CONSORTIUM FOR ROBOTICS AND UNMANNED SYSTEMS EDUCATION AND RESEARCH (CRUSER):

Logistics in Contested Environments

Warfare Innovation Continuum (WIC) Workshop September 2019

After Action Report

Prepared by Lyla Englehorn, CRUSER Associate Director
for
Dr. Brian Bingham, CRUSER Director;
and CAPT Jeff Kline USN retired, Professor of the Practice NPS Operations Research Department

NAVAL POSTGRADUATE SCHOOL

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- To our visiting subject matter experts, mentors and observers; and to our resident subject matter experts for sharing their time and expertise with the participants to better prepare them for their work.

- To all the participants for your time, professionalism, input based on your unique experience and expertise, and especially your willingness to help shape the future of our Navy.

EXECUTIVE SUMMARY

This Consortium for Robotics and Unmanned Systems Education and Research (CRUSER) sponsored Warfare Innovation Continuum (WIC) workshop was held 23-26 September 2019 on the campus of the Naval Postgraduate School (NPS) in Monterey, California. The three and a half day experience allowed NPS students focused interaction with faculty, staff, fleet officers, and visiting engineers from Navy labs and industry. The workshop culminated in a morning of final concept briefs and fruitful discussion regarding the role of unmanned systems in the future naval force. This workshop also directly supported the Secretary of the Navy's (SECNAV) direction that CRUSER foster the development of actionable operational concepts for robotic and autonomous systems within naval warfare areas and work with our industry partners.

The September 2019 workshop "Logistics in Contested Environments" tasked participants to apply emerging technologies to shape the way we fight. Within a near future extended conflict scenario, concept generation teams were given a design challenge: *How might emerging technologies be employed to support logistics in contested environments to accomplish missions more effectively and/or with less risk?* With embedded facilitators, teams had three days to meet that challenge, and presented their best concepts on the final morning of the workshop.

This September 2019 WIC workshop included 130 registered participants in the roles of team members, presenters, mentors, and observers – the full participant pool included representatives from 45 different organizations. Half of the workshop participants were NPS students drawn from curricula across the NPS campus. For this workshop, the final roster also included participants from The Johns Hopkins University Applied Physics Lab (JHU/APL), the Naval War College (NWC), Draper Labs, and Lockheed Martin. Fleet commands included Naval Air Systems Command (NAVAIR), Naval Undersea Warfare Center (NUWC) Newport, several Naval Surface Warfare Centers (NSWC), U.S. Fleet Forces (USFF), the Office of the Chief of Naval Operations (OPNAV), and the Office of Naval Research (ONR). The Royal Australian Navy (RAN) and the New Zealand Defence Force also sent representatives.

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. CRUSER and Warfare Innovation Continuum 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:

Assured Comms and Navigation: *cross-domain system of assets that requires ad hoc network for comms and navigation*
Business Use Case: *organizational solutions that may require cost-benefit analysis, policy revision or development, or other business process*
Ship-to-Shore Delivery: *concepts that aide the delivery of supplies from ship to shore*
Undersea Infrastructure: *development of the undersea infrastructure to support logistics*

Concept Development: *logistics support concepts in process that may warrant modification and further development*

Selected concepts will begin CRUSER's next Innovation Thread, and members of the CRUSER community of interest will be invited to further develop these concepts in response to the FY21 Call for Proposals. NPS students participating in Directed Study for the Warfighter (ME 4901 or IS 4800) will have the opportunity to prototype and test concepts of interest. and technical members of the CRUSER community may present proposals at a future technical continuum gathering such as TechCon 2020.

I. BACKGROUND

Sponsored by the OPNAV N9I Chair, Systems Engineering Analysis, and the Consortium for Robotics and Unmanned Systems (CRUSER), this Warfare Innovation Continuum (WIC) workshop was held on campus during Naval Postgraduate School (NPS) Thesis & Research Week, 23-26 September 2019. Tasked with developing concepts of operation (CONOPS) in a near future global scenario with simultaneous conflicts on several distinct fronts, participants generated and proposed technologies to support their CONOPS.

A. ORIGINS

Innovation and concept generation are key drivers for 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.

One of CRUSER's primary mandates is to develop a community of interest for unmanned systems education and research, and provide venues for communication. These workshops were also 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. 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. Following the fleet interests, last year's 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 technologies within a near future conflict in an urban littoral environment.

In the September 2019 WIC workshop focused on sustained logistics support with the design challenge: *How might emerging technologies be employed to support logistics in contested environments to accomplish missions more effectively and/or with less risk?* With embedded facilitators, seven concept generation teams had three days to meet that challenge and presented their best concepts at the end of

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

the workshop. Participants from government, industry and academia worked this design challenge and presented just over 20 unique concepts. Their work is the subject of this report.

B. PLANNING AND EXECUTION

Planning for this workshop began in earnest several months in advance of the event. 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.

1. Workshop Participants

Workshop participants were recruited from across the full CRUSER community of interest 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.

Figure 1. September 2019 Warfare Innovation Continuum (WIC) workshop participants

This September 2019 WIC workshop included 130 registered participants (*see Figure 1*) in the roles of team members, presenters, mentors, and observers – the full participant pool included representatives from 45 different organizations. Half of the workshop participants were NPS students drawn from curricula across the NPS campus. For this workshop, the final roster also included participants from The Johns Hopkins University Applied Physics Lab (JHU/APL), the Naval War College (NWC), Draper Labs, and Lockheed Martin. Fleet commands included Naval Air Systems Command (NAVAIR), Naval Undersea Warfare Center (NUWC) Newport, several Naval Surface Warfare Centers (NSWC), U.S. Fleet Forces (USFF), the Office of the Chief of Naval Operations (OPNAV), and the Office of Naval Research (ONR). The Royal Australian Navy (RAN) and the New Zealand Defence Force also sent representatives.

The seven concept generation teams were organized to maximize diversity of participant experience. Team workrooms provided 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. A group networking event was scheduled on the first night to enhance group dynamics, and prepare individuals to work efficiently in an intensive team environment. 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.

2. Workshop Design

The September 2019 workshop, “Logistics in Contested Environments,” 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.

Scenario

All participants were given an overview of the future scenario titled “Global War 2030 – two years in” focused on sustaining a future global conflict in multiple theaters two years after the start of hostilities. Derived from current open source media reports, this scenario reflects published thinking by current global military stakeholders. Teams were tasked with developing concepts of operations to counter multiple threats in a global warfare scenario but were not required to address the conflict in its entirety. A copy of their scenario is included at the end of this report (*see Appendix B*).

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 these six team presentations are included at the end of this report (*see Appendix A*), as well as the full workshop schedule (*see Appendix C*).

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II. CONCEPT SUMMARY

Knowledge-leveling concept overviews and technology injects related to the design challenge started the exploration into the problem space. Stakeholder perspective statements also focused the concept generation work. Based on the plenary session guidance, read-ahead materials, and subject matter expert input, each team generated numerous concepts and then selected their best ideas to present in their final briefs. Following the final briefs on Thursday 20 September 2019, CRUSER and WIC leadership identified ideas with potential operational merit that aligned with available resources for broader dissemination within the CRUSER community of interest.

A. Concepts and Technologies

Several emerging concepts and technologies were introduced during the plenary sessions on the first three days of the workshop.[2] 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. Plenary topics included logistics vectors, afloat subsistence, joint logistics, post supply chain logistics, and global logistics challenges.

The knowledge-leveling plenaries on Monday included an overview of logistics concerns from a variety of perspectives, a portfolio of emerging robotics and autonomy related technologies, a couple of developing technology case studies, industry perspectives on global logistics concerns, and a seminar on logistics lessons learned from history – specifically The Pacific Theater in WWII. Throughout the plenaries, speakers shared several examples of military approaches to innovation – some successful, some not – and lessons learned through past efforts.

B. Concepts of Interest

Key criteria used by the CRUSER selection committee to select concepts from all those proposed for further development were:

1) Is the concept feasible (physically, fiscally)?
2) Is the concept unique?
3) Is the concept testable?

The following taxonomy of systems was developed from selected concepts presented by each team, as well as additional concepts submitted, but not developed. Identified categories of interest include:

Assured Comms and Navigation: *cross-domain system of assets that requires ad hoc network for comms and navigation*

- ***Attritable Comms / Log System:*** current logistics distribution and resupply systems (*see p. 20*)
- ***SEASTAR:*** *Starry Night* system and *Sea Kelp* modular delivery system deployed in tandem leveraging celestial navigation (*see p. 26*)

[2] A schedule is available as Appendix C of this full workshop report.

Business Use Case: *organizational solutions that may require cost-benefit analysis, policy revision or development, or other business process*

- •***Logistics Force:*** four-star combatant command (COCOM) with funding from National Budget (*see p. 18*)
- •***MilMart:*** an Amazon Marketplace for the logistics supply officer (*see p. 41*)
- •***S.S. King's Point:*** reinvigorate the Merchant Marines through public private partnerships (*see p. 46*)
- •***LSX:*** *Landing Ship Expeditionary* to mirror the LSTs of WWII (*see p. 48*)

Ship-to-Shore Delivery: *concepts that aide the delivery of supplies from ship to shore*

- •***Sea Kelp:*** modular delivery system (*see p. 27*)
- •***ACDC:*** Autonomous Container Delivery Craft (*see p. 39*)
- •***PEA-PODS:*** Prepackaged Expeditionary Autonomous Precision Overboard Distribution System (*see p. 53*)
- •***ROOMBA:*** Remote Operated Overboard Mobile Boxes Ashore (*see p. 54*)

Undersea Infrastructure: *development of the undersea infrastructure to support logistics*

- •***ATLANTIS:*** Automated Theatre Logistics Arsenal Naval Tactical Integrated System (*see p. 31*)
- •***Submersible Deployed Fuel Bladder:*** forward deployed (*see p. 23*)

Concept Development: *logistics support concepts in process that may warrant modification and further development*

- •***Submersible Deployed Fuel Bladder:*** forward deployed (*see p. 23*)
- •***STEAAL:*** Surreptitious Tactical Expeditionary Alternate Acquisition Logistics (*see p. 56*)
- •***SEASTAR:*** *Starry Night* system and *Sea Kelp* modular delivery system deployed in tandem leveraging celestial navigation (*see p. 26*)

Unclassified details of these concepts as presented are included in Appendix A of this full workshop report.

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 Thursday 26 September 2019, CRUSER leadership identified ideas with potential operational merit that aligned with available resources. In brief, identified concepts fell into four primary topic areas:

Assured Comms and Navigation: *cross-domain system of assets that requires ad hoc network for comms and navigation*
Business Use Case: *organizational solutions that may require cost-benefit analysis, policy revision or development, or other business process*
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In addition to the concepts and technology proposals, the September 2019 workshop also supported other equally vital 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.

A. Warfare Innovation Continuum (WIC)

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.

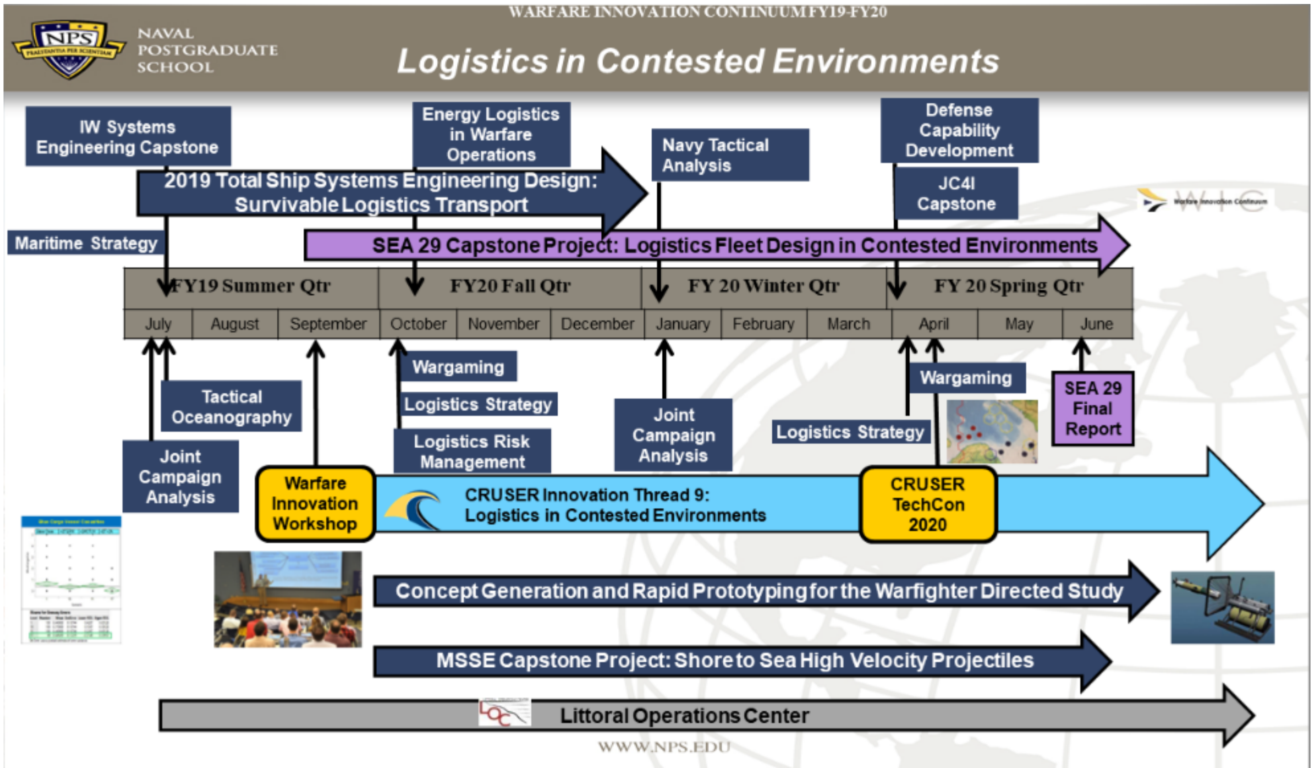

Figure 2. FY19-20 NPS Warfare Innovation Continuum (WIC), Logistic in Contested Environments.

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 FY19-20 WIC, "Logistics in Contested Environments" (*see Figure 2*), address the question, *"How might emerging technologies support logistics in a future battlespace?"* Final reports are available for all prior continuums dating back to 2013.

B. CRUSER Innovation Thread

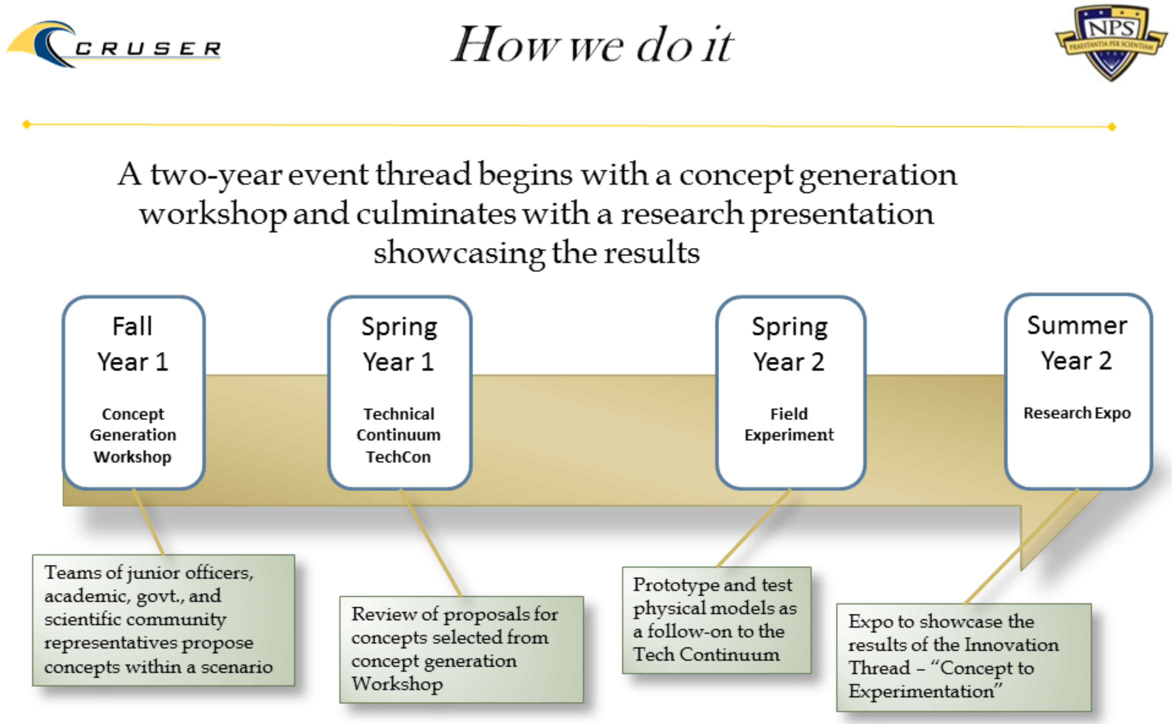

Figure 3. CRUSER Innovation Thread structure.

CRUSER organizes activities around a programmatic Innovation Thread structure (*see Figure 3*) in parallel with the Warfare Innovation Continuum thread. Each innovation thread starts with a concept generation workshop traditionally in September each year. Concepts of merit are identified, and technical members of the CRUSER community of interest are asked to submit proposals on how these concepts might actually work. Proposals are presented at an annual Technical Continuum (TechCon) or through a more formal call for proposals, and several are awarded seed funds to prototype and test the idea either through field experimentation or other means. Finally, findings of the seeded projects are presented to CRUSER sponsors and other community of interest members.

Since 2011 CRUSER has made progress along eight innovation threads (*see Figure 4*). The first seven Innovations Threads are complete, the eighth thread is underway, and Innovation Thread #9 started with this September 2019 Warfare Innovation Workshop and will finish in FY21.

Figure 4. CRUSER Innovation Thread overview as of October 2018.

APPENDIX A: Final Concepts

Five teams presented their final briefs on Thursday 26 September 2019, and were each given 15 minutes to present their most developed and promising concepts. The following concept summaries detail these final presentations. The team working the challenge at the classified level presented on Wednesday afternoon. A truncated, unclassified summary of the concepts they generated is included in this report.

A. Team Demeter

Figure 5. Members of Team Demeter *(pictured from left to right*) Jessica Wilson, Ann Gallenson, Dr. Michael Ouimet, LT Brian Bird USN, Maj Matthew Morse USMC, LT Kylen Lemenager USN, LTCDR Andy Robinson (New Zealand), Kevin Allshouse, and Capt Shawn Kunzler USMC (not pictured: Josh Smith)

The members of this team (*see Figure 5 and Table 1*) included five junior and mid-level officers representing the U.S. Navy and U.S. Marine Corps (USMC) and the New Zealand Navy, two early career engineers, one NPS faculty member, and four NPS students. This team was facilitated by an NPS faculty member and a guest from academia, and their work was supported by an NPS intern.

Table 1. Members assigned to Team Demeter (*alphabetical by last name*)

NAME	PERSPECTIVE	AFFILIATION
Mr. Kevin Allshouse	*Innovation & experimentation*	USINDOPACOM J81
LT Brian Bird USN	*Student*	NPS Defense Analysis student
Ms. Ann Gallenson	*Facilitator*	NPS Center for Executive Education
Capt Shawn Kunzler USMC	*Combat engineer*	NPS National Security Affairs student
LT Kylen Lemenager USN	*Surface warfare*	NPS Systems Engineering Analysis student
Maj Matthew Morse USMC	*Logistician/PhD Student*	NPS Modeling & Simulation student
Dr. Michael Ouimet	*Machine learning*	NIWC Pacific
LTCDR Andy Robinson	*Supply officer*	New Zealand Navy
Mr. Josh Smith	*Facilitator*	JHU/APL TANG

Team Demeter, also called the “Triple Threat Logisticians”, presented three concepts:

1) Logistics Force
2) Attritable Comm / Log System
3) Forward Deployed Fuel Bladder

Figure 6. In 2032 the U.S. Marines (*bottom left*) have landed on the island of Natuna Besar (*top left*) occupied by hostile Chinese forces and must resupply in a degraded communications environment (*top right*) and nearby supply depots are empty (*bottom right*).

The challenge, restated by Team Demeter, is that it is the year 2032 and we’ve been fighting the Chinese for two years (*see Figure 6*). The Chinese have invaded Natuna Besar (*see Figure 6, top left*), a contested island in the South China Sea, and it is the job of the U.S. Marines to get them off this island. The Marines have landed on the island (*see Figure 6, bottom left*) controlled by the Chinese and they need supplies, but communications have been denied so how do they get what they need?

1. Logistics Force

The first challenge that Team Demeter addressed was in this scenario *how does the USMC get supplies and return to the fight ASAP?* Their proposed solution is the Logistics Force. In a compromised communications environment without access to the logistics network, the Marines in this scenario had to retreat to resupply. Team Demeter proposed universalizing everything within the fight so when the Marines pull into port unannounced – any allied port such as Darwin, Australia in this example – they can leave with everything that they need from fuel to medical supplies with a very short turnaround time. In a denigrated communications environment where resupply becomes an issue due to unavailable standard networks, retreat to resupply may be an option. Although there are supplies available via afloat sea bases, both distance and compromised communications create a complicated environment. In this scenario a commander’s backup plan may be to sail to Darwin Australia as it is only a couple of days away. The Australian military has common training, expertise and equipment to provide the resupply needed to return to the fight.

