in their own Team Channel within the MS Team created for the WIC Workshop. This provided a virtual substitute for the classrooms traditionally used for individual workspaces while maintaining the ability of team members and facilitators to share many ideas at several stages in concept development. All participants were encouraged to leverage their individual expertise and experience, regardless of their team assignments. Mentors and panelists were able to "visit" the virtual rooms to give guidance and feedback when requested by the teams. Senior members of CRUSER, NPS leadership and academic community, as well as visiting subject matter experts were invited to attend any and all of the workshop activities that fit their interest and schedule. All were encouraged to attend the final concept presentations on Thursday morning (*see Figure 1*).

2. Workshop Design

The September 2020 workshop, "Resurrecting War Plan Blue," leveraged the innovation lessons learned in previous workshops and was designed specifically to inspire innovative and rapid concept generation using tools of user-centered design. It was also the first rapid concept generation workshop to be held on the NPS 'Virtual Campus' (*see Figure 2*).

Figure 2. NPS President VADM Ann Rondeau USN (ret) welcomed workshop participants to the NPS 'Virtual Campus' (21 September 2020).

Scenario

All participants were given an overview of the future scenario titled "Global War 2035 – War Plan Blue" (*see Appendix B, page 71*). From workshop lead NPS Professor of the Practice Jeff Kline's[4] submitted article "Resurrecting War Plan Blue" published in the July 2020 issue of the U.S. Naval Institute (USNI) Proceedings[5]:

> *The United States eventually became the great "Arsenal of Democracy" but only because of two fortuitous factors: time and distance. If the continental United States had not been thousands of miles from the major battlefields, the nation would not*

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[4] *Captain Kline retired after 26 years of service, including to two sea commands. He currently is a professor of practice in the Naval Postgraduate School Operations Research Department, where he teaches campaign analysis, systems analysis, and executive programs in strategic planning and risk assessment. He has served on the Chief of Naval Operations' Fleet Design Advisory Board and several Naval Study Board Committees of the National Academies.*

[5] CAPT Jeffrey E. Kline USN (ret) "Resurrecting War Plan Blue" *USNI Proceedings*, July 2020 Vol. 146/7/1,409 (https://www.usni.org/magazines/proceedings/2020/july/resurrecting-war-plan-blue)

have had the time to properly organize for war. ***– Historian Kerry E. Irish on WWII mobilization***[6]

Time and distance—with the emergence of submerged-launched cruise missiles, hypersonic weapons, cyber warfare, undersea infrastructure, swarmed autonomous unmanned systems and anti-ship ballistic missiles, the great ocean barriers may no longer provide even a temporary refuge for the United States to prepare for an extended major conflict. In an era of great power competition between technologically advanced economies, clearly demonstrated investment in war preparations may be the best deterrent to prevent that future war. This does not necessarily mean an arms race to employ more forces, but rather the systematic preparations to absorb initial conflict, employ follow-on forces, sustain those forces, and, if necessary, mobilize the nation for an extended conflict.

Joint Publication 4-05, Joint Mobilization Planning[7]*, is comprehensive in addressing the resource areas needing attention during a mobilization effort—legal authorities, funding, environment, manpower, material and equipment, transportation, facilities, industrial base, training base, health services, communications, and host-nation (allied) support. It incorporates mobilization lessons from the most recent conflicts in Afghanistan and Iraq, and provides a solid template for planning joint mobilization. But, it is written with mobilization as "…the process of assembling and organizing national resources to support national objectives in time of war or other emergencies."*

Will the current technologies of conflict allow the time to plan then mobilize after hostilities' commencement? One could argue the Pentagon's planning, programming, budgeting and execution (PPBE) cycle is designed to invest in adequate forces to prepare for the worst contingencies. However, PPBE is constrained by addressing only the Department of Defense's budget, not the full range of national resources, and its nature is to recommend marginal changes to existing force capabilities—not major force structure changes that may be required for an extended conflict. It can, however, provide resources to assess where national investment is needed to create a resilient posture, and inspire planning efforts across executive departments. Cold war civil preparations for nuclear survival in the event of total war with the Soviet Union provides an example. It, however, addressed the extreme. U.S. force structure, basing and nuclear posture during the Cold War was adequate to deter direct conventional conflict with the Soviet Union. When conflict did occur, it was through third party surrogates (Israel-Egypt, Afghanistan, Vietnam, Cuba, etc).

Today, emerging great power capabilities challenge our capacity to engage across the full spectrum of conflict—particularly if that conflict is purposely drawn out by an adversary. We risk

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[6] Kerry E. Irish, "Apt Pupil: Dwight Eisenhower and the 1930 Industrial Mobilization Plan," *The Journal of Military History* 70, no. 1 (January 2006): 53

[7] Joint Publication 4-05, *Joint Mobilization Planning* (23 October 2018), ix, www.jcs.mil/Portals/36/Documents/Doctrine/pubs/jp4_05.pdf?ver=2018-11-13-170517-383

a Pyrrhic Victory—one in which we win the conventional war but lose the strategic peace due to our inability to reconstitute forces as quickly as the war's losers. While nuclear deterrence remains paramount, the environment our conventional forces find themselves may be more a reflection of 1930 than 1980—potentially facing major powers from the two oceans, with the added dimensions of cyber and space. In the inter-war years the color war plans addressed conflict with various countries designated by specific colors. These later evolved into the Rainbow plans just before the beginning of World War II. In these plans, the United States was designated Blue The term "War Plan Blue" referred to those communications, studies and plans dealing with the U.S. preparations before war—regardless of adversary—usually developing mobilization plans but also forward base preparedness.

The 2020-2021 NPS WIC explores a new *War Plan Blue* effort – a series of studies and actions proposed to be coordinated by the Joint Staff, but including the Departments of Homeland Security, Commerce, and elements of private industry. Its purpose is to explore strategic choices and make recommendations for national actions in preparation for information age conflict. Its goal is to see those recommendations funded and acted upon to demonstrate a national resilient posture, and therefore deter potential hostilities. There are many calls for such an effort. There are, however, new strategic opportunities influenced by emerging technologies we may consider in critical resource areas: industry, people, and infrastructure. The September 2020 WIC Workshop participants were tasked to address this effort.

Process

The U.S. Navy (USN), and DoD writ large, have encouraged innovation at all levels and have pointed to Silicon Valley as an innovation exemplar. Product and software development based on user needs led Silicon Valley to become an innovation leader. These user-focused processes have evolved into what is now practiced as "Design Thinking" in industry, academia, and now the military. The WIC Workshop employs tools of design for rapid and effective concept generation.

With the help of embedded facilitators, the teams use these tools to address the given design challenge. User input is gleaned from a variety of subject matter experts, and senior military, academic, and industry leaders serving as mentors. Some of this input is given formally in the form of plenary briefs to assembled participants or as part of organized interviews, or informally throughout the workshop. This user input, as well as the assembled team's experience in the given problem space is the data that begins their concept generation process. The second day of the workshop is focused on divergent creation of choices, and the third day begins by converging on concepts to fully describe for presentation. Summaries of five of the six team presentations are included at the end of this report (*see Appendix A, pp 23-66*), as well as the full workshop schedule (*see Appendix C, p. 71*).

II. CONCEPT SUMMARY

Three knowledge-leveling Discovery Panels started the exploration of the problem space providing concept overviews and technology injects related to the design challenge. This workshop also included a Discovery Panel on innovation in military spaces. Based on the plenary session guidance, read-ahead materials, and panelist input, each team generated numerous concepts and then selected their best ideas to present in their final briefs. Following the final briefs on Thursday 24 September 2020, NWSI leadership identified ideas with potential operational merit that aligned with available resources for broader dissemination.

A. Concepts and Technologies

Several emerging concepts and technologies were introduced during the plenary Discovery Panels on the first two days of the workshop.[8] Teams were encouraged to consider how these concepts and technology injects might benefit combined and allied forces in the scenario presented, but they were not required to include presented technologies in their final selected concepts. Each panelist had ten minutes to present a prepared statement introducing their topic, and then participated in a moderated discussion and answered questions from participants. The four primary panel topics were:

1) Intelligence, Reconnaissance, and Surveillance (ISR) and Defense Technology
2) Industrial Resilience and Supply Chain Vulnerability
3) Intelligent Autonomous Systems (IAS) and Biologics
4) Innovation

Participants heard from two panels on the first day of the workshop. The first panel covering ISR and defense technology (*see Figure 3*) was moderated by an NPS Dean, and included representatives from a think tank, a warfare center, a defense contractor, an NPS research project, and a U.S. Army development command. The panelists presented both emerging technologies and thoughts on how these technologies might impact a future conflict. The second panel, moderated by a guest from Headquarters Marine Corps, took a closer look at industrial resilience and explored potential supply chain vulnerabilities. Panelists included representatives from the tech industry, warfare centers, academia, and mainstream media. Topics presented ranged from semiconductors to resilience of the financial sector, and included thoughts about industrial risk assessment and asymmetric warfare. The first day of the workshop concluded with a spotlight talk by Dr. P.W. Singer on the role of fiction in wargaming what a future conflict may look like. Joining more traditional intelligence products[9] such as HUMINT and SIGINT, Dr. Singer presented a compelling case for the importance of FICINT – or

[8] Please see Appendix C on page 91 for the full workshop schedule listing panelists and topics presented.

[9] There are six basic intelligence sources, or collection disciplines: signals intelligence (SIGINT), imagery intelligence (IMINT), measurement and signature intelligence (MASINT), human intelligence (HUMINT), open-source intelligence (OSINT), and geospatial intelligence (GEOINT) (excerpted from the Office of the Director of National Intelligence "What is Intelligence" https://www.dni.gov/index.php/what-we-do/what-is-intelligence)

intelligence products from fictional stories – as teams explored their design challenge and considered what might be in the "realm of the possible" in a future conflict.

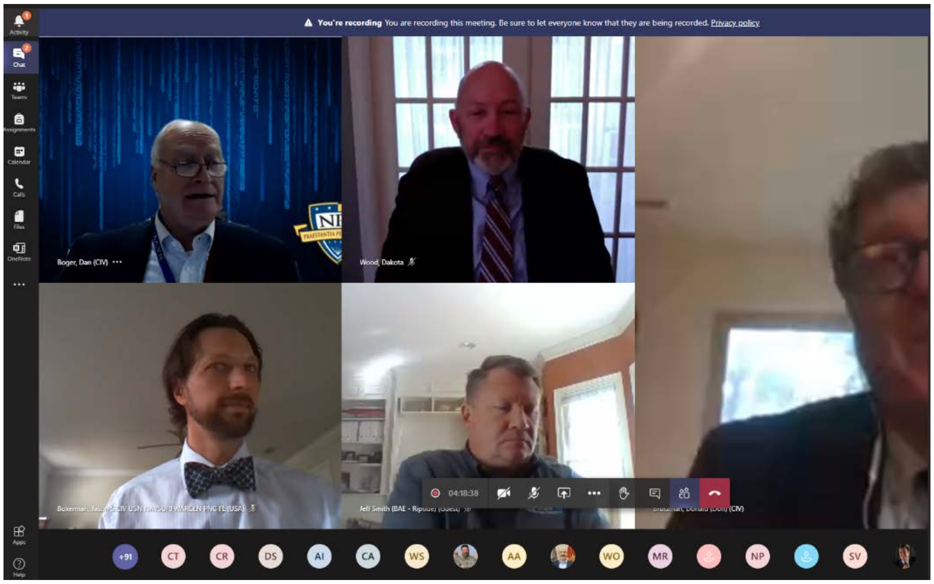

Figure 3. Moderated panels introduced workshop participants to key issues to consider during concept generation work. Discovery Panel I (pictured) covered topics on intelligence, surveillance, and reconnaissance (ISR) and defense technology (21 September 2020).

The third panel on IAS and biologics started the second full day of the workshop and explored the role of autonomy, artificial intelligence (AI), and other emerging technology in future conflict. Panelists included a representative from the tech industry, another military academic institution, a warfare center and a DoD contractor, and was moderated by the director of the NPS field experimentation family of programs. This panel further explored a future scenario involving a Pacific battlespace and included thoughts about new domains such as cyber and space, as well as thoughts on the ethical use of autonomy in warfare. The third day of the workshop started with the final scheduled panel. Moderated by an NPS innovation facilitator, the panelists included current and former WIC Workshop concept generation team facilitators from industry, academia, and warfare centers. Leveraging the experience of the first day of concept generation, this panel addressed overarching thoughts on the creative process essential for productive concept generation work and touched on how to address complex problem spaces and the state of the military innovation space.

B. Concepts of Interest

Key criteria used to select concepts of interest from all those proposed for further development were:

- Is the concept feasible (physically, fiscally)?
- Is the concept unique?
- Does the concept solve a key problem or fill a key gap?
- Is the concept testable?

The 2020 concepts of interest are:

- ***Distributed Autonomous Logistics:*** *repurpose existing commercial systems during wartime*
- ***AI for Port Operations:*** *integrate AI into forward port operations*
- ***Project Shell Game:*** *dynamic sea bases to keep adversaries guessing at location and function of forward bases*
- ***Resilient Infrastructure:*** *high speed internet utility, "ruggedize" utilities for resilience, agile manufacturing, spare production capacity, re-shore with automation*
- ***(Camo) Green New Deal:*** *whole-of-society approach to leverage elements of social investment programs and repurpose them in the event of war*
- ***Robotics and Autonomy for MILDEC:*** *(details restricted)*
- ***Sensor Network System of Systems:*** *full overarching concept of wide area autonomous sense, track, and interdiction platforms*
- ***Networked Citizenry:*** *incentivize skill generation and usage of networked citizenry and general population*
- ***Tailored Industry Liaison Teams (TILTs):*** *groups to support rapid mobilization through quick reorganization of private assets*

These concepts will guide NPS student and faculty exploration through FY21 within the WIC. Unclassified details of these concepts as presented are included in Appendix A (pp 23-67) of this workshop report.

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III. WAY AHEAD

Of all the ideas generated through the facilitated design process, each team selected concepts to further explore and present in their final briefs. Following the final briefs on 24 September 2020, NWSI leadership identified nine ideas with potential operational merit that aligned with available resources (*see list pp. 16-17*). These concept outcomes not only plant idea seeds for research across the NPS campus, but the concepts from each annual workshop are taken with participants back to home organizations and commands to inform future work. The *(Camo) Green New Deal* concept has traction within the warfare center community as well as the Naval War College and is moving forward as a proposal to higher levels right out of the gate. The System Engineering Analysis (SEA) cohort will also use the foundation of the workshop concepts to begin their capstone project required for their Master's degree with anticipated completion in eighteen months.

A key outcome of the annual WIC Workshop is all participants leave the workshop experience with a set of tools to approach the next complex problem space they face in their careers. Innovation is more than a buzz word – the work of innovation takes tools, but does not require a significant investment of time. With a task defined by exploration of the problem space a solution might come from anywhere, and is more likely to emerge rapidly through focused work by a small team looking at the same problem space through the many lenses of different perspectives.

A. Naval Warfare Studies Institute (NWSI)

The mission of the Naval Warfare Studies Institute (NWSI) is to coordinate NPS inter-disciplinary research and education to accelerate and enhance warfare concept and capability development.

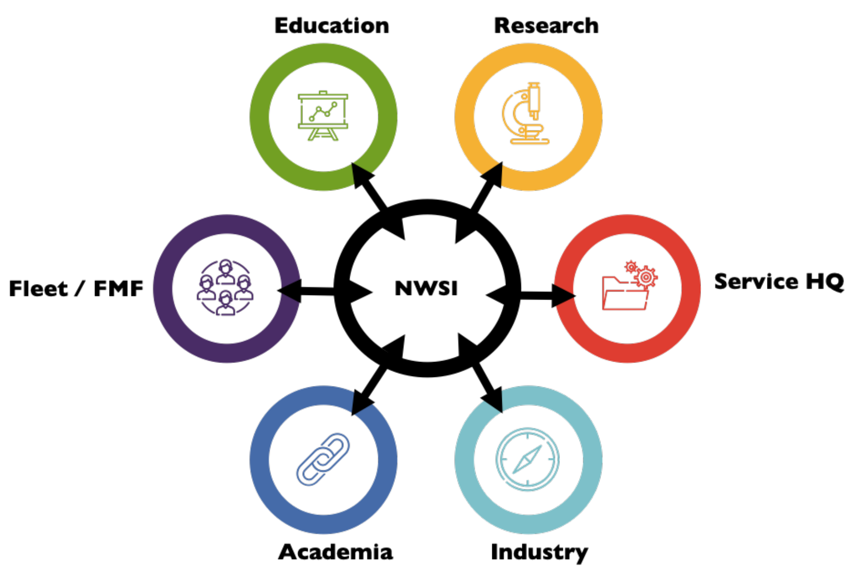

Figure 4. Naval Warfare Studies Institute (NWSI) at NPS is a hub for warfighter expertise.

NWSI is a hub of experts that enable teamwork and collaboration with the NPS innovation ecosystem to optimize NPS' inter-disciplinary educational and research response to Naval warfighting needs (*see*

Figure 4), and accelerate and enhance tactically and technically informed solutions to the Naval forces. NWSI provides a portal to access NPS talent, resources, and facilities. NWSI informs, coordinates, integrates, and advocates in support of the USN N7 and U.S. Marine Corps (USMC) Combat Development and Integration (CD&I) requirements through interaction with the following NPS activities:

- Warfare Innovation Continuum (WIC)
- Consortium for Robotics and Unmanned Systems Education and Research (CRUSER)
- Consortium for Intelligent Systems Education and Research (CISER)
- Wargaming Center
- Littoral Operations Center
- Field Experimentation (FX)[10]
- NPS Modeling Virtual Environments and Simulation (MOVES) Institute
- Athena – an online collaborative research discovery tool
- NPS Naval Research Program (NRP)
- Calhoun – the NPS digital repository managed by the Dudley Knox Library
- NPS Big Ideas Exchange (BIX)
- Seapower Conversations

Please visit the NWSI website (https://nps.edu/web/nwsi) for more information about the institute, partner efforts, and to apply for membership.

B. Warfare Innovation Continuum (WIC)

Under the program umbrella of NWSI, the Warfare Innovation Continuum (WIC) encompasses the successful research, education, and experimentation efforts, ongoing at NPS and across the greater Naval Enterprise. The goal of the continuum is to align regularly scheduled class projects, integrated research and special campus events into a broad set of coordinated activities that will help provide insight into the opportunities for future naval operations, fleet architectures, and fleet design. Exploring a new topic area each fiscal year, the WIC is a coordinated effort to execute a series of cross-campus educational and research activities that share a central theme. Classes, workshops and research projects are synchronized to leverage and benefit from prior research that results in a robust body of work focused on each annual topic area.

The WIC is a series of coordinated cross-campus educational and research activities with a central theme. By incorporating topics of fleet interest into established academic courses and by supporting student thesis project research, students and faculty promote research that aligns with fleet priorities while simultaneously achieving the educational requirements for the graduate students. The 2020-2021 WIC "Resurrecting War Plan Blue" (*see Figure 5*) address the question *"How might emerging technologies; concepts; joint, combined and coalition forces contribute to enhancing the resiliency of naval forces, logistics, and support facilities in an extended campaign against a peer adversary? How do*

[10] Includes several emerging technology related programs including the Joint Field Experimentation (JIFX) program and the Sea Land Air Military Robotics (SLAMR) initiative.

we best prepare for war in the era of competition and robotics warfare?" Final reports are available for all prior continuums dating back to 2013.

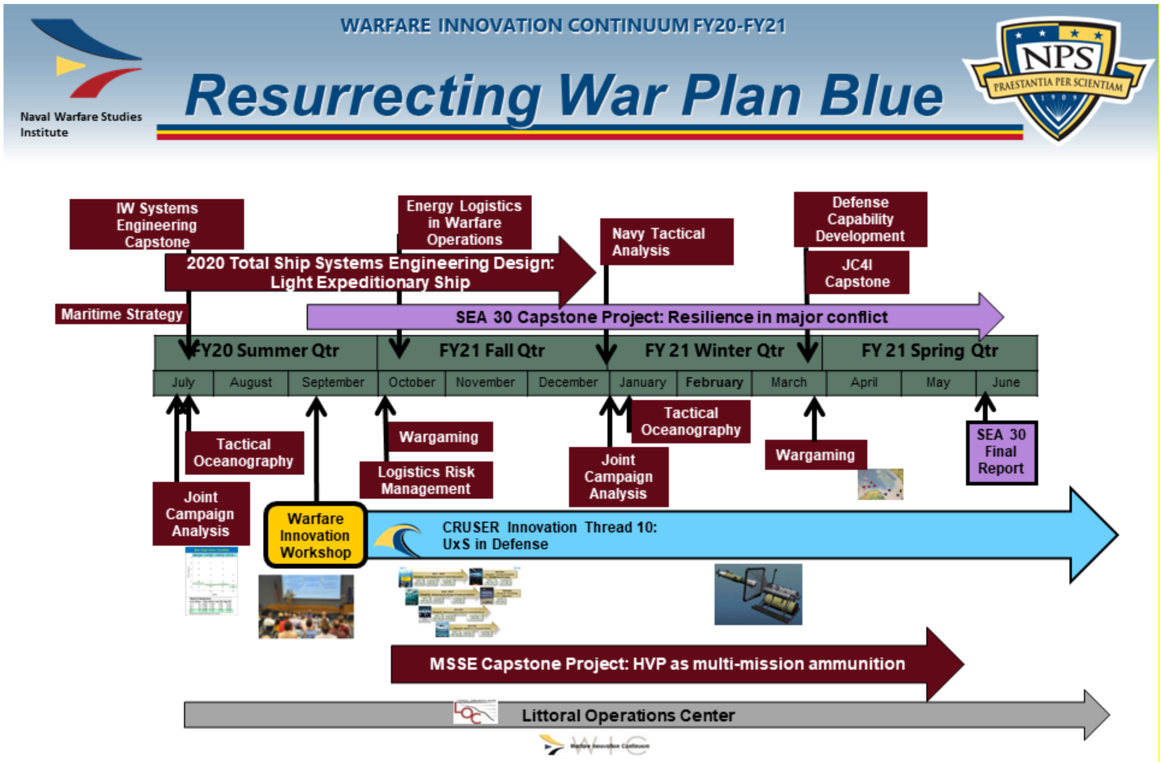

Figure 5. NPS Warfare Innovation Continuum (WIC) 2020-2021, Resurrecting War Plan Blue.

C. CRUSER and CISER Support

Both CRUSER and CISER provided labor support for the personnel to support this workshop. Planning takes six months, with the last three months pulling full time effort. The start of September each year involves labor hours to plan and prepare from several individuals throughout not only NPS, but the full Naval research enterprise as facilitators and subject matter experts. The week of the workshop is an "*all hands on deck*" effort for the broader NPS Field Experimentation (FX) team which includes JIFX, SLAMR, and CRUSER; and this year we were fortunate to have additional support personnel from CISER.

In addition to the concepts and technology proposals, the September 2020 workshop also supports other elements of CRUSER's charter: 1) the advancement of general unmanned systems knowledge among the participants; and 2) a greater appreciation for the technical viewpoints for officers, or the operational viewpoint for engineers. The information interchange and relationship building that occurred during this event were characteristic of the workshop venue, and support CRUSER's overall intent.

Final concepts of interest from this WIC Workshop will also filter through researchers involved with both CRUSER and CISER throughout FY21, inspiring new research threads and contributing to research already underway.

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APPENDIX A: Final Concepts

Five teams presented their final briefs on Thursday 24 September 2020, and were each given 15 minutes to present their most developed and promising concepts. The following concept summaries were created from these final presentations. The team working the challenge at the classified level presented on Thursday afternoon and a summary of their concepts is available through vetted request.

