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The Center for Strategic and Budgetary Assessments is an independent, nonpartisan policy research institute established to promote innovative thinking and debate about national security strategy and investment options. CSBA's analysis focuses on key questions related to existing and emerging threats to U.S. national security, and its goal is to enable policymakers to make informed decisions on matters of strategy, security policy, and resource allocation.

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Cover: Military Sealift Command Photo by Garrett Long.

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Executive Summary

The current and programmed defense maritime logistics force of the United States is inadequate to support the current U.S. National Defense Strategy and major military operations against China or Russia. The Summary of the 2018 National Defense Strategy specifically highlights “resilient and agile logistics” as one of eight capability areas that need to be strengthened to prepare the United States for an era of renewed great power competition. Despite this, the Navy’s Fiscal Year (FY) 2019 30-Year Shipbuilding Plan submitted to Congress decreased the percentage of spending on logistics forces compared to previous plans, and the Navy’s FY 2020 30-Year Shipbuilding Plan further reduces the logistics force as a proportion of the fleet. Current maritime logistics plans lag behind the projected size of the Navy Battle Force, the Navy’s future operating concepts, and the emergence of adversary threats to logistics. Decades of downsizing and consolidation with the goal of achieving greater efficiency have left U.S. defense maritime logistics forces brittle while simultaneously contributing to the decline of the U.S. shipbuilding industry and the Merchant Marine. Failing to remedy this situation when adversaries have U.S. logistics networks in their crosshairs could cause the United States to lose a war and fail its allies and partners in their hour of need. An unsupported force may quickly become a defeated one.

The current and programmed maritime logistics force has been shaped by decisions and analyses predicated on now-outdated assumptions and operating concepts. Chief among these decisions was the retirement of most Navy expeditionary logistics capabilities in the 1990s following the end of the Cold War, along with a heightened reliance on forward shore facilities that are now increasingly vulnerable. Today’s world, in which sophisticated adversaries challenge the U.S. military across domains, is dramatically different from the futures envisioned during the 1990s, 2000s, or even early 2010s. This report identifies five key maritime logistics planning assumptions that should shift to reflect the new environment:

1. from secure, proximate resupply facilities to distant and/or contested basing;
2. from assumed rear theater sanctuary to global conflict;
3. from gradual force buildup to forward deterrence and rapid response;

4. from short-duration to potentially protracted conflicts; and
5. from low attrition to high attrition planning.

The Navy and other Services have already begun responding to current and emerging challenges in their combat forces, yet commensurate shifts in logistics preparations are lagging behind. In general, Navy and other Service concepts emphasize geographic distribution within and across theaters, decreased dependence upon fixed sites, and greater force resilience in the face of attack, each of which carries logistics costs. With these new concepts in mind, CSBA modeling of estimated Navy peacetime and wartime logistics demands for its projected FY 2019, 2033, and 2048 Battle Force identified major gaps in logistics capacity that would hinder the fleet's ability to employ its preferred concepts at scale during conflict.

Beyond what the Navy itself needs to support naval ships and aircraft, DoD also currently faces a sealift gap of approximately 200,000 square feet (equivalent to one to two ships, depending on their capacity and assuming no attrition) to move joint forces during a major conflict and is only able to generate 65 percent of required capacity. It also faces a shortage of more than 1,900 mariners during protracted operations. The Government-owned sealift fleet is rapidly approaching a capacity cliff; more than half of Ready Reserve Force ships will reach the end of their service lives within 15 years despite service life extension efforts and suffer from reduced readiness rates. The U.S. commercial fleet—from which DoD draws ships and mariners—is either barely stable or continues to shrink. At present, the United States is running a dangerous experiment: can a country be the preeminent naval power without being a strong overall maritime power? Without action, this will force DoD to rely on foreign commercial markets for sealift and other special maritime logistics capabilities at a time when China has increasingly dominant positions in these markets and may wield its economic influence against the United States.

Thankfully, there are viable options for the United States to improve the resilience of its maritime logistics architecture—provided it acts quickly. Recognizing changes in the operating environment and Joint Force demands and prioritizing combat effectiveness over peacetime efficiency, a new architecture would meet current and future requirements. This would allow the fleet to fight in a more effective, distributed, and sustained manner while supporting U.S. Joint Force power projection. This fleet would be numerically larger, more differentiated, and—through some of the options highlighted in this report—only moderately more expensive than the programmed force.

Through a National Fleet approach coordinated among the Navy, the U.S. Department of Transportation (DOT) Maritime Administration (MARAD), and the broader Merchant Marine, the United States could transition to a resilient maritime logistics architecture within

15 years.[1] Employing mature technologies; a mix of modifications, chartering, and stipends; and new construction, DoD could acquire or support the key platforms of this proposed architecture for roughly $47.8 billion (in FY 2019 dollars) over the next 30 years. This added cost represents 6 percent above what the agencies are already planning on spending on Navy procurement, Military Sealift Command charters, and MARAD Maritime Security Program (MSP) stipends over that period. It corrects the Navy's current logistics deficit while improving overall fleet lethality, agility, and resilience, and it would revitalize the U.S. maritime sector.

Beyond concepts and funding, shifting to a new defense maritime logistics architecture will require bureaucratic champions inside and outside the Navy. These champions must not only articulate new logistics concepts, but also commit to providing the senior support and resources necessary to innovate while developing, procuring, and sustaining the next generation of maritime logistics forces.

The maritime logistics architecture proposed in this study offers stakeholders options to address shortfalls in an affordable and sequenced manner that would increase U.S. operational, and in turn strategic, resilience.

This study describes the composition of the current force, identifies challenges to the current strategic approach to maritime logistics, and reviews the historical evolution of U.S. maritime logistics. It then identifies threats and the operational concepts needed to overcome them before assessing the current and programmed force's expected performance in potential scenarios. Informed by these assessments, it proposes a new maritime logistics fleet architecture. The study then examines realistic options for building the future force and concludes by synthesizing the top findings, identifying areas for further examination, and offering actionable recommendations for DoD, MARAD, and Congress.

An outline of this study's top recommendations begins below. It is followed by a table and figure summarizing CSBA's proposed logistics fleet architecture. Appendix A at the end of the study lists key near-term recommendations by U.S. Government entity.

1 The National Fleet refers to U.S. Navy, U.S. Coast Guard, U.S. Merchant Marine (supported by MARAD), National Oceanic and Atmospheric Administration, U.S. Army, and other U.S. governmental and non-governmental maritime assets. "The term merchant marine refers to the commercial ships or fleet of a nation, and to the people who operate them. The U.S. Merchant Marine also serves as an auxiliary in time of war or national emergency, transporting goods or materiel needed by the Armed Forces." "Frequently Asked Questions," MARAD, available at www.marad.dot.gov/about-us/frequently-asked-questions/.) This study focuses on the National Fleet inputs of the U.S. Navy and Merchant Marine.

Study Recommendations

At-Sea Fleet Support

Refueling. The Navy should field a more diverse refueling fleet that addresses current and projected gaps in wartime refueling capacity. A mixed fleet would provide greater fuel capacity, would be relatively economical, would have redundancy in multiple platforms, and would only require a moderate increase in personnel.

1. "Go Big" by adopting Consolidated Logistics (CONSOL) and Modular Fuel Delivery System (MFDS)-equipped commercial tankers that would preposition a portion of war reserve fuel afloat and allow other refueling ships to resupply from tankers staged at intermediate locations, rather than having to transit longer distances to rear-area fuel depots. Some tankers could be Government-owned, while others long-term chartered and on a specialized tanker MSP stipend.

2. "Go Small" by adopting commercial Offshore Support Vessels (OSVs) as light oilers (T-AOLs) with MFDS equipment to refuel combatants operating forward.

3. "Go Fast" by adopting a procurement approach of "2 for 1 in '21", the construction of two oilers per year for a total of a billion dollars, starting in FY 2021. The Navy should buy additional T-AO 205s, its new oiler, to meet wartime demands.

4. "Go Different" by developing low-cost unmanned or minimally manned systems for providing fuel at sea in highly contested areas, especially for smaller combatants and future classes of medium and large unmanned vehicles.

5. Critically evaluate whether a future fast combat support ship (T-AOE) class provides the best value for the future threat environment and, if so, transition from T-AO 205 to a new T-AOE class toward the latter half of the accelerated T-AO 205 program (such as in FY 2028).

Cargo and Munitions. The Navy should shift to a new scalable and distributed approach to distributing cargo and delivering munitions to ships at sea.

1. Transition toward distributed aviation logistics operations, especially through greater use of the CMV-22B (the Navy's cargo delivery variant of the MV-22).

2. Improve efficiency with new Roll-on/Roll-off (RO/RO) Dry Cargo/Ammunition, Resupply ships (termed T-AKER) that would transfer cargo and munitions underway to other logistics ships.

3. Increase combatant logistical self-reliance through increased stocks of spare parts and improved onboard fabrication capabilities.

The Navy should also increase combatant effectiveness through new munitions logistics capabilities. This should be undergirded by appropriate investments in munitions and other expendables and commensurate infrastructure.

1. Adopt the aforementioned T-AKER ships.
2. Improve capabilities to reload munitions, including Vertical Launch System (VLS) cells and torpedoes, at anchor with existing auxiliary ships.
3. Field a capability to conduct VLS rearming at sea underway and at anchor, such as on a new class of modified containerships, termed Missile Rearmament Ship (T-AKM).
4. Develop new weapons technologies and concepts that yield greater operational effectiveness and logistical supportability.
5. Consider a new generation of more effective and easily sustained weapons launchers.

Towing and Salvage. Taking into account current and future operating assumptions, the Navy should revise its wartime tug requirement from 8 to 15-26 and meet the new requirement with a revised acquisition approach.

Expeditionary Maintenance and Repair. The Navy requires new afloat expeditionary maintenance and repair capabilities to provide peacetime and wartime support.

1. Expand the submarine tender fleet and acquire new surface tenders to support distributed and protracted operations far from shore facilities.
2. Acquire and obtain assured access to a force of Float-On/Float-Off (FLO/FLO) ships to serve as ship transports and mobile floating dry dock repair stations. Some could be Government-owned, while others could be enrolled in specialized FLO/FLO MSP slots or engaged in a public-private partnership.
3. Acquire a force of light unmanned system tenders to support Navy unmanned surface and underwater vehicles.

Search and Rescue (including Combat Search and Rescue) and Medical Support Afloat.

1. The Navy should develop the capacity to meet wartime high frequency and quantity search and rescue requirements, including through the acquisition of new, long-range rescue platforms (such as the tiltrotor CMV-22B, the amphibious US-2, and unmanned or minimally-manned surface vessels).
2. Unit-level survival and medical capabilities should be boosted, and the Navy should consider a different mix of fleet medical capabilities, including a new class of small hospital ships (such as one based on the EPF or other design) and a new class of

large hospital ships (such as one based on the Common Hull Auxiliary Multi-mission Platform), with priority given to more smaller hospital ships.

Joint Force Maritime Logistics: Sealift

The current sealift force faces gaps in meeting current requirements, and the DoD's Mobility Capabilities and Requirements Study 2018 (that should reflect requirements articulated in the new National Defense Strategy and address current and future levels of risk) may result in a larger sealift capacity requirement.

Sealift of Fuel. The Joint Force requires the capability to transport fuel to supply the operations of different Services.

To meet tanker requirements, DoD and MARAD should:

1. Improve financial incentives for U.S. tanker operators, including reforming the MSP to create specialized categories and compensation levels for tankers, consider offering a small stipend to Voluntary Tanker Agreement participants in domestic trade to equip, organize, and train operators, and pursue other reforms to improve the degree of U.S.-flagged ship competitiveness on the open market.

2. Increase cargo for U.S.-flagged tankers by having the Defense Logistics Agency raise the proportion of fuel purchased from U.S. refineries to increase the amount of fuel transported by U.S. tankers and consider mandating that as a condition to export liquefied natural gas and crude oil applicants transport a gradually increasing portion of the energy on U.S.-built and U.S.-flagged tankers.

DoD also requires the ability to transfer bulk quantities of fuel from the sea to shore in locations where fuel terminals have been damaged or where existing terminals are nonexistent or low throughput. This capability is critical for amphibious and distributed aviation operations. As of 2019, DoD only has the capacity to conduct high throughput bulk fuel transfer using two ships (soon to be one with the retirement of the SS *Petersburg*). To address requirements, the Navy should:

1. Acquire additional fuel transfer systems

2. Develop more effective ship-to-shore transfer concepts and systems

Sealift of Dry Cargo and Munitions. To recapitalize the sealift force, DoD should:

1. Perform service life extension of select existing Government ships (mostly to 50 years and some to 60)

2. DoD should critically evaluate the military utility of RO/RO ships in the U.S.-flag and open market and acquire suitable ships for the government fleet. At the same time,

DoD should construct RO/ROs similar to existing Large, Medium-Speed, RO/ROs (LMSRs) or, alternatively, more smaller RO/ROs for greater resilience.

3. Improve the Merchant Marine's contribution to sealift by ensuring MSP is fully funded at authorized levels and increasing the length and periodicity of renewal of MSP coverage; expanding the MSP fleet and stipend amount (to the full operating differential level) to extend sealift capacity, global reach and influence, and commercial competitiveness of U.S.-flag operations; enacting tax, liability, and policy reforms to further increase U.S.-flag competitiveness; and consider chartering U.S.-flag commercially-owned sealift ships to complement Government-owned ones and consider the utility of Dual-Use Vessel programs in which militarily useful U.S.-built ships operating in coastal trade would be partially sponsored by the Navy and MARAD and operated by commercial operators in exchange for contingency access.

Hardening of Maritime Logistics

Navy and Merchant Marine maritime logistics ships and their supporting networks are currently soft targets. An analytically-driven approach that identifies key investments in hardening can provide a high degree of operational value at a moderate cost. Specifically, the Navy should:

1. Integrate maritime logistics forces with electromagnetic maneuver warfare and information operations, including by adding secure command, control, and communications and counter-intelligence, surveillance, and reconnaissance systems on logistics ships and by fielding secure U.S. Government, Allied Government, and commercial logistics communications systems and networks.

2. Improve Navy concepts and techniques for the protection of logistics ships under different conditions, including against kinetic and non-kinetic threats.

3. Incorporate defensive systems on Combat Logistics Force (CLF) and select other maritime logistics ships.

4. Implement sealift readiness instruction to prepare Merchant Marine officers and crews for operations in contested environments.

Incorporating Logistics into Navy System Design

The Navy should continue and deepen efforts that ease the logistics requirements of current and future platforms. It should modify current and future systems to improve efficiency and reduce costs, pursue new technologies with a high logistics impact that can generate major tactical and operational advantage, and critically evaluate the logistical impact of future ship and aircraft requirements.

Organization for Sustainment Success

Improvements in the organization of the defense maritime logistics community should be pursued to increase specialization, innovation, and flexibility. There are opportunities for improvement within the U.S. Government (especially within DoD and MARAD), with the U.S. Merchant Marine and broader commercial sector, and with allies and partners. As directed by Congress in 2014, the DOT, which oversees MARAD, (and in cooperation with the Navy, the rest of DoD, and the Coast Guard) should develop and release a National Maritime Strategy that articulates a whole of government approach to revitalizing the U.S. maritime sector.

Table 1 summarizes this study's proposed maritime logistics architecture, while Figure 1 summarizes this study's representative wartime laydown of logistics forces in a notional conflict in which U.S. forces fight against China while deterring opportunistic Russian aggression.

TABLE 1: PROPOSED MARITIME LOGISTICS ARCHITECTURE

	FY 2019		FY2033		FY2048	
Ship Type	**Navy, Current**	**CSBA, Proposed**	**Navy, Projected**	**CSBA, Proposed**	**Navy, Projected**	**CSBA, Proposed**
Fuel						
Fast Combat Support Ship (T-AOE)	2	2	2	2 + TBD	0	TBD
Replenishment Oiler (T-AO)	15	19	18	22	20	24
Light Oiler (T-AOL)***		12		20		23
CONSOL Tanker (T-AOT)**	6	19	6	20	6	22
Cargo and Munitions						
Dry Stores Ship (T-AKE)	12	12	12	13	12	15
CONSOL Cargo Ship (T-AKER)***		4		4		4
Missile Rearmament Ship (T-AKM)***		5		5		6
Towing and Salvage						
Salvage/Fleet Tug (T-ATS)	5	15	8	16	8	17
Float-On/Float-Off Heavy Lift Ship**		8		8		8
Maintenance and Repairs						
Submarine Tender (AS)*	2	5	2	5	2	5
Surface Combatant Tender (AD)*		4		4		4
Unmanned System Tender				5		8
CSAR and Medical						
Hospital Ship (T-AH)*	2	2	TBD	2	TBD	2
Expeditionary Medical Ship (T-AHL)		5		5		5
Navy Battleforce Fleet**	299	315	325	347	337	364

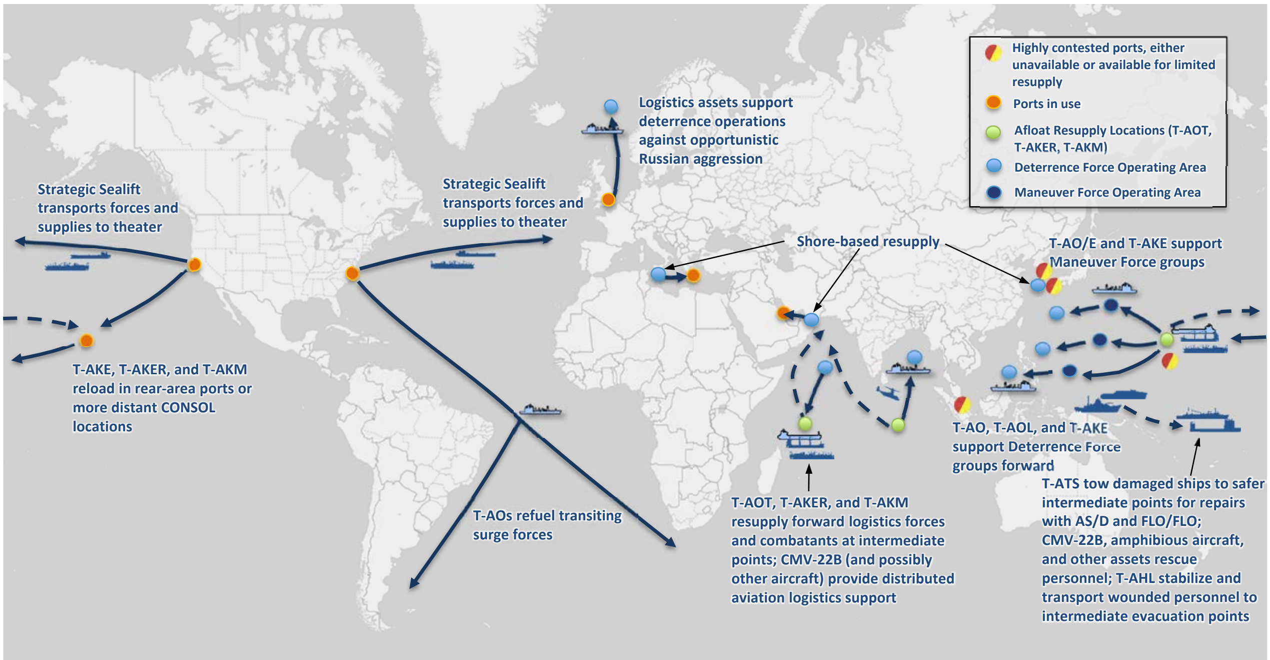
* Potential candidate for the Common Hull Auxiliary Multi-Purpose (CHAMP) vessel.

** Portions of this fleet may be applicable for long-term charter or a variant of the Maritime Security Program. Current CONSOL tankers are MSC longer-term charters and not counted in the Navy Battleforce.

*** Portions of this fleet may applicable for placement into the Ready Reserve Force.

**** Current Navy Battleforce counting rules omit many types of auxiliaries. The CSBA, Proposed Battleforce count projections have added to the Navy, Projected Battleforce count any additional buys for planned Navy programs (T-AO 205, AS(X)), along with Surface Combatant Tenders, Unmanned System Tenders, and Light Hospital Ships. T-AOTs, T-AKERs, T-AKMs, and T-AOLs are, for all intents and purposes, part of the CLF in the view of this study, but partial placement into the RRF, in MSP, or on MSC long-term charter complicates their counting as part of the Battleforce.

FIGURE 1: COMBINED WARTIME LAYDOWN OF PROPOSED MARITIME LOGISTICS FORCE



CHAPTER 1

Introduction

Logistics is the lifeblood of military forces. Military strategists routinely recognize the importance of adequate logistical support to conduct operations. Despite this, logistics forces are seldom appropriately resourced, among the last communities to receive augmentation during budget growth, and among the first to receive scrutiny during austerity.

During World War II, the United States fielded a massive logistics force of thousands of vessels and other assets that supported U.S. and Allied forces in an unrelenting advance across numerous fronts to defeat the Axis Powers.[2] In the Cold War, the core capability of this Navy and Merchant Marine force was preserved and improved to sustain a global military force that could credibly counter Communist aggression.[3] Finally, in the aftermath of the Cold War, guiding strategies reaffirmed the importance of U.S. logistics forces in providing the United States an enduring power projection strategic competitive advantage against potential challengers.[4]

In 2019, however, there are numerous indications that this area of U.S. competitive advantage now threatens to become a major weakness. Adversaries of the United States—the People's Republic of China and the Russian Federation, in particular—have developed the means to degrade, deceive, and exploit the U.S. logistics architecture, with cascading effects on U.S. combat forces. Moreover, decades of cuts to logistics capability, capacity, and posture have resulted in a relatively small and brittle U.S. logistics force that at times chose and at times was forced to prioritize peacetime efficiency over wartime effectiveness and resiliency against capable adversaries.

2 Worrall Reed Carter, *Beans, Bullets, and Black Oil: The Story of Fleet Logistics Afloat in the Pacific During World War II* (Washington, DC: U.S. Government Printing Office, 1953).

3 Thomas Wildenberg, *Gray Steel and Black Oil: Fast Tankers and Replenishment at Sea in the U.S. Navy, 1912-1995* (Annapolis, MD: Naval Institute Press, 1996).

4 Les Aspin, *Report on the Bottom-Up Review* (Washington, DC: Office of the Secretary of Defense, October 1993).

These growing logistics gaps pose three challenges. First, robust logistical capacity, capability, and readiness are some of the clearest and most compelling indicators to adversaries of U.S. military credibility, not only for short, sharp clashes but more importantly for protracted "gray zone" conflicts and high-intensity wars. The United States' logistics shortfall undercuts U.S. deterrence and invites aggression. Second, U.S. logistical gaps threaten the ability of the Joint Force to develop and execute novel Concepts of Operation (CONOPS) for contested environments that exploit disaggregation and exterior lines of communication. Without adequate logistics capable of supporting these new concepts, U.S. forces may be forced to fight in ways and from locations that greatly increase their risk, such as in a highly concentrated manner or relying on contested basing. Furthermore, U.S. forces may be unable to project power to counter aggression and aid allies and partners. Third, and most serious, logistics vulnerabilities could cause the United States to lose a war—especially against China in the vast Indo-Pacific region—if significant improvements do not take place.

This report focuses on the U.S. defense maritime logistics force (hereafter referred to as maritime logistics), the community of U.S. government and commercial assets that logistically support the U.S. Navy and Marine Corps at sea and ashore and provide sealift support to the Joint Force. Building on the initial insights on naval logistics generated by CSBA during its 2017 Alternative Fleet Architecture study,[5] this report answers in detail two questions: Is the U.S. maritime logistics force adequate to support U.S. strategy and operational concepts against adversaries? If not, how can the United States improve the operational resilience of its maritime logistics?[6]

This report contends that the current and programmed maritime logistics force is not adequate to support U.S. strategy and operational concepts against adversaries, and the United States can significantly improve the operational resilience of its maritime logistics by adopting new DoD and MARAD maritime logistics concepts, capabilities, capacities, and posture, some of which look substantially different than the existing force. In scoping the effort, the study analyzes five areas of maritime logistics support at and from the sea:

1. **Fuel**: at-sea distribution of fuel to naval forces and sealift to forces ashore from sea systems;
2. **Cargo and Munitions**: at-sea distribution of dry cargo and munitions to naval forces and the sealift of dry cargo and munitions to forces ashore;

5 Bryan Clark, Peter Haynes, Bryan McGrath, Craig Hooper, Jesse Sloman, and Timothy A. Walton, *Restoring American Seapower: A New Fleet Architecture for the United States Navy* (Washington, DC: Center for Strategic and Budgetary Assessments, 2017).

6 The study employs the following definition of operational resilience developed by RAND: "Operational resilience: The capacity of a force to withstand attack, adapt, and generate sufficient power to achieve campaign objectives in the face of continued, adaptive enemy action." Jeff Hagen, Forrest E. Morgan, Jacob L. Heim, and Matthew Carroll, *The Foundations of Operational Resilience—Assessing the Ability to Operate in an Anti-Access/Area Denial Environment* (Santa Monica, CA: RAND Corporation, 2016), p. 68.

3. **Towing and Salvage**: at-sea transport and recovery of naval platforms and systems; and

4. **Expeditionary Maintenance and Repair**: austere and at-sea maintenance and repair of naval forces;

5. **Search and Rescue and Medical Requirements**: at-sea rescue of personnel and transport and treatment of medical patients.

This study's scope is confined to at-sea elements of the U.S. maritime logistics enterprise and sealift; other critical areas of the enterprise are not systematically analyzed. For example, shore base and Defense Fuel Support Point fuel stores and distribution systems should be critically examined to determine whether they are resilient in the face of adversary threats and whether they should be rebalanced. Similarly, U.S. naval weapons inventory, naval magazine capacity, and stores deserve close study to determine whether there are enough magazines and weapons in them at the right locations. Additionally, U.S. Government and commercial logistics networks ashore face documented vulnerabilities that adversaries could exploit.[7] Finally, maritime logistics cooperation with U.S. allies and partners, such as Australia, Japan, Korea, NATO, New Zealand, Taiwan, Singapore, and the Compact of Free Association states, should significantly improve.

This study describes the composition of the current maritime logistics architecture, assesses challenges to the current strategic approach to maritime logistics, and reviews the historical evolution of U.S. maritime logistics. It then identifies threats and the operational concepts needed to overcome them before assessing the current and programmed force's expected performance in potential scenarios. Informed by these assessments, it proposes a new maritime logistics fleet architecture. The study then examines realistic options for building the future force and concludes by synthesizing the top findings, identifying areas for further examination, and offering actionable recommendations for DoD, MARAD, and Congress.

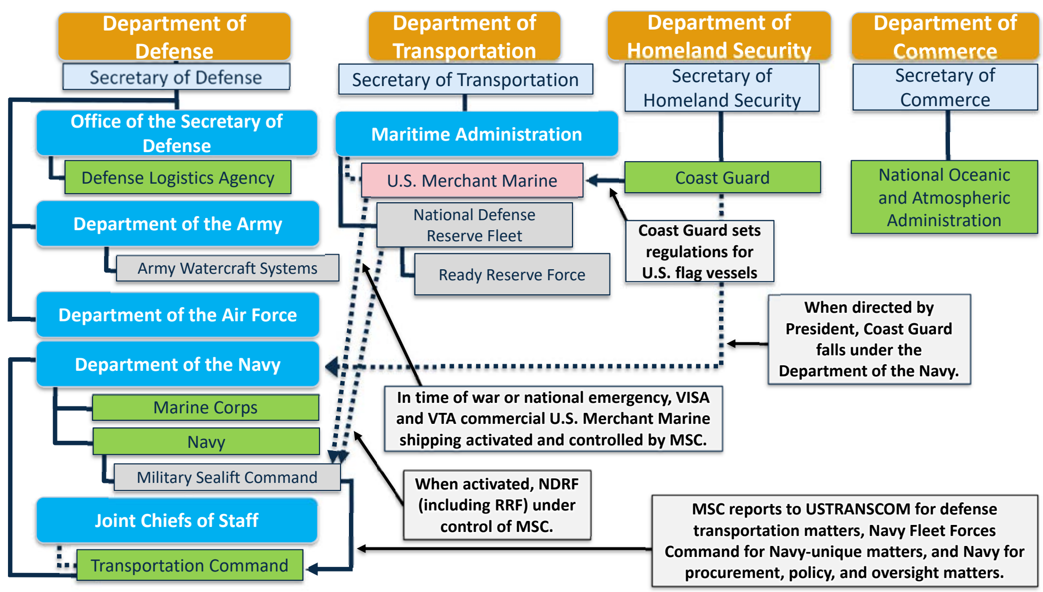
7 General Darren W. McDew, then-Commander of USTRANSCOM testified to Congress in 2017: "The greatest challenge USTRANSCOM faces every day is the threat of attack from the cyber domain. Although cybersecurity is a DoD-wide focus area, USTRANSCOM is distinctly vulnerable because the majority of the Command's transportation data resides within and travels through the unsecure commercial internet. . . . Due to these challenges, USTRANSCOM is prioritizing our key cyber concerns." General Darren W. McDew, Commander, USTRANSCOM, "On the State of the Command," statement before the Senate Armed Services Committee, May 2, 2017, pp. 17–18, available at www.armed-services.senate.gov/download/mcdew_05-02-17.

CHAPTER 2

Current U.S. Maritime Logistics

The United States maritime logistics enterprise involves a diverse array of U.S. Government and commercial U.S. Merchant Marine assets that work together as part of a National Fleet to meet the demands of the Navy, other Services, and U.S. partners. Figure 2 summarizes the U.S. Government organizations responsible for managing, operating, and supporting the National Fleet, the focus of this study.

FIGURE 2: SUMMARY OF U.S. GOVERNMENT ORGANIZATIONS RESPONSIBLE FOR MARITIME LOGISTICS ENTERPRISE



In its current form, the Navy's fleet logistics concepts principally revolve around supporting concentrated Carrier Strike Groups (CSGs) and to a lesser degree Amphibious Ready Groups (ARGs) and other naval forces. The Navy uses an efficient hub-based model to support forward-operating forces, depicted in Figure 3. U.S. Government and predominantly U.S.-flag contracted Merchant Marine shipping transports fuel and materiel to forward naval logistics hubs, where it is loaded aboard shuttling Combat Logistics Force (CLF) ships that either relieve or replenish CLF station ships operating with CSGs.

The current CLF consists of 15 *Henry J. Kaiser*-class Fleet Replenishment Oilers (T-AO), 12 *Lewis and Clark*-class Dry Cargo/Ammunition Carriers (T-AKE), and two *Supply*-class Fast Combat Support Ships (T-AOE). Other fleet logistics assets include five fleet ocean tugs and rescue and salvage ships (planned to be replaced with eight new tugs [T-ATS(X)]), two submarine tenders (AS), two large hospital ships (T-AH), expeditionary basing and transport ships (two Expeditionary Transport Dock [ESD] ships, three of a planned six Expeditionary Sea Base [ESB] ships, and eight of a planned 14 Expeditionary Fast Transport [EPF] ships), and number of other fuel and cargo auxiliaries.

Complementing surface logistics for the fleet, Navy Reserve and commercial fixed-wing aviation bring urgent cargo and passengers to Navy forward hubs, while aircraft (fixed-wing C-2As and in the next few years tiltrotor CMV-22Bs) deliver personnel and supplies to CVNs and ship-based rotary aviation (MH-60S, MH-53E, and other helicopters) distribute supplies throughout the fleet via vertical replenishment (VERTREP).

FIGURE 3: MODERN U.S. MARITIME LOGISTICS NETWORK, FROM SHORE TO SHIP

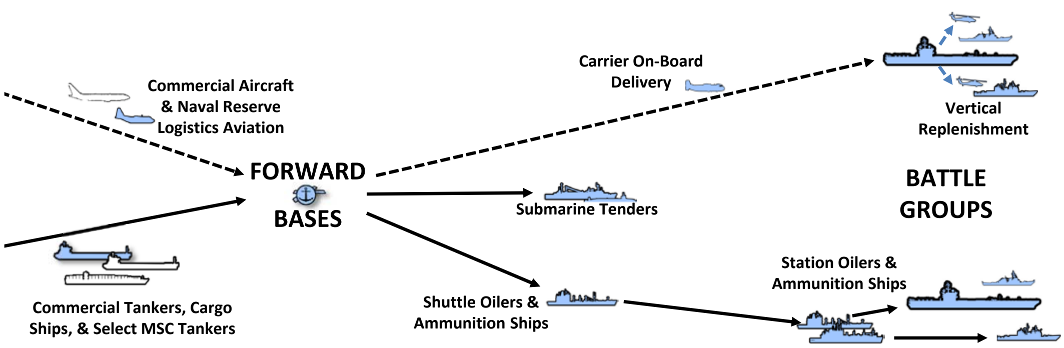


Figure inspired by Congressional Budget Office, *Issues and Options for the Navy's Combat Logistics Force* (Washington, DC: Congressional Budget Office, 1988), p. 6, available at http://www.dtic.mil/dtic/tr/fulltext/u2/a530785.pdf.

Afloat forces are employed in all three phases of strategic mobility: prepositioning, deployment (or surge), and sustainment.[8] These sealift assets transport units' vehicles, equipment, and other systems along with necessary supplies to areas of interest. To assemble sealift sufficient to support U.S. military requirements, DoD and MARAD rely on a mix of U.S.

8 Joint Chiefs of Staff (JCS), *Sealift Support to Joint Operations*, Joint Publication 4-01.2 (Washington, DC: JCS, August 31, 2015), p. ix.

Government and Merchant Marine ships and personnel. There are four primary components of the U.S. strategic sealift force, as described in Table 2. The Navy (through MSC) and MARAD jointly manage sealift capabilities to permit the deployment and sustainment of U.S. forces during peacetime and war. MSC's general policy is to use commercial sealift wherever possible to support the U.S.-flagged Merchant Marine in peacetime. During contingencies requiring significant quantities of sealift, in addition to the Maritime Prepositioning Force, the MSC Surge Fleet would be activated to transport forces. If necessary, the MARAD-managed RRF would also be activated to transport and sustain forces. Lastly, additional, non-previously chartered U.S. Merchant Marine ships would be activated through the Voluntary Intermodal Sealift Agreement and Voluntary Tanker Agreement.

TABLE 2: U.S. STRATEGIC SEALIFT FLEET

Strategic Sealift Component	Function	
Prepositioning Fleet	• ***Forward deploys*** equipment closer to potential conflict areas to facilitate rapid deployment of Marine Corps Air Ground Task Forces (MAGTFs) and to provide initial equipment and sustainment support for Army and USAF units. • Government-owned (MSC operated) purpose-built ships	
	Maritime Prepositioning Force (MPF) 2 x *Bob Hope*-class T-AKR Large, Medium-Speed Roll-On/Roll-Off (RO/RO)(LMSR) 2 x *Watson*-class T-AKR LMSR 1 x *Shughart*-class T-AK Combined Container-RO/RO Ship 5 x *Bobo*-class T-AK Dry Cargo Container Ships 2 x *Lewis and Clark*-class T-AKE 2 x *Montford Point*-class T-ESD Mobile Landing Platforms	**Army and Air Force Prepositioning Stocks** 5 x *Watson*-class T-AKR LMSR 4 x T-AK Dry Cargo Container Ships (disparate ships)
Surge Force	• ***Projects forces*** by rapidly transporting Joint (especially 1st stage Army) vehicles and equipment from CONUS • Government-owned (MSC operated) purpose-built or converted ships	
	MSC Surge Force 3 x *Sergeant Matej Kocak*-class T-AK Dry Cargo Container Ships 2 x T-AK Dry Cargo Container Ships (disparate ships) 5 x *Bob Hope*-class T-AKR LMSR 2 x *Gordon*-class T-AKR LMSR 1 x *Watson*-class T-AKR LMSR 2 x *Shughart*-class T-AK Combined Container-RO/RO Ship	
Ready Reserve Force (RRF)	• Continues ***projecting forces*** and provides ***sustainment*** capability • Government-owned (MARAD-operated) former commercial ships, part of National Defense Reserve Fleet	
	MARAD RRF 35 x RO/RO of mixed capability 6 x Crane Ship (ACS) 2 x Barge Ships (AKR) 2 x Aviation Logistics Support Container Ships (AVB) 1 x Tanker (AOT)	
Maritime Security Program (MSP)	• Focused on providing ***sustainment*** capability, although can project forces; also ***conducts commerce*** and provides steady-state transportation and sustainment to DoD forces overseas • Commercially-owned and operated U.S.-flag Merchant Marine ships. Operators make ships, crews, and intermodal logistics networks available to DoD in war or national emergency in exchange for participation in Voluntary Intermodal Service Agreement or Voluntary Tanker Agreement and receipt of a stipend	
	MSP 24 x Containership 10 x Geared Containership 6 x Heavy Lift 18 x RO/RO 2 x Tanker	

The United States has developed a maritime logistics enterprise optimized for forward presence and power projection under low threat levels. However, as the rest of this report will discuss, the fleet logistics and sealift fleets that served the United States well 15 years ago in Operation Iraqi Freedom and support ongoing operations face gaps in capability and capacity. Although they have proven their value in the past, they are insufficient for the future.

DoD now requires a maritime logistics force focused on providing support in combat against great power competitors, specifically China and Russia. The transformation of the current force will require a renewed pursuit of wartime effectiveness over peacetime efficiency. To guide these efforts, DoD should first examine challenges to the current strategic approach.

CHAPTER 3

Challenges to the Current Strategic Approach

Since World War II, the United States has held three enduring global interests: maintenance of a favorable balance of power that prevents the rise of a regional or global hegemon, continuation of economic access, and the open promotion of liberal democratic values. In support of these interests, the United States has extended economic relationships and security commitments across the world, and wherever significant deployments of U.S. forces support those commitments, there is a maritime link in the logistics support chain that transports and sustains them. This chapter examines relevant U.S. strategy and scenarios that should guide the assessment of current and future maritime logistics needs.

Implications for Maritime Logistics from U.S. Strategy

Maintaining global interests requires maritime power to conduct commerce and to deploy, project, and sustain U.S. forces. Promoting American economic prosperity has long been a pillar of U.S. grand strategy; economic vitality facilitates other U.S. policy goals at home and abroad.[9] The goods and services underpinning the U.S. economy continue to be linked to the sea. Twelve percent of U.S. GDP is derived from exports, and the United States spends 15

9 Promoting American prosperity is one of the pillars identified in the recently released U.S. National Security Strategy. White House, *National Security Strategy of the United States of America* (Washington, DC: The White House, December 2017), available at www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf.

percent of GDP on imports.[10] More than 69 percent of U.S. foreign trade and 99 percent of non-Canada and Mexico trade goes by sea.[11]

The combination of the U.S. Merchant Marine and the U.S. military are the ultimate safeguards of this seaborne commerce and its place within the U.S. economy. Navy and Coast Guard vessels also support the maintenance of a free and open global economic order and safeguard U.S. maritime economic zones.

The other facet of U.S. maritime power is military power projection. The United States has maintained forward-deployed and expeditionary power projection capabilities throughout its history and especially since the end of World War II to confront challengers at distance from American shores.[12] Navy combatants and the Navy logistics vessels and services that support them constitute part of this first line of U.S. defense. In addition, more than 90 percent of the military cargo needed by U.S. forces has been transported by sea.[13] Movement of military cargos in volume by ship is likely to remain the most efficient and cost-effective method of transportation for the foreseeable future.

This logistical backbone that supports the Joint Force is receiving new attention. The 2017 National Security Strategy of the United States calls for a force sufficiently large to be "capable of operating at sufficient scale and for ample duration to win across a range of scenarios" and asserts military "readiness requires a renewed focus on training, logistics, and maintenance. We must be able to get to a theater in time to shape events quickly. This will require a resilient forward posture and agile global mobility forces."[14] In the face of a changing operational environment, the 2018 National Defense Strategy specifically notes "resilient and agile logistics" as one of eight capability areas that need to be strengthened to prepare the United States for an era of renewed great power competition. The National Defense Strategy states:

> Investments will prioritize prepositioned forward stocks and munitions, strategic mobility assets, partner and allied support, as well as non-commercially dependent distributed logistics and maintenance to ensure logistics sustainment while under persistent multi-domain attack.[15]

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10 Organisation for Economic Co-operation and Development (OECD) data from 2016. "Trade in Goods and Services," *OECD Data*, March 12, 2018, available at data.oecd.org/trade/trade-in-goods-and-services.htm.

11 Trade percentages are as measured by weight. See "Freight Moved in Domestic and International Trade," in Department of Transportation (DOT), *Freight Facts & Figures 2017*, Bureau of Transportation Statistics (Washington, DC: DOT, updated November 15, 2017), available at www.bts.gov/bts-publications/freight-facts-and-figures/freight-facts-figures-2017-chapter-2-freight-moved.

12 U.S. Navy, U.S. Marine Corps, and U.S. Coast Guard, *A Cooperative Strategy for 21st Century Seapower*, Revised (Washington, DC: U.S. Navy, U.S. Marine Corps, and U.S. Coast Guard, 2015), available at www.navy.mil/local/maritime/150227-CS21R-Final.pdf.

13 John Frittelli, *Cargo Preferences for U.S.-Flag Shipping* (Washington, DC: Congressional Research Service, October 29, 2015), p. 1.

14 White House, *National Security Strategy of the United States of America* (2017), pp. 28–29.

15 Department of Defense (DoD), *Summary of the 2018 National Defense Strategy of the United States of America*: *Sharpening the American Military's Competitive Edge* (Washington, DC: DoD, January 2018), p. 7, available at www.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-StrategySummary.pdf.

The current force is not prepared or postured to do this, nor do current modernization plans adequately pursue the capabilities necessary to meet this goal. This report examines the maritime logistics component and offers some solutions.

Scenarios for U.S. Maritime Logistics

In identifying maritime logistics capabilities that merit the greatest emphasis, this report examines relevant notional scenarios to reveal distinct operational needs. Several scenarios are mentioned to contextualize how maritime logistics support national defense and U.S. commitments abroad and capture, at a general level, expectations regarding how forces might be employed in conflicts. The two pacing scenarios for this study involve war with China and war with Russia. The former scenario emphasizes naval and air logistics, while the latter emphasizes sealift and air logistics. Both will require extensive levels of naval, air, and sealift logistics. The scenarios are examined for FY 2019 and FY 2033 (14 years in the future). Two additional scenarios are considered: a conflict with North Korea and a concurrent conflict against a great power adversary and an opportunistic aggressor.

This report uses a conflict with the People's Republic of China (PRC) as one of its two chief planning scenarios. Overall, the scenario features U.S. action to counter PRC aggression swiftly and reverse PRC gains, backed by the commitment to conduct a prolonged, global compellence campaign as necessary.