Structure

Team Demeter proposed this Logistics Force be led by a Four-Star Admiral, sitting beside the Chairman of the Joint Chief of Staff and Secretary of Defense (SECDEF), and have dedicated funding in the National

Budget. "If we're going to put a lot of emphasis on logistics let's make it part of the plan from acquisitions to operations." Development plans and designs for the future will include the standardization of parts and materials, and simplified standard networks that talk the same language. "Every part has the same identification number" further hardening the system to defend it against the adversary and sustain the lines of communication across the global front. With funding directly from the National Budget gives fiscal stability to support this initiative.

Industry will be essential to the success of Logistics Force, so Team Demeter recommended building alliances with industry for early buy-in with incentives. Improving relationships with the commercial sector is a resource to develop. "If we can incentivize our foreign and domestic partners we can stay ahead of the logistics train" that the private sector is currently driving. The private sector is by far exceeding the military capabilities "and they can teach us versus us trying to recreate the wheel." Beyond having allied buy-in, they can also share the same parts so it does not matter if it comes from the Army or the Navy or the New Zealand Navy or the Australian Army– it can all be used and there is no degradation to the fight." With universal standardization it will not matter which branch of the military or even which country the parts come from. It becomes a streamlined process.

Envisioned as a branch line system to oversee different elements of the logistics process, Logistics Force will bring universal standards. With similar training, supply officers across the forces, from joint forces, allied forces, and industry partners will speak the same language and all understand the full system they are all working within. This applies to the network, processes, and the inventory system. A civil-military relations effort would bring together civilian and military partners into industry sites to train, teach and illustrate ways to improve and adapt. Next, Team Demeter recommended review of current operations to identify shortfalls. The team also cautioned that the war we plan for is the not one we will get, so analysis of how the environment is changing will be essential to identify emerging technology to advance logistics capabilities. Prototyping and testing potential solutions leveraging emerging technology is key to Logistics Force. Exploring of new technologies will be a continuous process to provide a warfighting edge. Controlling the command and control structure to harden and defend the structure, ensuring the system is secure to establish networks across joint components – "an Amazon-esque military logistics chain" – that expands throughout the world. With nodes and hubs linked to commercial industry positioned across the globe available to military logistics professionals in the event of a major conflict provides immediate efficiency gains in the logistics chain.

Impact

Two primary impacts of Logistics Force will be 1) to keep the warfighter in the fight with national mobilization and 2) the ability to load out much lighter because deploying forces do not need to bring everything they may need. "Logistics is a lot easier if you are not carrying that much." Creating a broad community that know how to provide services to military consumers will improve interoperability and streamline mobilization. By incentivizing industry through vehicles such as a national or multi-national endowment for defense industry start-ups it broadens the spectrum of people in allied nations that understand the military customer and the logistics demand signals likely during prolonged conflict. This will also broaden the people and locations that all use common equipment and have a common understanding and are therefore able to provide the required logistics services. Two years into a major high-end conflict the focus will be on how to maintain the conflict and mobilize resources and personnel with the right expertise that understand the equipment as the original personnel start to attrite and the resources begin to wear out. “Have we broadened the base that we can draw resources from?”

Next Steps

To implement the Logistics Force combatant command (COCOM) the first step is to establish Logistics Force as COCOM with Federal funding and initially allocate a part of National Budget to develop the infrastructure. Next, build a network of industry and allied nation partners, and incentivize those groups. Finally, consolidate supply networks and inventory. This final task will take time and effort to effectively standardize parts and components across all branches and partners in industry and allied nations – “so everyone speaks the same language.” Once operational, Logistics Force may provide us a new way of looking at supply networks.

2. Attritable Comms/Log System

Standardization and interoperability is huge, but what system do we need? The current system using oilers, large logistics ships, and advanced naval bases is limited by the fact that that their large footprint constrains establishment. There is a heavy burden of manpower and equipment that goes into ship-to-shore operations and distribution. Using existing platforms does not lend itself well to distributed operations. Current logistics distribution and resupply systems are also dangerous.[3] Underway replenishment (UNREP) is the transfer of fuel, food, ammunition, repair or replacement parts, people, and mail from supply ships to combatants like frigates, destroyers, and aircraft carriers. The current alternative is vertical replenishment (VERTREP) which supplies ships with helicopters. These methods of replenishment are vulnerable to enemy intervention as they both leave a large footprint in the battlespace and allow enemy analysts to forecast operations through our very observable resupply.

Figure 7. Underway replenishment (UNREP) on the left and U.S. Marines and Sailors offload supplies during the two-week Pacific Blitz exercise on the right (photo by Lance Cpl. Betzabeth Galvan/1st Marine Logistics Group).[4]

Team Demeter proposed a more holistic approach leveraging emerging technology. Autonomous systems allow us to distribute supplies at a much lower cost so survivability becomes moot. Inexpensive platforms that are more easily attrited – lost to the fight – increase the robustness and survivability of

[3] Salter and Ocbazghi (2017) “Here are the dangerous and intense methods the US Navy uses to keep its warships supplied at sea” Business Insider by Lamar Salter and Emmanuel Ocbazghi 10 November 2017. Last accessed 18 October 2019 at https://www.businessinsider.com/dangerous-methods-us-navy-uses-keep-warships-supplied-unrep-vertrep-carrier-department-of-defense-at-sea-2017-7

[4] Photo source: https://seapowermagazine.org/the-future-of-expeditionary-logistics-now/

the logistics system. Current transportation and distribution platforms used for advanced naval bases (*see Figure 7*) are expensive and cannot be put at risk. "If you lose an oiler that's a big hit."

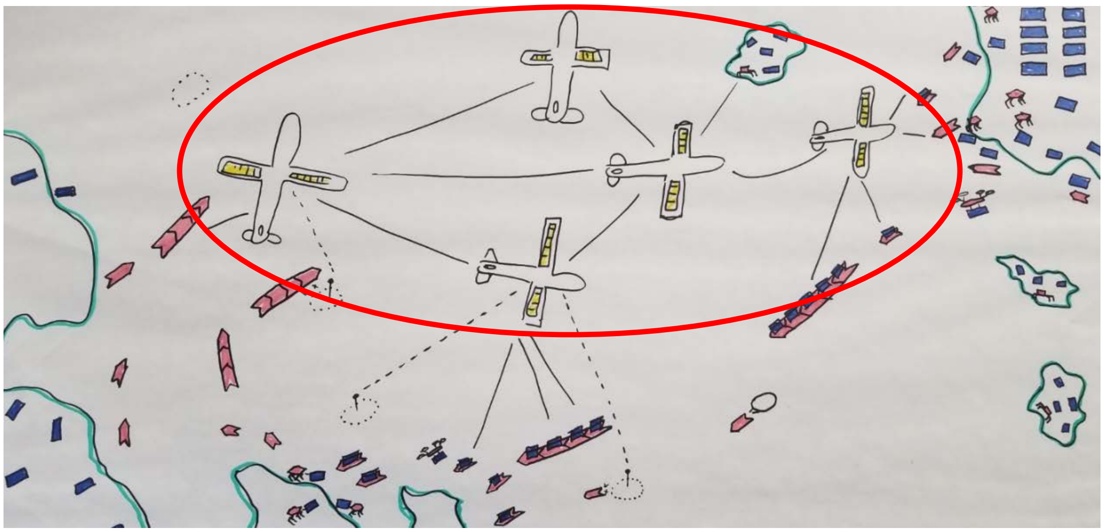

Figure 8. Proposed attritable communications and logistics system with solar powered UAV (in red circle) network nodes, Team Demeter (September 2019).

Team Demeter proposed a distributed system where supplies are not consolidated but distributed across many islands in the battlefield by robots. Survivability is increased through distribution. This full attritable communications and logistics system (*see Figure 8*) includes expeditionary advanced operating bases (EAOB) outlined in green, solar powered communications gliders in yellow, submersible fuel bladders in the dashed outlined circles, strategically positioned supply boxes in blue with Big Dog unmanned ground vehicles (UGVs) (*see Figure 8 in red and Figure 9, right*) providing perimeter security, and blue supply boxes in transit via modular SeaTrain unmanned surface vehicles (USVs) (*see Figure 8 in red and Figure 9, left*). The loss of a couple of pieces of the full system is easily absorbed by other parts of the system – therefore the team deemed it attritable. Distributing submerged fuel bladders across the battlefield rather than consolidating all fuel in a 1.2 million gallon fuel container means "we no longer have to worry about having everything shot up like the British did in the Falkland Islands when the Argentinians strafed their fuel bladders."[5] If supply battalions consolidate all our supplies as they are currently trained to do it puts those supplies at risk – "it has to be distributed otherwise it's just a big target."

The solar powered unmanned aerial vehicles (UAVs) (*see Figure 8, in red circle*) used to establish a robust, attritable network are the key to this proposal. In conjunction with various autonomous vehicles, a self-sustained network that can relay deliveries and arrivals seamlessly through the UAVs is essential. Team Demeter again emphasized the importance of a holistic approach suggesting that individual platform replacement only shifts the risk and does not mitigate it. To embed redundancy in communications, key to this concept is a batch communications network built around solar-powered fixed wing gliders (*see Figure 9, center*). Boeing produced a product that uses solar panels on the wings

[5] Privratsky, Kenneth L. (2014). Logistics in the Falklands War. Barnsley, South Yorkshire: Pen and Sword Books.

to recharge batteries to stay aloft indefinitely[6] which would enable persistent communications in denied or degraded environments. Manned or unmanned assets could communicate directly to the glider overhead maintaining a lower communications profile. This message would then be routed between the network of drones to whomever needs the information. “Any two assets in the battlefield could communicate using this network.”

Figure 9. Proposed elements of the attritable communications and logistics system include the modular Sea Train USV[7] (left), a solar powered UAV glider[8] (center), and the Big Dog UGV[9] (right).

Robustness is built into the network. If one of the drones should be lost, the others could reposition themselves and the mesh network will reroute data when any node in the network is destroyed. Attributes of the full system include autonomy, modularity, scalability, survivability, and low energy pull. Autonomy (*see Figure 9*) allows the vehicles and vessels to work together across domains to locate, load, and deliver supplies seamlessly. Optical recognition will aid in location of pre-positioned supplies with automated inventories of Quadcoms, and all vehicles will self-load and proceed with delivery. The modular system design (*see Figure 9, left*) ensures all assets in the full system will connect with all containers regardless of weight or size. All assets will be easily scalable to dock with each other to increase capacity should they encounter a load that is too heavy. “A UAV may only have medium lift capacity itself, it goes and docks with a larger UAV so rather than six rotors or four rotors it now has 12 or 16 rotors and can create that additional lift.” Being ubiquitous the system elements carry smaller loads, but they are everywhere so can get supplies to targets more easily. Communicating less frequently will reduce the system’s energy requirement, as will small adaptations like deployable and retractable sails to take advantage of wind power when available and save battery power.

The first steps for implementation will be to 1) identify modular container critical design elements, 2) get proof of concept through prototyping and testing, and 3) achieving interoperability. Current and future vessel design will need to incorporate elements to accommodate the modular supply containers, both domestically and internationally. Much of the required technology already exists, so it is time to start prototyping and testing for proof of concept focusing on the communications web and robotic and autonomous system designs. Improving interoperability at the tactical level, among assets under the

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[6] Boeing's Aurora Flight Services announced today the introduction of their high-altitude pseudo-satellite called Odysseus, a vessel it says is the world's most capable solar-powered autonomous aircraft. **SOURCE:** https://interestingengineering.com/boeings-solar-autonomous-aircraft-can-fly-forever-and-its-due-in-2019

[7] Photo source: https://www.seasnake.net/

[8] Photo source: https://time.com/62055/google-solar-drone-titan/

[9] Photo source: https://makezine.com/2015/05/06/boston-dynamics-bigdog-line-robots-nearly-impossible-knock-even-kicked/

control of different branches of the U.S. military, and with those operated by allied partner nations is something that could also begin now.

3. Submersible Fuel Bladder

How might we refuel at sea in contested environments? The key to refueling at sea would be to introduce a submersible, collapsible fuel bladder system with ballast, positioning, communications and fueling systems (*see Figure 10*). Key features include the ability to be strategically pre-positioned and then repositioned in and out of the contested environment. Functional components include a periscopic mechanism that pops up for communications, positioning, and fueling. This also facilitates hiding and deception. The propulsion system is similar to that of the wave glider to leverage the power available in the waves and currents.

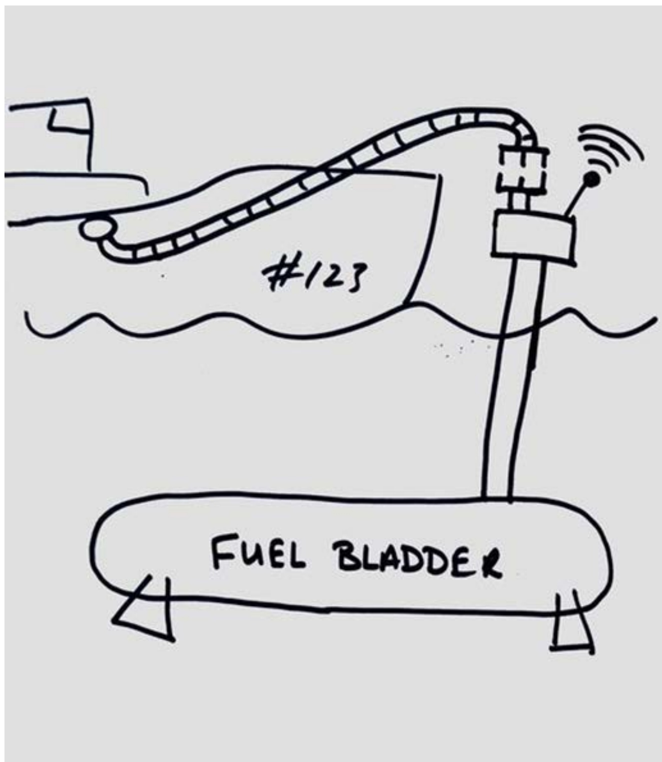

Figure 10. Submersible fuel bladder concept, Team Demeter (September 2019).

Non-combatants will transport these bladders to just outside the threat range and deploy them, and then the bladders will steer themselves into position. Ships can then refill them or refuel from them. If needed, the fuel bladder can be programmed remotely to leave the contested area to be refilled and redeployed. As a defense mechanism, the global positioning system (GPS) tracking system will limit where the fuel bladder can be moved once in a predetermined position – and only a few key officers on the vessels using these resources will be aware of these latitude and longitude restrictions. If the fuel bladder is moved from its programmed allowable position a small device in the periscope will detonate creating a bomb that is fueled by the fuel within the bladder itself. This device will also be encrypted, and a verification process will be required before a U.S. or allied vessel can either take fuel from or refill the bladder as needed.

This scalable and distributable fuel bladder fills a tactical gap as it will increase fleet endurance within a contested environment. Combatant warships will be able to deploy, redeployed, and reposition the fuel bladders in contested waters as needed. Warships can take fuel as needed and refuel the bladders as directed. Combined with increased missile technology and ranges, the use of these submersible fuel bladders keeps non-combatant vessels out the contested zone. Further research and development of the fuel bladder material is required, as well as periscope system capability development.

B. Team Diagon

Figure 11. Members of Team Diagon (pictured from left to right) Justin Amoyal, Luis Rivera, Katie Janney, Zack Akilan, Capt Alex Preston USMC, Jonathan Douglas, Maj Kyle McCarley USMC, LT Michael Shofner USN, Shane Griffin, Lance Lowenberg, and LT John Hawley USN

The members of this team (*see Figure 11 and Table 2*) included four junior and mid-level officers from both the U.S. Navy and U.S. Marine Corps, four early career engineers, three mid-level career resources, and three NPS students.

Table 2. Members assigned to Team Diagon (*alphabetical by last name*)

NAME	PERSPECTIVE	AFFILIATION
Mr. Zack Akilan	*Artificial intelligence engineer*	JHU/APL
Mr. Justin Amoyal	*Systems engineer*	NSWC Operational Logistics R&D
Jonathan Douglas	*Medical*	NHSS OPNAV N0931/N42M
Mr. Shane Griffin	*Cybersecurity*	NAVWARSYSCOM
LT John Hawley USN	*Facilitator*	NavalX
Ms. Katie Janney	*Underwater autonomy*	LMCO
Mr. Lance Lowenberg	*Facilitator*	NIWC Pacific
Maj Kyle McCarley USMC	*Combat engineer*	NPS Operations Research student
Capt Alex Preston USMC	*Logistics officer*	NPS Information Warfare student
Mr. Luis Rivera	*Environmental engineer*	Military Sealift Command
LT Michael Shofner USN	*Surface warfare*	NPS Systems Engineering Analysis

The concepts generated and presented by Team Diagon are summarized in a classified annex to this report available by vetted request through appropriate channels. Please email your request to CRUSER Associate Director Lyla Englehorn at laengleh@nps.edu or englehornla@nps.navy.smil.mil.

C. Team Hermes

Figure 12. Members of Team Hermes *(pictured from left to right)* CDR Sean Dougherty USN, David Aaron, Karl Anacker, LCDR Rudy Mason USN, Matthew Sobocinski, Jeff Hookilo, Brett Vaughan, Kayla Saunders, George Campbell, and Jefferson Huang (not pictured: Maggie Galle)

The members of this team (*see Figure 12 and Table 3*) included two junior and mid-level U.S. Navy officers, four early career engineers, one NPS faculty member, and two NPS students. The team was facilitated by a private sector design consultant and a government civilian, and was augmented by embedded resources from OPNAV N4i, the Military Sealift Command, and an industry defense contractor.

Table 3. Members assigned to Team Hermes (*alphabetical by last name*)

NAME	PERSPECTIVE	AFFILIATION
Mr. David Aaron	*Acquisition logician*	NSWC OPNAV N4i
Mr. Karl Anacker	*Naval architect*	Military Sealift Command
Ms. George Campbell	*Scientist*	NIWC Atlantic
CDR Sean Dougherty USN	*Naval aviator*	NPS Systems Engineering Analysis student
Ms. Maggie Galle	*Facilitator*	Restless Creation, Inc.
Mr. Jeff Hookilo	*Artificial intelligence*	Middle Canyon, Inc.
Prof Jefferson Huang	*Operations analysis*	NPS Operations Research faculty
LCDR Rudy Mason USN	*Supply corps officer*	NPS Defense Management student
Ms. Kayla Saunders	*Energy analyst*	USINDOPACOM J81
Mr. Matthew Sobocinski	*Software engineer*	Lockheed Martin
Mr. Brett Vaughan	*Facilitator*	ONR

Team Hermes focused on two key areas of concern: 1) survivable and agile communication networks and logistics delivery platforms; and 2) the operating in a challenging mission environment to overcome "the tyranny of distance." Moving logistics supplies over long distances without expending too many resources during the transport itself, and then moving needed materials from the beachline to the warfighter on land were focus areas.

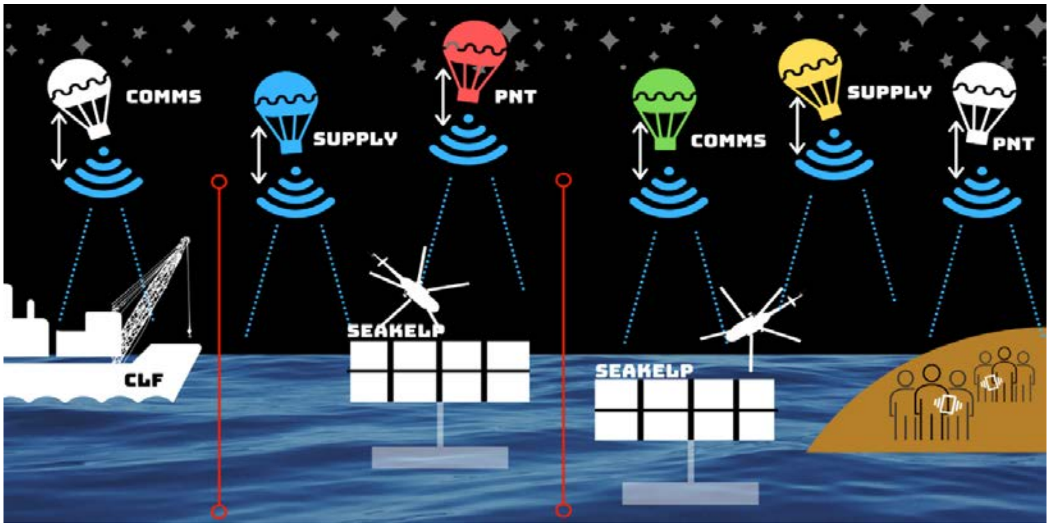

Figure 13. SEASTAR concept of employment to support logistics incorporating Sea Kelp and Starry Night, Team Hermes (September 2019).