A. Team AI

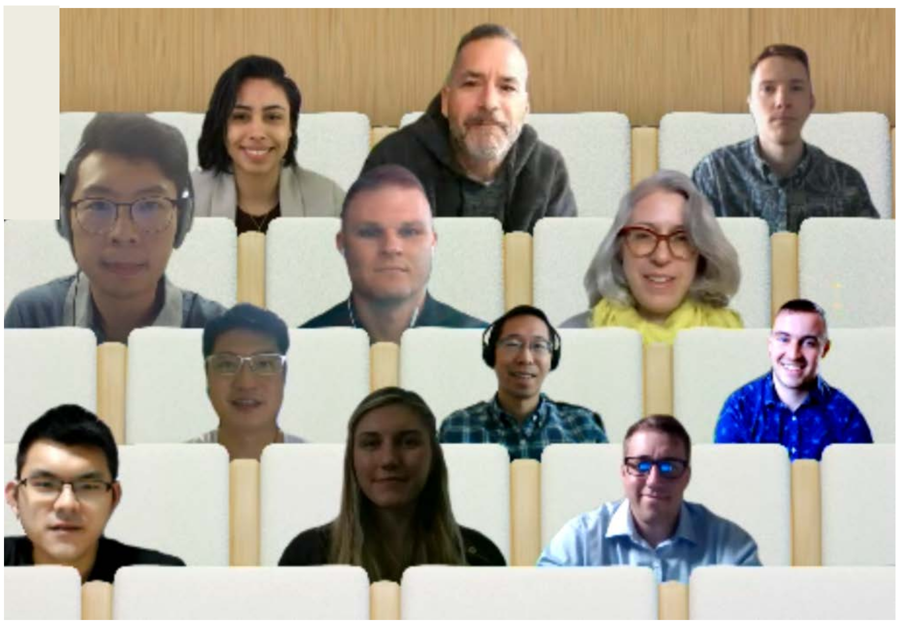

Figure 6. Members of Team AI *(pictured from left to right*) ROW 1 (*bottom*): Ming Hui Peh, Madison Weathersby, Benjamin Branson ROW 2: Jason Yap, Chris Chang, Kyle Reese ROW 3: Eugene Boon Kien Lee, John Schmaltz, Kristen Tsolis ROW 4 (*top*): Yvonne Sanchez-Garcia, Brett Vaughan, Andrew Pfau (not pictured: Wes Royston, Matt Largent and Todd Lyons)

The members of this team (*see Figure 6 and Table 1*) included six junior officers representing the U.S. Navy and U.S. Marine Corps and the Republic of Singapore Air Force, and five early career engineers from warfare centers and industry. This team was facilitated by two NPS faculty members and two guests, and the team included four NPS students.

Table 1. Members of Team AI (*alphabetical by last name*)

NAME	PERSPECTIVE	AFFILIATION
Capt Benjamin Branson USMC	*Combat engineer officer*	NPS Electrical Engineering
Chris Chang	*Electrical engineer*	Lockheed Martin
Dr. Matt Largent	*Facilitator*	NIWC Atlantic
Eugene Boon Kien Lee	*Staff officer – logistics*	Republic of Singapore Air Force
Col Todd Lyons USMC (ret)	*Facilitator*	NPS Innovation Instructor
Ming Hui Peh	*Infantry officer*	NUS/TDSI
LT Andrew Pfau USN	*Submarine officer*	NPS Computer Science
Kyle Reese	*Robotics engineer*	NUWC Newport

LT Wesley Royston USN	*Systems engineer*	UUVRON-1
Capt Yvonne Sanchez Garcia USMC	*Logistics officer*	NPS Computer Science
Capt John Schmaltz USMC	*Amphibious assault officer*	NPS Defense Systems Analysis
Kristen Tsolis	*Facilitator*	NPS RoboDojo
Brett Vaughan	*Facilitator*	ONR AI Portfolio Manager
Madisyn Weathersby	*Aerospace engineer*	NIWC Atlantic
Jason Yap	*Engineer*	DSO National Laboratories

Team AI's design challenge was:

How might we harness extant and emergent AI capabilities to enable unmanned systems, augment human decision-making, and enhance battle space awareness in order to improve resiliency in forward basing and ports or aid in defense of those bases and ports?

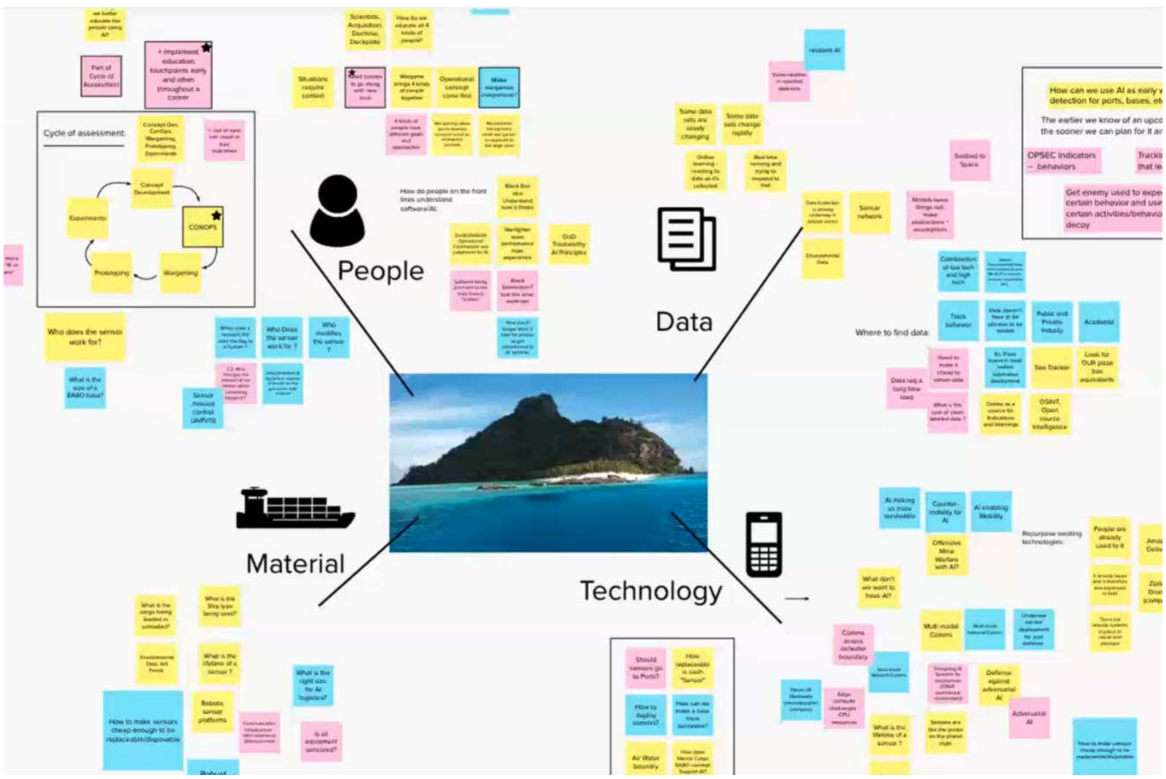

Figure 7. Team AI mind map synthesis of data gathered in the problem space.

After gathering data in the problem space, through a mind mapping process the team sorted their data into recurring themes of people, data, technology and materials (*see Figure 7*). These themes then led to their key ideas, and at the end of their process Team AI presented four concepts:

1) Cycle of Assessment
2) Distributed Autonomous Logistics
3) AI for Port Operations
4) AI-Enabled C2

1. Cycle of Assessment

The first recurring idea was a cycle of assessment. Behind the success of every idea the team looked at was an assessment cycle like this. In the given scenario, we are in 2035 and have successfully integrated AI systems into key domains. How did we actually get there? Team AI proposed that we got there by using this cycle of assessment as it embraces the fact that whoever adapts the quickest ultimately wins. This is a model of thinking that can be applied to any challenge. Their proposed cycle (*see Figure 8*) begins with the concept development phase, then CONOPS, wargaming, prototyping and then experimentation.

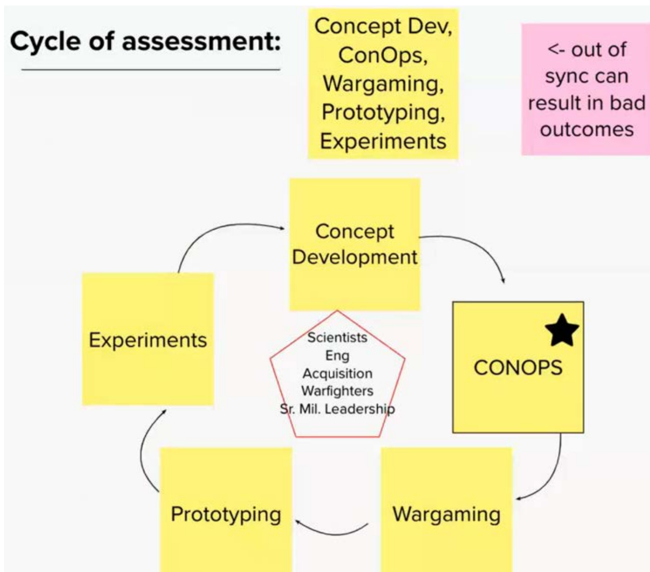

Figure 8. Cycle of assessment concept.

At the core of the cycle are the key players required for each phase (*see Figure 5, center*) to ensure that we are asking and solving the *right* questions. The key players are scientists, engineers, warfighters, and senior military leadership. These are the very people that work to develop both the CONOPS for AI and the associated AI technology. For data, cycle of assessment is applied to find innovative and resilient ways to get the necessary data and ensure it is the right data. Additionally, the cycle of assessment also affords concurrent implementation of a smaller scale version of the idea/problem at hand.

Team AI then reviewed the challenges and risks associated with implementing this cycle of assessment, key among these is the civil-military divide when it comes to cooperating and working together. The civilian workforce is focused on efficiency; the military is very focused on resilient systems that can withstand attacks. The current COVID-19 environment has forced the civilian sector to look towards resilient systems as well, and maybe there is an opportunity here to align interests. Another roadblock is that industry is hesitant to share data. This data sharing is critical to execute this cycle of assessment, but is hindered because of proprietary information or licenses agreements. Finally, there is risk when the cycle is out of synch because it may result in bad outcomes.

2. Distributed Autonomous Logistics

The second idea presented by Team AI was distributed autonomous logistics (*see Figure 9*) built on existing commercial infrastructure with the intent to repurpose existing commercial systems during wartime.

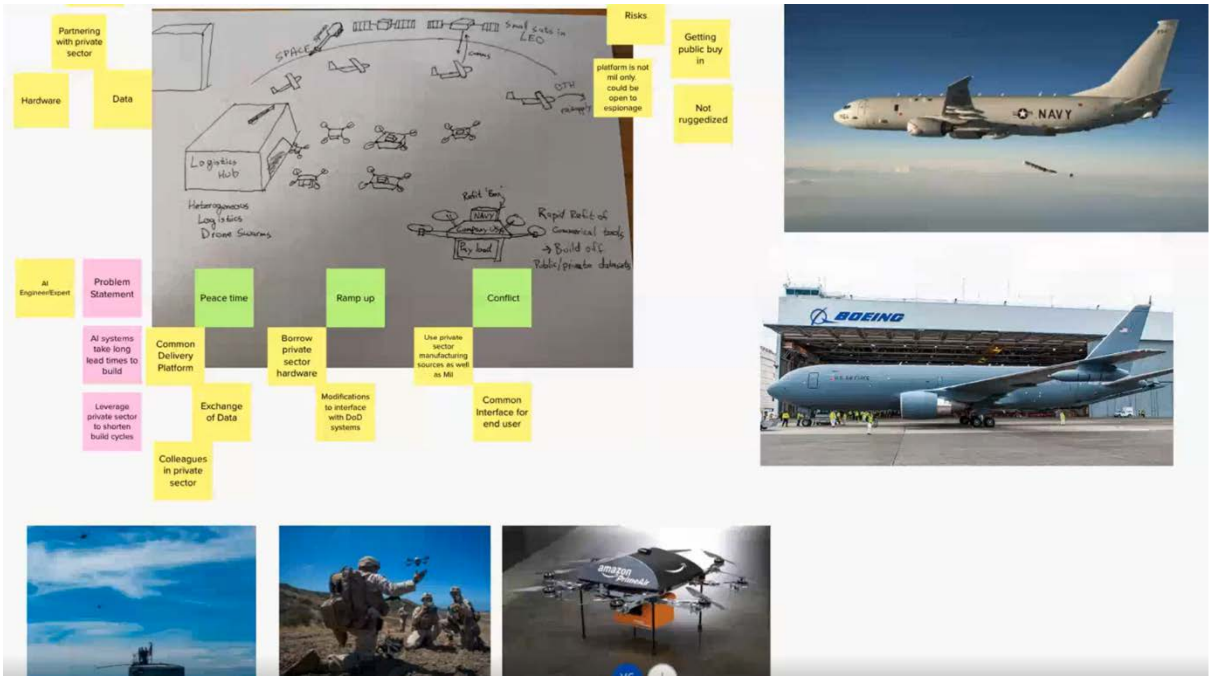

Figure 9. Distributed autonomous logistics concept.

A future DoD AI engineer needs to develop distributed autonomous logistics systems, but these systems need to perform at high volume and low cost per unit. However, AI systems require long lead times to develop the data sets, and the AI software and hardware used in these systems. It cannot be completed overnight or developed and deployed quickly right in the middle of a conflict. This is a shared problem between the DoD and the commercial sector. The DoD could partner with the private sector to share data, data collection assets and hardware in order to lower the cost and shorten production times. In peak conflict a DoD AI engineer could exchange sensor and performance data with their commercial sector partners. They can work with colleagues in academia in autonomous systems to solve problems and remain at the cutting edge of this research, and in so doing they will build relationships and trust between the DoD and their commercial sector partners. In the lead up to conflict, our future AI engineer could rapidly transition the commercial hardware to DoD command and control systems and communication systems through prebuilt modifications developed during peacetime to interface with the commercial sector applications and hardware. During conflict this partnership provides a ready commercial sector to build these systems at low cost and high volume. The loss of a few of these systems would not be detrimental to the overall mission accomplishment.

Some risk associated with this is these systems are not as recognized as organically built DoD systems and therefore are more susceptible to possible loss due to weather, environment or combat. Efforts must me made to convince the public that these AI systems are trustworthy, and that the DoD is not seeking to weaponize the commercial sector platforms. Successful examples of this DoD-commercial partnership include the U.S. Navy's P-8 Poseidon maritime patrol aircraft, and the U.S. Air Force's KC 46 tanker (*see Figure 6*). These are built on reliable commercial platforms such as the Boeing 737 and the Boeing 767 airframes which have been repurposed for used by the Air Force and the Navy.

3. AI for Port Operations

Team AI's third concept was a plan to integrate AI into forward port operations (*see Figure 10*). What would forward basing ports look like with integrated AI?

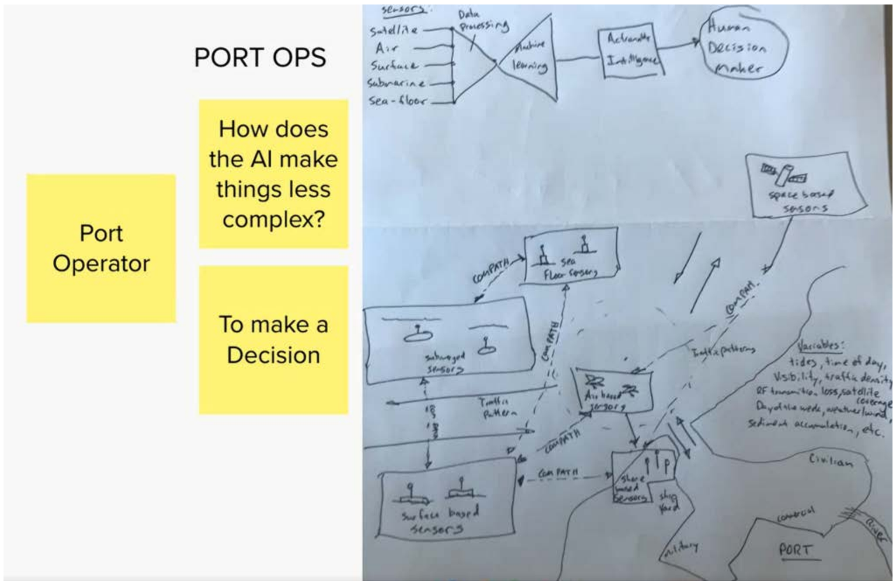

Figure 10. AI for port operations concept.

Team AI first identified a number of variables that are present in a forward basing port such as tides, time of day, visibility, and traffic density and determined that there are many different variables for the AI to monitor in forward basing ports. After reviewing these variables the team looked to answer the questions *What does a "sensorized" port look like? How many different sensors do we have and where are they?* From this exploration the team decided that the sensors needed to be as resilient and as robust as redundant as possible. For instance, sensors should be placed on boats, on buildings, under the water, on the water to return data on the tides, time of day, and all of the other key variables. If one sensor has to go down for maintenance, or if it suffers cyberattack or anything to that effect, then the system as a whole still has an appropriate amount of data to keep working off of. Finally, once we have all of this data moving through our system, we wanted to utilize our AI to actually push that information ahead to a human decision maker.

This "sensorized" environment could be employed for a standard port environment or could be deployed in a forward operating base in any operational area throughout the world in peacetime or war. Once we have this "sensorized" environment or battlespace with all of these sensors in place it is extremely resilient because there are sensors on the sea floor, satellites in space, and unmanned undersea vehicles all communicating. All assets in the system have passive communication channels which make the system very hard to defeat because an adversary would need to take out everything at once which is extremely difficult. Once we have all of these sensors and the lines of communications, what we need to do is take through data processing, both locally at the sensor level. For instance, an unmanned surface vehicle (USV) or maybe a unmanned aerial vehicle (UAV) would process the data *in situ* on the vehicle and then send the processed data through the communication circuits to the infrastructure for further regressive analysis or classification using machine learning. From the processed and analyzed data the system would use stored knowledge of the battlespace to query the data for actionable intelligence. The resulting recommendation or actionable intelligence would then be passed back through this resilient communications network to human decision maker to take appropriate action or pass it further to the right decision point for either defense of the port or successful operations in the in the battlespace.

This AI for port operations also has utility in peacetime scenarios. The data collected by the deployed sensor network could be used by AI systems to optimize safety, command and control, and logistics around the port. From the perspective of a port operator the AI system could be used to define tasking priorities, which would lessen demands on operators. An example of a use case will be monitoring weather and tidal data to predict salmon migration. This would allow us to predict when extra fishing vessels may come into port – a busier day. To ensure the success of AI systems in port operations going forward, it is critical that military and civilians collaborate effectively to define which variables and factors are of key importance in specific AI systems.

4. AI-Enabled C2 for Port Security

The final concept presented by Team AI, AI-Enabled Command and Control (C2) to enhance port security, was created and presented by the three TDSI participants from Singapore. The impetus for this concept was the realization that with more advanced weapons such as a hypersonic missile, our response reaction time is greatly reduced. Therefore, the team identified the need to shorten the OODA loop[11] to ensure mission success. Secondly, the team identified a need to reduce the cognitive workload for the operators in the future where the operating environment is expected to be much more volatile, uncertain, complex and ambiguous (VUCA). The concept provides a solution for the operational commander for decision making, the warfighter – both pilots and naval ship commanders, logistics planners, and base and port operators. In this concept AI aims to be a force multiplier, and the cognitive burden will shift from human-in-the-loop to human-on-the-loop.

The team proposed to leverage AI to enhance existing command and control systems for port security (*see Figure 11*). The key idea is during peacetime there is a human-in-the-loop design enhancement that is easily shifted to enable human-on-the-loop execution during a period of tension and conflict. The team used OODA loop to frame the concepts from peace to conflict period. During peacetime the system would engage in aggressive data collection to build the database and to observe and appreciate the pattern of life. Then the system would be given tools such as design scenarios and countermeasures

[11] The OODA loop is the cycle observe–orient–decide–act developed by U.S. Air Force Colonel John Boyd after his experiences dogfighting in the Korean War. Today, the OODA loop is one of the most popular decision-making frameworks in the world, both in professional Western militaries and beyond. Businesses such as Dell and Scotts Miracle-Gro have implemented OODA-like processes, and Boyd's OODA loop has been considered in professional sports as a means to improve athlete game speed. *(drawn partly from https://thestrategybridge.org/the-bridge/2020/3/17/the-ooda-loop-and-the-half-beat)*

to develop and enhance the machine learning models. The results of the models will be tested in more challenging settings, and eventually during live exercises and operations. This model could be further used to determine the level of human intervention, and provide possible scenarios. This model is iterative to provide for continuous improvement of the system for a more robust response.

In a period of tension or conflict, the system will detect anomalies and alert the operator, auto-cue other systems within the same network, or engage other sensors for enhanced surveillance of the target of interest. This allows the AI system to automate basic decision making for a dynamic response. An AI-enabled C2 system will allow commanders and operators to prosecute time-sensitive, planned, and unanticipated targets with dynamic planning, tasking, and controlling of sensors and weapons platforms to shorten the response time. Employment of this system also reduces the uncertainty of commanders and operators will face to decide on the best course of action.

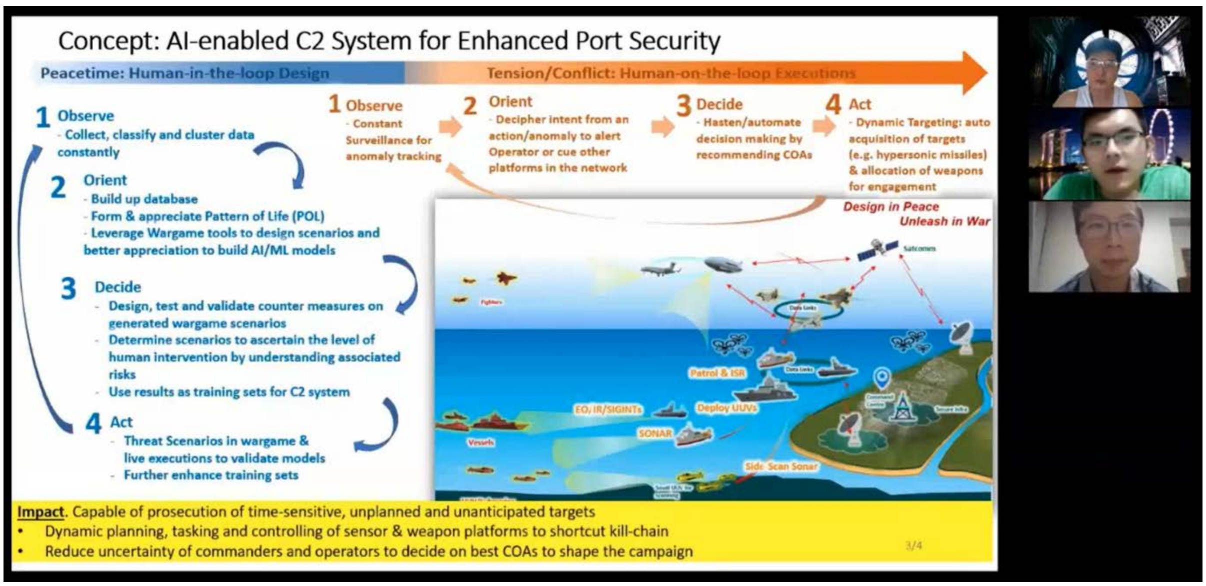

Figure 11. AI-enabled C2 system for enhanced port security concept overview.

The team next presented the challenges and risk associated with this concept. Over time, stakeholders might increase their dependency on technologies. With this increase reliance on technologies comes a dependence on power supply, and high susceptibility to technology disruptions such as suspension of power. In addition, due to fast development in computer technology these systems may be obsolete in a short period of time. Data is also a challenge because a functional system requires integration of data in a shared network. To fuse different types of data across various sensors and platforms, and to then distribute data across the full network requires sharing multiple data sources and formats. It requires a large data processing capability which draws power, and is time consuming requiring a lot of effort in the background. Cost is another challenge that needs to be balanced with the operational and systems requirements such as full autonomy or semi-autonomy, and high fidelity or low fidelity processing. Cost will vary from different combinations of requirements across different platforms.

Risks for the operator and stakeholders include loss of operational instinct. Over time operators may lose operational competency and tactic knowledge due to heavy reliance on AI. Exposure to electronic and cyber-attacks will also be increased, and so risk of cyber-attacks and spoofing by adversaries as the AI system will link all platforms through a single network. Finally, there will be ongoing debates on the legally and ethics of using AI weapon systems. Where does the legal responsibility lie in the event of a "wrong" decision made by an AI system? This is a major hurdle which we need to address before harnessing the potential of AI.

There is great liberating potential when incorporating AI in C2 systems. However, the challenges and risks must be addressed to reach the full potential of the AI technologies. Ultimately, this last idea connects back to the Cycle of Assessment concept from the very beginning because the outcomes of AI-enabled C2 serve to further develop the concepts themselves and also develop additional concepts for development. These concepts might ultimately serve as a bridge between the civil and military sectors.