A conflict with the PRC would require high levels of maritime logistics support. Conflict with the PRC could be instigated by Chinese aggression against Taiwan, Japan, the Philippines, or other nations in the region. It could also be caused by efforts to control passage through international water or airspace. Regardless of the initial cause of the conflict, it may not remain localized. Due to spreading Chinese military presence across the world, it is likely that U.S. military forces would need to conduct operations not only across the Indo-Pacific region but elsewhere. Accordingly, maritime logistics support would be needed in the different areas U.S. naval forces would operate. The vast distances of the Indo-Pacific region and high operational tempo of naval forces would almost certainly stress elements of maritime logistics. This report estimates that to maintain a high tempo of distributed operations in a conflict with China the Navy's forward-operating fleet afloat may consume more than 150,000 barrels (bbl) of F-76 naval and JP-5 aviation fuel per day; over the course of a month, the fleet may consume greater than 4.5 million bbl—the equivalent of 14 tanker loads.[16] The fleet might fire more than 360 Vertical Launch System (VLS) cells per day (more than 10,800 a month, or more than thirteen times the number of Tomahawk cruise missiles, a type of weapon that can be fired

16 This estimate calculates the refueling demands of the portions of the Navy's programmed FY 2019 fleet that are forward-deployed countering PRC aggression in the scenario (96 surface ships, exclusive of oilers and tankers), using the laydown and concepts discussed in CSBA's 2017 alternative fleet architecture study, *Restoring American Seapower*. For more information on the inputs and methodology behind these estimates, see Chapter 6 and Appendix B on Quantitative Assessments. Of note, tankers are assumed to have a capacity of 320,000 bbl, the upper limit of militarily useful tankers as defined by Joint Publication 4-01.2. There are 42 gallons (approximately 158.9 liters) in a barrel of fuel.

from VLS, fired by the Navy during Operation Iraqi Freedom in 2003), and employ more than 10,000 tons of other munitions and expendables over a month.[17] These and other supplies would need to be transported across the vast Pacific and Indian Oceans, with the 4,000 nm journey from Pearl Harbor to the western Pacific taking nearly 10 days at a moderately fast 20 kn and the 8,700 transit from Pearl Harbor to the central Indian Ocean taking nearly 21 days at the same speed.[18]

Additionally, rapid, high-capacity sealift would be necessary to project sufficient combat power to deny further and roll-back Chinese gains. This would likely focus on the deployment and sustainment of ground forces such as ground-based fires (to both primary bases and new Expeditionary Advanced Bases and Multi-Domain Battle operating sites the Marine Corps and Army, respectively, envision), naval shore-based support, and shore support for air forces. In some cases, it may also require the use of sealift to reinforce or sustain partners under attack. This would likely involve the deployment of not only prepositioned forces, but also the activation of the Military Sealift Command (MSC) Surge Force, MARAD Ready Reserve Force (RRF), and the U.S. Merchant Marine's Maritime Security Program (MSP) ships to project forces forward and then sustain them.[19] Additionally, with peacetime patterns of fuel transport in the Indo-Pacific likely disrupted by a Sino-U.S. conflict, the Joint Force (the U.S. Navy and Air Force in particular) will need to rely on additional organic or chartered tankers and over-the-shore fuel distribution systems to bring fuel from beyond the theater and distribute it across the theater. U.S. Transportation Command (USTRANSCOM) has identified a requirement for 86 fuel tanker ships.[20]

During the conflict, it is likely U.S. forces (including MSC and other sealift assets) would come under attack, requiring search and rescue and medical, towing and salvage, and expeditionary maintenance and repair support. Assuming the attrition of 20 percent of the deployed force in a set period of time, more than 30 manned ships could be damaged or destroyed with nearly

17 This estimate calculates the munitions demands of the portions of the Navy's programmed FY 2019 fleet that are forward-deployed countering PRC aggression in the scenario, using the laydown and concepts discussed in CSBA's 2017 alternative fleet architecture study, *Restoring American Seapower*. It assumes surface combatants fire an eighth of their VLS magazine capacity per day and reload from either ships or shore points an average 1,250 nm away. There are an estimated 5,916 VLS cells in the portion of the fleet that is forward-deployed countering PRC aggression in the scenario. This firing rate would equate to approximately 1.8 reloads per cell per month. For more information on the inputs and methodology behind these estimates, see Chapter 6 and Appendix B on Quantitative Assessments. As a historical point of reference, during Operation Iraqi Freedom in 2003, the U.S. Navy launched 802 BGM-109 Tomahawks. Wallace T. Martin, *Arming the Fleet: Providing Our Warfighters the Decisive Advantage, 1943–2011*, 3rd edition (China Lake and Point Mugu, CA: Naval Air Warfare Center Weapons Division, 2013), p. 62.

18 Transit time estimates assume a 15 percent evasion distance tax and a true speed of 20 kn.

19 Surge Force and RRF ships are government-owned ships maintained in a reduced operating status by MSC and MARAD, respectively. Through the MSP, U.S.-flag operators provide DoD contingency access through participation in the Voluntary Intermodal Sealift Agreement or Voluntary Tanker Agreement to their commercial, U.S.-flag ships and intermodal logistics network in exchange for a stipend that partially offsets the higher cost of operating a vessel as U.S.-flagged.

20 Lieutenant General Stephen Lyons, U.S. Army, Deputy Commander of USTRANSCOM, "Logistics and Sealift Forces," statement before House Armed Services Committee Subcommittee on Seapower and Projection Forces, March 22, 2016, p. 3.

2,800 personnel killed and more than 5,700 requiring rescue or medical attention, and heavy aviation losses could result in scores to hundreds of aviators needing rescue.[21]

The second chief planning scenario in this study is a conflict with Russia initiated by an invasion of the Baltic states. Overall, the scenario would likely feature a U.S. commitment to counter Russian aggression swiftly and reverse Russian gains, backed by the commitment to conduct a prolonged, global compellence campaign as necessary. In this scenario, U.S. and other NATO forces would engage Russian forces in Europe and may engage Russian forces throughout the Mediterranean, the North Pacific, the Arctic, and other parts of Eurasia. Maritime logistics support would be needed in the different areas U.S. naval forces would operate.

To deny further and roll-back Russian gains, rapid, high-capacity sealift would be needed to project sufficient combat power, especially ground forces. This would likely involve the deployment of not only prepositioned forces, but also the activation of the MSC Surge Force, the MARAD RRF, and the U.S. Merchant Marine's MSP ships to move forces forward and then sustain them.[22] USTRANSCOM has identified a requirement for 91 Roll-On/Roll-Off (RO/RO) ships in a challenging scenario, in addition to other sealift assets.[23] In addition, with Europe a net importer of fuel, the Defense Logistics Agency (DLA) would need to work with MSC to transport additional fuels to the theater (especially military-unique fuels and additives) and work with local refineries to increase production. Lastly, as with a China scenario, it is likely maritime forces (including CLF and sealift assets) would come under attack, requiring search and rescue and medical, towing and salvage, and expeditionary maintenance and repair support.

In a conflict with North Korea on the Korean Peninsula, maritime logistics forces would need to use sealift assets to rapidly reinforce U.S. and Republic of Korea military forces. Additionally, maritime logistics support, especially from CLF supporting carrier operations, would be needed to sustain a high tempo of naval strike operations.

In the post-Cold War era, the United States adopted a "two major regional contingencies" force sizing construct to deter and respond to opportunistic aggression in the event the United States became engaged in a major conflict. Although originally sized to defeat two countries

21 For more information on the inputs and methodology behind these estimates, see Chapter 6 and Appendix B on Quantitative Assessments.

22 During the Cold War, the United States annually exercised a rapid division-level reinforcement of Europe known as REFORGER (Return of Forces to Germany) to deter Soviet aggression. These exercises, in which forces were deployed forward, complemented plans of storing six divisions worth of equipment in warehouses, primarily in Germany. Although the U.S. Army never met the objective of six divisions worth of equipment, it did amass multiple divisions of hardware. The REFORGER exercises ended in 1993. The theater-prepositioned stocks and forward deployed units that the planned division would fall in on have since dwindled to a small amount of brigade-level equipment, increasing the materiel that will need to be transported during a contingency. Russian aggression in the Baltics is of particular concern; the relative isolation of the Baltic States from the rest of NATO and the Russian ability to contest transit across the Baltic Sea precludes easy reinforcement and resupply by sea.

23 Lyons, "Logistics and Sealift Forces," p. 3.

approximating Iraq and North Korea, in the contemporary environment, U.S. forces may confront both China and Russia or a great power and a smaller regional challenger simultaneously. The Summary of the 2018 *National Defense Strategy* calls for sizing the fully mobilized Joint Force to be capable of "defeating aggression by a major power; deterring opportunistic aggression elsewhere; and disrupting imminent terrorist and WMD threats."[24]

Any of the above scenarios would likely require extensive levels of naval and air logistics and sealift. Therefore, some aspects of the maritime logistics force may need to be sized to conduct concurrent operations. Through a process of assessment that included modeling, this study sized the maritime logistics force to be capable of defeating aggression by a great power adversary and simultaneously supporting modest deterrence forces in another theater.[25]

Shifting Operational Environment for Logistics

Adversaries of the United States (in particular China and Russia) have developed multi-domain capabilities that threaten U.S. combat and logistics forces across the spectrum of conflict. Coupled with a revisionist intent to expand their territory and influence, eject the United States from regions, and change the international order, these adversaries pose major threats to U.S., allied, and partner forces. Although much of the current discussion regarding anti-access/area-denial (A2/AD) capabilities focuses on the sensors and weapons needed to destroy U.S. forces in theater and keep reinforcements out, the ability to impose friction deep within the logistics chain offers additional means to slow U.S. reactions and undercut support for forward forces. For logistics planners supporting operations at any level between gray zone and high-intensity conflict, A2/AD begins before U.S. assets even leave the Continental United States.[26]

In an effort to counter U.S. maritime logistics, PLA forces may employ the PLA's "Active Strategic Counterattacks on Exterior Lines" operational guidance theory.[27] Roughly equivalent to the doctrine of Western militaries, operational guidance theory asserts the PLA's interest in employing capabilities to target relatively undefended enemy rear echelon deployment and support systems. Such an approach would degrade the combat potential of an enemy operating on exterior lines of communication, such as the United States.

24 DoD, *Summary of the 2018 National Defense Strategy*, p. 6.

25 This force-sizing approach incurs significant risk, since it is not appropriate to defeat two great power adversaries simultaneously. This study estimated that the naval non-logistics forces necessary to defeat two great powers simultaneously would significantly exceed the planned size of the Navy's fleet, even at the Navy's 2016 Force Structure Assessment objective Battle Force of 355 ships. To effectively estimate the requisite maritime logistics force to defeat two great powers simultaneously, additional non-logistics, primarily combat, forces would be needed.

26 For more information on gray zone operations, see Bryan Clark, Mark Gunzinger, and Jesse Sloman, *Winning in the Gray Zone: Using Electromagnetic Warfare to Regain Escalation Dominance* (Washington, DC: Center for Strategic and Budgetary Assessments, 2017).

27 "Active Strategic Counterattacks on Exterior Lines," or [积极的战略外线反击作战] is a rare Chinese doctrinal term introduced in English in Anton Lee Wishik II, "An Anti-Access Approximation: The PLA's Active Strategic Counterattacks on Exterior Lines," *China Security* 19, 2011, p. 37.

The PLA's counter-logistics approach is informed by its post-Operation Desert Storm analysis of vulnerabilities in the U.S. methods of warfare likely to be brought against China.[28] Specifically, Chinese authors highlighted the logistics challenges associated with U.S. air and naval operations in the Western Pacific as a major vulnerability.[29] Accordingly, Chinese campaign concepts call for consideration of preventive or preemptive attacks on U.S. forces to achieve strategic and operational surprise and deny U.S. forces the ability to mass forces and supplies. Given the importance of logistics to U.S. concepts of operation, Chinese concepts and capabilities that seek to target them merit close attention.

China has developed powerful forces capable of challenging the U.S. ability to project power, deter and defeat aggression, and operate effectively in the various warfighting domains. Today the PLA Navy (PLAN) boasts the largest fleet in the world in terms of numbers of ships and second largest in terms of tonnage, with a large portion of ships built in the last decade. The PLA also has a very modern air force, which increasingly operates at a significant distance from the Chinese Mainland and will likely field new aircraft—such as a low-observable bomber—in the near future. The PLA Rocket Force deploys a wide array of conventional land-attack and anti-ship cruise and ballistic missiles and will likely field new hypersonic missiles in the near future. Guiding these weapons, the PLA has a dense long-range surveillance network and increasingly adopts new Intelligence, Surveillance, and Reconnaissance and command and control technologies, to include greater use of artificial intelligence. The PLA's Strategic Support Force and intelligence apparatus provide it with information superiority capabilities, the capability to conduct cyber and kinetic attacks globally, and the ability to attempt to coerce government and commercial actors.[30] Collectively, these forces combine to field a potent A2/AD complex (as shown in Figure 4). The major threat posed by China will grow as the PLA continues to develop capabilities, posture, and forces suited for global power projection, in addition to its existing regionally-focused forces.[31]

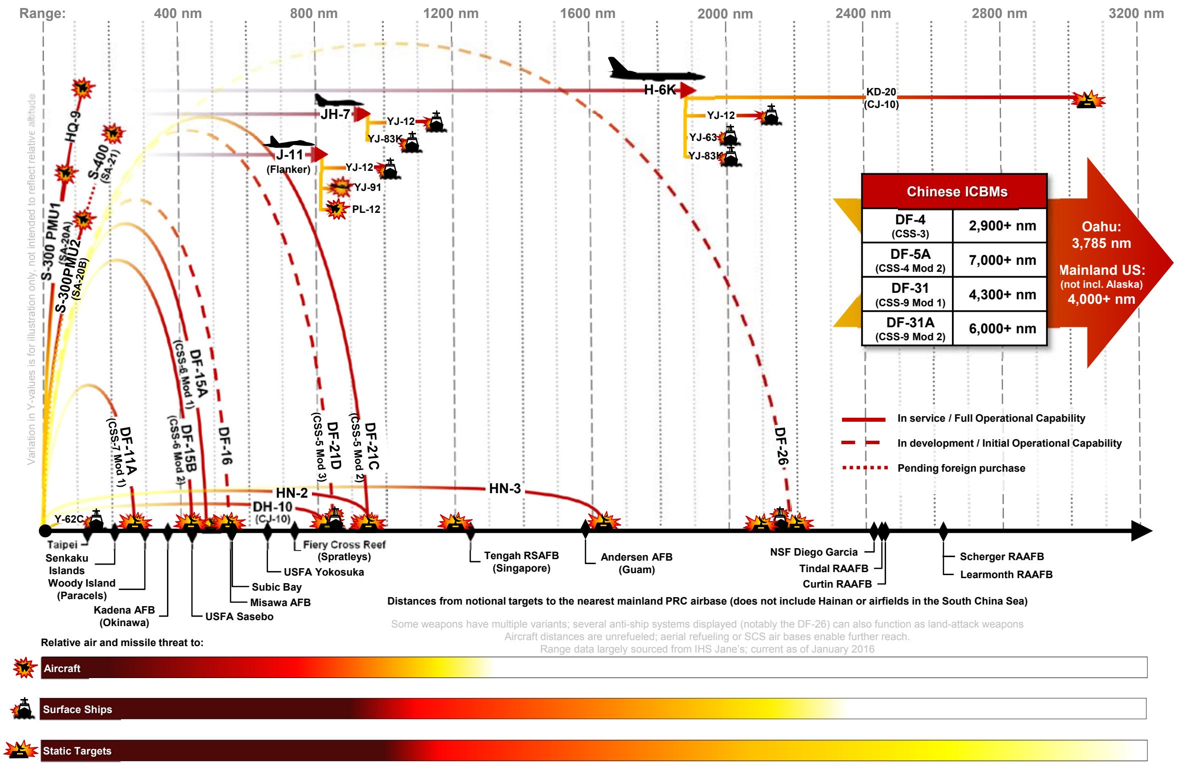
28 The PLA has also examined historical campaigns and the importance of counter-logistics. For example, PLAN analyses of the World War II Guadalcanal campaign point out how "Japanese forces were not only inadequately supplied, but also critically failed to target American rear supply depots." Lyle Goldstein, "China's Navy Is Studying the Battle of Guadalcanal," *The National Interest*, August 26, 2018, available at https://nationalinterest.org/feature/chinas-navy-studying-battle-guadalcanal-heres-why-it-matters-29687.

29 In Operations Desert Shield and Desert Storm, it took the United States six months to transport several divisions' worth of ground forces and other supplies to the region. The slow buildup of "iron mountains" of military materiel at forward bases in the Persian Gulf furnished coalition forces with the support necessary to deter further Iraqi encroaches into Saudi Arabia and then to later expel them from Kuwait in a matter of days. Mark Stokes, *China's Strategic Modernization: Implications for the United States* (Carlisle, PA: U.S. Army War College, Strategic Studies Institute, 1999), pp. 79–97, 135–145.)

30 Office of Naval Intelligence (ONI), *The PLA Navy: New Capabilities and Missions for the 21st Century* (Washington, DC: ONI, 2015), pp. 13–25; and Office of the Secretary of Defense (OSD), *Military and Security Developments Involving the People's Republic of China 2016*, Annual Report to Congress (Washington, DC: DoD, 2016), pp. 22–29.

31 *China's Military Strategy* (Beijing: The State Council Information Office of the People's Republic of China, May 2015), available at http://news.usni.org/2015/05/26/document-chinas-military-strategy.

FIGURE 4: CHINESE ANTI-ACCESS/AREA-DENIAL COMPLEX



Data to build this graphic was derived from IHS Jane's (2019); National Air and Space Intelligence Center (NASIC), Ballistic and Cruise Missile Threat (2017); and CSIS Missile Threat (2019).

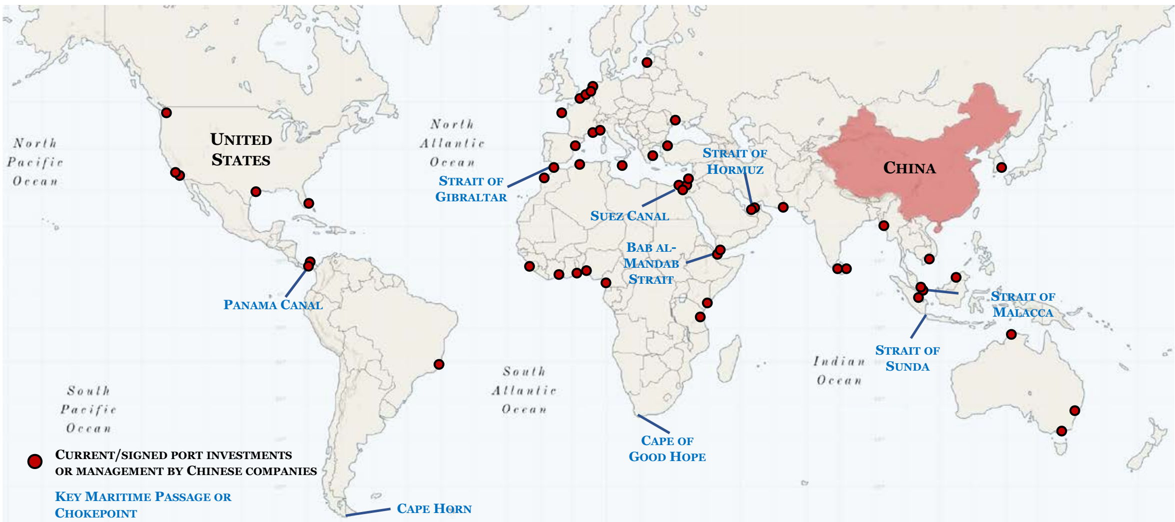
Another area that China's Communist Party has emphasized is developing an integrated maritime strategy. In addition to building up its Navy, Coast Guard, and maritime militia, China has crafted a global lead in the commercial maritime industry.[32] China's government, in cooperation with its State Owned Enterprises, has systematically developed the largest global network of ports (as depicted in Figure 5), the largest shipbuilding industry, and a world-class merchant marine that incorporates national defense features and regularly exercises with its Navy.[33] As part of its Made in China 2025 plan, the Chinese leadership has emphasized maritime equipment and high-tech shipping as one of ten key sectors to integrate advanced

32 Norwegian global quality assurance and risk management company DNV GL and Norwegian consultancy Menon ranked China as the "leading maritime nation" in a comparison of global maritime industries in 2018: this was assessed by its place in shipping (in terms of ship ownership), finance and law, maritime technology, and ports and logistics. "The Leading Maritime Nations of the World," Menon and DNV GL, DNVGL, 2018, available at www.dnvgl.com/news/china-tops-the-table-dnv-gl-and-menon-economics-release-leading-maritime-nations-of-the-world-2018-128591.

33 Dennis Blasko, "China's Merchant Marine," paper presented at the China as a Maritime Power Conference, July 28–29, 2015, p. 21, available at www.cna.org/cna_files/pdf/china-merchant-marine.pdf.

information technology with industry.[34] It has also used industrial espionage and joint ventures to accelerate its shipbuilding development. In a contingency, the PRC may be able to use its network of ports and merchant marine to project power or deny access to the United States. Even in ports not directly controlled by China, the PRC's massive trade footprint may allow it to impede the loading/unloading and transshipment of U.S. and allied military cargos in a time of crisis. Coupling the scale and sophistication of Chinese capabilities with an economy capable of rivaling or surpassing that of the United States in the future results in a China that is a peer threat in the Indo-Pacific and an increasing concern in other geographic areas.[35]

FIGURE 5: GLOBAL PORTS WITH MAJOR INVESTMENT OR CONTROL BY CHINESE COMPANIES



Today, the PRC is at the forefront of the strategic and operational challenges facing U.S. maritime logistics. It is, however, by no means the only country pursuing this approach.[36] Russia has also made great strides in its capabilities to disrupt U.S. maritime logistics.

Russia has been rebuilding its military over the past decade. It has employed its forces to invade and occupy parts of Ukraine, support the Assad regime in Syria, and harass NATO

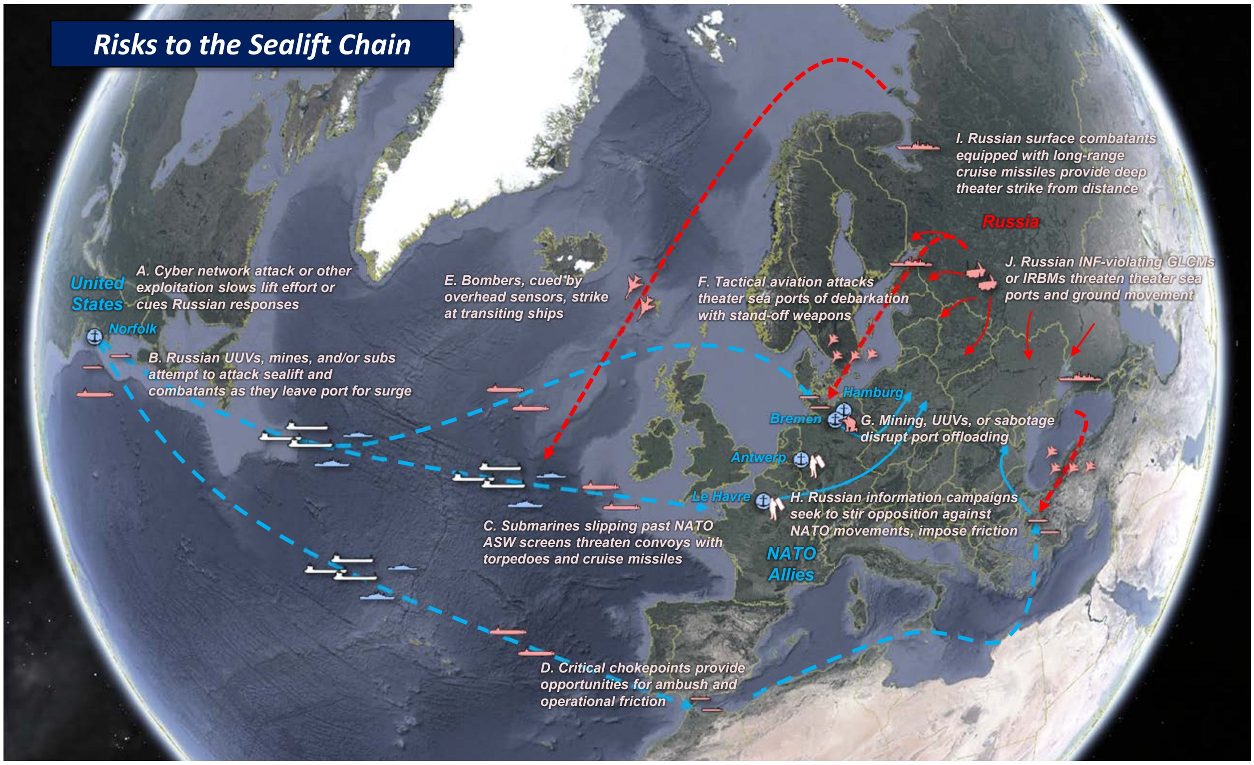
34 Michael Brown and Pavneet Singh, *China's Technology Transfer Strategy: How Chinese Investments in Emerging Technology Enable a Strategic Competitor to Access the Crown Jewels of U.S. Innovation* (Washington, DC: Defense Innovation Unit Experimental, 2018), p. 34, available at https://admin.govexec.com/media/diux_chinatechnologytransferstudy_jan_2018_(1).pdf.

35 Comprehensive National Power is a Chinese quantitative assessment of a state's net military, economic, and cultural power. China Institute of Contemporary International Relations, *Global Strategic Pattern: International Environment of China in the New Century* (Beijing: Shishi Press, 2000).

36 For a description of the A2/AD challenge and some of the components of the Chinese approach, see Andrew Krepinevich, *Why AirSea Battle?* (Washington, DC: Center for Strategic and Budgetary Assessments, 2010).

forces. Moreover, it has rapidly modernized its long-range engagement and targeting capability by fielding long-range ground, air, and sea-launched missiles. Furthermore, the Russian navy has fielded new classes of very quiet and capable submarines.[37] The combination of Russia's long-range fires and submarine forces may provide it the ability to interdict U.S. and allied logistics at sea and at ports of embarkation and debarkation (as shown in Figure 6).

FIGURE 6: SOME POTENTIAL THREATS TO SEALIFT SHIPS IN A RUSSIA SCENARIO



As with China, Russia also has sophisticated cyber and unconventional means to target U.S. logistics. Among others, U.S. logistics networks are highly vulnerable to cyberattack and exploitation. General Darren McDew, then-Commander of U.S. Transportation Command testified in March 2018: "threats in the cyber domain pose the greatest threat to our decisive logistics advantage."[38] Although a more detailed discussion of this topic is outside the scope of this report, absent major changes in both U.S. Government and commercial logistics networks, adversary cyber operations hold the potential of seriously exploiting or disrupting U.S. maritime logistics in particular and Joint Force plans in general to disastrous effect.

37 Kathleen H. Hicks, Andrew Metrick, Lisa Sawyer Samp, and Kathleen Weinberger, *Undersea Warfare in Northern Europe* (Washington, DC: Center for Strategic and International Studies, 2016), pp. 10–12.

38 General Darren W. McDew, Commander, USTRANSCOM, statement before the House Armed Services Committee, Readiness Subcommittee and the Seapower and Projection Forces Subcommittee, March 8, 2018, p. 18.

Chinese and Russian counter-logistics capabilities (consisting of an integrated mix of whole-of-society measures) will surpass those of other countries. Nonetheless, many of the military capabilities that China and Russia have developed and deployed are also proliferating to other nations such as North Korea and Iran. In particular, technologies for land and anti-ship cruise and ballistic missiles and long-range radars are allowing these regional powers to develop their own local battle networks to threaten or attack U.S. and allied combat and logistics forces.

Conclusion

The world is changing around the U.S. maritime logistics force, whose concepts are still designed for late Cold War-style operations but whose reduced size and less-resilient capabilities are those of the post-Cold War era. New operational concepts and investments geared toward addressing operating in contested environments should consider how the maritime logistics force can become more resilient against the aforementioned threats. With significant portions of that logistics network integrated with commercial markets for fuel, shipping, port access, and other activities, the Navy, other Services, and MARAD will need to cooperate with industry and Congress to ensure the United States can continue to send forces abroad at the time and place of its choosing, and then sustain those forces for however long it may take to maintain the national interest.

CHAPTER 4

The Evolution of U.S. Maritime Logistics

This chapter identifies key moments in the history of the U.S. maritime logistics force and offers select observations on the history of the force in order to illuminate the evolution of these forces and inform the remainder of this report.[39]

Historical Evolution of the U.S. Maritime Logistics Force

The development of U.S. maritime logistics in the late 19th and 20th centuries paralleled the rise of the United States as a global power. Tracking the evolution of the force illuminates how critical decisions shaped the force. For the purposes of this chapter, maritime logistics is divided into fleet logistics and strategic sealift.

Fleet logistics support to forward-deployed naval vessels has been the main conceptual driver of maritime logistics for the U.S. Navy. Encapsulated by changes in concepts and technology, modern fleet logistics can be divided into four distinct eras (and a possible fifth) as shown in Figure 7.

39 This chapter is a small subset of a larger, forthcoming work by the authors on the evolution of U.S. maritime logistics. It is heavily informed by the following works: Wildenberg, *Gray Steel and Black Oil*; Carter, *Beans, Bullets, and Black Oil*; and Robert O. Work, *Thinking About Seabasing: All Ahead Slow* (Washington, DC: Center for Strategic and Budgetary Assessments, 2006).

FIGURE 7: ERAS OF U.S. NAVY FLEET SUPPORT LOGISTICS

Anchorage Era	Expeditionary Era	Fast Logistics Era	Forward Presence Era	Agile Logistics Era?
< 1917	1917-1957	1957-1991	1992-2018	2019?
Ships reliant on fixed shore facilities, and on coaling stations in particular. Expeditionary logistics, to the extent it existed, relied on seized or secure anchorages for unstable ship-to-ship transfers.	Experimentation leads to the birth of reliable underway replenishment during WW I. Post-war progress stalled, with only minor Interwar improvement. U.S. Navy rapidly innovates during WW II and enters the Cold War with mature expeditionary logistics concepts and forces.	Cold War operational and technological demands lead to next-generation improvements in fleet support, including Fast Combat Support Ships (AOEs), STREAM and FAST transfer systems, VERTREP, and nuclear propulsion.	Peace dividend and perceived lack of threat to forward U.S. support facilities leads to dramatic downsizing of logistics fleet, especially expeditionary logistics forces, and cancellation of new logistics capabilities. Cost efficiency, not resiliency, becomes the prime metric.	Growing awareness of renewed great power competition may drive shift to a National Fleet approach for a resilient logistics architecture. Diversification of fleet support assets grants Navy options for agile and scalable support in contested areas.

In the Anchorage Era, Navy ships resupplied either in port or at anchorage. The Spanish-American War and the subsequent Great White Fleet expedition revealed the Navy's challenges deploying long distances. During the early 1910s, Navy ships made evolutionary improvements to speed the loading of coal at anchorage and began a transition to oil-fired ships, with longer cruising ranges and requiring less personnel to man powerplants.

In 1917, however, the second era began: the Expeditionary Era. During this period, innovative officers and bureaucratic champions impelled changes in fleet logistics. Lieutenant Chester Nimitz conducted the first operational underway replenishment of fuel in 1917, based on concepts and equipment he and a small team designed. Subsequent developments in this era improved underway replenishment technology using repurposed commercial ships, and by 1939 then-Rear Admiral Chester Nimitz mandated underway replenishment of not only small combatants but also large ones previously deemed too unwieldy to refuel at sea.

Over the decades, the demands of War Plan Orange, the U.S. plan to combat Japan in the Pacific, spurred innovative thinking on both the logistical viability of previous plans and how to sustain U.S. naval maneuver forces that later facilitated the Navy's World War II Pacific campaigns. Further innovations during World War II culminated in the ability to transfer large amounts of fuel and cargo (including munitions) underway by 1944. The fleet also fielded numerous mobile and relocatable ships and platforms able to sustain, maintain, and repair or salvage battle-damaged ships, granting the fleet an expeditionary capability not reliant on forward bases.

The Fast Logistics Era began with the Navy's 1957 Mobile Logistics Conference, in which Chief of Naval Operations Admiral Arleigh Burke rejected evolutionary improvements to World War II-era technologies and demanded new concepts and major systems improvements. Most notably, this phase was manifested in the development of purpose-built, multi-product logistics ships and specialized, high-transfer rate and weight underway replenishment technologies (e.g., STREAM and FAST). Fast combat support ships (AOE) were the ultimate development of the era, designed to support the Navy's fundamental operational concept of fast maneuver warfare. During this era, the Navy also introduced nuclear-powered submarines and surface ships, altering fleet logistics requirements.

The fourth and current era of fleet logistics, the Forward Presence Era, began in the early 1990s. During this era, the fleet logistics force has been optimized to minimize cost and to provide support from secure, forward bases in generally uncontested waters. This focus on cost was reflected in a reduction in the size of its logistics forces, especially its AOEs, submarine tenders, destroyer tenders, repair ships, and other auxiliaries. Furthermore, to save costs, self-defense systems were either not incorporated on new logistics vessels or removed from existing ones. Interestingly, the Navy continues to widely adopt weapons technologies (such as VLS) without an effective means to reload them at sea. Finally, the Navy has adopted a new ship class (the *Freedom*-class Littoral Combat Ship) with short range at moderate to high speeds that requires a significantly higher frequency of oiler support if shore basing is unavailable.

Logistics architecture development during this period stumbled, as the Navy continued to develop and operate logistics vessels and systems only one or two generations removed from their World War II forbears that only incorporate modest evolutionary improvements, and regressed by shrinking the fleet's most capable at-sea replenishment platforms (AOEs) from a force of eight to a mere two. Whether the Navy enters into a potential fifth era of Agile Logistics starting in 2019 remains to be seen.

In contrast to fleet logistics support, less changed for sealift concepts in the past century. The 1898 acquisition of merchant sealift for the invasion of Cuba was fundamentally similar to the Navy's World War I seizure of merchant shipping and repurposing and construction of new merchant vessels in World War II. From World War II onwards, military features of cargo shipping received more attention, but since the Korean War national sealift has been dependent on a mix of Government-owned and commercial U.S Merchant Marine shipping and largely reliant on high-capacity fixed port infrastructure for access. The introduction of RO/RO vessels, national military sealift fleets, and prepositioned equipment stocks afloat have changed the speed of response, but not the fundamental approach. A noteworthy exception is the near-complete elimination of port access-insensitive sealift platforms, such as Landing Ship, Tanks (LSTs), from the force.

Whereas the first Gulf War demonstrated U.S. proficiency in deployment and sustainment en masse in an uncontested buildup, it also laid bare the chronic under-resourcing of U.S. Government maritime logistics readiness and the long-term decline of the U.S. Merchant Marine since its World War II zenith. U.S. maritime logistics underwent changes following the first Gulf War. The 1993 Bottom-Up Review created a new force-sizing construct for the post-Cold War era that heightened reliance on rapid strategic mobility, even as it reduced overall force structure and defense resources. This resulted in new investments in maritime logistics in the early- to mid-1990s, principally in a fleet of Government-owned RO/ROs and in the establishment of the Maritime Security Program (MSP) to secure DoD access to a large fleet of U.S.-flag Merchant Marine vessels, their crews, and their global intermodal logistics networks.[40]

Post-Desert Storm investments in maritime logistics paid dividends during the buildup and sustainment of forces for Operation Iraqi Freedom. A large Government fleet of purpose-built and converted ships allowed the rapid deployment of intact units of military equipment, while a mix of RRF and MSP ships addressed sustainment demands. MSC and MARAD ships were quickly activated within an average of three days, and the use of chartered foreign vessels was minimized.

In spite of the success of U.S. maritime logistics in Operation Iraqi Freedom, the fleet's capacity and readiness have atrophied over the past 15 years. One of three U.S. Marine Corps Prepositioning Squadrons was disestablished in 2012. Moreover, within the Surge Force and RRF, the average age of ships continues to rise, with average ages of 28 and 43 years in the respective fleets—far beyond most of the ships' expected service lives. Significant portions of the sealift fleet face aging out within a decade. The U.S. Merchant Marine is either barely stable or continues to shrink, and the Government and commercial sealift fleets would face a manning shortfall in a protracted war.[41]

Overall, the U.S. maritime logistics architecture has significantly evolved throughout the 20th and early 21st Centuries to overcome challenges. In the contemporary force, DoD has developed an effective and efficient maritime logistics enterprise optimized for forward presence and power projection under low threat levels. However, as the rest of this report will discuss, the fleet logistics and sealift fleets that served the United States well 15 years ago in Operation Iraqi Freedom and support ongoing operations face gaps in capability and capacity when facing great power competitors.

Observations on the Evolution of the Force

This study's review of the history of the U.S. maritime logistics force generated a number of observations that shaped the report's subsequent analysis. This section articulates major observations that informed the work.

Putting Naval Logistics Concepts into Practice. The Navy has identified innovative logistics concepts in both peacetime and conflict but often fails to resource logistics capabilities adequately until urgently required—usually only once the deficiency has become painfully

40 "Maritime Security Program," MARAD, available at https://www.marad.dot.gov/ships-and-shipping/strategic-sealift/maritime-security-program-msp/. The MSP stipend was adopted as a more economical way of partially replacing the previous Operating Differential Subsidy Program (ODSP). ODSP was instituted in the Merchant Marine Act of 1936.

41 Maritime Workforce Working Group (MWWG), *Maritime Workforce Working Group Report* (Washington, DC: DOT/MARAD, 2017), p. 24, available at https://www.maritime.dot.gov/sites/marad.dot.gov/files/docs/mariners/1026/mwwg-report-congress-finalr3.pdf.

obvious. Logistics innovation has rarely been a priority. Emerging naval concepts of operation, particularly those involving significant demands on logistics, need to be exercised in peacetime with significant portions of the fleet to identify and remedy logistical shortfalls. The Navy's Fleet Problems of the 1920s and 1930s may not have spurred the Navy to correct its logistics deficiencies, but they did call attention to what would need to be corrected at greater scale during a conflict. Similarly, the large-scale Nifty Nugget mobilization exercise of 1978 exposed the flaws behind decades of assumptions regarding mobilization and deployment for a large-scale conflict in Europe and prompted major revisions to DoD's organization. Today, almost as much time has passed since Desert Storm (1990-1991) as passed between the end of World War II and Nifty Nugget. Without critical self-assessment and opportunities for exercise, the U.S. military will be unable to adopt new concepts on a widespread basis or have in hand roadmaps for action if conflicts break out. The passage of time also allows assumptions to ossify, even if they no longer comport with reality.

Mobilization. Modern acquisition processes are not configured for major mobilization and surge production. Immediate production requires existing designs. Maritime Commission efforts prior to World War II created Government-owned designs with broad industry input that could be handed out to shipbuilders, of all sizes, so that they could contribute to the war effort. While pre-war warship and tanker production was concentrated at a few major firms, wartime efforts were able to involve many more companies thanks to government organization and information sharing. Beyond production, major wars reveal shortfalls in technology, and new developments obsolesce prior designs. In both world wars, ships built during the war had been outclassed by the end of the conflict.[42] Surge production needs to be prepared for well in advance of conflict and wartime emergency acquisition does not need to be built for the same service life standards to which the Navy and other Services are now accustomed. "Good enough" designs relied upon in extremity may look quite different than what the Navy or other Services sought in peacetime. This point is not limited to logistics.

Furthermore, the growing divergence in commercial and military logistics ship designs over the latter half of the 20th Century, the shrinking size of the U.S. Merchant Marine, and the competitive nature of the international maritime market challenge approaches that defer peacetime acquisition of an appropriate maritime logistics force in favor of wartime recruitment of logistics assets from the commercial sector. If DoD requires logistics support quickly in order to deny enemy gains, slow approaches that take numerous months or years to generate sufficient logistics capacity will likely be inadequate.

Finally, to fully utilize the commercial maritime sector (and other components critical to the U.S. maritime logistics force), DoD will need to assess commercial capabilities and capacities closely in peacetime and coordinate with and integrate their capabilities. Rather than assuming the market will provide necessary capabilities, DoD must understand and exercise

42 For more on this topic, see: Thomas Hone, "Naval Reconstitution, Surge, and Mobilization: Once and Future," *Naval War College Review* 18, no. 3.

the U.S. commercial logistics force structure, just as it understands and exercises its military logistics force structure.

U.S. Merchant Mariner Base. So long as the U.S. Government holds logistics shipping in reserve for conflict, it will need to find mariners to crew those assets. Patriotic U.S. Merchant Mariners—the "Fourth Arm of Defense" in words spoken by President Franklin D. Roosevelt and echoed by former Secretary of Defense James Mattis—will be willing to go into harm's way.[43] During every major conflict, from the shipwrecked convoy routes of the North Atlantic to the sweltering waters of the Mekong, U.S. civilian crews have sailed into war zones. During World War II, the Merchant Marine suffered a higher casualty rate than any of the military Services.[44]

Troubling, however, is the likely shortage of Merchant Mariners in a contingency. The activation of the National Defense Reserve Fleet (NDRF) during Vietnam and of the RRF during Desert Storm strained the number of available crews, and the Merchant Mariner base continues to decline. Engineers, radio operators, and other mariners with special skills will be in particularly high demand, while the increasing complexity of and certifications required for modern ships will increase the training time for volunteers or draftees during a conflict. If the U.S. Merchant Marine withers, the community of sailors on which U.S. maritime logistics currently depends will decline with it. Just as carefully as they assess naval logistics or sealift ship assets, Navy and MARAD logistics planners should assess and steward U.S. Merchant Mariner readiness and capacity. Similarly, the United States should view the availability of militarily useful sealift and logistics auxiliaries as a strategic capability and shift away from the assumption that market activity alone, unsteadily supported by the U.S. Government, will be sufficient to maintain this community.

Lessons from and Differences with World War II. The Second World War has been the last time the U.S. Navy faced a peer naval power in combat and had to provide maritime logistics in a highly contested environment. A perusal of the lessons of World War II—especially the Pacific Campaign—may illuminate many logistics areas rich for reconsideration by the Navy in a contemporary conflict with China. For example, during the war, Japanese forces overran the Dutch fuel refineries upon which the Asiatic Fleet relied, dramatically extending U.S. fuel lines of communication to the Middle East and Pearl Harbor. Similarly, U.S. access to

43 In support of the Merchant Marine Act of 1936, President Franklin D. Roosevelt described the Merchant Marine as the Fourth Arm of Defense (along with the Army, Navy, and Marine Corps). In 2018, Secretary of Defense James Mattis used the same language. James N. Mattis, "Commencement Address by Secretary Mattis at U.S. Merchant Marine Academy," DoD News, June 16, 2018, https://dod.defense.gov/News/Transcripts/Transcript-View/Article/1552464/commencement-address-by-secretary-mattis-at-us-merchant-marine-academy/.

44 Of the 243,000 Merchant Mariners serving in World War II, 9,521 died. This includes total killed at sea as well as those that died as prisoners of war and from combat wounds ashore. Accordingly, 3.9 percent of Merchant Mariners were killed. The Marine Corps was the Service with the next highest casualty rate, with 2.94 percent of serving Marines killed during World War II. Arthur *R. Moore, A Careless Word—a Needless Sinking: A History of the Staggering Losses Suffered by the U.S. Merchant Marine, Both in Ships and Personnel, during Wo*rld War II (Kings Point, NY: American Merchant Marine Museum, U.S. Merchant Marine Academy, 1998). Cited at "U.S. Merchant Marine Casualties during World War II," U.S. Merchant Marine, available at www.usmm.org/casualty.html.

many of the East Asian refineries from which DLA Energy acquires fuel in peacetime could be contested, forcing the United States to secure fuel from refineries much farther away and dedicate more tankers to transport fuel. Additionally, during World War II, the Navy developed a robust, expeditionary logistics force capable of supporting forces afloat and at anchor. Most notably, a Service Squadron 6 was established to provide underway support, and a Service Squadron 10 was established to provide sustainment, maintenance, and repairs and salvage at anchor. Aspects of these forces could be adopted by the Navy. Furthermore, in the Pacific campaign, the Navy developed units to establish expeditionary airbases ashore; a similar approach could support contemporary distributed naval and Air Force aviation. Lastly, the Navy and Army developed capabilities to provide inter and intra-theater transport and logistics in austere, archipelagic environments; much of the same geography that was contested in World War II could be contested in a contemporary war in which Army and Marine forces would need to land to deploy sensors, fires, and other capabilities.

However, a contemporary war with China would differ from World War II's Pacific Campaign in a number of ways. Most significantly, China's industrial capacity and Comprehensive National Power is much greater than that of Imperial Japan and may match or eclipse that of the United States. This may provide China with a massive capacity for wartime mobilization. Second, modern Chinese battle networks are capable of detecting and targeting forces at great ranges, complicating World War II-inspired approaches that would rely on staging logistics forces at intermediate bases ashore or at anchor. Finally, Chinese operational guidance theory emphasizes the targeting of information systems and logistics. Accordingly, U.S. maritime logistics forces would likely be targeted across their entire effects chains. In contrast, during the Pacific Campaign in World War II, Japanese submarines and aircraft "never aggressively went after U.S. supply ships."[45] As Admiral William F. Halsey, Commander Third Fleet, observed in 1944: "There has been too great a tendency to discount the need for adequate escorts for oiler and CVE groups. We have been extremely lucky; our oiler groups [...] were pure submarine bait."[46] It is likely that Chinese and possibly Russian forces would contest U.S. maritime logistics in a conflict.

U.S. maritime logistics history offers many parallels to the present. Although the details of modern challenges may differ due to technology, geography, or other factors, the processes and concepts employed to overcome past challenges hold lessons applicable to the challenges the Navy faces today. More sobering, this history should also illustrate that the Navy is prone

45 This was observed by then-Captain Henry Eccles (subsequently Rear Admiral and among the U.S. Navy's most influential logistics thinkers of the 20th Century) in his lecture at the Naval War College on logistics and the employment of Service Forces during the war in the Pacific, held March 30, 1946. Hal M. *Friedman, Digesting History: The U.S. Naval War College, the Lessons of World War Two, and Future Nav*al Warfare (Newport, RI: Naval War College Press, 2010), p. 59.

46 Admiral Halsey made this comment in his after-action report for Operational Stalemate II, the operation to seize Peleliu Island in the Palau archipelago. In response to the threat, he recommended that "a minimum of one escort per oiler and two per CVE should be provided. This will become important as we move closer to Empire waters. Also, for extensive long-range operations, one fleet tug and one salvage ship should be assigned with each group of three oilers which are kept at sea in advanced positions.*" Carter, Beans, Bullets, and* Black Oil, p. 194.

to making the same logistics mistakes time and again unless those logistics communities are championed by leaders who allocate appropriate levels of resources and explain the importance of logistics to broader audiences.