The SEASTAR concept (*see Figure 13*) focused on low cost, autonomous and modular delivery units and communication platforms. Combining machine learning technologies, SEASTAR will counter the enemy threat and mitigate challenges posed by the environmental conditions in highly contested environments. The two elements of SEASTAR are 1) Sea Kelp and 2) Starry Night. Together the Sea Kelp and Starry Night systems that make up the SEASTAR are intended to support the five-vector logistics model (*see Figure 14*) – refuel, rearm, resupply, repair, revive.

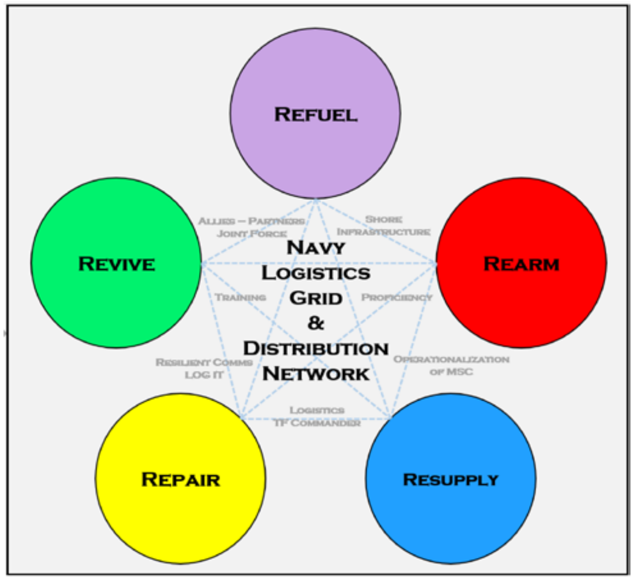

Figure 14. The five-vector model of maritime sustainment presented to workshop participants 23 September 2019.

1. Sea Kelp

If the warfighter has a logistics need “we hope he seeks help from the Sea Kelp.” In the concept of operations (CONOPS) develop by Team Hermes, the warfighter on the beach would use communications nodes in the Starry Night network to request logistics support (*see Figure 13, bottom right*). Envisioned as a barge type device (*see Figures 15 and 16*), the Sea Kelp will harness wave glider technology (*see Figure 16*) to maneuver from the combat logistics force (CLF) vessel in the controlled environment to the delivery area in the contested environment (*see Figure 13*).

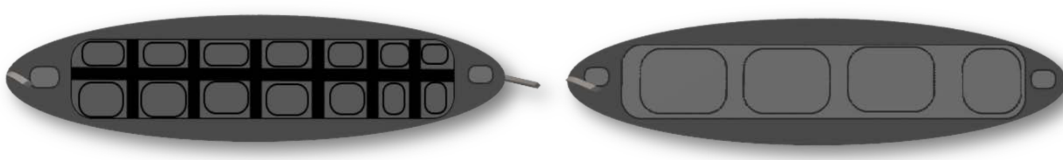

Figure 15. Sea Kelp top view of different modular loadout variants, Team Hermes (September 2019).

Once in the delivery area, vertical lift drones[10] will take supplies from the Sea Kelp barge to the warfighters at the time and place they have requested delivery. Once supplies are delivered, the Sea Kelp vessel would return to the CLF ship positioned safely outside of the contested littoral environment

[10] Much like those currently being developed by Elroy Air (https://www.elroyair.com/)

to be resupplied using modular configurable boxes that simply drop back in to the Sea Kelp carrier to replace those delivered to the warfighter.

Figure 16. Sea Kelp side view, Team Hermes (September 2019).

The design of the Sea Kelp allows for close support in littoral environments, although it is flexible enough for multi-purpose theatre requirements. Heavy lift drones would be required for the Sea Kelp to transition supplies to land. These multi-modal devices could also accommodate personnel if necessary for casualty evacuation (CASEVAC). For personnel recovery at sea a SOLAS[11] type raft could attach to the front or back of the Sea Kelp vessel. Salt-water activated pods would be available on loitering assets in contested littorals to create a CASEVAC afloat platform should the need arise. A fiberglass hull is a low-cost but durable, and materials are readily available for initial production and repair in the field; and fiberglass will elude detection, increase the range, and provide a quieter ride with less maintenance. Dual propulsion for endurance, operation in a wide variety of sea states, and endurance loitering in littorals are all key Sea Kelp design considerations.

Sea Kelp's long-range mission capability enhances the Navy's need to provide low cost survivable logistical support within contested areas of interest (AOIs). Sea Kelp will allow for U.S. Navy ships to standoff many hundreds of miles – outside the enemy's reach in most cases – while still supporting warfighters in highly contested environments. Team Hermes presented a proposed deployment model using optimization models to support personnel deployed in theatre while maintaining a defensive distributed position as the Sea Kelp vessels approached the contested littorals inland of the First Island Chain. A built-in level of redundancy will guarantee a high service level – meeting the logistics needs of those in the field without added a burden of oversupply. Key to Sea Kelp's success is the communications network integrated with the Starry Night system.

2. Starry Night System

The Starry Night system works in conjunction with Sea Kelp to create the full SEASTAR concept. Deploying a swarm of high-altitude balloons will enable three key capabilities in a contested environment: 1) communications, 2) supply, and 3) precision, navigation and timing (PNT) (*see Figure 17*).

[11] A raft that meets Safety of Life at Sea (SOLAS) Convention standards

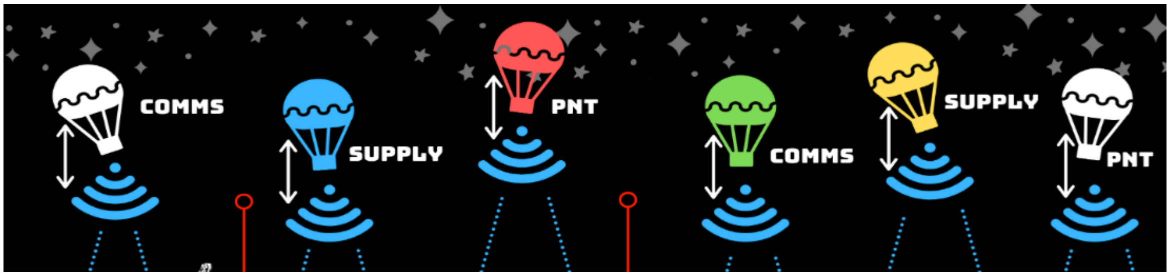

Figure 17. Starry Night System, an element of SEASTAR

High-altitude balloon technology is low size, weight and power (SWaP) and low cost. The adversary would need to determine if the cost of using a ballistic missile to destroy one of these atmospheric resources is warranted.

Improved communication is the primary use case. Balloons could be meshed into a network and allow ships to communicate or be used for navigational purposes or if the cloud cover becomes an issue. Balloons could replace satellite technology or be used as a jamming device. Finally, balloons can be fitted with cameras that take images of the night sky and develop celestial navigation benefits using machine learning algorithms. Logistically the balloons can move in a relatively fast manner across contested environments. By using a swarm design, some balloons may be used primarily as decoys or hold logistic payloads with the ability to send them down to a targeted area.

In conclusion, the SEASTAR concept that delivers the Sea Kelp and Starry Night System allow for flexible low-cost alternatives to enhance logistics and communication platforms in highly contested environments.

D. Team Osiris

Figure 18. Members of Team Osiris *(pictured from left to right*) CAPT Tony Nelipovich USNR, Warren Grunwald, Tonya Smith, LCDR Pam Bodzioch USNR, LT Candice Tisdale USN, LT Christopher Girouard USN, LT Joseph Rego USN, Terry Dang, Peng Zhang, and 1stLt Kevin Yarnell USMC (not pictured: Dave Nobles)

The nine members assigned to this team (*see Figure 18 and Table 4*) included five junior and mid-level officers from both the U.S. Navy and U.S. Marine Corps, four early career engineers, one civilian leader, and three NPS students. The team was facilitated by a visiting civilian academic and an ONR reservist, and their concept generation work was augmented by an additional reservist assigned to support the activity.

Table 4. Members assigned to Team Osiris (*alphabetical by last name*)

NAME	**PERSPECTIVE**	**AFFILIATION**
LCDR Pam Bodzioch	*Human resource officer*	ONR Great Lakes
Mr. Terry Dang	*Mission engineer*	NUWC Newport
LT Christopher Girouard USN	*Engineering duty officer*	NPS Systems Engineering student
Mr. Warren Grunwald	*Software engineer*	Draper Laboratory
CAPT Tony Nelipovich USNR	*Facilitator*	ONR
Mr. Dave Nobles	*Facilitator*	TANG / Johns Hopkins
Mr. Christian Ramos	*Electrical engineer*	NAVAIR
LT Joseph Rego USN	*Submarine officer*	NPS Systems Engineering Analysis student
Ms. Tonya Smith	*Acting branch head*	DC I&L NexLog, MCWL
LT Candice Tisdale USN	*Ops logistics planner*	COMPACFLT N4
1stLt Kevin Yarnell USMC	*Logistics officer*	NPS Defense Management student
Mr. Peng Zhang	*Machine learning engineer*	NIWC Pacific

To remain responsive to warfighter needs, through rapid facilitated concept generation Team Osiris proposed two distributed staging concepts. As they generated their solutions (*see Figure 19*) they remained focused on domain integrity – "keeping things together and specific allowing each domain to operate independently, but when required work together." Their distributed staging systems ATLANTIS and ASTRO were designed to increase survivability and reduce susceptibility to anticipated threats. The team also generated hashtag #OSIRISLogisticsApproach.

Figure 19. Initial concept generation work, Team Osiris (September 2019).

1. ATLANTIS – Automated Theatre Logistics Arsenal Naval Tactical Integrated System

The mythical city of Atlantis was known for developing advanced technology, and as a superior naval power – a maritime superpower. ATLANTIS – the automated theatre logistics arsenal naval tactical integrated system – enables dominance of the sea domain that will be critical in the war of 2032. In the Battle for the Philippine Sea (*see Appendix B*) in 2032 the primary concern the First Island Chain is anti-submarine warfare (ASW). The U.S. and our allies are projected to have 13 Virginia Class submarines assigned to the area where our adversary will likely have nearly 60 People's Liberation Army-Navy (PLA-N) diesel and nuclear submarines. The allied submarines assigned within the First Island Chain are taking out enemy submarines, and each has approximately 24 torpedoes. The scenario includes 104 enemy vessels across multiple domains, and nearly 2400 People's Republic of China (PRC) flagged merchant vessels that often double as logistics transports and maritime militia vessels during conflict. The 312 torpedoes will not suffice against such an overwhelming force. Team Osiris proposed ATLANTIS as a way to resupply allied submarines on station in the First Island Chain.

Team Osiris proposed placing underwater caches of weapons and other supplies years in advance in strategic pre-planned positions just outside the First Island Chain that are designed to blend into the natural environment, ideally becoming habitats over time (*see Figure 20*). As they will be prepositioned on the sea floor for years, materials will need to be selected to endure underwater conditions. With advanced knowledge of ATLANTIS cache positions, communications will activate when an allied submarines hovers over the site. Unmanned underwater vehicles (UUVs) will then facilitate the resupply of torpedoes from the ATLANTIS cache to the allied submarine.

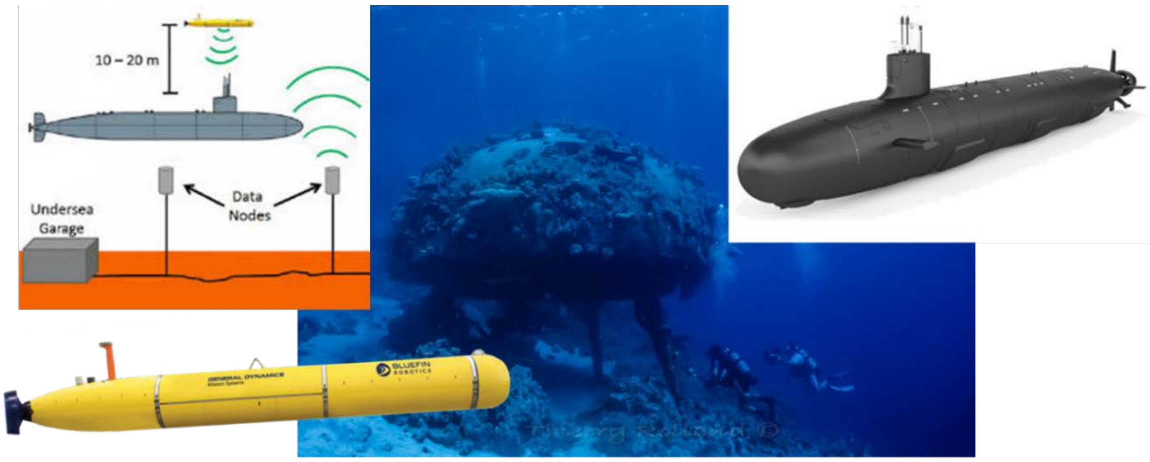

Figure 20. Automated theater logistics arsenal naval tactical integrated system (ATLANTIS) concept elements, Team Osiris (September 2019).

Stealth will be a key design element, as the ATLANTIS caches will need to hide in plain sight for years, so camouflage to blend into the seafloor is essential. Positions will also need to be carefully chosen to avoid detection – Team Osiris recommended placement on the edge of a shelf. Materials that resist salt water corrosion and will withstand marine life colonization will also be important. An advanced and scalable communications capability will allow a cache placed years earlier to successfully interact with assets in need in 2032. More work needs to be done to figure out how to initially deploy the ATLANTIS caches, reposition them to meet dynamic mission needs, and restock them in theater once the supplies are sapped.

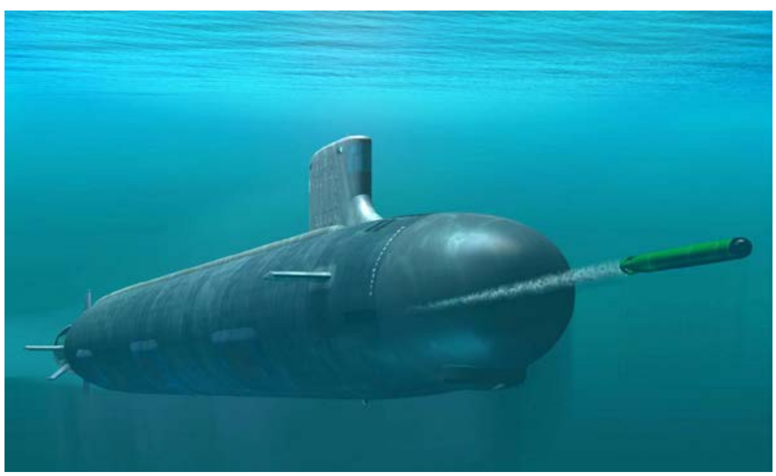

Figure 21. An artist rendering of the only underwater submarine conflict in history. On 9 February 1945 the HMS Venture, the first of the new V-class submarines, fired four torpedoes at the U-Boat U-864 on a secret mission Operation Ceasar.[12]

The ability to provide underwater torpedo replenishment is a key deliverable for the cache and will allow the submarine force to avoid trips for replenishment, but this technology has not yet been developed. Although submarine assets are essential in the battlespace, submarine conflict is quite rare

[12] Roblin (2017). "The True Story of the Only Underwater Submarine Battle Ever" The National Interest, Sébastien Roblin 18 November 2017. Last accessed 17 October 2019 at https://nationalinterest.org/blog/the-buzz/the-true-story-the-only-underwater-submarine-battle-ever-23253

(*see Figure 21*). Using the torpedo tubes themselves as an access point for delivery has not been done – to "backload" a torpedo to load into a tube. Currently, we use a weapons shipping hatch which introduces mechanical arms and other impediments to make underwater resupply very challenging. ATLANTIS will allow the submarine force to remain stealthy, and avoid the 6,000 nautical mile journey to Hawaii or the 2,000 nautical miles to Yokosuka or Guam for weapons resupply. The PLA-N forces will have a harder time finding our underwater assets, or have any reason to suspect that allied submarines are running low on weapons. ATLANTIS will allow allied submarines to remain on station inside the First Island Chain and be a force multiplier in the region.

2. ASTRO – Autonomous Space-Based Timely Replenishment On-Demand

Air, sea, and land are no longer the only domains available to support the solution. Team Osiris stated in their presentation "we have TENTH Fleet for cyber[13] and a new Space Force is in development.[14] What is the future of logistics in these new domains?" The autonomous space-based timely replenishment on-demand (ASTRO) system leverages the space domain to support logistics.

Figure 22. Example of current mode of replenishment.

Currently the military does not have a timely manner for replenishment. The ability to resupply is critical among the five central elements of logistics. "You can't revive, refuel, repair, or rearm unless you are resupplying to maintain the force" the team says. Although futuristic, the ASTRO concept builds on some work underway today and combines these projects to get to the next level (*see Figure 22*).

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[13] Since its establishment on Jan. 29, 2010, U.S. Fleet Cyber Command (FCC)/U.S. TENTH Fleet (C10F) has grown into an operational force composed of more than 14,000 Active and Reserve Sailors and civilians organized into 28 active commands, 40 Cyber Mission Force units, and 27 reserve commands around the globe. (SOURCE: https://www.public.navy.mil/fcc-c10f/Pages/home.aspx)

[14] "Documents Reveal How the Space Force Would Launch in 90 Days" Defense News, September 2019 https://www.defensenews.com/digital-show-dailies/2019/09/16/documents-reveal-how-the-space-force-would-launch-in-90-days/

Figure 23. Proposed future replenishment mode leveraging the domain of space.

There has been a significant focus on interoperability within the DoD for joint operations, however interoperability between DoD and industry is key to working in the space domain as many industry players are way ahead in their exploration (*see Figure 23*). It is time to engage industry like in World War II, to establish relationships to prepare for a potential future conflict. Team Osiris states "Jeff Bezos and his Amazon idea is brilliant. You can get furniture delivered the next day, but we are still waiting on parts in Okinawa." How can we leverage what exists in the civilian industry now to improve our military systems? Building relationships with commercial industry might be a solid starting point.[15] Elon Musk and Tesla created reusable rockets and pods to deliver supplies to the international space station – how might this advance be incorporated into future logistics? Although this concept is a one-off and cannot yet be manufactured to scale in an inexpensive way, the concept itself is solid. Team Osiris wants to harvest this concept as part of ASTRO and take it to the next step.

Figure 24. Current organizations leveraging the domain of space.

How do we create something in space to deliver something to the warfighter? CLF ships are vulnerable and do not have adequate capabilities to defend against an attack at sea. In 2032, with capabilities

[15] Amazon is building a new headquarters building in Crystal City right across from the Pentagon. (SOURCE: Business Insider 21 September 2019 https://www.businessinsider.com/crystal-city-arlington-amazon-hq2-changes-2019-9)

degraded 50% two years into a conflict, how do we ensure that these ships are resupplied in a timely manner? Supplies required to maintain an adequately large force in theater include Class III, Class V, and Class IX[16] supplies which could be stored and delivered from space. In the future, food might be harvested from a space station and delivered from space to the warfighter on the battlefield. ASTRO could launch and maintain a dedicated space station and use reusable pods to transport supplies on demand within about 90 minutes in a 100-meter radius of the resupply target (*see Figure 24*). Resources pre-positioned in space to support logistics would eliminate the need for logistics ships placed in the threat zone without the ability to defend themselves, and replenishment from space decreases the time span from request to delivery.

Figure 25. Notional future CONOPS involving the domains of near and outer space where supplies from a space station (*left*) are transported in a reusable pod (*center*) to a vessel in need of resupply (*right*).

There are already resources in space such as trash and asteroids – work needs to be done to harness and harvest those resources already available in the space domain. Industry is already working to harvest energy from asteroids, and the DoD needs to partner in these efforts. How might we produce disposable and low-energy pods to replenish from space immediately upon request? Team Osiris recommends that we reimagine resupply by rethinking the way we replenish at sea and consider a multi-domain approach. In summary, the team states "we need to take risks to occupy these domains that are not yet fully utilized, and to do that effectively will require industry partnerships – and these relationships need to be built now to develop effective interoperability to maintain domain integrity and be ready for a future conflict."

Figure 26. Proposed ASTRO seal.