B. Team Base

Figure 12. Partial membership of Team Base (*pictured from left to right*) ROW 1: Nicholas (Wei Xiang) Ng, Aaron Marchant, Kristen Wheeler ROW 2: Eric Hahn, Steve O'Grady, Misha Blocksome (not pictured Miroslav Bernkopf, Adrian Chua, Sam Hansford, Marianna Jones, Trevor Klemin, Emily Nystrom)

The members of this team (*see Figure 12 and Table 2*) included five junior officers from the U.S. Navy, U.S. Marine Corps, and U.S. Army; three early career engineers from warfare centers, academia, and Singapore; and two NPS faculty members. The team was facilitated by an NPS faculty member and two guests, and included three NPS students.

Table 2. Members of Team Base (*alphabetical by last name*)

NAME	PERSPECTIVE	AFFILIATION
Capt Miroslav Bernkopf USMC	*Aviation supply officer*	NPS Computer & Information Science
Dr. Misha Blocksome	*Unconventional warfare*	NWS Assistant Professor
Adrian Chua	*Mechanical engineer*	Republic of Singapore Air Force
Eric Hahn	*Energy systems analyst*	NPS Energy Academic Group
Dr. Sam Hansford	*Mechanical engineer*	JHU Applied Physics Lab
Marianna Jones	*Facilitator*	NPS Systems Engineering
CPT Trevor Klemin USA	*Logistics officer*	NPS GSOIS
LT Aaron Marchant USN	*Submarine officer*	USS OLYMPIA SSN-717
Nicholas (Wei Xiang) Ng	*Land systems engineer*	ST Engineering
Dr. Emily Nystrom	*Data scientist*	NIWC Atlantic
Steve O'Grady	*Facilitator*	NUWC Newport

LCDR Kristen Wheeler USN (ret)	*Facilitator*	Student

Team Base's design challenge was:

> *How might unmanned systems and emerging technologies be leveraged to enable developing and operating forward bases under a missile and mine threat umbrella? How can they reduce risk to operations, or reduce the number of people exposed to risk?*

From that initial challenge Team Base identified supply chain resilience, location of bases, and protection of bases as key areas of the problem space. The exploration query the team explored around supply chain resilience was *How might we create a strategy using technology (i.e. big data modeling, digital twins, unmanned surveillance) in order to support base supply chain resiliency?* For base location the team explored the question *How might we leverage technology (AL/big data) in order to optimally locate forward bases so that national and global security vulnerabilities are mitigated?* The base protection question they explored was *How might we orchestrate the use of technology, nature, and allied capabilities in order to protect our bases so that the U.S. and allies deter aggression?* After further ideation the team decided to focus on protection of bases in their concept generation work.

Team Base presented two concepts:

1) grumpyBEAR
2) Project Shell Game

1. grumpyBEAR

Surveillance of bases and units is expensive and inflexible. In response, Team Base proposed a low-cost flexible base surveillance and interdiction system they called grumpyBEAR. The system is comprised of unmanned sensors and effectors with AI-enabled decision support and human-on-the-loop C2 to optimize positioning of limited surveillance assets and respond to potential threats. Rather than employing a separate set of sensors, grumpyBEAR would leverage sensors on existing unmanned systems and existing deployed sensors, and would decide where to place fixed stationary sensors and other limited surveillance assets using AI-enabled decision tools – AI trained using big data and field intelligence. Then if there is an initial cue from the existing surveillance assets we could send out an asset such as a UAV to respond to a potential threat.

The team then demonstrated how grumpyBEAR might operate using two different CONOPS. The first scenario starts with the surveillance and detection system (*see Figure 13, top*). Once an anomaly or potential threat is detected the sensor signals a central hub, which then sends drones to reacquire and reassess the potential threat or target. These drones could sit and loiter in positions and wait and for some kind of motion before they activate, or they could activate immediately to begin a methodic search. Once the target is reacquired and reassessed, the AI-informed system would classify the targets and make the decision to engage via third party shooter.

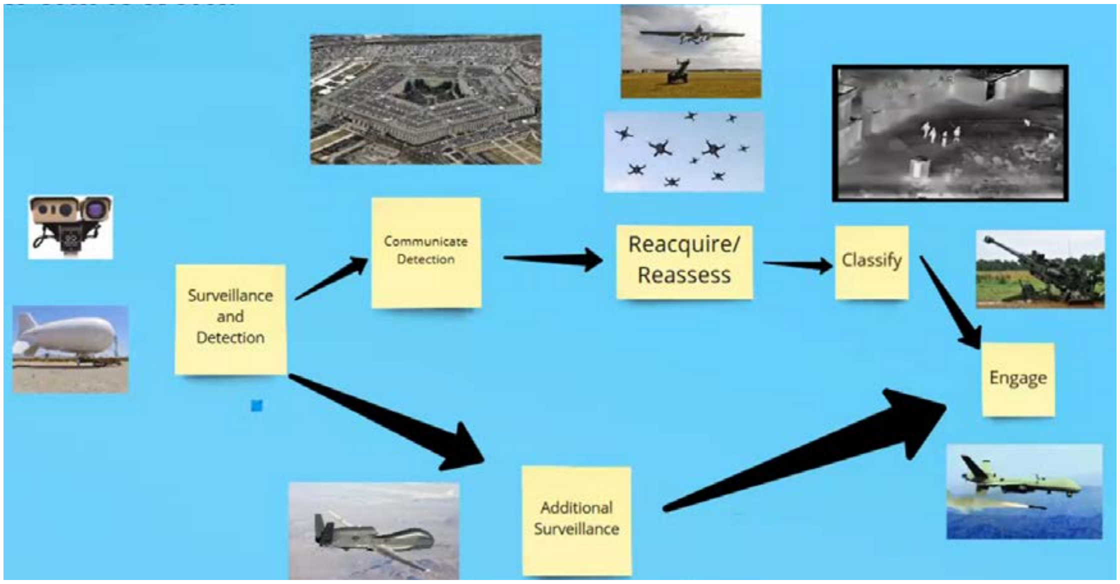

Figure 13. Two grumpyBEAR concept overview scenarios (*top left to right, bottom left to right*).

The second scenario (*see Figure 13, bottom*) leverages existing surveillance infrastructure for surveillance and detection the grumpyBEAR system would add intelligence gathering using an additional asset. Additional surveillance from a larger base could be larger UAV's that are equipped for surveillance to provide a more dense surveillance infrastructure. If these additional surveillance assets detect incoming targets, for instance a missile or ground troops, decisions could be made to engage using a third-party shooter.

Figure 14. Beneficiaries of grumpyBEAR concept would be forward stationed military (*left*) and civilian law enforcement (*right*).

Primary beneficiaries of the grumpyBEAR system would be the military in bases stationed throughout the world (*see Figure 14, left*). This system could also be leveraged by law enforcement (*see Figure 14, right*) in a riot situation or Super Bowl celebration should they need additional assets for surveillance to ensure the activity does not "get too rowdy and they end up burning things down."

Areas to be developed for this concept include communication channels, robust AI classification methods, identification of ideal locations for future operations centers, and creating purchasable packages for each echelon of stakeholder groups. Communication methods and channels between drones is central to the functionality of grumpyBEAR. Is a direct line of sight method such as optical coms optimal, or is interval communications where you burst information at predetermined times? Both methods avoid continuously broadcasting information. A big data set is required to train an AI system to classify various threats. The method to choose an ideal location for the central hub or operations center is also an area to explore. Would it be best to establish a temporary hub locally where it might be a geographically "central brain" on or nearby a base? Or would a larger more permanent hub at an installation further away be the best choice? Finally, each echelon of user would require a fully developed purchasable package of assets and sensors to set up their system to meet their unique needs. A small forward operating base would not require the same package as a larger operating base where they have runways and other infrastructure capable of handling larger surveillance assets.

Potential future applications include domestic repurpose, and during times of conflict grumpyBEAR could easily leverage existing commercial assets. Incorporating existing surveillance from coalition and allied forces would expand the reach and capabilities of the system. Eventually, expansion to mobile units would enable a small mobile squadron on a patrol to have these small assets that help push out a security perimeter.

2. Project Shell Game

Team Base's second concept was called Project Shell Game. Traditional terrestrial or land bases are not mobile so are easy to surveil. Sea basing allows for more mobile bases, and this mobility makes them harder to surveil.

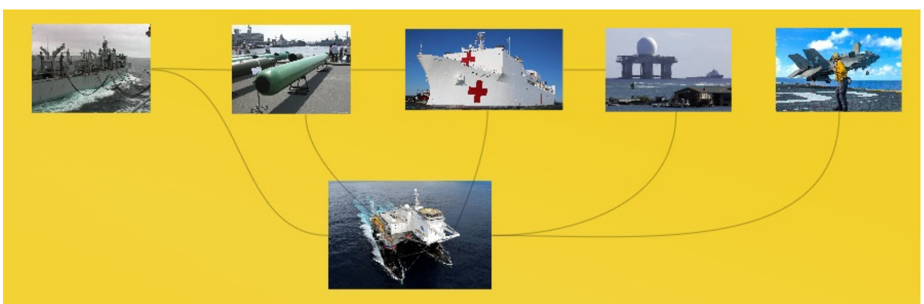

Figure 15. Project Shell Game concept for a mobile sea base (*bottom*) that incorporates several key forward base capabilities (*top*) such as repair, resupply, refueling, medical, ISR, and heliport.

In the given scenario "War Plan Blue 2035" protecting maritime bases will be more crucial and more difficult than ever, especially those bases that are fixed on an island or an atoll. Those kinds of bases are not mobile so are easy to surveil and therefore easy to attack. What if we could set up a kind of shell game to keep our adversaries guessing not only where our bases were, but what we are using them for? Dynamic sea bases used in Project Shell Game are mobile base platforms at sea that are defended by emerging and autonomous technology. A sea base is obviously not as robust as a complete land or island port base, but something larger and with more capability than an aircraft carrier. The sea bases envisioned in Project Shell Game would be able to replenish fuel and weapons, repair assets, provide medical care, and possibly provide counter-ISR and a small landing area such as a heliport or helipad for small aircraft (*see Figure 15*). A sea base would be accessible for naval vessels of all kinds including aircraft, and both surface ships and submarines – maybe even with covert sub-sea access points (*see Figure 16, right*).

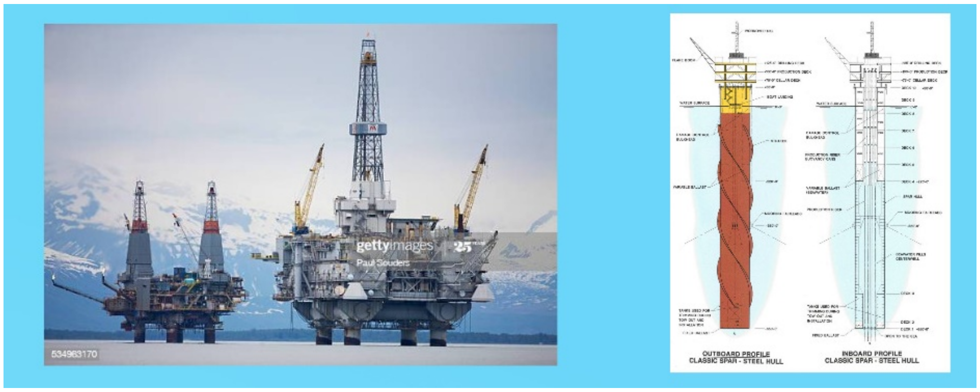

Figure 16. Project Shell Game sea base configuration (*left*) and access options (*right*).

Not only could sea bases provide unique capabilities for naval forces, but also for other DoD "three letter agencies" or even executive departments like the Department of State. Anything that you could use a base for on land or a forward operating base (FOB) on land is something you could use a sea base for as a sea base is essentially a movable FOB at sea. The ability to reposition the base, even if it is to reposition slowly, would be hugely beneficial as it would likely confuse or at least slow down adversaries in targeting the base. Multiple sea bases positioned together in a "String of Pearls" configuration (*see Figure 16, left*) could provide interior lines of communication at sea to support forces forward into theater. "As a submariner myself, the whole idea of quickly expending ordnance and then getting somewhere close by to resupply would be an amazing capability." There is also a cost benefit as many of the standard costs to set up a forward base in a foreign country would be moot – no exorbitant fees or humans, which also enables forces to be more covert. The team noted that some key engineering issues will need to be addressed as Project Shell Game is developed.

Defense of mobile sea bases would be through integrated unmanned systems. An integrated swarm of UAVs (*see Figure 17*) could scramble radar, project 3D images to confuse adversary sensors, and provide defensive fires. The team also gave several examples of potential frame styles (*see Figure 18*) including a spar platform[12], catamaran, or a "flip ship."

Figure 17. Defense of mobile sea bases options if using UxVs.

[12] A **spar platform** consists of a large-diameter single vertical cylinder supporting a deck, a typical fixed platform topside, and a hull moored using a taut catenary system of 6 to 20 lines anchored into the sea floor. (excerpted from "Our World of Energy" https://www.ourworldofenergy.com/vignettes.php?type=oil-and-gas&id=7)

Figure 18. Mobile sea base frame options include spar platform (*left*), catamaran (*center*), or "flip ship" (*two at right*).

Challenges for the Project Shell Game concept include cost and maintenance. DoD budgets are already contentious for the building of warships. Diverting resources to build afloat bases will meet resistance. However, the repurposing of existing platforms may mitigate this challenge. Ironically, while these platforms will assist the logistic readiness of our fleet, the ability to maintain the afloat bases will be costlier in both materials and personnel. The use of heterogeneous sea base platforms will also add to the complexity where each will have its own set of unique maintenance requirements. Some of these challenges could also be mitigated by contracting commercial companies that already use similar existing platforms so are experienced in the operation and maintenance. Cost savings, mobility, versatility, and ease of defense of mobile sea bases make exploration of this concept an investment for future operations in contested maritime theaters.

C. Team Industry

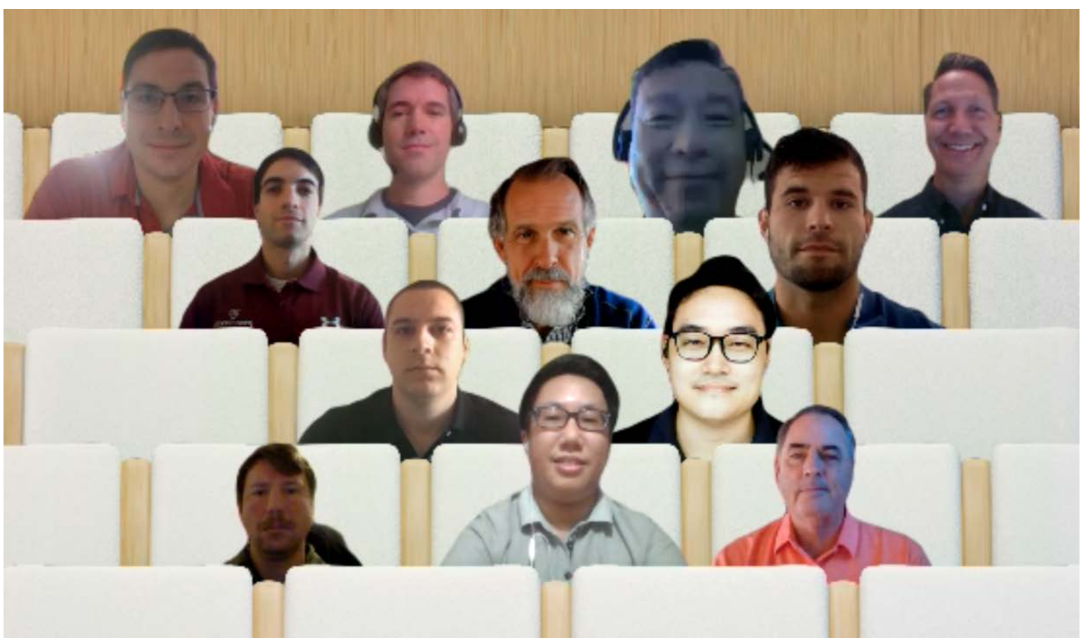

Figure 19. Members of Team Industry (*pictured from left to right*) ROW 1: Alex Kavall, Alvin Chan, Steve Koepenick ROW 2: Colin Hust, Marcus Jai Tai ROW 3: Cameron Brand, Don Thieme, Erik Molina ROW 4: Alejandro Maldonado, Matt Miller, Sinker Wu, Garth Jensen

The members of this team (*see Figure 19 and Table 3*) included three junior officers from the U.S. Navy and U.S. Marine Corps and the Singapore Armed forces; and six early career engineers from academia, warfare centers, industry, and Singapore. The team was facilitated by three senior level guests from warfare centers and industry, and included three NPS students.

Table 3. Members of Team Industry (*alphabetical by last name*)

NAME	**PERSPECTIVE**	**AFFILIATION**
Cameron Brand	*Structural engineer*	JHU Applied Physics Lab
Alvin Chan	*Systems engineer*	TDSI
LT Colin Hust USN	*Surface warfare officer*	NPS Systems Engineering Analysis
Garth Jensen	*Facilitator*	NSWC Carderock
LT Alexander Kavall USN	*Surface warfare officer*	NPS Systems Engineering Analysis
Steve Koepenick	*Facilitator*	NIWC Pacific
Capt Alejandro Maldonado USMC	*Infantry officer*	NPS Space Systems
Matthew Miller	*Mechanical engineer*	Lockheed Martin
Erik Molina	*Mechanical engineer*	NSWC Panama City
Marcus Tai	*Mechanical engineer*	ST Engineering
Choon Seng Tan	*Infantry officer*	Singapore Armed Forces
Dr. Don Thieme	*Facilitator*	NWC Wargaming (contractor)
Sinker Wu	*Operations research analyst*	Raytheon

Team Industry's design challenge was:

> *How might we reimagine and redesign our policies, practices, and technologies across government, industry, and the Nation such that if or when the time comes to emplace War Plan Blue for a new era (2025- 2049), the US and allies will be ready to answer the call with the requisite: Complexity at Scale, Agility to Pivot, and Resilience?*

Team Industry explored infrastructure, data, and workforce solutions, and proposed three concepts:

1) Resilient Infrastructure
2) Digital Thread
3) (Camo) Green New Deal

They first refined their broad tasking statement into smaller portions, the first of which as *How might the United States increase its economic complexity between now and the year 2026?* Economic complexity is measured through analysis of economic geography and dynamics of economic activities using methods inspired by complex systems, networks and computer science. What makes the field of economic complexity unique is the study of the geography of activities using an outcomes-based approach. Instead of trying to figure out what capabilities or factors drive an economy, economic complexity uses data on the geography of economic activities to infer the presence of bundles of capabilities. In essence, economic complexity measures the amount of productive knowledge that each country holds. A country's economic complexity is a better predictor of economic growth than other standard economic indicators. To measure economic complexity, the economic complexity index (ECI) is used. The ECI is a measure of the capacity of an economy, which can be inferred from data collected from locations and the activities present. The ECI has been shown to predict important macroeconomic outcomes, including a country's level of income, economic growth, income inequality, and greenhouse gas emissions. The factors that determine the country's ECI values are diverse. It is estimated by using data sources such as trade, employment, stock market, and patent data.

For the U.S. to increase its economic complexity by the year 2026, the team proposed the pursuit of adjacent and transformational innovation through increased investment in sectors with high economic complexity. Tangibly, this means developing new products in addition to incrementally improving existing products. The U.S. could leverage and improve upon current skills within current industries, while increasing investments in sectors such as the automobile and pharmaceutical industries that have been identified to be of high economic complexity. Secondly, the U.S. should develop, deploy and integrate Fourth Industrial Revolution (4IR)[13] technologies at scale to support its industries. This will in turn improve the overall labor and capital productivity in the U.S. and help to boost overall economic complexity. The U.S. might also look towards amassing greater intellectual capital through education, training, and upskilling of its workforce. This will allow the country to work towards pursuing opportunities in sectors with high economic complexity which involve technology innovation and development – the U.S. is already quite strong here and will most certainly achieve greater economic complexity by 2026. A final recommendation is to increase trade liberalization to enable technology transfer through the import of advanced capital goods. Such imports of capital goods also boost the overall export earnings growth and increases foreign capital inflows into the U.S., resulting in gross domestic product (GDP) growth, , research and development investment capital availability, and technological progress. Trade liberalization will also pave the way for the emergence of new capabilities, knowledge and skills, which in turn will improve the overall economic complexity – creating a cycle to ensure increased economic complexity by 2026.

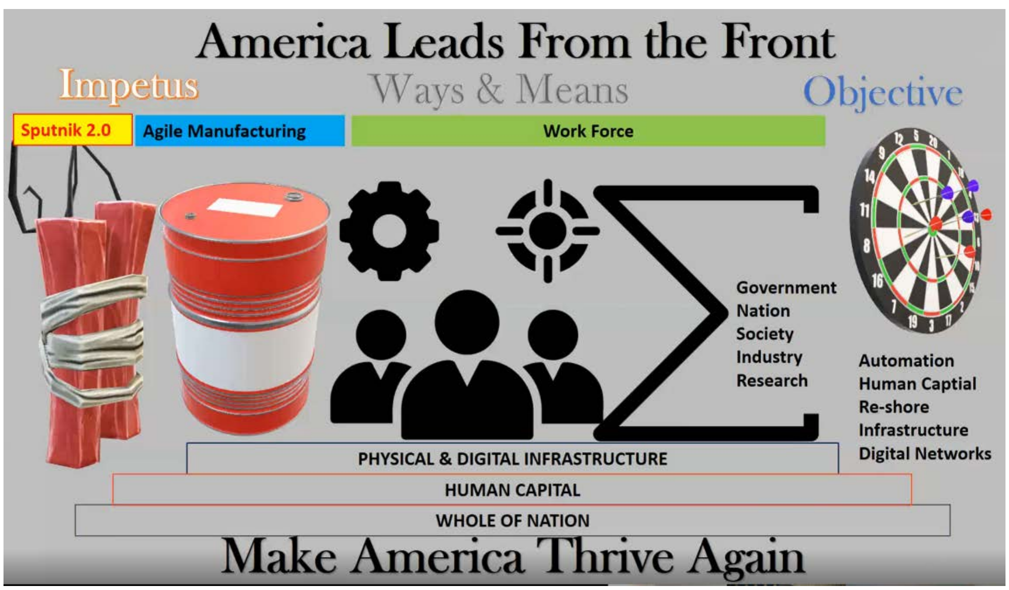

Figure 20. Team Industry analysis of status quo and way forward, impetus to objective (*left to right*).

In addition to economic complexity and the drive for sustained innovation, the U.S. is dealing with increasingly intense and frequent forest fires that destroy regional infrastructure and impact our

[13] **The Fourth Industrial Revolution (4IR)** is characterized by the fusion of the digital, biological, and physical worlds, as well as the growing utilization of new technologies such as artificial intelligence, cloud computing, robotics, 3D printing, the Internet of Things, and advanced wireless technologies, among others. (*adapted from Brookings Institute Foresight Africa 2020 report, 8 JAN 2020* https://www.brookings.edu/research/the-fourth-industrial-revolution-and-digitization-will-transform-africa-into-a-global-powerhouse/)

climate, the COVID-19 pandemic[14] that is testing our resilience as a nation, and the resulting need to quickly adapt to virtual schooling and revisit the education system moving forward. Team Industry labeled this "our Sputnik moment[15] – Sputnik 2.0" – that will change how the U.S. moves forward from here. The team contended that the way to advance is to pursue agile manufacturing, and one of the keys to get there is a workforce that is educated, skilled and experienced in the essential areas – the workforce is the foundation and we build from the bottom up (*see Figure 20*). A whole-of-nation approach starts with the human capital required, and the physical and digital infrastructure is built on top of that. Integration of society, industry, research, nation, and government is also key to achieve the objectives of automation, increased human capital, re-shoring of critical industries, building the infrastructure required, and creating the digital networks that link all of that together.

Responding to our Sputnik 2.0 moment requires a whole-of-society response – and a whole-of-society response requires the participation and motivation of that society. What might motivate society to participate? The Green New Deal is a perfect target of opportunity. This sweeping policy proposition already has political support by those that would typically oppose rearming, and it already includes large funding for modernizing industry, rejuvenating energy, rebuilding infrastructure, and reeducating and reskilling people. The challenge is how do you sell that long-term investment to politicians? How do you bring conservatives on the right on board without losing the liberals on the left in the process? The key is to educate all decision-makers and show them the ways that it could be beneficial for them and their constituents. For instance, agile manufacturing as a result of this reinvestment is dual use, good for the civilian economy, and good for military. An investment in agile manufacturing creates jobs for constituents in the districts of politicians on all sides of the aisle in infrastructure rebuilding projects. A key component of the program is retraining for members of the current workforce to be better positioned to participate in the workforce of the future. Industry is another essential element of this whole-of-society response, and much of this work will involve contracting with industry which should result in increased revenue. Retraining and reskilling programs will give industry the trained workforce they have been clamoring for through vehicles such as apprenticeship programs and partnering.