CHAPTER 5

New Operating Concepts & Implications for Logistics

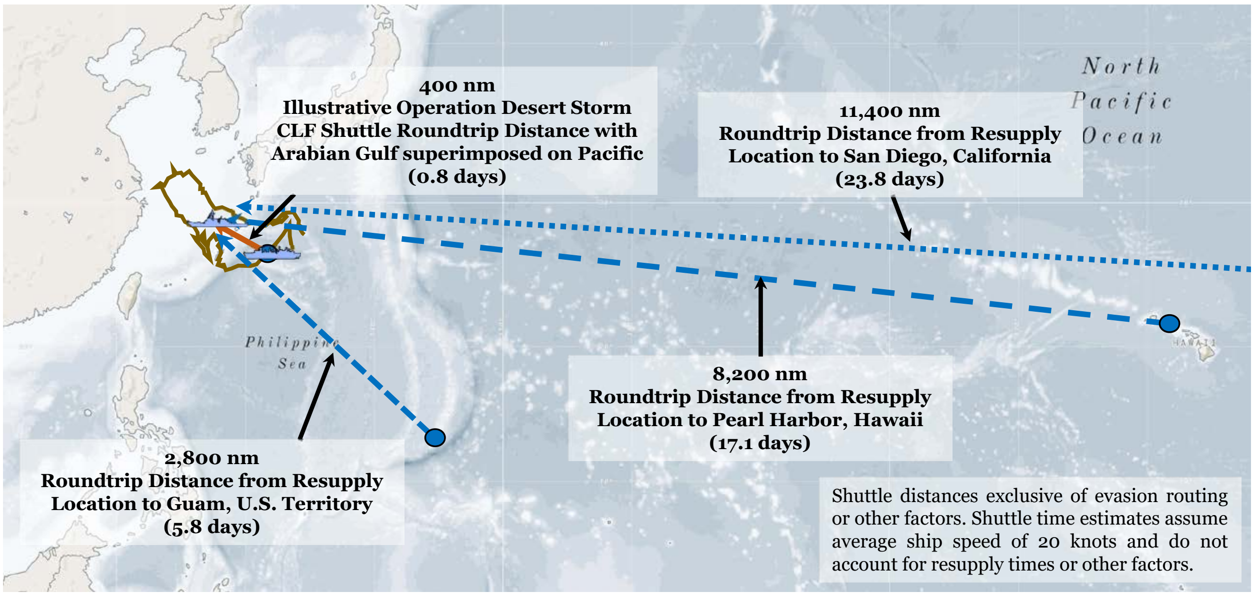
A combination of changes in the threat environment and Joint Force demands are driving the need for new maritime logistics operational concepts and capabilities. By understanding the character of adversary threats and demands levied by Navy and other Service combat and logistics concepts, DoD can develop new and refine existing concepts and capabilities for maritime logistics that improve the current force and shape the development of a future maritime logistics fleet architecture. This chapter reexamines current operating assumptions and explores new operational concepts.

Changing Assumptions

Mounting threats from China, Russia, and other adversaries utilizing modern technology targeting U.S. military vulnerabilities will increase the risk to combat and logistics forces ashore and at sea. To adapt to these changing circumstances and maintain the viability of the future U.S. maritime logistics architecture, DoD leaders should reexamine assumptions for current and future warfighting scenarios. Review of a few long-held assumptions reveals how adversaries may critically undermine U.S. operations, especially maritime logistics operations.

From Secure and Proximate to Distant and/or Contested Basing. For the past several decades, the United States has enjoyed uncontested access to logistical support bases in the territory of allies and partners and forward U.S. territory near potential conflict areas. This proximity permitted combatant resupply directly from shore facilities. It also allowed rapid CLF resupply, reducing time spent in transit and increasing available station time to provide greater replenishment capability to combatants. This efficiency through proximity reduced the overall CLF required during contingencies.[47] Figure 8 compares Operation Desert Storm CLF shuttling distances in the Arabian Gulf with potential shuttling distances in the Pacific. Furthermore, access to overseas, fixed infrastructure led the Navy to reduce its mobile logistics support force of tenders, floating dry docks, and other auxiliaries, expecting maintenance and repair activities to take place at uncontested forward locations, rather than afloat, expeditionary ones.[48] Finally, access to proximate bases facilitated the buildup and intra-theater movement of U.S. forces and supplies once disembarked from Strategic Sealift.

FIGURE 8: COMPARISON OF DISTANCES IN ARABIAN GULF AND PACIFIC



As noted earlier, access to these close-in bases will be increasingly contested. The Navy and other U.S. planners should anticipate that adversaries will threaten U.S. access to these forward facilities in multiple dimensions. Although the United States should increase its own efforts and cooperation with allies and partners to defend forward bases, it is likely that—at least for the early stages of a conflict—the locus of logistical support will need to come from a mix of bases far from the area of operations and contested bases at sea and ashore closer in. This will likely increase the required number of logistics assets, as extended transit distances raise the number of logistics assets needed.

From Rear Sanctuary to Global Conflict. In the past, the United States has benefited from rear area sanctuaries.[49] This includes not only a homeland separated from challengers by two oceans but the sanctuaries within operational theaters afforded by the strategic depth of

47 It also reduced the type and variety of cargos carried; if the CLF were not properly loaded, it could (presumably) return to port for more.

48 James W. Hammond, "The United States Needs Mobile Afloat Basing," *Proceedings* 143, no. 11, November 2017.

49 This report defines rear area sanctuaries as areas that support a conflict but are not subject to the conflict.

U.S. partners. Enemies generally lacked the ability to perform sustained, conventional attacks on U.S. theater logistics hubs and combat force marshaling points with mass and precision. Now, China and Russia have the ability to attack U.S. military and commercial assets globally—including in the Continental United States—with conventional military forces, paramilitary or special operations forces, and cyber-attacks. Depending on their strategic aims and operational campaign plans, adversaries may choose to limit strikes against U.S. assets in rear areas, or they may choose to strike in force. In addition to mass attacks, they could choose to employ a variety of limited kinetic and non-kinetic attacks against U.S. rear targets to degrade or exploit U.S. logistical force flow. This reality breaks the old paradigm of regional conflicts and has the implication that a reinforcing maritime logistics force flow from the United States may be delayed, placing a priority on robust maritime logistics in or near potential areas of interest.

From Gradual Buildup to Rapid Response. In the run-up to Operations Desert Storm and Iraqi Freedom, the United States methodically transported combat and logistics forces to Southwest Asia over the course of months before attacking Iraqi forces. It is unlikely the United States would be able to accomplish such a force flow against a peer challenger for two reasons. First, adversaries—especially China—have concluded that they should interrupt any potential large force buildup, including through preventive or preemptive strikes, before it takes place in order to maximize their advantage. Second, adversaries may seek to swiftly execute a fait accompli, or operations that accomplish aims, such as seizing territory, before the United States could respond in support of its allies and partners. In response, maritime logistics forces should prepare to rapidly support combat forces that, through either forward presence or rapid deployment, deny adversary objectives.

From Short to Potentially Protracted Cross-Domain Conflicts. Over the past few decades, U.S. conventional dominance allowed planners to envision rapid and decisive operations to defeat regional foes, thus lowering logistical transportation and sustainment requirements.[50] Today, the decreasing margin of U.S. conventional superiority relative to China and to a lesser degree Russia may mean that maritime logistics forces should be prepared to support cross-domain conflicts ranging from long-running sub-conventional conflicts (gray zone warfare) to short, sharp conflicts of high-intensity violence to protracted high-intensity wars. The growing possibility of U.S. engagement in protracted conflict increases the need for large pre-war stocks of supplies (from parts to fuel to weapons), resilient capabilities to sustain forward forces, and capabilities for inter and intra-theater transportation and distribution of forces and critical supplies even under adversary threat.

50 This attitude of rapid dominance is not unique. Notable examples of other "rapid" military plans that yielded longer and unexpected results include not only historical cases, such as Napoleon Bonaparte's 1812 invasion of Russia or the early 20th century German General Staff's so-called Schlieffen Plan, but also contemporary cases, such as U.S. operations in Afghanistan (which, at the time of this report, are in their 18th year). For an examination of how political and military planners of war have often taken insufficient account of the possibility of long wars, see Lawrence Freedman, *The Future of War: A History* (New York: Public Affairs, 2017).

From Low Attrition to High Attrition Planning. Over the past few decades, U.S. planners assumed little to no attrition among either major combat or logistics forces. This assumption reduced the requirement for both combat and logistics forces since combat losses would not increase the total number of assets required.[51] Additionally, light levels of attrition meant that the maritime logistics force's ability to tow and repair damaged ships and care for wounded soldiers, sailors, and airmen could be small, in some cases relying on complementary commercial support close to the conflict.

In a future conflict with a peer adversary, U.S. armed forces would likely suffer high levels of attrition. There would be high demand for the ability to tow and repair damaged ships—perhaps without access to commercial towing and heavy-lift support—and to provide care for mass casualties in a short period of time. Moreover, maritime logistics forces themselves would likely suffer significant attrition: logistics facilities ashore would be targeted and ships would be sunk. This attrition would likely extend to not only maritime logistics assets supporting Navy operations, but also the full range of government and commercial Strategic Sealift shipping. Therefore, the United States will be required to procure more maritime logistics assets than it would if zero to low attrition is assumed.

Overall, the scale and sophistication of adversary capabilities call into question the viability of traditional U.S. concepts of operation as well as the validity of many long-held planning assumptions, including those involving maritime logistics.

New Operational Concepts

Faced with challenges to its ability to counter adversary aggression, the U.S. military has developed operational concepts and capabilities in an attempt to achieve campaign objectives and minimize U.S. vulnerabilities. This section reviews Navy and other Service operating concepts to identify their impact on maritime logistics.

Navy Operational Concepts

The U.S. Navy is developing operational concepts that levy new demands on logistics forces, including Distributed Lethality (DL), Electromagnetic Maneuver Warfare (EMW), and Distributed Maritime Operations. The Navy has also adopted new operational concepts focused on logistics: Distributed and Agile Logistics (DiAL) and Operational Logistics in a Contested Maritime Environment (OPLOG). Each of these concepts has implications for current and future maritime logistics forces.

51 These assumptions have formed, in some cases, unfortunately, a self-reinforcing cycle, in which staffs do not plan for attrition of logistics assets, and analysts assume that it will not happen or that it is outside the scope of their analysis.

Distributed Lethality

The Navy's DL concept calls for individual or small groups of platforms, organized into Surface Action Groups (SAGs), to operate across a wide area in contested environments.[52] These units are to "seize maritime-operations areas for subsequent activities (including power projection), perform screening operations for larger formations, and hold adversary land targets at risk."[53] By geographically distributing networked forces that are capable of defending themselves, the concept aims to complicate adversary targeting and rapidly engage adversaries.

To maximize its effectiveness, DL requires high levels of maritime logistics support. DL envisions that SAGs would operate independently of CSGs. Since World War II, the CSG has been the primary U.S. Navy power projection and sea control formation. Accordingly, CLF support has focused on addressing the logistics requirements of a small number of forward-operating CSGs. By concomitantly deploying multiple CSGs and DL SAGs across large theaters such as the Indo-Pacific, the requirement for CLF support would increase, as the CLF T-AOs, T-AKEs, and T-AOEs focused on supporting CSGs would not be in the same location to support DL SAGs.[54] This could require more CLF assets to support the SAGs, or it would reduce the on-station time of CLF ships supporting CSG operations as they leave station to support nearby SAGs. In addition, greater dispersal requires individual surface combatants to spend more time transiting to rendezvous points with CLF ships (or shore logistics sites), decreasing the relative percentage of time and fuel burned on station fulfilling their mission.

In the future, force dispersal under the DL concept is likely to increase through the introduction of two new classes of capabilities: new Low Probability of Intercept/Low Probability of Detection (LPI/LPD) beyond line of sight communications and longer-range weapons (such as the anti-ship enabled Tomahawk Block IV, the Long-Range Anti-Ship Missile, and the future Next Generation Strike Weapon). These capabilities will allow DL SAGs to disperse farther while remaining networked and retaining the ability to concentrate fire when required.

By operating in contested environments, it is likely that DL SAGs would rapidly expend large quantities of munitions, which would need to be resupplied in theater. Without theater munitions replenishment, surface combatants would need to transit back to a protected base, which could entail roundtrips of weeks or over a month. Since DL SAGs might be operating in contested areas where shore-based logistics would be at considerable risk, surface combatants

52 Thomas Rowden, Peter Gumataotao, and Peter Fanta, "Distributed Lethality," *Proceedings* 141, no. 1, January 2015. A SAG is a "temporary or standing organization of combatant ships, other than carriers, tailored for a specific tactical mission." JCS, *DoD Dictionary of Military and Associated Terms* (Washington, DC: DoD, February 2019), p. 226, available at www.jcs.mil/Portals/36/Documents/Doctrine/pubs/dictionary.pdf?ver=2018-07-25-091749-087.

53 Rowden, Gumataotao, and Fanta, "Distributed Lethality."

54 In a 2017 report, the U.S. Government Accountability Office (GAO) expressed concern with the Navy's lack of assessment regarding the impact of more distributed operations on the required number and type of logistics ships. John Pendleton, *Navy Readiness: Actions Needed to Maintain Viable Surge Sealift and Combat Logistics Fleets* (Washington, DC: GAO, 2017). Similarly, U.S. Navy Captain Kevin Eyer (ret.) wrote, "Naval Surface Forces' new distributed lethality (DL) strategy seems to be a fine idea. . . . Where are the oilers necessary to support this wide, sustained dispersion?" Kevin Eyer, "Distributed Lethality: Don't Drink the Kool-Aid," *Proceedings* 143, no. 4, April 2017.

would likely need to rely on at-sea maritime logistics support, such as that provided by CLF ships, to not only refuel but also to rearm. Although the Mark 41 Vertical Launch System (VLS) is the Navy's primary surface combatant weapon launch platform, the Navy lacks the means to rapidly reload VLS cells at anchor or underway.

It is likely that surface combatants will be damaged or sunk in a high-intensity conflict. Given the cost of modern warships and the time it takes to build new ones, the requisite capacity to tow to an area of relative safety and repair damaged warships will be important. Finally, it will be important to have medical support capabilities suitable for retrieving and caring for potentially large numbers of casualties resulting from a high-intensity conflict.

Electromagnetic Maneuver Warfare.
The Navy is implementing the Electromagnetic Maneuver Warfare (EMW) concept to exploit the electromagnetic spectrum (EMS) in future naval operations.[55] Under EMW, the Navy seeks greater control over its radio frequency (RF) emissions and will incorporate "low-to-no power" communications and sensor systems.[56]

The Navy may also change the operating profiles of its ships in ways that make surveillance and targeting more difficult but may also increase maritime logistics demands. This may include greater dispersion of formations, which would, as discussed above, increase CLF capacity requirements. Even more significantly, ships may operate at higher average speeds in order to maneuver to avoid detection by adversary ISR systems. This high-speed maneuvering over considerable distances would be a significant departure from the slow, efficient cruise speeds of ships loitering at designated stations during recent power projection operations.

Another component of EMW may include the greater use of distributed and unmanned systems for counter-ISR missions.[57] In order to carry out counter-ISR missions, unmanned platforms—such as unmanned surface and undersea vehicles—would likely need to operate separately from the units they would seek to protect. Consequently, these platforms may need to receive their own logistical support (such as fuel and maintenance) from maritime logistics assets distinct from those that support the units they are protecting. Additionally, EMW may entail the use of additional expendable EMS systems, such as decoys, which may increase rates of resupply for ships. Both factors would increase overall fleet logistical requirements.

55 Mark Coffman, "Advancing Electromagnetic Maneuver Warfare," *Navy Warfare Development Command NEXT* 3, no. 2, Summer/Fall 2015, available at www.nwdc.navy.mil/NeXT%20Assets/ current/NeXTw2016.aspx.

56 Clark, Haynes, McGrath, Hooper, Sloman, and Walton, *Restoring American Seapower*, p. 24.

57 Ibid.

Distributed Agile Logistics.

In 2015 the Navy revealed it had developed a Distributed Agile Logistics (DiAL) concept to improve logistics resiliency and reliability in contested environments.[58] DiAL represents a major departure from earlier Navy concepts of logistics in uncontested environments.

First, DiAL "shifts reliance from vulnerable shore bases to more survivable afloat and ashore hubs."[59] This shift will likely result in a need for survivable afloat hubs, such as Consolidated Logistics tankers for fuel and ESB and ESD ships or other ships as intermediate supply and distribution points for dry cargo at sea. While some existing ships may potentially be repurposed or re-tasked to accomplish these missions, it is likely that this shift will generate requirements for greater maritime logistics capacity.

Second, DiAL identifies a need for the Navy to improve its ability to conduct expeditionary maintenance in theater. To do so, it will likely require more ships than the two aging submarine tenders presently in service.

Third, DiAL calls for an increase in in-theater rearmament capabilities, including rapid at-sea VLS rearming. Some existing ships—including select sealift platforms—could possibly be used for this mission. Given anticipated high rates of weapon expenditure, however, it is likely that the Navy will need to either integrate VLS rearming capability more widely onto existing ships or procure dedicated assets for this purpose.

Fourth, as the name suggests, DiAL calls for the future maritime logistics force to be distributed and to support increasingly distributed combat operations. This distribution will require more and differently-arrayed platforms to sustain missions than a force previously sized to provide support at a limited number of concentrated hubs through an efficient but brittle hub-and-spokes model. DiAL will need to accommodate the increased logistics requirements of dispersal alongside efforts to address the emerging logistics needs of future systems and planned fleet growth.

Distributed Maritime Operations.

In 2017 the Navy announced that the Navy Warfare Development Command had developed a new concept titled Distributed Maritime Operations (DMO). DMO is "a central, overarching operational concept that will weave together the principles of integration, distribution, and maneuver to maximize the effectiveness of the fleet Maritime Operations Centers to synchronize all-domain effects."[60] Although little information has been publicly released on the concept, its overarching nature suggests that it will encapsulate and preside over subordinate

58 Ray Mabus, "Innovation in Logistics," Secretary of the Navy, December 12, 2015, available at www.secnav.navy.mil/innovation/Documents/2015/12/InnovationInLogisticsMemo.pdf.

59 Navy Project Team, *Alternative Future Fleet Platform Architecture Study* (Washington, DC: U.S. Navy, October 27, 2016), pp. 10–11, available at news.usni.org/wp-content/uploads/2017/02/FFA-Final-Review-2-Feb-17.pdf.

60 "CNO Visits Navy Warfare Development Command," Navy Warfare Development Command, April 13, 2017, available at www.navy.mil/submit/display.asp?story_id=99893.

DL, EMW, and DiAL concepts. As conveyed in its title and reiterated by its lead author, DMO will allow the fleet to operate effectively while "distributed over vast distances," which would require considerable logistical support.[61]

Operational Logistics in a Contested Maritime Environment.
Following the public announcement of both DiAL and DMO, the Chief of Naval Operations signed a new concept paper on 10 September 2017 entitled "Operational Logistics in a Contested Maritime Environment" or OPLOG.[62] According to a Navy press release, "the OPLOG concept presents a warfighting approach to logistics support which incorporates the fundamentals of maneuver warfare, encourages the development of new logistics capabilities, and envisions improved operational protection, increased mobile logistics capacity, and well-defended logistics information to enable sustained logistics."[63] OPLOG aims to transform, refine, and develop naval logistics capabilities across seven core logistics functions: deployment and distribution; supply; maintenance; logistics services; operational contract support; engineering; and health services.[64]

A Design for Maintaining Maritime Superiority, Version 2.0.
In December 2018, the Chief of Naval Operations released *A Design for Maintaining Maritime Superiority, Version 2.0*. The document provides a framework to guide Navy behaviors and investments. Although not a concept, it identifies as a priority area effort to "posture logistics capability ashore and at sea in ways that allow the fleet to operate globally, at a pace that can be sustained over time. [and] Assess and develop options for improved ability and resilience to refuel, rearm, resupply, and repair."[65] The document signals Navy leadership's growing recognition of the criticality of improved logistics concepts and capabilities.

Other Service Operating Concepts

In addition to the Navy, other U.S. Services have developed operating concepts that have considerable implications for maritime logistics, especially the sealift component of the force. For example, the Air Force and Marine Corps have adopted aviation concepts that emphasize distributed operation from numerous bases in order to complicate adversaries' ability to target aircraft at bases in mass. In order to provide logistics at different locations, the Air Force and Marine Corps could consider maritime logistics options to support their new concepts, particularly for fuel. An increase in the number of locations where maritime logistics assets would

61 Ibid.

62 "Navy Warfare Development Command Publishes Operational Logistics in a Contested Maritime Environment Concept," Navy Warfare Development Command, September 14, 2017, available at www.navy.mil/submit/display.asp?story_id=102415.

63 Ibid.

64 Ibid.

65 John M. Richardson, *A Design for Maintaining Maritime Superiority*, Version 2.0 (Washington, DC: U.S. Navy, December 2018), p. 8, available at https://www.navy.mil/navydata/people/cno/Richardson/Resource/Design_2.0.pdf.

need to sail to would increase the requirement for ships, such as tankers. Additionally, many potential locations—especially in the Pacific—from which austere air operations could be conducted lack well-developed port facilities and have either low-throughput or non-existent bulk fuel storage and distribution infrastructure, placing a premium on Joint Logistics Over the Shore transfer capabilities.

As another example, the Marine Corps' Expeditionary Advance Base Operations (EABO) concept calls for establishing "dispersed and largely mobile forward basing infrastructure that enables a persistent alternative force capability set that is similarly designed to be difficult to target and inherently resilient."[66] Furthermore, the Army's Multi-Domain Battle concept calls for ground combat forces capable of outmaneuvering adversaries through the extension of combined arms across all domains, including by providing offensive and defensive fires within the littorals. These concepts envision transport to and in some cases maneuver in the littorals, which will likely require maritime logistics support in the littorals.[67]

Although some portion of the assets and supplies for these and other Joint concepts can be transported by air, most will require sea transport given their size, weight, and quantity. This will place a premium on a large and responsive Strategic Sealift force.

Observations

The current maritime logistics force is the product of a series of force structure decisions taken since the 1990s that in general assumed an uncontested or lightly contested operating environment. Key choices and studies informing those choices include the 1990s decision to reduce the Navy's fleet of nine destroyer and eleven submarine tenders and two repair ships to only two submarine tenders, the 2005 cancellation of the T-AOE(X) Fast Combat Support Ship project, the 2011 T-AO(X) Analysis of Alternatives that determined the capabilities and capacity of the refueling fleet, the 2012 Towing and Salvage Ship Recapitalization Analysis of Alternatives that established an eight-tug requirement, the 2013 Dry Cargo Sufficiency Analysis that examined the sufficiency of the CLF's dry cargo force, and the Mobility Capabilities and Requirements Study 2016 that did not factor attrition in setting sealift requirements. Breaking with these past assessments, future maritime logistics decisions should adopt planning assumptions consistent with current and coming challenges. The world of 2019 in which adversaries challenge U.S. military forces across domains is dramatically different from the world anticipated during the 1990s, 2000s, or even early 2010s.

66 "Innovation Industry Day Announcement—Marine Corps Warfighting Laboratory—EABO 2019," *FedBizOps*, Marine Corps Warfighting Laboratory, February 2, 2018, available at www.fbo.gov/index?s =opportunity&mode=form&id=5ad0e3a3809bf73ddeda57b1bd32aaf1&tab=core&_cview=1.

67 "Multi-Domain Battle: Evolution of Combined Arms for the 21st Century, 2025–2040," U.S. Army Training and Doctrine Command (TRADOC), Version 1.0, October 2017, p. 59, available at https://admin.govexec.com/media/20171003_-_working_draft_-_concept_document_for_multi-domain_battle_1_0.pdf.

Changes in the threat environment and emerging Joint Force concepts are changing the demand for future maritime logistics force. Without a capable and appropriately sized maritime logistics force, many of the operational concepts envisioned by the Navy and the other Services cannot be fully executed. Furthermore, whereas the Navy's logistics force is already inadequate for the current fleet, if as planned the Navy grows in size, it will likely require an even larger maritime logistics force than programmed.

To prevail in future conflicts, the Navy and other Services should develop new maritime logistics concepts that build on DiAL and OPLOG and encompass all elements of the National Fleet to both identify and resource the requisite maritime logistics capabilities, capacity, and posture appropriate for the nation. In short, the nation needs a new maritime logistics architecture.

CHAPTER 6

A New Maritime Logistics Architecture

The United States should adapt its maritime logistics architecture to address Joint Force demands and changes in the threat environment. There is no single solution to current U.S. maritime logistics challenges. Rather, the U.S. maritime logistics enterprise needs to improve its concepts, capabilities, capacity, and posture, collectively and with an overarching plan. Further, these improvements should prioritize combat effectiveness and resiliency over peacetime efficiency. Given competing fiscal demands in other warfighting areas, DoD will need to consider the full range of logistics options available carefully and choose those that result in the greatest operational benefit relative to cost as expressed in both money and operational risk. Collectively, this process should result in a maritime logistics force that is larger, more differentiated, and affordable.

This chapter proposes systems and concepts to help address gaps in the current and future U.S. maritime logistics architecture. It is organized into sections on fleet fuel logistics; fleet cargo and munitions; towing and salvage; expeditionary maintenance and repair; search and rescue (including Combat Search and Rescue) and medical support afloat; and Joint maritime logistics for both fuel and unit equipment/sustainment sealift (also referred to as Strategic Sealift). Although focused on logistics assets afloat, the chapter takes into account the contributions of shore logistics infrastructure and forces. The chapter also highlights potential solutions to harden maritime logistics networks and assets, changes to current and future ship and aircraft design, and how to organize the maritime logistics community for success.

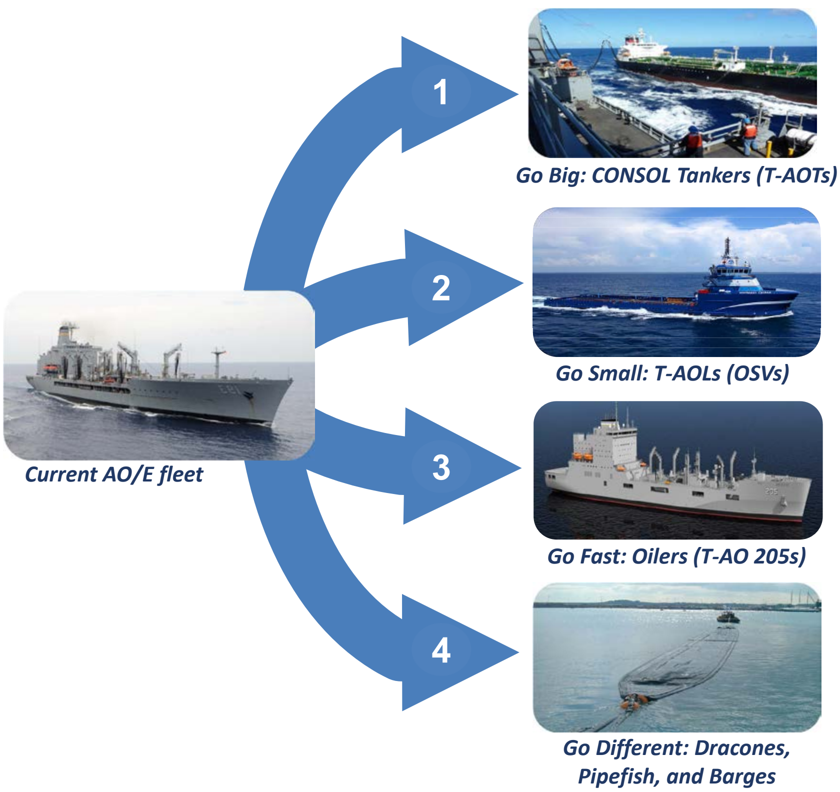
Navy Fleet Fuel Logistics

Fuel is the lifeblood of modern naval forces. Naval surface vessels and aircraft will likely continue to rely on carbon-based fuels as their primary source of energy for the foreseeable future. Over a century ago, U.S. naval officer and historian Alfred Thayer Mahan emphasized the enduring importance of maintaining access to this critical supply: "Fuel stands first in importance of the resources of the fleet. Without ammunition, a ship may run away, hoping to fight another day but without fuel she can neither run, nor reach her station, nor remain on it, if remote, nor fight."[68] Today, the U.S. Navy needs to develop new concepts and capabilities to provide fuel to allow its forces to reach their stations, to maneuver, and to fight.

Towards a Different Fleet Refueling Capabilities Mix

This study recommends the U.S. Navy adopt a mixed approach to fuel distribution that leverages the specialized attributes of both government and commercially-derived vessel designs to improve the Combat Logistics Force's (CLF) capacity, efficiency, and resilience. As shown in Figure 9, this approach can be summarized as, "Go Big, Go Small, Go Fast, and Go Different."

FIGURE 9: NEW REFUELING CAPABILITIES MIX



Photos courtesy of U.S. Navy, Eastern Shipbuilding, GD NASSCO, and Trelleborg.

68 Wildenberg, *Gray Steel and Black Oil*, p. vi.

Go Big

The Navy should begin by buying and long-term chartering more fuel product tankers.[69] Tankers (T-AOTs) can store far greater quantities of fuel than current CLF oilers. For example, Military Sealift Command's (MSC) long-term chartered tanker MT *Empire State* can store approximately 331,000 barrels (bbl) of fuel, more than twice the 156,000 bbl capacity of the Navy's new *John Lewis*-class oiler (T-AO 205).

Tankers can be modified relatively easily to receive the refueling equipment from CLF ships on either two or four stations in order to support Navy CLF operations. These Consolidated Logistics (CONSOL) tankers can transfer fuel from their larger stores to replenish T-AOs, T-AOEs, or T-AKEs underway, as shown in Figure 10, in low to moderate sea states. The Navy developed this CONSOL capability during the Cold War and over the past few years has re-initiated its ability to transfer fuel from MSC CONSOL tankers to CLF ships.[70]

FIGURE 10: CONSOL TANKER AND FAST COMBAT SUPPORT SHIP CONDUCT CONSOL TRANSFER OF FUEL

CONSOL tanker MT *Empire State* and fast combat support ship USNS *Rainier* conduct CONSOL transfer of fuel. Photo courtesy of U.S. Navy.

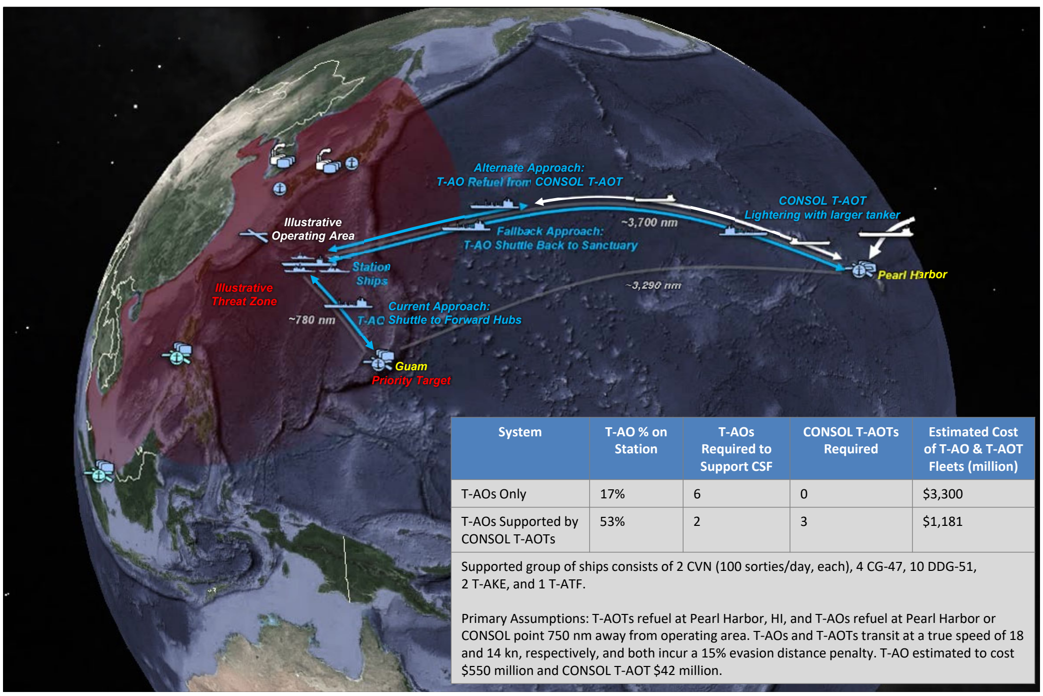
69 As of 2019, MSC has one Government-Owned tanker, the USNS *Lawrence H. Gianella*, and five tankers under long-term charter.

70 "MSC Ships USNS *Rainier* and MT *Empire State* Conduct CONSOL-at-Sea During RIMPAC 2016," *Sealift* blog, Military Sealift Command, July 18, 2016, available at mscsealift.dodlive.mil/2016/07/18/msc-ships-usns-rappahannock-and-mt-empire-state-conduct-consol-at-sea-during-rimpac-2016/.

The Modular Fuel Delivery Systems (MFDS) is a Navy standard fuel Standard Tensioned Replenishment Alongside Method (STREAM) delivery system that has been packaged into a module to allow rapid installation on a tanker. MFDS enables a tanker to offload fuel from two to four stations simultaneously to logistics and other surface vessels, effectively mimicking the refueling capabilities of an oiler. This capability is beneficial for naval operations as a redundancy measure in the event of high oiler demand or attrition. MFDS should be installed on Government-Owned tankers and should be considered for installation on tankers under long-term charter.

CONSOL and MFDS capabilities have three primary benefits. First, they increase the amount of fuel stored at sea, which if properly postured and protected, can be relatively safer and more rapidly accessible than many ashore fuel storage options. Second, they increase the efficiency of the refueling architecture by enabling specialized T-AOEs, T-AOs, and T-AKEs to operate more forward as station ships that distribute fuel and other supplies to combatants, while the T-AOTs operate farther back as large fuel stations from which other logistics ships can refuel. This refueling efficiency is depicted in Figure 11. Third, equipping T-AOTs with CONSOL or MFDS capabilities (instead of simply relying on less-expensive skin-to-skin exchanges, known as lightering) has the major benefit of enabling T-AOTs to transfer fuel in a wider range of sea states. This capability maximizes the efficiency of the refueling architecture and reduces the vulnerability of T-AOTs, which otherwise may have to conduct lightering operations at a smaller number of sheltered or in low sea-state locations.

FIGURE 11: CONSOL AOTS IMPROVE REFUELING ARCHITECTURE EFFICIENCY



System	T-AO % on Station	T-AOs Required to Support CSF	CONSOL T-AOTs Required	Estimated Cost of T-AO & T-AOT Fleets (million)
T-AOs Only	17%	6	0	$3,300
T-AOs Supported by CONSOL T-AOTs	53%	2	3	$1,181

Supported group of ships consists of 2 CVN (100 sorties/day, each), 4 CG-47, 10 DDG-51, 2 T-AKE, and 1 T-ATF.

Primary Assumptions: T-AOTs refuel at Pearl Harbor, HI, and T-AOs refuel at Pearl Harbor or CONSOL point 750 nm away from operating area. T-AOs and T-AOTs transit at a true speed of 18 and 14 kn, respectively, and both incur a 15% evasion distance penalty. T-AO estimated to cost $550 million and CONSOL T-AOT $42 million.

Product tankers can be either built new in U.S. shipyards or purchased new or slightly used on the open market. Contingency access to commercial U.S.-flag tankers can also be secured via an expanded MARAD Maritime Security Program (MSP). Small and medium tankers would be small enough to fit into a large number of government and commercial ports and moorings and yet large enough to provide a significant quantity of fuel. While a sizing decision should be subject to further analysis, a CONSOL tanker that could carry 280,000-330,000 bbl may be an appropriate range commonly found on the open market. 330,000 bbl would be equivalent to more than 9 days of endurance for a Carrier Strike Force, consisting of two CVNs (conducting 100 aircraft sorties per day each), 14 cruisers and destroyers, two T-AKE, two EPF, and one T-ATF.[71]

Go Small

The second recommended refueling fleet change for the Navy is a "Go Small" approach of acquiring a fleet of Offshore Support Vessels (OSV) that can serve as light oilers. OSVs are ships used by the commercial oil and gas industry for energy exploration and platform support.[72] OSVs normally carry sizable tanks (between 4,700-35,000 bbl depending on the size of the vessel) for storing fuel, water, and drilling mud and are designed to hold position well with dynamic positioning systems in open seas.

Equipped with lightering and underway replenishment equipment, 300-foot class OSVs with a fuel capacity of approximately 25,000-30,000 bbl could allow the Navy to distribute fuel to forces afloat and ashore in more contested areas, where employing larger logistics ships would be prohibitively risky, and multiple OSVs could operate across a broader geographic area than a single, larger CLF vessel. Equipped with UNREP equipment and acting as light oilers (T-AOL) (as depicted in Figure 12), OSVs would be well suited for resupplying fuel to independent surface combatants and SAGs. For example, a large OSV could have approximately 28,000 bbl of fuel storage.[73] It would be capable of refueling a SAG consisting of two DDG-51s and one FFG-7 (a surrogate for future FFGs) twice at a 50 percent safety fuel level before shuttling back to shore or other logistics vessels to refuel.[74] OSVs could also provide fuel to unmanned vessels, including large unmanned surface and undersea vehicles. OSVs are unlikely candidates to support CVNs or LHAs, given the large amount of fuel required for

71 CSBA analysis of Navy ship fuel consumption rates.

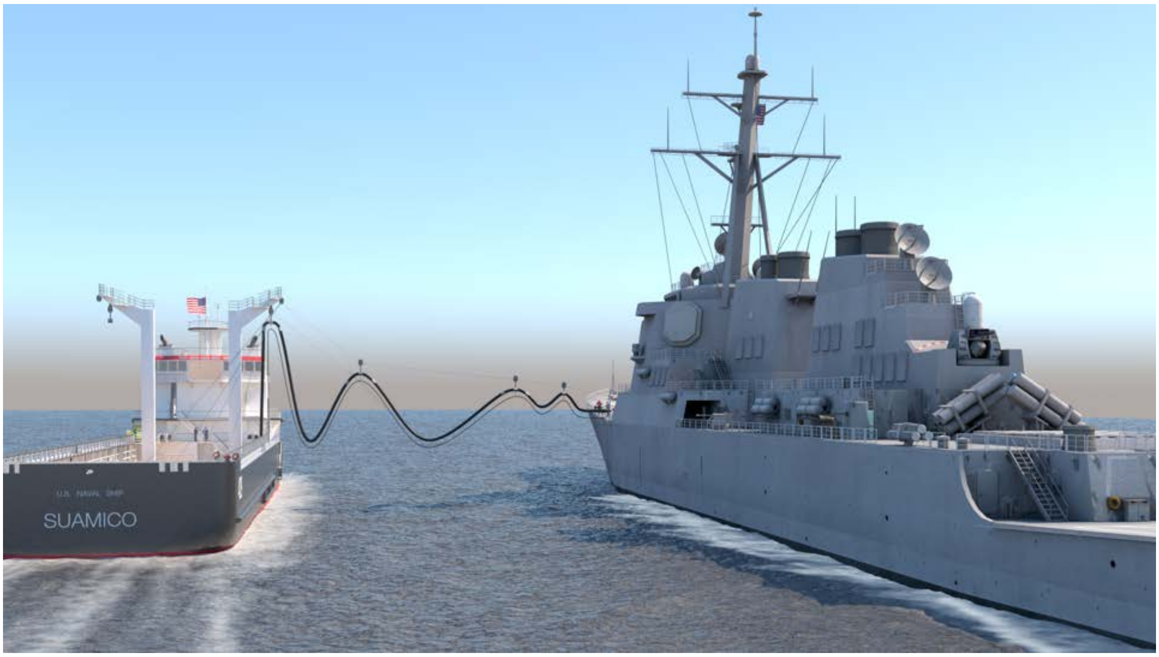
72 This report uses the term OSVs to refer to the broad range of vessels of this type. Some Platform Support Vessels could also be promising candidates for the light oiler role.

73 In comparison, a T-AKE carries 23,450 bbl of cargo fuel, which does not include the T-AKE's own sizable bunker fuel tanks. "Lewis and Clark (T-AKE 1) Class Dry Cargo/Ammunition Ship," General Dynamics NASSCO fact sheet, available at https://nassco.com/pdfs/T-AKE-Fact-Sheet.pdf.

74 This analysis uses estimated DDG-51 and FFG-7 fuel capacities and consumption rates drawn from: Troy C. Morse, *Optimization of Combat Logistics Force Required to Support Major Combat Operations* (Monterey, CA: Naval Postgraduate School, September 2008), pp. 43–44, available at https://apps.dtic.mil/dtic/tr/fulltext/u2/a488887.pdf.

flight operations and LHA propulsion.[75] OSVs are versatile platforms that could also be configured to support a number of other missions, such as resupplying expeditionary operations ashore, rescue operations, and light tenders for unmanned vehicles.

FIGURE 12: T-AOL BASED ON OSV WITH STREAM GEAR REFUELING DDG-51



OSVs are attractive because of their modularity and because they are inexpensive. This, coupled with small crew sizes, may justify OSV operations in environments too dangerous for more expensive CLF assets with far larger crews. For example, a U.S.-built 300-ft class OSV with extensive UNREP modifications to provide one refueling station on each side and other changes could cost less than $40 million and require a crew of approximately 20; in contrast, at currently planned rates of production, a T-AO 205 will cost approximately $550 million and require a crew of approximately 95.[76] For the cost of a single T-AO 205, the Navy could buy and modify more than 13 OSVs, potentially increasing force resiliency and flexibility in contested operating areas. Given the T-AO's greater capacity and centralized efficiency, OSVs would complement rather than substitute T-AOs. A future logistics architecture could

75 Other disadvantages of OSVs include slow speed and that, even if equipped with UNREP gear, most would only be capable of refueling with one station on each side, compared to two to three on oilers. This limitation effectively doubles the amount of time refueling would take for a combatant capable of refueling from two stations, such as a cruiser or destroyer, as compared to refueling from an oiler.

76 This $40 million figure assumes a 5-year old U.S.-built OSV on the open market valued at $25 million and up to $15 million in additional modifications. Estimates drawn from Horizon Ship Brokers and Compass Maritime. A new U.S.-built OSV may cost between $50–60 million.

capitalize on the operational advantages of both systems. This report hereafter refers to OSV used by the Navy for refueling as light oilers (T-AOLs).

Go Fast

The third recommended approach is "Go Fast," in which the Navy accelerates procurement of new oilers (T-AOs). The T-AO 205 shipbuilding program (previously the T-AO(X)) is a program to build a new class of 20 double-hulled oilers for the Navy. T-AO 205s will be capable of carrying 156,000 bbl of fuel in addition to dry cargo capacity and aviation capability.[77] Embarking a large MSC crew and Navy complement of approximately 95 (with additional berths available), T-AO 205s are designed for sustained, high-tempo refueling and resupply operations for the full range of Navy ships.

These 20 oilers are designed to replace the aging T-AO 187 *Henry J. Kaiser*-class oilers, which were procured between FY 1982 and FY 1989 and have a 35-year service life. The first T-AO 205 was procured in FY 2016 and is scheduled for delivery November 2020. The Navy's shipbuilding plan calls for procuring the ships at a rate of one per year, apart from three years in which a second ship will be procured.[78] This rate of acquisition will result in only a modest increase in the size of the oiler fleet (from 17 T-AO/Es to 20) by the end of T-AO 205 construction, and this increase will likely be offset by two factors. First, the fuel storage capacity of new, double-hulled T-AO 205s will be 13 percent less than 12 of the 15 T-AO 187 oilers (the single-hulled variants) that they replace.[79] Second, the overall size of the Navy fleet is projected to increase (by 8 percent by FY 2033 and 12 percent by FY 2048, compared to FY 2019), so that despite the increased number of oilers, the ratio of T-AO/Es to the rest of the fleet is projected to increase only slightly (from 5.6 percent in FY 2019 to 6.1 percent in FY 2033 and back down to 5.9 percent in FY 2048). This modest net increase of between one to three oilers (depending on when the Navy retires its two AOEs) falls short of what is logically necessary to support the Navy's projected fleet expansion, let alone support the Navy's new distributed operating concept, or be resilient in the face of emerging adversary threats to the U.S. maritime logistics enterprise.