[16] Class III is fuel, Class V is ammunition, and Class IX is repair parts

3. Undeveloped concepts

Additional generated but undeveloped solutions:

- Decoy Fleets
- Blockchain
- Reimagining RAS
- Escorts (manned and unmanned)
- Underwater Bases/Cache
- Renewable Energy System/Harvesting

E. Team Peko

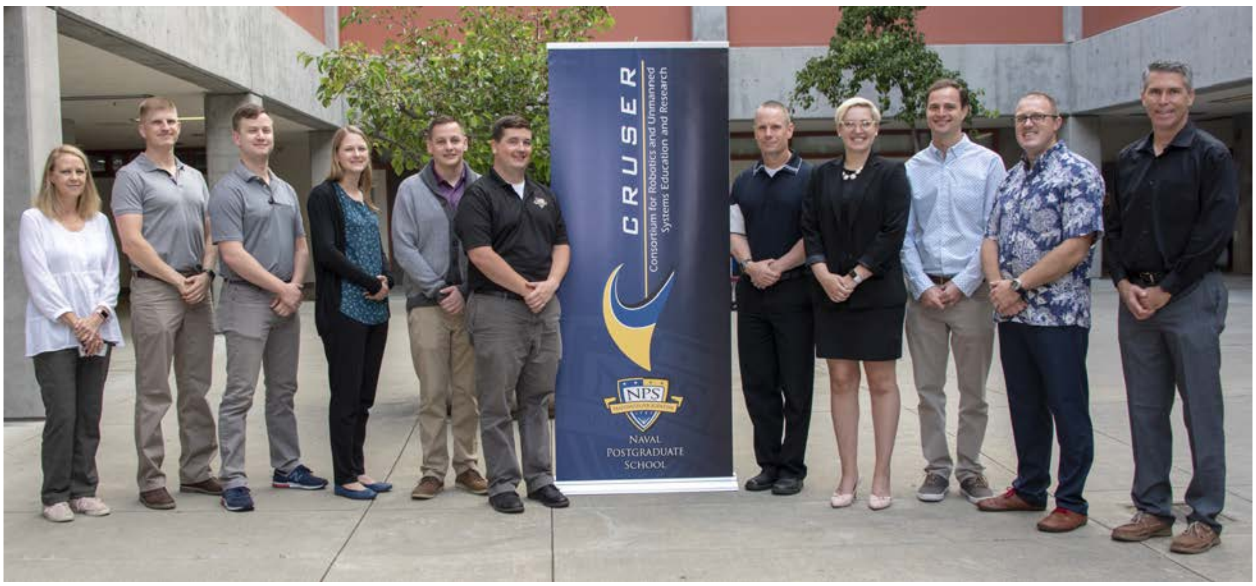

Figure 27. Members of Team Peko *(pictured from left to right*) Dr Judy Conley, Capt Barry Loseke USN, LT Dakota Sicher USN, Dr Reid Smith, LT Benjamin Sandridge, LT Rick McClain USN, LtCol Roy Miner USMC, Sierra Palmer, LT Matt Winne USNR, LCDR Dana Canby USN, and Steve O'Grady,

The members of this team (*see Figure 27 and Table 5*) included five junior and mid-level officers from both the U.S. Navy and U.S. Marine Corps, three early career engineers, one NPS faculty member, and three NPS students. The team was facilitated by civilian professionals from warfare centers.

Table 5. Members assigned to Team Peko (*alphabetical by last name*)

NAME	PERSPECTIVE	AFFILIATION
LCDR Dana Canby USN	*Surface warfare officer*	SMWDC - AMW Division N8/9
Dr. Judy Conley	*Facilitator*	NSWC Carderock
Capt Barry Loseke USMC	*Aviation supply corps*	NPS Defense Management student
LT Rick McClain USN	*Mechanical engineering*	NPS Mechanical Engineering student
LtCol Roy Miner USMC	*Data driven logistics*	HQ Marine Corps I&L NexLog
Mr. Steve O'Grady	*Facilitator*	NUWC Newport
Ms. Sierra Palmer	*Mission engineer*	NUWC Newport
LT Benjamin Sandridge	*Surface warfare officer*	NPS Systems Engineering Analysis student

LT Dakota Sicher USN	*Submarine officer*	NUWC Newport
Dr. Reid Smith	*Operational logistics*	JHU/APL
LT Matt Winne USNR	*Engineer*	Military Sealift Command

Team Peko immediately recognized the overwhelming size of the problem space of logistics in contested environments, and to generate tangible concepts they had to first break the problem space into categories. Based on the data they gathered through Mentor interviews and their own experience in the problem space, they curated the categories into a group of problems using "problem trees." Each identified problem was placed on a "trunk" and the effects of that base problem all hung as "leaves" of the tree. The five foundational problems the team identified were:

1) Vulnerability of logistics ships
2) Lack of repair capability at the edge
3) Ability to rearm VLS at sea
4) Ability to transition supplies between ships and shore
5) Lack of logistics command and control

The team then generated solutions to those five separate problems – "ideas to develop into concepts" – and discovered that several ideas to solve different problems worked well together as a concept.

1. VADER – VLS At-Sea Device for Expeditionary Rearming

The inability to rearm vertical launching systems (VLS) underway is an obstacle for effective logistics support. VLS is a primary capability on many U.S. Navy surface combatants[17], and some submarine assets.

Figure 28. Current VLS reload in port[18] (*left*) and underway (*right*).

[17] **U.S. Navy Fact File MK-41 VLS:** The MK 41 Vertical Launching System (VLS) is installed aboard United States Navy (USN) surface combatants including Ticonderoga Class Guided Missile Cruisers (CG 47), Arleigh Burke Class Guided Missile Destroyers (DDG 51) and multiple allied Navy platforms. MK 41 VLS is capable of launching multiple Standard Missile variants, Tomahawk, Vertical Launch Anti-Submarine Rocket (ASROC) and Evolved SEA SPARROW missiles. (SOURCE: https://www.navy.mil/navydata/fact_display.asp?cid=2100&tid=550&ct=2)

[18] Sailors assigned to the destroyer Benfold and Navy Munitions Command remove an expended missile canister from the destroyer's vertical launch system in Guam. The Navy is planning on bringing back its capability to reload a surface combatant's missiles while the ship is at sea, a move analysts say reflects the increasing conventional threat faced by today's sea service. (PO3 Jason Amadi/Navy) U.S. Navy photo (SOURCE:

In-port reloading by crane pier side (*see Figure 28, left*), as is common today, is safe but not tactical and requires removal of combat capability from theatre to rearm. Although more tactically sound, current at-sea reloading capability by crane is unsafe due to risk to personnel, missiles or other VLS payloads due to pitch and roll of the platform(*see Figure 28, right*).

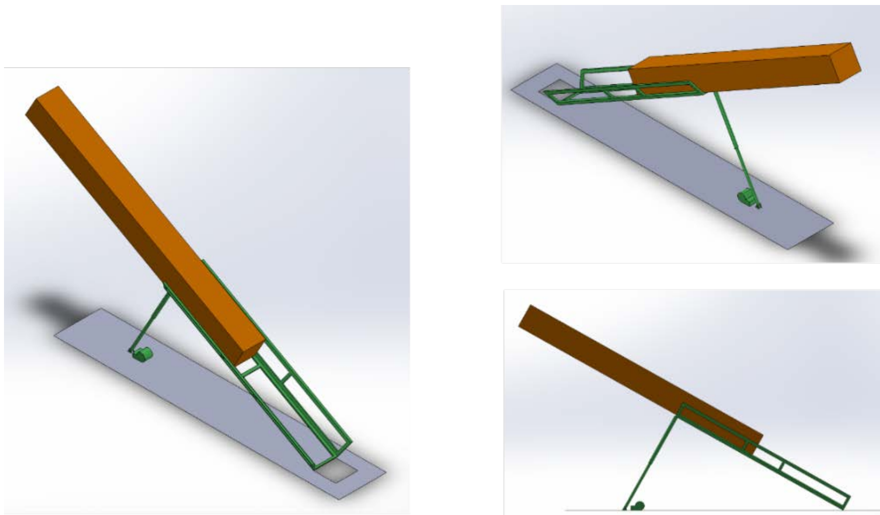

Figure 29. VLS at-sea device for expeditionary rearming (VADER) concept mechanism, Team Peko (September 2019).

To address this capability gap, Team Peko proposed the VLS at-sea device for expeditionary rearming (VADER) as a materials solution that can be aerially delivered to a ship from a supply asset. VADER is quickly assembled on deck and would include a hydraulic ram to stand it up over the missile cell and keep it locked into place like a jig (*see Figure 29*) allowing for concise physical alignment of the missile without the need to account for pitch and roll.

https://www.navytimes.com/news/your-navy/2017/08/01/navy-planning-to-bring-back-at-sea-missile-reload-capability/)

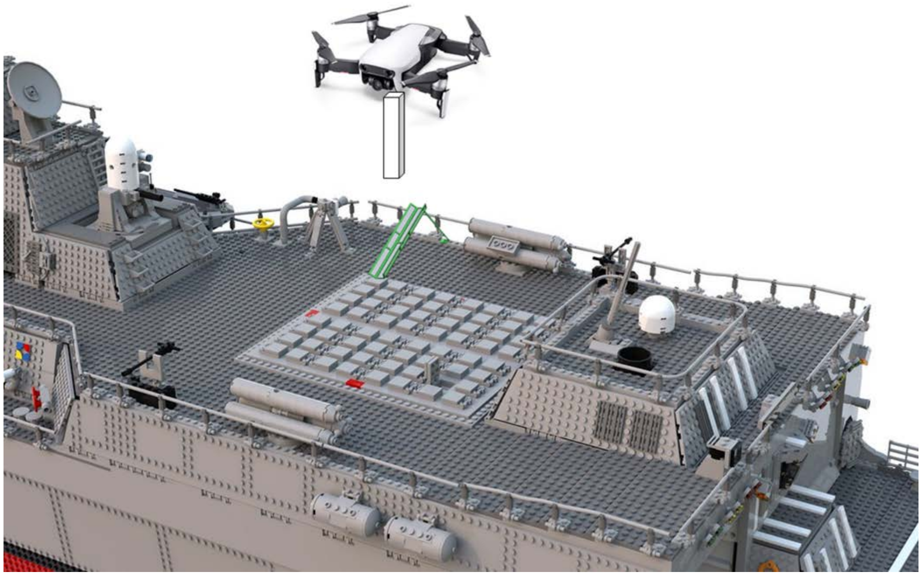

Figure 30. VLS at-sea device for expeditionary rearming (VADER) concept of operations employing a UAV for payload positioning, Team Peko (September 2019).

VADER's simple design allows it to be stowed on a supply asset, enables delivery of payloads by either unmanned (*see Figure 30*) or manned aerial vehicles for remote replenishment in theater while underway, and requires minimal alterations to current ships and canisters. Most importantly VADER enables much safer at sea rearming of VLS.

2. ACDC – Autonomous Container Delivery Craft

The autonomous container delivery craft (ACDC) enables the delivery of fuel and supplies to the expeditionary advanced base (EAB) on the beach in a contested environment – "your logistics delivery vehicle on the highway to hell." Team Peko addressed the three-part logistics triangle – getting what you need, where you need it, when you need it – by focusing on the "when" part of the triangle. They devised a mothership concept using a standard container ship and modified CONEX[19] boxes (*see Figure 31*).

[19] Container Express (CONEX) is a standard aluminum shipping container introduced in 1952 by the Transportation Corps replacing the heavier steel "Transporter" box. (SOURCE: U.S. Army Transportation Museum https://web.archive.org/web/20130215105008/http://www.transportation.army.mil/museum/transportation%20museum/conex.htm)

Figure 31. ACDC combines a container vessel with CONEX boxes for beach delivery, Team Peko (September 2019).

Small, fast, stealthy delivery vehicles may not be able to deliver as much cargo or fuel individually, but a swarm of them transiting continuously will meet the resupply need and reduce the risk a single larger asset might face.

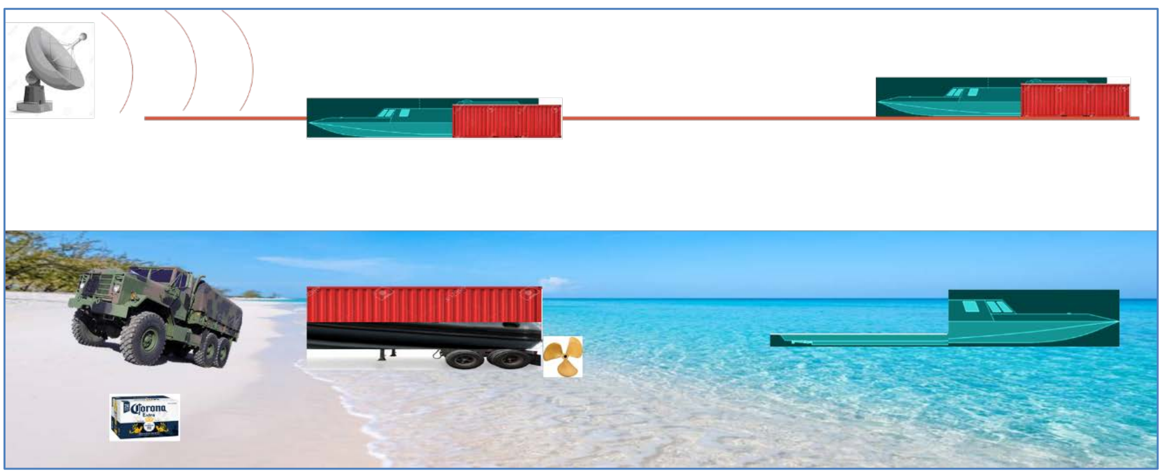

Figure 32. ACDC semi-submersible transport vessel and landing delivery kit, Team Peko (September 2019).

The ACDC transport vessel itself would be semi-submersible, and high-speed much like the self-propelled semi-submersibles used by drug smugglers out of Central America. Equipped with an early warning system to detect adversary radar, the ACDC would autonomously adjust course and mode of operation based on probability for detection. The ACDC concept also includes a landing delivery kit comprised of an inflatable sponson[20] with wheels (*see Figure 32*) designed to accommodate a standard CONEX box, and a high-power low-battery life propulsion system to transport the cargo an additional 20-30 yards to shore.

The design considerations primarily focused on cost and flexibility. The ACDC is part of a fleet of cheap and expendable assets so if you lose one it does not jeopardize the mission. A flexible design allows the

[20] similar to what is found on a rigid-hulled inflatable boat (RIB)

CONEX box kits – landing delivery kit, autonomy kit, cargo configuration, refrigeration, fuel storage – to be adjusted based on mission needs. Its scalable design is capable of transporting variable sized and numbers of containers. ACDC's semi-submersible design enables clandestine pre-positioning, increased transit speed, and when dispersed in a swarm ACDC provides a logistics web rather than the traditional logistics chain.

Beyond standard logistics resupply, Team Peko proposed several additional uses for the ACDC vehicles. With additional work, ship refueling may be possible. Due to the small size of the vehicle it would not be capable of a full refueling, however it may allow a DDG to stay on station a bit longer. An electronic warfare package in a CONEX box might be quite useful for deception – "once you make it [a CONEX box] waterproof it will float." A floating CONEX box could also serve as a communications relay and node in mesh network, or the ACDC could serve as a Trojan horse improvised explosive device (IED).

3. MilMart

From the operator's perspective, current supply systems are cumbersome, unreliable, and mysterious. Current operators are much more confident in their ability to order something from Amazon than their ability to requisition something using their service or company's supply system. The MilMart is a global supply system that eliminates the disjointed supply system currently in place (*see Figure 33*).

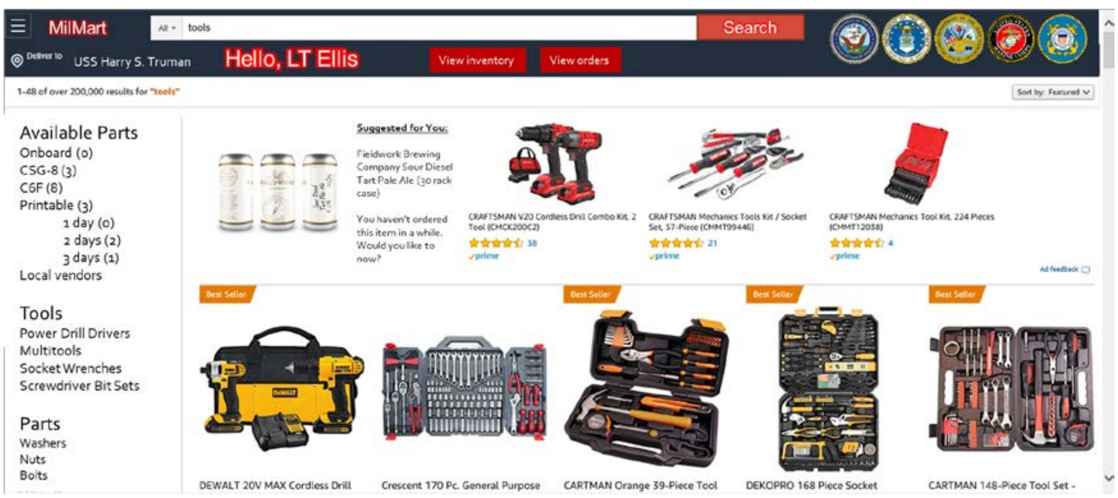

Figure 33. MilMart supply system, Team Peko (September 2019).

"Our current supply system is difficult to use resulting in sailor workarounds." Sailor workarounds result in bad data – and bad data results in waste, either through unnecessary surpluses or undersupplied vessels not ready for deployment. Recognizing that current supply practices are incompatible with the future distributed unit operating environment, MilMart provides the operator with the ability to locate the needed parts on their ship, within their strike group or EAB. if the parts or supplies requested are not readily available, MilMart would automatically search for alternatives from local vendors or quickly created using additive manufacturing.

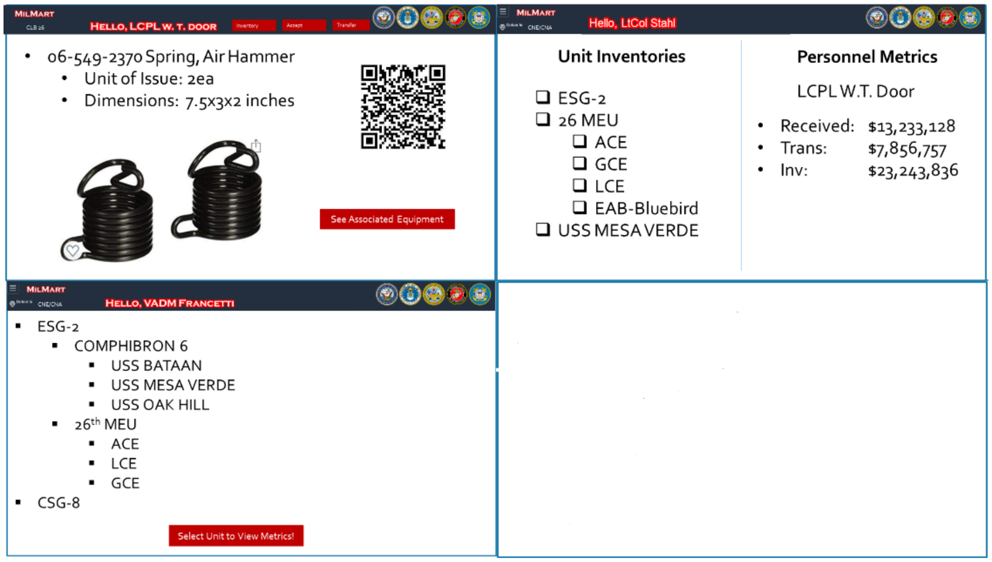

Figure 34. MilMart concept submenu sample, Team Peko (September 2019).

MilMart is scalable. Using scanned quick response (QR) codes (*see Figure 34, top left*) requisitions would be easily tracked, avoiding workarounds "and no Zebra cakes changing hands" to complete a transaction. These transactions will be trackable from the ship level, to the strike group level, all the way to the joint level, and allows the tracking of inventory across services to generate the data necessary for a more predictive logistics support during a conflict.

MilMart will also have a gamification component (*see Figure 35*) to reward the behavior of users when they make accurate inventory selections and reduce waste. "Your sailors will want to be accurate and they want to be doing the work because they want to win the interservice Goblet of Fire!" Users will also have access to technical manuals (*see Figure 35 bottom left*) to install the parts they order, and MilMart will include an image search function (*see Figure 35 bottom right*) to assist with inventory selection – to avoid ordering an entire water purification system if all that is needed is the $22 gear.

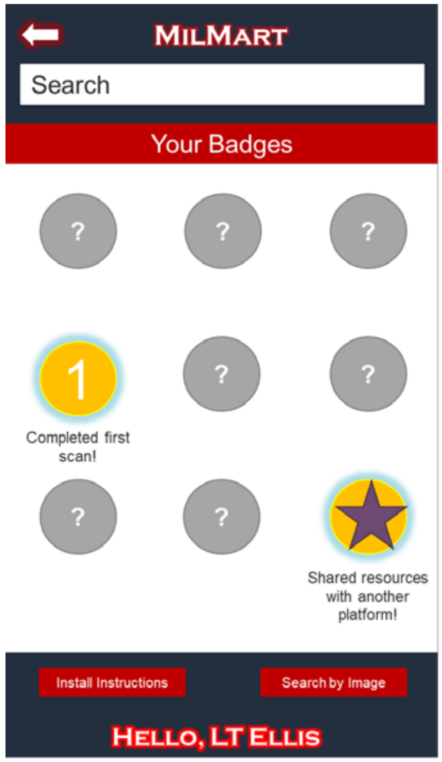

Figure 35. The sailor interface allows for gamification of MilMart, in the style of Starbucks.

MilMart will require a significant cultural shift from a centralized supply corps and give the power to requisition needed parts and supplies into the hands of the warfighter. MilMart will required large-scale data input on the front end before it is fully operational, and the system must be hardened to ensure standalone operation in an enduring conflict. "When our Marines are in their EABs they can quickly scan the ACDC as it comes ashore and know the inventory in there without having to laboriously decipher a bunch of NSNs."