The primary challenge this opportunity presents is the work of reaching political consensus, or at least compromise. This shift to a whole-of-society approach will require political work in advance. Politicians will need to discuss this thoroughly in advance so that they can find their place in either through active support, or at least acquiescing and allowing passage. The program benefits make the investment worthwhile. The benefits to the country, whether or not there is an escalation from great power competition to great power war, is the resulting industrial resilience, agility and capacity through increased industrial automation. It is also important to note that this level of industrial resilience, agility and capacity will be required should the nation find itself involved in any future war. This program would also energize the economy to support that industry and other social programs in peacetime, or

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[14] The **COVID-19 pandemic** was caused by a 2019 outbreak of coronavirus disease (COVID-19). COVID-19 is an infectious disease caused by a coronavirus discovered in 2019. (adapted from the World Health Organization website https://www.who.int/health-topics/coronavirus#tab=tab_1)

[15] A **Sputnik moment** is a trigger mechanism. The original Sputnik moment came a couple of weeks after Sputnik 1, the first Earth-orbiting satellite, was launched into orbit by the Soviet Union on Oct. 4, 1957. At the time, Sputnik was the first human-built object launched into orbit and it triggered significant effort in the U.S. space program.

any future war effort, through human capital reinvestment – which will also help avert some of the social risks of the automation transformation. These infrastructure investments in both human and physical development will increase GDP and reduce climate impacts simultaneously. Support of this program displays international leadership on climate-related challenges and presents an opportunity for collaboration with the rest of the world without causing alarm which may result from a well-publicized rearming campaign. Finally, this dual-purpose hybrid or *new* Green New Deal program is a worthy counter to Chinas expansive (and expensive) "Belt and Road" buildup initiative.[16]

1. Resilient Infrastructure

The three primary infrastructure needs identified were universal connectivity, resilient utilities, and agile manufacturing. First, communication is key for both civil and military use. Depth of communications infrastructure "allows us to have AI enabled even if AI isn't ready yet." High speed Internet access portals for all would ensure this future scalable environment for AI – and Team Industry recommended exploration of high-speed internet as a standard utility. As COVID-19 shows, access to data is essential - it should be a utility for all U.S. households like power or water. Next, the team contended that it may be time to "sunset" our traditional utility grids and look to rebuild them in a new way. Essential utility grids and infrastructure needs to be ruggedized so that we have a modern electrical, transportation, and communication network that cannot be taken down when just one node is taken out. In a mosaic approach, if one part of the network goes down, the Eastern Seaboard does not go out. We also see this as an enabler for rapid data transfer.

For agile manufacturing, the communications update to our utilities will enable this agile manufacturing approach. Leveraging new processes such as additive manufacturing provides the capacity to quickly produce as needed in a crisis, and to buy us time to incorporate more traditional means of production. For example, quickly building a swarm of drones to counter an adversary while munitions, tanks, airplanes, and ships complete production and are ready to engage in the fight. While additive manufacturing is not the answer for everything, if employed thoughtfully is a very intelligent way to achieve success by distributing production and integrating distribution. Common or standardized equipment will be key in case one factory is negatively impacted, either through attack or malfunction, equipment could be moved right away to another factory to continue production. If the equipment could not be moved, data could be shared to the same piece of equipment somewhere else – again allowing production to continue seamlessly so no production time is lost.

2. Digital Thread

To achieve the envisioned agile manufacturing state advanced data security and integrity will be key, and the Digital Thread concept assures both. The Digital Thread is a start to finish knowledge repository with data-centric security and constant data backup. For instance, a hand drawn sketch from an engineer could go through this repository all the way through to the warfighter at the other end. There is a data package for every product created. This data represents the economic-intellectual capital of the

[16] China's Belt and Road Initiative, reminiscent of the Silk Road, is a massive infrastructure project that would stretch from East Asia to Europe. (source: Council on Foreign Relations "Backgrounder" https://www.cfr.org/backgrounder/chinas-massive-belt-and-road-initiative)

nation though, and if it gets into the wrong hands it could be very damaging, so advanced security is central to this concept. This requires advanced techniques such as data centric security like blockchain distributed ledgers, broad use of encryption and cyber hygiene protocols. Data integrity is key to this, things like constant data backup so if something does happen you can go back in time to five minutes ago and just continue from where you were.

3. (Camo) Green New Deal

The Camouflaged Green New Deal – or (Camo) New Green Deal – is a whole-of-society approach to leverage elements of social investment programs and repurpose them in the event of war. Human capital is key to this concept, and the "Workforce: 17 to 75" (*see Figure 21*) is a way to look at the human capital as a long-term resource to be developed to its full potential over the lifetime of each worker. Outcomes include an expansion of the workforce, the job market, and enhanced job security. The (Camo) Green New Deal will strengthen the economy and help the U.S. become a more self-sufficient nation while increasing GDP and therefore tax revenues. When a conflict arises, whether it is a future pandemic or a conflict with another country or global war, the U.S. will be well prepared to react proactively. The intent of the (Camo) Green New Deal is to promote the greater good of the U.S., and does not serve as a primary means to solely prepare for war.

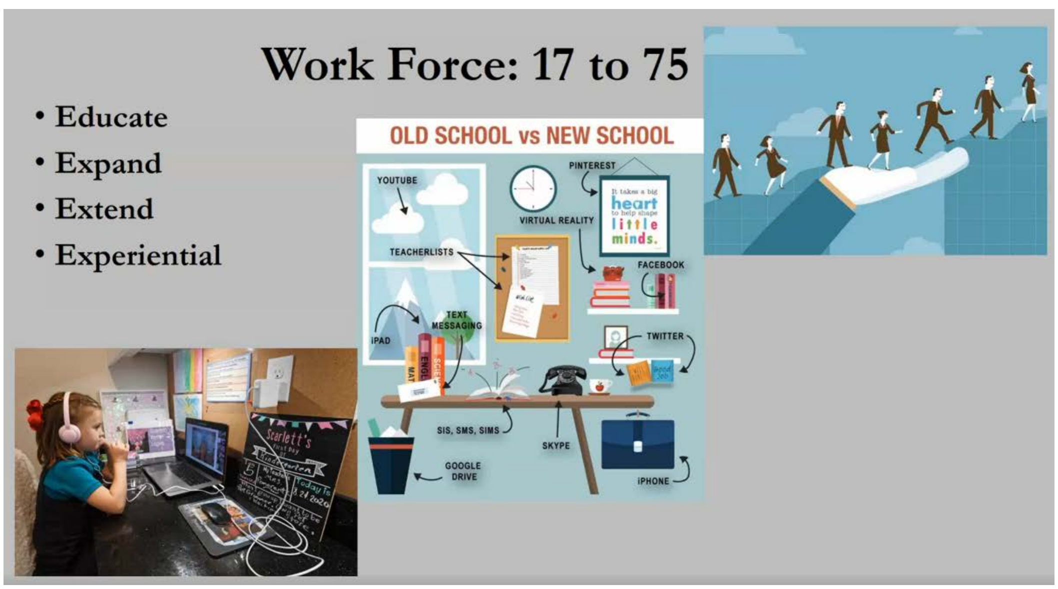

Figure 21. Human capital is key to the (Camo) Green New Deal concept and should be considered an investment over the lifetime of a worker.

The (Camo) Green New Deal is a policy approach with four primary phases. Educating the current and future workforce is the start, with continued enhanced STEM research[17] and more emphasis on cyber

[17] In an ever-changing, increasingly complex world, it's more important than ever that our nation's youth are prepared to bring knowledge and skills to solve problems, make sense of information, and know how to gather and evaluate evidence to make decisions. These are the kinds of skills that students develop in science, technology, engineering, and math—disciplines collectively known as STEM. (excerpted from the U.S. Department of Education https://www.ed.gov/stem)

programs. Similar to Midwestern land grant universities, all schools should offer agricultural programs and incentivize skilled manual labor by bolstering trade schools. The expansion included in the program will spur job growth linked to the (Camo) Green New Deal and more onshoring of economic activities currently outsourced overseas. Repurposing the U.S. labor force ties in with economic policies, and also allows for autonomy without lost paychecks. Getting away from U.S. import dependence and exporting more U.S. products will likely require expansion of the workforce increasing capacity and capabilities. DoD acquisition processes would need review and likely updates to allow for more joint contracts with smaller, medium and large companies working together, focused on faster and more diverse production capability while reducing the nefarious effects of the so-called "valley of death" between prototypes and full-scale production. Increased experiential learning would create less stagnant learning environments in public school systems and universities – virtual learning experiences that tie practical experience in industry, new technology and operational environments together to find, promote, and inspire new talent.

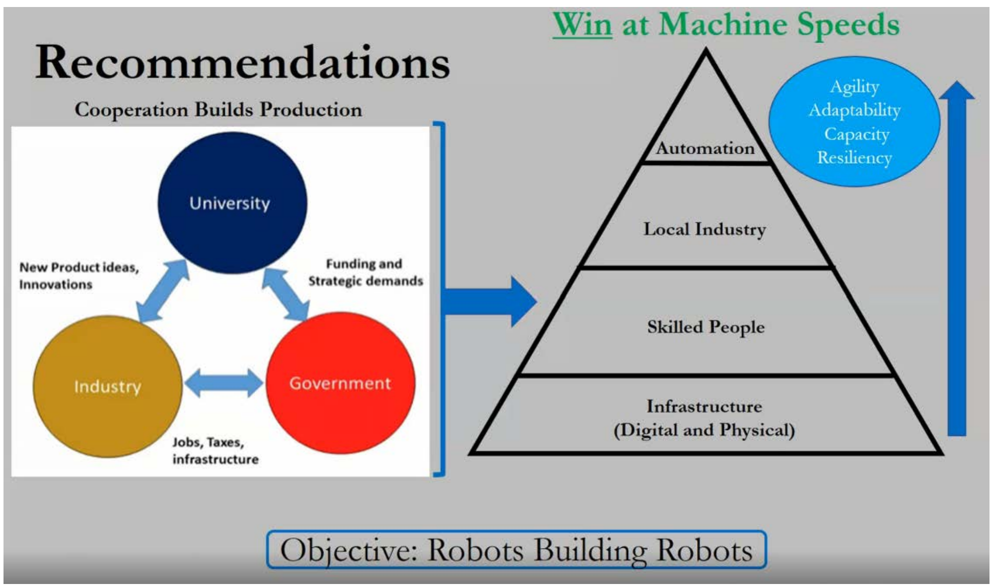

Figure 22. Team Industry overarching recommendation – robots building robots – through cooperative working relationships (*left*) and the pyramid of production (*right*).

The overarching objective is to have robots building robots – to have the physical and digital industry using automation to build the autonomous weapons that we need for the war of the future. Creating a cooperative environment with academia, industry and government where the government is primarily priming the pump and coordinating the other legs will help the U.S. reach that goal. Together this whole-of-society effort will be needed to build the pyramid of production (*see Figure 22*) that will support production of machines at scales and speeds required to achieve decisive advantage. "We don't necessarily need to bring the jobs back that we've lost. We need to bring the production back" – especially in key industries through automation. To avoid alienating allies, trading cooperation needs to remain open with the rest of the world while we create new jobs here to keep our own workforce invested in this project.

D. Team Misdirect

Figure 23. Members of Team Misdirect *(pictured from left to right)* Col Randy Pugh USMC, Christian Thiessen, Matthew Lineberry, Christopher Richards, and Nathan Haynes.

This team (*see Figure 23 and Table 4*) consisted of two Marine Corps officers, one Marine Corps Staff NCO, and one Navy officer – these four NPS students represent four different on-campus curricula. Team Misdirect was facilitated by the NWSI Deputy Director.

Table 4. Members of Team Misdirect (*alphabetical by last name*)

NAME	**PERSPECTIVE**	**AFFILIATION**
Capt Nathan Haynes USMC	*Infantry Officer*	NPS Computer Science
GySgt Matthew Lineberry USMC	*Foreign Area Staff NCO*	NPS National Security Affairs
Col Randy Pugh USMC	*Facilitator*	NPS Senior Marine
LT Christopher Richards USN	*Cryptologic Warfare Officer*	NPS MSEE Program
Capt Christian Thiessen USMC	*Infantry Officer*	NPS Information Warfare Systems Engineering

Team Misdirect's design challenge was:

> *How might we use emerging technologies and unmanned systems to enhance or create Information Warfare effects to achieve operational or tactical objectives in a specific operational scenario?*
>
> *Or….*
>
> *H0x wmight wee us merging econ & UxS 2 > # IW affects to ^^^*

Team Misdirect generated concepts involving robotics and autonomy for military deception, and the details are summarized in a classified annex to this report available by vetted request through appropriate channels. Please email your request to NWSI Associate Ms. Lyla Englehorn at laengleh@nps.edu or englehornla@nps.navy.smil.mil.

E. Team Port

Figure 24. Members of Team Port (*pictured from left to right*) ROW 1: Andrew Benton, Russell Sunda, Wen Xian Ong ROW 2: Gabe Benjamin, Ralph Grossman ROW 3: Carl Oros, John Hawley, Dave Newborn ROW 4: Bryan Ek, Zach White (not pictured Alex Viana)

The members of this team (*see Figure 24 and Table 5*) included five junior officers from the U.S. Navy and U.S. Marine Corps and the Republic of Singapore Air Force, and two early and mid-career engineers from warfare centers and Naval commands. The team was facilitated by an NPS faculty member and two guests, and included four NPS students.

Table 5. Members of Team Port (*alphabetical by last name*)

NAME	PERSPECTIVE	AFFILIATION
Capt Gabriel Benjamin USMC	*Communications*	NPS National Security Affairs
Capt Andrew Benton USMC	*Aviation C2 & Fires integration*	NPS Information Systems & Technology
Dr. Bryan Ek	*Scientist*	NIWC Atlantic
LT Ralph Grossman USN	*EOD officer*	SUBDEVRON5
John Hawley	*Facilitator*	JWH Enterprises LLC
Dave Newborn	*Facilitator*	NSWC Carderock
ME5 Wen Xian Ong	*Airforce engineer*	Republic of Singapore Air Force
Dr. Carl Oros	*Facilitator*	NPS Information Sciences

LT Russell Sunda USN	*Surface warfare officer*	NPS Systems Engineering Analysis
Alex Viana	*Deputy program manager*	NAVFAC Headquarters
Capt Zachary White USMC	*Communications*	NPS ESE & Applied Math

Team Port's design challenge was:

> *How might IAS and other emerging technologies make ports under threat of mine, torpedo, and missile attacks more resilient to provide services and ensure naval vessels can safely break out of the confined port channels?*

From that design challenge Team Port defined their objective as:

> *How might we use intelligent autonomous systems and other emerging technologies to make ports under threat of mine, torpedo, and missile attacks more resilient to provide services and ensure naval vessels can safely break out of the confined port channels?*

Figure 25. A U.S. battleship sinking during the Pearl Harbor attack, 7 December 1941.[18]

On 7 December 1941 the Imperial Japanese Navy Air Service attacked Pearl Harbor (*see Figure 25*), resulting in a total loss of four battleships, 188 aircraft, and 2335 lives. Today and in the future envisioned in War Plan Blue 2035 there is a tactical need to defend ports and defend departing vessels from mine, missile, and torpedo attacks.

Team Port presented seven components that would work together within the overarching Sensor Network System of Systems (SoS) concept:

1) Satellite Sensor
2) Aerostat
3) Buoy Sensor Network

[18] **Image source:** National Archives, Washington D.C.

4) Undersea Buoy Sensor Grid
5) Trip Wires
6) AI C2 Data Handler
7) Decentralized Torpedo Launch Points

To defend the port and the breakout of the port they proposed the Sensor Network SoS, a full overarching concept demonstrated in two scenarios: the defense of Yokosuka Naval Base[19] that has evolved into a joint Japanese Maritime Self Defense Force and US Navy base, and the defense and breakout of an expeditionary port. Adversary missiles, torpedoes, and mines are primary threats in In both of these scenarios.

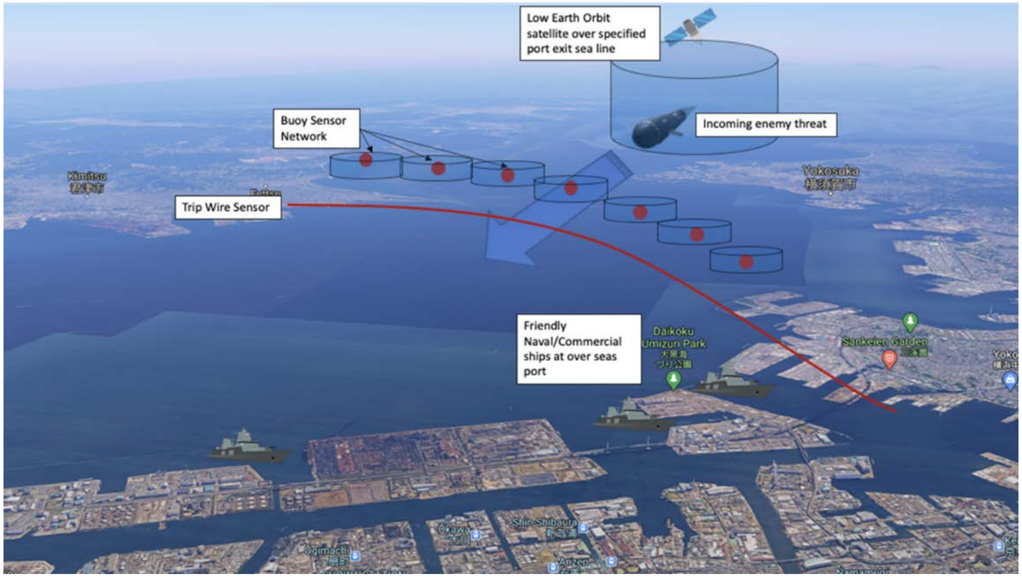

Figure 26. Sensor network system-of-systems CONOP to defend Yokosuka.

While the DoD continues the rapid buildup of forces prior to any future conflict, the port and assets in the port must be kept safe. A CONOP for the defense of the Yokosuka Naval Base demonstrates how the proposed Sensor Network SoS components (*see Figure 26*) might protect a port. This full network of sensors will straddle across multiple domains including land, surface, subsurface, air and space.

1. Satellite Sensor

The first component of the Sensor Network SoS presented by Team Port was the Satellite Sensor, a low Earth orbit (LEO) satellite over specified port exit sea lanes (*see Figure 27*).

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[19] **Yokosuka** comprises 568 acres and is located 43 miles south of Tokyo at the entrance of Tokyo Bay and approximately 18 miles south of Yokohama. Yokosuka is on the Miura peninsula in the Kanto Plain region of the Pacific Coast in Central Honshu, Japan. CFAY is the largest overseas U.S. Naval installation in the world and is considered to be one of the most strategically important bases in the U.S. military. (source: https://www.cnic.navy.mil/regions/cnrj/installations/cfa_yokosuka.html)

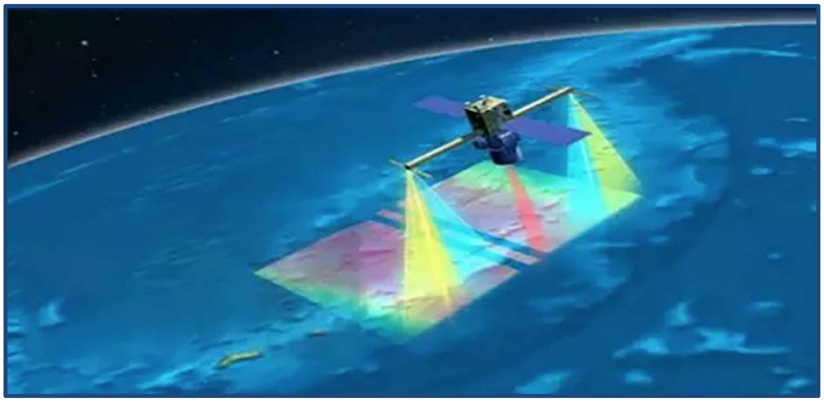

Figure 27. The satellite will use LiDAR technology and a microwave radar to identify targets.[20]

From the space domain the team chose satellite sensors to detect adversaries beyond 12nm. Specifically, LEO satellites, as they are capable of providing persistent 24/7 coverage. These satellites would be equipped with synthetic-aperture radar (SAR) and electro-optical infrared (EO/IR) sensors to detect surface threats, and magnetic or gravitational anomaly detectors (MAD/GAD) and lasers will be used to detect sub-surface threats. This is technically feasible today. China has been developing anti-submarine warfare (ASW) capabilities under Project Guanlan, meaning “watching the big waves”, since 2018. The Guardian satellite, a component of Project Guanlan, deploys lasers to detect submarines as deep as 500m beneath the surface (*see Figure 28*).

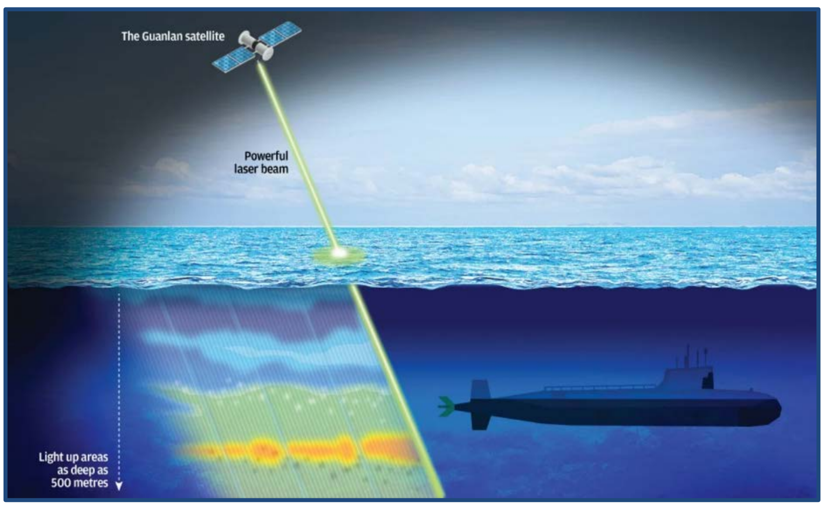

Figure 28. Proposed satellite sensor CONOP as part of Sensor Network SoS would sense undersea threats much like The Guardian satellite in China’s Project Guanlan.[21]

[20] Image source: Pilot National Laboratory for Marine Science and Technology

[21] Image from “Will China’s new laser satellite become the ‘Death Star’ for submarines?” by Stephen Chen, South China Morning Post 1 OCT 2018 (*https://www.scmp.com/news/china/science/article/2166413/will-chinas-new-laser-satellite-become-death-star-submarines*)

2. Aerostat

The next component of the Sensor Network SoS presented by Team Port was the Aerostat (*see Figure 29*), a "sensor and shooter" that would provide persistent coverage above and beyond the port from the aerial domain.

Figure 29. The Aerostat component of the Sensor Network SoS.

The Aerostat would be tethered to the port and powered directly from the port's power grid, so capable of providing persistent sensor coverage. The Aerostat would have an ample payload package of both sensors and electronic weapons (*see Figure 30*). The sensor package would include SAR, EO/IR, and MAD. To shorten the *sense-shoot* OODA loop reaction time, the Aerostat will also be equipped with high energy lasers (HEL) and high-power microwave (HPM) to eliminate threats such as hypersonic munitions or drone swarms.

Figure 30. Aerostat payload package would include SAR, EO/IR, MAD, HEL (*left*), and high-power microwave technology.

3. Buoy Sensor Network

After space and air, the next layer of sensors that the adversary would face inbound toward friendly forces is the Buoy Sensor Network which combines multiple existing sensors (LiDAR, RADAR, SONAR)[22] onto a single platform (*see Figure 31, bottom*) to ensure detection of incoming friendly forces or threats in air, surface, and undersea environments. The buoy sensor (*see Figure 31, top*) is designed to be rapidly deployable. Each buoy will auto navigate to the desired location and change location on demand, then interlink with other buoy sensors, friendly ships, or shore nodes to form an ad hoc network.

[22] Light detection and ranging (LiDAR), radio detection and ranging (RADAR), and sound navigation and ranging (SONAR).