To increase the size of the oiler fleet, the Navy should accelerate the procurement rate of T-AO 205 oilers. The proposed procurement strategy is shown in Figure 13. This approach will generate multiple benefits. First, it will increase the total number of oilers in the fleet, as T-AO 205s enter the fleet in numbers before T-AO 187s are retired. Second, it generates cost-savings as the shipbuilder (General Dynamics NASSCO) can shift to a more economical two-per year

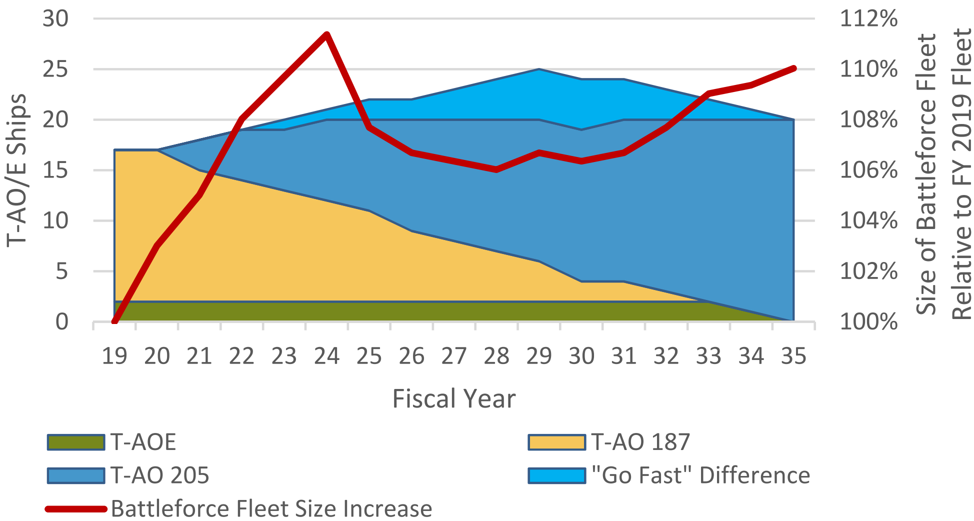
77 "General Dynamics NASSCO Awarded Contract to Build Next Generation of U.S. Navy Fleet Oilers," General Dynamics NASSCO press release, June 30, 2016, available at https://nassco.com/press-releases/general-dynamics-nassco-awarded-contract-to-build-next-generation-of-u-s-navy-fleet-oilers/.

78 Ronald O'Rourke, *Navy John Lewis Class Oiler Shipbuilding Program* (Washington, DC: Congressional Research Service, 2018), p. 5.

79 12 of the 15 T-AO 187s (the single-hulled variant) have a fuel capacity of 180,000 bbl, while three (the double-hulled variant) have a fuel capacity of 159,000 bbl. "Fleet Replenishment Oilers," U.S. Navy factsheet, available at www.navy.mil/navydata/fact_display.asp?cid=4400&tid=600&ct=4.

build rate, possibly reducing the unit cost to $500 million. Accordingly, this study recommends the Navy consider a procurement approach of "2 for 1 in '21," which procures two T-AO 205 per year at the cost of $1 billion total (or $500 million each) starting in FY 2021. Third, this accelerated procurement approach has the benefit of enabling the Navy to grow the size of the oiler fleet once T-AO 187s retire.[80] This growth in the T-AO 205 force will be essential to meet current and emerging demands, especially in light of the drop in fuel storage capacity that T-AO 205s provide compared to the single-hulled variants of the T-AO 187 class.

FIGURE 13: "GO FAST" OILER PROCUREMENT STRATEGY



Go Different

The final recommended approach is "Go Different," in which the Navy would field unmanned or minimally manned systems for providing fuel at sea. This class of systems would provide attritable refueling options in highly contested areas, especially for smaller combatants and future classes of larger unmanned vehicles. This approach would permit disaggregated and scalable logistics for large numbers of forward-operating vessels.

Candidate systems include dracones, Pipefish, and unmanned or minimally manned surface vessels (including barges). Dracones are large fuel bladders that can be towed into position (as shown in Figure 14). Used by the Royal Navy for supporting expeditionary operations, dracones are predominantly used for providing fuel and water to forces ashore. The Navy is currently working on the Pipefish concept, an unmanned, double-walled bladder system, to

80 T-AO 187s that retire should be placed in the NDRF to retain capacity until the entire T-AO 205 class is delivered and can be retained in a laid-up status as a wartime reserve.

provide fuel to forces afloat or ashore.[81] The Navy could also develop unmanned or minimally manned surface vessels, like OSVs or barges, to transfer fuel to forces afloat and ashore. Going "different" would field large numbers of low signature and attritable refueling systems suitable for supporting limited scale naval maneuver or expeditionary operations ashore in highly contested environments.

FIGURE 14: TUG TOWING A DRACONE

Photo Courtesy of Trelleborg.

Other Refueling Vessels

The Navy should also examine the role of other refueling vessels in its force. In particular, Navy Fast Combat Support Ships (T-AOE) and Dry Cargo/Ammunition ships (T-AKE) can play a major role in current and future Navy refueling fleet architecture.

T-AOEs

MSC operates two *Supply*-class T-AOEs, the USNS *Supply* and USNS *Arctic*. In 2014, the Navy decommissioned two other T-AOEs, the USNS *Rainier* and the USNS *Bridge*, as a cost-cutting measure.[82] These multi-product ships carry large quantities of fuel, ammunition, and supplies at high speeds of over 26 kn, enabling the AOE to remain on station with a fast-moving CSG.[83]

In the early 2000s, the Navy planned to replace the four aging *Sacramento*-class AOEs with four new T-AOE(X) to join the four *Supply*-class T-AOEs and form an eight-ship AOE fleet. However, the T-AOE(X) program was canceled in 2005 due to competing fleet demands and

81 U.S. Marine Corps, *Maritime Expeditionary Warfare Annual Report 2018* (Washington, DC: U.S. Marine Corps, August 2018), p. 32, available at https://www.mccdc.marines.mil/Portals/172/Docs/Seabasing/1%20Seabasing-What_Is_It/3%20Seabasing_Capabilities_Report/2018%20ANNUAL%20REPORT.pdf.

82 Sam LaGrone, "Navy to Decommission Two Oilers in Cost Saving Scheme," *USNI News*, April 29, 2013, available at https://news.usni.org/2013/04/29/navy-to-decommission-two-oilers-in-cost-saving-scheme.

83 "T-AOE," U.S. Navy factsheet, available at www.navy.mil/navydata/fact_display.asp?cid=4400&ct=4&tid=300.

a high anticipated cost of approximately $1 billion per ship.[84] Considering options for new T-AOE and Dry Cargo/Ammunition ships (T-AKE), the Navy saved funds by choosing to acquire zero T-AOE and twelve T-AKE allocated to support Navy missions, instead of a more expensive but capable mix of four new T-AOE and nine T-AKE.

Although the Navy's predominantly T-AO and T-AKE CLF force has performed well in supporting recent operations, the unique attributes and versatility of T-AOEs could provide tactical and operational advantages in high-intensity, contested operations. An AOE for every CSG (and possibly more for other major naval formations) would capably support the fleet; this was the Navy's intended fleet support concept during the late Cold War and early 2000s, before the Navy abbreviated the development of the AOE force in order to save cost. As a point of comparison, the PLAN has begun fielding new Type 901 AOEs, similar to the U.S. Navy T-AOE 6 *Supply* class, to support their growing number of Carrier Battle Groups and other distantly-operating naval forces.[85]

Despite the advantages of T-AOEs, procuring additional T-AOEs may come at a considerable cost. They are large, expensive vessels. High costs may crowd out funding for other logistics efforts, potentially decreasing resiliency across the entire logistics enterprise.

Accordingly, in the near-term, this study recommends the Navy retain its two active AOEs and shift them from supporting the 5th Fleet (responsible for operations in Arabian Gulf, Gulf of Oman, Gulf of Aden, Red Sea, and the Arabian Sea) to supporting the more demanding threat posed by China in the 7th or 3rd Fleets (responsible for operations in the Pacific). Additionally, the Navy should assess and, if appropriate, maintain the material condition of its two decommissioned AOEs to safeguard reserve AOE capacity. Finally, the Navy should evaluate whether a future T-AOE may be appropriate for the current and future threat environment and fleet demands. One option would be to begin construction of a new T-AOE class toward the latter half of the T-AO 205 program.[86] For example, in FY 2028 the Navy could begin transitioning from T-AO to T-AOE construction, ensuring new T-AOE would be available a few years later

84 Richard R. Burgess, "Navy Eyes $1 Billion Support Ships to Supply Carrier Strike Groups," *Seapower*, October 2004, p. 24.

85 The PLAN's 25-kn Type 901 AOEs are highly similar in design to the U.S. Navy T-AOE 6 *Supply*-class. In contrast to the U.S. Navy, the PLAN has armed its Type 901 with four 11n-barrel H/PJ-11 30mm close-in weapons systems guided by radars, electro-optical and infrared systems, and a fire control system. There has been speculation the PLAN may adopt nuclear-powered AOEs, which could further increase the degree of logistical independence of PLAN formations. Richard D. Fisher Jr., "China's CSIC unveils concept for nuclear-powered combat support ship," *Jane's Defence Weekly*, December 8, 2017.

86 In CSBA's 2017 Alternative Fleet Architecture study, a new T-AOE derivative of the *John Lewis*-class T-AO 205 was considered. The estimated lead ship cost of the new-build T-AOEs was $770 million, about 10 percent greater than the T-AO 205. This was to account for modifications that would enable it to carry ammunition as well as fuel and limited cargo. Like T-AKEs and T-AO 205s, this ship would be built to commercial standards and would likely be significantly more economical than the T-AOE 6 class or the T-AOE(X) class considered in the early 2000s. The feasibility and relative utility of such a ship merits additional examination. In order to achieve higher speeds, the T-AOE would likely need to be considerably longer to improve its fineness ratio and would need to have much more powerful engines. While a modified T-AO 205 may be suitable, this may result in a largely or wholly new ship design. Clark, Haynes, McGrath, Hooper, Sloman, and Walton, *Restoring American Seapower*, p. 122.

to replace existing T-AOE that will be nearing the end of their service lives and provide additional T-AOE to support CSGs and other naval forces.

T-AKE

MSC operates 14 Dry Cargo/Ammunition ships (T-AKE), of which 12 provide multi-product combat logistics support to the Navy and two support the Marine Corps via the Maritime Prepositioning Force. In addition to their dry cargo and refrigerated stores, T-AKEs can distribute fuel from their 23,450 bbl cargo fuel tanks.[87] Multi-product replenishment capability allows T-AKEs to complement T-AOs in support of large naval task forces or serve as the lead logistics asset for independent SAGs. This report modeled the impact of T-AKE presence in calculating fleet refueling requirements. Although T-AKEs' fuel storage capacity is insufficient to satisfy the demands of large naval formations, T-AKEs can assist with fuel distribution by refueling task force surface combatants and maintaining a fuel reserve in case shuttling oilers are delayed. T-AKEs' multiproduct capability also makes it a prime candidate to provide support to small SAGs or ships operating independently as part of a dispersed operating concept, thus allowing the Navy to husband its T-AOs and T-AOEs for more concentrated naval maneuver formations.

Recommended Refueling Fleet Composition

In assessing the appropriate type and quantity of logistics assets to support the fleet, including how and where to posture them, this study conducted qualitative and quantitative analysis to identify a promising mix of capabilities suitable for peacetime and wartime operations.[88] Specifically, the study examined the logistics requirements of the Navy's FY 2019, FY 2033, and FY 2048 programmed fleets. Naval forces were arrayed in peacetime and wartime laydowns in a manner consistent with the global posture described by CSBA in its Alternative Fleet Architecture study, and peacetime and wartime assessments were conducted.

CSBA analysis suggests that the currently programmed afloat refueling fleet is 'right-sized' to support the Navy's FY 2019, FY 2033, and FY 2048 programmed fleets in peacetime and could support a modest amount of additional peacetime demand. Accordingly, if the Navy effectively stewards its fleet of T-AOs and T-AOEs, the 17-20 it plans on having until FY 2048 should suffice for peacetime presence requirements, even as the size of the overall Battle Force is planned to grow to 325 ships by FY 2033 and 338 ships by FY 2048.

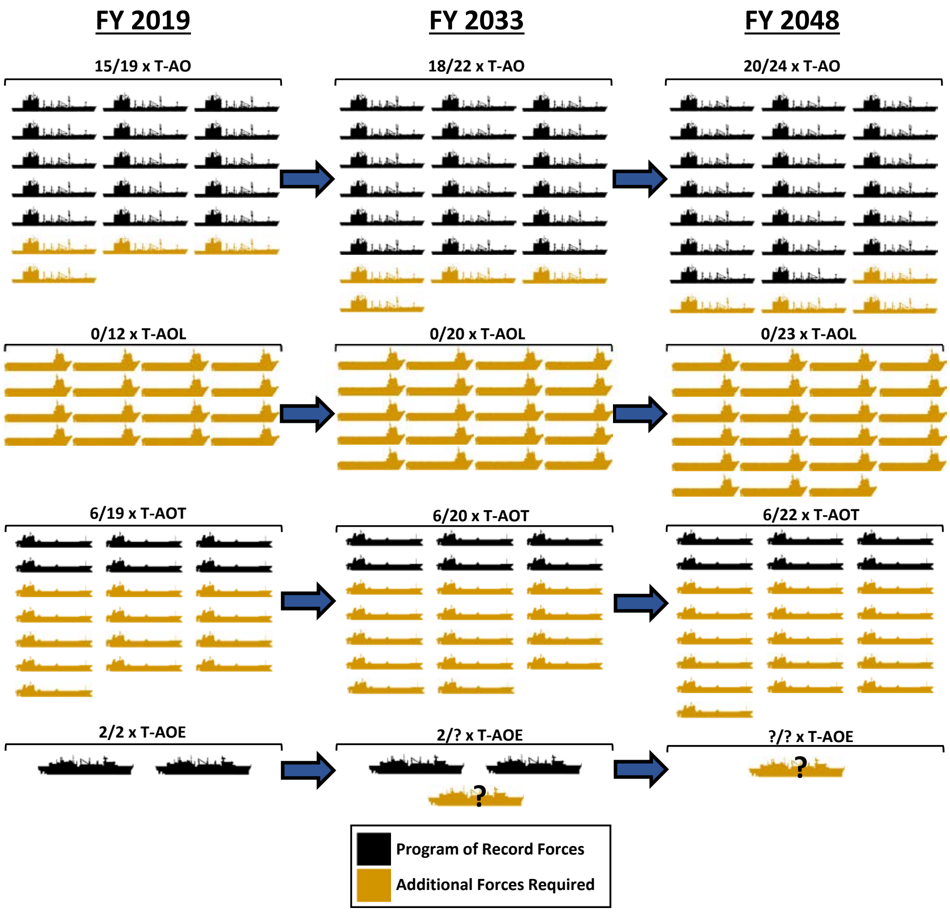
However, assessment of two scenarios (conflict with China while deterring Russia and vice versa) identified major gaps in the refueling capacity of the programmed CLF. For example, were the FY 2019 fleet to operate at a high operational tempo and in a highly distributed

87 "Lewis and Clark (T-AKE 1) Class Dry Cargo/Ammunition Ship," General Dynamics NASSCO fact sheet, available at https://nassco.com/pdfs/T-AKE-Fact-Sheet.pdf.

88 CSBA maritime logistics models based on methodologies used by the Navy's Strategic Mobility/Combat Logistics Division (N42) and CNA in its T-AO(X) analysis of alternatives and subsequent analyses. For additional information, see Appendix B on Quantitative Assessments.

fashion against China, and if CLF ships did not have access to forward bases to resupply, an all-T-AO/E force would require 37 T-AO/Es—20 more than the 17 currently in the force and costing an additional approximately $10 billion to acquire.[89] Given the 20-ship gap in the current force, the Navy would need to develop an operational design that was more logistically supportable but could reduce combat potential or incur additional risk to the force. In contrast, a mixed T-AO/E, T-AOT, and T-AOL force would require 19 T-AO/Es, 16 T-AOTs, and ten T-AOLs. This is two T-AO/Es, eleven T-AOTs, and ten T-AOLs more than currently in the force and would cost an additional $2.0–3.04 billion, depending on the provenance of the T-AOTs. Therefore, a mixed force that includes T-AO/Es, T-AOTs, and T-AOLs would not only likely be more resilient, but also would cost $6.9–8.0 billion less than an all-T-AO/E force.

FIGURE 15: PROPOSED REFUELING FLEET



89 A T-AO 205 is estimated to cost $500 million per ship, assuming faster than currently planned construction rates. A 320,000 bbl T-AOT is estimated to cost $140 million for a new U.S.-built tanker and $46 million for a 5-year old foreign-built tanker, including $20 million in modifications. A T-AOL is estimated to cost $50 million for a 5-year old U.S.-built OSV on the open market, including $20 million in modifications.

This study recommends the Navy develop a new refueling architecture emphasizing greater capacity and resilience. It should slightly increase the number of T-AOs it acquires, considerably increase the number of CONSOL and MFDS tankers it acquires (or otherwise acquires long-term access to), and acquire a fleet of T-AOLs for supporting independent units and small formations of naval forces in contested environments. The Navy should also develop new minimally manned or unmanned refueling systems, critically examine whether it should build T-AOEs in the future based on changes in the threat environment and fleet demands, and maximize the utility of T-AKEs to support small formations of naval forces. The proposed fleet, sized for a 20 percent attrition rate in the primary theater, is depicted in Figure 15.

Navy Fleet Cargo and Munitions Replenishment

Beyond fuel, Navy CLF assets distribute cargo (such as food, repair parts, and store items) and munitions to ships at sea. This allows combatants to remain forward, instead of having to retire periodically to resupply from naval bases. The Navy's fleet of T-AKE ships is the principal means of distributing cargo and munitions to ships at sea. Additionally, the Navy's fleet of C-2A aircraft delivers high-priority personnel and parts to aircraft carriers in a procedure known as Carrier Onboard Delivery (COD), while a variety of Navy helicopters deliver dry cargo and munitions to ships via Vertical Replenishment (VERTREP).

The Navy's current model of at-sea delivery has been effective in recent decades of uncontested operations. T-AKEs and aircraft rapidly shuttle from a network of unhardened and centralized forward shore depots to support ships at sea. This hub-and-spoke approach to cargo delivery has reduced on-ship storage requirements while simultaneously reducing redundancy and waste in the Navy parts and equipment supply chain. In many cases, the Navy has reduced, or even eliminated, stores of onboard spares and ships' ability to conduct intermediate-level at-sea maintenance of ship systems and aircraft. T-AKEs operating from similar weapons depots also replenish munitions expended by carrier aviation. Surface combatants and submarines have, since the end of the Cold War, had to reload at fixed shore facilities capable of handling munitions (with the exception of a small number of reloads from submarine tenders).

This approach will be inadequate in contested operations against China or Russia. Adversary strike systems are highly capable of identifying and attacking fixed shore facilities and large logistics vessels in port. Reviewing these challenges, and following a best-value approach, this study recommends the Navy adopt three initiatives to improve its ability to deliver cargo at sea and five initiatives to improve its ability to deliver munitions to ships at sea.

Distributing Cargo

To improve cargo distribution resilience, the Navy should pursue three initiatives: shift towards distributed aviation logistics operations, gain improved efficiency with supporting CONSOL Cargo and Munitions ships, and increase combatant logistical self-reliance.

Shift to Distributed Aviation Logistics Operations

The Navy should accelerate its shift away from the current hub-and-spokes model centered on the aircraft carrier and towards distributed aviation logistics operations.[90] Although the hub-and-spokes model has served the Navy well, the ability of the tiltrotor CMV-22B aircraft to either fly directly to a CVN or to a range of other ships with flight decks is the leading edge of a new set of capabilities that can enable a more effective model. To accelerate a shift to distributed aviation logistics operations, the Navy should pursue three initiatives.

First, the Navy should significantly increase the number of V-22-capable flight decks in the fleet, raising interoperability and in turn resilience throughout the fleet. Otherwise, the Navy risks underutilizing the CMV-22B's tiltrotor capability and continuing a Carrier Onboard Delivery (COD) model with the CVN as the central hub and few additional hubs.

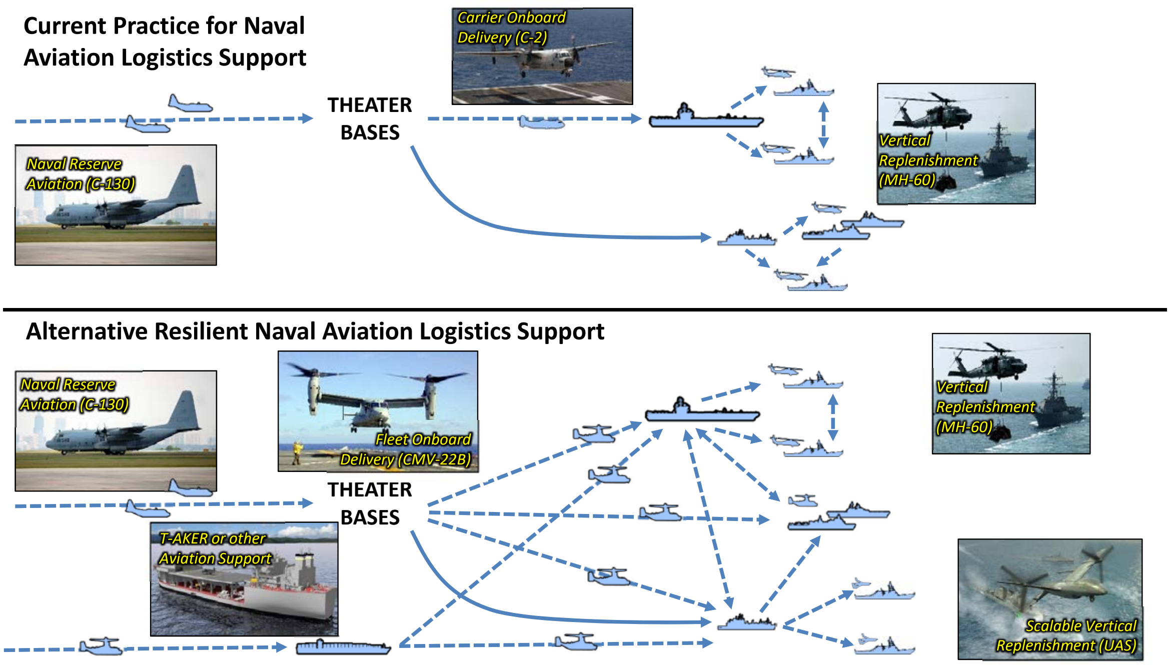
Second, the Navy should reassess the required number of V-22s in its fleet to support aviation logistics. The Navy currently plans on acquiring 44 CMV-22Bs solely to support the COD mission. The Marine Corps has a large fleet of MV-22 aircraft, which, while not as well suited to the aviation logistics mission as the CMV-22B, could play an ancillary role in some Amphibious Ready Group (ARG) aviation logistics support. Additional procurement beyond 44 CMV-22Bs, coupled with fleet modifications, would assist the Navy's distributed operating concepts.[91] Additional CMV-22Bs would also be needed to account for attrition or to take advantage of the CMV-22B's improved range and lift for other missions, such as Combat Search and Rescue or medical evacuation.

Third, the Navy should consider the utility of current and potential vertical-takeoff Unmanned Aircraft Systems (UAS) to distribute essential, time-sensitive cargo to address relatively lightweight Casualty Reports (system failures). Incorporating UAS into the Navy's aviation logistics model would permit a more scalable and responsive approach to time-sensitive logistics. Small- and medium-sized UAS could support low-weight, low-volume support requirements, while V-22s and rotary aviation could address larger payloads. This approach could improve combatant ship operational availability while giving each individual logistic ship greater "reach" with which to support the fleet. A depiction of the proposed approach is shown in Figure 16.

90 Of note, separate fleets of Navy and Joint aircraft and extensive commercial support provide inter and intra-theater logistics that deliver supplies to Forward Logistics Sites. The delivery of supplies from Forward Logistics Sites to CVNs is a small and critical portion of the logistics chain. The other portions of the logistics chain also require critical examination, especially in terms of the ability to swiftly and securely surge adequate levels of cargo but are outside the scope of this study.

91 For example, if the Navy wanted to provide dedicated CMV-22B support to three ARGs (or SAGs near the ARGs), the CMV-22B requirement could be approximately 23 additional aircraft. This estimate assumes two operational CMV-22B for each ARG, an aircraft availability rate of 60 percent, three aircraft for a forward-deployed attrition reserve of 40 percent, five aircraft for training, and five aircraft for peacetime attrition.

FIGURE 16: DISTRIBUTED, SCALABLE, AND RESPONSIVE AVIATION LOGISTICS SUPPORT



Photos courtesy of U.S. Navy, U.S. Marine Corps, DARPA, and seaforces.org.

Improved System Efficiency with Supporting CONSOL Cargo and Munitions Ships

The Navy should improve the system efficiency of its cargo and munitions distribution architecture. The Navy could pursue several methods to improve its ship-based cargo and munitions distribution capabilities. One includes the adoption of new transfer systems, including E-STREAM on CLF ships and Heavy UNREP capability on T-AKEs, CVNs, and LHAs, to reduce the time spent in this vulnerable evolution and enable the UNREP transfer of heavy F-35B and F-35C engines.[92]

Another improvement would be to adjust the Navy's cargo and munitions distribution architecture by introducing consolidated logistics vessels for dry cargo and reducing reliance on fixed shore support facilities. If adversaries disrupt access to forward shore-based logistics sites, Navy logistics ships, particularly T-AKEs, will need to transit long distances to logistics hubs farther back in theater.[93] This could increase the number of T-AKEs needed to support operations and/or reduce T-AKE UNREP availability (as illustrated in Table 3). Although the Navy's current fleet of T-AKEs could support several CSGs at these longer distances, it would

92 "UNREP," NSWC Port Hueneme, available at www.navsea.navy.mil/Home/Warfare-Centers/NSWC-Port-Hueneme/What-We-Do/Test-Evaluation/UNREP/.

93 Of note, it is likely that these intermediate and rear shore bases will also be contested kinetically and non-kinetically, albeit likely not at the same potential density of attack as forward bases.

be challenged to support a larger deployment of the battle force—especially if operational availability and attrition reserves were taken into account.

TABLE 3: IMPACT OF DISTANCE ON T-AKE REQUIREMENTS

Resupply Point for CSG Operating Near Marianas	Approximate One-Way Distance (nm)	T-AKE Required
Guam, U.S.	100	1
Yokosuka, Japan	1,250	1
Changi, Singapore	2,750	2
Honolulu, U.S.	3,300	2
San Diego, U.S.	5,250	3

This modeling calculates shuttle and station T-AKE requirements for a CSG consisting of one CVN, two CG-47s, five DDG-51s, and one T-AO 187. A 15 percent evasion distance multiplier is factored into the distances.

To address these challenges, the Navy could use an approach that maximizes the efficiency of forward-operating T-AKE through the use of supporting CONSOL ships for dry cargo.[94] The Navy could acquire or long-term charter a small number of commercially derived, converted heavy roll-on/roll-off (RO/RO) ships modified for UNREP CONSOL logistics. These Dry Cargo/Ammunition, Resupply (T-AKER) ships should be large enough to reload between two and three T-AKEs in a single run, with additional room for selective discharge, broken stowage, cargo staging areas, and aviation support.

FIGURE 17: POTENTIAL MODIFIED-COMMERCIAL T-AKER DESIGN

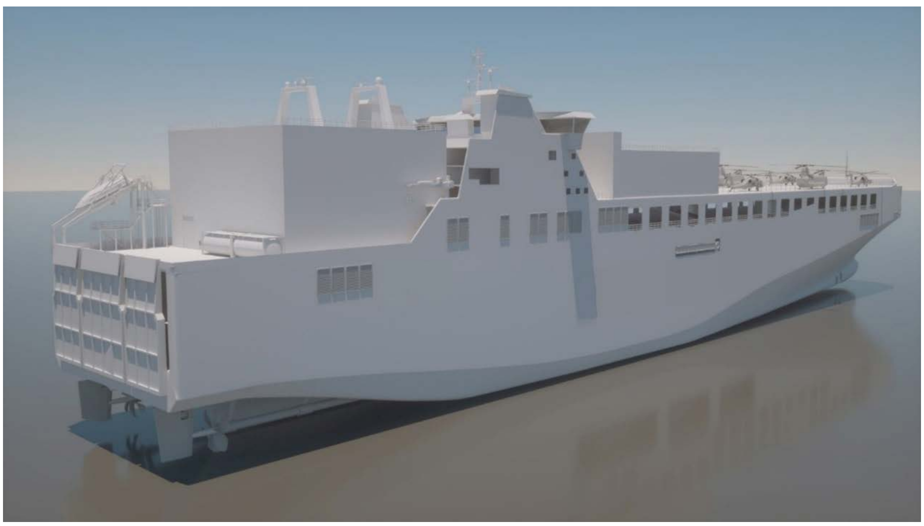


Image of Commercial Expeditionary Resupply Ship concept design courtesy of Maersk Line Limited.

94 While some aspects of this proposed approach are new, others are informed by the Navy's experience using Modular Cargo Delivery Systems for RRF ships during the 1980s.

Including T-AKERs in the future fleet would serve at least three purposes. First, it would maximize the efficiency of existing T-AKEs by allowing them to resupply from intermediate at-sea locations, instead of losing time on station transiting to distant bases. Second, T-AKERs could serve as a partial substitute for T-AKE if the required number of T-AKE exceeds the number of T-AKE in the fleet (12 in the CLF and two in the Maritime Prepositioning Force). Third, T-AKERs would provide an important hedge capability in case the Navy's distant resupply locations were degraded by an enemy.

Increased Combatant Logistical Self-Reliance

Beyond methods of UNREP or the means of getting dry cargo forward, the Navy should also take steps to increase combatant logistical independence and reduce cargo demand. Increased combatant self-reliance would aid in lowering the demands of logistics platforms while raising the operational availability of combatants.

There are three particularly promising areas the Navy could pursue. First, the Navy should increase stocks of supplies and spare parts aboard combatants and logistics vessels to increase readiness. Second, the Navy should increase maintenance conducted aboard ships at sea to improve the ability of ships and their aircraft to maximize operational availability, while reducing dependence on supply chains that may be disrupted. Third, the Navy should pursue increased Additive Manufacturing, also known as 3D printing, aboard ships to similarly reduce their dependence on contested supply chains.[95]

Munitions Rearmament

The ability to reload munitions is critical for protracted combat. Reloading munitions forward or at intermediate locations maximizes combatant time on station, where they can contribute to operations. Without some means of forward rearmament, ships that expend their magazines are compelled to depart station and undertake lengthy transits to and from rear reloading facilities.

The U.S. Navy's current ability to reload most ship and submarine munitions in an expeditionary manner is limited and hinders the Navy's operational effectiveness against capable adversaries. Navy ships and submarines currently lack an effective means of reloading the fleet's principal weapons launch system underway, Vertical Launch Systems (VLS). This system is used to fire weapons such as the Tomahawk Land Attack Missile (TLAM), the Standard Missile (SM) series, Evolved Sea Sparrow Missile (ESSM), and Anti-Submarine Rockets (ASROC), among others. At present, ships and submarines must retire to a suitable pier or harbor with a reloading barge or submarine tender, to replenish empty VLS cells. Similarly, submarines reload their torpedoes, missiles, and other large expendables pierside or with one of the two submarine tenders in service capable of slowly reloading weapons within

95 *A Design for Maritime Superiority* calls for the U.S. Navy to maximize the use of additive manufacturing. Richardson, *A Design for Maintaining Maritime Superiority*, p. 11.

sheltered anchorages. The Navy used to have an at-sea VLS reloading capability organic to most surface combatants but phased the capability out for reasons of cost and difficulty maintaining it following the end of the Cold War.[96]

To improve the resilience of the Navy's logistical capability, the Navy should start by acquiring appropriate stores of munitions and other expendables. Ample stores of advanced munitions and other expendables enable the force to fight more effectively using preferred CONOPS over a protracted period of time. Without appropriate stores, the force is obligated to rely on less effective or riskier CONOPS that use fewer preferred munitions and expendables or may lack the ability to fight altogether. Numerous reports and Congressional testimony have highlighted shortages in DoD's and the Navy's overall and forward-based preferred munitions stocks.[97] Most analysts expect that at current stocks of munitions, "Peacetime inventories of precision-guided munitions would be exhausted quickly in a high-intensity war against a powerful enemy."[98] In its current configuration, the U.S. defense industrial base is unlikely to be able to sufficiently surge production in the near term to offset wartime expenditures—even without taking into account potential attacks on defense-industrial facilities.[99] Accordingly, the Navy should rapidly increase its inventory of preferred munitions and expendables and more adequately configure the defense-industrial base to be capable of supporting surge production.

Furthermore, the force requires appropriate numbers of protected, hardened, and geographically distributed magazines and commensurate protected piers suitable for loading munitions. Limitations that restrict munitions loading to a small number of locations facilitate enemy targeting of forces at those locations. Consequently, the Navy should develop an improved capability to load munitions from multiple locations, leveraging the mobility of shore teams. Stocks of munitions (and reload sites) should be dispersed among forward, intermediate, and rear locations; however, the focus should be on fully loading forward-operating ships with munitions and storing the bulk of munitions at intermediate and rear sites. There is significant potential to improve forward munitions stocks, storage, and distribution capabilities. Cooperation with close allies on shared magazines and distribution procedures could yield major dividends. While forward magazines and distribution points will likely be more contested than intermediate or rear locations, they will continue to be critical in order to maintain the operational tempo of platforms, especially emerging classes of unmanned systems. For example, large unmanned underwater vehicles or large unmanned surface vehicles could

96 U.S. Navy cruisers and destroyers had a VLS reload capability using an organic strikedown crane. However, this slow and maintenance-intensive system was removed from combatants in the 1990s.

97 David Ochmanek, RAND Corporation, "Recommendations for a Future National Defense Strategy," testimony presented before the Committee on Armed Services, November 30, 2017, available at www.rand.org/pubs/testimonies/CT484.html.

98 Jan Van Tol, Mark Gunzinger, Andrew Krepinevich, and Jim Thomas, *AirSea Battle: A Point-of-Departure Operational Concept* (Washington, DC: Center for Strategic and Budgetary Assessments, 2010), p. 90.

99 "Every major combat operation since the 1973 Yom Kippur war has seen a far higher than expected expenditure rate for precision-guided munitions. Nonetheless, given 1) ordnance accounts are generally early "go-to" sources for funds when defense budgets tighten, 2) the high cost of most precision-guided munitions, and 3) fears of block obsolescence, the Services have tended to keep overall inventories relatively small." Ibid., p. 32.

potentially be resupplied from a wider range of locations forward in a lower-signature manner than large manned combatant platforms. Further back in theater and the homeland, magazine survivability will remain important. Facility hardening and protection will continue to be vital at this distance, where it should aim to drive the number of munitions (or the scale of a special forces attack) required to disrupt operations to a high, challenging level.

In terms of munitions distribution, five primary initiatives could potentially improve the Navy's capabilities. First, as previously discussed, it should adopt T-AKER ships to increase the efficiency of forward-operating T-AKEs and T-AOEs. This initiative would primarily support naval aviation aboard CVNs and LHAs and gun-based weapons and other expendables on surface combatants.

Second, the Navy should continue improving its ability to reload at anchor with current classes of auxiliary ships with cranes that use traditional mooring technologies, i.e., fenders and lines.[100] Although VLS reload at anchorage is an attractive intermediate step toward a more agile rearmament capability, it has limitations: in particular, the necessity of favorable weather conditions and slow transfer rates. Accordingly, the Navy should adopt improved crane technology for some existing auxiliaries.

Third, the Navy should develop a capability to conduct VLS Rearming at Sea (RAS). Although long desired, technical barriers have hindered previous VLS RAS efforts. Poor experiences with the 1980s shipboard strike-down cranes and the slow rate and complications involved in VLS reload at anchorage has led to the widespread belief that VLS reload between two moving ships is impractical. This may no longer be the case. The Navy may be able to leverage mature technologies predominantly derived from the commercial maritime sector and seabasing experimentation to field an effective capability. Principally, there are new crane, mooring, and weapon canister transfer system technologies that could enable the swift unloading and loading of VLS canisters in low to moderate sea states while underway or at anchor, in a manner that maintains a safe, fully-positive, and precise control of canisters and does not require modifications to combatants.

Operationally, VLS RAS would provide numerous benefits. First, it would increase fleet operational tempo by maximizing the presence of fleet assets forward vice in long transits to reload. For example, a VLS RAS capability in the Central Pacific on two to three ships could improve the forward presence of a wartime laydown of 48 cruisers and destroyers by an additional

100 In 2017 the U.S. Navy Chief of Naval Operations Admiral John Richardson expressed interest in "bringing back" expeditionary or underway VLS reloading. Hunter Stires, "CNO Announces the Return of Vertical Launch System At-Sea Reloading," *The National Interest*, July 5, 2017, available at http://nationalinterest.org/feature/exclusive-cno-announces-the-return-vertical-launch-system-21425.

approximately 5-18 cruisers and destroyers, depending on the fallback rearmament location.[101] Viewed in this light, a fleet VLS RAS capability provides a "value" in equivalent combatants of about $11-37 billion.[102] Second, VLS RAS would decrease fleet risk by increasing the number of reload locations from a fixed few to a mobile many. Third, this capability would enable more efficient use of high value or scarce munitions by allowing ships to unload munitions from combatants leaving the theater.

Starting with an at-sea demonstration leveraging these technologies on an existing ship, the Navy should progress to field a dual-crane capability on a suitable ship, such as a feeder containership (such as one similar to the ship depicted in Figure 18), which would allow the simultaneous rearmament of combatants' fore and aft VLS cells while underway. This report refers to this ship as a Missile Rearmament Ship (T-AKM).

FIGURE 18: ILLUSTRATIVE CONTAINERSHIP SUITABLE FOR VLS RAS

Image courtesy of Henk Jungerius.

A fourth initiative the Navy should pursue to enhance fleet supportability is new weapons technologies and concepts that provide sustained effects with a reduced logistical tail. Some new weapons (such as electronic warfare systems, high powered microwaves, lasers, and

101 This estimate subtracts the number of cruisers and destroyers of the 48-ship force that could be maintained on station if a VLS RAS capability could be provided to conduct reloads in the Central Pacific (17.8) from the number of cruisers and destroyers that could be maintained on station if the ships had to transit to Pearl Harbor, HI for reloads (12.3), for a difference of 5.5. It then subtracts the number of cruisers and destroyers of the 48-ship force that could be maintained on station if a VLS RAS capability could be provided to conduct reloads in the Second Island Chain (27.8) from the number of cruisers and destroyers that could be maintained on station if the ships had to transit to Seal Beach, CA for reloads (9.3), for a difference of 18.5. Including an attrition reserve of 40 percent and assuming a 90 percent operational availability rate, up to five VLS RAS ships would be needed to support operations of a 48-ship cruiser and destroyer force. Moreover, a VLS RAS capability could be highly useful even if forward ports were accessible, since the capability would alleviate reloading bottlenecks caused when multiple ships need to reload within a short period of time and also provide a means of transporting magazines farther forward. Similar analyses are applicable to the value of tenders for the submarine force.

102 This estimate assumes a cost of $2 billion for each cruiser or destroyer.

future hypervelocity projectiles) require less logistical resupply per engagement than missile interceptors.[103] Similarly, the Navy can further emphasize short-to-medium range missile interceptors (such as ESSM) that can fit multiple weapons within each VLS cell, increasing combatant defensive capacity per VLS cell dedicated to defense.[104] Another source of potential improvement would be to augment manned combatants with weapon-carrying unmanned systems that act as offboard magazines. As shown in Figure 19, if utilized principally as command and control assets, future surface combatants could increase their endurance forward while their large unmanned surface vehicles (LUSV) fire and shuttle back and forth to reload from a shore facility, tender, or T-AKM.

FIGURE 19: LUSV OFFBOARD MAGAZINES

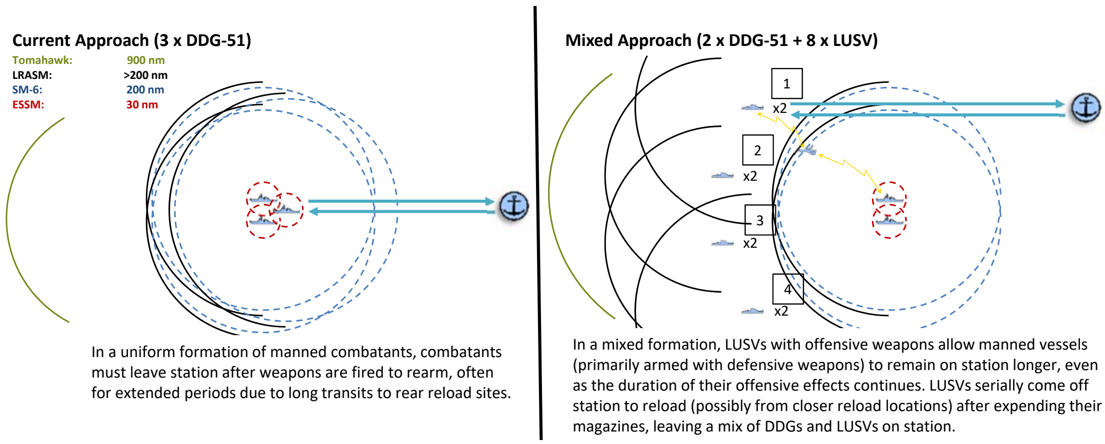


Figure ranges not drawn to scale. Figure ESSM and SM-6 range estimates are drawn from IHS Jane's. Tomahawk range is drawn from U.S. Navy, "Tomahawk Cruise Missile," U.S. Navy Fact File, available at www.navy.mil/navydata/fact_display.asp?cid=2200&tid=1300&ct=2. LRASM range estimate is drawn from Alan Jackson of Lockheed Martin in Oriana Pawlyk, "Live LRASM Test from F/A-18 Super Hornet Expected This Year," *DoDBuzz*, April 10, 2018, available at https://www.military.com/dodbuzz/2018/04/10/live-lrasm-test-f-18-super-hornet-expected-year.html.

Finally, the Navy should consider the next generation of surface missile launchers. Mk41 and Mk57 VLS systems have served the U.S. Navy and its allies and partners well for over four decades. However, as the Navy considers future surface combatant designs, it should examine whether there may be more effective or logistically supportable approaches to weapons launch. For example, as some missile types become larger, the Navy may find merit in new hot, cold, or electromagnetic-launch systems (diversifying from solely hot-launch

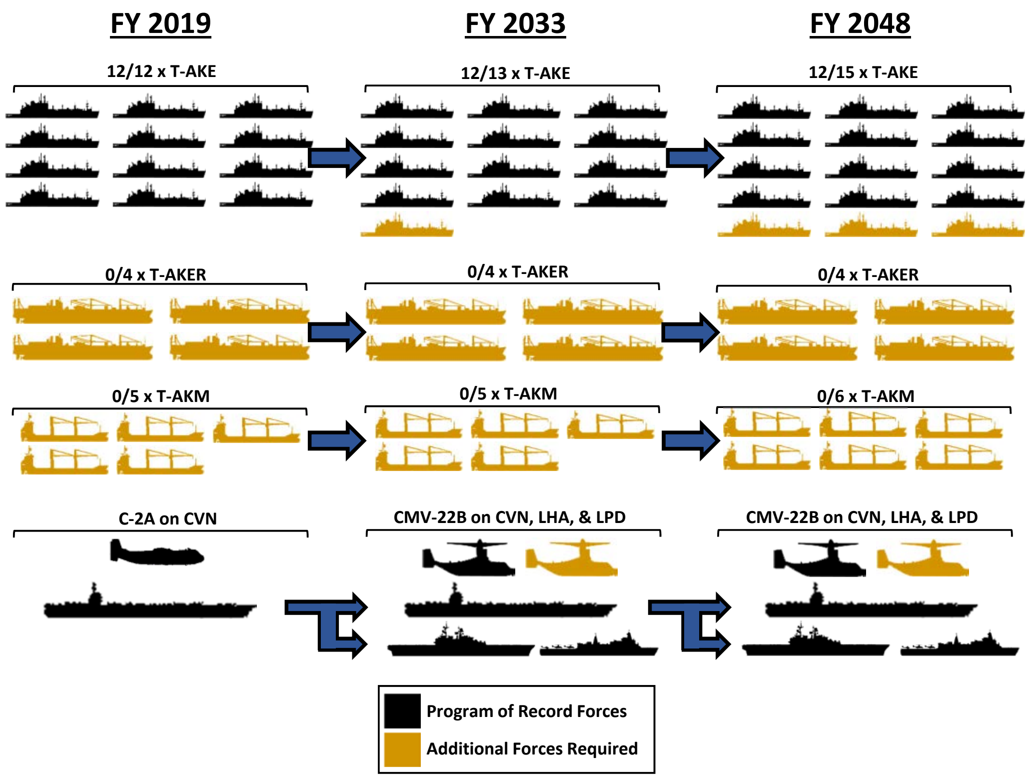
103 Of note, these systems will not obviate the need for long-range missiles—especially since many of these technologies are limited to line of sight engagement. Additionally, as a countervailing factor, Navy ships may need to expend larger quantities of expendables such as sensors and decoys for EMW operations.

104 Mark Gunzinger and Bryan Clark, *Winning the Salvo Competition: Rebalancing America's Air and Missile Defenses* (Washington, DC: Center for Strategic and Budgetary Assessments, 2016).