MilMart benefits include database analytics to push logistics and optimize peacetime supply. It will have a relatively small physical footprint, and its intuitive design will mean a simple training roll-out. This system will also provide accurate reporting through clean data, reduce manhours or "human fingerprint" required for an effective logistics system, resulting in a more responsive force.

F. Team Viridios

Figure 36. Members of Team Viridios *(pictured from left to right*) Garth Jensen, LT Bradley Nye USN, LCDR Audrey Carter USN, LT Benjamin Rathwell USN, Dr. Elena Shrestha, Capt Christian Toro, CAPT Eric Morgan USN, Kristen Tsolis, and Bill Jankowski (not pictured: LCDR James Gowling, Royal Australian Navy)

The members of this team (*see Figure 36 and Table 6*) included five junior and mid-level officers from both the U.S. Navy and U.S. Marine Corps, one senior Navy officer, one naval officer from a partner nation, two early career engineers, and three NPS students. The team was facilitated by a warfare center civilian and an NPS faculty member.

Table 6. Members assigned to Team Viridios (*alphabetical by last name*)

NAME	PERSPECTIVE	AFFILIATION
LCDR Audrey Carter USN	*Medical logistician*	OPNAV N0931
LCDR James Gowling	*Information warfare*	Royal Australian Navy
Mr. Bill Jankowski	*Mission engineer*	NUWC Newport and NPS DL student
Mr. Garth Jensen	*Facilitator*	NSWC Carderock
CAPT Eric Morgan USN	*Logistics leadership*	OPNAV N4i Logistics
LT Bradley Nye USN	*Surface warfare*	NPS Systems Engineering Analysis student
LT Benjamin Rathwell USN	*Surface warfare*	NPS Systems Engineering student
Dr. Elena Shrestha	*UAV design engineer*	JHU/APL
Capt Christian Toro USMC	*Logistics planner*	MARFORPAC G4
Ms. Kristen Tsolis	*Facilitator*	NPS Defense Analysis faculty

1. Approach

The team began by restating the broad design challenge "How might advancements in autonomy, machine learning, manned-unmanned teaming, emergent technologies, and unmanned systems be employed to enhance logistics in highly contested environments to accomplish missions more effectively and/or with less risk?" With that as their launching point they then gave a conceptual overview, splitting their solution space into two parts – logistics and contested environments.

Within logistics, they focused their work on leveraging private sector innovations – leveraging concepts developed by industry and partnering with industry to move forward. Modularity was also a key criterion in their solution space. "We're pushing for modular software so we can just pick up and go with whatever system it's integrating with. If we could do the same thing with hardware, we'd have more adaptable systems which shortens the acquisitions process." Policy, specifically acquisitions, was their third area of focus within the logistics solution space. "If we can modify our acquisitions process, we can leverage the commercial innovation and modularity to produce a better logistics chain." Team Viridios identified risk management as key in contested environments. Reducing susceptibility through use of decoys and deception, reducing vulnerability using weapons and armor, and increasing resilience were also important in this solution space.

After analysis of the problem space the team generated a lot of ideas spanning multiple disciplines, so they broke apart their solution space into topics as they began their work, each topic having attributes. Out of all the ideas generate during their divergent ideation (*see Figure 37*) the four topics that rose to the top were 1) commercial, 2) C4I and communications, 3) artificial intelligence and machine learning, and 4) unmanned systems.

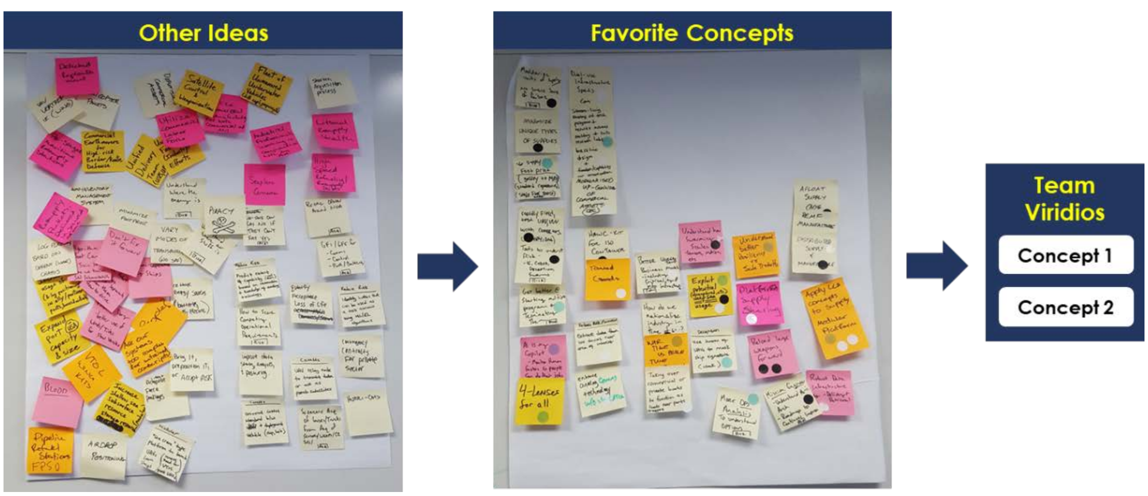

Figure 37. Team Viridios concept convergence process, September 2019.

2. Undeveloped Concepts

Team Viridios then shared four concepts they generated but chose not to develop further (*see Figure 38*). To better leverage industry, an "Internet of Things" approach to integrate devices for a full public-private partnership (*see Figure 38, top left*) in the logistics space was explored by Team Viridios. They gave the example of route planning as a prime mission to leverage industry assets. Using artificial intelligence and machine learning to predict enemy capabilities (*see Figure 38, top right*) was another interesting but undeveloped concept Team Viridios considered. "Machine learning is really good at pattern recognition" so if the enemy deploys an unfamiliar asset we may be able to predict it capabilities by using machine learning to analyze the components. UAV relay nodes in a degraded communications environment (*see Figure 38, bottom left*) was also considered but not pursued as a concept for development. Their final undeveloped concept was a "sea-crane type UAV" (*see Figure 38, bottom right*) which would remove the need to carry heave launch and recovery equipment and give VTOL capabilities to fixed-wing platforms. "Instead of having multiple rotary-wing vehicles plus fixed-wing vehicles we can 3D print different types of fixed wing platforms and use a uniform sea crane platform to launch and recover them."

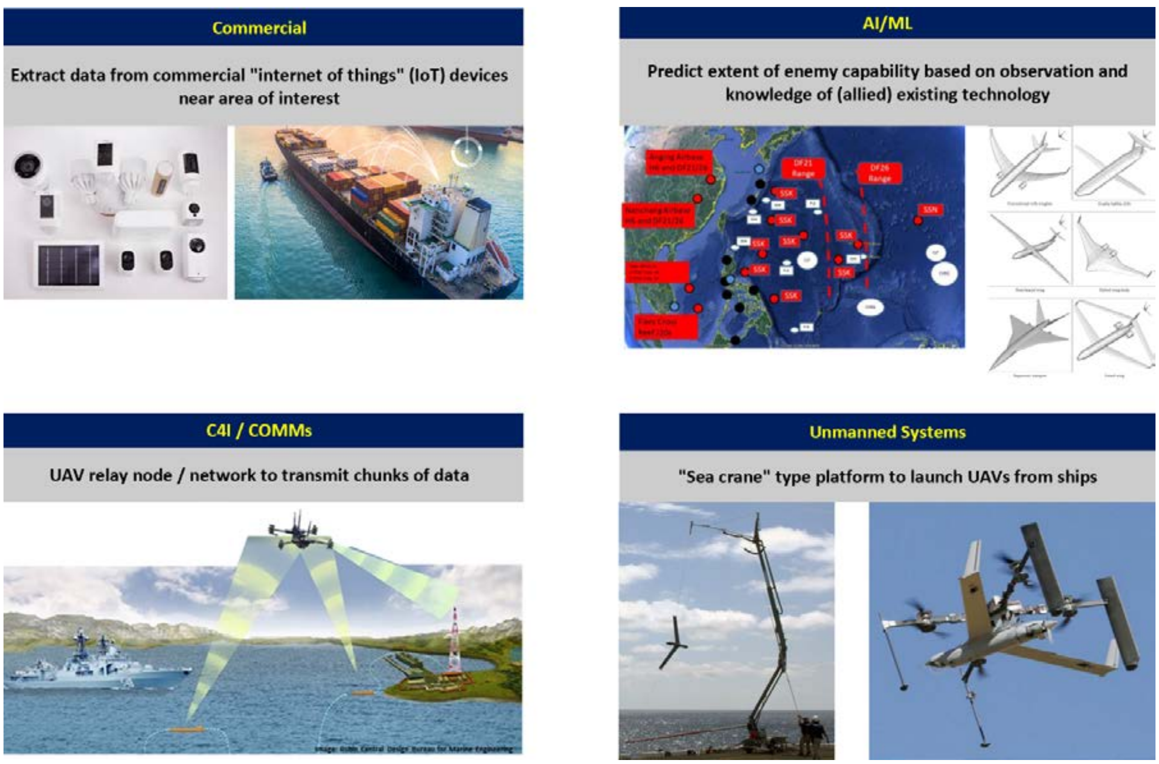

Figure 38. Undeveloped concepts, Team Viridios (September 2019).

Although not an exhaustive list, other undeveloped concepts generated by Team Viridios included:

- Algorithm Boot Camp – to enhance human capital
- Airdrop positioning
- Detached replenishment
- "Finding Dory" – better use of winds and tides to propel slow vessels
- "Hurri-Cats" – a catapult platform for ship-to-shore delivery
- Helicopter pallets

3. S.S. King's Point

Presented as the S.S. King's Point, the first of the two developed concepts presented is to rebuild the U.S. Merchant Marine with a public-private business model. This model may support not only getting ships built, but ensure they are crewed and available during a conflict. During WWII, the U.S. had a large domestic merchant fleet which it leveraged to supplement the logistic fleet to replenish supplies in two contested environments until shipbuilding efforts could be scaled to increase support. The Maritime Security Program currently consists of 60 rapidly aging ships with no current plan to replace them.[21] The total U.S. flagged merchant fleet consists of 182 ships as of 2016 out of the 42,000 merchant ships operating worldwide.[22] There are only 20 active U.S. shipyards building ships – this number includes naval shipyards. [23] One of the policy constraints is The Jones Act, Section 27 of the Merchant Marine Act of 1920, that mandates goods shipped between U.S. ports are to be transported on ships that are built, owned, and operated by U.S. citizens or permanent residents.

Working within the framework of The Jones Act to develop a robust merchant shipping ecosystem, Team Viridios proposed that the U.S. government create a business model to reconstitute a U.S. Merchant Marine fleet capable of bluewater operation that is built, flagged, and operated by U.S. entities. This was presented in three parts: 1) grow the number of ships, 2) grow the personnel available to operate the ships, and 3) grow the number of U.S. flagged ships. To grow the number of merchant ships available for a future logistics fleet, a U.S. government entity – possibly the U.S. Navy or the U.S. Department of Transportation – needs to explore alternate methods. Beyond contracting solutions, options may be an alternative – "purchasing an option on a ship that is built, manned and crewed by U.S. citizens providing a steady source of income for the operator in peacetime" leaves an asset in reserve to support the U.S. military during a conflict. The U.S. government could purchase merchant ships outright, and then lease them back to U.S. operators with the option to repossess these hulls during any future conflict. Australia and the United Kingdom already employ these joint ownership agreements for some of their sealift assets, and similar arrangements could be made with shipyards to build new vessels.

To grow the qualified personnel available to a future logistics force was a two-part proposal. First, the leasing agreements that give the U.S. the option to take possession of ships during a time of war would include incentives for operators to use Merchant Marine or U.S. Navy reservist (USNR) personnel during peacetime operations. Next, leveraging the increased throughput at institution such as the U.S. Merchant Marine Academy[24]and the Mass Maritime Academy[25] Team Viridios proposed creating "Able Seaman" non-degreeed vocational training programs to develop a future logistics force.

[21] Walton, Boone, Schramm (2019). "Sustaining the Fight Resilient Maritime Logistics for a New Era", Center for Strategic and Budgetary Assessments (CSBA) Timothy A. Walton, Ryan Boone, and Harrison Schramm; published 2019. Last accessed 17 October 2019 at https://csbaonline.org/uploads/documents/Resilient_Maritime_Logistics.pdf

[22] SOURCE: https://www.bts.gov/content/number-and-size-us-flag-merchant-fleet-and-its-share-world-fleet

[23] SOURCE: http://www.shipbuildinghistory.com/shipyards/large.htm

[24] Average incoming class size has been steadily increasing, from 255 incoming students in 2015 to 280 students in the incoming class of 2023 that started class on 5 July 2019 (SOURCE: https://www.usmma.edu/class-profile)

[25] Averaging just under 400 students enrolled as Freshmen in each entering class from 2015 to 2018 (SOURCE: reports posted at https://www.maritime.edu/facts-figures)

Finally, we should investigate legislation to make it more attractive to flag vessels in the U.S. What are the current obstacles? How might we mitigate these challenges? There is likely a policy solution, but it will take time to investigate, craft, adopt, and implement so this should start now.

Team Viridios then gave us an implementation plan. Design teams to include representatives from NAVSEA, the U.S. Coast Guard, and industry will work to develop a standard hull design and use common interfaces for all shipboard systems. A modular design will allow for drop-in subsystems for industry customization, and will enable the U.S. Government to retrofit for military missions should the need arise. A standard hull – "built as a truck" – also allows for experimentation with different control systems and crewing configurations such as partial, minimal, or optional manning using autonomy.

The resulting open-source design will be shared with all stakeholders, including allied nations – who will benefit from the increased interoperability resulting in improved surge capacity. Once built, owners will be encouraged to sell off these common hulled vessels early in their lifecycle to sustain demand at shipyards. For industry stakeholders, the focus will be on producibility, operational lessons learned and efficiencies, and improvements to subsystems. Industry stakeholders will also be incentivized to develop drop-in sensors and incorporate artificial intelligence and machine learning for increased operational efficiency.

To be successful, the scale of S.S. King's Point program needs to be large, producing at least ten ships a year each with a 20-year lifecycle – resulting in a 200-ship fleet available in the 2032 conflict in the workshop scenario. Ships with additional useful life will be sold to increase the fleet depth available. If successfully implemented, the S.S. King's Point program ensures that the U.S. resumes leadership role in some heavy industries we had in the 1940s through the 1980s. A robust U.S. Merchant Marine fleet would be available to assist domestic humanitarian assistance and disaster response (HADR) efforts.[26] The program would also improve ecological performance of U.S. transportation infrastructure, keep more transportation related expenditure funds domestic, and reduce our reliance on foreign nationals to meet our shipping needs. The S.S. King's Point program improves the U.S. Navy's access to merchant shipping during peacetime, and a common design provides for economies of scale for production. Finally, if successful this program will make other U.S. industries more competitive. New Orleans is large natural gas exporter and New England large natural gas importer but "most of the natural gas that gets burned in New England gets trucked over from Europe in an LNG tanker" because there are not Jones Act compliant means to get the natural gas from New Orleans to New England. The S.S. King's Point program would solve that.

4. LSX – Landing Ship Expeditionary

The next concept presented by Team Viridios was inspired by the history shared by Dr. David Kohnen from the Naval War College earlier in the week. The tank landing ship (LST) is the naval designation for ships first developed during World War II (1939-1945) to support amphibious operations by carrying tanks, vehicles, cargo, and landing troops directly onto shore with no docks or piers. Mirroring these

[26] Team Viridios posited that one factor hampering the recovery efforts in Puerto Rico after Hurricane Maria in September 2017 may have been the lack of available heavy lift U.S. ships.

rapidly constructed and deployed LSTs (*see Figure 39, right*), Team Viridios proposed the landing ship expeditionary (LSX) to carry a variety of containerized supply cargo (*see Figure 39, left*). "We won WWII because of LSTs." The Marine Corps wants twice the number of LPDs[27] to service their operations. The LSX could fill the LPD gap and provide the advantage of the LSTs in WWII.

Figure 39. At left are current containerized freight hauling equipment to be considered in a logistics ship design, and at right is a Republic of Korea Type 88 K1 main battle tank drives off the ROKN amphibious ship Sung In Bong (LST 685) onto Pohang Beach, Korea (image source Staff Sgt D. Myles Cullen USAF).

Modularity and a standard hull are key elements of the LSX design. "We want a cheap ship – a small ship." Beaching capability is key. An automated modular transport semi-submersible platform design (*see Figure 40*) would also accommodate beaching in contested littoral environments. A crane (*see Figure 40*) is an option for off or onloading. Designed and constructed through a civil-military partnership, the new LSX fleet would include other design features such as modular well deck configurations for scalability, accommodation for VTOL assets, and electronic warfare masking and decoy packages. This small ship – 200 passenger capacity – would accommodate modules for manufacturing, repair, medical and Role 2 enhanced (R2E)[28] surgical suites, housing, weaponry, storage, refrigeration, and all classes of supply.[29]

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[27] Amphibious transport dock ships or LPDs are warships that embark, transport and land elements of a landing force for a variety of expeditionary warfare missions.
SOURCE: https://www.navy.mil/navydata/fact_display.asp?cid=4200&tid=600&ct=4

[28] **NATO Logistics Handbook (OCT 1997):** Role 2 support is normally provided at larger unit level, usually of Brigade or larger size, though it may be provided farther forward, depending upon the operational requirements. In general, it will be prepared to provide evacuation from Role/Echelon 1 facilities, triage and resuscitation, treatment and holding of patients until they can be returned to duty or evacuated, and emergency dental treatment. Though normally this level will not include surgical capabilities, certain operations may require their augmentation with the capabilities to perform emergency surgery and essential post-operative management. In this case, they will be often referred to as Role 2+. In the maritime forces, Echelon 2 is equivalent to the land forces' Role 2+, as a surgical team is integral to this echelon. Maritime echelon 2 support is normally found on major war vessels and some larger logistics or support vessels, and at some Forward Logistics Sites (FLS).
SOURCE: https://www.nato.int/docu/logi-en/1997/lo-1610.htm

[29] U.S. Armed Forces classes of supply (SOURCE: https://www.dau.edu/cop/ammo/DAU%20Sponsored%20Documents/Military%20Classes%20of%20Supply.pdf):

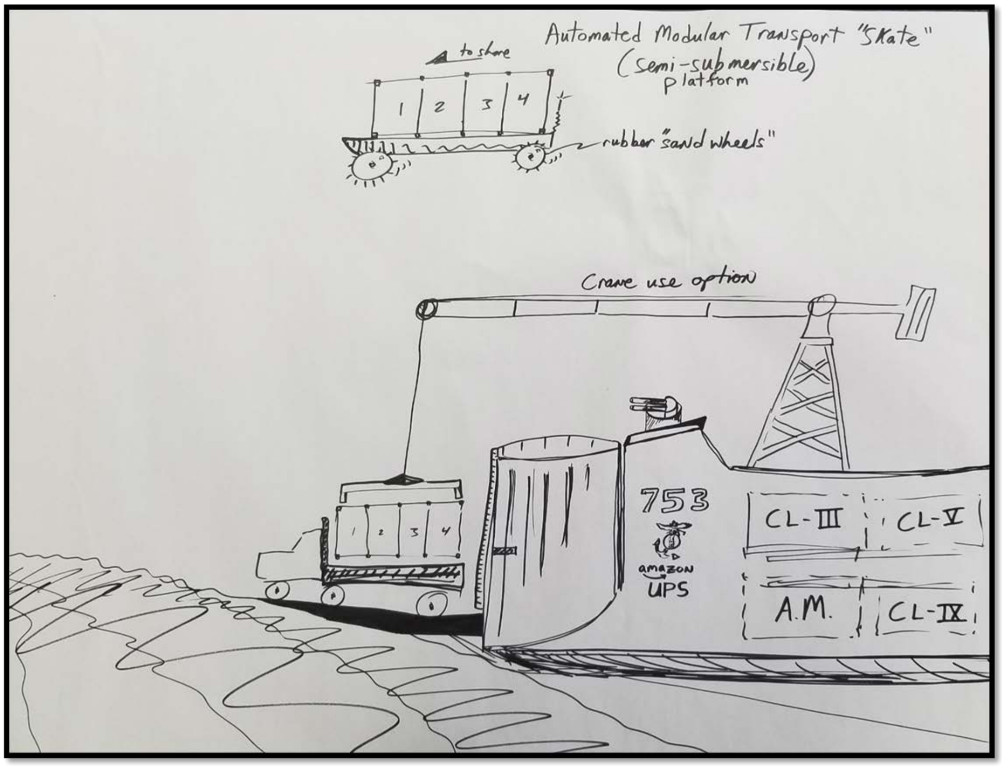

Figure 40. The landing ship expeditionary (LSX) concept, Team Viridios (September 2019).

Practical use is also key. "We don't want to create a massive fleet of ships that is not used." Private sector involvement in the design and construction is essential to create ships that serve commercial industry needs during peacetime operations. The LSX should have "Marine Corps applications and UPS[30] applications" (*see Figure 40*).