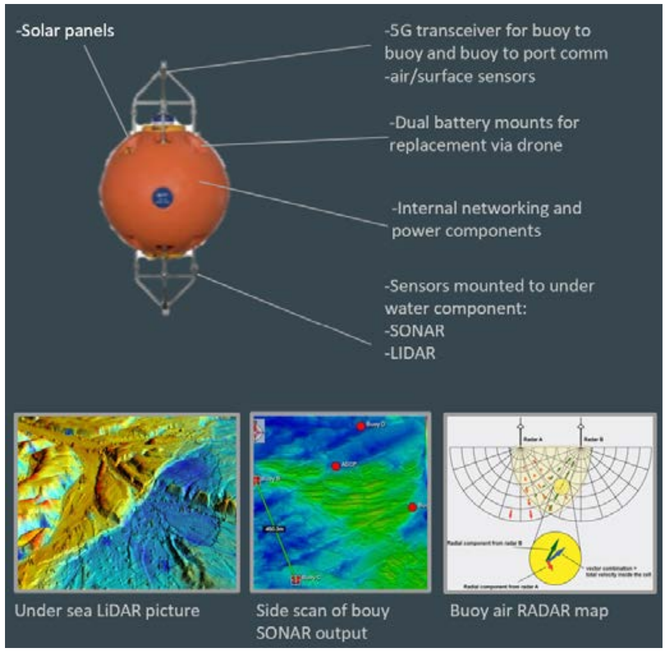

Figure 31. Buoy sensor network concept overview.

The buoy sensor would use 5G mm waveform communications (*see Figure 32*) for buoy-to-buoy and buoy-to-node data transfer, and this system will also push positional location and timing data. The system is powered using high voltage high amp replaceable battery with a solar panel for backup charging.

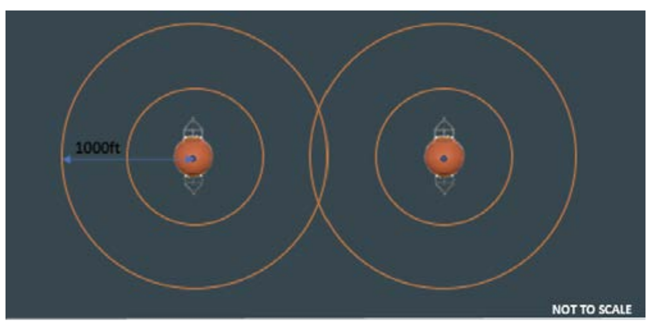

Figure 32. Buoy sensor network proposed two-way communications via a 5G mm mobile ad-hoc network, and LOS for communications within a 1000ft range *(graphic representation not to scale)***.**

Buoy sensor network batteries are replaceable as needed via air or surface drone (*see Figure 33*). The team detailed the drone power replenishment process to help describe the full concept. First, the buoy would signal when low on power and in need of replenishment. Upon signal receipt a drone would depart the base station at port with a replacement battery. Once on station above the buoy, the drone would add the replacement battery and then remove the low battery so that the buoy suffers no power interruption. The solar panel is a weather-dependent charge source for battery, and these batteries are intended to be high volt, high amp capable of propulsion power.

Figure 33. The buoy sensor network power would be replenished by drone when necessary.[23]

Possible research topics and new technology required to realize this concept include advancements in undersea LiDAR for detection of anomalies, and advancements in small form factor air RADAR to be mounted to the buoy.

4. Undersea Buoy Sensor Grid

The next component of the Sensor Network SoS is the Undersea Buoy Sensor Grid, a seafloor hydrophone network in conjunction with buoy network. The grid will consist of a group of buoy sensors, each with a tethered hydrophone extended down to the seafloor (*see Figure 34*).

Figure 34. Individual buoy sensor, a hydrophone extended down to the seafloor tethered to a buoy, intended to be deployed throughout a battlespace to form the Undersea Buoy Sensor Grid.

[23] Photo credit: University of Texas at Dallas (https://phys.org/news/2020-08-explore-retail-drone-delivery-logistics.html)

The Buoy Sensor Network will be combined as the next layer, after Satellite Sensors and Aerostats, with an undersea hydrophone network. This compliments satellite coverage, and as the ship is coming towards port it will be detected by the undersea hydrophone grid and buoy sensor network. Exact distribution and placement will depend upon the environment, but the grid will be placed between 3 and 12 nautical miles (NM) from port (*see Figure 35*). The Undersea Buoy Sensor Grid could be powered by and connected through undersea cables. Batteries are also an option, and the hydrophones could leech power from the buoys if their connection is ample.

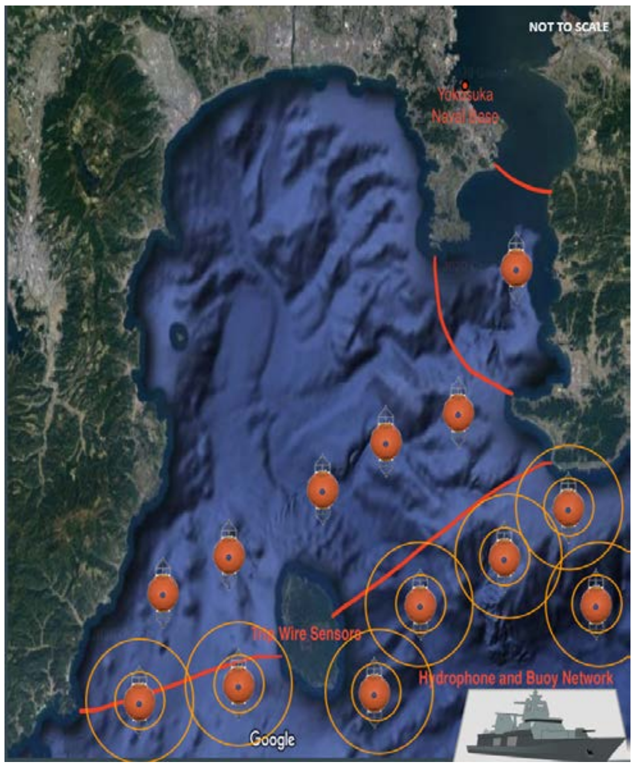

Figure 35. Undersea Buoy Sensor Grid would be placed between 3 and 12 NM from port *(not to scale)***.**

Like the Buoy Sensor Network, the Undersea Buoy Sensor Grid could have batteries replaced by drones, albeit unmanned underwater vehicles (UUVs) not UAVs. The seafloor hydrophone network would work in conjunction with buoy network. The hydrophones would be connected via an ad hoc network, and buoy-to-buoy connections would be used to send signals all the way back to shore and then to port.

5. Trip Wires

Trip Wires were the next component of the Sensor Network SoS presented. This series of seafloor cables are the next level of detectors for incoming ships or other threats and are intended to be laid out along the seafloor at different distances from port – perhaps at 1,3, and 5 NM (*see Figure 36*). Exact placement is going to depend greatly on seafloor geography. A ship or submarine passing above this trip wire will be detected and monitored. Technology for detection and monitoring might include sonar, electromagnetic signatures, magnetic or gravitational anomaly detectors. Power and connectivity for these cables would simply be from the shore end of the wires “so you wouldn't need a lot of connections to be made.”

Figure 36. Seafloor cables placed at different distances from a port comprise the Trip Wire concept, and work in conjunction with the Undersea Buoy Sensor Grid and the Buoy Sensor Network.

Potential challenges might include maintenance issues to repair cut or damaged wires – intentional or accidental by fishing net or anchor – on the seafloor. This is currently an issue for undersea internet cables so we may be able to look to them for solutions. The Trip Wires will also likely overlap the same coverage area with buoy network and undersea grid.

6. AI C2 Data Handler

Machine Learning will be needed for automatic identification to reduce human operator overload. The Sensor Network SoS will generate a huge amount of data to be handled. This process will be more efficient If data is automatically filtered for detection events and classified through an AI C2 "data handler" network, but to get to this point a large amount of previously captured data is required for machine learning to build models. Automatic identification and classification will reduce human operator overload. Once detection events are classified, if that classification is deemed important or if automated classification fails, a human operator would then be required for classification – "okay, that is a small fishing vessel" or "oh, that was a dolphin" or "no, that is a submarine we should look at it." A detection event in one sensor network would be highlighted for another network for the full Sensor Network SoS to correlate those detection events. For instance, the movement of a ship could be tracked as it is moving through the range of all the different sensor networks.

7. Decentralized Torpedo Launch Points

Once we have this data from these sensors, a target of interest has been identified and classified, kinetic action may be required. Decentralized torpedo launch points, are essentially launch points scattered throughout the ocean floor at strategic locations (*see Figure 37*) to launch both undersea and eventually airborne projectiles. These launch points could be disguised as marine life or a seafloor geographic feature with low signature. For power, the torpedo launch points will rely on undersea cables as well as a reserve mobile battery pack.

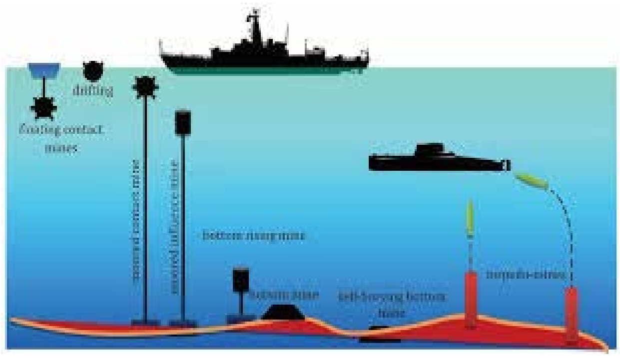

Figure 37. Decentralized torpedo launch points will be powered via undersea cables.

Like the other components of the Sensor Network SoS, the torpedo launch points could also be recharged, rearmed, or replaced using UUV delivery drones. Additionally, the undersea cable could be detached allowing the launch point to move with the help of UUV construction drones to a new location where the launch point would be re-attached to a power cable at the new location.

8. CONOP Overview for Sensor Network System of Systems (SoS)

Team Port then presented a CONOP overview of the Sensor Network SoS through two port scenarios.

Scenario 1: Established Port

The first of which being the defense of Yokosuka. Initially, Satellite Sensors detect objects of interest quite a distance from the port out at sea (*see Figure 38*). As the objects get closer the Undersea Buoy Sensor Grid detects them and gathers more data. At that point, the AI C2 “data handler” network would start presenting colors to the human staffers that are monitoring the entire system. One of the AI recommended actions would be to move a mobile buoy closer to the objects to gather more data. At that point the objects – or singular object – will be identified either as a friend or foe vessel, or a false positive identification of a neutral object that poses no threat. If the object or objects of interest indeed pose a threat, the AI C2 network would then recommend additional courses of action (COAs) that may include kinetic response options if warranted via the strategically positioned Decentralized Torpedo Launch Points, unmanned systems (UxS) swarms, and other kinetic options. If the objects are still actively moving toward the port, the high-fidelity cable Trip Wires placed at varying distances from the port would be able to gather even more accurate intelligence, and the “kill chain” cycle would continue until the object or objects are neutralized.

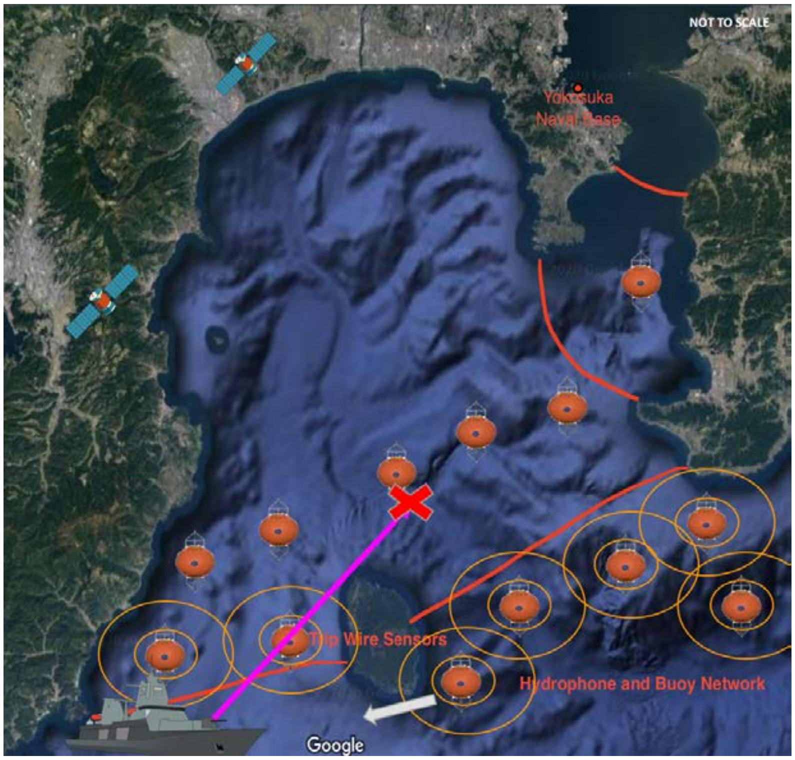

Figure 38. System Network SoS overview demonstrated through the defense of Yokosuka from a potential threat approaching the port (*unknown vessel in bottom left*).

In this scenario, the Sensor Network SoS could also incorporate versatile human-assist robots in multiple domains to serve as "dock workers", but should a threat to the port be identified these assets could easily shift to port defense tasking on demand. Quick reaction force (QRF) drone swarms could be supplemented by reserve drone forces stored in low orbit satellite storage that could rapidly deploy from space. Both of these options could be employed as a segmentally implemented defense sensing network as funding and ability to deploy becomes available.

There are diplomatic considerations in an established joint port like Yokosuka. We need to establish data sharing agreements with Japan. Ideally, we will be able to share enough data with Japan so they can protect themselves and we can strengthen our alliance, but not so much that we are giving away sensitive secrets. Additionally, we need to make sure that we are coordinating with Japan on the electromagnetic spectrum side to ensure there is a spectrum manager and there is no interference with local emergency management or other port stakeholders. Civil-military relationships in a busy port environment are essential considerations. We also need to ensure that our standard operating procedures (SOPs) are incorporating the Japanese forces in any response action, both human and AI, to strengthen our alliance and increase resiliency in the environment and in response to any future threat such as those included in the given scenario. Finally, a joint port environment is ideal for allied wargaming of SOPs to test reaction to sensor signals, and any future wargame should include liaison officers from Japan augmenting our forces and a method for Japan to measure the extend that U.S. forces are augmenting Japanese forces.

Scenario 2: Expeditionary Port

The second scenario Team Port used to demonstrate the System Network SoS concept was the defense of an expeditionary port (*see Figure 39*), where a lack of time and resources to establish the robust defense systems found in traditional established ports creates unique vulnerabilities. Naval vessels in a commercial port not designed for military presence in a partner country must protect themselves and the port from missile, torpedo, and mine threats while making required repairs. After successful resupply, naval vessels then need to safely break out of this port to join the conflict.

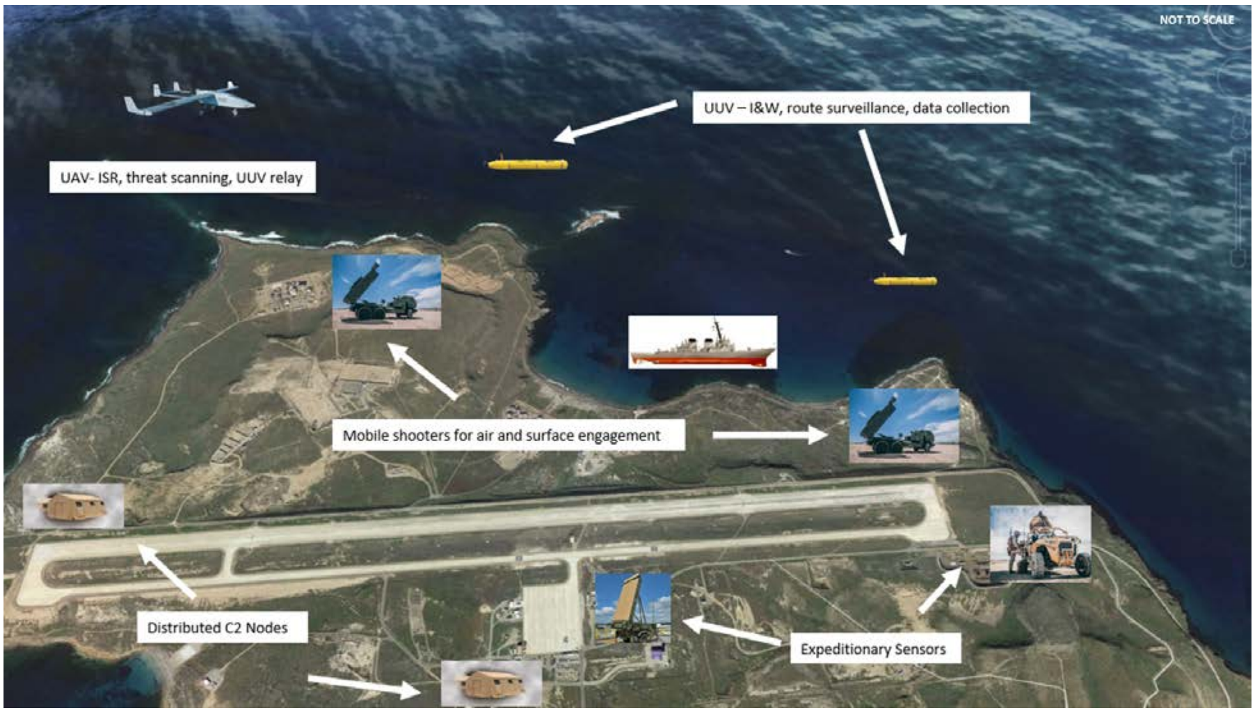

Figure 39. Defense of an expeditionary base using the Sensor Network SoS.

In this expeditionary port scenario, a deployable Sensor Network SoS of UxS and manned weapons that provides real-time AI-enabled port breakout defense will enhance standard naval vessel defensive weapons systems. The sensors for the systems in this deployable version of the Sensor Network SoS will be primarily AI-enhanced human-machine teams (*see Figure 40*). The deployable kinetic capabilities available would all be mobile and capable of engaging threats in air, surface, and subsurface. Dispersed, mobile, multi-domain C2 nodes with integrated common tactical picture (CTP) from land, subsurface, air domains would ensure persistent communications within the network, and augmented reality would assist in data management and prioritization to prevent operator overload.

When thinking about land-based systems allow naval forces to breakout of port, Team Port tried to answer the following questions:

- *How to we find, fix, track, and target threats in the air, surface, and subsurface domains?*
- *How to we engage those threats while ensuring force protection?*
- *How does the commander effectively C2 assigned forces?*

- *How can technology aid in the decision-making process and shorten the kill chain?*

The "find, fix, track, and target potential threats" function is best accomplished using AI-aided human-machine teams of sensors to quickly identify, track, and prioritize threats to port breakout across multiple domains. These sensors need to be able to scan and track targets in multiple domains and must be dispersed to ensure survivability.

Figure 40. Land-based systems such as this light marine air defense integrated system (LMADIS) as part of a human-machine team are a component of the deployable Sensor Network SoS.

Mobile, semi-autonomous, multi-domain shooters are best suited to engage threats in this expeditionary scenario. These assets could be either swing loaded with ordnance for multiple domains – for instance air and surface simultaneously – or have interchangeable ordnance loads based on the targeted domain. Commanders could exercise C2 of their assigned forces with dispersed, mobile C2 nodes staffed and resourced to independently conduct C2 and integrate fires across all relevant domains which would require a C2 system that is capable of taking inputs from multiple sensors and data formats, and integrating them into a CTP. The integration of AI will help prioritize the display of information allowing for faster decision-making. These nodes might also need the capability to initiate or authorize release of limited weapons and integrate fires with other surface, subsurface, and air assets should the speed of human decision-making be too slow. However, more analysis of autonomous kinetics options needs to be done before implementing this capability. Lastly, the use of augmented reality systems could add speed to the decision-making process and shorten the kill chain. Picture a system that provides a heads-up display (HUD) akin to those that pilots use, but networked with the sensors and the integrated into AI-enhanced C2 system to prioritize and display information to the user allowing human operators to make the best decisions in the circumstances.

Some existing technology currently in the field to incorporate into the Sensor Network SoS include the light marine air defense integrated system (LMADIS) (*see Figure 40*) to conduct mobile air surveillance and the G/ATOR radar system[24] for large scale air surveillance.

[24] The Northrop Grumman AN/TPS-80 Ground/Air Task-Oriented Radar (G/ATOR) (https://www.northropgrumman.com/land/radar-systems-land/an-tps-80-ground-air-task-oriented-radar-g-ator-one-radar-many-missions/)

Figure 41. Multidomain shooters are envisioned as the kinetic component in the deployable Sensor Network SoS used in the expeditionary scenario.

Mobile shooters such as LMADIS are capable of limited electronic attack, and when coupled with HIMARS[25] and THAAD[26] for anti-surface and anti-air capability could fill a full kinetic complement (*see Figure 41*). The common aviation command and control system (CAC2S) is an existing multi domain command control system used to integrate fires with maneuver and can take inputs in multiple data formats to create an interactive CTP. Three required capabilities to develop are multi-domain ordnance, semi-autonomous sensor and shooter vehicles or prime movers, and AI enhancements for all systems.

Multi-Domain Needs & Requirements

In a scenario where the U.S. Naval force has been mined into port, either established or expeditionary, vessels may be sunk in the channel. There may be other obstructions blocking the channel. Military and commercial vessels are not able to get to sea. Prior to any port breakout attempt, routine surveys must be conducted using UUVs (*see Figure 42*) to build a common operating picture (COP) to understand the environment and provide data for later change detection.

Figure 42. Before port breakout, UUVs conduct routine surveys, and deploy passive and active sensor arrays and transponders.

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[25] The Lockheed Martin M142 High Mobility Artillery Rocket System (HIMARS) is a light multiple rocket launcher developed in the late 1990s for the United States Army, mounted on a standard Army M1140 truck frame (https://www.lockheedmartin.com/en-us/products/high-mobility-artillery-rocket-system.html)

[26] The Lockheed Martin Thermal High Altitude Area Defense (THAAD) weapons system (https://www.lockheedmartin.com/en-us/products/thaad.html)

During these port survey missions, the UUVs might also deploy passive or active sensor arrays or transponders to create the ad hoc Buoy Sensor Network, Undersea Buoy Sensor Grid, and Trip Wire components of the Sensor Network SoS if not already in place.

Figure 43. During breakout, UUVs deployed for route clearance to sea.

Then during a port breakout, the UUVs will be deployed to conduct route clearance to sea (*see Figure 43*). Rapid detection of anomalies will be enabled using the database of previous target surveys, and automatic target recognition using onboard AI will allow the UUVs to identify and destroy mines in-stride by dropping explosive payloads on threats. The AI-enabled UUVs could conduct intelligent route selection for the ship based on known ship size and operating parameters in consideration of identified threats. Simultaneously some UUVs could move ahead to provide indication and warning attack, or even self-sacrifice by colliding with incoming enemy submarines, torpedoes or adversarial UUVs.

To achieve this CONOP requires modular payloads that match the form factor of existing naval systems like torpedoes and Tomahawk Air Land missiles (TLAMs) for ease of storage and launch. High density, long endurance power sources and communication interfacing solutions between the air and water domains are also capabilities that still require development to reach the point where they are sufficient for this CONOP. Other desired capabilities include:

- Local geo-referencing ability for operation in GPS-denied areas
- Modularity to handle yet-to-be-developed payloads
- Integration into UxS COP and mission planning architecture
- Integration of a standardized data-type into a DoD cloud-based, worldwide, common data repository to drive AI (think JEDI)
- Off-site UxS operations center (most likely CONUS) to increase resilience to continue mission if host platform is destroyed
- Ability to detect, identify, and neutralize bottom and volume mines
- Ability to function autonomously as a team (swarm capability)
- Ability to operate in poor weather conditions
- Capability for advanced sensors and payloads (deployable comms floats, underwater target marking transponders, explosive payloads, etc.)

- Ability to avoid enemy interference, underwater acoustic jamming, etc.
- Ability to self-scuttle if needed
- Ability to provide defensive and offensive capabilities against enemy UUV, submarine, torpedo, ship, counter-swimmer
- Provide dead-drop of supplies using UUV disguised as natural marine life

UUV sonar data could also be shared with the port host country and civilian port operators, strengthening relationships and alliances while shoring security of the port.