VLS systems).[105] In addition, adoption of container-form factor launchers could facilitate global transport and installation across multiple Navy ship types, introducing additional fleet flexibility, and could provide rapid options for reload afloat and ashore.[106] Small, trainable launchers could also provide a reloadable means to deploy numerous small payloads.

Overall, by implementing new concepts and adding new platforms, the Navy can shift to a more resilient cargo and munitions replenishment architecture. Figure 20 depicts the key elements of CSBA's proposed fleet, sized for a 20 percent attrition rate in the primary theater.

FIGURE 20: PROPOSED CARGO AND MUNITIONS FLEET



105 Both Russian Navy and PLAN surface combatants utilize both hot- and cold-launch on different ship designs and for different weapons. The U.S. Navy currently uses only hot-launch VLS systems, in which the missile ignites in the cell, onboard its surface combatants. A cold-launch weapon (used by U.S. submarines when firing missiles) is ejected by a gas generator. Hot-launch systems generally achieve faster initial acceleration compared to cold-launch systems. Cold-launch systems allow larger and more energetic missiles to be fired from combatants due to reduced concerns for ship damage from rocket exhaust. An electromagnetic launch system would use a changing magnetic field to accelerate a payload.

106 Of note, China, Russia, and Israel have developed missile systems that can be disguised within containers and aboard cargo ships. Jamie Seidel, "Israel and Russia Testing Missile Systems That Can Be Hidden Aboard Cargo Ships," *News Corp Australia Network*, June 23, 2017, available at www.news.com.au/technology/innovation/israel-and-russia-testing-missile-systems-that-can-be-hidden-aboard-cargo-ships/news-story/84fddac3db50330c41972e252e7fcd25. New weapon reload technologies, including containerized launchers, could have a major impact on fleet design, increasing the combat utility of auxiliaries and a wide variety of commercial ship designs. For a discussion of using merchant designs as warships, see Steve Wills, "Merchant Warships and Creating a Modern 21st Century East Indiaman," CIMSEC, September 12, 2018, available at cimsec.org/merchant-warships-and-creating-a-modern-21st-century-east-indiaman/37576.

Towing and Salvage

The Navy's towing and salvage fleet supports at-sea transport and recovery of naval platforms and systems. Five MSC tugs (three T-ATF Fleet Ocean Tugs and two T-ARS Rescue and Salvage Vessels), complemented by contractor tug support, currently perform this mission.

FIGURE 21: FORMER USS BELLEAU WOOD TOWED BY USNS NAVAJO

Photo courtesy of U.S. Navy.

In peacetime, this force is responsible for towing damaged ships, salvaging military vessels and aircraft, rescuing personnel from damaged submarines, and debeaching ships. In general, the fleet has required regular ocean towing support; regular salvaging of military aircraft and occasional salvaging of contemporary or historic ships; and constant standby submarine rescue services. Debeaching requirements for amphibious landings have diminished over recent decades with the retirement of the Navy's Landing Ship, Tank ships and a reduction in the size of the Army amphibious watercraft fleet.[107] Navy ships do occasionally run aground or collide, however.[108]

In wartime, the towing and salvage force would be responsible for the same set of peacetime missions, but their character and frequency will likely change and increase. Navy vessels must be towed periodically due to equipment failure. As documented by the U.S. Government Accountability Office, since 2012 the readiness of the surge sealift and combat fleets has

107 The Army is currently recapitalizing its Landing Craft Mechanized, Mark 8 (LCM-8) fleet with the Army Maneuver Support Vessel Light (MSVL). It plans on acquiring future Army Maneuver Support Vessel Medium and Large vessels. All three ship classes are capable of beaching and may increase the demand for debeaching support. Additionally, emerging concepts for the amphibious landing of heavier equipment (especially offensive and defensive fires) in support of Multi-Domain Battle and Expeditionary Advanced Base Operations may contribute to an increase in debeaching support. Of note, the U.S. Army has six *MGen. Nathanael Greene*-class large coastal tugs used for coastal and ocean towing, docking operations, and undocking operations of large ocean vessels.

108 Recent grounding incidents include the 2009 case of the USS *Port Royal* off Hawaii, the 2013 case of the USS *Guardian* off the Philippines, and the 2017 case of the USS *Antietam* off Japan.

declined, with annual mission-limiting casualty reports rising.[109] Given the fleet's lower state of readiness, more ship steaming days during conflict may result in a higher number of propulsion failures that require towing support.

Beyond accidents and equipment failure, a future war against a capable adversary would likely result in significant attrition. Throughout the latter half of the 20th Century, a mix of robust ship design, professionalism, and heroism has resulted in crews saving U.S. Navy ships, despite successful shell, torpedo, bomb, mine, anti-ship missile, and suicide boat strikes.[110] If unable to proceed on their own, and if a commander deems it prudent to attempt to tow a ship given the state of conflict, damaged ships may require one of three towing options. First, a nearby combatant or support ship could take the ship under tow. Second, an MSC or commercial tug can tow the ship to an intermediate location, where it can receive expeditionary repairs or be lifted onto a heavy-lift ship for transport. Finally, tugs may tow the damaged ship all the way to a rear location.

Other wartime towing and salvage missions include salvaging military vessels and aircraft (especially rapid recovery of sensitive equipment), rescuing personnel from damaged submarines, and debeaching ships. The debeaching mission extends beyond support to amphibious and other grounded ships to also include the rapid clearance of ports and channels of damaged friendly ships and sunken enemy blockships.

To improve its towing and salvage capability, the Navy should pursue five initiatives. First, the Navy should refine its concepts and posture for wartime towing and salvage (and subsequent repair, as discussed in the next section).

Second, the Navy should reexamine its wartime towing and salvage requirements. Informed by the 2012 Towing and Salvage Ship Recapitalization Analysis of Alternatives, the Navy set its tug requirement at eight and plans to acquire eight through the T-ATS program.[111] Since 2012, a number of operating assumptions have likely changed, such as the level of fleet attrition, access to nearby bases, wartime geographic distribution of forces, and projected fleet size. This study's quantitative analysis estimates that the Navy's FY 2019 fleet may have a revised

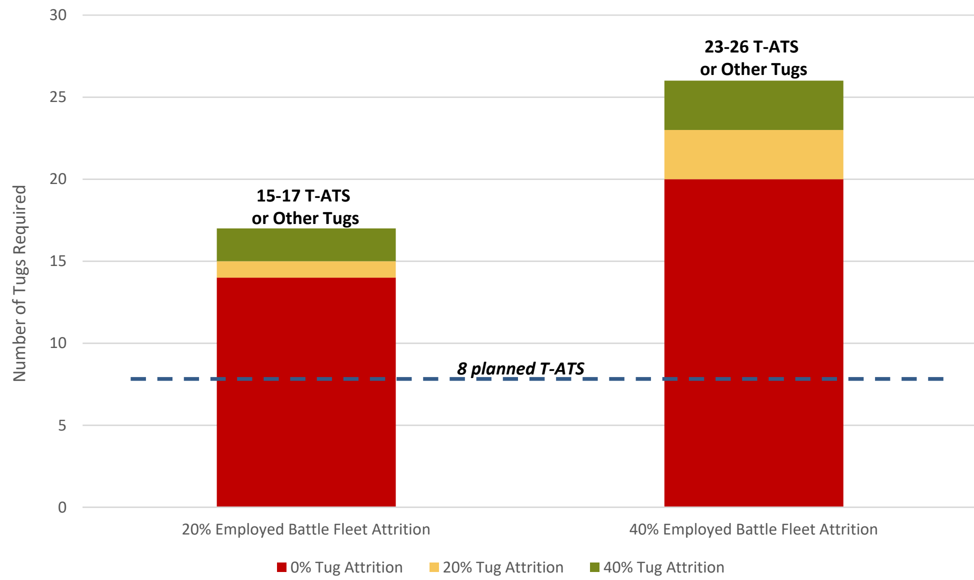
109 Pendleton, *Navy Readiness*.

110 Incidents include the 1967 bomb, torpedo, and shell attack by Israel of the USS *Liberty*, the 1987 Exocet ASM attack by Iraq of the USS *Stark*, the 1988 mine attack by Iran of the USS *Samuel B. Roberts*, the 1991 mine attacks by Iraq of the USS *Tripoli* and USS *Princeton*, and the 2000 suicide boat attack by al-Qaeda of the USS *Cole*.

111 Bill Hardy, "Towing, Salvage, and Rescue Ships," 2016 Salvage Executive Steering Committee briefing slides, March 10, 2016, available at http://seawaves.com/wp-content/uploads/2016/07/T-ATSX-Update-Brief.pdf.

wartime demand for 15-26 tugs, as depicted in Figure 22.[112] This estimate considerably exceeds the five current and eight planned tugs.

FIGURE 22: ESTIMATED FY19 WARTIME TOWING AND SALVAGE REQUIREMENT



Third, with an expanded force, the Navy should improve the peacetime posture and wartime laydown of its tugs, prepositioning them at key ports ready to debeach or salvage sunken ships to maintain effective port operations and deploying them in battle group operating areas, ready to recover damaged ships and tow them to rear shipyards or to Float-On/Float-Off (FLO/FLO) mobile dry docks or transports located at intermediate areas (as discussed in in the next section).

Fourth, the Navy should consider reevaluating its T-ATS acquisition strategy to meet revised requirements. The current program is scheduled to procure eight new-build ships one a year, with the final ship delivered in 2025. Total program cost is projected to cost over $680

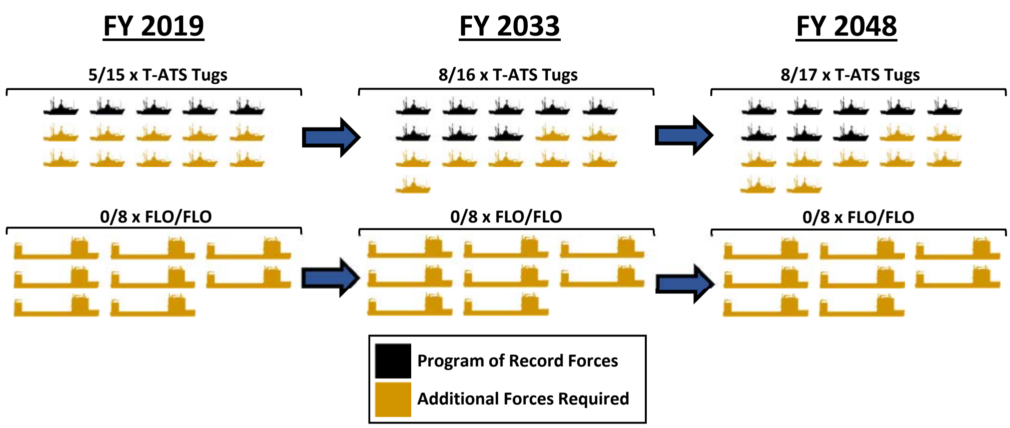
112 In summary, this analysis sets levels of attrition to the forward-deployed battle fleet (20 percent and 40 percent). It then assumes 60 percent of ships hit will not be immediately sunk or rendered non-recoverable; tugs will be tasked to recover 75 percent of damaged floating ships; and the probability a damaged ship stays afloat is a function of the time in which a tug can arrive to provide assistance. This analysis assumed that the probability a tug would be able to tow a damaged ship that does not immediately sink decreases by 10 percent every 12 hours. The requirement for tugs includes two tugs supporting submarine rescue and other emergent missions on the East Coast of the Continental United States, two tugs supporting submarine rescue and other emergent missions on the West Coast of the Continental United States, one tug supporting port clearance at another port, and seven to sixteen tugs supporting towing requirements forward, plus the requisite number of tugs to reach a 90 percent availability rate. Tug 20 percent and 40 percent attrition rates are applied to tugs operating in the forward-deployed battle area, vice a global rate of attrition.

million, with all but $50 million occurring within the FY 2019 FYDP.[113] As a point on value, if the fleet of tugs rescues a single incapacitated major combatant that otherwise could not be rescued, the entire fleet of tugs will have paid for itself. To meet revised requirements, the Navy should shift to producing two tugs per year to rapidly meet the estimated tug requirement of 15-26 tugs.[114] Additionally, if deemed necessary to close urgent gaps, the Navy could acquire or long-term charter some U.S.-built Anchor Handling Tug Supply vessels on the open market to partially meet gaps, while T-ATS are built.

The fifth initiative the Navy should pursue is a deepening of contingency agreements with other countries (especially allies) and commercial ship operators for towing support.

Figure 23 below depicts the proposed towing and salvage force. It includes FLO/FLO vessels that are discussed in the next section. It is sized to provide wartime support, assuming 20 percent battle fleet and 20 percent tug attrition rate in the primary theater.

FIGURE 23: PROPOSED TOWING AND SALVAGE FLEET



Expeditionary Maintenance and Repair

In peacetime, U.S. forces draw upon a global network of forward commercial partnerships, allied and partner locations, and bases to conduct naval maintenance and repair.[115] In wartime, as the number of naval forces operating surges and as battle damage occurs, demand for maintenance and repair will increase. In contrast with peacetime operations, though, the

113 The Navy has budgeted approximately $75 million for each vessel, while ship construction costs are estimated at $63 million for each vessel. Cost and timelines available via Office of the Under Secretary of Defense (OUSD)(Comptroller)/Chief Financial Officer (CFO), *Department of Defense Fiscal Year 2019 Budget Request, Shipbuilding and Conversion, Navy*, vol. 1-1 (Washington, DC: DoD, February 2018), pp. 215–218, available at https://www.secnav.navy.mil/fmc/fmb/Documents/19pres/SCN_Book.pdf.

114 The Navy may consider it useful to build two blocks of T-ATS, the latter block with diesel-electric capability that increases fuel efficiency at low speeds.

115 Of note, there are significant opportunities to deepen partnerships with allies to improve the maintenance and repair of U.S. forces forward.

same convenient fixed forward maintenance and repair sites supporting ongoing naval operations are likely to be easy targets for an enemy. Naval forces would either need to conduct maintenance and repairs at intermediate expeditionary locations or retrograde—if capable—to rear facilities.

Wartime demand for expeditionary maintenance and repair would largely consist of two functions. First, as in peacetime, routine maintenance and voyage repairs would be necessary to sustain combatant operations, especially to keep pace with higher ship operational tempo. Second, battle damage, salvage, and repair would be needed. This study bifurcates battle damage repair into two sets of demands: light and heavy.

Light battle damage repairs would fix minor external structural damage and swap damaged parts, components, and even small systems with operating ones. Improving light repair capabilities could allow surface combatants sustaining minor damage to return to battle more quickly than if they retrograded to a major shipyard.

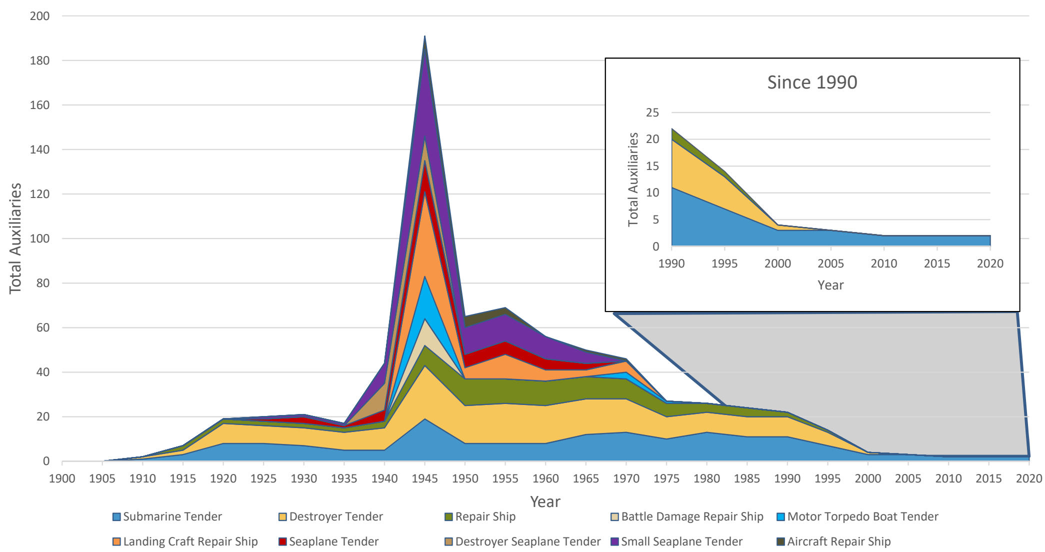
In contrast, expeditionary heavy battle damage repair capabilities would emphasize ship stabilization over returning combatants to battle-worthy condition. Heavily damaged ships are likely to require lengthy, invasive repairs. Expeditionary heavy repair capabilities closer to the combat area would consequently serve a triage function. The extent of damage suffered by ships coming in under their own power or via tow will need to be assessed. Those ships that can be patched up to steam onwards to a rear area drydock on their own should, freeing up additional tow assets. Other ships may require battle damage repairs to enable their towing to a rear area drydock. Ships requiring additional assistance should be prepared for transit aboard FLO/FLO heavy lift ships to a rear-area drydock.

This tiered approach to battle damage repairs is consistent with the historical record. In World War II, Service Squadron 10 and other units were equipped with repair ships and tenders, tugs and barges, and floating docks, to repair and salvage damaged ships at intermediate locations. During and shortly after the Cold War, the Navy retained tenders, repair ships, and floating dry docks to serve as intermediate maintenance and repair and command and control sites for submarines and destroyers. In 1990, the Navy had 11 submarine tenders, 9 destroyer tenders, and 2 repair ships in service. In the Gulf War, destroyer tenders and repair ships aided stabilizing the USS *Samuel B. Roberts*, the USS *Princeton*, and the USS *Tripoli* after the ships struck mines. In 2005, emergency repairs by the submarine tender USS *Frank Cable* repaired the nuclear attack submarine USS *San Francisco* sufficiently, after it had a catastrophic collision with an undersea mountain, to enable it to transit on the surface to Bremerton, Washington for more extensive repairs.[116] Overall, the historical record demonstrates the enormous utility of expeditionary maintenance and repair capabilities afloat for not only routine maintenance or minor repairs, but also major damage.

116 Patrick T. Rawlinson, "The Importance of Submarine Tenders to a Modern Naval War: Naval Combat Logistics and Sea Basing," *The Submarine Review*, September 2017, p. 14.

Despite the historical record, Navy expeditionary repair capabilities have atrophied (as shown in Figure 24): two submarine tenders and fly-away teams are all that remain of Service Squadron 10's descendants.[117] In scenarios in which the United States lacks safe access to forward bases to conduct maintenance and repair, a dearth of expeditionary maintenance and repair would result in lower wartime operational availability rates and an increased loss percentage of damaged ships and submarines.

FIGURE 24: SIZE OF NAVY TENDER AND REPAIR SHIP FORCE OVER TIME



To improve expeditionary maintenance and repair, the Navy should take three major steps. These initiatives would have significant utility in peacetime, particularly in the event of major accidents, while enhancing fleet resiliency and survivability during conflict.

First, the Navy should expand the tender fleet. The Navy requires tenders to conduct expeditionary maintenance and repair for both submarines and surface combatants. Although a single class of tenders, built on a common design, like the Common Hull Auxiliary Multi-mission Platform (CHAMP) or another design (such as one based on the ESB hull), may be sufficient to support both submarines and surface ships, additional analysis could determine whether differentiated tenders (in terms of design, equipment, and personnel onboard)

117 This capability was in part replaced by the development of qualified yards and maintainers in forward locations. However, this shore-based capability is less flexible and more sensitive politically and militarily than afloat expeditionary maintenance and repair support.

should be pursued or not.[118] The CHAMP concept is examining the utility of a common hull for five missions: strategic sealift, aviation intermediate maintenance support, medical services, command and control, and submarine tending.[119] A common hull approach may generate shipbuilding and fleet maintenance cost efficiencies; however, the distinct requirements for these different missions will likely mean a single hull will not be suitable for all missions.

Second, the Navy should acquire a force of Float-On/Float-Off (FLO/FLO) ships.[120] These ships would have two purposes: ship transport and mobile dry dock. In their role as ship transports, Navy FLO/FLO ships could support the peacetime regular movement of small ships (such as patrol craft and minesweepers) between theaters, as well as irregular ship movements (such as transporting damaged ships, as was necessary in 2017 for the USS *John S. McCain* and the USS *Fitzgerald*, both displayed in Figure 25). In wartime, FLO/FLO ships would be postured at intermediate locations to receive heavily damaged ships unable to continue on their own or under tow for transport to rear-area repair yards.

FIGURE 25: ARLEIGH-BURKE-CLASS DDGS LOADED ABOARD FLO/FLO

USS *Fitzgerald* being loaded onto the FLO/FLO MV *Transshelf*, with the ship submerged for loading (left). USS *John S. McCain* loaded aboard the FLO/FLO MV *Treasure* (right). Neither FLO/FLO is U.S.-flagged. Photos courtesy of U.S. Navy and Singapore Ministry of Defence.

The second primary purpose of FLO/FLO ships would be to serve as mobile dry docks at intermediate locations to assist tenders in repairing ships. If additional ballast and other modifications were made to new Expeditionary Transfer Docks (ESD), then they could serve

118 While tenders should be capable of reloading weapons on surface combatants and missiles and torpedoes on submarines, this study recommends the tender force focus principally on expeditionary maintenance and repair, while the aforementioned VLS RAS T-AKM ships focus on rearmament. The large quantity of VLS cells to be reloaded would either greatly increase the size of tenders or force tenders to reduce time on station spent on maintenance and repair of ships due to the need to shuttle weapons from rear magazines. Another concept worth additional analysis is the potential utility of differentiation in the submarine tender fleet. One class of larger submarine tenders would provide a broad range of support to submarines, including maintenance, repair, and reloads, while another class of smaller submarine tenders would focus on resupplying weapons, food, and other key supplies.

119 Justin Katz. "Navy Still Eyeing CHAMP, but Not Ruling Out Single-mission Ship Designs," *Inside Defense*, October 19, 2018, available at https://insidedefense.com/insider/navy-still-eyeing-champ-not-ruling-out-single-mission-ship-designs.

120 FLO/FLO ships are sometimes referred to as Heavy Lift Ships or Semi-Submersible Heavy Transport Vessels (SSHTV). The term Heavy Lift Ship also refers to other ships capable of carrying large loads. Therefore, for clarity, this report uses the term FLO/FLO.

as an FLO/FLO ship in the ship transport or mobile dry dock roles. Alternatively, the Navy could acquire new or used open-stern FLO/FLO based on a commercial design or long-term charter ones with U.S. crews on the open market. Another option to secure access to some of these ships may be a public-private partnership in which a commercial company leased a U.S. Government-owned FLO/FLO for commercial use, with the Navy maintaining contingency priority. A final option would be to establish a specialized, higher MSP stipend and slots for FLO/FLO, incentivizing currently foreign-flagged and operated FLO/FLOs to join the U.S. fleet.[121] This could be a cost-effective option to secure necessary FLO/FLO access.

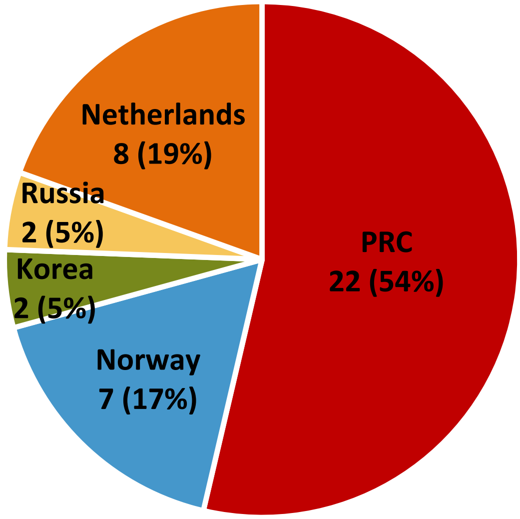
Overall, the Navy should shift to an approach that secures assured access to FLO/FLO ships, rather than relying on the financially, politically, and threat-sensitive services of FLO/FLO ships on the open market. As opposed to other segments of the global maritime industry, the FLO/FLO market is small (with only 41 vessels 15,000 gross tons or more, a minimum size to transport U.S. destroyers, across the world), and ownership is concentrated in five countries.[122] As shown in Figure 26, Chinese companies own more than half of the FLO/FLO market and continue to gain greater market share through a mix of shipbuilding, scrapping, and operating subsidies. There are no U.S.-flagged or owned FLO/FLOs, and only 17 are owned by U.S. allies.[123] During a conflict involving China or Russia, their FLO/FLO operators would not charter their ships to the United States, and China and Russia would likely exert pressure on other FLO/FLO operators to not cooperate with the United States or else face repercussions. Additionally, the availability of FLO/FLO ships for chartering fluctuates due to market factors, primarily driven by the oil and gas sector. There is an inverse relationship between the price of oil and gas and slack capacity in the FLO/FLO market. Therefore, if a conflict took place at a time when the price of oil or gas was high, it may be difficult for the Navy to charter one of the 17 FLO/FLO ships owned by allies (assuming the operators or their owner's countries were not dissuaded from working with the United States due to Chinese or Russian coercion)—even if the Navy offered higher spot charter rates since many of these ships would be locked in longer-term contracts. Lastly, foreign FLO/FLO crews may be reluctant to operate in a warzone. In summary, the FLO/FLO market is small, competitive, and contested, and the Navy should shift from an approach that optimistically assumes the market of foreign-owned ships will provide requisite capacity during conflicts.

121 Market research indicates the current annual stipend of $5 million per vessel would be inadequate to offset FLO/FLO operating differentials. However, a specialized annual stipend of $8.5 to $12 million may incentivize select operators to join the U.S.-flag fleet through MSP.

122 As an example of this growing trend, in August 2018, Dutch dredging and heavylift firm Boskalis (the parent company of Dockwise, the company that transported the USS *John S. McCain* and USS *Fitzgerald* after their 2017 collisions) announced that due to lower demand in offshore energy and "Asian" (i.e., Chinese) overcapacity in the market, it would exit the lower-end of the heavy lift market and scrap 12 of its smaller vessels, leaving it with a fleet of eight large open stern ships. This reduction in the number of vessels in the market will accelerate the trend of a small and decreasing number of vessels available for DoD to contract. "Boskalis 2018 Half Year Report," Boskalis, August 2018, available at https://boskalis.cld.bz/Boskalis-2018-Half-Year-Report/7/#zoom=z.

123 The MV *American Cormorant* (AK-2062) was the last U.S.-flagged or owned FLO/FLO ship. It was under long-term contract to MSC for the prepositioning of Army lighterage until 2002.

FIGURE 26: FLO/FLO SHIPS IN GLOBAL MARKET



The third initiative the Navy should pursue to improve its expeditionary maintenance and repair capability is to acquire a force of light unmanned system tenders to maintain, repair, and rearm future fleets of unmanned surface and subsurface vehicles. These smaller tenders would maximize the operational availability of forward-operating unmanned vehicles by minimizing the time unmanned vehicles would need to spend in transit. For small to medium-sized unmanned vessels, a modified EPF could be configured with a suitable crane for launch and recovery while retaining sufficient space to conduct internal maintenance and repair. The EPF flight deck could similarly support unmanned aerial systems, particularly if configured with a hangar. For larger unmanned surface vehicles and undersea vehicles, Multi-Purpose Support Vessels (MPSVs) could be good candidate support platforms. MPSVs have a low freeboard to work alongside lightering unmanned vehicles, large cranes to lift large unmanned vessels out of the water, and ample deck space (some of which could be enclosed) to work on unmanned vessels.

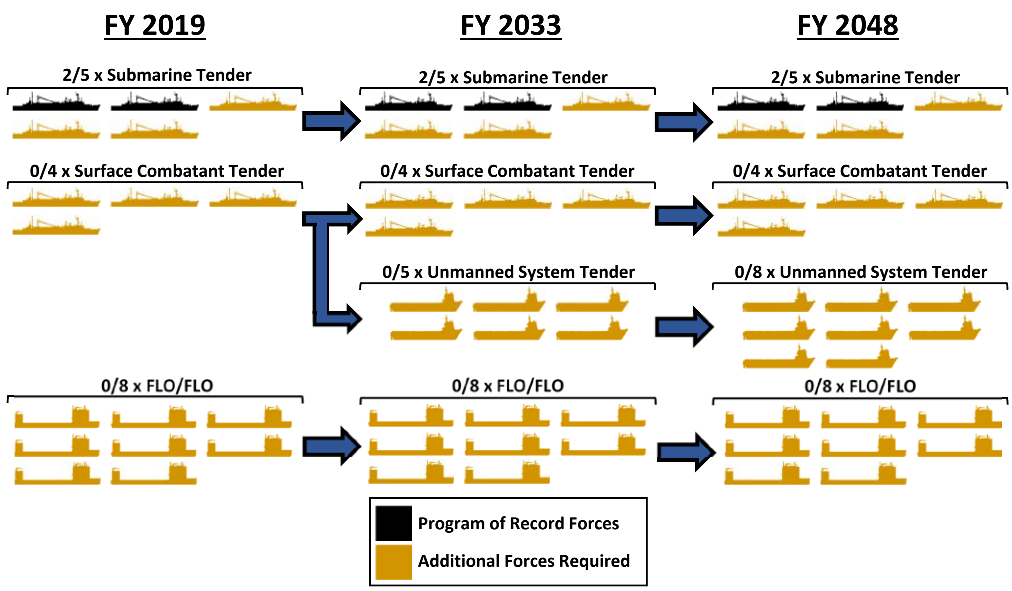
In summary, although the Navy has continued to devote modest resources to its at-sea replenishment force, its expeditionary maintenance and repair capabilities have dwindled. As a result, the Navy has largely shifted to a forward "garrison force" that relies on a network of forward ports, vice expeditionary capability, to sustain itself in forward combat theaters.[124] Faced with major threats to the current way of operating, the Navy should restore its expeditionary capability. Figure 28 below depicts CSBA's proposed force.

124 The Cold War and post-Cold War "Garrison Force" contrasts with World War II "Expeditionary Force." Robert O. Work, *To Take and Keep the Lead: A Naval Fleet Platform Architecture for Enduring Maritime Supremacy* (Washington, DC: Center for Strategic and Budgetary Assessments, 2005), p. 393.

FIGURE 27: POTENTIAL OPTIONS FOR LIGHT TENDERS

Modified EPF (left) or Multi-Purpose Support Vessels (right) could serve as light tenders. Images courtesy of U.S. Navy and Hornbeck Offshore.

FIGURE 28: PROPOSED EXPEDITIONARY MAINTENANCE AND REPAIR FLEET



SAR (to include CSAR) and Medical Support Afloat

Robust Search and Rescue (SAR)—to include Combat Search and Rescue (CSAR)—and medical support afloat are critical to the Navy's ability to fight a protracted conflict against a capable adversary.[125] The two capabilities increase the survival rates of personnel (essential to being able to sustain a protracted conflict) and increase personnel confidence in the

125 This section focuses on the Navy's ability to rescue personnel at sea or in the littorals and provide temporary medical support before transfer to a more capable shore facility. In so doing, it does not strictly adhere to some definitions of logistics missions. Nonetheless, it is included in this report given its criticality and relatively underappreciated nature. The term Combat Search and Rescue is used to refer to the recovery of personnel from contested areas in general, rather than solely refer to recovery of personnel from combat areas. An alternate term could be Contested Personnel Recovery (CPR).

operational design since they know there is a reasonable chance of their being rescued if their unit is unsuccessful in defending against the enemy.[126] This confidence, in turn, enables local commanders to exercise a higher degree of calculated risk against deadly enemies.

The Navy has dedicated SAR organic in the fleet and medical support afloat forces. The requirements that have shaped these forces in the past two decades are unlikely to be sufficient, however, for mass rescue and medical support potentially required in a major conflict against a peer or near-peer adversary.

TABLE 4: ESTIMATE OF POTENTIAL SHIP PERSONNEL MEDICAL SUPPORT DEMANDS FOR THE FLEET OF FY 2019 IN A CHINA SCENARIO

Category	Number of Ships and Personnel
Number of Total Ships in Primary Theater	190
Number of Ships Sunk	15
Number of Ships Damaged but Afloat	23
Number of Injured Personnel from Damaged Ships that Sunk	1,473
Number of Uninjured Personnel from Damaged Ships that Sunk	2,947
Number of Injured Personnel on Damaged Ships that Stay Afloat	1,326
Total Number of Personnel from Sunk or Damaged Ships Requiring Rescue or Medical Attention	5,746

A high-intensity naval conflict against either China or Russia could greatly exceed any Navy combat casualty experience since World War II. Table 4 portrays a potential outcome if, of the Navy's FY 2019 fleet of ships in the primary theater (using the concepts and laydown described in CSBA's Alternative Fleet Architecture study), 20 percent were damaged in which 40 percent of damaged ships (8 percent overall) either sunk or were rendered otherwise unrecoverable (either immediately after the enemy attack or in a later period), and 60 percent of damaged ships (12 percent overall) stayed afloat and were recoverable.[127] The number of personnel to rescue from these events and medically treat on or evacuate from ships—even if staggered in time—would be considerable. This would be aggravated by the time-sensitive nature of personnel recovery and treatment, coupled with the dangers of rescue in a

126 As a historical example, during the Battle of Britain, Great Britain's relative superiority rescuing its downed airmen gave it a key advantage over the Luftwaffe.

127 This simple assessment assumes that 25 percent of personnel on ships that sink die, 25 percent are injured, and 50 percent are uninjured. It also assumes that 15 percent of personnel on ships that stay afloat die, 15 percent are injured, and 70 percent are uninjured. In general, these percentages may overestimate casualty rates for personnel on large and hardened ships (such as CVNs) and underestimate them for smaller ships and submarines. Factors used in this estimate are derived from professional judgement. These figures are similar to results observed during the Falklands War of 1982. During that war, of 23 frigates and destroyers sent by the Royal Navy to the South Atlantic, four were sunk and another four damaged. Of note, three of four damaged warships that did not sink were struck by bombs that did not explode. Had they exploded, the number of ships that sank may have been higher. Andrea Ungaro and Paola Gualeni, "An Overview of Warships Damage Data from 1967–2013," Proceedings of the 12th International Conference on the Stability of Ships and Ocean Vehicles, Glasgow, UK, June 14–19 2015, available at www.shipstab.org/files/Proceedings/STAB/STAB2015/Papers/12.1-2-%20Ungaro.pdf.

combat zone. Similar analyses requiring the recovery of scores to hundreds of personnel can be conducted for naval aircraft attrition and the over-water attrition of land-based Air Force, Marine Corps, and Army aircraft, requiring maritime CSAR.

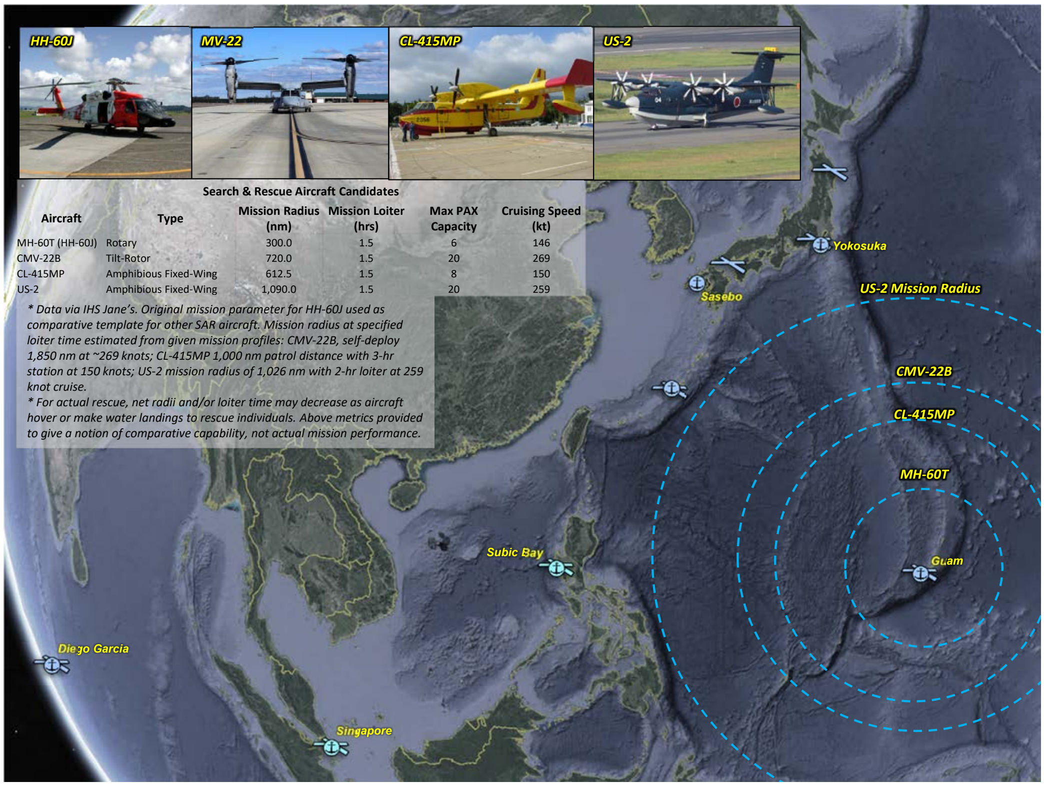
A series of Navy wargames and subsequent analysis and exercises involving towing and salvage, expeditionary maintenance and repair, and CSAR and medical support of mass sailor and aviator casualties in the threat environment could provide significant insights to inform Navy options to improve these capabilities. Informed by insights generated, the Navy could pursue three lines of effort to improve CSAR capabilities.

First, it should improve combatant personnel rescue capability and preparedness. Combatants entering a combat area are unlikely to be alone, and surviving combatants are likely to be the most immediate source of aid. Beyond combatants, T-ATS and T-AOLs could also play an auxiliary role rescuing personnel, leveraging their low freeboard and in some cases excess berthing capacity to rescue personnel. Moreover, large unmanned and minimally-manned vessels may have utility for personnel rescue.

Second, the Navy should improve its aviation-based CSAR capability. The Navy's MH-60 helicopters, while effective for CSAR near a host ship, are ill-suited for long-range CSAR. As the Navy both considers employing carrier aviation farther from CVNs to reduce risk to the carrier and adopts a more distributed approach to surface warfare, this will increase demand for long-range rescue capability. CMV-22Bs could potentially conduct CSAR missions from a wide range of flight decks, provided they are procured in numbers greater than solely required for the COD mission. Despite this, even CMV-22Bs would face challenges rescuing large numbers of personnel at range.[128] The Navy should consequently consider acquiring amphibious aircraft for CSAR missions. Although amphibious aircraft have reduced aerodynamic efficiency compared to conventional aircraft, they are capable of waterborne and land takeoff and landing. They also have greater range than helicopters and, under appropriate conditions, can land and recover more personnel in the water than hovering helicopters or tilt-rotors. The Japan Maritime Self-Defense Force (JMSDF) and PLAN have procured amphibious aircraft for this purpose. If distributed across a theater, a mix of rotary and amphibious aircraft could provide a rapid rescue capability. Figure 29 depicts CSAR aviation options.

128 A major limitation of most helicopters and tiltrotor aircraft is the need to hover to hoist personnel onboard when conducting water rescues. These aircraft burn a considerable amount of fuel while hovering, which reduces available time on station and in turn decreases the ability to rescue large numbers of personnel from the water. Additionally, CMV-22B would need to hover at a high altitude.

FIGURE 29: COMPARISON OF CSAR AVIATION OPTIONS



Search & Rescue Aircraft Candidates

Aircraft	Type	Mission Radius (nm)	Mission Loiter (hrs)	Max PAX Capacity	Cruising Speed (kt)
MH-60T (HH-60J)	Rotary	300.0	1.5	6	146
CMV-22B	Tilt-Rotor	720.0	1.5	20	269
CL-415MP	Amphibious Fixed-Wing	612.5	1.5	8	150
US-2	Amphibious Fixed-Wing	1,090.0	1.5	20	259

** Data via IHS Jane's. Original mission parameter for HH-60J used as comparative template for other SAR aircraft. Mission radius at specified loiter time estimated from given mission profiles: CMV-22B, self-deploy 1,850 nm at ~269 knots; CL-415MP 1,000 nm patrol distance with 3-hr station at 150 knots; US-2 mission radius of 1,026 nm with 2-hr loiter at 259 knot cruise.*

** For actual rescue, net radii and/or loiter time may decrease as aircraft hover or make water landings to rescue individuals. Above metrics provided to give a notion of comparative capability, not actual mission performance.*

Photos courtesy of U.S. Coast Guard, U.S. Marine Corps, Jerry Gunner, and aeroprints.com.

Third, the Navy should improve its delineation of CSAR roles and missions with the U.S. Air Force and other Joint partners. Commensurately, the Navy should improve its CSAR cooperation with allies and partners, including conducting mass at-sea CSAR and casualty recovery exercises. CSAR exercises with the JMSDF, in particular, could be a rapid means of not only improving alliance cooperation for this mission in an area of potential conflict but also to test the suitability of the US-2 or other amphibious aircraft for the U.S. Navy.

Beyond CSAR, the Navy will also need to change its approach to at-sea medical support. A major conflict may result in mass casualties at sea, rather than periodic incidents to which the Navy has become accustomed. If confronted with a major influx of patients, it is unlikely the Navy will be able to provide the same speed or level of medical care as has been provided in recent conflicts. The "Golden Hour" standard of medical care pursued during recent operations may not be possible given the scarcity of recovery assets, challenges of mass recovery, and theater distances.[129]

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129 "The Golden Hour standard used in emergency medicine and trauma care states a person should receive definitive care within one hour to ensure optimal outcomes." Joseph J. Hudak III, *The Origins of the "Golden Hour" of Medical Care and Its Applicability to Combat Medicine* (Fort Leavenworth, KS: U.S. Army Command and General Staff College, December 6, 2015), available at www.dtic.mil/dtic/tr/fulltext/u2/a624140.pdf.

Nonetheless, there are major improvements the Navy could adopt to enable a more distributed medical support capability to improve personnel survival in major conflicts. First, the Navy should boost unit-level survival and medical capabilities. Areas for improvement include: increasing the duration of life support provided aboard ship and aircraft life rafts; preparing CMV-22Bs for medical evacuation roles and making them more available throughout the fleet; embedding more paramedic-level hospital corpsmen aboard ships; upgrading the medical facilities on large ships; and preparing rapid-reaction Navy medical teams at standby sites proximate to major naval maneuver operations that may incur casualties. These initiatives would distribute medical capabilities to sea, closer to where they may be needed.

Second, the Navy should change how it thinks about fleet medical treatment. Present fleet medical treatment rests in limited capability aboard combatants for routine injuries and health, some expanded capability aboard amphibious warfare ships and carriers, two large hospital ships configured for a full range of medical support, and larger shore facilities. This medical treatment configuration is sufficient for neither a surge in casualties resulting from a major naval combat engagement nor the geographic distribution of potential casualties likely in a future maritime conflict against a sophisticated adversary. The most immediate way to deepen conflict casualty treatment capacity would be to prepare to surge additional medical personnel to combatants for mass casualty treatment. This, coupled with mass casualty CSAR, should be exercised periodically both in independent exercises and in large scale fleet exercises.

The Navy should consider a different mix of fleet medical capabilities for the future. Subject to more analysis, the Navy should consider two new classes of small and large hospital ships. A larger number of hospital ships would support a shift to a more distributed maritime operations construct.

Small hospital ships would transit to a zone between the intermediate and forward areas to receive patients via ship and aircraft (and depending on the location directly recover personnel itself). A small hospital ship variant (such as one based on the EPF, depicted in Figure 30, or another ship) could treat patients onboard and then transit to an intermediate location, where patients could be transferred to a large hospital ship or transferred via aircraft (to include MV-22 and amphibious aircraft that landed alongside) to a transportation hub that would ferry them to a major shore medical facility. More economical than large hospital ships, the Navy could acquire more of these ships and posture them throughout a theater. Additionally, these smaller hospital ships would be more economical and responsive to operate in peacetime for HA/DR or goodwill missions than larger ships.[130]

130 Alison Vernon, *Do Naval Engagement Missions Have an Impact in Host Nations and Why?* (Alexandria, VA: Center for Naval Analyses, 2008), p. 3. See also Edilberto M. Salenga, *Developing Soft Power Using Afloat Medical Capability* (Carlisle, PA: U.S. Army War College, 2009), available at www.dtic.mil/cgi-bin/GetTRDoc?AD=ada500907.