The LSTs constructed and deployed in WWII were demilitarized and used as small freighter, ferries, and dredges. LSTs at the end of their lifecycle were used as targets in aquatic nuclear bomb testing because amphibious operations were not thought to be as likely after the introduction of nuclear capabilities in warfare. Current "roll-on/roll-off" or RoRo commercial shipping[31] used primarily for automobile

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Class I – Subsistence (rations)
Class II - Clothing & Equipment
Class III - Petroleum, Oil and Lubricants (POL)
Class IV - Construction Materials
Class V - Ammunition
Class VI - Personal Demand Items
Class VII - Major End Items
Class VIII - Medical Material
Class IX - Repair Parts
Class X - Material for Nonmilitary Programs

[30] United Parcel Service https://www.ups.com/us/en/Home.page
[31] RoRo or Roll on Roll off ship is a special type of vessel which is used for the transportation of automobile vehicles. Also known as car carriers, these vessels have special inclines (ramps) constructed so as to make the

transport on ferries grew out of the effectiveness of the LSTs. The commissioning of Newport class of ships in 1969 introduced a pointed ship bow that increased the speed of the traditional LST from 15 knots to 20 knots. With further innovation in design the LSX will increase effectiveness and reduce risk to the supply chain of the future. We envision the war of our future to look very similar to the wars of the past – ships designed for World War II will have a role to play.

G. Team Vulcan

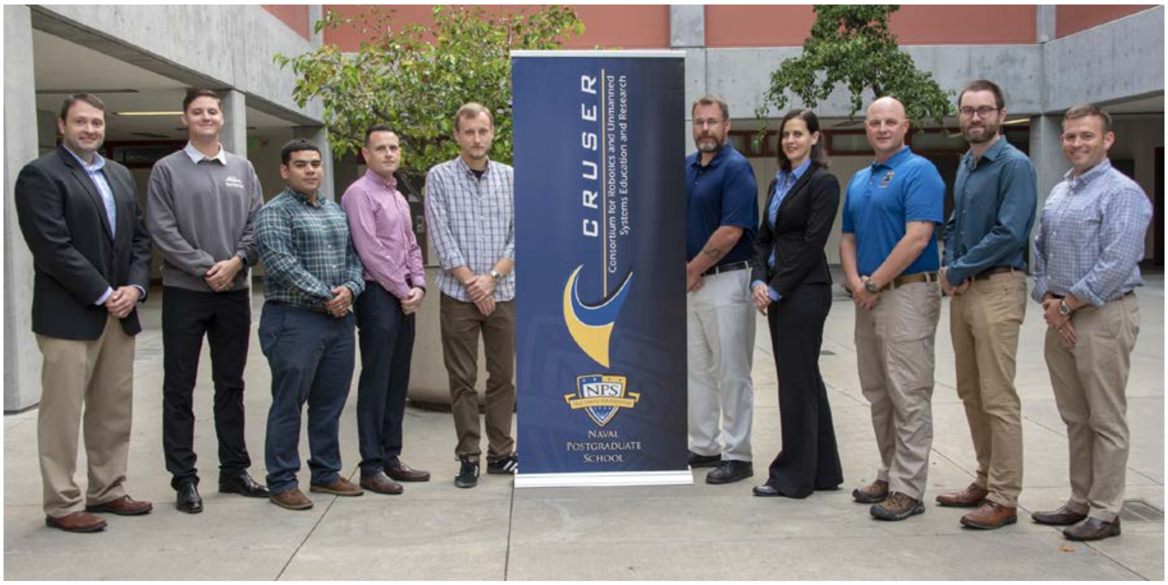

Figure 41. Members of Team Vulcan *(pictured from left to right*) CPT Paul Miller USAR, LT Shane O'Donnell USN, LT Roberto Garcia USN, Capt Steven D. Kasdan USMC, Jeremy Lerch, Jeff Parker, Dr. Misha Blocksome, CPT Ryan Campbell USA, Brendan Bongi, and CDR Chris O'Connor USN

The members of this team (*see Figure 41 and Table 7*) included five junior and mid-level officers from the U.S. Navy, Marine Corps, and Army, two reservists, two early career engineers, one NPS faculty member, and two NPS students. The team was facilitated by an NPS alum and a reservist.

Table 7. Members assigned to Team Vulcan (*alphabetical by last name*)

NAME	PERSPECTIVE	AFFILIATION
Dr. Misha Blocksome	*Unconventional warfare*	NPS Assistant Professor – NWC Monterey
Mr. Brendan Bongi	*Systems engineer*	NUWC Newport
CPT Ryan Campbell USA	*Logistics officer*	DLA-PACIFIC
LT Roberto Garcia USN	*Surface warfare*	NPS Systems Engineering Analysis student
Capt Steven D. Kasdan USMC	*Ground supply*	NPS Operations Research student
Mr. Jeremy Lerch	*Software engineer*	Draper Lab
CPT Paul Miller USAR	*Facilitator*	USSOCOM

loading and the unlading of vehicles and cargo easier and more convenient. (SOURCE: https://www.marineinsight.com/types-of-ships/different-types-of-roll-on-roll-off-ships/)

CDR Chris O'Connor USN	*Facilitator*	USFF
LT Shane O'Donnell USN	*Logistics officer*	NAVSUP/OPNAV N4i
Mr. Jeff Parker	*Facilitator*	Military Sealift Command

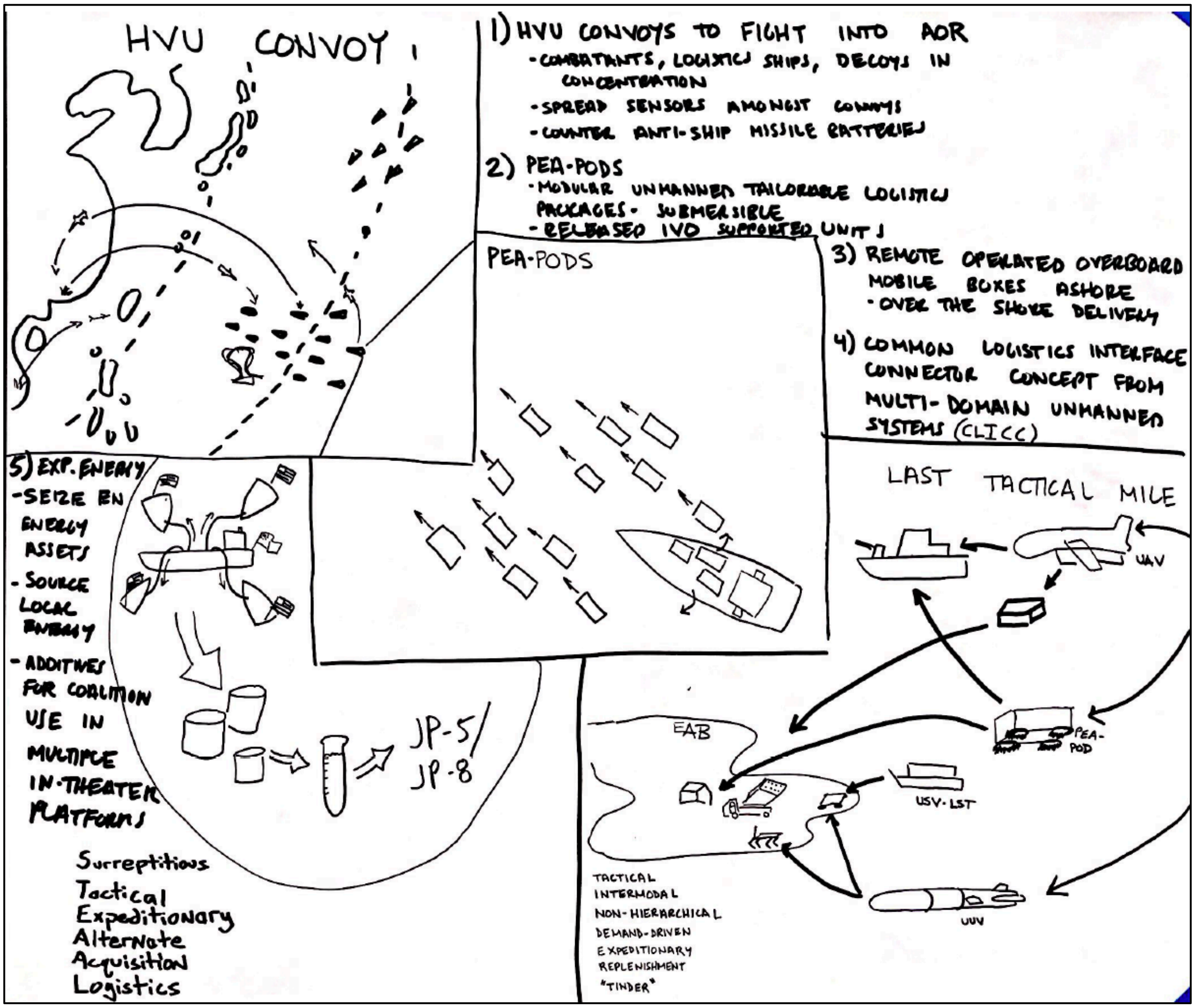

Figure 42. Team Vulcan overview of nested strategic to tactical concepts, September 2019.

Team Vulcan presented a series of nested concepts, from strategic down to tactical logistics (*see Figure 42*). They assumed they would have a "fight into the fight" and the objective of that fight would be sea control, sea denial, and advanced expeditionary bases. As logisticians, they framed their challenge to ensure the right supplies get to the end user when and where they need it. They began their work exploring how they might use existing technologies in new and novel ways, and then how might we employ emerging technologies in ways that would benefit our coalition but be disruptive to the enemy.

Using a convoy is an ideal way to "fight into the fight." The HIDE convoys are large, comprised of may inexpensive vessels, and will have the ability to fight back. When the HIDE convoy enters the enemy targeting envelope, when the enemy fires the HIDE convoy will produce counter-battery fire.

Distribution and disaggregation are a method of defense. Using multiple large convoys to get into the area of operations, as the convoy gets closer to the First Island Chain they will increase disaggregation to increase survivability. With resilience and redundancy increasing as the convoy moves into the fight, their proposed multi-nodal and multi-modal force will operate across multiple domains – undersea, surface, and air. The ultimate goal is to ensure that Marine ashore and surface combatants get exactly what they need when they need it in a standardized manner. The team also proposed a method of standardization to ensure that when an LST hits the beach and the ramp comes down the Marines have what they need to unload the Quadcon[32] and move it where they need it on shore. Standardization will allow the Marine in the fight "to know how he is going to get what he needs where he needs it when he needs it."

1. HIDE – High-Value Identifiable Deceptive Expeditionary Convoy

The first step in the set of nested concepts is getting close enough to enable the short-range components to be effectively deployed. To get from the Second Island Chain to the First Island Chain safely and en masse Team Vulcan proposed the high-value identifiable deceptive expeditionary (HIDE) convoy (*see Figure 43*).

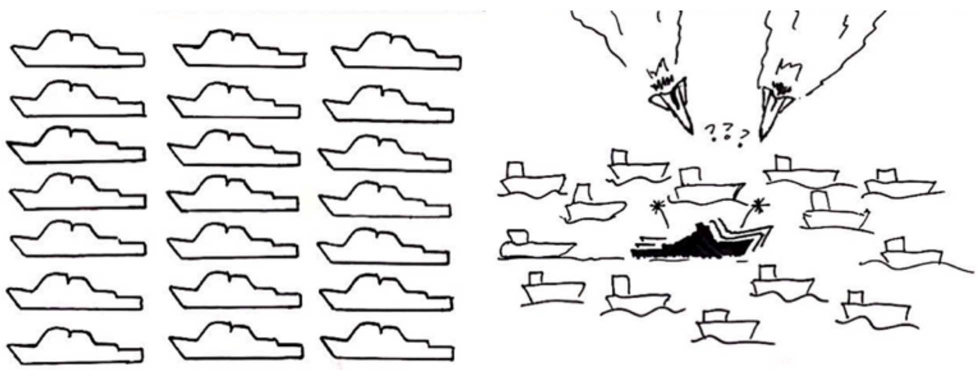

Figure 43. High-Value Identifiable Deceptive Expeditionary (HIDE) convoy concept, Team Vulcan (September 2019).

To disguise the logistics transports, and mix them up in such a way that the enemy might not know what to shoot at, Team Vulcan proposed a low-cost hull design based notionally on some sort of highly capable surface combatant – "something an enemy would need to worry about." The hull design would be modular so it could be made into a decoy or a transport. This gives the commander the flexibility to put together convoys of different types based on the mission set. "If you want you could put together an entire convoy of logistics platforms. Get that high capacity to the front." You could mix in decoys to force the enemy to make some tough decisions, and you could mix actual combatants into the convoy to get them to the fight safely and put the enemy at risk. The goal of the HIDE convoy is to confuse the enemy's kill chain, to cause the adversary to doubt their decisions, and question their next steps.

2. PEA-PODS – Prepackaged Expeditionary Autonomous Precision Overboard Distribution System

The second step of the full series of nested concepts is to deploy a modular, low-cost logistics package. Team Vulcan proposed the prepackaged expeditionary autonomous precision overboard distribution

[32] A standard dry freight container http://www.seabox.com/products/list/quadcon-dry-freight-containers

system – named PEA-PODS (*see Figure 44*). Using swarm deployment, a main ship will offload at sea while underway without slowing down. Each system is self-powered, uses a variable ballasting system, and can be submerged for seafloor recovery or floated for UAV or self-guided unmanned delivery. This type of technology is available to employ in the near future as it combines current technology from separate systems in a new way – "equipment available today that we would repurpose to meet our new needs."

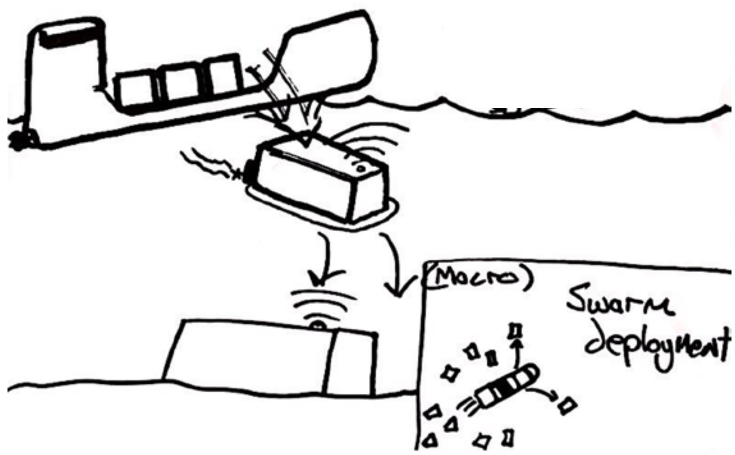

Figure 44. Prepackaged Expeditionary Autonomous Precision Overboard Distribution System (PEA-PODS), Team Vulcan (September 2019).

Some key features include the unit's low cost as it uses existing materials such as standard shipping containers or 20-foot equivalent units (TEUs), variable ballast system (VBS) for submersible operations, and a floatation system to allow for beach delivery. Seafloor recovery is depicted in the drawn concept (*see Figure 44*). A GPS or a radio frequency identification (RFID) tracker would be attached with an artificial intelligence module tied to a small motor for autonomous operation.

Pre-positioned in small packages throughout an area of operations, PEA-PODS will provide effective logistics support by sprinkling or "fairy dusting" supplies all over the battlefield. These packages can be submerged until requisitioned without the need for crude operations. PEA-PODS are available upon request with multiple recovery options.

3. ROOMBA – Remote Operated Overboard Mobile Boxes Ashore

A potential recovery option for a submerged PEA-POD is a remote operated overboard mobile box ashore (ROOMBA). Using a very rudimentary CONOPS (*see Figure 45*), the PEA-POD – in the form of a CONEX box – is dropped and sinks to the bottom and the ROOMBA is deployed for recovery. Using a variable ballast system, the PEA-POD will float a bit upon the recovery vehicle approach to allow the ROOMBA to position itself under the PEA-POD. Once the two vehicles connect the ROOMBA will bring the PEA-POD to shore.

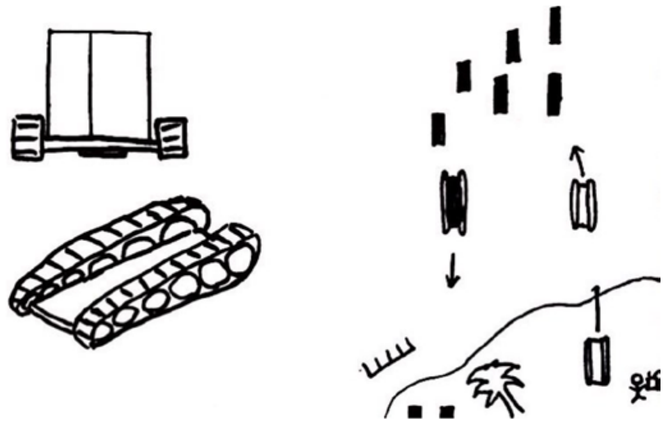

Figure 45. Remote Operated Overboard Mobile Boxes Ashore (ROOMBA) concept of operations to recover a submerged PEA-POD, Team Vulcan (September 2019).

The parking lot in the bottom left of the figure above (*see Figure 45*) is a proposed charging station that uses wave powered kinetic battery power regeneration. When the ROOMBA senses that there is not enough battery available for an entire roundtrip to retrieve the requisitioned PEA-POD it will dock itself to be recharged to full power and then complete the mission assigned – much like the Roomba[33] vacuum cleaner might do in your home. The ROOMBA would be equipped with an RFI device or little tracker to access box inventory details so that the logisticians on the ground will always know what is in the box and where the box is within the area of operations.

4. TINDER – Tactical Intermodal Non-Hierarchical Demand-Driven, Expeditionary Replenishment System

The ROOMBA retrieval of pre-positioned PEA-PODS will enable the use of the tactical, intermodal, non-hierarchical, demand-driven, expeditionary replenishment system –TINDER for logistics. "You swipe right on what you need and swipe left on what you don't need." If you swipe right on something available on the ocean floor "it's a match", and the logistics officer inputs how and when they want the requisitioned supplies. If the supplies are not readily available, TINDER with requisition the supplies for you. The forces back at your main base will load a box and get the PEA-POD dropped in an area close enough to be retrieved by ROOMBA or another recovery vehicle. Once the PEA-PODS have been recovered and brought to shore they would be delivered into a connection system to a ground vehicle that could transport the PEA-POD inland – or continue on the ROOMBA for short distances.

5. CLIC – Common Logistics Interface Connector

The ROOMBA is one method of delivering these logistics packages, but in a situation where a subsea recover is not required or driving supplies up on the beach is challenging the common logistics interface connector (CLIC) for the last tactical mile will fill that gap. By standardizing the interfaces on all packages – mechanical, electrical, communications – so that multiple different vehicle types would all conform to this same interface and be able to recover these packages and deliver them. UAVs, UUVs, and USVs

[33] iRobot Roomba Robot Vacuums https://www.irobot.com/roomba

would be equipped with a standard interface to recover pre-positioned logistics packages and deliver them to where they need to be.

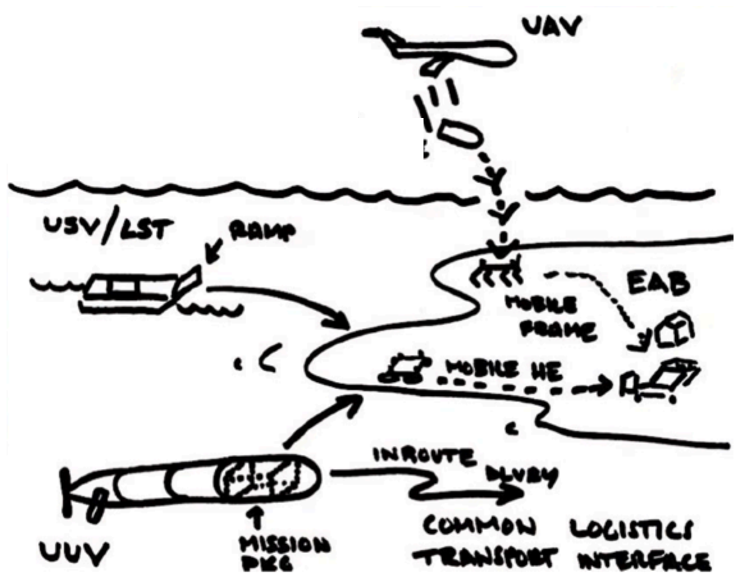

Figure 46. Common Logistics Interface Connector (CLIC), Team Vulcan (September 2019).

If the enemy cuts off a standard supply route or prevents access to the beach – either actively or due to detection concerns – the package could be retrieved by a quadcopter or other UAV (*see Figure 46*). This flexibility in recovery vehicle and route ensures that supplies get to those who are fighting the fight.

6. STEAAL – Surreptitious Tactical Expeditionary Alternate Acquisition Logistics

What happens when, despite all our best efforts, supplies still cannot get to those fighting the fight – such as a stranded group of Marines? Team Vulcan proposed the surreptitious tactical expeditionary alternate acquisitions logistics (STEAAL) strategy as a next step(*see Figure 47*).