Figure 44. Before breakout small UAVs would be routinely deployed to scan and map the environment.

Similar to the UUVs, before any port breakout attempt swarms of small UAVs (*see Figure 44*) will be routinely deployed to scan and map the environment around the port, monitoring for land and sea threats, building data for the common operating picture, and establishing a pattern of life for later change detection.

Figure 45. During breakout, UAS deployed individually or in swarms to find, fix, and finish surface and air threats.

During breakout, larger UAVs (*see Figure 45*) will be deployed individually or in swarms to find, fix, and finish surface and air threats using AI to automatically recognize targets and engage based on defined rules of engagement (RoE) or human direction. Again, the system would continuously feed the COP for situational awareness and target handoff, and might be used as a communications relay between other forces – both manned and unmanned, U.S. and allied. For example, a UAV could hover and dip an acoustic transducer into the water to relay tasking or receive data from a UUV.

Similar to the UV is modular payloads are needed to allow use of offensive weapons, complete logistics lift missions, or for ISR.

Desired capabilities for air assets incorporated in the Sensor Network SoS include:

- Electromagnetic spectrum compatibility and intelligent sensing for deconfliction to avoid blue-on-blue jamming.
- Local geo-referencing ability for operation in GPS-denied areas
- Large amounts of bandwidth to handle yet-to-be-developed payloads
- Integration into UxS Common Operating Picture and Mission Planning architecture to feed real-time SA (think a targeting/fire control version of SPIDERS3D)
- Integration of a standardized data-type into a DoD cloud-based, worldwide, common data repository to drive AI (think JEDI)
- Off-site UxS operations center (most likely CONUS) to continue mission (resilience) if host platform is destroyed
- Ability to conduct HVU escort, able to identify and/or prosecute threats on land or sea
- Ability to function autonomously as a team (swarm capability)
- Ability to operate in poor weather conditions
- Capability for advanced sensors and payloads (LiDAR, acoustic transducers, weapons, lasers, etc.)
- Smaller, cheaper UAVs may be used for swarms, attacks, etc. while larger, heavier UAVs may be used for logistics, heavy lift, and resupply

Standing operation orders (OPORD)[27] are needed for both routine UAV and UUV operations in critical ports. Scanning and mapping ports and operating areas will feed the big data needed to train AI to enable rapid decision making through change detection algorithms. Baseline sweeps may also help in geo-referencing ability for later GPS-denied operations.

[27] *An **operation order (OPORD)** is a directive issued by the leader to his subordinate leaders in order to effect the coordinated execution of a specific operation. A five-paragraph format is used to organize the briefing, to ensure completeness, and to help subordinate leaders understand and follow the order* (SOURCE: James Mason University ROTC briefing accessed 30 October 2020 at https://www.jmu.edu/rotc/_files/operationorder.pptx#:~:text=An%20operation%20order%20(OPORD)%20is,understand%20and%20follow%20the%20order)

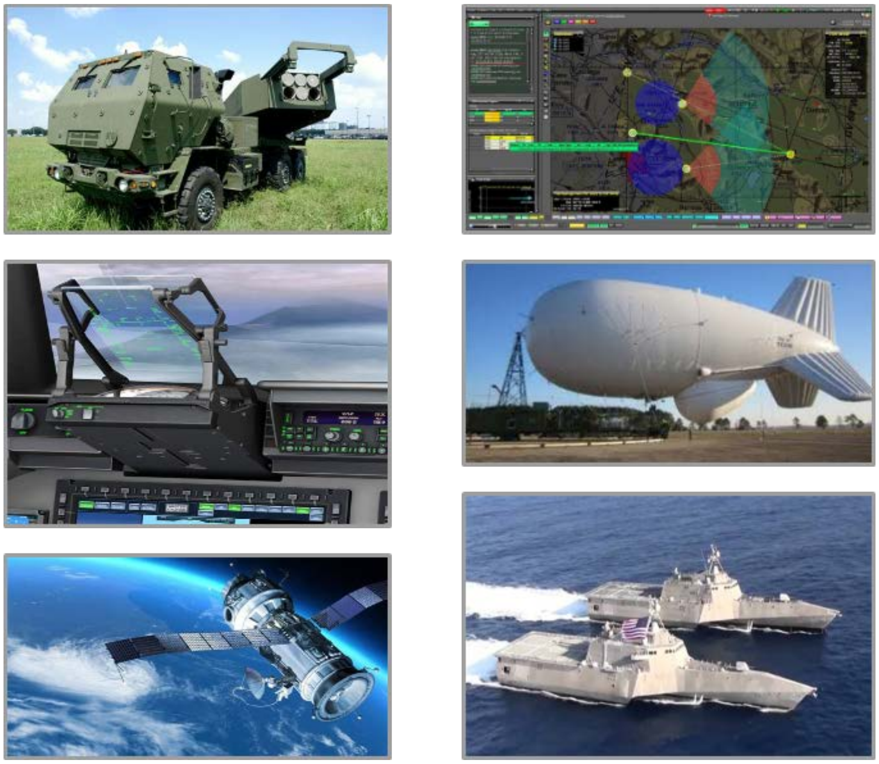

Figure 46. An array of current technologies that inspired ideas for desired future capabilities to develop to incorporate into the Sensor Network SoS concept, both mature technology (*left column*) and emerging technology (*right column*).

The Sensor Network SoS is Team Port's proposed solution for both home and away fight. However, "the anonymous elephant in the room right now" is how we get there from where we are now. Team Port recommended development of several capabilities to help realize their Sensor Network SoS concept. Several current technologies and systems (*see Figure 46*) inspired this list of Team Port's ideas for desired future capabilities:

- Hybrid C2 Nodes
- Multi-domain munitions
- AI, anomaly detection, data fusion
- Integrated sensors on buoys
- 5G for integrated nodes
- Rapidly-deployed, local geo-referencing
- Standardized data repository and COP
- Cross-domain comms (i.e. air/water interface)
- High energy density power sources
- Standing OPORDS to drive continuous peacetime UxS data collection
- "Trip wire" detection
- MAD/GAD

Technology maturation is necessary to get to a future Sensor Network SoS to enhance resiliency under the threat of mines, torpedo and missile attacks and ensure naval forces can safely break out of confined port channels. Team Port hopes their ideas will help inspire and develop new technologies and kept building for the future warfare.

F. Team Warfighter

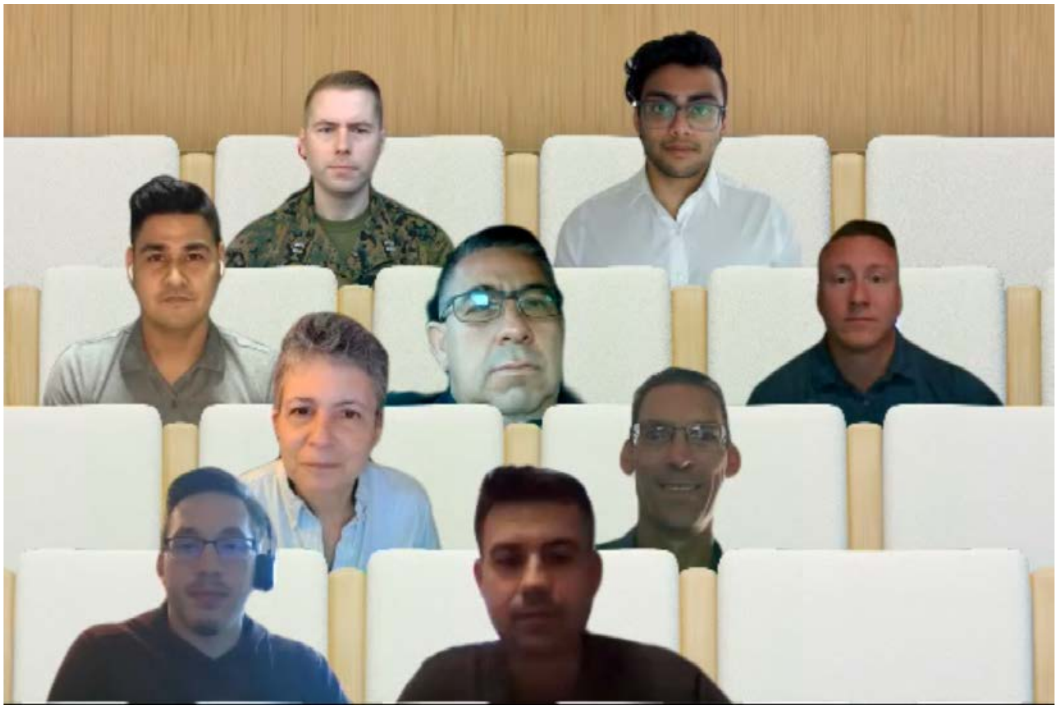

Figure 47. Members of Team Warfighter (*pictured from left to right*) ROW 1: Christopher Torbitt, Alexandru Cristian Hudisteanu ROW 2: Ann Gallenson, Tony Nelipovich ROW 3: Robert Justin Naquilla, Jesus Serrano, Isaac Williams ROW 4: Sean Harper, Matthew Thommana (not pictured Joel Li, David Mortimore, Ayodele Olabisi, Kyle Snyder)

The members of this team (*see Figure 47 and Table 6*) included five junior officers from the U.S. Navy and Marine Corps, and officers from Romania and Singapore; two early career engineers, two members of the law enforcement community, and a biochemist. The team was facilitated by a NPS faculty member, a U.S. Navy reservist, and a warfare center representative; and this team included four NPS students.

Table 6. Members of Team Warfighter (*alphabetical by last name*)

NAME	PERSPECTIVE	AFFILIATION
Ann Gallenson	*Facilitator*	NPS Center for Executive Education
Capt Sean Harper USMC	*Infantry officer*	NPS Operations Analysis
LTN Alexandru Cristian Hudisteanu	*International*	Romanian Navy
Joel Li	*Ammunitions engineer*	Singapore Army
David Mortimore	*Facilitator*	NUWC Newport
Robert Justin Naquilla	*Combat engineer officer*	Singapore Army
Tony Nelipovich	*Facilitator*	US Navy Reserves
Ayodele Olabisi	*Medical Corps Officer*	Naval Research Lab
Jesus Serrano	*Law enforcement*	Calexico Police Department

Kyle Snyder	*Robotics Program Mngr*	Cherokee Nation Strategic Programs
Matthew Thommana	*Electrical engineer*	JHU Applied Physics Lab
Christopher Torbitt	*RF engineer*	Lockheed Martin
Maj Isaac Williams USMC	*Artillery officer*	NPS Space Systems

Team Warfighter's design challenge was:

> *How might emerging technologies assist in reducing dependency on U.S. full mobilization? How might the Reserves and National Guard enhance integration with unmanned platforms? What missions or roles might they contribute to or assume?*

Team Warfighter subdivided their efforts into two sections, the domestic warfighter and the partner warfighter, and presented four solutions – two domestic and two with allied partners.

1) Network Citizenry
2) Tailored Industry Liaison Teams (TILTs)
3) Forward Staged Additive Manufacturing
4) Interoperable Space and Cyber Architecture

In the years leading to the 2035 dispute our main adversary, China, is able to employ its full civilian industry and military immediately to support national efforts. This cooperation is natural due to the structure of the Chinese government. However, the U.S. public currently does not possess such an ability to mobilize as fully and as quickly. The current separations between potential U.S. manpower is part of the problem. Active duty military, military reservists, and National Guard are familiar entities. However, two portions of U.S. civilian society that Team Warfighter proposes to align to the national interests are the networked citizenry as members of our industry partners and within the general population. These two groups include people in industries that will support any future war effort with materials, like miners and chip designers, as well as lay people who contribute to the economic machine and have potential to transfer their skills in a direct form of manpower support for conflict. These two groups are important because they comprise 99% of the population and so represented a significant untapped resource. From their exploration of the problem space, Team Warfighter defined their domestic problem as:

> *How might the United States construct a large, capable dynamic, an employable national workforce that is willing to help in the war effort?*

They proposed two solutions to this question. These solutions do not attempt to solve all of the domestic warfighter challenges, nor do these solutions fully resolve the question at hand. However, Team Warfighter's ideas may lay the groundwork to construct a large force to leverage in a future conflict.

1. Networked Citizenry

Team Warfighter's Networked Citizenry concept incentivizes skill generation and use of networked general population for shared national defense and security. Higher education sought by many in the general public is increasingly out of reach due to prohibitively high costs that continue to rise. However, access to higher education is essential to develop the human capital necessary to support any future war effort. Team Warfighter proposed two changes to incentivize a workforce that is more aligned to national wartime effort. First, service roles should be specialized to attract a more diverse populace; and second, policies should be enacted to promote direct civilian incentives for education and engagement with the military. Currently, many of programs are focused on pushing talent into the military first – however, these programs often have a set of duties that may not be attractive to those wanting to work in the field. Specialization of support and warfighter roles might be can be used to attract civilians who already have useful skill sets for defined positions but may not have a desire to take on the full range of tasks common in current military positions.

Team Warfighter contends that there are many current requirements that could be relaxed to accommodate this specialization – for instance, the war of tomorrow is likely to be less physical than in the past so common physical requirements will no longer be necessary. Incentivizing the general populace to acquire necessary wartime skills with minimal duties in return could be an important step to more closely align the 99% of the population to a shared national goal. Introducing a unique set of national challenges and lesson learned through past conflicts to a larger share of the general population is a start. Past generations felt they could only serve the nation in the military by offering their brawn, or brute strength. Today however, other skills requiring intelligence are increasingly important to military efforts. Team Warfighter proposed that a future populace will be more likely to offer their skills to support a future war effort if they have already been exposed through higher education to the unique challenges of war, and already have the skills required to face these unique challenges.

2. Tailored Industry Liaison Teams (TILTs)

The proposed Tailored Industry Liaison Teams (TILTs) are envisioned as specialized private sector teams to support rapid mobilization through a quick reorganization of private assets to public assets to support the war effort. Creation of contracts in advance of any conflict that stipulate the initial conditions for execution will help to rapidly and fully mobilize during wartime. Team Warfighter acknowledged that this is a very nuanced subject, as many current companies are global, and strict regulation and contracting can sometimes hinder the free market in which they have prospered and lead companies to relocate to other nations. Before implementation, the unintended consequences of such policies must be carefully considered. Tax incentives could be given to companies who provide conflict preparation support, and reimbursement could be made available to reduce the barrier to entry. This sort of policy level action will more closely align academia, the private sector and the warfighter, and result in quick mobilization of people and assets in response to a future conflict (*see Figure 48*).

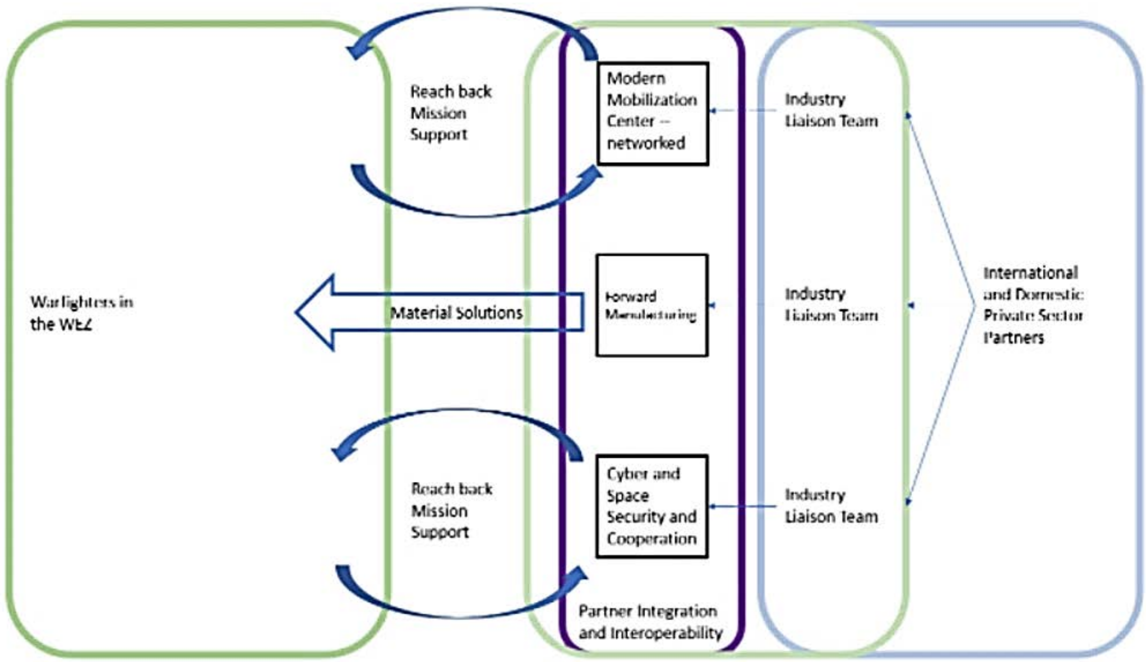

Figure 48. Integrated Tailored Industry Liaison Teams (TILTs) activated to support a future war effort.

Once implemented, Team Warfighter recommended periodic wargaming and training exercises to validate TILTs' rapid acquisition capacity, build familiarity with the required process, and facilitate resource integration when needed in advance of any required real-world, real-time support.[28]

These domestic solutions, Networked Citizenry and TILTs, do not exist in a vacuum. They aid each other, and will aid the partner nation warfighter as well. Incentives for a skilled populace will support rapid mobilization of a Networked Citizenry. A large, skilled populace requires a constant and large supply of material resources. Dynamic and tailored production incentives and support contracts through TILTs will help to enable the warfighters of tomorrow. These concepts could easily be extended to include our partner nations to assist allied forces and enhance our mobilization response to larger areas. The partner warfighter extension could also help to align multinational goals, and further the collective force and direction of the applied force.

3. Forward Staged Additive Manufacturing

The first of two concepts from the perspective of the partner warfighter presented was Forward Staged Additive Manufacturing (AM) to leverage capability and capacity in close proximity to the battlespace. As Team Warfighter was framing and defining this portion of their problem statement they looked at the original design challenge. The team wanted to focus domestically, but also wanted to ask the question, *What can we do for our partners and what can our partners do for us in that future context?* Given the current and proposed international security architecture, their partner warfighter problem definition was:

[28] Much like the periodic Advanced Naval Technologies Exercise (ANTX) executed by NUWC Newport (https://www.navsea.navy.mil/Home/Warfare-Centers/NUWC-Newport/What-We-Do/ANTX-2020/)

How might we aid in the organization training and development of partner resources to accomplish shared objectives in future conflicts?

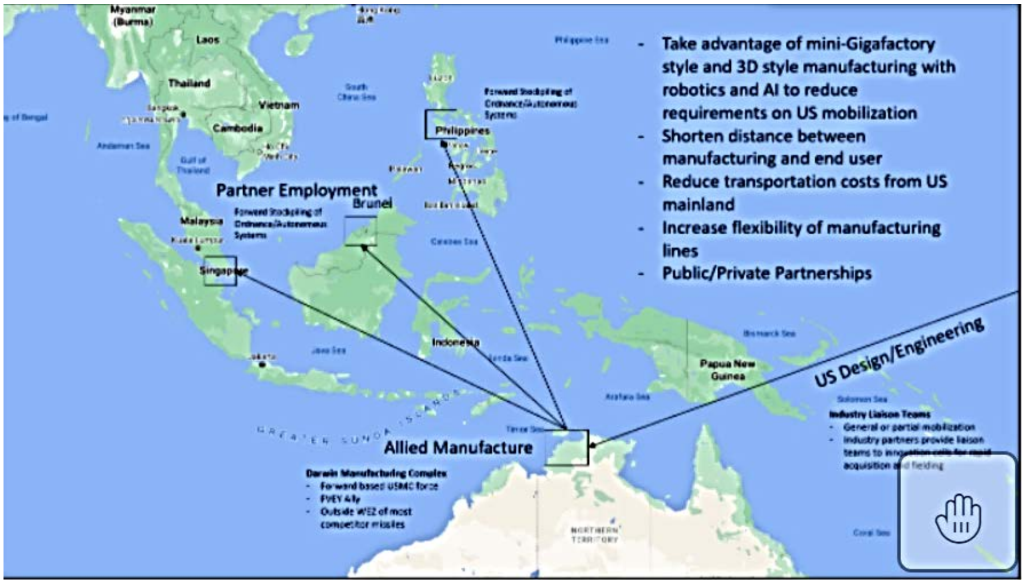

Figure 49. Forward Staged Additive Manufacturing (AM) capability might be staged in Darwin, Australia to bring capacity and closer to a prospective future battlespace.

Their first proposed solution used forward staged AM capability and capacity located in partner nations. Team Warfighter demonstrated this concept by sharing a vignette. In response to the scenario given with the design challenge they proposed an allied manufacturing complex in Darwin, Australia (*see Figure 49*). They envisioned that this complex would be engineered by U.S. personnel drawing capability from the Networked Citizenry driving the design of the complex and aiding the allied nation to manufacture key components for individual UAV's and full UAS. Distributed maritime operations (DMO) and expeditionary advanced basing operations (EABO) CONOPS both involve significant use of autonomous systems, and these assets will need a lot of very specific parts. Moving the manufacture of these specific parts closer to the front increases responsiveness to the demands of the warfighter actively involved in the conflict and takes less of a toll on U.S. domestic logistics systems. If many required components are manufactured in Darwin it will be easier to stockpile components forward in strategic locations such as Singapore. The required intellectual capital would not only come from the U.S. in this scenario. Our partners in Singapore are some of the most innovative globally, and Singapore has been recently recognized as one of the best places to innovate and do business. A networked approach with our partners in designing and implementing AM for a variety of required autonomous systems will improve interoperability overall.

The number one benefit of the Forward Staged AM concept is deterrence. “If we place a manufacturing facility in Darwin, Australia, that's something that our potential enemy is going to be very fixated on.” That ability to manufacture components on demand, especially if this capability is distributed to multiple locations across the Pacific, it will lend a lot of credence to our partners that the U.S. is invested in these partner alliances – “we are with them and they are with us.” This concept requires public-private partnerships so will improve relationships with industry. These complexes are envisioned as multipurpose production facilities that in peacetime would could produce things like personal protective equipment (PPE) in preparation for something like the COVID-19 pandemic, and then in wartime these flexible AM lines could be reprogrammed and retooled to produce UAV and UUV equipment and parts needed for the war effort. This Forward Staged AM concept adds flexibility to manufacturing lines, reduces the distance to the front in wartime, and allows for forward stockpiling of materials in strategic locations. Finally, the design and engineering could occur anywhere.

4. Interoperable Space & Cyber Architecture

Team Warfighter's final concept, Interoperable Space and Cyber Architecture, leverages partner nation capability in these domains and enhance U.S. capacity (*see Figure 50*). Through discussion with international members of their team, the team as a whole discovered that many allied nations have space and cyber capability, but they lack capacity – the U.S. has capacity but could use support with capability. To enhance the interoperability of U.S. cyber defense architecture the team explored a partner relationship like a "cyber commons" to leverage individual strengths of many allied nations toward a shared security goal. This "cyber commons" would also improve future interoperability through shared standardization among nations as technology develops and advances. The team also suggested conducting cyber exchanges where either reserve or active duty U.S. military personnel visit and work with partner nation cyber organizations – either virtually or in person – to improve skills for all involved, and to strengthen networks and relationships.

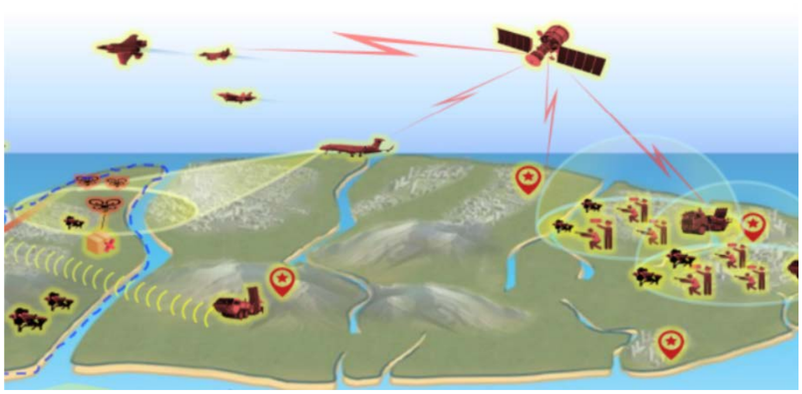

Figure 50. The Interoperable Space and Cyber Architecture concept relies heavily on the U.S. working closely with partner nations to improve security for all in these two domains.