FIGURE 30: EPF-BASED SMALL HOSPITAL SHIP DESIGN CONCEPT

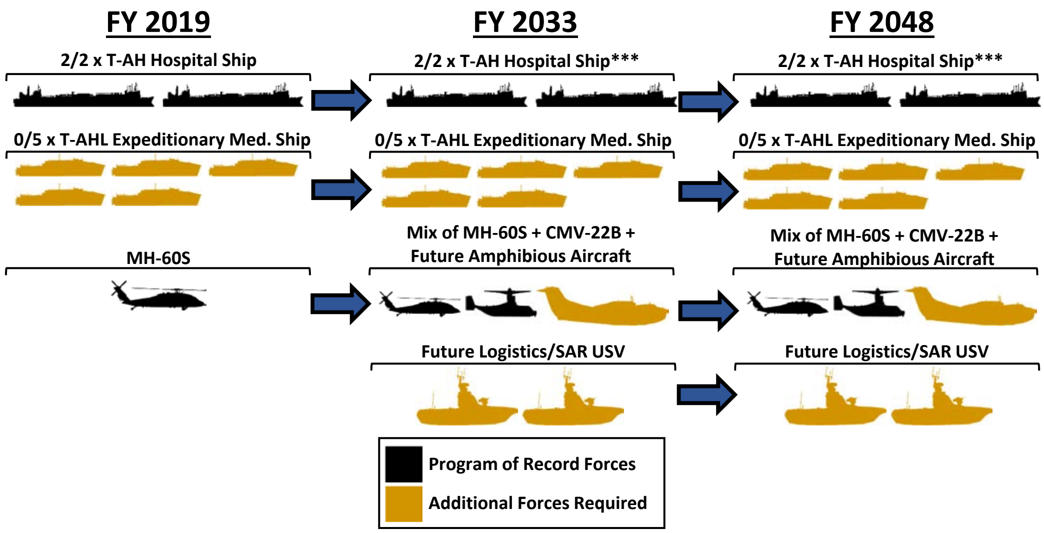
Image courtesy of Austal USA.

A small number of large hospital ships—such as ones based on the CHAMP concept design under consideration by the Navy—could provide medical care for a high throughput of mass casualties at intermediate staging points. MV-22 aircraft onboard the large hospital ship and amphibious aircraft operating alongside would enable the large hospital to receive patients from the front and send them farther to the rear.

As with CSAR capabilities, the Navy should increase its medical treatment cooperation with other Services and allies in a third line of effort. Assessments should seek to determine anticipated medical requirements more accurately and test those in exercises.

Overall, the Navy should develop a medical support force that is both more disaggregated and better suited to high throughput demands. By boosting unit level medical capabilities and establishing a larger number of medical hubs, the force can become more responsive and resilient. While additional analysis is required to determine the appropriate number and type of CSAR and medical assets, this study proposes a representative mix of small and large hospital ships (with priority given to numerous small hospital ships) and a family of CSAR systems (as depicted in Figure 31).

FIGURE 31: PROPOSED CSAR AND MEDICAL SUPPORT FLEET



Joint Force Maritime Logistics: Sealift

The Joint Force also requires an improved maritime logistics architecture. In addition to the logistics requirements of naval forces afloat, Navy forces ashore, Army, Air Force, and Marine Corps assets require extensive sealift support, the use of cargo ships to transport military cargo. Sealift is the foundation of U.S. military power projection, transporting over 90 percent of DoD wartime transportation requirements.[131] Despite this importance, however, Government-owned sealift ships are rapidly aging out of usefulness and the U.S.-flagged commercial fleet, along with the merchant mariner base vital to both the commercial fleet and the government's Surge and Ready Reserve fleets, continues to shrink under a steady barrage of market and policy forces. Absent dramatic improvements, U.S. sealift forces would face major challenges and may fail to meet Joint Force demands in a major war.

This section identifies options to rapidly and decisively improve U.S. sealift. Through a National Fleet approach, the United States could leverage an operationally effective and fiscally efficient mix of U.S. Government and commercial assets that will meet current and future requirements. This section is divided into the sealift of fuel and the sealift of cargo and munitions.

131 McDew (2018), pp. 8–9. Strategic airlift complements strategic sealift by enabling the rapid transportation of relatively small quantities of forces and supplies. However, because of its far greater capacity and efficiency, strategic sealift is the foundation of U.S. power projection. As a comparison, one Large Medium Speed Roll-On/Roll-Off (LMSR) ship could transport approximately 39,700 metric tons in two voyages over 30 days from Norfolk, VA to Antwerp, Belgium, while a single C-17 transport aircraft could transport approximately 1,120 metric tons over those 30 days. It would take over 35 C-17s costing approximately $9.3 billion to match the 30-day lift capacity of a single LMSR costing approximately $600 million.

Sealift of Fuel

Sealift plays a critical role in providing fuel to the Joint Force. All modern U.S. military forces require large quantities of fuel to conduct operations. As discussed in the previous section on afloat maritime logistics, the Navy requires large quantities of fuel afloat to support combatants and naval aviation. This study estimates the Navy's FY 2019 fleet may require between 16 and 22 tankers to support Navy afloat distribution demands alone in a major war. Similarly, the Navy utilizes bulk quantities of fuel ashore in storage tanks at ports, and the Air Force, Army, and Marine Corps also require bulk quantities of fuel ashore. This section on Sealift of Fuel examine the capability and capacity of DoD to transport and distribute fuel from the sea to the shore.[132]

Tanker Requirements

In 2016, Lieutenant General Stephen Lyons, U.S. Army, then-Deputy Commander of USTRANSCOM, testified that a series of DoD mobility studies, informed by the then-current National Military Strategy, validated DoD's sealift requirement of 86 petroleum tanker ships.[133] This requirement, based on the Mobility Capabilities and Requirements Study 2016, consists of the number of tankers DoD estimates it would need in a planning scenario to sustain operations.

The 2018 National Defense Authorization Act directed a new Mobility Capabilities and Requirements Study, which should reflect requirements articulated in the new National Defense Strategy and address current and future levels of risk.[134] As part of this study, the DoD requirement for tankers should be reexamined. There are a variety of reasons why the new requirement may need to be greater than the previous 86 tanker requirement. First, the tanker requirement should account for anticipated levels of attrition.[135] As revealed in Senate testimony in April 2018 by then-Commander of USTRANSCOM General Darren W. McDew, the previous requirement of 86 tankers did not consider the effects of attrition.[136] Second, the tanker requirement should adequately account for the increased distribution of forces (such as those at air bases) across and within theaters. Lastly, given the resurgence of concepts such as using lightering, CONSOL, or MFDS tankers to support naval forces afloat, it is possible that tankers used to support the Navy are not included in the sealift requirement of 86.

This study does not provide an assessment of the required size of the sealift tanker fleet. However, given prevailing factors, it is possible it could be in excess of 86 tankers (exclusive of those tankers supporting Navy afloat requirements). For the purposes of illustrating potential

132 This section considers but does not model sources of fuel. In a conflict with great powers, access to fuel will likely be politically, economically, and militarily contested by both sides.

133 Lyons, "Logistics and Sealift Forces," p. 3.

134 McDew (2018), p. 5.

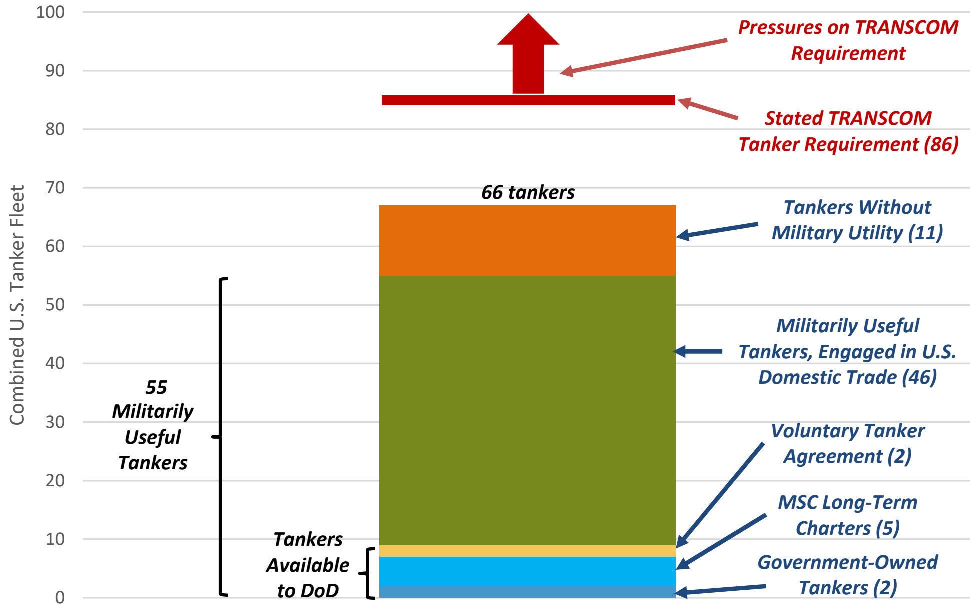
135 This should include both direct attrition (damage to ships), as well as indirect or functional attrition in which ships are not physically damaged but unusable because they are unable to leave port, or other reasons.

136 McDew (2018), p. 5.

improvements to the tanker force, this study assumes the tanker requirement remains constant at 86.

To assess whether the United States has access to the requisite number of tankers to address increasing wartime demand, it is worth examining the U.S. and global tanker market. As shown in Figure 32, the seven MSC owned and chartered tankers and two U.S.-flagged commercial Voluntary Tanker Agreement (VTA) tankers are insufficient to meet DoD's current 86-tanker requirement, let alone one that rises to accommodate current and future challenges.[137]

FIGURE 32: AVAILABILITY OF U.S.-FLAGGED TANKERS



Of note, 46 of the 52 tankers with military utility are engaged in domestic commerce (commercially transporting crude or liquid products from one part of the United States to another); therefore, drawing upon these tankers in a contingency (absent replacement tankers) could cause severe disruptions to the U.S. energy system and broader economy.

DoD could pursue several options to meet contingency tanker requirements. One option for DoD is to charter foreign-flagged tankers and their crews. However, this approach relies on a major assumption: DoD will be able to charter enough tankers in a future war, against a peer or near-peer adversary with significant market influence and coercive power, to satisfy U.S. military operational demand. There are several ways this assumption could fail. First, reliance on foreign-flagged tankers assumes there is sufficient spare capacity in the tanker market to accommodate a surge in demand. If a major conflict were to take place during a period

137 The VTA is an agreement that facilitates cooperation between tanker operators and the government (and grants shipowners anti-trust immunity for cooperating amongst themselves) if the government determines it necessary to requisition tankers in contingencies.

of high utilization and minimal spare capacity, DoD would likely face difficulty obtaining adequate capacity. For example, as shown in Figure 33, if a conflict requiring 86 Medium Range (MR) tankers were to have taken place in the period between 2003-2008 or 2014-2015, there may have been an insufficient number of tankers in the global market to satisfy DoD requirements.[138]

FIGURE 33: GLOBAL MEDIUM-RANGE TANKER SUPPLY/DEMAND POSITIONING, 2003–2018 (PROJECTED)

Data and graphic provided by George P. Los, Head of Tanker Research at the Charles R. Weber Company. Medium Range Tankers constitute 40,000–59,999 deadweight ton tankers. This is the class of tankers that most closely fit the definition for tankers with military utility in Joint Publication 4-01.2. They are sufficiently large to transport a considerable amount of product, while small enough to enter a large number of ports. It may be desirable to use some larger tankers for certain purposes.

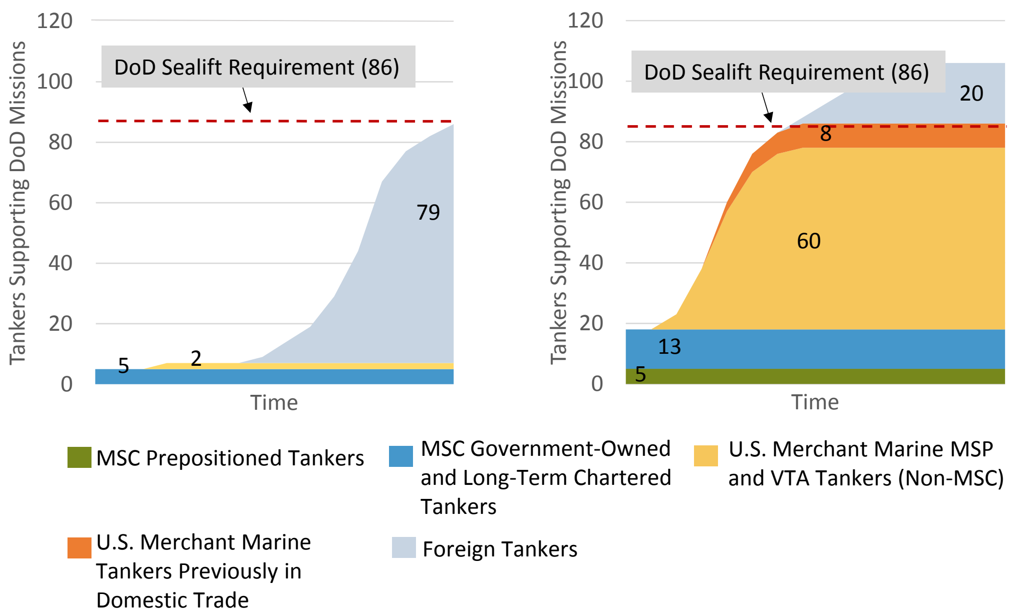
Second, assuming there is sufficient spare capacity in the tanker market, it may take weeks to months for inactive tankers or tankers engaged in international trade to be made ready to sail for DoD use, to arrive at refineries or storage points with military fuels, and to sail to points of operational demand. Third, the global tanker market itself is increasingly economically and politically contested. Chinese and Russian flagged or owned tankers comprise a growing portion of the international market, and China or Russia may seek to exert pressure on tanker operators during a major conflict not to cooperate with the United States or else face repercussions. Together, these concerns suggest that the potential pool of commercial foreign-flag tankers available during a conflict may be smaller than peacetime size may indicate—even if there is slack capacity in the market. Finally, during a conflict, foreign-flag commercial ships (such as tankers) may be reluctant to operate in a warzone, especially as Russian and Chinese counter-shipping capabilities would dwarf those of previous conflicts.

138 In these situations, DoD could attempt to reprioritize market demand by paying higher rates to charter tankers, but given the risks involved with transporting fuel in a conflict between great powers, and given growing Chinese economic leverage, many tanker operators may refrain from responding to the financial incentive. As a countervailing factor, during times of conflict, the commercial market may contract, leaving many shipowners with underutilized assets. These underutilized assets could be available for charter.

Therefore, for a variety of reasons, it is prudent for there to be a sizable core force of U.S.-flagged oceangoing tankers that DoD can reliably call upon during conflicts. An option available to DoD to meet wartime tanker requirements is to acquire a large U.S. Government-owned fleet of sealift tankers subordinate to MSC and manned by MSC mariners. This would cost DoD an additional approximately $8.59 billion to construct and $532 million per year to man and operate 76 more tankers necessary to meet the 86-tanker requirement.

An alternative approach—and this study's recommendation—is to develop a more cost-efficient National Fleet approach that leverages a mix of U.S. Government and commercial U.S. flag tankers. Under this approach, DoD should acquire or long-term charter enough tankers to meet immediate contingency demands and support a U.S.-flagged tanker Merchant Marine large enough to support surge and sustainment tanker requirements. Figure 34 illustrates how this approach would unfold during a conflict to provide a more assured and more rapidly-available tanker force.

FIGURE 34: CURRENT AND ALTERNATE APPROACHES TO SECURING DOD SEALIFT TANKER SUPPORT IN CONFLICT



A National Fleet approach to tanker sealift is challenged by the small size of the U.S. tanker fleet and U.S. mariner force. The U.S. tanker Merchant Marine has shrunk over the past decades due to a range of market and policy forces. To develop an effective National Fleet approach to tankers, the U.S. Government should cooperate to identify an optimal mix of incentives to support an appropriately-sized tanker force. In addition to acquiring or long-term chartering the requisite number of floating storage and peacetime delivery tankers, two classes of major initiatives should be pursued: increased financial incentives and additional cargo.

In terms of incentives, to grow the U.S. flag tanker fleet, Congress should reform the MSP (that provides through MARAD a stipend to partially offset the higher cost of operating a vessel as U.S.-flagged in exchange for contingency access to DoD) to create specialized categories and compensation levels for certain classes of ships (such as tankers and FLO/FLO ships), rather than the current, uniform approach.[139] Militarily-useful tankers would receive a tanker-appropriate stipend of between $7-10 million per year, participate in the VTA, be equipped with appropriate national defense features (to include CONSOL equipment), and crews would be trained for support to DoD during contingencies.[140] Given the ability of operators to quickly purchase or charter and reflag foreign vessels (in approximately 90 days), this could lead to an immediate growth in the size of the U.S.-flag tanker fleet.

Additionally, the Navy should exercise its authority to fund the construction or installation of appropriate National Defense Features (to include CONSOL equipment) on newly-built U.S.-built tankers (and if necessary, the requisite number of existing U.S.-built tankers). These features would include CONSOL receive stations and a secure radio room.[141]

Another source of financial incentives for U.S. tanker operators should be tax and policy reform that positively aligns the tax treatment of U.S. tanker operators with the tax treatment of most foreign tanker operators. Changes in mariner taxes, a continuation of the U.S. tonnage tax alternative to the corporate income tax, and personal injury and liability reforms are three areas where tax and policy changes could help make U.S. flag tankers more competitive in international trade.[142]

The second major initiative DoD should pursue to grow the size of the U.S. flagged tanker fleet is to increase U.S. preference cargo. First, DoD should increase the purchase of fuel from U.S. refineries, which would increase the security of the U.S. military operational fuel supply and to increase the size of the U.S. flagged tanker fleet. As an estimate using fuel volumes transported in FY 2017, if DLA Energy were to shift purchases of 100 percent of its currently tanker-delivered Outside the Continental United States fuel (6.9 million barrels) from foreign refineries to U.S. refineries and 25 percent of its currently pipeline-delivered Outside the Continental

139 "Maritime Security Program," MARAD, available at https://www.marad.dot.gov/ships-and-shipping/strategic-sealift/maritime-security-program-msp/. The MSP stipend was adopted as a more economical way of partially replacing the previous Operating Differential Subsidy Program (ODSP). ODSP was instituted in the Merchant Marine Act of 1936.

140 Similarly, reform of MSP should include allowing tanker operators to participate in MSP while carrying preference cargo. During periods in which they were chartered by the U.S. Government, the MSP stipend could be decremented by an appropriate amount.

141 Of note, ships would not be equipped with secure radio equipment in peacetime, but rather have an appropriately-constructed secure radio room and supporting connections for the installation of transmitting and receiving systems.

142 Most maritime nations (such as the United Kingdom) are granted a complete tax rebate on income earned on vessels in international trade. MARAD's 2017–2021 strategic plan identifies "income tax relief and liability insurance reform" as promising areas to reduce the operating cost differential between U.S. and foreign-flagged ships. DOT/MARAD, *Maritime Administration Strategic Plan: Navigating the Future, 2017–2021* (Washington, DC: DOT/MARAD, 2017), p. 15, available at https://www.maritime.dot.gov/sites/marad.dot.gov/files/docs/resources/3606/marad-strategic-plan-2017-2021-20170119-final-signed.pdf.

United States fuel (5.75 million barrels) from foreign refineries to U.S. refineries, this would likely generate an increase in the tanker lift requirement sufficient to support four and three tankers, respectively.[143] These seven new tankers would transport fuel for DLA Energy, in addition to the six currently engaged in those activities, for a total of thirteen.

Another measure to increase U.S. preference cargo is to mandate that as a condition to export crude oil applicants transport a gradually increasing portion of crude oil on U.S.-built and U.S.-flagged tankers.[144] This approach would increase the number of U.S.-flagged tankers engaged in the crude oil trade. During a conflict, these modern, double-hulled tankers could be cleaned in a matter of weeks if necessary and loaded with military fuels. Table 5 shows the impact of the gradual implementation of such a plan.

TABLE 5: POTENTIAL IMPACT OF ENERGY EXPORTS ON U.S.-BUILT AND U.S.-FLAG SHIPS ON TANKER AND MARINER NUMBERS[145]

Percent of Product to Travel on U.S.-Built and U.S.-Flagged Vessels		Date	Estimated Required Number of Tankers to Meet Requirement		Estimated Number of Additional U.S. Mariners Generated
LNG	Crude Oil		LNG Tankers	Crude Oil Tankers	
0%	1%	2023	0	3	150
2%	1%	2024	3	3	300
3%	4%	2026	4	12	800
5%	4%	2028	7	12	950
5%	8%	2029	7	24	1,550
7%	8%	2030	10	24	1,700
8%	10%	2032	12	31	2,150
10%	10%	2034	16	31	2,350
11%	10%	2036	18	31	2,450
13%	10%	2038	22	31	2,650
15%	10%	2040	25	31	2,800

143 While DLA should pursue these goals, it could partially waive these targets if necessary (in contingencies or if demand cannot be reasonably met by U.S. refineries). Data for analysis drawn from Defense Logistics Agency (DLA) Energy, "Fiscal Year 2017 Fact Book," DLA briefing slides, December 2017, slide 48, available at www.dla.mil/Portals/104/Documents/Energy/Publications/E_Fiscal2017FactBookLowRes2.pdf; and Military Sealift Command (MSC), *2017 in Review: Empowering Global Warfighting Capabilities* (Norfolk, VA: MSC, 2018), p. 50, available at https://www.msc.navy.mil/annualreport/2017/MSCAnnual17.pdf.

144 The Energizing American Shipbuilding Act of 2018, introduced into the House by Congressman John Garamendi and into the Senate by Senator Roger Wicker, proposes this approach for crude oil and liquefied natural gas exports. "Energizing American Shipbuilding Act," S.2916, 115th Congress, 2017–2018, available at www.congress.gov/bill/115th-congress/senate-bill/2916/text.

145 Table percentages, dates, and tanker numbers drawn from the "Energizing American Shipbuilding Act" bill. Mariner estimates assume an average of 25 crew members per tanker and that there are two mariners for every tanker billet, since commercial mariners typically work six months at sea and receive six months of shore leave.

Another benefit of this approach is that the Merchant Marine's base of U.S. Mariners with tanker qualifications would grow. DoD and MARAD have identified a shortfall of at least 1,929 U.S. Merchant Mariners to crew U.S. sealift ships over a protracted conflict.[146] This cargo preference initiative would play a major role in addressing the current shortfall in the number of U.S. Merchant Mariners. Lastly, this initiative would support the U.S. shipbuilding industrial base, improving the efficiency and competitiveness of U.S. yards to build not only tankers but also other ships of interest to DoD.

The combination of increased financial incentives and greater preference cargo can combine to economically increase the size of the U.S. flagged tanker fleet in the near term. Leveraging a mix of 18 MSC Government-Owned and long-term chartered tankers, 60 U.S. Merchant Marine MSP and VTA tankers, and eight U.S. Merchant Marine tankers in domestic trade, a National Fleet approach could meet the requirement at a total annual cost of $694 million—significantly less expensive than a government-acquired and operated force.[147] This would not only meet national security needs but also would foster the creation of a robust Merchant Marine with attendant economic benefits to the U.S. maritime and energy industries.[148] Another benefit of this approach is that it would be scalable to a potentially growing tanker requirement.

As a final measure, DoD should carefully track and assess the foreign-flagged tanker market. This effort would have two benefits. It would facilitate cooperation with friendly countries and the chartering of foreign tankers during conflict, especially to backfill U.S. tankers engaged in domestic commerce that may be activated. It would also assist in dissuading third-party operators from providing fuel to an adversary during conflict.

Fuel Distribution from Sea to Shore

The sealift tanker force is necessary not only to transport fuel at sea and between ports but to transfer it from sea to shore. In addition to normal offloading, DoD requires specialized capabilities to transfer bulk quantities of fuel from tankers to shore at locations where ports or moorings may have been damaged or where there is no bulk fuel terminal, such as in an amphibious landing or an airfield at an austere site.

To meet these requirements, DoD uses two sets of capabilities that use submerged and floating hoses to transfer fuel from amphibious ships, Maritime Prepositioning Ships (MPS), and tankers to shore storage systems. The first is the Offshore Petroleum Discharge System

146 Estimates drawn from "Table 3. Estimation of Demand for Mariners Under Surge Fleet FOS (Full Operating Status) Conditions for Initial Activation and Sustained Surge" in MWWG, *Maritime Workforce Working Group Report*, p. 24.

147 In contrast, an all-government acquired force could cost approximately $9.72 billion to construct and $682 million per year to man and operate. This assumes each tanker has an average capacity of 280,000 bbl, each costing $113 million to acquire and $15 million annually for each of ten active tankers and $7 million annually for each of 76 tankers in a Reduced Operating Status. To fully man these ships, the Government would need to draw upon the Merchant Mariner base, which already faces major shortfalls.

148 Depending on the amount of increased fuel from U.S. refineries, it may be necessary for U.S. refineries to increase their utilization rates or expand production (and possibly storage) capacity.

(OPDS). One OPDS is integrated on the ship USNS *VADM K.R. Wheeler* (T-AG 5001) and is designed to mate with tankers, while the other OPDS is integrated onto the RRF tanker SS *Petersburg* (T-AOT-9101).[149] The second, lower-throughput system is the Amphibious Bulk Liquid Transfer System (ABLTS), four of which are embarked on each of the two MPS Squadrons. Both systems either provide fuel directly to a bulk fuel tank (such as an expeditionary fuel storage facility) or provide it to an Inland Petroleum Distribution System (IPDS), which is a series of pipes that could transport it to a port, airfield, or other ground forces.

In a great power conflict, it is highly unlikely two OPDS (and eight complementary ABLTS) to provide fuel support at two or fewer locations would suffice to meet DoD requirements. If as previously, discussed DoD adopts more geographically distributed operating concepts, it is likely there would be a demand for ship-to-shore bulk fuel transfer capabilities across multiple theaters and within multiple locations in theaters. Further, given evidence that major adversaries may seek to specifically target U.S. logistics as a way of slowing U.S. military operational tempo, over-the-shore fuel logistics may provide a means to reconstitute operations at major bases whose fuel storage has been damaged or destroyed during adversary operations.

The Joint Force requires major improvements in ship-to-shore bulk fuel transfer capability and capacity. For capability in the near-to-midterm, the Navy should research and develop a ship-to-shore bulk fuel transfer system suitable for both shallow and deep water with faster emplacement and relocation times and higher transfer rates.[150] The Navy should also examine the utility of large dracones and barges to store fuel offshore and transfer it ashore.[151] Considering capacity, DoD should acquire a larger number of ship-to-shore and inland bulk fuel transfer systems to better align with the threat environment and corresponding operational concepts. Although this study does not provide a recommendation on what level of over-the-shore fuel distribution systems may be necessary to support current or future joint operations, the present capability to support operations at two (soon to be one with the retirement of the SS *Petersburg*) or fewer locations is likely inadequate, and this issue warrants further study.

Sealift of Dry Cargo and Munitions

The Joint Force requires the ability to transport large quantities of dry cargo and munitions in peace and war. The Mobility Capabilities and Requirements Study 2016 validated a DoD requirement of 19.9 million square feet of sealift capacity and 11 special capability ships in order to meet combat force projection mobility requirements at acceptable risk in DoD's most

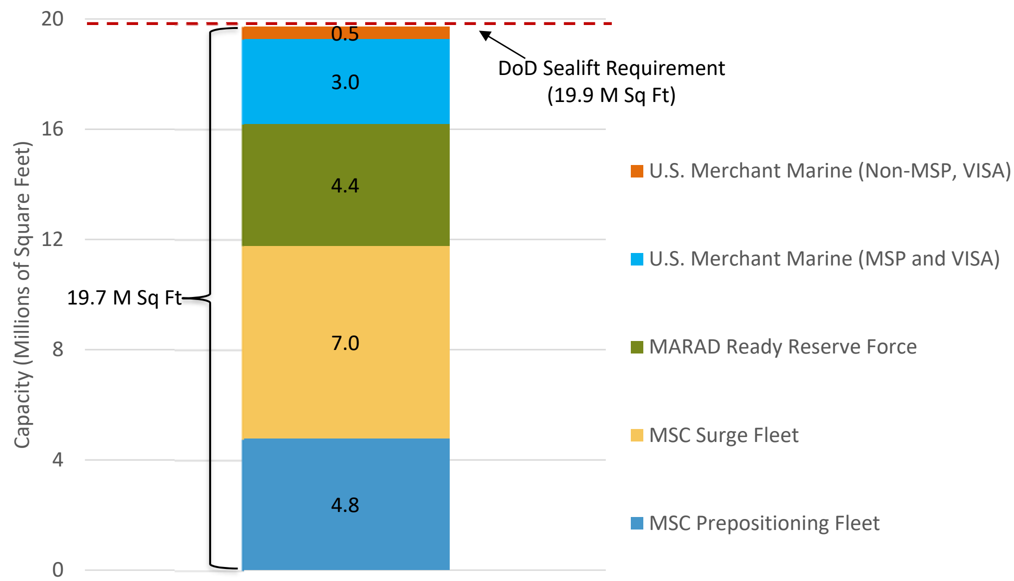
149 As of 2001, the Navy had five OPDS tankers: USNS *Henry J. Kaiser*, USNS *Mediterranean*, SS *Chesapeake*, USNS *Indian Ocean*, SS *Petersburg*, and USNS *Guam*. Kimberly A. Weaver, *The Inland Petroleum Distribution System: Can It Fuel the Force?* (Carlisle, PA: U.S. Army War College Strategy Research Project, April 10, 2001), p. 16, available at http://www.dtic.mil/dtic/tr/fulltext/u2/a391222.pdf.

150 Consulting the marine industry (in particular the offshore energy industry), the Navy should critically analyze the full range of technical capabilities to accomplish this CONOPS and, if necessary or advisable, change the CONOPS.

151 Dracones are large bladders that can be filled with fuel or other liquids and towed through the water.

demanding wartime scenario.[152] To meet this requirement, DoD plans on activating the entire force of government and commercial sealift. Specifically, DoD relies on the four elements of the sealift force: the MSC Prepositioning Fleet, the MSC Surge Force, the RRF, and the U.S. Merchant Marine (primarily through MSP).[153] As displayed in Figure 35, estimates of U.S. sealift capacity available to DoD in a contingency suggest it would fall short of reaching its required capacity of 19.9 million square feet.

FIGURE 35: ESTIMATED 2019 U.S. GOVERNMENT AND COMMERCIAL SEALIFT CAPACITY AVAILABLE TO DOD FOR CONTINGENCY



Data from commercial sealift figures in “MSP Brochure,” MARAD, July 1, 2017, available at www.marad.dot.gov/wp-content/uploads/pdf/MSP-Brochure-7-1-2017.pdf; and Appendix 7 on sealift in Office of the Chief of Naval Operations (CNO), *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for FY 2019* (Washington, DC: DoD, February 2018), pp. 22–23, available at www.secnav.navy.mil/fmc/fmb/Documents/19pres/LONGRANGE_SHIP_PLAN.pdf.

Unfortunately, the National Fleet faces grave challenges that will likely exacerbate current gaps and hinder DoD’s ability to meet sealift requirements. In particular, of the Government sealift fleet, even with service-life extension funding for 22 ships, all 11 special capability ships and 30 of 65 RO/RO vessels could age out within the next 15 years.[154] Additionally, as the Government fleet has aged, it has suffered lowering readiness rates, aggravated by obsolescent propulsion technology and lower levels of maintenance funding.[155] As a result of readiness issues, General Stephen Lyons, Commander of USTRANSCOM, testified in 2019 that the

152 Lyons, “Logistics and Sealift Forces,” p. 3; and MWWG, *Maritime Workforce Working Group Report*, p. 134.

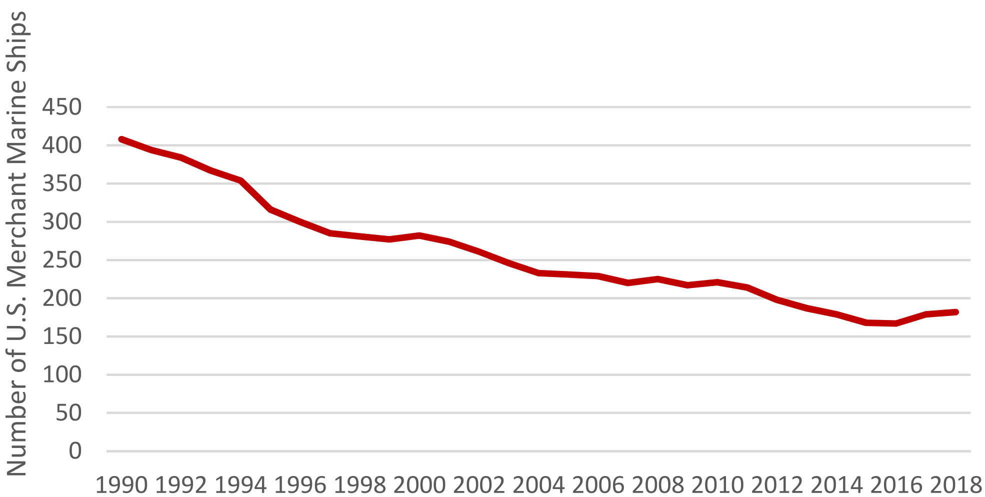
153 This force is described in further detail in Chapter 2 of this report.

154 McDew (2018).

155 Pendleton, *Navy Readiness*.

sealift fleet is able to generate only 65 percent of DoD's required capacity.[156] Lastly, the U.S. commercial fleet is either barely stable or continues to shrink (as portrayed in Figure 36), which endangers commercial sealift capacity available to DoD. As the size of the Merchant Marine has declined, there has been a commensurate reduction in the number of U.S. mariners available to work on both commercial and Government ships. In 2017, MARAD and DoD conducted a study that concluded the United States faces a deficit of at least 1,929 civilian mariners required to simultaneously operate the DoD and commercial fleets—assuming all qualified mariners voluntarily went to sea, assuming no augmentation of ships for wartime functions, and assuming there was no enemy attrition.[157] The frequently used motto, "People are our greatest asset" is exceptionally true in the case of the Merchant Marine's contributions to sealift. In summary, the United States is likely incapable of independently meeting its current sealift requirements. It likely lacks sufficient nominal U.S. Government and commercial capacity, and its gap is likely aggravated by low MSC Surge and RRF readiness rates and a dearth of mariners to operate the ships.

FIGURE 36: U.S.-FLAG PRIVATELY OWNED MERCHANT FLEET, 1991–2017



Includes self-propelled, cargo-carrying vessels of 10,000 gross tons and above. Data from MWWG, *Maritime Workforce Working Group Report*.

Absent decisive action in the near term to improve the force, DoD will face a major reduction in the number of forces that can be projected and sustained abroad in the 2020s. The U.S. risks losing its power projection competitive advantage. This section examines the sealift capacity requirement and provides a National Fleet approach to meet the requirement in an operationally effective and cost-efficient manner.

156 "TRANSCOM Commander: Sealift Fleet Urgently Needs Recapitalization," DoD, March 8, 2019, available at https://dod.defense.gov/News/Article/Article/1779895/transcom-commander-sealift-fleet-urgently-needs-recapitalization/.

157 MWWG, *Maritime Workforce Working Group Report*.

Determining Sealift Requirements

The 2018 National Defense Authorization Act directed a new Mobility Capabilities and Requirements Study, which should reflect requirements articulated in the new National Defense Strategy and address current and future levels of risk.[158] As part of this study, the DoD sealift requirement was reexamined. There are a variety of reasons why the new sealift requirement may change and will likely need to be greater than the previous requirement of 19.9 million square feet of capacity and 11 special capability ships.

First and foremost, changes in the planning scenarios informing the requirement may lead to a change in the requirement. For example, the sealift requirements in a Russia scenario would likely be different from the sealift requirements for a North Korea scenario. Similarly, different scenarios may levy changes in the requirements for special capability ships, such as Offshore Petroleum and Discharge Ships.

The second major factor affecting the development of the new sealift requirement is assumptions regarding the threat environment. In particular, the sealift force could suffer attrition, which was not factored in the previous sealift requirement.

FIGURE 37: GROWTH IN VEHICLE SIZE AND WEIGHT OVER TIME

Era	Vietnam		Desert Storm		Contemporary		Category Weight Growth (%)
Vehicle Class	System	Weight (lbs)	System	Weight (lbs)	System	Weight (lbs)	
General Purpose Mobility	M151 Jeep	3,000	M998 Humvee	7,650	JLTV	16,000	533
Main Battle Tanks	M60 Patton	101,400	M1 Abrams	120,000	M1A2	144,000	142
Trucks	M35 2.5 Ton	12,465	M35A2 2.5 Ton	12,880	LMTV 2.5 Ton	22,904	184

Images courtesy of Gavin Broad, U.S. Air Force, U.S. Navy, and Oshkosh Defense.

The third major factor affecting the development of the new sealift requirement is growth in DoD vehicle size and weight. Over the past decades, DoD vehicles have become significantly larger and heavier (as portrayed in Figure 37). This decreases the amount of cargo space available on ships and in turn decreases the level of military utility of many ships in the sealift fleet (especially commercial or converted commercial ships), as the militarily usable capacity of ships diverges from the nominal capacity.

158 McDew (2018), p. 5.

Finally, if DoD's assumptions regarding access to forward theater infrastructure change, it could have a major impact on the size and composition of its sealift force (both cargo-carrying ships and special capability ships). Since the late 1950s, DoD has sized and shaped its sealift force with the assumption of assured access to forward theater infrastructure.[159] If DoD determined that in scenarios of interest ports of embarkation or access to forward theater infrastructure could be contested, then it may drive changes in the size and composition of the sealift forces.

Overall, there are a number of factors that may significantly impact DoD's sealift capacity and composition requirements. This study does not provide a specific estimate of the new requirements for the sealift force, but assuming the continued use of campaign designs that require considerable sealift capacity, it will likely need to be larger and more access insensitive than the current force.[160]

Meeting Sealift Requirements

DoD should recapitalize its sealift force in partnership with MARAD. Without a swift recapitalization program, DoD risks a significantly degraded force projection and sustainment capability that will not only undercut U.S. warfighting potential but also decrease the effectiveness of U.S. conventional deterrence. The nation should pursue a viable National Fleet approach that swiftly leverages the best attributes of the Government and commercial fleets to meet its sealift requirement. Cognizant of competing priorities for resources, sealift recapitalization should be both operationally-effective and cost-efficient. This study proposes a three-part approach to meet requirements: service life extension of select Government ships, acquiring new ships (foreign and U.S. built), and improving the Merchant Marine (both ships and crews).

SLEP of Select Government Ships. The Navy should perform Service Life Extension Program (SLEP) modifications on a select number of aging sealift vessels for which investment would enhance readiness. SLEP has the advantage of being economical and partially supporting the U.S. industrial base by providing work for ship repair yards. It ultimately, though, is a short-term investment that defers necessary recapitalization. However, due to the fact that the Navy has delayed Sealift recapitalization until beyond 2018, SLEP is a necessary component of the recapitalization plan, since alternate plans would be highly difficult to achieve in terms of cost and schedule.

Acquiring New Ships (Foreign and U.S.-built). The central component of the sealift recapitalization strategy should be the acquisition of new ships to replace existing ones. Recapitalization of the 11 special capability ship force should be the highest priority since nearly the entire fleet will age out in the 2020s, but the rest of MSC Surge and RRF fleets will

159 Work, *Thinking About Seabasing*.

160 If DoD adopted new campaign designs or capabilities in the future that required less sealift capacity, then the sealift capacity requirement may decrease. The transition to such a force would likely take time.

also require recapitalization in the 2020s and 2030s. Overall, of the Government sealift fleet, even with SLEP of 22 ships, all 11 special capability ships and 30 of 65 RO/RO vessels could age out within the next 15 years.[161]

The nation will need to buy both foreign- and U.S.-built ships to recapitalize the sealift force. This is because the delay of sealift recapitalization by the Navy has compressed the sealift replacement schedule to a period within the mid-to-late 2020s and 2030s in which ships will likely age out faster than a new construction program could replace them.[162]

The United States has experience buying foreign-built ships to incorporate into its sealift fleet.[163] It was done in the 1980s; it was done in the 1990s; and it will need to be repeated in the 2020s. In the National Defense Authorization Act for FY 2019, Congress has recognized this situation and accordingly authorized the Navy (through MARAD) to procure up to seven foreign-constructed vessels after certifying the Navy has initiated an acquisition strategy for the construction of no fewer than ten new U.S.-built sealift vessels, with the lead ship anticipated to be delivered no later than 2026.[164] In order to achieve delivery by 2026, the Navy will need to move swiftly, since construction would need to start in 2023 and as of early 2019 no design has been agreed upon or funding allocated to the program.

This challenging situation provides an opportunity for a division of labor: appropriate foreign-constructed ships can be used to meet certain RO/RO Surge and Sustainment requirements, while unique U.S.-constructed ships can be used to meet specialty sealift ship, other sealift RO/RO, and novel auxiliary requirements.[165]

In procuring foreign-built ships, the Navy and MARAD generally face two classes of options: buy used, foreign-constructed ships on the open market or buy used foreign-constructed U.S.-flag ships. Both options provide the Navy and MARAD an opportunity to rapidly replace sealift capacity that is aging out and will involve the cost to acquire and the cost to modify (likely in a U.S. shipyard, which would support the U.S. ship repair industrial base).

161 McDew (2018).

162 Even with the SLEP of certain ships, the Navy may need to replace five to ten sealift ships per year within this period. This would be in addition to other Navy shipbuilding programs and the continuance by shipbuilders of commercial shipbuilding projects. While this replacement rate is within the current industrial capacity of the U.S. shipbuilding industry, it may be challenging to achieve. If an all-U.S. new construction program were desired, expansion of existing industrial capacity (at existing shipyards or by reactivating inactive shipyards) would make this approach more feasible.

163 There are 36 foreign-built hulls out of 61 hulls in the MARAD RRF and MSC Surge Force.

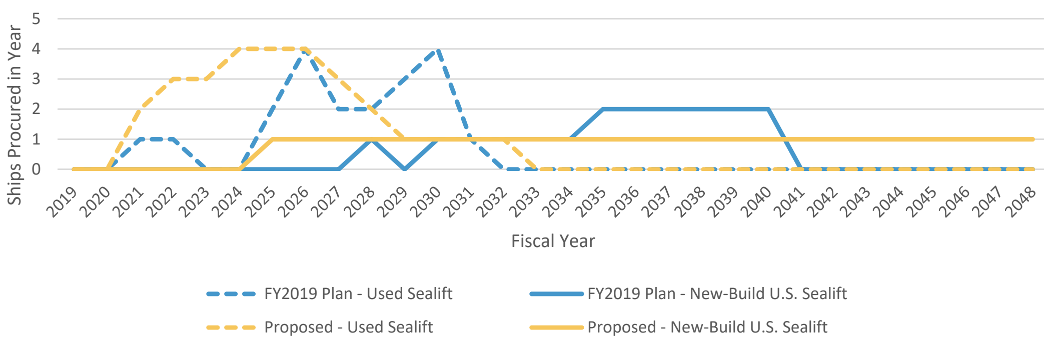
164 "Purchase of Vessels Using Funds in National Defense Sealift Fund," sec. 1012, in "John S. McCain National Defense Authorization Act for FY 2019" H.R. 5515, 115th Congress, 2017–2018, available at https://www.congress.gov/bill/115th-congress/house-bill/5515/text.

165 Of note, originally-commercial foreign-constructed ships in Maritime Prepositioning Squadrons (MPS) underwent extensive modifications to provide for not only RO/RO capacity, but also container cells and tanks needed to provide a proportional amount of the 30 days' worth of sustaining munitions, supplies, fuel, and water. In the early 1980s, these modifications cost approximately $150 million, the equivalent of $387 million in 2019. In general, significant modifications can match or exceed the cost of a hull.

New U.S.-built ships should be a critical component of DoD's sealift strategy. New U.S.-built ships offer a solution that will have a long-term effect (compared to alternative approaches of extending the lives of existing Government ships or acquiring used foreign ships of varying ages). New ship designs can be optimized to maximize military utility, for both sealift and specialty ship requirements. This makes new U.S.-built ships the best candidates for replacing existing MSC Surge ships (especially LMSR classes) and auxiliaries.

One approach to U.S. construction would involve the development and acquisition of a common, modular hull that would meet different sealift and specialty ship requirements.[166] As the Navy considers a potential Common Hull Auxiliary Multi-Mission Platform (CHAMP) acquisition approach, it should consider the relative costs and benefits of pursuing an all-CHAMP design, compared to one that used CHAMP for specialty ship and other auxiliary ship requirements and acquired a more conventional and economical LMSR-based design that could provide greater sealift capacity, at the expense of organic aviation and other capabilities.