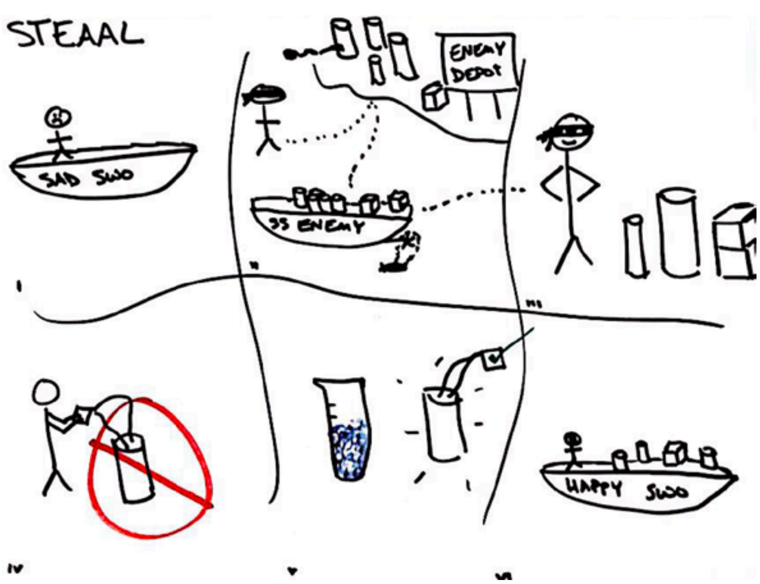

Figure 47. Surreptitious Tactical Expeditionary Alternate Acquisition Logistics (STEAAL), Team Vulcan (September 2019).

For instance, a surface warfare officer (SWO) does not have access to the supply chain as it has been cut by the enemy – “you have a sad SWO” (*see Figure 47, top left*). However, the enemy’s supplies are still in close proximity and presumably have fully functional and hardened supply chains. Why not take their supplies? Targeting the enemy’s depots and ships, not for destruction but for supply recovery, would fill the gap. A variety of unmanned systems could be employed to foul the propeller of a vessel carrying supplies, or to syphon off fuel from a depot somewhere using Marines or SEALs[34] or other special operations force to go take the fuel that you need from any enemy vessel in your sights. Food would be fairly easy to acquire using this method, but fuel is a bit trickier as there are different types of fuel. However, there are new chemical additives that could turn standard commercial jet fuel into JP5 or JP8[35]. To successfully acquire and use enemy fuel you would need mobile equipment to test the acquired fuel to accurately identify what you have (*see Figure 47, bottom center*)., and then a selection of additives to transform it into the quality of fuel you need. “This logistics for when you have no logistics.”

7. Winning the War at Sea

The goal of these nested concepts is to not only to support the logistics needs of the warfighter, but win full war at sea. What if the enemy locates multiple convoys and fires, revealing their position but hitting none of our assets of value? This tactical error enables allied forces to conduct a counterattack while the original convoy continues on to penetrate the First Island Chain. The CONOPS proposed by Team Vulcan provides deception by using integration of logistics, combatants, and decoy vessels. Once that HIDE convoy penetrates the First Island Chain, a swarm of PEA-PODS would deploy and distribute supplies throughout the battlefield. Using TINDER for logistics, the warfighter will requisition needed supplies. The multi-dimensional platforms such as ROOMBA and CLIC will get the supplies to where they are needed. If the supply chain is cut or challenged, the STEAAL strategy to confiscate, refine and redistribute goods to allied forces will supply those fighting the fight until supplies are again readily available.

[34] U.S. Navy Sea, Air, and Land (SEAL) Team – the primary special operations force of the U.S. Navy

[35] Jet propellant 5 and jet propellant 8 are jet fuels widely used by the U.S. military

H. Team Kronos

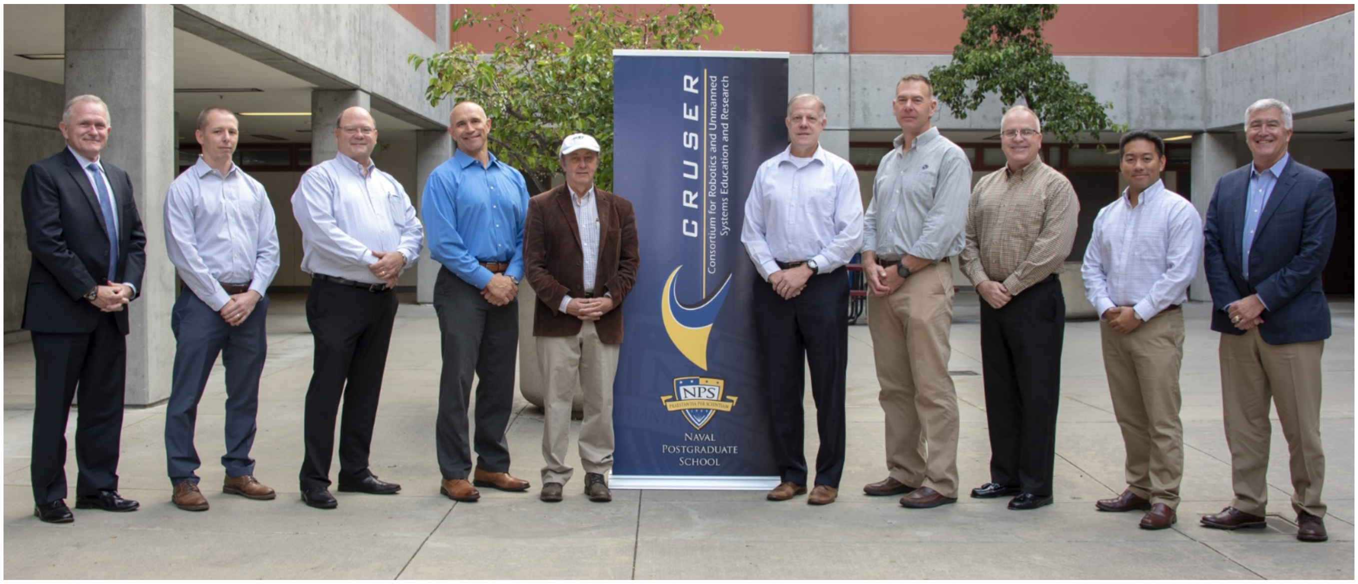

Figure 48. Members of Team Kronos *(pictured from left to right*) Professor William Glenney, Mr. Matthew Young, Dr. Jim Keener, CAPT Ed "Tick" McCabe USN, Dr. Shelley Gallup, Mr. John Coffey, Col Chris Braney USMC, Mr. Mike Graham, Mr. Kawa Amina, and CAPT Glen Sears USN (ret).

The members of this team (*see Figure 48 and Table 8*) included senior leaders from the U.S. Navy and Marine Corps, as well as representatives from warfare centers, the Naval War College, and industry. They were facilitated by a military innovation leader.

Table 8. Members assigned to Team Kronos (*alphabetical by last name*)

NAME	AFFILIATION
Mr. Kawa Amina	USINDOPACOM J46X
Col Chris Braney USMC	Installations & Logistics HQ USMC
Mr. John Coffey	NECC N3/5 DACOS
Dr. Shelley Gallup	NPS Associate Professor
Professor William Glenney	U.S. Naval War College
Mr. Aaron Harris	TRANSCOM
Dr. Jim Keener	NSWC Dahlgren
Col Todd Lyons USMC (ret)	NPS Innovation
CAPT Ed "Tick" McCabe USN	NPS Air Warfare Chair
CAPT Glen Sears USN (ret)	LMCO
Mr. Matthew Young	NSWC OPLOG

The members of Team Kronos served in the role of Mentor for the concept generation teams, with scheduled touchpoints throughout the process to provide input and guidance. This team was also tasked with crafting recommendations for the DoD Innovation Enterprise. The team explored innovation in the context of logistics in contested environments, and started with a simplified challenge to answering two questions about the Innovation Enterprise: "What is it, and how do we make it better?" They produced recommendations on the broad innovation level, and a second set of recommendations related to innovation around logistics in contested environments.

Team Kronos first defined innovation as the adoption of a new practice in a community – "not the pursuit of the next shiny object and not something the tech guys dream up." Even if the innovation does not transition, if the creator intends the product – an object, system, or process – to end up in the hands of the user it still meets the definition adopted by Team Kronos. Innovation happens everywhere, from a young sailor who has an idea about how something might be done better, to an idea taken from one community and used in a different community for a different purpose to make things better.

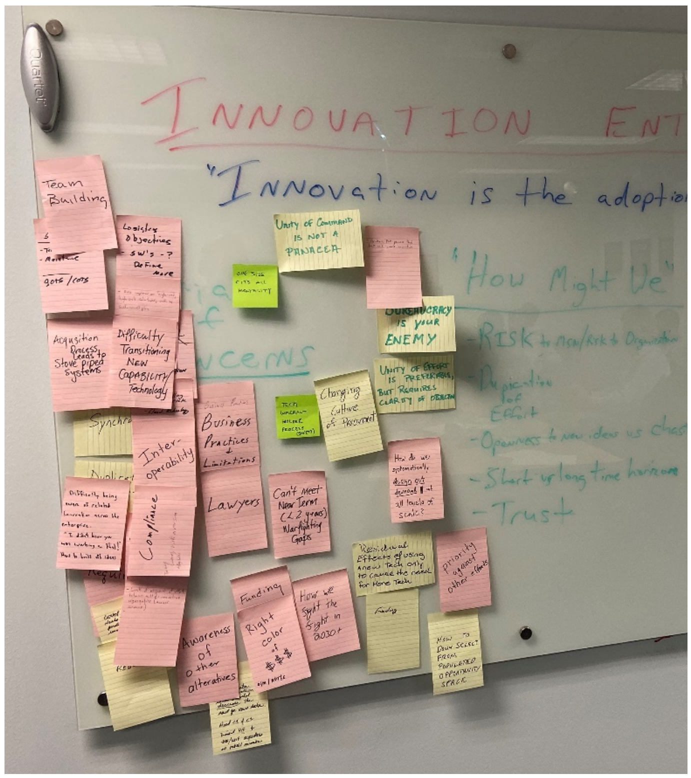

Figure 49. Artifacts from innovation discussion, Team Kronos (September 2019).

They then explored their collective concerns with innovation as currently pursued within the DoD Enterprise community (*see Figure 49*). There was a lot of concern around duplication of effort "where we don't know we are all working on the same thing." If everyone is innovating but not sharing information we may be wasting resources in parallel efforts. Related is the priority of innovation when compared to Programs of Record. You have these big Programs of Record with significant resources, however resources also need to be dedicated to innovation in order to make existing Programs of Record better and produce the Programs of Record of the future.

Recognizing that many units are using their operations and maintenance (O&M) funds[36] for innovation, and warfare centers and NPS use research development test and evaluation (RDT&E) funds[37] for innovation efforts; Team Kronos worked to identify the most effective use of finite resources. The team Interviewed an industry entrepreneur to start their data gathering. He told them "I've got this great system but I don't know who to partner with on the government side." From the government side, there are thousands of vendors to choose from. Public-private partnerships were a rich source of discussion. Because of the current focus on "fight tonight" many current efforts have a short-term focus, however the team discussed the value of a longer term view for innovation efforts – as the 2032 workshop scenario forces. The industry representative also shared that there are mechanisms in place to mitigate many process challenges, so Team Kronos did not spend much time on business practices and other innovation challenges. However, with innovation efforts it is often important to funders to know what you doing – and for Congress to confirm that the funds are going toward what was intended. This led to the Team Kronos recommendation for flexibility – with innovation it is important to lay the foundation but to then to have the flexibility to explore without a defined destination.

Team Kronos then moved into ideation with the prompt of "how might we…" to which their answers ranged widely. Their facilitator had them draw their models before discussion (*see Figure 50*) and some explored a hierarchical model, others a process flow model, some a web. Their first recommendation "really low hanging fruit" – is to change obligation rates for two year RDT&E funds. Right now projects are required to expend 90% of RDT&E funds in the first year. This framework does not allow ample time to explore the problem space thoroughly, which is an essential first step for effective innovation through user-centered design. "I need to spend some time talking to my users and really understanding the operator needs to be successful – but if I have to obligate my funds within the first 60-90 days it kind of short changes the process." Obligating funds before the problem is defined generally leads to poor solutions. "These are two-year funds, so we just need to change how we think about it" to foster innovation.

[36] DAU Glossary Definition: Operation and Maintenance (O&M) appropriations are used to finance "expenses" not related to military personnel or RDT&E/[…]. **SOURCE: Defense Acquisition University *Acquipedia*** https://www.dau.edu/acquipedia/pages/articledetails.aspx#!339

[37] DAU Glossary Definition: RDT&E appropriation accounts finance research, development, test and evaluation efforts performed by contractors and government installations to develop equipment, material, or computer application software;[…]. RDT&E funds are also used to pay the operating costs of dedicated activities engaged in the conduct of Research and Development programs. RDT&E funds are used for both investment-type costs (e.g., sophisticated laboratory test equipment) and expense-type costs (e.g., salaries of civilian employees at R&D-dedicated facilities). **SOURCE: Defense Acquisition University *Acquipedia*** https://www.dau.edu/acquipedia/pages/articledetails.aspx#!174

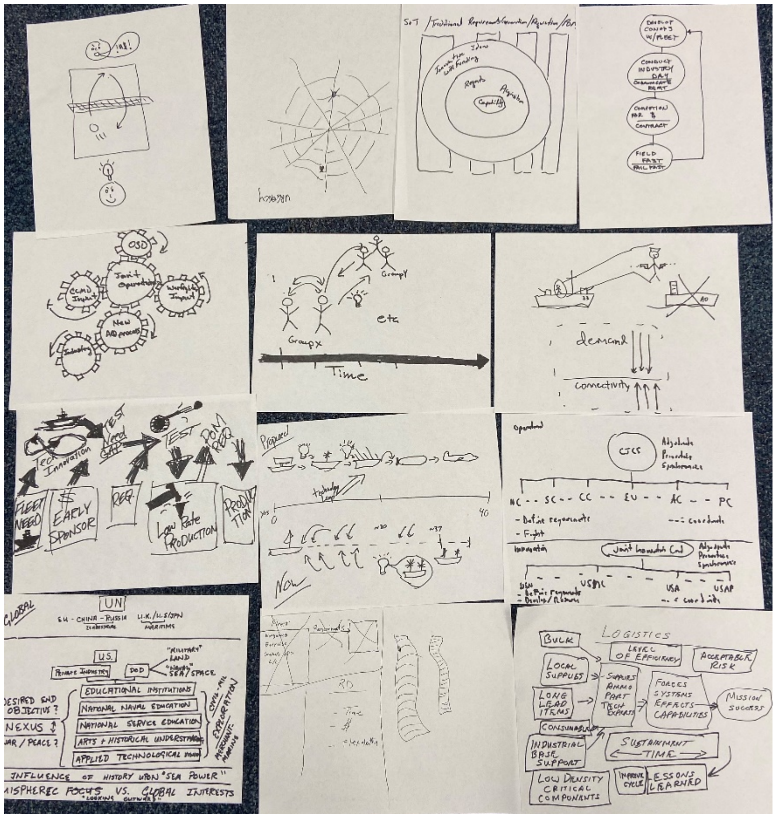

Figure 50. Next level artifacts from innovation discussion, Team Kronos (September 2019).

Their next recommendation was to create an internal venture capital system for innovation where organizations have some funds set aside for innovation efforts. There are two examples at Naval Postgraduate School – the Consortium for Robotics and Unmanned Systems Education and Research (CRUSER)[38] and the Naval Research Program (NRP)[39]. Both programs have funds dedicated to seed good ideas. Programs like this give funders the transparency they need "so that we know where our money is." Currently, this transparency is not always present with innovation efforts. The Navy Analytics Office would share that most of the money currently spent on innovation and experimentation is spent outside the normal established processes which makes it hard to track and report. "We don't need brand new resources. We need a better organization to use current resources more effectively." Along that same line, Team Kronos recommended that we make RDT&E funds more flexible. "If you are a 6-1 project but then you realize you have an opportunity to do some 6-4 work – more applied work – you get penalized if you try to do that – to convert between the different colors of money." This is a fairly low risk proposal because the funds are still obligated to the same project, but just allocated to work that will actually get the idea through prototyping and testing and into the hands of a warfighter. Right now to ensure auditability and tracking, the comptrollers are the obstacle. Team Kronos expects this to be a straightforward policy shift that could be accomplished today.

[38] CRUSER website https://my.nps.edu/web/CRUSER

[39] NPS Naval Research Program website https://my.nps.edu/web/naval-research-program

Finally, the question was asked by one of mentors "how do we Resource COCOMs to fund mission specific innovation?" and realized that each geographic COCOM has specific needs that are not applicable across the entire force. Getting each COCOM mission specific funds would help. For example, SOCOM has extra resources aligning with their "man, train, and equip" function as well as being a combatant command which allows them the flexibility to address specific needs in their specific mission set. If that could be applied more broadly it would benefit the innovation enterprise throughout the COCOMs.

Several teams working this design challenge suggested standardization and modularity as key to their generated concepts – these constraints drive innovation and allows for more creativity to reach a solution. Team Kronos identified a critical need for joint requirements – the ability for us to bring some of these requirements at the joint force level through the COCOMs to uniformly identify the key elements for success would allow us to do a better job. Reducing number of information systems would also help. We are killing ourselves with information – "one member of the group talked about taking 156 incoming information sources and combining them into one outgoing information source." With that proliferation of information systems there is not time to improve any one system so "you end up making them all generally okay but not great." Reducing the number of information systems increases transparency and repeatability across the joint force.

Finally, bringing in allies and partners early is critical to successful logistics support in a contested environment – "we are not going to do it all from the base of the United States." A sense of urgency to move forward is missing. There is not the same sense of urgency around logistics as there is to innovate at the "sharp end of the stick" in hypersonics and other emerging technology. However, as we have learned in previous conflict, logistics support will win the war. Underlying their entire discussion was the notion that commanders must own the risk. If you optimize a system to be efficient you are becoming more fragile and less attritable. To be effective in combat a command must be willing to take losses.

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:

Global War of 2030—two years in.

A fictional scenario to support academic work

2030 Political, Social, and Economic narrative:

Although **China's** economic growth began to slow in 2020, she continued her political, fiscal, economic, and military expansionism**--** particularly strengthening trade infrastructure between Asia and Europe under the "Belt and Road" initiative. In 2030 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.

Relationships between **Russia** and China are thriving, underwritten by a strong energy trade and common desire to challenge the United States national power. China depends on the Trans-Siberian pipeline developed after negotiations with Russia on oil purchases were signed in 2014. Further economic ties were generated by a series of trade agreements that began in 2023.

In 2030, Russia's economy is stabilized by Europe's and China's consistent demand for her oil. They have the fifth largest GDP and are beginning to address internal social challenges. They have maintained control of Crimea, retain forces on the Ukraine-Russian border, have modernized their missile programs, increased their modern submarine fleet and continue annual military exercises on the borders of neighboring Baltic countries. President Putin's successor continues the rhetoric of a greater Russia through exploitation of opportunities provided by a warming Arctic and reclaiming traditional Russian lands. Since the agreement signed in 2017 between **Russia and Syria** to allow Russian expansion, sovereignty and use of the naval facility at Tartus, Russia formed a permanent naval group and improved the facilities to homeport 15 ships there. They also retain their use of the Syrian Hmeymim airbase. With extensive aid from Russia, Syria was able to rebuild their land and air forces.

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.

Tensions have eased somewhat on the **Korean Peninsula** after **North Korea's** participation in the 2018 Olympics and follow-on leadership summits. However, North Korea continues developing greater ballistic missile and cruise missile capabilities. The successful submarine launched ballistic missile in 2017 was followed by a series of failures, then successes of both land launched and sea launched ballistic missiles and well as shore to ship cruise missiles.

Japan and the United States have strengthened their social, economic, and military ties in response to the growing influence of both China and Russia. The Yokosuka naval facility has evolved to a joint JMSDF and United States Navy base with RONALD REAGAN and its air wing, three United States DDGs, eight United States LCSs, and the Japanese fleet sharing the installation. In Sasebo, the United States Navy retains LHA-6, LPD-25 and LSD-52 and two LCS for mine clearance and protection.

The United States also established closer ties to **Singapore**, stationing eight LCSs, a squadron of 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 2015 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.

War in the Pacific and Indian Ocean:

The tensions began to build in 2027. Several countries along the "Belt and Silk" road de-faulted on Chinese loans to build the ports, roads, pipelines and other infrastructure supporting trade between China, Asia, Africa and Europe. In response to the defaulted loans, and to ensure trade was uninterrupted, China forcefully occupied critical facilities and placed Chinese companies to manage and operate them. Violent civil protests against Chinese workers occurred in Malaysia, Pakistan, Djibouti Vietnam and Indonesia. China began taking a harder international stance to what it perceived as unfair bias against its business practices.