Many smaller allied nations have little or no capability or capacity in space, and so the U.S. could fill a very big role to provide access to the space domain for partner nations. Beyond just the military sector, these relationships could also be commercial. Recent examples include projects like Starlink[29] and the WorldView Legion satellite constellation[30] where companies like Maxar are working on geospatial imagery. Getting U.S. partners access to those resources could help smaller nations develop in the space

[29] *With performance that far surpasses that of traditional satellite internet, and a global network unbounded by ground infrastructure limitations,* ***Starlink*** *will deliver high speed broadband internet to locations where access has been unreliable, expensive, or completely unavailable.* (from https://www.starlink.com/)

[30] "*Earth imaging constellation will change everything. We're not just launching more satellites. In 2021 we will deploy a legion,* ***WorldView Legion****, providing unprecedented visibility into our changing planet to solve the biggest challenges facing our world today*." (from https://www.maxar.com/splash/it-takes-a-legion)

domain and would aid U.S. security in the long term, developing more robust information sharing between allies and enabling any future mass mobilization that touches the space domain.

Other ideas that fit within the Interoperable Cyber and Space Architecture concept include leveraging the U.S. as a key enabler for 5G technology, autonomous platforms, high speed networks, and data communications for allied partners. The team also suggested that allied nations conduct joint cyber multilateral exercises within allies. This concept would require development of rules of engagement (RoE) in both the space and cyber domains, much like the United Nations Convention on the Law of the Sea (UNCLOS) for the maritime domain. LEO satellites are an example of a candidate technology to leverage with partners in the space domain. With shorter transmission delays and low power requirements, LEO satellites could be used in a satellite network across and between allied nations acting as transmission and detection networks. These satellites are easy to launch, replenish, and an entire constellation of satellites could be updated to accommodate changing technology and software. The greater the number of allies the more robust the network.

With incentives for building a bigger knowledge base with the Networked Citizenry concept, building TILTs to integrate the U.S. industrial base with the U.S. military to rapidly create, develop, acquire and field new technologies, Forward Staged AM to add capability and capacity in strategic locations in peacetime to better support any future war effort, and establishing interoperability and access to space and cyber defense systems with our allies now will all help the U.S. better respond to any future conflict.

G. Mentors

Each year the workshop employs a small group of senior level professionals from a variety of perspectives to serve as Mentors. The “Mentor” role is inspired by Homer’s Odyssey:

> *When he left Greece for the Trojan War, Odysseus left his son Telemachus in the charge of his old friend Mentor to share knowledge and friendship to guide the son in the absence of his father.*

Mentors in the WIC Workshop serve as trusted advisors, providing expertise and guidance to those at an earlier place in their career to advance their ideas, grow their confidence, and build their networks. For the 2020 WIC Workshop “Resurrecting War Plan Blue” received additional guidance:

> *As a nation we have not really thought about how well our nation might withstand a major conflict since the Cold War. As mentors, to continue to stress this theme to the participants may inspire them come up with new ways to increase resilience, or find even more vulnerabilities in our nation’s preparations. In the end, however, we hope the work shop will provide insights on how emerging technologies or new ways in our industrial processes will increase our ability as a nation to sustain an extended war, and therefore a more serious deterrent to war.*

The ten members of the Mentor Corps 2020 included:

Dr. Chris Bassler, Senior Fellow - Center for Strategic and Budgetary Assessments (CSBA)

Dr. Chris Bassler is Senior Fellow at the Center for Strategic and Budgetary Assessments (CSBA), where he researches maritime operating concepts, joint aerospace capabilities, technology & innovation, and overall U.S. & allied military strategies. He previously served as Chief Strategy Officer for the F-35 Joint Program Office, and in other assignments in OPNAV, ONR, and the Navy labs- as an engineer, scientist, designer, and strategist. He has a PhD in Aerospace Eng. and MA in Security Policy

Dr. Jenn Brower, Senior Engineering Manager – Raytheon

Dr. Jennifer Brower is a Senior Engineering Manager AT Maritime, Raytheon Missiles & Defense. She was Chief Scientist, Prometheus, doing signal processing, and consulted in cyber security and advanced textiles. At RAND, she led the Congressionally-mandated Advisory Panel to Assess Domestic Response Preparedness for WMD and has written on the threat of infectious disease, infrastructure protection and info warfare. She has a PhD in Environmental Eng and Microbio from Harvard and a BE Dartmouth.

Dr. Tom Choinski, Director for Undersea Warfare - NUWC Newport

Dr. Choinski is the Deputy Director for Undersea Warfare at NUWC HQ. He has 40 years of experience in innovation, engineering, science & technology and management culminating in an interdisciplinary approach to innovation. Tom's current pursuits focus on innovation ecosystems and artificial intelligence. Previously, he stood up the Emergent and Transformational Systems Division, served as the CNO Strategic Studies Group's (SSG) Science Advisor, led the first COTS SONAR installation on an SSBN, held engineering positions in industry and served as an adjunct professor at the New York Institute of Technology. He has published over 70 papers, as well as a Ph.D. dissertation on *Dramaturgy, Wargaming and Technological Innovation in the United States Navy* and a book chapter on *Artificially Intelligent Techniques for the Diffusion and Adoption of Innovation for Crisis Situations*. Tom holds graduate degrees in engineering and business. He completed an MIT Seminar XXI fellowship in Foreign Politics, International Relations and the National Interest. Dr. Choinski received a Meritorious Civilian Service Award for his contributions to the CNO's SSG. The National Society of Professional Engineers selected him as one of the Top Ten Federal Engineers of the Year in 2008.

Dr. Paul Gelpi, MCU Professor of Military History

Dr. Paul D. Gelpi is a Professor of Military History at the Command & Staff College. He joined the faculty of the Command & Staff College in 2007 and was promoted to Professor in 2010. He served as the Electives Program Coordinator from 2007 to 2009 and as the Operational Art Course Director from 2009 to 2012. In 2012, he became the Communications Program Coordinator. He has also held positions with a number of institutions of higher learning and, since 2016, has served as an Adjunct Senior Professorial Lecturer in the School of International Service at American University. His principal scholarly interests are U.S. military history, primarily aviation history and airpower theory, and the history of culture and ideas in the Early Republic and 20th-century America, especially the Cold War era. Dr. Gelpi received his Ph.D. in history at The University of Alabama and earned his M.A. and B.A. in history at the University of New Orleans. [excerpted from posted MCU bio]

Dr. Sorin Lungu, Long Range Strategy Branch Head USMC Headquarters, Programs & Resources, Programs Assessment & Evaluation Division

During October 2006-July 2020 Dr. Lungu was a Professor in the Department of National Security and Industrial Base at the Eisenhower School of National Security and Resource Strategy at the National Defense University (Washington, DC). During August 2010 – July 2017 he was the faculty lead for the

Aircraft Industry Study program (where he taught also Industry Analysis and International Comparative Defense Business Environments). He also developed and lead (September 2010-March 2020) the (Indo-Pacific focused) Long-Term Strategy electives concentration program, where he taught courses in diagnostic net assessment, defense strategic planning, military technology diffusion and Asian defense markets dynamics, and directed research and wargaming (funded by OSD Net Assessment and USAF Office of Commercial and Economic Analysis). He served as the Chair of the Department of National Security and Industrial Base during August 2017-July 2019 when he advised, led and implemented the redesign and refocus of the Industry Studies program and Industry Analysis course in support of the strategic imperatives of the 2017 NSS and 2018 NDS. During August 2019-July 2020 he performed HQE duties on a detail at the Pentagon supporting DJ-7’s efforts focused on the development of the Joint Warfighting Concept (with a focus on protracted warfare and industrial base, peace-time competition and red team activities).

LTC Kelly McCoy USA, NPS NSA Strategy Chair

LTC Kelly McCoy is the Strategy Chair at the Naval Post Graduate School, teaching the intersection of technology, national security, and policy. His experience includes serving as an engagement strategist at a major army command, a theater strategist at USSOUTHCOM, and 41 months of experience in combat and intelligence operations in Iraq and Afghanistan. He holds a dual Bachelor of Arts from Chapman University and a master’s in public administration from the George Washington University.

Mr. Terry McKearney, President - The Ranger Group

As an NPS student, did my thesis for Wayne Hughes on the impact of the original Orange plans on ship design and how they effected the early battles of WWII. He used the data I compiled in Fleet Tactics. I and my company have recently worked on an ONR/NIWC INP/FNC to develop undersea UUV architecture, where we've used wargaming and facilitated workshops to develop fleet user requirements and assess the potential functionality of these systems in Phase to Phase 3.

COL Gregory Reilly USA (ret), NWC Associate Professor - Joint Military Operations

U.S. Army COL retired. Commanded A Cavalry Squadron during two - one-year deployments to Iraq. Served as the US Southern Commander's Director of the Commander's Action group; Strategic Initiatives Group ISAF and Commanded Joint Task Force Bravo. Other Deployment include Desert Shield and Storm, Bosnia and Kosovo. Graduated from the School of Advanced Military Studies at Fort Leavenworth and the U.S. Naval War College Senior Course.

Mr. Glen Sears, Senior Strategy Analyst – LMCO

Joined Lockheed Martin in 2012 following 30 years’ Navy service as a SWO. His last Navy assignment was Executive Director of the CNO's Executive Panel providing independent civilian advice on strategy and technology innovation. Served in six CG/DD/DDG" deploying globally and commanding USS TICONDEROGA (CG-47). Also commanded TF 53, Logistics and Strategic Sealift Forces Central Command, supporting FIFTH Fleet. Ashore included Joint Staff, OPNAV, AEGIS(PMS400), and USNA. NPS Weapons Eng '89.

CDR Nick Ulmer USN, NPS Operations Research

Nick Ulmer is the Program Officer for the 361 and 362 curricula in the Operations Research Department and also serves as a lecturer for elective courses in Operational Logistics and Energy Logistics. He is a U.S. Navy Supply Corps officer. His sea assignments include USS PASADENA and USS BOXER. His shore assignments include contracting in Naples, Italy and a deployment to Iraq. He has also done tours at NAVSUP Weapon Systems Support (WSS) and the Bureau of Naval Personnel (BUPERS).

APPENDIX B: Scenario

Developed by retired Navy Captain and Professor of the Practice in the NPS Operations Research Department Jeff Kline, the following scenario was the environment given for the design challenge:

Preparing for Global War of 2035: War Plan Blue

A fictional scenario to support academic work

All Data on platforms and weapon systems have been derived from unclassified sources (Janes IHS, USNI publications, and websites.) Request for information may be addressed to Prof. Jeff Kline at jekline@nps.edu

2035 Political, Social, and Economic narrative:

Although the world's economic growth was severely arrested by the 2020 COVID 19 pandemic, countries around the world began studying their own nation's economic fragility with a goal of investing in national capabilities to address the most vulnerable sectors. None more so than the United States. U.S. production industries were given significant tax incentives to invest in more reliable sources of metals, commodities, and labor. Service and food sectors were granted significant funds to mature technologies which enabled additional resident work and home deliveries. The financial sector was explored for risk associated with international investments and encouraged to focus on more domestic and regional development.

As other nations followed suit, regional trade blocks began to emerge de facto with various degrees of unity. Lead by the United States, Mexico, Canada, and Brazil, the western hemisphere block is the most stable and near self-reliant. The Indo-South East Asian block-- with India and Australia sharing leadership in economic cooperation-- is next and included Indonesia, the Philippines, Kenya, Singapore, Taiwan, Vietnam, Thailand, and Brunei. The African Union's 55 member states expanded their organization's activities and accelerated their Agenda 2063 resulting in improved economic cooperation, growth, and social programs across the continent.

Less stable is the Russian-European trade region with tensions existing between the oil supplier, Russia, and the oil consumers, the rest of Europe. The most fractious region is Asia, with competition between China and Japan for political, economic and military leadership intensifying daily. Japan maintains her strong relationship with the United States and the Western trade block, while China continues her political, fiscal, economic, and military expansionism: attempting to "bridge" the Eurasian trade regions through infrastructure investment between Asia and Europe under the "Belt and Road" initiative. In 2035 China is the world's first economy, has a large and growing middle class population and consequently generates a higher demand for oil and natural gas, which she depends on Russia to provide.

China populated several islands terra-formed through dredging in 2015 with military installations. For example, Fiery Cross Reef has a squadron of J-20s with 10 Dark Sword UCAVs, while Fiery Reef, Mischief Reef, Gaven Reef, and Hughes Reefs have surface to air installations (S-500), anti-surface cruise missile mobile sites (advanced YJ-62s), electronic surveillance and communication sites, and ship support facilities. China is now building facilities on terra-formed islands made from the western end of the Scarborough Shoal reef, protested by the Philippines and the United States.

Japan and the United States have strengthened their social, economic, and military ties in response to the growing influence of both China and Russia and instability in the Asian region. The Yokosuka naval facility has evolved to a joint JMSDF and United States Navy base. In Sasebo, the United States Navy retains amphibious lift capability for both the U.S. Marine Corps and the Japan Maritime Defense Forces.

The United States also established closer ties to **Singapore**, stationing a squadron of LCS and P-8s and their shore support in the city-nation. The United States now maintains logistic support bases in Diego Garcia and pre-positioned expeditionary supplies in Subic, with joint agreements with the U.K. and Philippines respectively. These bases can act as "rapid build-up" support bases if the host country agrees. Additionally, the Philippines have invited the United States Air Force to use Clark AFB as an expeditionary field, expanding its role beyond joint training exercises. The United States Air Force has retained Kadena AFB on Okinawa, and III MEF occupies the air base in Henoko village. In addition, a U.S. Marine rotational force is in **Darwin, Australia**.

Australia has executed the programs envisioned in their 2016 defense white paper and built up their air and naval forces with the intent of closer cooperation with the United States. For example, 8 of a planned 12 Shortfin Barracuda SSKs are now operational and the RAAF operates 15 P-8 and 7 MQ-4C Triton from Edinburgh conducting frequent bi-lateral exercises with the United States and other countries from the Western hemisphere and Indo-South East Asian trade blocks.

The Edge of Conflict: Back in 2025

In the future scenario just described, extended conflict within and across regions is more likely across all spheres of national power—economic, society, financial, information, and military. In 2026 the President issues a classified Executive Order for the Department of Defense to resurrect the 1930's War Plan Blue process. War Plan Blue was a series of studies and plans to identify and execute preparations to improve the nation's ability to respond--and increase its resilience to maintain-- an extended conflict with Germany or Japan. The updated effort will address the same objectives for Russia and China. The order specifically highlighted the need to identify emerging technologies which may be employed in national defense, manufacturing, mobilization, transportation, communications, health services, and host-nation (allied) support. Recognizing the efforts to increase the self-reliance of the national economy in response to COVID 19, the Presidents wants to apply similar measures to other national sectors to prepare for an international crisis.

A major interagency, inter-state, and industry organization is formed to address the national sectors previously listed. Inside the team focusing on national defense, questions arise on the United States' ability to defend and maintain forwarding basing in an extended conflict as envisioned by the concepts of expeditionary basing, distributed maritime operations, and cross domain operations. This straight forward operational question has tactical and strategic implications, particularly when sea lines of communication may be threatened along the United States shoreline and ports, along the route, and approaching the final port destinations. The tactical need for "port breakouts" to defend ports and departing ships from submarine missile and torpedo attacks, as well as the strategic need to maintain space-based ISR capabilities come into play. And, on a national scale, can the national population support the need to reinforce and replace forces forward deployed, and if not, can forces deployed forward in 2035 be designed to minimize the need for reinforcement and replacement through unmanned systems and autonomy? And where might these forward based forces be located? What is the best geographic locations for employing weapons, force defense, logistic resupply, and rapid construction? Are these locations political feasible from an allied view point? Can exercises be conducted with allies to make them more political feasible?

As George Washington said, "To Be Prepared for war is one of the most effective means of preserving the peace".

And now, the work begins.

<u>Orders of Battle in 2035</u>

The following list is not exhaustive. Programs and/or platforms not listed but programmed for IOC earlier than 2035 may be introduced.

From the Order of Battle *(see next section)* ***the disposition of United States Forces are as follows:***

US Forces Immediately Available for use in the Europe in 2032

Maritime Forces

IWO JIMA ESG with MAGTAF embarked conducting bi-lateral exercise with Spain in Bay of Biscay
BUSH CSG underway in transit from Norfolk to Med 150 nm west of STROG
Two Virginia class SSN on patrol in North Atlantic
2 LCS (One mine warfare and one ASW configured) in port Gothenburg, Sweden
2 DDGs in port visit Malta
2 DDGs in Rota, Spain
1 DDG in the Eastern Med on TBMD station
Three JHSV's operating in English Channel with French forces

Air Forces

35 F-35Cs in Aviano, Italy
25 F-22s in Aviano Italy
16 P-8s in Italy
2 AWACS from Ranstein USAF

Army forces

2nd Cavalry Rgt (Stryker) in Vilseck, Germany
173rd Airborne Brigade in Vicenza, Italy
41st Field Artillery Brigade Grafenworhr, Germany

12th Combat Aviation Bde, Ansbach, Germany
10th Army Air and Missile Defense Kaiserslautern, Germany
U.S. Army NATO Brigade, Sembach, Germany
21st Theater Sustainment Command, Kaiserslautern, Germany

US Forces engaged in 2nd Battle for Philippine Sea in South/East China Sea, Philippine Sea, and Western Pacific

Maritime and Land Forces
Three SSNs on patrol in South and East China Sea
Two SSNs on patrol in Western Philippine Sea
Two SSNs on patrol in Eastern Philippine Sea
GW CSG underway 300 nms east of Guam
REAGAN CSG underway in Eastern Pacific
Two DDGs and three LCS providing TBMD and area ASW 50 nm west of Guam
Three DDGs with five MSC ships transiting Philippine Sea toward Port of Tacloban, Leyte, Philippines
Squadron of P-8s in Guam and another Squadron in Singapore
Five DDGs, Six SSNs, 4 LDUSV, 20 MDUSV, 5 TRITONs, 10 LDUUV in Guam
Eight LCS in Singapore
Three JHSV's currently in port White Beach, Okinawa
Three DDGS, Four FFGs in Yokosuka, Japan
Remaining Pacific Fleet forces in Hawaii and CONUS bases
40 Anti-ship mobile missile batteries (Naval Strike Missile) USMC/ARMY along first island chain
30 C4ISR mobile sites USMC/ARMY along first island Chain
15 mobile air defense sites USMC/ARMY long first island Chain (Patriot)
4 Marine Corps EABF with 20 F35B in bases per the scenario

Air Forces
8th and 51st Fighter Wing South Korea (40 F-16 Mission Capable)
18th Fighter Wing Kadena, Okinawa (15 F-35 and 10 F-22 Mission Capable)
35th Fighter Wing Misawa, Japan (25 F-22 and 20 F-35 Mission Capable)
3rd Air Wing Elmendorf, Alaska (30 F-22, 20 F-35, 15 Global Star UAV Mission Capable)
15th Air Wing Pearl Harbor (30 F-22, 20 F-35 mission capable)
Expeditionary Air Wing, Andersen AFB, Guam
    6 B-1, 4 B-2, and 4 B21 Mission Capable
    25 F22 and 15 F-35 mission Capable
    4 E-8C
Expeditionary Air Wing Pearl Harbor
    6 B-1, 4 B-2 and 6 B21 Mission Capable
50 KC 46 Tankers are available throughout theater

Robust Special Operations Forces and logistics exist and many are forward executing the "Global SOF" concept including Riverine Forces (Riverine Forces are currently based in San Diego and Norfolk

Russian Forces available in conflict Regions

<u>Mediterranean, Baltic and Eastern Atlantic (SSNs and SSKs) :</u>
NAVY

4- Project 885-M Yasen M-class SSGN (on patrol Atlantic)
4 – Lada class conventional Submarines (Kilo replacement) in Med
2 – Kilo (Project 636) class Submarines in Med
1– Leader class CG (Project 23560)
4 – Grigorovich(Project 11356M) FFGH
3 – Gorshkov (Project 22350) FFGH
4 – Buyan-M class corvette
In Kaliningrad:
4 Gorshkov (Project 11356M) FFGH
4 Modified Alligator Class (LSTHM)

AIR FORCE In Syria

10 – SU57 in Syria
20- SU35S in Syria
3 – AN-30 Surveillance A/C in Syria
15 Tu-160 Blackjack in Russia

AIR FORCE In Baltic

25 – SU35S in Kaliningrad
5 – AN-30 Surveillance A/C in Kaliningrad
15 Tu-160 Blackjack in Russia

LAND FORCES

336th Marine Brigade (2000 men and fighting vehicles) in Kaliningrad
152nd Guards Missile Brigade SS22 Stone missile in Kaliningrad Oblast
2 Brigades from the 76th Air Assault Division with airlift
5 Brigades in position along Suwalki Gap

<u>Pacific:</u>
NAVY

4 – Petersburg-class conventional Submarines (Kilo replacement)
3 – Dolgorukiy-class SSBN
3 – Severdvinsk-class SSGN
1 – Kilo SSN
1 – Lider-class CG(N)
2 – Sovremenny DDG

6 – STEREGUSHCHIY Class FFG
2 – Gorshkov FFG
10 SVIYAZHSK class PGM
25 – SU-30M Aircraft
10—Altius M UCAVs

Multiple small vessels and support ships

AIR FORCE

25 – SU57
5 – AN-30 Surveillance A/C

Japan Maritime Self Defense Forces

20 - SSK (Improved Oyashio Class)
5 - SSK (Old Oyashio Class)
4 - DDHM (Future Destroyer Class: aviation capable)
10 - DDGHM (Improved Kongo Class: 5 TBMD capable)
5 - DDGHM (Kongo Class)
9 - DDGHM (Murasame Class)
4 - FFGM (Abukuma Class)
5 - LPD (Oosumi Class)
20 - PGGF Hayabusa Class
50 - MMA Boeing 767
50 - F-35C
40 - F-35 VSTOL for Deploying on Future Destroyer Class

China's Forces

4 SSBN (Type 94) (All based in Jianggezhuang with one always on patrol)
6 SSN (Type 95) (Based in South China Seas Fleet)
6 SSN (Type 93) (6 based in South China Fleet and deploy to I/O while remaining in Northern Fleet)
30 SSK (Type 041 Yuan) (20 in South China Fleet and deploy to I/O, while remaining 10 are stationed in Northern Fleet)
8 SSK (Type 039G Song) (4 in South China Fleet and 4 in Northern Fleet)
5 SSK (Kilo 636) (All in South China Fleet)
2 DDGs (Sovermenny-modified) (3in South China Fleet Deploying to I/O, 2 in North Seas Fleet)
4 DDGs (Type 52D Luyang class) (both in East China Sea Fleet)

2 DDGs (Type 52C Luyang class) (both in South China Sea Fleet)
2 DDGs (Type 52B Luyang II class) (All in South China Fleet deploying to I/O)

20 FFGs (Type 054 A Jiangkai II class) (2 based in Burma, 4 always deployed to Pakistan, 8 in South Seas Fleet and 6 in North Seas Fleet)
10 FFGs (Type 053 Jiangwei I class) (All based in East Seas Fleet)
5 FFGs (Type 53 Jianghu V class) (All based in East Seas Fleet)
20 Corvettes (Type 056 Jiangdao corvette) (10 in South China Sea and 10 in East China Sea)
60 PGGF (HUOBEI Class) (8 deployed to Pakistan, 8 deployed to Burma, 30 in South Seas Fleet, 10 in East Seas Fleet, 4 in North Seas Fleet)
25 Older PTGs of various class. (All deployed in South Seas Fleet)
1 LHD (Type 081 class) In support of Guangzhou Military District Forces
5 LPD (YUZHAO class Type 071) All in support of Guangzhou Military District Forces
25 LST Yuting II Class All in support of Guangzhou Military District Forces

200 Su-33 Flanker Land-based maritime capable aircraft (20 in Woody Island, 20 in Pakistan, 30 in Myanmar and 130 remaining in China)
100 FC-1 Fierce Dragon (20 with Pakistan Air Force, 80 remaining on China mainland)
300 J-10 Vigorous Dragon (20 in Burma, 40 in Pakistan, and 240 remaining in China
100 J-11 Aircraft (20 in Pakistan, 80 remaining in China)
25 J-20 Air superiority fighter (all in China)
60 Chinese Y-8FQ MMA (ASW, ASUW, ELINT and Maritime Search capable with Boeing 767 range. 5 deployed to Pakistan, 5 deployed to Malaysia, 5 deployed to Burma, 5 deployed to the Seychelles, 20 to South Seas Fleet, 10 to East Seas Fleet and the remaining to North Seas Fleet)
20 H-6K and 25 H-20 (sleath) bombers ASCM capable
10 TU-154 M/D and 20 Y-8XZ Electronic intelligence and Electronic Warfare aircraft
80 Y-8/Y-9 Transport Lift Aircraft
20 Y-20 Strategic Lift Aircraft and Tanker variants