FIGURE 38: POTENTIAL RO/RO RECAPITALIZATION ACQUISITION PROFILE



Assuming a recapitalization program of approximately 53 Government ships between FY 2019 and FY 2048, acquiring approximately 29 foreign-built sealift ships (with an assumed militarily useful capacity of 150,000 square feet per ship) and 24 U.S.-built sealift ships (with an assumed militarily useful capacity of 370,000 square feet per ship, roughly similar to the capacity of current LMSRs) would allow the Navy to rapidly acquire enough foreign-built ships to offset the projected drop in sealift capacity in the near-term. It would also provide U.S. shipyards with enough work to stably produce RO/ROs at a rate of one per year (thus avoiding shipbuilding "boom and bust" cycles), in addition to special missions sealift designs and other naval auxiliaries discussed elsewhere in this report. This profile is depicted in Figure 38 below. Acquisition costs could be reduced further if the Navy and USTRANSCOM find certain large foreign-built RO/ROs align well with their requirements, allowing a reduction

166 In addition to sealift and specialty ship (auxiliaries) missions, additional potential missions include sealift, aviation intermediate maintenance support, medical services, command and control, and submarine tending. "RFI and Industry Day—Common Hull Auxiliary Multi-mission Platform," *FedBizOps*, Solicitation Number N00024-18-R-2236, U.S. Navy, Naval Sea Systems Command, May 7, 2018.

in the acquisition number of foreign-built RO/ROs, if DoD is able to charter appropriately-modified U.S.-flagged commercial ships vice owning them, or if DoD identifies novel ways to cooperate with the Merchant Marine to generate additional capacity (as discussed in the next sub-section).

As an alternative, DOD should consider acquiring U.S.-built RO/ROs with a smaller capacity of approximately 185,000 square feet per ship, instead of larger 370,000 square feet per ship RO/ROs. These smaller RO/ROs would be capable of accessing a wider range of ports. Additionally, they would provide greater fleet resilience than larger RO/ROs, since attrition to the same number of individual ships would result in a smaller loss of transported equipment. The loss of a single 185,000 square foot RO/RO would result in the loss of approximately half of an Army brigade's equipment set, while the loss of a 370,000 square foot RO/RO would result in the loss of a nearly an entire Army brigade equipment set.[167] Lastly, a smaller class of RO/RO may align well with CHAMP hull requirements, thus maintaining fleet commonality. If 185,000 square foot RO/ROs were acquired, this study estimates a total of 73 ships (31 foreign-built and 42 U.S.-built) would be needed between FY 2019 and FY 2048.

Improving the U.S. Merchant Marine

The third major component of the sealift recapitalization strategy should be improving the U.S. Merchant Marine (in terms of both ships and crews). In addition to supporting the U.S. economy, the Merchant Marine plays a critical role providing sealift capacity. To develop an effective National Fleet approach to sealift recapitalization, DoD and MARAD should cooperate to identify an optimal mix of incentives to support an appropriately-sized force. Three classes of major initiatives should be pursued: continuation of financial incentives (in particular robust MSP and preference cargo commitments) and novel ways to cooperate, tax and policy reforms, and merchant marine labor reforms.

First, DoD and MARAD should continue and provide improved stability for financial incentives that lead U.S.-flag operators to retain or expand sealift capacity relevant to national security. In particular, the U.S. Government should: ensure MSP is fully funded at authorized levels, in cooperation with Congress and the Administration change the MSP law to increase the length and frequency of renewal of MSP contracts,[168] and informed by the results of the new sealift requirement, increase the number of MSP slots to an appropriate number that addresses potential gaps in sealift capacity. Additionally, the U.S. Government should

167 In the 1990s, during a period of uncontested U.S. power projection capability, the Navy decided to select LMSR RO/ROs of a large size and capacity. Given the contemporary possibility of attrition, smaller RO/RO designs may be better suited for the current operating environment.

168 For example, in terms of length, MSP's duration could be changed to 20 years, which would more closely match ship life. In terms of frequency, MSP could be authorized for ten years (e.g., FY 2019–2028). Then, in FY 2020, MSP would again be authorized for ten years (FY 2020–2029). This approach could also be implemented if MSP were extended for a longer period of time, such as 20 years. Overall, this approach would provide operators with greater stability and would decrease the risk that, as the end of the MSP period approaches, operators would defer investment into their U.S.-flag fleet.

maintain preference cargo levels and direct and enforce all departments and agencies to comply with cargo preference requirements.[169]

In addition to collaborating with the U.S.-flag internationally-trading fleet via MSP, MARAD and DoD should consider greater sealift collaboration with the U.S. fleet. For example, Dual Use Vessels, militarily useful U.S.-built ships operating in commercial trade, could be employed in peacetime by commercial operators to transport goods and in conflict to lift sealift assets. Under this approach, the Navy would construct militarily-useful RO/ROs, such as fast trailerships, and lease them to commercial operators for a nominal fee in exchange for assured contingency access.[170] This approach would generate significant cost savings for the government since it would be cooperating with industry to fund the operation of the ships. Additionally, this would have the environmental benefit of displacing more carbon-intensive high-weight road traffic on busy highways with shipping and would alleviate congestion on busy highways and rail lines near the U.S. coasts. Lastly, the Navy and MARAD would obtain a larger pool of merchant mariners than if the Navy built ships to place them in Reduced Operating Status with smaller caretaker crews in RRF. Adopting Dual Use Vessels could provide an opportunity to increase the number of U.S.-built ships economically.

FIGURE 39: ORCA-CLASS AS A POTENTIAL DUAL-USE VESSEL DESIGN

An Orca-class transports cars and other cargo between Washington state and Alaska. TOTE Maritime Alaska's Orca-class has approximately 360,000 square feet of deck capacity (approximately 300,000 square feet of which are high and heavy militarily useful decks) and can navigate at 24 kn. "TOTE Orca Class Trailership Fact Sheet," General Dynamics NASSCO, available at https://nassco.com/products/construction/commercial-construction/commercial-ship-portfolio/tote-orca-class-trailership-fact-sheet/. Image courtesy of Tote Services.

169 Government-impelled cargo, or preference cargo, is cargo moving "either as a direct result of federal government involvement; or, indirectly through financial sponsorship of a federal program; or, in connection with a guarantee provided by the federal government." This includes "100% of military cargo, 100% of Export-Import Bank cargo, at least 50% of Civilian Agency cargo, and at least 50% of agricultural cargoes." "Cargo Preference," MARAD, available at www.marad.dot.gov/ships-and-shipping/cargo-preference/. Preference cargos are critical since the current MSP stipend of $5 million per year "covers about 80 percent of the operating cost differential between U.S. and foreign-flag vessels," and the rest of the differential must be offset. Andrew Von Ah, *Maritime Security: DOT Needs to Expeditiously Finalize the Required National Maritime Strategy for Sustaining U.S.-Flag Fleet* (Washington, DC: GAO, August 2018), p. 17.

170 During contingency activations, these ships could be backfilled by ships on the open market or reflagged ships through the use of national security waivers. The use of trailerships would also mean that containers carried on these ships could be transported on roads and rail if necessary.

Another promising approach would be for MSC to charter commercially-owned and operated U.S.-flag ships to meet some surge sealift requirements. Commercial ships could be used for a set period of time (such as two to three years) and then cycled back into commercial operation. This approach could help the U.S. Government economically meet a portion of strategic sealift requirements and would align Government and contractor incentives to ensure surge capacity is kept at a high state of readiness and modernization.

Tax and policy reforms are the second class of major initiatives the U.S. Government should pursue to encourage a robust Merchant Marine. As discussed in the section on tanker sealift, tax and policy reform should positively align the tax treatment of U.S.-flag operators with the tax treatment of most foreign-flag operators. Changes in mariner taxes, a continuation of the U.S. tonnage tax alternative to the corporate income tax, and personal injury and liability reforms are three areas where tax and policy changes could help make U.S.-flag ships more competitive in international trade.

The third major initiative the U.S. Government should pursue to improve the Merchant Marine are merchant marine labor reforms. Properly resourced, MARAD should more aggressively promote U.S. maritime industry recruitment, maximize mariner retention, incentivize the retention of mariner certificates, and more accurately track the pool of qualified and recently-qualified mariners.

Overall, the Navy and MARAD should pursue creative, viable, and economical approaches to meet sealift requirements that draw from both the Government and commercial fleets.

Hardening of Maritime Logistics

Increasing the lethality, agility, and resilience of the fleet requires a comprehensive approach. The U.S. maritime logistics community is no exception. The logistics fleet should change in composition and operations to match changes in the broader battle fleet. This extends to logistics fleet survivability and logistics auxiliary interaction with other combatants. The harder it is for an adversary to disrupt the logistics fleet, the greater the resilience of the total fleet.

Adversaries have developed doctrine and capabilities to disrupt U.S. logistics forces as a way to reduce U.S. operational tempo and gain an operational advantage. CLF ships are currently soft targets with modest training for high-end warfare and few means with which to defend themselves. Other components of the maritime logistics force, such as other MSC ships and the Merchant Marine, are even more vulnerable. Given the importance of logistics forces to sustaining distributed or protracted operations and the high cost of many classes of logistics ships and the scarcity of U.S. merchant mariners, the Navy should develop new methods to protect its maritime logistics force.

Defense against modern anti-ship weapons is expensive. Extending the same level of protection afforded to high-end surface combatants to naval auxiliaries could be cost prohibitive. At the same time, some defensive investments may affordably enhance logistics survivability, particularly when multiple lines of effort complement each other. Specifically, this study recommends focussing on four lines of effort to harden maritime logistics: integration with electromagnetic maneuver warfare, convoy and escort concepts and naval augmentation, defensive systems, and recoverability.

Integration with Electromagnetic Maneuver Warfare

The Navy's Electromagnetic Maneuver Warfare (EMW) concept seeks to integrate and exploit the electromagnetic spectrum (EMS) for naval operations.[171] One important reason for improving the ability to operate in the EMS is to deny or degrade an enemy's ability to find and target naval forces. Maritime logistics operations should be better integrated with EMW counter-ISR and information operation (IO) activities to protect logistics by deceiving, denying, and degrading enemy battle networks.

First, logistics forces afloat will need to take practical actions to minimize their signatures to prevent inadvertently revealing their location or identity. These actions should not aim to make most logistics platforms "stealthy" but rather reduce the type and amount of emissions generated by platforms. Second, maritime logistics forces should be integrated with Navy C-ISR and IO efforts. To support these efforts, Navy logistics ships and their shore command and control organizations will need improved command, control, and communications (C3) tools. Third, the Navy should incorporate counter-ISR systems on select maritime logistics ships, such as the CLF, to complement other Navy efforts.

To conduct and support these efforts, permanent Navy Military Detachments should be embarked on CLF and select other MSC ships. In other cases, Navy Selected Reservists could provide this support during a contingency mobilization. Both permanent Military Detachments and Selected Reservist teams would bring knowledge and authorities on board the auxiliary to support its military functions, including operating C3 and Precision Navigation and Timing (PNT) systems, managing EMS emissions, using counter-ISR systems, and, if necessary, overseeing defensive armament.

Convoy and Escort Concepts and Naval Augmentation

A second line of effort to enhance hardening is the improvement of Navy convoy and escort concepts and naval augmentation. The Navy should continue to develop and exercise its concepts for the convoying and escort of MSC and non-MSC logistics forces. This includes defining requirements for escorted or convoy operations and developing or refining tactics, techniques, and procedures for escorting and convoying under different ISR and other threat regimes.

171 Coffman, "Advancing Electromagnetic Maneuver Warfare."

The Navy has traditionally resisted naval escort of its support forces since combatants escorting auxiliaries are not executing other missions.[172] In 2018, Maritime Administrator Mark Buzby stated: "The Navy has been candid enough with Military Sealift Command and me that they will probably not have enough ships to escort us. It's: 'You're on your own; go fast, stay quiet.'"[173]

Today, the relatively small CLF and Strategic Sealift force is not sized for high attrition rates. Accordingly, the Navy should both increase the size and composition of its logistics forces (to create an attrition reserve), as well as protect its valuable logistics forces with new escort concepts. Although escort duties may impose virtual attrition on the combatant force, an associated increase in logistics survivability likely improves overall operational effectiveness sufficiently to justify the deviation.[174] There are some indications that the Navy is beginning to evaluate future escort requirements as at least one means with which to deal with emerging counter-logistics challenges.[175]

Defensive Systems

Because of the growing number and sophistication of enemy sensors and intelligence networks, EMW operations will not be able to completely prevent attacks on logistics. To improve the resilience of its logistics architecture, the Navy should also add defensive systems to its key logistics platforms. Specifically, the Navy should adopt select defensive systems for the CLF and some other MSC logistics ships to complement the capabilities of escort ships. These systems would add a second layer of protection to escorts' defenses and against many classes of threats significantly improve logistics ship survivability.[176]

Passive defense systems may be promising for the defense of small logistics vessels. However, for large ships with unique signatures such as T-AO/Es, T-AKEs, and proposed T-AKER, T-AKM, and tenders, the Navy will likely need to predominantly rely on active defense systems, such as air and missile defenses (e.g., SeaRAM), torpedo defenses (e.g., Anti-Torpedo

172 Although the U.S. Navy and merchant marine did convoy and escort in the Battle of the Atlantic, escort requirements in the Pacific were not as geographically expansive, since the Imperial Japanese Navy (IJN) did not mount an extensive anti-shipping campaign. In contrast, China or Russia may decide to conduct anti-shipping operations.

173 David B. Larter, "'You're on Your Own': US Sealift Can't Count on Navy Escorts in the Next Big War," *Defense News*, October 10, 2018, available at www.defensenews.com/naval/2018/10/10/youre-on-your-own-us-sealift-cant-count-on-us-navy-escorts-in-the-next-big-war-forcing-changes/.

174 The IJN provides a historical lesson of a failure to size or protect the logistics force. Before the war, the IJN only acquired a small oiler and tanker fleet. During much of the war, the IJN did not escort its tankers, and a lack of secure communications for non-combatant tankers allowed U.S. naval intelligence to predict the fleet's maneuvers by tracking the advance movements of its fleet tankers and oilers. Subsequent tanker shortfalls severely limited the IJN fleet's operational freedom and greatly contributed to its demise in major actions, such as the Battle of Leyte Gulf.

175 The Navy's planned FFG(X) should be well-suited for escorting other ships, which could be a leading indicator of the Navy's growing embrace of the escorting mission.

176 In addition to the proposed self-defense capabilities of logistics ships, it is essential for logistics ships to be escorted, as escorts not only provide another layer of defense, but also provide the ability to proactively or reactively attack threat platforms.

Torpedo Defense System [ATTDS])[177], or new trainable launchers onto key ships. If the Navy installed both SeaRAM and ATTDS across all 29 CLF vessels, procurement and installation would cost approximately $46.6 million per ship and $1,351 million for the fleet. Although this is a large investment, it is a fraction of the cost of the assets protected. If during a conflict, these modifications and concepts saved two to three CLF vessels, the Navy's investment would have paid off. These active defense systems are not stand-alone solutions but should instead be implemented alongside other survivability enhancements and concepts previously mentioned. Lastly, the Navy should embark a naval detachment to operate the largely stand-alone defensive systems.[178]

FIGURE 40: SEARAM AND ANTI-TORPEDO DEFENSIVE SYSTEMS

SeaRAM defensive system (left); Anti-Torpedo Torpedo Defense System (right). Images courtesy of Windows713 and Applied Physics Laboratory.

Recoverability

As a final hardening line of effort, the Navy should improve ships' ability to recover from damage. As discussed in the sections on towing and salvage and expeditionary maintenance and repair, modern anti-ship weapons are deadly. Yet, with robust designs and training, ships can withstand significant damage.[179] However, many MSC and all commercial sealift ships are built to commercial standards that do not necessarily emphasize armoring and internal compartmentalization that aid in recoverability.[180] Even so, some commercial designs

177 Sam LaGrone, "Navy Develops Torpedo Killing Torpedo," *USNI News*, June 20, 2013, available at https://news.usni.org/2013/06/20/navy-develops-torpedo-killing-torpedo.

178 On some classes of ships the naval detachment may be permanently embarked, while on other classes it could be embarked during contingencies. This detachment would also support EMW operations. Civilian mariners would legally be capable of operating defensive systems; however, in order to maximize tactical proficiency with these systems, it may be advantageous to leave their operation to naval detachments. Of note, the United Kingdom's Royal Fleet Auxiliary developed a model where they trained their civilian government mariners to conduct tactical operations and operate the associated defensive equipment.

179 Gerry Roncolato, "Fitzgerald Proves Damage Control Is Exhausting," *Proceedings* 143, no. 7, July 2017, available at www.usni.org/magazines/proceedings/2017-07/fitzgerald-proves-damage-control-exhausting.

180 Ronald O'Rourke, *Navy Ship Acquisition: Options for Lower-Cost Ship Designs* (Washington, DC: Congressional Research Service, 2005).

have proven resilient due to industrial safety demands. Informed by the historical record and assessments of current and future threats, MSC and MARAD should continue and as necessary deepen a realistic damage control training program. It should also recognize the tradeoffs inherent in some commercial designs: in some cases, low survivability commercial designs may have great value due to their low cost and operational contribution.

Incorporating Logistics into Navy System Design

The most far-reaching improvements to afloat logistics may come from designing ships and other platforms to be more efficient, more resilient, and more logistically independent. This section consequently highlights three areas: modifications to current and future systems to improve efficiency and reduce costs, emerging technologies with major logistics impacts, and logistics requirements for future system design.

First, the Navy should pursue modifications to current naval ships and aircraft that improve efficiency and reduce sustainment costs for both financial and operational reasons. Given ship service lives measured in decades, even modest improvements in efficiency and lifecycle cost can have major savings over time. There are a variety of new technologies that merit examination on new and existing ships and aircraft to reduce logistics demands and lower lifecycle costs. Integrated electrical storage systems and hybrid electric drives are a set of promising technologies that can provide logistical and tactical advantages. For example, battery-powered electric drives on surface ships can allow ships to more precisely control their propeller output, thus improving ships' fuel efficiency and reducing their fuel consumption.[181] Additionally, battery-powered electric drives on surface ships can reduce the level of vibration caused by the power plant and cavitation caused by the propeller, especially when silently operating on battery power, which in turn reduces ships' acoustic signatures and generates a tactical advantage. Lastly, battery-powered electric drives can be easily integrated with a ship's electric and directed energy sensors and weapons (or their own energy storage systems), thus making it easier for the fleet to introduce new high-power radars, electronic warfare systems, railguns, lasers, and high-powered microwaves.

In terms of other technologies, the Navy should consider installing fins to increase propulsive efficiency on some ships; using epoxy coatings instead of paints on some ships and areas of ships to minimize support costs; incorporating lighter ship components when appropriate to decrease ship weight and improve fuel efficiency; and automating logistics status data

181 In 2016 the Navy announced it would begin outfitting DDG-51 Flight IIAs with a hybrid-electric drive (HED) to propel the ship at speeds under 13 kn, such as during ballistic missile defense or maritime security operations. This technology is expected to extend a DDG's time on station before refueling and save fuel costs. In March 2018, the Navy announced the HED would complete installation onto the USS *Truxtun* (DDG-103) but halted upgrades of further DDGs, given other priorities and a desire to see if the technology can be improved before more widely outfitting it to the fleet. David Larter, "US Navy Canceling Program to Turn Gas-guzzling Destroyers into Hybrids," *Defense News*, March 8, 2018, available at https://www.defensenews.com/naval/2018/03/08/the-us-navy-is-cancelling-a-program-to-turn-gas-guzzling-destroyers-into-hybrids/.

collection on ships to inform predictive logistics development. Overall, greater platform self-sufficiency and reduced demand result in a more agile force.

Second, DoD should pursue emerging technologies with major logistics impacts. DoD is currently developing a range of new technologies to improve its combat performance in great power conflict. Modernization of logistics systems should be on par with modernization in the combat arena, as both areas can generate tactical and operational advantage. Technologies to consider include novel propulsion technologies (such as the aforementioned integrated electrical storage and propulsion systems and compact nuclear fusion and fission reactors that could be used to power manned and unmanned warships and possibly aircraft) and lightweight and wide diameter semi-rigid hoses and new receptacles that would enable higher UNREP fuel transfer rates (thus decreasing the total time ships spend distributing fuel and in turn reducing their vulnerability). Many of these systems could significantly reduce sustainment demands. Overall, technologies with the potential for revolutionary impacts on logistics chains should be critically examined and pursued.

Third, major logistics demand reductions may be achieved by setting logistics-conscious requirements and performance parameters for future system designs. The Navy should implement a systematic approach that accounts for how proposed ships and aircraft will impact the current and projected logistics architecture. This should explicitly include quantification of potential requirements for additional logistics assets. Looking to the near future, the Navy's FFG(X) program, Large and Medium USV programs, Orca unmanned underwater vehicle program, and examination of light or medium aircraft carrier concepts all require careful logistics consideration, including how the technical parameters and concepts of operation for these capabilities may impact broader Navy fleet logistics.

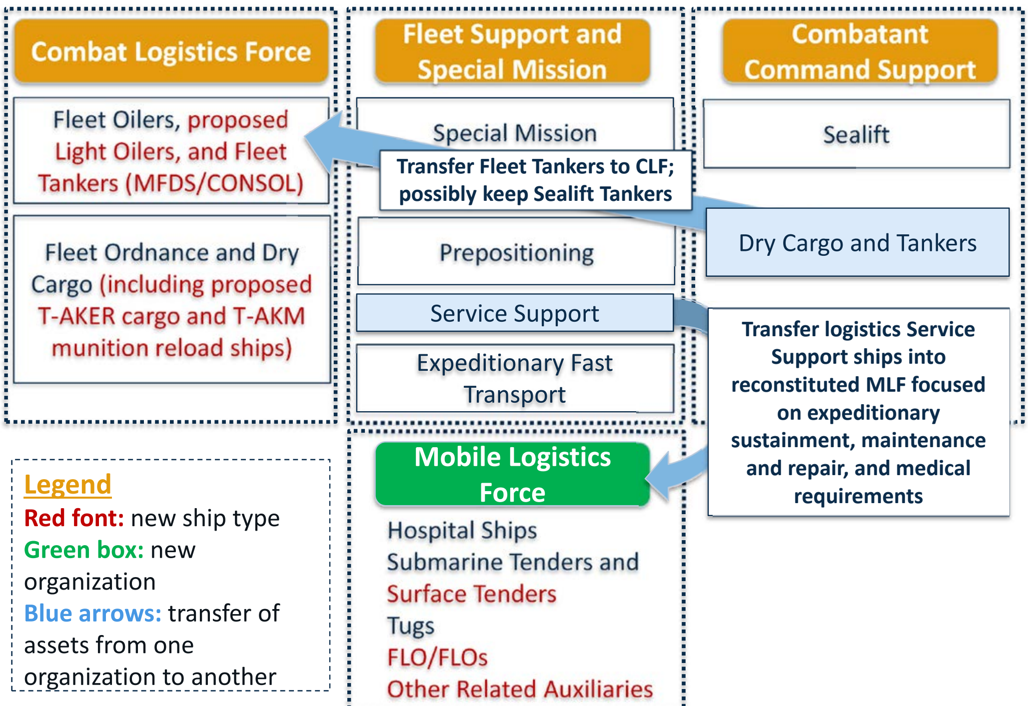
Overall, the Navy should carefully consider the impact of system design choices on logistics requirements. Over the past decade, lowering lifecycle costs has been an increasingly important element of ship and aircraft design. Moving forward, this emphasis on lifecycle cost reduction should be continued and complemented with a pursuit of logistics technologies and approaches that generate tactical and operational advantage.

Organizing for Sustainment Success

In addition to improving concepts and capabilities, improvements in the organization and coordination of the defense maritime logistics community should be pursued to address gaps in the current and future U.S. maritime logistics architecture. In general, the U.S. Government should focus on three lines of effort: improving coordination within the Government (especially between DoD and MARAD), improving coordination externally with the Merchant Marine and broader commercial sector, and enhancing cooperation with allies and partners.

Organizationally within DoD, MSC should restructure the grouping of assets in order to promote greater specialization and transparency. MSC's organizational structure should be reformed to reflect the more diverse force structure needed to meet requirements. MSC should begin by shifting management of tankers that would conduct at-sea fuel transfers in conflicts to the CLF. This proposed arrangement will help ensure a clearer distinction between Navy-supporting CONSOL/MFDS tankers and Joint Force-supporting sealift tankers and will discourage double-counting of assets (in which the tankers that are needed to support Navy ships afloat in contingencies are assumed to be simultaneously supporting Strategic Sealift requirements). T-AOLs and other refueling platforms that would support Navy at-sea requirements should be incorporated into the CLF. Similarly, the proposed T-AKER cargo and T-AKM munition reload ships discussed in this report should fall under the CLF. Additionally, MSC should consider reorganizing the Service Support force to place hospital ships, tenders, proposed FLO/FLOs, and other related auxiliaries in a new Mobile Logistics Force (MLF) focused on expeditionary sustainment, maintenance and repair, and medical requirements that would mimic the role played by Service Squadron 10. This reformed organizational structure is shown in Figure 41.

FIGURE 41: REORGANIZATION OF MSC ASSETS



Furthermore, the Navy and MARAD should carefully examine what organizational reforms are needed to engender innovation and training in the logistics enterprise. This includes an improved alignment of conceptual development with resource sponsorship and opportunities for cultivating, disseminating, and rewarding bottom-up approaches to logistics innovation.

Lastly, the Navy and MARAD must better organize to leverage its personnel. In addition to improving the health and size of the Merchant Mariner base, the Navy should carefully examine how to leverage its active and reserve pool better in contingencies. In particular, the Navy should examine designating a portion of Selected Reserve or Individual Ready Reserve sailors and officers to augment Strategic Sealift Officers as military detachments aboard commercial U.S.-flag vessels used in contingencies.

Externally, DoD should better organize its interactions with the Merchant Marine and broader commercial sector. In general, rather than assuming the U.S. or foreign commercial sectors will be willing and capable to provide assets and personnel during contingencies, DoD should carefully assess and track the markets and support the U.S. commercial logistics community. Just as DoD commanders intimately know their military order of battle, they should understand the capabilities and limitations of their supporting commercial order of battle. To support this, as an example, DoD should more closely incorporate cleared U.S.-flag ship operators and providers of key supplies in wargames and exercises. Additionally, DoD should establish contingency contracts with commercial providers that accelerate contingency activities in cyber exploited or degraded environments. DoD should also develop and implement capabilities to interact with the commercial sector in a more secure manner, which may include the proliferation of more opaque solicitations, as well as a separate non-Internet-based communications and command and control/management network for preferred, cleared contractors.

As a third line of effort, DoD should increase its logistics cooperation with allies and partners. DoD routinely operates in concert with many of its allies and partners in peacetime and has plans to execute operations in crises or conflicts. The Summary of the 2018 National Defense Strategy emphasizes “Resilient and Agile Logistics” with allies as one of eight capability modernization areas.[182] There are three areas rich for cooperation with allies and partners. First, DoD should deepen efforts to establish a shared understanding of potential threats and desired operating patterns through exchanges to more effectively identify opportunities for complementary and additive cooperation. Second, DoD should reform existing Acquisition and Cross-Servicing Agreements to expand their scope to more items, streamline approval processes (for peacetime and conflict usage), and securely introduce greater transparency into the availability of parts and consumables. Similarly, Foreign Military Sales procedure reforms are needed to expedite the purchase of items (especially key parts and consumables needed to maintain system availability rates at high levels). These reforms could include standing Indefinite Delivery, Indefinite Quantity-type contracts that allow key FMS partners to more rapidly order and receive approved items. The third area for cooperation is improved mutual access to logistics infrastructure in the United States and in other countries. These efforts would aim to increase the number of logistics support locations and increase the resilience of existing U.S. and Allied or partner operations.[183]

182 DoD, *Summary of the 2018 National Defense Strategy*, p. 7.

183 *A Design for Maritime Superiority* calls on the Navy to build on existing logistics partnerships with allied nations and expand relationships with partner nations. Richardson, *A Design for Maintaining Maritime Superiority*, p. 15.

CHAPTER 7

Building the Future Fleet

This chapter discusses how the recommendations contained in this study may be implemented alongside the Navy's FY 2019 30-Year Shipbuilding Plan and in light of the Navy's FY 2020 30-Year Shipbuilding Plan. It examines how the Navy might attempt to meet this study's proposed logistics requirements by either FY 2033 in one implementation scenario or FY 2048 in another. Implementation scenarios are described and costed in FY 2019 dollars.[184]

This chapter examines not only the Battle Force Fleet, which includes MSC's CLF ships and several other classes of auxiliaries but also examines sealift procurement, MSC charters, and MSP expansion. Without these communities, a full accounting of the National Fleet's maritime logistics architecture cannot be made.

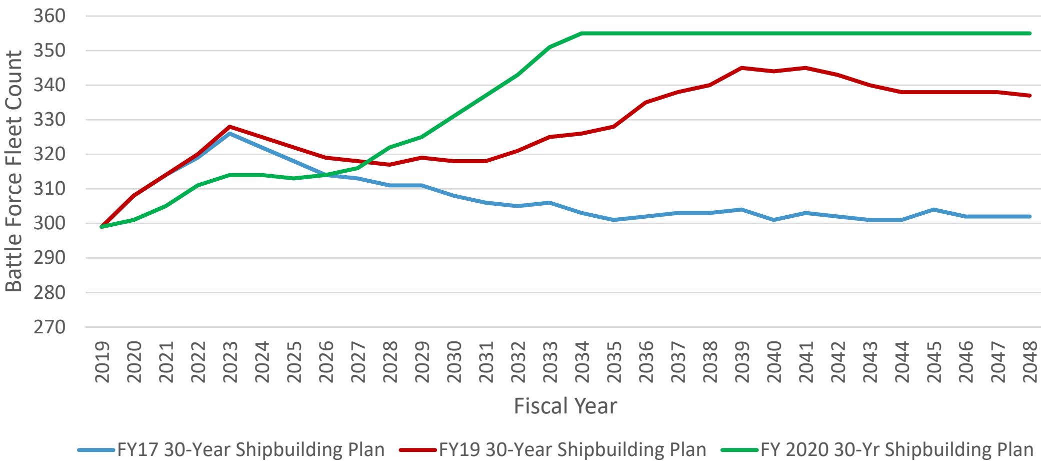
The FY 2019 and FY 2020 Shipbuilding Plans & the Maritime Logistics Baseline

The Navy's 2016 Force Structure Assessment, the first since 2012, revised the Navy's Battle Force Fleet requirement upwards from 308 to 355 ships.[185] These changes have been reflected in subsequent shipbuilding projections. Compared to the force of the FY 2017 30-Year Shipbuilding Plan, which was aligned with the 308-ship requirement, the FY 2019 30-Year Shipbuilding Plan, which is aligned more closely with the 355-ship requirement, reflects revisions to Navy shipbuilding plans as it works towards a larger force. The FY 2019 plan (shown in Figure 42) constitutes an average 19 percent increase in per-year ship procurement and a nearly $150 billion cumulative difference in procurement spending by FY 2046, compared to the FY 2017 plan.

184 Additional explanation of the costing methodology can be found in Appendix C on Cost Methodology.

185 "2016 Fleet Force Structure Assessment Executive Summary," U.S. Navy, December 15, 2016, available via Politico at http://static.politico.com/b9/99/0ad9f79847bf8e8f6549c445f980/2016-navy-force-structure-assessment-fsa-executive-summary.pdf.

FIGURE 42: RELATIVE CHANGE IN BATTLE FORCE PROJECTION, FY17, FY19, AND FY20



The Navy's FY 2019 30-Year Shipbuilding Plan (and other shipbuilding plans over the past few decades) resourced fleet logistics well below historical levels. The current period of great power competition is more analogous to the late Cold War period, when the Navy planned for war against the Soviet Union, than the last two and a half decades of conflict in (from a maritime perspective) permissive environments and presumed U.S. geopolitical dominance. Between 1962 and 1988, the CLF alone received an average of four percent of the shipbuilding budget.[186] In the FY 2017 plan, across years FY 2019-FY 2046, CLF accounted for 2.07 percent of anticipated total procurement. This proportion fell in the FY 2019 plan to 1.78 percent over the same period, or 1.95 percent across the entire 30-year period. This falls far short of the historic 'great power competition' era level of CLF expenditure.[187]

The historic four percent figure was for CLF alone, not accounting for the larger fleet of tenders, expeditionary repair, and other logistics auxiliaries in the Navy at that time. Even broadening the Navy's shipbuilding plans to account for all logistics procurement still fails to meet that relative 4 percent marker. Funding for CLF, the T-ATS towing and salvage replacement program, a future submarine tender, T-EPF expeditionary fast transports, and the remaining T-ESB expeditionary mobile bases accounted for 2.86 percent of total planned procurement in FY 2019-FY 2046 years of the FY 2017 Shipbuilding Plan. Total logistics auxiliary funding fell in the FY 2019 Shipbuilding Plan to 2.56 percent over the same period, or 2.67 percent across the entire 30-year plan. In absolute terms, the FY 2019 shipbuilding plan

186 James Blum, *Issues and Options for the Navy's Combat Logistics Force* (Washington, DC: Congressional Budget Office, 1988), p. xiii, available at www.dtic.mil/dtic/tr/fulltext/u2/a530785.pdf.

187 Using relative spending as an argument that the Navy is likely spending too little on logistics can be met with counterarguments that a) combatant complexity has increased far more than auxiliary complexity, driving increased relative cost, b) the adoption of commercial standards and derivative designs where possible has reduced CLF costs, or c) a combination of both trends. The "right" level of relative spending on CLF and other maritime logistics forces in the modern era may consequently be different than in the past. What this exercise demonstrates, however, is that the Navy's relative effort spent on logistics is less than 50 percent what it was the last time it faced a peer competitor.

spends $147 billion more than the FY 2017 plan over the overlapping period. Of this additional amount, only $4.3 billion is spent on logistics ships.

The Navy's FY 2020 30-Year Shipbuilding Plan continues this downward trend. In spite of growth to a 355-ship Battle Force inventory, the FY 2020 shipbuilding plan decreases the proportion of CLF and Command and Support ships from 21 percent at the end of the FY 2019 plan to 19.7 percent at the end of the FY 2020 plan. In general, the plan keeps the same number of logistics ships as the FY 2019 plan, while significantly increasing the number of other ships, thus exacerbating projected logistics gaps.

In summary, although the Navy faces more sophisticated adversaries that can specifically target fleet logistics and other joint logistics support. This reality is not accounted for in current inventory planning. In the face of these threats, the Navy seeks to operate in a more distributed fashion and enhance fleet resiliency. Yet in terms of budgeting, the Navy's relative effort on the logistics to support this shift has declined.

Requirements for a Fully-Supported Maritime Logistics Force

TABLE 6: LOGISTICS AUXILIARY REQUIREMENT RECOMMENDATIONS

	FY 2019		FY2033		FY2048	
Ship Type	**Navy, Current**	**CSBA, Proposed**	**Navy, Projected**	**CSBA, Proposed**	**Navy, Projected**	**CSBA, Proposed**
Fuel						
Fast Combat Support Ship (T-AOE)	2	2	2	2 + TBD	0	TBD
Replenishment Oiler (T-AO)	15	19	18	22	20	24
Light Oiler (T-AOL)***		12		20		23
CONSOL Tanker (T-AOT)**	4	19	4	20	4	22
Cargo and Munitions						
Dry Stores Ship (T-AKE)	12	12	12	13	12	15
CONSOL Cargo Ship (T-AKER)***		4		4		4
Missile Rearmament Ship (T-AKM)***		5		5		6
Towing and Salvage						
Salvage/Fleet Tug (T-ATS)	5	8	8	16	8	17
Float-On/Float-Off Heavy Lift Ship**		8		8		8
Maintenance and Repairs						
Submarine Tender (AS)*	2	5	2	5	2	5
Surface Combatant Tender (AD)*		4		4		4
Unmanned System Tender				5		8
CSAR and Medical						
Hospital Ship (T-AH)*	2	2	TBD	2	TBD	2
Expeditionary Medical Ship (T-AHL)		5		5		5
Navy Battleforce Fleet****	299	315	325	347	337	364

* Potential candidate for the Common Hull Auxiliary Multi-Purpose (CHAMP) vessel.

** Portions of this fleet may be applicable for long-term charter or a variant of the Maritime Security Program. Current CONSOL tankers are MSC longer-term charters and not counted in the Navy Battleforce.

*** Portions of this fleet may be applicable for placement into the Ready Reserve Force.

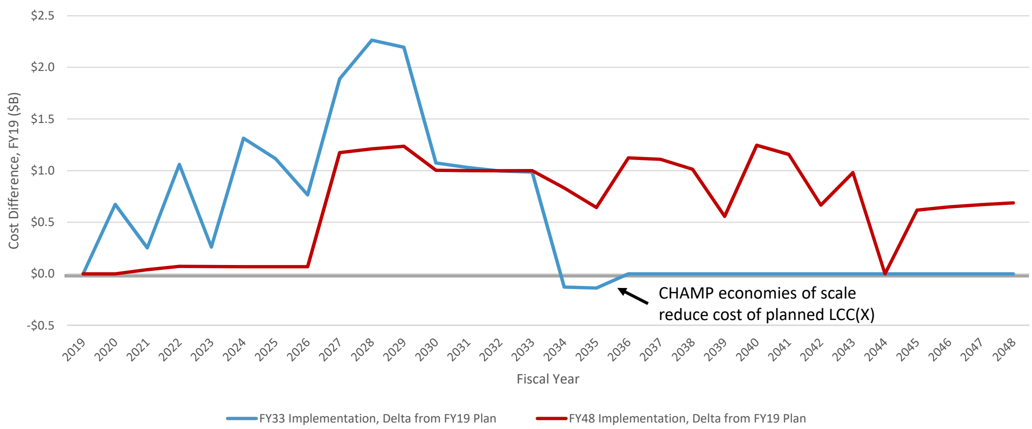
**** Current Navy Battleforce counting rules omit many types of auxiliaries. The CSBA, Proposed Battleforce count projections have added to the Navy, Projected Battleforce count any additional buys for planned Navy programs (T-AO 205, AS(X)), along with Surface Combatant Tenders, Unmanned System Tenders, and Light Hospital Ships. T-AOTs, T-AKERs, T-AKMs, and T-AOLs are, for all intents and purposes, part of the CLF in the view of this study, but partial placement into the RRF, in MSP, or on MSC long-term charter complicates their counting as part of the Battleforce.

To more fully support the Navy's proposed Battle Force Fleet described in the Navy's FY 2019 30-Year Shipbuilding Plan, this study recommends the following logistics force, displayed in Table 6. Requirements are based on demands identified in Chapter 6.

Implementation Scenarios

This study developed two logistics shipbuilding scenarios that build off the Navy's FY 2019 30-Year Shipbuilding Plan. The first emphasizes correcting the Navy's existing logistics deficit and achieves most recommended auxiliary counts by FY 2033. The second largely delays logistics vessel construction until after the coming shipbuilding procurement bow wave, beginning in the late 2020s and ending in FY 2036, to meet requirements by FY 2048. Figure 43 below compares the cost of both plans. Furthermore, two other sections assess costs for this study's recommended strategic sealift force and for this study's expansion of the MSP and long-term charters.

FIGURE 43: ADDITIONAL COST OF FY33 AND FY48 IMPLEMENTATION SCENARIOS COMPARED TO FY19 30-YEAR SHIPBUILDING PLAN



Shipbuilding: Implementation by FY 2033

This scenario achieves most recommended Navy logistics requirements by FY 2033. It does so at an estimated cost of less than $16 billion over FY 2020 to FY 2035, or for little more than 2.1 percent additional cost beyond the Navy's current FY 2019 30-Year Shipbuilding Plan. It adds 68 ships to the Navy's fleet (as shown in Figure 44), although most would be operated by MSC and a portion would be placed in the RRF. The plan's above-baseline costs peak in years FY 2028-FY 2029 at above $2 billion per year, before falling just ahead of the Navy's planned procurement peak between FY 2030 and FY 2036. To meet requirements, it uses a mix of acquisition, MSC long-term charters, MSP stipends, and support to the domestic fleet. The fleet's composition is shown in Figure 45.

FIGURE 44: FY33 IMPLEMENTATION, NEW ACQUISITION ALONGSIDE BATTLE FORCE FLEET

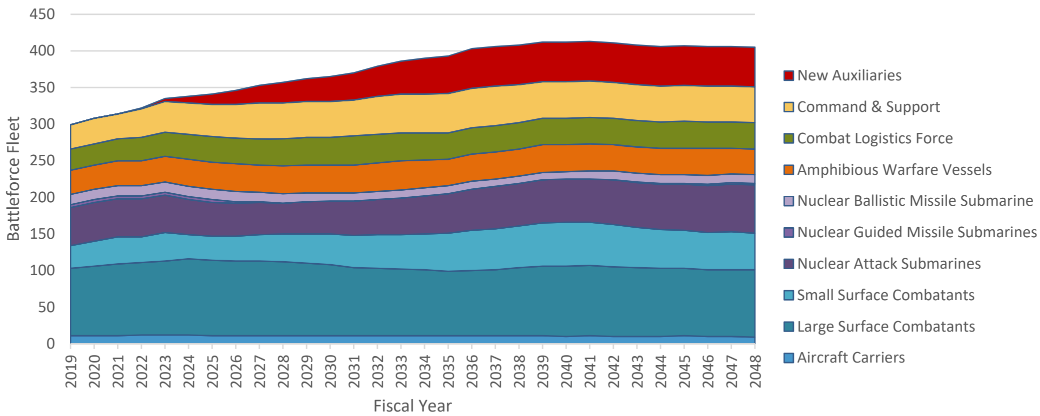
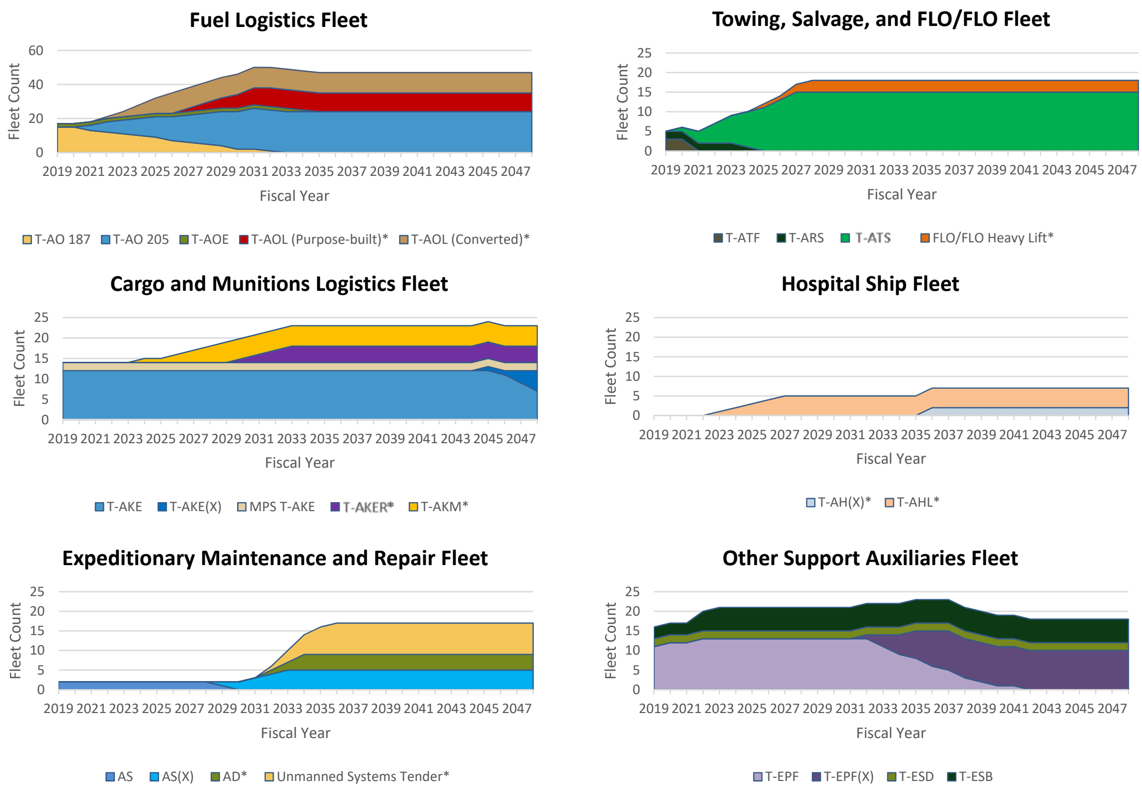


FIGURE 45: FY33 IMPLEMENTATION, LOGISTICS FLEET COMPOSITION



Shipbuilding: Implementation by FY 2048

Compared to the preceding scenario, this approach achieves this study's logistics recommendations more gradually, targeting implementation by FY 2048 and the end of the Navy's FY 2019 30-Year Shipbuilding Plan. This is depicted in Figure 46. Due to both slower build rates and the greater impact of outyear ship cost inflation, this approach costs $20.4 billion in aggregate or roughly 2.7 percent beyond the Navy's current shipbuilding plan. It provides all of the same ships as called for in the above scenario, with the exception of dropping the two T-AH replacements in favor of the disaggregated approach. This approach keeps additional logistics costs low until FY 2026 and then continues more evenly through the completion of the 30-year plan. The plan never exceeds more than $1.3 billion in additional funds beyond the baseline in any given year.