In the spring of 2029, a Chinese deep-sea exploration ship exploded without warning 100 nautical miles north of Natuna Besar. China claimed either Vietnam, Indonesia or the Philippines were responsible. They mobilized their South China Seas fleet and demanded restoration from all three countries, or they would "secure" their sea. One month later the Chinese sank a patrolling Vietnamese ship using a land-based surface to surface missile launched from Woody Island (YJ-62) in the Paracels and moved a squadron of SU-37s to Woody Island. They announced all traffic through the South China Sea would henceforth be subject to inspection and control by Chinese forces. They threatened to assume governorship of the island of Natuna Besar Indonesia in compensation for the attack on their deep-sea exploration ship and to control the South China Sea's southern approaches. The 1st Marine Brigade at Zhanjiang, Guangdong embarked in the South China fleet's amphibious flotilla (13 landing ships modernized Type 71 LPDs and Type 72II LSTH) and were underway in 24 hours.

During these events, a Philippine helicopter fired on a PLAN Type 56 corvette conducing gunnery exercises four miles from Palawan Island. In response, China also threatened invasion of Palawan. The PLA's 124th

Amphibious Mechanized Infantry Division in Guangzhou district were designated for this operation.

The war started early in 2030 with China's rapid and successful occupation of Natuna Besar, Indonesia and Palawan, Philippines. Chinese PLAN and Maritime Patrol ships began to stop and inspect all merchant traffic through the South China Sea, which brought demarche protests from Japan, South Korea, Australia, Singapore, Vietnam, India and the United States. The United States, honoring the mutual defense treaty with the Philippines and Japan, and entering a defense agreement with the other protesting countries, began stopping and inspecting Chinese flag ships world-wide in proportional response while mobilizing forces. During one such inspection in the Indian Ocean, a U.S. DDG was torpedoed by an unknown submarine. War was declared by all participants. North Korea allied itself with China.

The war quickly evolved to a maritime war of attrition with China's sea control threatened by allied submarines inside the first island chain, and allied sea control threatened by PLAN submarines, ballistic missiles, and cruise missiles around and outside the first island chain.

Now, in early 2032, all sides have lost from 10-15% of their submarines, ships, aircraft, and crew. Weapon inventories are down to 50% for allies and 70% for PLAN and North Korea. Although under threat of ballistic missile attack, allied expeditionary air fields are operating in the area of operations from Dong Tac, Vietnam; Kumejima Airport in Japan; Clark airfield in the Philippines; Singapore; Nangapinoh airfield, Borneo, Indonesia. Smaller land-based forces with mobile C4ISR, air defense and anti-ship missile capabilities have been placed in various locations in the first island chain to act as a kinetic barrier to PLAN surface combatants and PLAAF air forces. The sea lines of communication to maintain logistics to these mobile bases are challenged by Chinese diesel submarines, anti-ship ballistic missiles and H20 bombers with anti-ship cruise missiles. U.S. and allied maritime forces must fight their way across the Philippine Sea in a campaign now known as the Second Battle of the Philippine Sea.

Allied submarine forces have focused on intercepting and sinking re-supply convoys to Natuna Besar and Palawan for the past eight months. Long range strikes have occurred against People's Liberation Army forces on both islands. The allies now plan to move inside the first island chain to retake first Natuna Besar and then Palawan.

<u>Conflict in Central Mediterranean and the Baltic 2032</u>

With the United States' engaged in the Pacific, Russia increased its adventurism across the cyber, social media, and insurgent spectrum. With a full promise of Russian support, Serbia conducted a lighting invasion of Montenegro to reclaim traditional Serbian lands. Bosnia and Herzegovina and Croatia came to Montenegro's aid and Serbian forces were halted outside of Podgorica. After a week of fighting, a very rough front was established on the Moraca River extending from Podgorica to Niksic.

Russia announced her full support of Serbian actions, declared a quarantine of all military supplies flowing into the Adriatic, and sortied six surface combatants from Syria and two nuclear powered attach submarines (SSNs) which were visiting on a Mediterranean deployment. She also sortied ten more submarines from the North Seas fleet into the Atlantic.

Russia also began to build forces along the eastern boarders of Latvia and Lithuania announcing concern for the ethnic Russians living in both those countries. Soon civil protests began across both countries from ethnic Russians claiming persecution. NATO began to respond by mobilizing its rapid reaction force. Five thousand NATO troops with mechanized and artillery support were airlifted to bases in both Latvia and Lithuania.

In mid-summer of 2032, Russian forces began to move into southern Lithuania from Belarus to connect with Kaliningrad through the Suwalki Gap. Lithuanian and NATO forces were defeated in 24 hours and Russia controlled all Lithuanian lands south of Kaunas.

NATO invoked Article 5 for collective defense and began to fully mobilize.

Orders of Battle in 2032 reflecting attrition

The following list is not exhaustive. Programs and/or platforms not listed but programmed for IOC earlier than 2030 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 large displacement UUVs (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 continental U.S. (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

Mediterranean, Baltic and Eastern Atlantic (SSNs and SSKs) :

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

Pacific:

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

Philippines Forces

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

Indonesia Forces

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

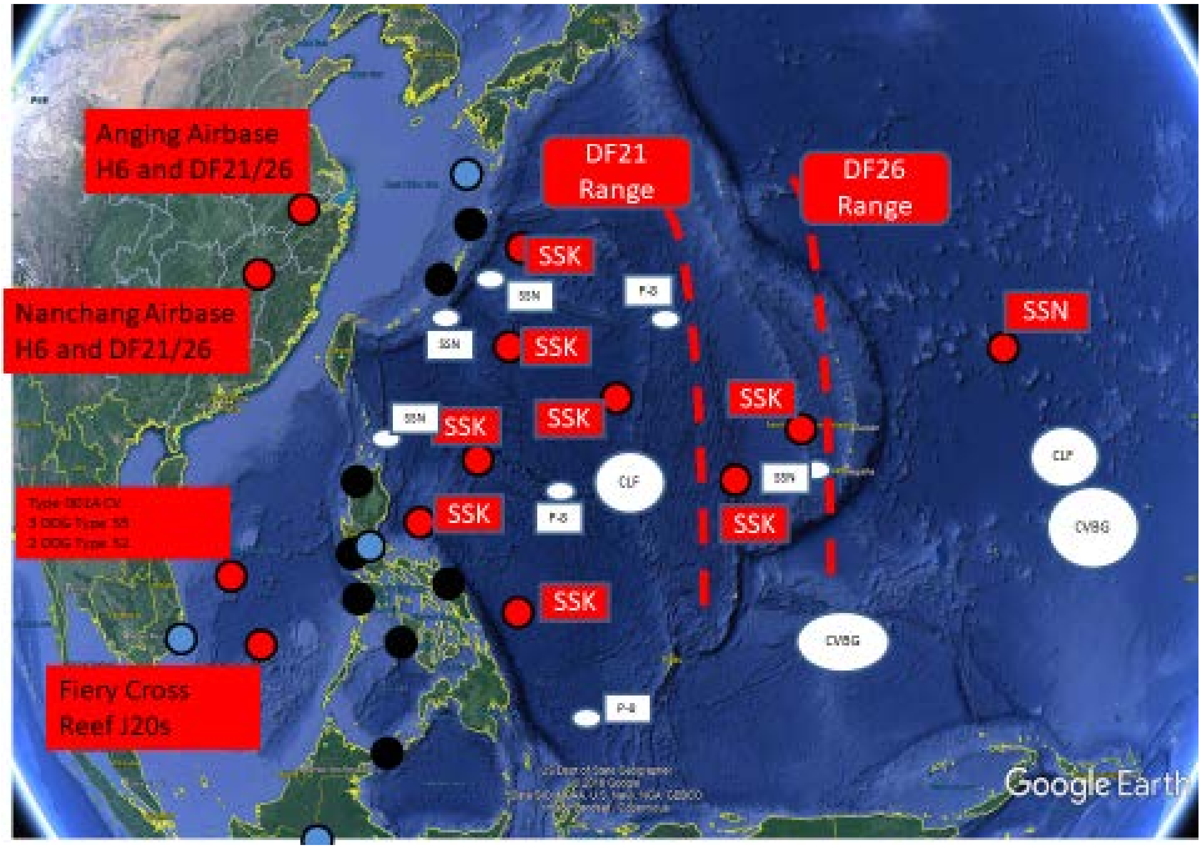

Figure 51. Year 2032 Second Battle of the Philippine Sea.

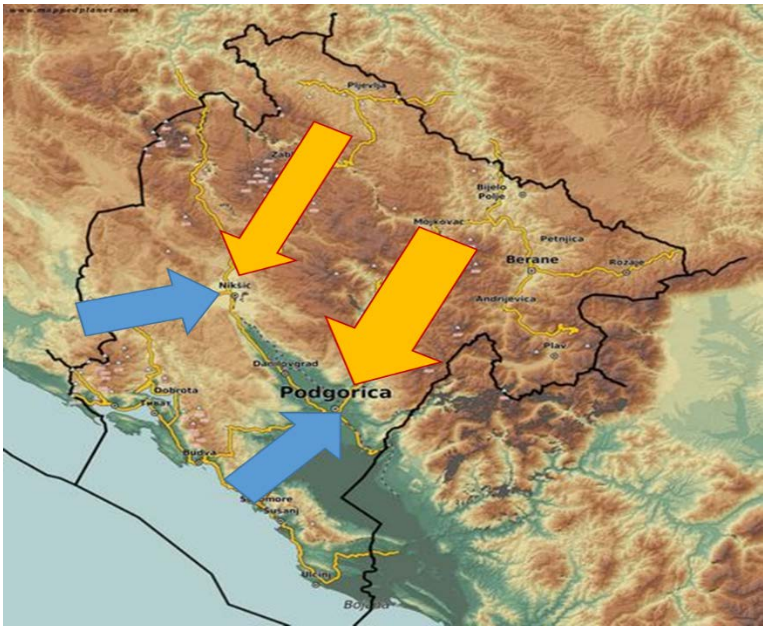

Figure 52. Situation in Adriatic

Figure 53. Russian invasion through the Suwalki Gap

Sea Lines of Communication

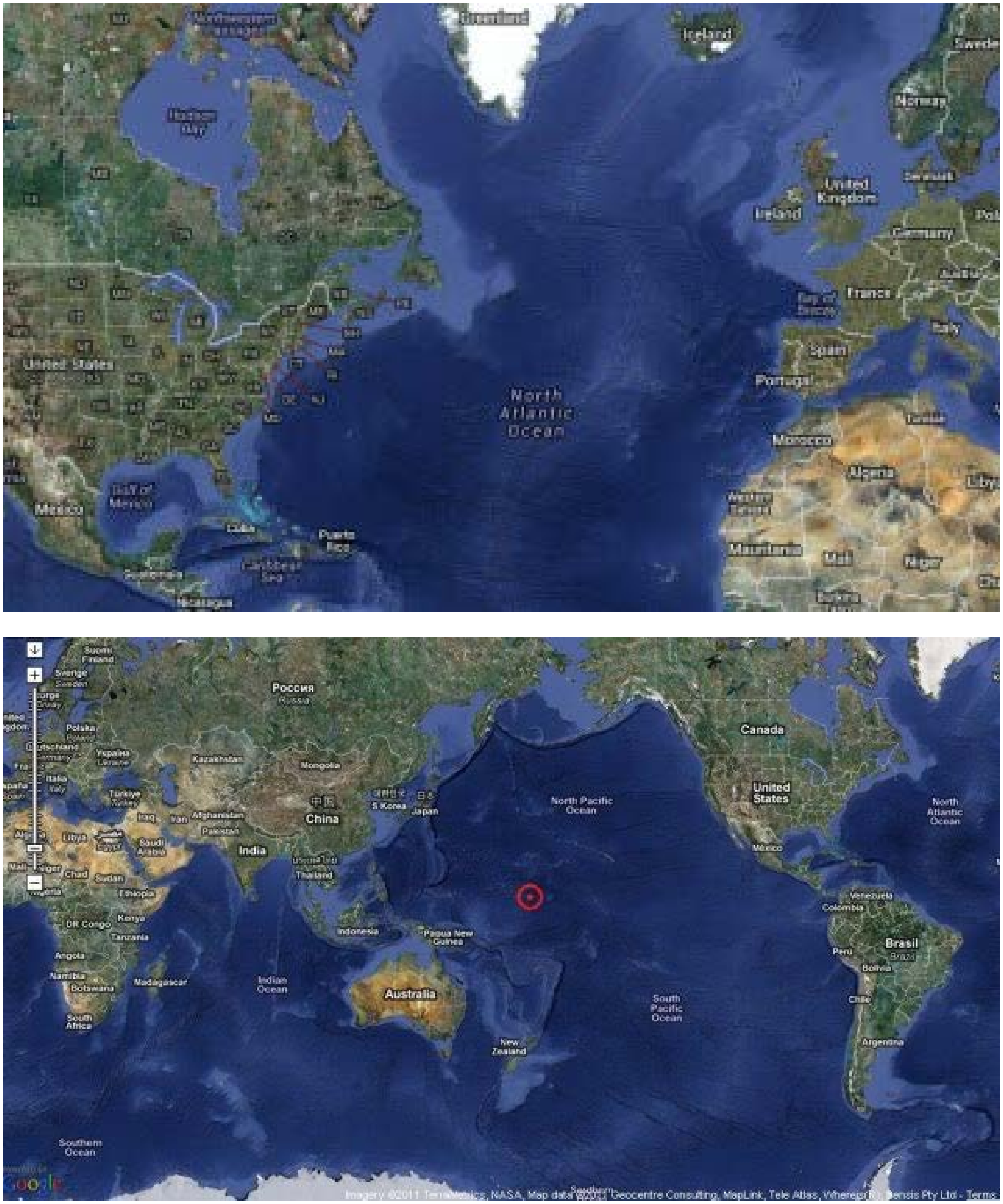

Figure 54. Sea lines of communication envisioned in 2032.

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

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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 (Janes IHS, USNI publications, and websites.) Request for information may be addressed to Prof. Jeff Kline at jekline@nps.edu

APPENDIX C: Workshop Schedule

The three and a half day workshop started on Monday morning with a series of knowledge leveling briefs, followed by initial team meetings. Both Tuesday and Wednesday started with full group technical inject sessions followed by a full day of team generation work. Teams presented their final concepts on Thursday morning and the workshop adjourned by noon to accommodate outgoing travel.

MON – 23 September

0800	Registration	**GLASGOW 102**
0830	Welcome	Dr. Steven Lerman, NPS Provost
0845	NPS Warfare Innovation Continuum & Scenario	CAPT Jeff Kline USN (ret), NPS Professor of Practice Operations Research
0915	*Focusing Logistics Outcomes*	CAPT Eric Morgan USN, OPNAV N4i Logistics Analytics Branch (LAB)
0940	*Afloat Subsistence Operations*	CDR Chris O'Connor USN, USFF Fleet Services Officer
1005	*Challenges for Joint Logistics in the Indo-Pacific*	Mr. Kawa Amina, USINDOPACOM J46X
1030	**BREAK**	
1100	*Post Supply Chain Logistics Decisions*	Dr. Ken Doerr, NPS Associate Professor Graduate School of Defense Management
1125	Team Introductions	Ms. Lyla Englehorn, NPS CRUSER Associate Director
1145	**LUNCH**	
1300	*Global Logistics Challenges*	Ms. Merritt Baer, AWS Global Accounts Principal Security Architect
1325	*Developing Technology Case Study: Counter-Drone Technology*	Mr. Jamie Hyneman, M5 Industries Founder
1350	*NPS Total Ship Systems Engineering*	LT Christopher Girouard USN, NPS TSSE Student
1415	*Innovation in a Data-Driven Environment*	Dr. Maura Sullivan, FATHOM5 Founder & COO

1440	Tasking	CAPT Jeff Kline USN (ret), NPS OR
1500	Initial Team Meetings	**BREAKOUT ROOMS**
1600	Icebreaker	**TRIDENT ROOM**
TUES – 24 September		**GLASGOW 102**
0800	Welcome	Dr. Brian Bingham, NPS CRUSER Director
0810	*Emerging Technology Inject*	Mr. Mike Tall, NIWC Pacific
0835	*Developing Technology Case Study: Elroy Air, Autonomous VTOL Aerial Logistics*	Mr. David Merrill, CEO Elroy Air and Capt. Alex Preston USMC, NPS
0900	*Emerging Technology Inject*	LT Josh Malia, NUWC Newport
0925	Process	Ms. Lyla Englehorn, NPS CRUSER
1000	Discovery Interviews – ***Mentors***	**BREAKOUT ROOMS –*meet in Glasgow Courtyard***
1000	***PARALLEL** Follow on briefs*	***STBL B18***
1130	Concept Generation – **Divergent**	**BREAKOUT ROOMS**
1200	**BROWN BAG SEMINAR:** *Somewhere over the RAINBOW:' Considering the Pacific Campaign and the Global Context of the Second World War*	Dr. David Kohnen, Naval War College John B. Hattendorf Center for Maritime Historical Research Director
1300	Concept Generation – **Divergent to Convergent**	**BREAKOUT ROOMS**
	Innovation Enterprise Discussion – ***Mentors***	**GLASGOW 102**
WED – 25 September		**GLASGOW 102**
0800	Welcome	Mr. Carl Oros, NPS CRUSER Associate Director
0810	*Accelerating Unmanned Logistics*	CAPT George Galdorisi USN (ret), NIWC Pacific
0835	*Logistics & Future Warfare*	Professor William Glenney, Naval War College Institute for Future Warfare Studies
0900	*From Concept Generation to Experimentation*	Dr. Raymond Buettner, NPS FX Director

0925	*'Logistics - What is that!' Winston S. Churchill, Admiral Ernest J. King, and the Allied Battle of Combined Command in the Second World War*	Dr. David Kohnen, Naval War College John B. Hattendorf Center for Maritime Historical Research Director
1000	Concept Generation – **Convergent**	**BREAKOUT ROOMS**
	Lab Tour – ***Mentors***	***departs @1000 from GLASGOW 102***
1030	Directors & Chairs Rotation	**BREAKOUT ROOMS**
1200	**LUNCH**	
1300	Concept Development – **Final Push**	**BREAKOUT ROOMS**
1500	***PARALLEL*** *Final Concept Presentation*	***STBL B18***
THUR – 26 September		**GLASGOW 102**
0800	Team Photos & Evaluation	
0830	Final Briefs	
1200	**ADJOURN**	

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LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

ACDC	autonomous container delivery craft
AOI	area of interest
ASTRO	autonomous space-based timely replenishment on-demand
ATLANTIS	automated theater logistics arsenal naval tactical integrated system
CASEVAC	casualty evacuation
CLF	combat logistics force
CLIC	common logistics interface connector
CNO	Chief of Naval Operations
COCOM	combatant command
CONEX	Container Express
CONOPS	concept of operations
CONUS	continental United States
CRUSER	Consortium for Robotics and Unmanned Systems Education and Research
DoD	U.S. Department of Defense
EAB	expeditionary advanced base
EAOB	expeditionary advanced operating base
GPS	global positioning system
HIDE	high value identifiable deceptive expeditionary convoy
IED	improvised explosive device
JHU/APL	The Johns Hopkins University Applied Physics Laboratory
LDUUV	large displacement unmanned undersea vehicle
LST	tank landing ship
LSX	landing ship expeditionary
NAVAIR	Naval Air Systems Command
NPS	Naval Postgraduate School
NRP	NPS Naval Research Program
NSWC	Naval Surface Warfare Center
NUWC	Naval Undersea Warfare Center
NWC	Naval War College
ONR	Office of Naval Research
OPNAV	Office of the Chief of Naval Operations
PEA-PODS	prepackaged expeditionary autonomous precision overboard distribution system
PLA-N	People’s Liberation Army – Navy
PNT	positioning, navigation, and timing
PRC	People’s Republic of China
QR code	quick response code
R2E	Role 2 enhanced
RAN	Royal Australian Navy
RFID	radio frequency identification

ROOMBA	remote operated overboard mobile boxes ashore
SEAL	U.S. Navy Sea, Air, and Land Team special operations force
SECDEF	U.S. Secretary of Defense
SECNAV	U.S. Secretary of the Navy
SOLAS	Safety of Life at Sea Convention
SSN	nuclear powered attach submarine
STEAAL	surreptitious tactical expeditionary alternate acquisitions logistics
SWaP	size, weight, and power
SWO	surface warfare officer
TechCon	CRUSER Technical Continuum
TEU	20-foot equivalent unit
TINDER	tactical intermodal non-hierarchical demand-driven expeditionary replenishment
UAV	unmanned aerial vehicle
UGV	unmanned ground vehicle
UNREP	underway replenishment
U.S.	United States
USAF	U.S. Air Force
USFF	U.S. Fleet Forces
USMC	U.S. Marine Corps
USN	U.S. Navy
USNR	U.S. Navy Reserves
USV	unmanned surface vehicle
UUV	unmanned undersea vehicle
VBS	variable ballast system
VERTREP	vertical replenishment
VLS	vertical launching system
WIC	NPS Warfare Innovation Continuum

September 2019 Warfare Innovation Continuum (WIC) Workshop: *Logistics in Contested Environments Final Report*

POC: Ms. Lyla Englehorn or cruser@nps.edu