Guangzhou Military Region Land and Missile Forces

124th Amphib Mech Division
144th Division
121st Infantry Division
123 Motorized Division
80 DF-21Ds (Anti-ship Ballistic Missile) Range 1500 km
40 DF-26 (Anti-ship Ballistic Missile) Range 5000 km
100 CSS-5s
100 CSS-3/DF-4 LRBM

Chinese UAVs

160 Soaring Dragon (High Altitude Long Endurance)
Speed: 470 kts; Range: 4700 nm; Alt: 57,000 ft; Function: ISR

100 Pterodactyl (Stealth Medium Altitude Long Endurance)
Speed: 174 kts; Range: 2500 nm; Alt: 17,000 ft; Function: ISR, Strike

224 ZOND UAV (High Altitude Medium Endurance)

Speed: 135 kts; Range: 6000 nm; Alt: 49,000 ft; Function: ISR, EW

300 ZOND UCAV (High Altitude Long Endurance)
Speed: 135 kts; Range: 6000 nm; Alt: 49,000 ft; Function: ISR, EW, Strike

30 Dark Sword UCAV
Speed: (Unk) Supersonic; Range: Unk; Alt: Unk; Function: Strike, Air-to-Air

Australia Maritime and RAAF forces

8 SSK Barracuda submarines advanced AIP SSKs
3 DDG "SEA 5000" project destroyers. Capabilities similar to FLT III Burke DDG
10 PGMs "SEA 1180" project missile boats or OPVs. Capabilities and size of current Armidale-class boats
24 MH-60R combat helicopters.
70 F-35 Lightning II JSF
12 P-8 Poseidon Maritime Patrol Aircraft
7 Triton UAS

Taiwan Naval Forces and Air Forces

4 New Generation Frigates NCSIST (8 ASCM, phased-array air defense radar and missile capable of 75 nm intercepts)
4 Tuo Jiang Missile Corvettes
30 Kaung Hua 6 upgrade Fast Attack Missile craft
2 Hai Lung II attack submarines
12 P-3 C aircraft
25 F-35A
60 F-16E/F

Vietnam Naval Forces

3 SSK (Kilo)
4 FFGM (Gepard)
2 FSGM (Project 12418)
10 FSGM (Tarantul V class)
8 PGM (Svetlyak class)
8 PGM (OSA II)

Singapore's Naval and Air Forces

3 SSK (Challenger Class improvements)
6 FFGM (Formidable Class)

3 Victory Class Corvettes
7 PGM (new class)
4 MCM
32 F-35s
20 Apache Longbow

Other countries contributions limited to their own territorial waters: Philippines and Indonesia

<u>Philippines Forces</u>

3 Blue Water Escorts (Hamilton Class)
1 LCU
3 SSK (Chang Bogo Class)
4 Corvettes (Minerva Class)
1 FFG (Maestral Class)

<u>Indonesia Forces</u>

6 FFG (Yoni Class)
3 SSK (Chang Bogo Class)
2 SSK (Cakra Class)
23 Corvettes (Nakhoda Ragam Class)
Various Fast Attack and Patrol Craft

Operational Areas

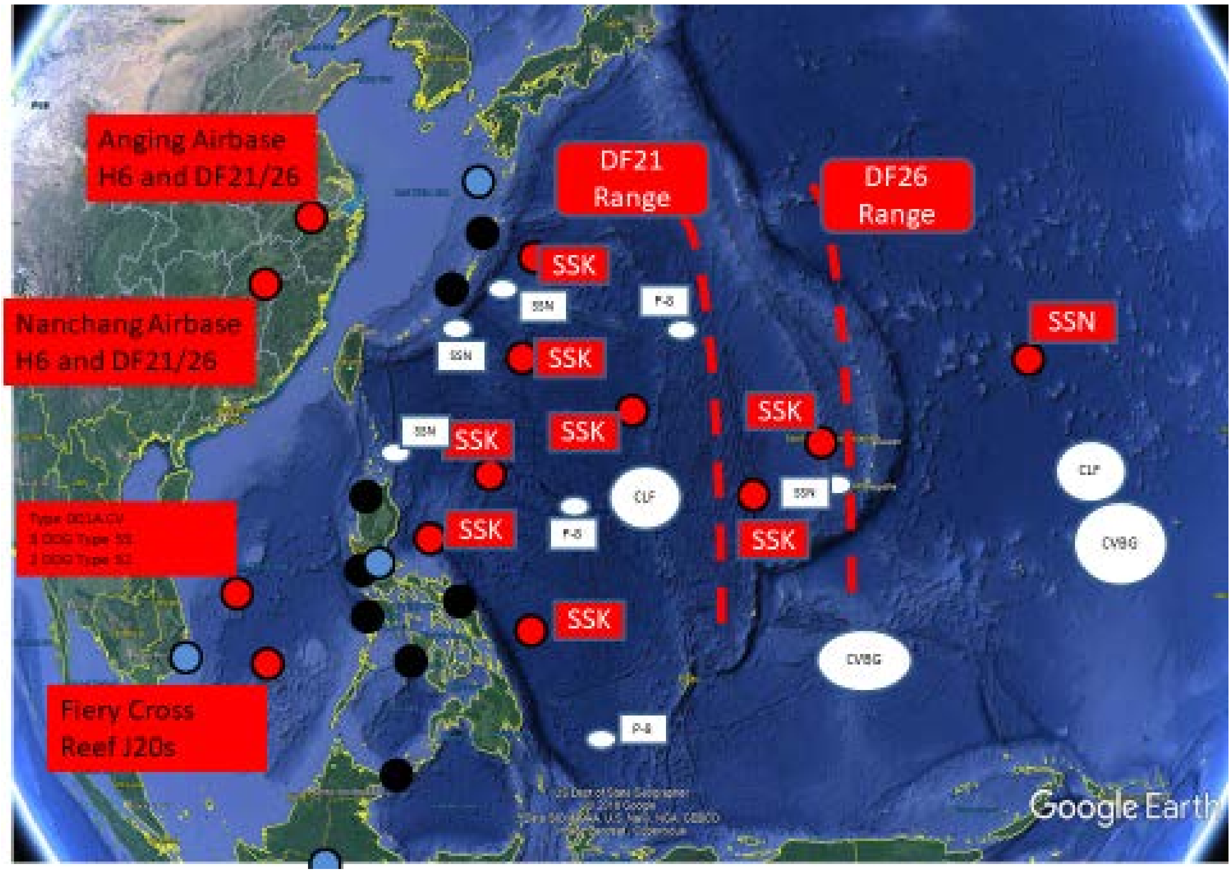

Figure 51. Overview of *Year 2032 Second Battle of the Philippine Sea* as included in the *Global War 2035: War Plan Blue* scenario.

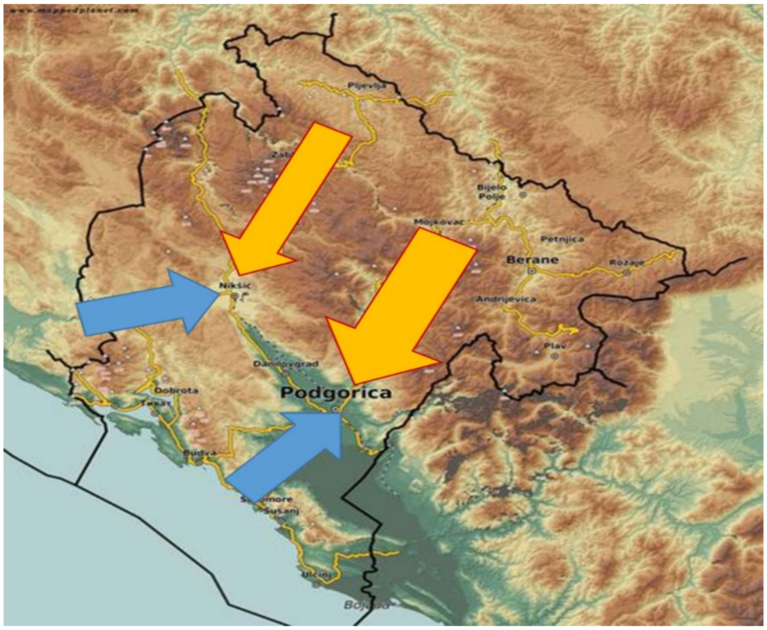

Figure 52. Situation in the Adriatic as described in the *Global War 2035: War Plan Blue* scenario.

Figure 53. Russian invasion through the Suwalki Gap as described in the *Global War 2035: War Plan Blue* scenario.

Sea Lines of Communication

Figure 54. Atlantic Ocean areas requiring robust sea lines of communications in the *Global War 2035: War Plan Blue* scenario.

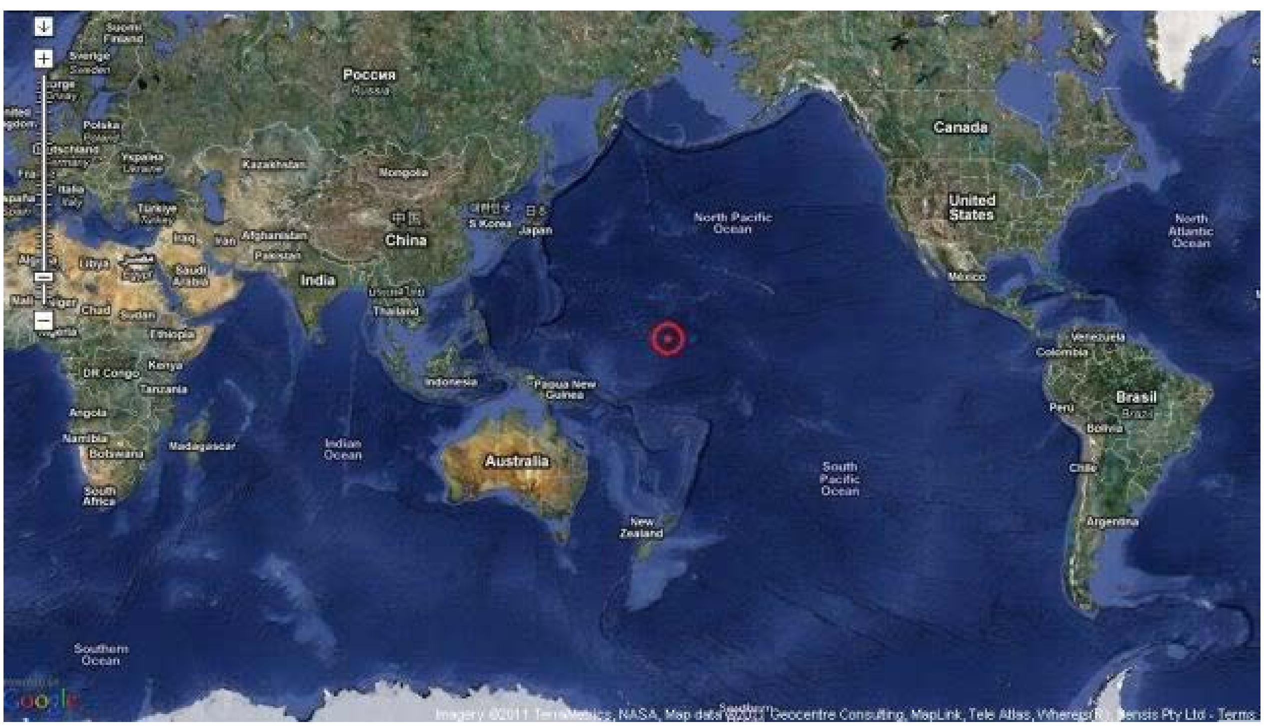

Figure 55. Pacific Ocean area requiring robust sea lines of communication in the *Global War 2035: War Plan Blue* scenario.

Additional Reference Information on Weapon Systems

USA Forces

CVN-78 (GERALD FORD Class)

- Max Speed: 30+ kt
- Self Defense Missiles:
    - Evolved Sea Sparrow Missile (ESSM)
    - Rolling Airframe Missile (RAM)
- Aircraft carried:
    - 12 x F-35C
    - 36 x F/A-18E
    - 12 x EA-18G
    - 8 x MQ-25A Stingray (UAV Tanker)
    - 4 x E-2D (early warning)

DDG-1000 (ZUMWALT Class)

- Max Speed: 30+ kt

- Launcher:
  80 cells - Mk 57 Advanced Vertical Launching System (VLS)
- Missiles Supported:
  - Maritime Strike Tomahawk (MST)
  - SM-6 (Extended Range SAM and SSM)
  - SM-2 (Medium Range SAM)
- Guns: 2 x Electro-Magnetic Rail Gun (EMRG)
- Organic Aircraft
  - 1 x MH-60R ASW/SUW
  - 1 x Tactically Exploitable Recon Node (TERN – vertical take-off UAS)

DDG-51 Flt III (ARLEIGH BURKE Class)

- Max Speed: 30+ kt
- Radar: SPY-6(V) Air and Missile Defense Radar (AMDR)
- Launcher:
  96 cells - Mk 41 Vertical Launching System (VLS)
- Missiles Supported:
  - Maritime Strike Tomahawk (MST)
  - SM-6 (Extended Range SAM, SSM and Terminal BMD)
  - SM-2 (Medium Range SAM)
- Organic Aircraft
  - 1 x MH-60R ASW/SUW

- 1 x Tactically Exploitable Recon Node (TERN – vertical take-off UAS)

  OR

- 2 x MH-60R ASW/SUW

DDG-51 Flt IIA (ARLEIGH BURKE Class)

- Max Speed: 30+ kt
- Radar: SPY-1D(V)
- Launcher:
  96 cells - Mk 41 Vertical Launching System (VLS)
- Missiles Supported:
  - Maritime Strike Tomahawk (MST)
  - SM-6 (Extended Range SAM, SSM and Terminal BMD)
  - SM-2 (Medium Range SAM)
- Organic Aircraft
  - 1 x MH-60R ASW/SUW
  - 1 x Tactically Exploitable Recon Node (TERN – vertical take-off UAS)

    OR

  - 2 x MH-60R ASW/SUW

LCS (INDEPENDENCE Class)

- Max Speed: 50 kt
- Box launchers supporting:
    - 4 x Over-the-Horizon Weapons System (OTH-WS, SSM)
    - 11 x Sea Rolling Airframe Missile (RAM)
- Organic air assets:
    - 1 x MH-60R Helo
    - 1 x UAV MQ-8B Fire Scout

LHA-6 (AMERICA Class)

- Max Speed: 22 kt
- Self Defense Missiles:
    - Evolved Sea Sparrow Missile (ESSM)
    - Rolling Airframe Missile (RAM)
- Organic air assets:
    - 12 x F-35B
- b. 4 x Tactically Exploitable Recon Node (TERN – vertical take-off UAS)

Mk VI Fast Patrol Boat

- Max Speed: 45 kt
- Box launcher supporting:
  2 x Over-the-Horizon Weapons System (OTH-WS, SSM)

Medium Displacement Unmanned Surface Vehicle (MDUSV)

- Max Speed: 27 kt
- Cruising Range: 10,000nm at 12kt
- Box launcher supporting:
  4 x Over-the-Horizon Weapons System (OTH-WS, SSM)
- Special Capabilities:
  a. Autonomous
  b. Towed Airlift of Naval Systems (TALONS) – parasail sensor platform

SSN-774 (VIRGINIA-Class)

- Max Speed: 34 kt
- Weapons:
    a. 4 x Bow Tubes (magazine capacity for 38 Mk-48 ADCAP)
    b. 12 x VLS cells (carries Maritime Strike Tomahawk)

P-8A Poseidon

- Max Speed: 34 kt
- Weapons:
    a. 4 x Bow Tubes (magazine capacity for 38 Mk-48 ADCAP)
    b. 12 x VLS cells (carries Maritime Strike Tomahawk)

Patriot Advanced Capability – 3 (PAC-3)

- Capabilities:
    a. Terminal-phase ballistic missile defense
    b. Air warfare
- 96 missiles per PAC-3 battery

Terminal High Altitude Area Defense (THAAD)

- Capabilities:
    a. Terminal-phase ballistic missile defense
    b. Air warfare
- 96 missiles per PAC-3 battery

All data on platforms and weapon systems have been derived from unclassified sources such as Janes IHS, USNI publications, and other open source websites. ***Request for information may be addressed to Prof. Jeff Kline at jekline@nps.edu***

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APPENDIX C: Workshop Schedule

The three-and-a-half-day workshop started on Monday morning with an overview of the workshop, scenario, and design challenge followed by two of three knowledge leveling Discovery Panels. Initial team meetings concluded the first day. Both Tuesday and Wednesday started plenary Discovery Panels followed by a full day of concept generation work. Teams presented their final concepts on Thursday morning and the workshop adjourned by noon – because screen fatigue is real.

MON – 21 September

		NPS Teams MAIN ROOM (virtual)
0830	Welcome	VADM Ann Rondeau USN (ret), NPS President
0845	NPS NWSI, Warfare Innovation Continuum & Scenario	CAPT Jeff Kline USN (ret), NPS NWSI Director
0930	Process & Resource Review	Ms. Lyla Englehorn, NPS NWSI Associate
1000	BREAK	
1030	**Discovery Panel I**	**Intelligence, Surveillance, Reconnaissance (ISR) & Defense Technology**

SPIDERS3D Visualization Tool	Dr. Don Brutzman, NPS Information Sciences
The Promises of Technology and the Realities of War	LtCol Dakota L. Wood USMC (Ret), Senior Research Fellow, Defense Programs, The Heritage Foundation
A Few Thoughts on UxS	Mr. Jason Boxerman, NSWC Panama City
Future Naval UUV Applications	Mr. Jeff Smith, BAE Systems - Riptide
Mobile Microgrid Capabilities	Mr. Michael Gonzalez & Mr. Noel Pleta, U.S. Army Combat Capabilities Development Command (DEVCOM)
MODERATOR	Dr. Dan Boger, NPS GSOIS Acting Dean

1200	BREAK

1230	**Discovery Panel II**	**Industrial Resilience & Supply Chain Vulnerability**

Critical Minerals and Strategic Materials	Dr. Shannon Brown, NPS CHDS
Semiconductor Manufacturing Trends and Risks	Mr. Ajit Manocha, SEMI President & CEO
Asymmetric Industrial Warfare	Mr. David Newborn, NSWC Carderock
System Analysis & Risk Assessment	Dr. Elisabeth Paté-Cornell, Stanford University School of Engineering
The Dangers of Financialization	Ms. Rana Foroohar, Financial Times
MODERATOR	Dr. Sheila Vaidya, Headquarters Marine Corps

1400	Tasking	CAPT Jeff Kline USN (ret), NPS NWSI Director
1415	Initial Team Meetings	**Virtual BREAKOUT ROOMS**
1500	**"After Hours" Talk –** *Useful Fiction: How A Story Well Told Can Allow Us to Understand the Future*	Dr. P.W. Singer, New America

TUES – 22 September		**NPS Teams MAIN ROOM**
0830	Welcome NPS CRUSER	Dr. Brian Bingham, NPS CRUSER Director
0845	**Discovery Panel III**	**Intelligent Autonomous Systems (IAS) & Biologics**

Enhanced Warfighters	Dr. Raymond Buettner, NPS Information Sciences
Making a New War Plan Blue *Work*: Leveraging Unmanned Maritime Systems	CAPT George Galdorisi USN (ret), NIWC PAC
Persistence in the Pacific	Mr. JD Work, MCU Bren Chair of Cyber Conflict & Security
Worse than Death: the Terrible Threat of Artificial Superintelligence	Mr. Jonathan Cefalu, CEO & Founder NeuroBinder
Rethinking Space Systems Architecting from an AI Perspective	Mr. Zigmond Leszczynski, The Aerospace Corporation
MODERATOR	Dr. Raymond Buettner, NPS Information Sciences

1015	**BREAK**	
1100	Concept Generation – **Divergent**	**Virtual BREAKOUT ROOMS**
1100	Mentor Tasking	**NPS Teams MAIN ROOM**
1300	Concept Generation – **Divergent to Convergent**	**Virtual BREAKOUT ROOMS**

<u>WED – 23 September</u>		**<u>NPS Teams MAIN ROOM</u>**
0830	Welcome & Admin Notes	Dr. Carl Oros, NPS CRUSER Associate Director
0845	**Discovery Panel IV**	**Innovation**

Complexity	Mr. Garth Jensen, NSWC Carderock
Wargaming to Approach Military Challenges	Dr. Don Thieme, NWC Wargaming
Approaching Gnarly Military Challenges Through Design	Mr. Dave Nobles, JHU/APL TANG
The Military v. Corporate Innovation Divide	Mr. John Hawley, JWH Enterprise LLC
MODERATOR	Col Todd Lyons USMC (ret) NPS Innovation Facilitator

0930	**BREAK**	
1000	Concept Generation – **Convergent**	**Virtual BREAKOUT ROOMS**
1100	Directors & Chairs Rotation	**Virtual BREAKOUT ROOMS**
1300	Concept Development – **Final Push**	**Virtual BREAKOUT ROOMS**

<u>THUR – 24 September</u>		**<u>NPS Teams MAIN ROOM</u>**
0800	Team Photos & Evaluation	
0830	Final Briefs	
1200	**ADJOURN**	

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LIST OF FIGURES

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LIST OF ACRONYMS AND ABBREVIATIONS

4IR	Fourth Industrial Revolution
AI	artificial intelligence
AM	additive manufacturing
ASW	anti-submarine warfare
BIX	NPS Big Ideas Exchange
C2	command and control
CAC2S	common aviation command and control system
CISER	Consortium for Intelligent Systems Education and Research
CNO	Chief of Naval Operations
COA	course of action
COCOM	combatant command
CONOPS	concept of operations
CONUS	continental United States
COP	common operational picture
CRUSER	Consortium for Robotics and Unmanned Systems Education and Research
CTP	common tactical picture
DoD	U.S. Department of Defense
EABO	expeditionary advanced basing operations
ECI	economic complexity index
EO/IR	electro-optical infrared sensors
FOB	forward operating base
GAD	gravitational anomaly detectors
GDP	gross domestic product
GPS	global positioning system
HEL	high energy lasers
HPM	high-power microwave
HUD	heads-up display
HVU	high value unit
IAS	intelligent autonomous systems
ISR	intelligence, surveillance, and reconnaissance
JHU/APL	The Johns Hopkins University Applied Physics Laboratory
LDUUV	large displacement unmanned undersea vehicle
LEO	low Earth orbit satellites
LiDAR	light detection and ranging
LMADIS	light marine air defense integrated system
MAD	magnetic anomaly detectors
MCWL	Marine Corps Warfighting Lab
MOVES	NPS Modeling Virtual Environments and Simulation Institute
NIWC	Naval Information Warfare Center

NM	nautical mile (*about 1.15 miles*)
NPS	Naval Postgraduate School
NRP	NPS Naval Research Program
NSWC	Naval Surface Warfare Center
NUWC	Naval Undersea Warfare Center
NWC	Naval War College
NWDC	Navy Warfare Development Command
NWSI	NPS Naval Warfare Studies Institute
ONR	Office of Naval Research
OODA	observe–orient–decide–act loop
OPNAV	Office of the Chief of Naval Operations
PPBE	planning, programming, budgeting and execution
QRF	quick reaction force
RADAR	radio detection and ranging
RoE	rules of engagement
SAR	synthetic-aperture radar
SECNAV	Secretary of the Navy
SONAR	sound navigation and ranging
SOP	standard operating procedures
SoS	system of systems
STEM	science, technology, engineering, and math
TDSI	Temasek Defence Systems Institute
UAV	unmanned aerial vehicle
UGV	unmanned ground vehicle
UNCLOS	United Nations Convention on the Law of the Sea
USAF	U.S. Air Force
USFF	U.S. Fleet Forces
USMC	U.S. Marine Corps
USMC CD&I	USMC Combat Development and Integration
USN	U.S. Navy
USNI	U.S. Naval Institute
USNR	U.S. Navy Reserves
USV	unmanned surface vehicle
UUV	unmanned undersea vehicle
UxS	unmanned systems – all domains
UxV	unmanned vehicle
VUCA	volatile, uncertain, complex and ambiguous
WIC	NPS Warfare Innovation Continuum