FIGURE 46: FY48 IMPLEMENTATION, NEW ACQUISITION ALONGSIDE BATTLE FORCE FLEET

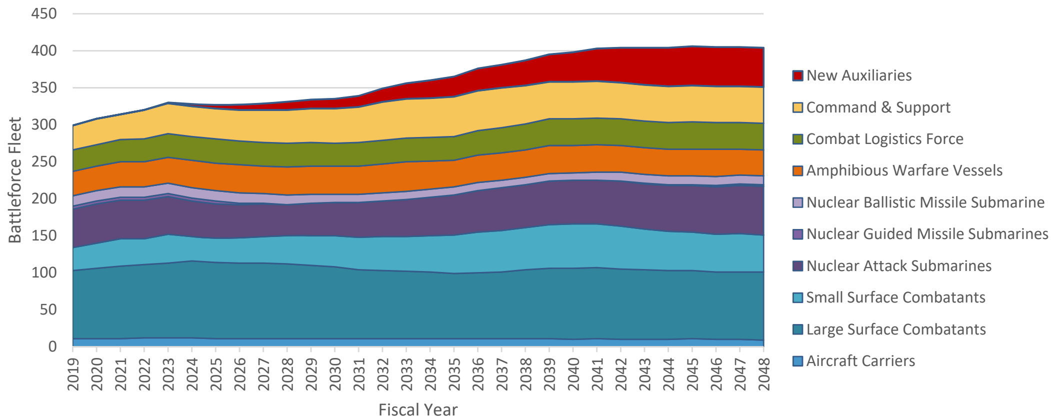
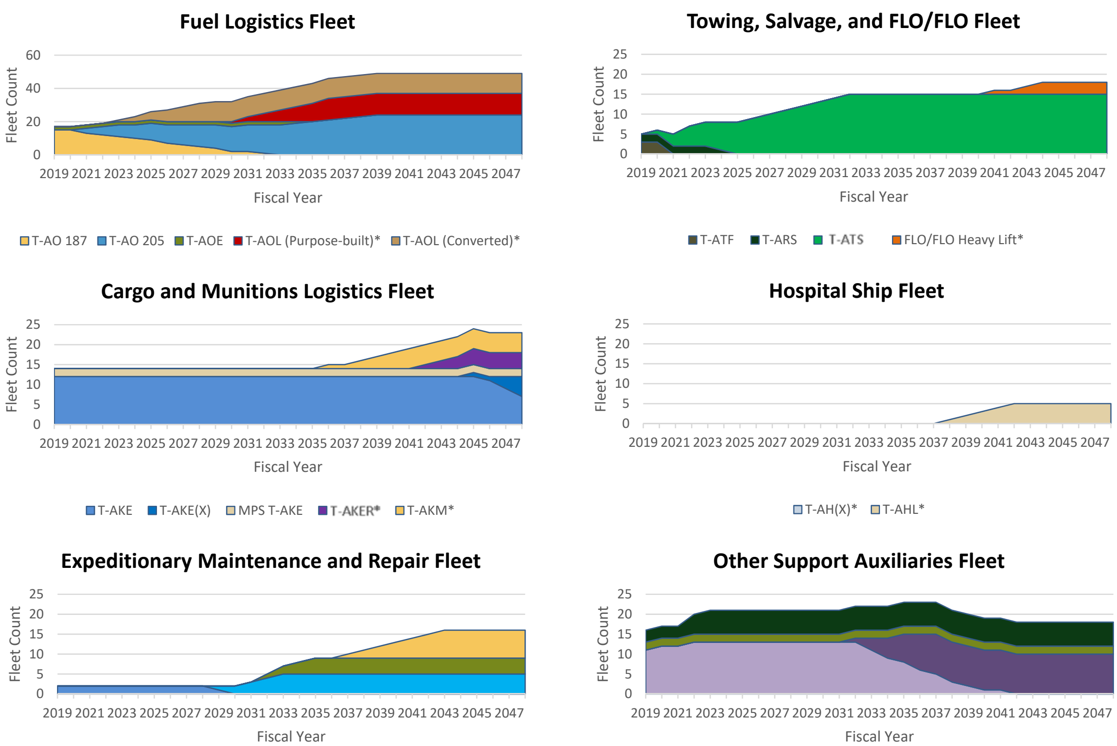


FIGURE 47: FY48 IMPLEMENTATION, LOGISTICS FLEET COMPOSITION



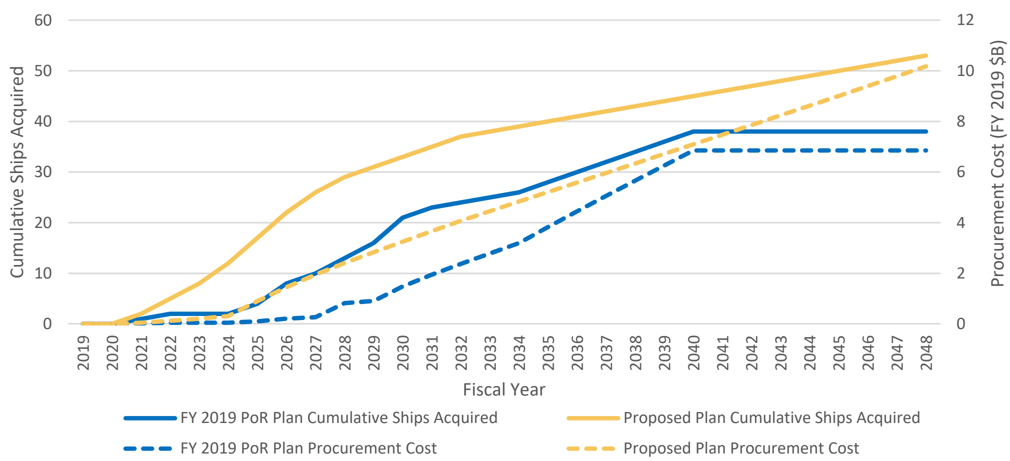
This approach spreads acquisitions out over a longer period. In general, apart from refueling assets, this scenario delays T-AKER CONSOL cargo ship, T-AKM missile rearmament ship, and FLO/FLO heavy lift ship procurement until the mid- to late-2030s, after the procurement peak under the FY 2019 30-Year Shipbuilding Plan. The composition of the fleet is depicted in Figure 47.

Sealift

The Navy's FY 2019 30-Year Shipbuilding Plan included planned procurement of sealift ships under the Auxiliary Vessel Plan appendix. Procurement funding for sealift recapitalization is separate from other Navy Shipbuilding and Conversion procurement funding, and these vessels are not included in the Navy's Battle Force Fleet. The Navy's FY 2019 Plan called for 18 new, U.S.-built RO/RO sealift vessels by 2040, along with 20 used vessels procured off the open market. Used vessels will be procured in the near-term, along with SLEP for select ships, to cover capacity until the new ships are delivered.

The proposed scenario shown in Figure 48 was driven by three major considerations, elaborated upon in Chapter 6. First, the existing sealift fleet is rapidly approaching the end of its useful life. Aggressive replacement will buy down risk below what is currently planned. Second, used foreign-built RO/ROs will allow the sealift fleet to gain the requisite capacity to offset the aging out of ships in the short to medium term. Third, a stable U.S.-built RO/RO line could help to avoid some challenges associated with recurring sealift recapitalization surges in the future.

FIGURE 48: FY19 SEALIFT SHIPS ACQUIRED AND PROCUREMENT COSTS



Includes program of record and proposed plans.

For these reasons, and to help increase the size of the sealift fleet to deal with current and future challenges, the proposed sealift procurement plan acquires 29 used and 24 new, U.S.-built sealift ships over the next 30 years. Used foreign vessels are acquired at a faster pace over nearly the same timespan as in the Navy's proposed plan. The first RO/RO is procured in FY 2025, as opposed to FY 2028 in the Navy's submitted plan, and production continues at one-ship per year through the end of the 30-year plan (until FY 2048), instead of concluding in FY 2040. This proposed scenario has a combined cost of $10.1 billion, or $3.3 billion beyond the existing sealift plan. This additional cost procures 15 additional ships and more than 3.5 million additional square feet of militarily useful cargo space; it reduces the average sealift fleet age at a faster pace and maintains an active shipbuilding line for military sealift to help avoid a similar sealift recapitalization crisis in the 2040s.

As an alternative, DoD should consider acquiring U.S.-built RO/ROs with a smaller capacity of approximately 185,000 square feet per ship, instead of larger 370,000 square feet per ship RO/ROs, since they provide greater fleet resilience in the face of potential attrition and greater access to port locations. If 185,000 square foot RO/ROs were acquired, this study estimates a total of 73 ships (31 foreign-built and 42 U.S.-built) would be needed between FY 2019 and FY 2048.

Maritime Security Program and Other Non-Shipbuilding Support

Beyond Navy shipbuilding and sealift, the U.S. Merchant Marine fleet and mariner base require substantial investment if they are to remain capable of supporting DoD's wartime needs. Previous chapters have identified a growing need for CONSOL tankers to support Navy operations, tankers to support strategic sealift, FLO/FLO and towing and salvage vessels for contingency operations, and an expanded merchant mariner base to provide enough sailors to activate the RRF and support protracted maritime logistics operations. Sustaining this fleet in peacetime is not without cost.

The proposed expanded fleet assumes that MSC's existing charters continue and that MSC charters an additional five tankers for prepositioned fuel stores afloat, which would be released for further use in a conflict after unloading their initial stocks.[188] It also assumes that changes in DLA contracting for DoD fuel could support an additional seven U.S.-flagged tankers, for a total of 13 tankers supporting joint fuel demand via DLA. Each of these chartered vessels is assumed to cost MSC approximately $15 million per year. If all these vessels were chartered, MSC's annual charter expense would more than double from roughly $150 million to around $340 million.[189]

This analysis did not dramatically alter the composition of the RRF. Given that the RRF requires increasingly scarce mariners to remain viable, the proposed implementation scenario stressed long-term MSC charter and MSP vessels over vessel procurement and placement into the RRF. The exceptions to this rule were T-AOLs, T-AKERs, T-AKMs, and T-ATS purchased

188 Existing charters include prepositioned container ships for Army and Air Force needs, one dry cargo ship, four CONSOL-equipped tankers, and two other tankers providing fuel shipment support to DLA.

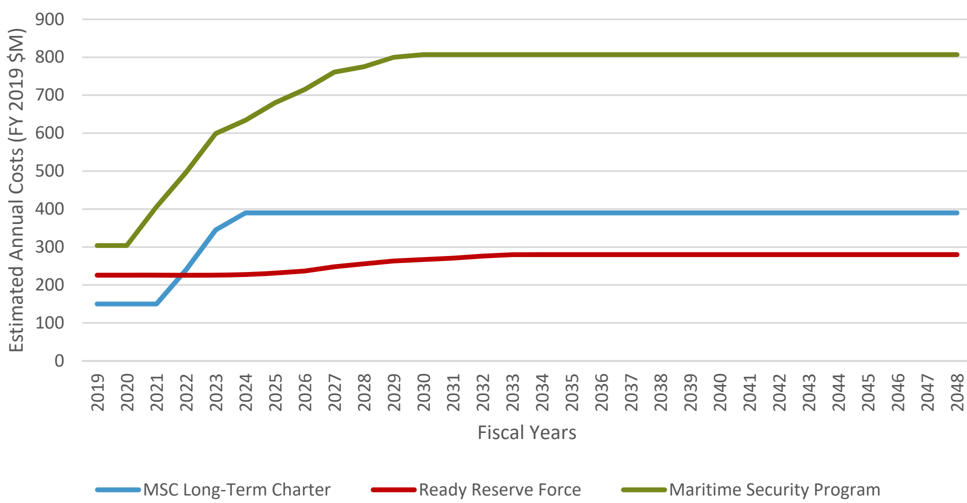
189 Costs associated with the USNS *Lawrence H. Gianella*, MSC's sole tanker owned outright for polar resupply, are not included in these figures.

and/or modified by the Navy in excess of peacetime requirements. These vessels had military-specific features that may make them unsuitable or more uncompetitive for commercial operation. In all, this scenario assumes up to 12 modified T-AOLs, two T-AKERs, three T-AKMs, and seven T-ATS may be candidates for placement into the RRF. Although the cost of maintaining these additional vessels may add up over a 30-year span, the relative difference between status quo and this revised fleet is modest compared to other fleet adjustments.

MSP, run by MARAD, would need to grow. If expanded to meet the requirements suggested by this study, MSP may need to more than double from its current 60 billets to 139. This larger figure accounts for all present-day MSP members, five new FLO/FLO members, 21 CONSOL tankers to support Navy CLF operations, and 53 additional U.S.-flagged tankers engaging in international trade to help meet USTRANSCOM's Joint sealift tanker requirements without undue reliance on foreign-flagged ships.

Using the existing MSP ships and those added above, a cost estimate was projected for the next 30 years. This plan would increase MSP's annual cost from roughly $300 million at present to more than $800 million per year beginning in 2030 when fully realized (as shown in Figure 49).[190] This annual investment would help revitalize the U.S. Merchant Marine, increase demand for the Merchant Mariner base, increase planning stability for U.S. ship operators, support the U.S. shipbuilding and ship repair industry, increase U.S. military maritime logistics resiliency, and also provide other strategic benefits in a period when China's clout in international maritime trade grows ever larger.

FIGURE 49: MSP, RRF, AND MSC CHARTER COSTS



190 MSP stipends were sustained at $5 million in FY 2019 dollars for most ship classes, increased to $7 million for tankers, and increased to $11 million for future FLO/FLO ships.

The final cost category included here is aggregate DoD (likely through MARAD) stipends to vessels engaged in U.S. domestic commercial activity that may be militarily useful. As previously suggested, a minor stipend of $500,000 was used as a placeholder to cover costs borne by exercises and modifications necessary to support military needs during a contingency. If half of the 46 militarily-useful tankers engaged in U.S. domestic trade participated, annual costs would amount to $11.5 million.

Observations on Requirements and Implementation

A National Fleet approach combining the more rapid (but less expensive) FY 2033 shipbuilding scenario, the proposed sealift plan, and the expansion to MSC charters and the MSP fleet would cost more than $47.8 billion over the next 30 years. This would require funding increases for the maritime logistics portions of Navy Shipbuilding and Conversion, Navy sealift procurement funds, MARAD's MSP and RRF maintenance, and MSC's working capital funds and operational costs. There would also be uncalculated additional costs for Navy operations and sustainment (O&S), and for procurement of other items like an expanded CMV-22B or amphibious aircraft buy, defense features for auxiliaries, secure logistics communications and cyber networks, additional spare parts, components, and systems, and additional munitions and other expendables. It would require Congressional buy-in, along with expanded cooperation with U.S. shipbuilders and the U.S. Merchant Marine. This exercise charts an admittedly aggressive course towards maritime logistics resiliency and adaptability.

Despite the cost, these efforts ultimately appear affordable. Assuming that these estimates are roughly correct, $47.8 billion represents little more than a 6 percent plus-up for these accounts. Increases to maritime logistics accounts could either be funded with additional total resources or by reallocating a small portion of currently-planned combatant resources in favor of a more resilient logistics fleet that would generate outsized positive effects for the combatant force.

Most of the suggested additions to the Navy shipbuilding plan leverage existing Navy or commercial-derivative designs. The technologies underpinning proposed alternative auxiliaries are mature. U.S. tanker and other ship operators can reflag their vessels within a relatively short period provided incentives align properly. These aggregate outlays represent a low relative cost for a renaissance in U.S. maritime logistics and the commensurate resiliency and force multiplication effects for the U.S. Joint Force. Further, these investments could have powerful secondary effects on the American economy, while providing strategic options for combating PRC maritime economic coercion in peacetime.

These are initial estimates that warrant follow-on analysis. Gaps remain, particularly for Navy O&S costs. This exercise, however, suggests such a National Fleet Approach could be well within the reach of the Navy and broader U.S. maritime sector if senior leadership decided to move in this direction.

CHAPTER 8

Conclusion

The United States' current and programmed defense maritime logistics force is not adequate to support U.S. strategy and operational concepts against China or Russia. It faces two major challenges. First, the Navy's at-sea logistics force is vulnerable to both current and emerging threats, while increasingly lagging behind in the capabilities and capacity necessary to support the Navy's distributed warfighting concepts. It has been repeatedly cut to minimize cost and optimized to provide support from secure, forward bases in generally uncontested locations. Second, the sealift force faces an imminent decline in capacity as ships age out and a shortage of mariners, both of which endanger the nation's ability to rapidly project power. These challenges erode traditional U.S. strategic competitive advantages of operating effectively on exterior lines and projecting power abroad. Collectively, they risk undercutting deterrence and inviting aggression that takes advantage of U.S. weaknesses in sustaining forces over protracted conflicts. Ultimately, they could cause the United States to lose a war—especially against China in the vast Indo-Pacific.

U.S. maritime logistics evolved throughout the 20th century in phased bursts of innovation and construction.[191] For example, in the Interwar Period between the two world wars, the Navy developed novel logistics concepts and technologies and made some logistics investments to support the fleet, but it was not until World War II that the Navy surged logistics forces from the U.S. Merchant Marine and rapidly constructed additional assets. In 2019, if a major conflict broke out, it is unlikely the Navy would be able to build, buy, or surge to address logistics gaps in a strategically-relevant timeframe (if at all). China's growing influence in the international maritime industry, the smaller size of the U.S. Merchant Marine and shipbuilding industrial base, and the need to rapidly respond to adversary aggression to defend allies and partners means the Navy needs to develop appropriate logistics concepts and forces now.

191 This history can be summarized into Anchorage, Expeditionary, Fast Logistics, and Forward Presence Eras. For additional information, see Chapter 4 on the Evolution of U.S. Maritime Logistics.

The Summary of the 2018 National Defense Strategy specifically notes “resilient and agile logistics” as one of eight capability areas that need to be strengthened to prepare the United States for an era of renewed great power competition.[192] In spite of this, the Navy’s FY 2019 30-Year Shipbuilding Plan decreased relative spending on logistics auxiliaries to less than half of the proportion spent during the Cold War, and the Navy’s FY 2020 30-Year Shipbuilding Plan continues this downward trend.

Whether or not the Navy shifts into a new era of fleet logistics that addresses current threats and emerging fleet demands remains to be seen. Based on the historical record of change, a shift into a new era will require not only novel concepts and capabilities for an improved logistics architecture, but also bureaucratic champions inside and outside the Navy that, like Admiral Burke in 1957, are able to reject the status quo and call for and fund new approaches at significant scale. In short, the Navy must not only talk about new logistics concepts, such as Operational Logistics in Contested Maritime Environments but commit to developing and buying the requisite logistics forces.

Thankfully, there are viable options for the United States to improve the resilience of its maritime logistics force. Through a National Fleet approach that leverages the best attributes of the Navy, MARAD, and broader Merchant Marine, the United States can rapidly and relatively economically transition to a resilient maritime logistics architecture. Prioritizing combat effectiveness and resiliency over peacetime efficiency, this new architecture would allow the Navy to fight in a distributed manner (that more effectively targets the enemy and counters enemy targeting), at a higher tempo (that denies compellence aims and keeps pressure on the enemy), and in a sustained manner if conflict becomes protracted, while bolstering Joint power projection through improved sealift.

A new maritime logistics architecture would not only draw forces from DoD (predominantly the Navy) but would also require robust support from the U.S. Merchant Marine. Deeper cooperation with the Merchant Marine allows the nation to grow capacity more economically, supports the creation of a robust commercial fleet that directly helps the rest of the U.S. economy, and provides Merchant Mariners for MSC and MARAD positions (in addition to commercial billets). Moreover, as this report’s analysis demonstrates, for both Navy at-sea logistics requirements and for sealift requirements, the wartime force requirement is now significantly larger than the peacetime requirement. A National Fleet approach helps to economically bridge the growing gap between smaller peacetime requirements and larger wartime requirements, by maintaining a sizable portion of wartime surge requirements in the Merchant Marine. This approach also helps insulate the United States and its allies from a PRC maritime strategy designed to augment its coercive economic power while reducing U.S. global access.

192 DoD, *Summary of the 2018 National Defense Strategy*, p. 7.

Current U.S. Government policies are designed to maintain a minimum Merchant Marine fleet size necessary for DoD, rather than a healthy commercial sector that supports U.S. commercial and defense needs. Additionally, the Navy, Marine Corps, and Coast Guard *Cooperative Strategy for 21st Century Seapower* does not discuss cooperation, much less integration, with MARAD and the broader Merchant Marine. At present, the United States is running a dangerous experiment: can a country be the preeminent naval power without being a strong overall maritime power? One of the chief recommendations of this report is that the U.S. Government develop, release, and implement a comprehensive, national strategy to increase the competitiveness of and grow the U.S. Merchant Marine and broader U.S. maritime sector. This will require not only MARAD, but also the Navy, the rest of DoD, and the Coast Guard to all champion and promote the U.S. maritime sector. Although Congress called for the DOT to develop such a strategy in 2014, it has yet to be released as of early 2019.[193] Future Service seapower strategies should also incorporate MARAD and the broader Merchant Marine.

This report has considered new concepts, capabilities, capacities, and posture and evaluated them to identify those that result in the greatest operational benefit relative to cost as expressed in both money and operational risk. It has also sought executable recommendations on how to address identified shortfalls in a time-phased and affordable manner. The core elements of this report's proposed architecture could be acquired through a mix of modifications, chartering and stipends, and new construction within 15 years. Including Navy combatant, auxiliary, and sealift procurement costs, MSC charters, the MSP program, and changes to RRF sustainment, this report's proposed approach may cost roughly 6 percent above what the U.S. government already plans to spend in these areas. Given the current logistics deficit incurred by both the Navy and commercial maritime sector, this corrective cost would be relatively low as the United States reorients for great power competition. Moreover, given that these investments improve Navy lethality and remove potentially mission-ending vulnerabilities, they would have an outsized impact on the operational performance of the force. Overall, the United States can field a maritime logistics force that is numerically larger, more differentiated, and—through some of the options highlighted in this report—only moderately more expensive.

Figure 50 depicts key units of the proposed fleet maritime logistics architecture, identifying requirements for supporting projected Navy fleet requirements in FY 2019, FY 2033, and FY 2048. Figure 51 depicts the proposed strategic sealift fuel transport and over-the-shore distribution fleet and dry cargo and munitions fleets.

193 "In 2014, Congress statutorily mandated that the DOT develop two national strategies related to the U.S.-flag fleet, one a national sealift strategy focused on ensuring the long-term viability of the U.S. Merchant Marine (U.S. flag vessels and U.S.-citizen mariners) and the other a national maritime strategy focused, among other things, on increasing the competitiveness of internationally trading U.S.-flag vessels." Von Ah, *Maritime Security: DOT Needs to Expeditiously Finalize the Required National Maritime Strategy,* p. 10.

FIGURE 50: PROPOSED AT-SEA FLEET MARITIME LOGISTICS FORCE

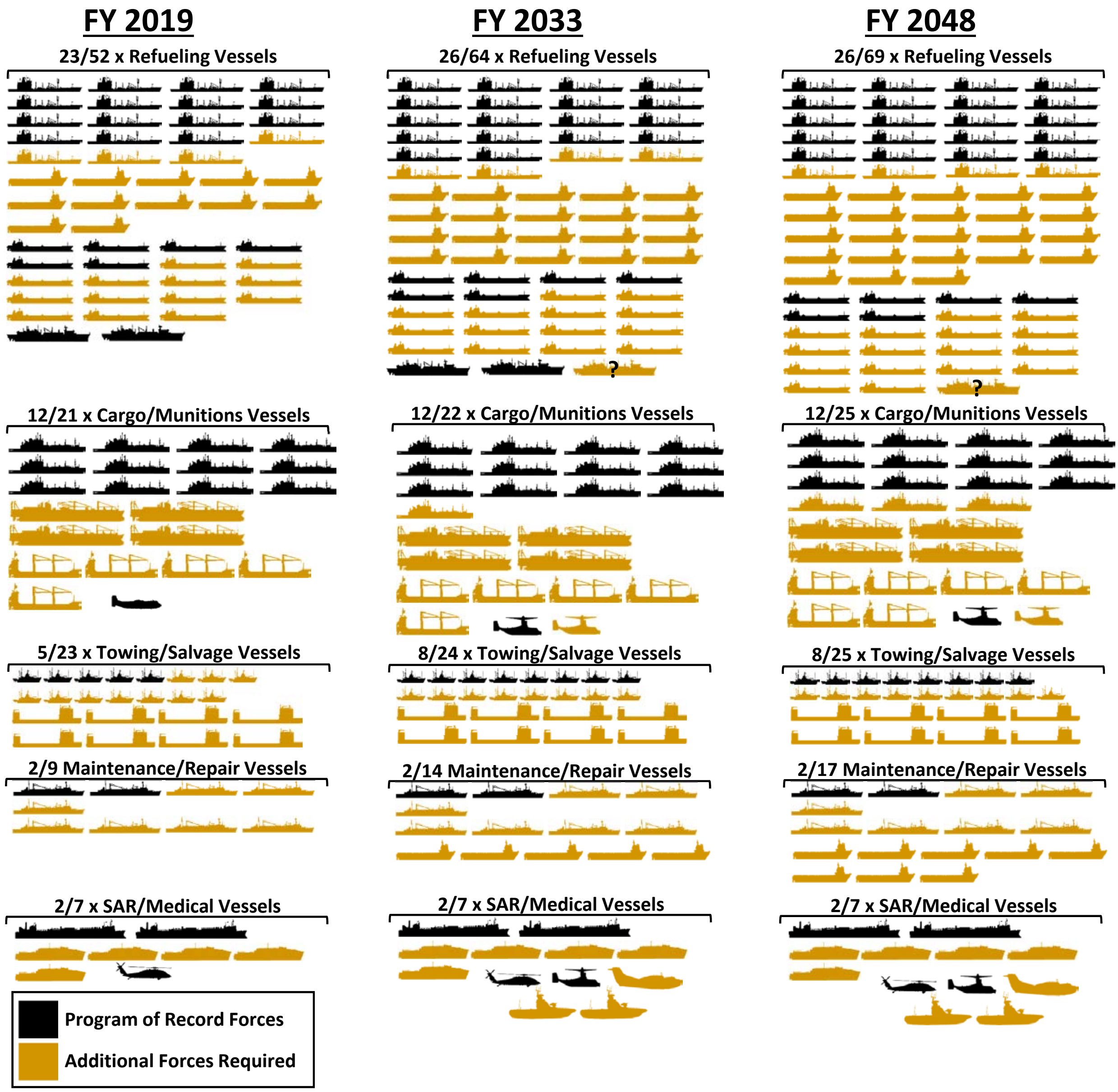
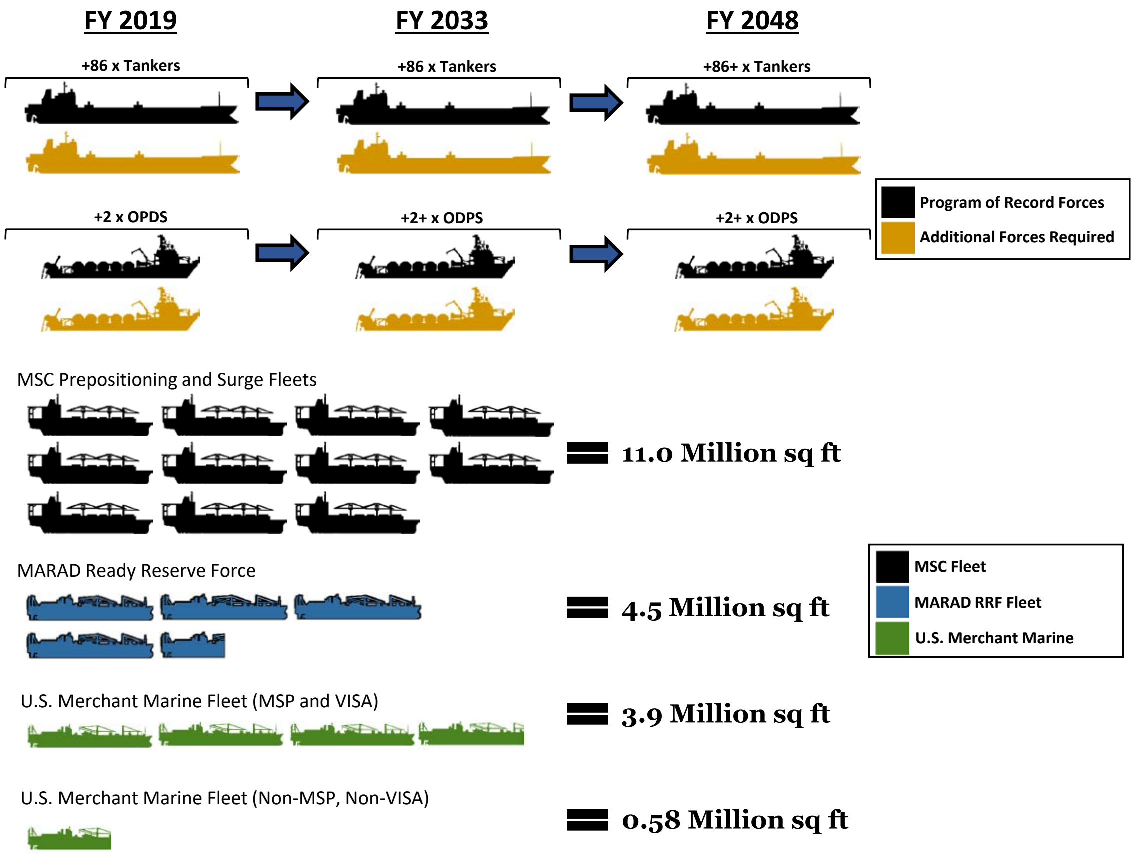


FIGURE 51: PROPOSED STRATEGIC SEALIFT FUEL TRANSPORT AND OVER-THE-SHORE DISTRIBUTION FLEET AND DRY CARGO AND MUNITIONS FLEETS



Today's maritime logistics force emphasizes peacetime efficiency over wartime effectiveness. It is too small and vulnerable to support U.S. strategy and operational concepts against China or Russia, and as threats advance and the U.S. fleet grows and matures novel operational concepts, it will be increasingly inadequate. Absent decisive change, weaknesses in U.S. maritime logistics will constrain the ability of U.S. forces to fight in preferred ways and could cause the United States to lose a war—especially against China in the vast Indo-Pacific.

This report's proposed maritime logistics architecture responds to changes in threats and Joint Force demands. It proposes new logistics concepts, capabilities, capacities, and posture that would improve the performance of the force. Leveraging mature technology and a National Fleet approach, the key platforms of the proposed architecture could be acquired through a mix of modifications, chartering and stipends, and new construction for roughly 6 percent above the U.S. Government's currently planned expenditures in this area. That six percent would harden an Achilles' heel of U.S. power projection and do more to ensure a prompt and sustained response to aggression than many other options imagined today. To reduce costs, albeit at greater risk, the Navy and other agencies could still implement portions of this plan to improve maritime resiliency. If wholly implemented, however, this logistics fleet would be larger, more differentiated, and more resilient. The combatants this logistics force supports could fight more aggressively, for longer, and with greater confidence in overcoming adversary challenges.

These investments are not a 'logistics tax' or distraction from Navy investments in future combatants. They would instead be a powerful signal of U.S. resolve and credibility, a revitalizing charge to the American maritime industry, and a force multiplier for the U.S. Joint Force. In World War II, the Navy struggled for nearly two years to muster the logistics capability necessary to engage in major offensive operations in the Central Pacific. The United States may not have such a luxury of time in future great power conflicts. As former Secretary of Defense James Mattis is fond of saying, "Americans have no God-given right to victory on the battlefield."[194] Forethought and effective planning with regard to maritime logistics will be an important part of ensuring the Navy and broader Joint Force have the tools necessary to seize victory despite current and future challenges.

194 James Mattis, "Remarks as Delivered by Secretary of Defense at Air Force Association 2017 Air, Space and Cyber Conference," National Harbor, MD, September 20, 2017, available at https://dod.defense.gov/News/Speeches/Speech-View/Article/1318960/air-force-association-2017-air-space-and-cyber-conference/.

APPENDIX A

Summary of Near-Term Recommendations by U.S. Government Entity

TABLE 7: U.S. NAVY RECOMMENDATIONS

Year	Recommendations
FY 2019	Conduct force size, shape, and posture studies for the following maritime logistics areas: refueling, dry cargo and munitions, towing and salvage, expeditionary maintenance and repair, SAR (to include CSAR), and medical support afloat. Include attrition of both combatants and logistics forces in these analyses, along with new Navy fleet operating concepts, and when possible conduct integrated assessments across logistics areas. Incorporate insights from studies (even if preliminary) in 2019 Force Structure Assessment.
	Reassess the required number of CMV-22B in the fleet
	Assess options to increase hardening of maritime logistics assets, including the placement of defensive armaments aboard CLF and select other maritime logistics ships
	More closely incorporate cleared U.S.-flag ship operators and providers of key supplies and services in wargames and exercises
	Consider chartering U.S.-flag commercially-owned sealift ships to complement Government-owned ones and consider the utility of Dual-Use Vessel programs
FY 2020	Aggressively increase inventories of supplies, spare parts, preferred munitions, and other expendables
	Realistically incorporate all aspects of the maritime logistics enterprise into wargaming and exercises, including long-duration large scale exercises where the maritime logistics enterprise is subject to risk and losses
	Begin incorporation of systems to harden maritime logistics forces aboard vessels
	Convert an OSV into a light oiler and use it to experiment refueling combatants
	Reorganize MSC to incorporate platforms that provide at-sea support to CLF ships into the CLF, and create a new Mobile Logistics Force (MLF)
	Begin recapitalizing sealift fleet via SLEP and acquiring used foreign and new U.S.-built ships; consider CHAMP for specialty ship and other auxiliary requirements and an LMSR-based design for RO/RO requirements
	In cooperation with USTRANSCOM, DLA, other Services, and MARAD, begin development of capabilities to interact with the commercial sector in a more secure manner, which may include the proliferation of more opaque solicitations for logistics services and supplies, as well as a separate non-Internet-based communications and network for preferred, cleared contractors
	Prepare to accelerate T-AO 205 procurement to continuous two per year in FY 2021 (“2 for 1 in ‘21”)
	Research and develop new ship-to-shore bulk fuel transfer system
	Generate a series of plans for the major expansion of the U.S. shipbuilding and U.S. ship operating industries in case of a national emergency in cooperation with USTRANSCOM, DLA, other Services, and MARAD
FY 2022	Conduct at-sea demonstration of VLS Rearming at Sea using Navy ships

TABLE 8: U.S. DOT (INCLUDING MARAD) RECOMMENDATIONS

Year	Recommendations
FY 2019	As mandated by Congress in 2014, develop and release a National Maritime Strategy in cooperation with the Navy, the rest of DoD, the Coast Guard, and NOAA
	Identify actions to decrease the time and cost of bringing vessels under the U.S. flag
	Assess appropriate rates for a specialized MSP stipend for tankers and FLO/FLO ships; assess the ability of U.S. Merchant Marine (including through the addition of reflagged ships) to supply additional ships and crews for additional MSP cargo, tanker, and FLO/FLO slots
	Identify options to revitalize the Voluntary Tanker Agreement, including providing small stipends to VTA participants in international and domestic trade to equip, organize, and train operators to support naval operations
	Identify tax, liability, and other reform options for Congress that would increase the competitiveness of U.S.-flag operators
	In cooperation with the Navy, carefully track and assess the foreign-flagged market of militarily-useful vessels

TABLE 9: USTRANSCOM RECOMMENDATIONS

Year	Recommendations
FY 2019	Build on findings of Mobility Capabilities and Requirements Study 2018 to critically examine options to meet the sealift dry cargo and tanker requirements

TABLE 10: DLA RECOMMENDATIONS

Year	Recommendations
FY 2020	Shift purchases of 100 percent of currently tanker-delivered Outside the Continental United States fuel from foreign refineries to U.S. refineries and 25 percent of its currently pipeline-delivered Outside the Continental United States fuel from foreign refineries to U.S. refineries

TABLE 11: U.S. ARMY, U.S. MARINE CORPS, AND U.S. AIR FORCE RECOMMENDATIONS

Year	Recommendations
FY 2019	Factor potential attrition of sealift assets with force equipment into force-sizing and posture assessments
	Provide inputs to Navy and USTRANSCOM on current and emerging concepts that would require the delivery of fuel over the shore

TABLE 12: U.S. COAST GUARD RECOMMENDATIONS

Year	Recommendations
FY 2019	Identify actions to decrease the time and cost of bringing vessels under the U.S. flag
	Begin development of criteria to inform potential manning rule changes

TABLE 13: CONGRESS RECOMMENDATIONS

Year	Recommendations
FY 2019	Request and upon receipt critically review and consider implementing recommendations of the forthcoming National Maritime Strategy
	Critically review findings of Mobility Capabilities and Requirements Study 2018 and request follow-on analyses as necessary
	Provide oversight on the aforementioned Navy maritime logistics force size, shape, and posture studies to ensure they adopt realistic assumptions; ensure maritime logistics forces appropriately included in 2019 Force Structure Assessment.
	Encourage U.S. Government agencies to adopt the aforementioned recommendations
FY 2020	Improve MSP to increase the length of its coverage, expand the number of slots, and provide specialized slots and stipends for tankers and FLO/FLO ships
	Mandate increasing percent of LNG and crude oil product to travel on U.S.-built and U.S.-flagged vessels, starting in 2023

APPENDIX B

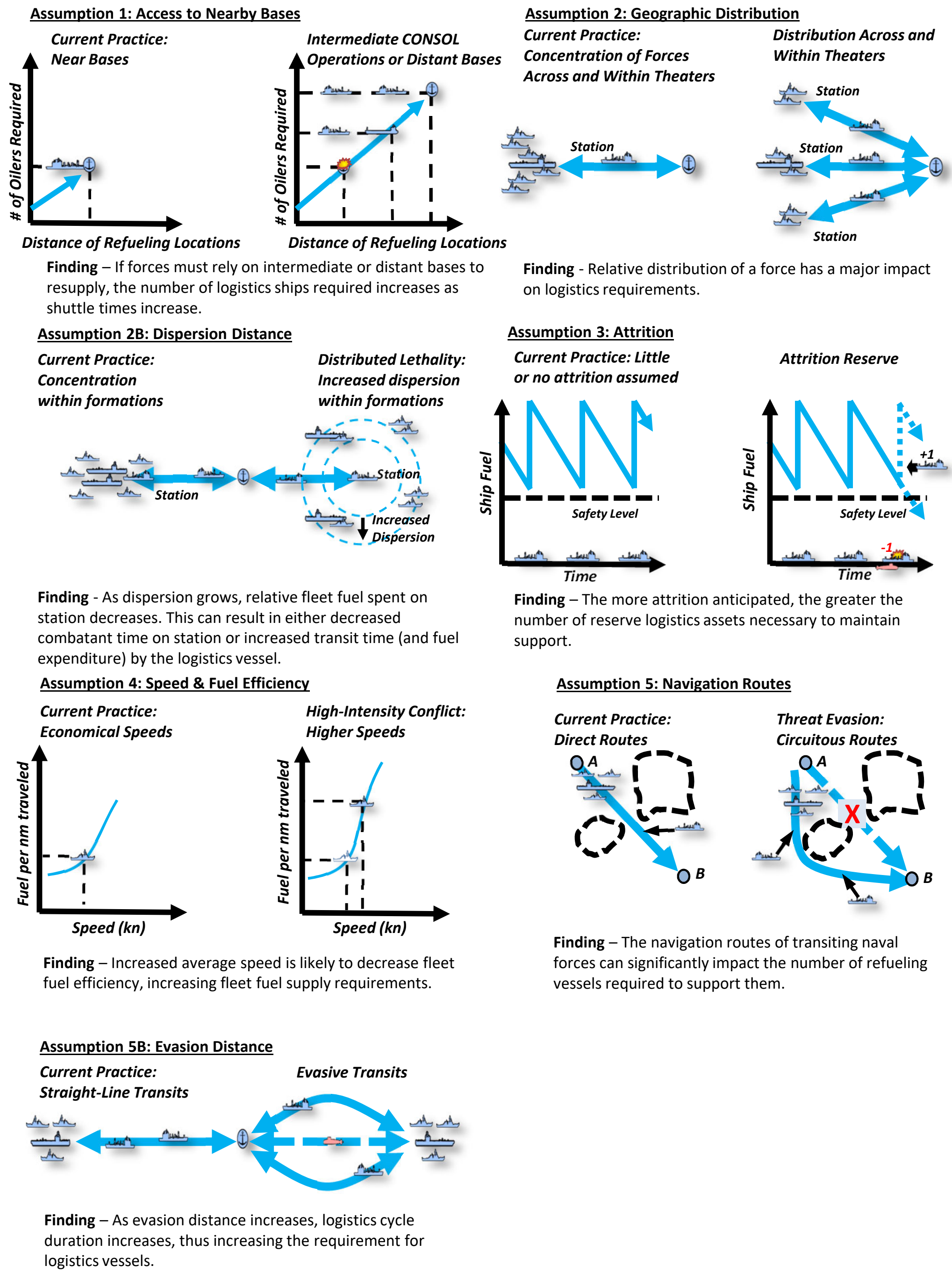
Quantitative Assessments

This study conducted peacetime and wartime assessments that informed the shaping, sizing, and posture of the maritime logistics force. The methodologies used for both the peacetime and wartime refueling, cargo, and reloading assessments are based on the methodologies and models employed by the Office of the Chief of Naval Operations (N42) and CNA in the 2011 T-AO(X) Analysis of Alternatives and subsequent analyses, with some deviations, in particular to account for T-AOT and T-AOL refueling and T-AKE, T-AKER, and T-AKM resupply and reloading. The methodologies used for the towing and salvage assessments, expeditionary maintenance and repair assessments, and personnel recovery and medical assessments were summarized in the body of the report.

To assess peacetime capacity requirements, the study examined the historical frequency of logistics activities (especially refueling) of U.S. ships and Allied ships by region and used that data to extrapolate future peacetime logistics frequency demand, assuming an increase in logistics demand commensurate with an increase in fleet size. It then compared logistics frequency demand with available supply (the average and 75th percentile capabilities of CLF vessels to conduct resupply operations in areas where they are postured). If additional vessels were needed to address demand, then the CLF requirement for a given fleet would increase.

To identify wartime requirements, this study's analysis employed a deterministic model to calculate the number of logistics vessels needed to maintain levels of support (especially in terms of fuel, cargo, and munitions) of given battle forces. This study adopted a set of quantifiable, conservative planning factors to aid in sizing a resilient logistics force capable of sustaining a large portion of the fleet at a high operating tempo. Five of the most important factors and their impact on modeling outcomes are depicted in Figure 52 on the subsequent page.

FIGURE 52: IMPACT OF PLANNING FACTORS ON LOGISTICS REQUIREMENTS



APPENDIX C

Cost Methodology

To evaluate the feasibility of our recommended maritime logistics fleet, this study includes estimates of the cost of new ship construction for both the Navy's President's Budget FY 2019 shipbuilding plan and CSBA's recommended logistics enhancements. This methodology builds on the methodology behind CSBA's 2017 Alternative Fleet Architecture Study, which was in turn largely informed by CBO's shipbuilding cost estimation methodology.[195] This study also includes rough order estimates for future MSP program stipends, RRF ship sustainment, and MSC charters.

Given many vessels analyzed are derivative of commercial designs or modifications of existing vessels, industry-provided cost figures substituted for areas where no existing Navy program was sufficiently similar for cost analogies. Similar conversations provided figures for MSC charter costs, MSP stipends, or special equipment. Where these figures weighed on the implementation scenarios, they were cited in the text for transparency.

This study has sought reasonable cost estimates based on Navy or other official publications wherever possible to ensure accuracy. More important than accuracy, however, is that the same method was applied to both the Navy's 30-year shipbuilding plan and CSBA's alternatives, mitigating differences that may have arisen if different methodologies had been applied to both. For example, if cost growth curves are off, they will be off together across both shipbuilding plan estimates, allowing for meaningful relative comparison. Consequently, the largest remaining source of potential error that could impact relative cost comparisons involves the original cost estimation for new ship types performing unique logistics functions whose development costs may exceed the bounds of CBO's analogous ship costing method. Although estimates for these ship types were informed by discussions with stakeholders in the maritime logistics community, they warrant further analysis and should be viewed as a first-order treatment of the estimation problem.

195 Clark, Haynes, McGrath, Hooper, Sloman, and Walton, *Restoring American Seapower*, pp. 130–131. For more on CBO's cost estimation methods, see Eric Labs, *How CBO Estimates the Cost of New Ships* (Washington, DC: Congressional Budget Office, April 2018), available at www.cbo.gov/system/files?file=115th-congress-2017-2018/reports/53785-cost-estimates-new-ships.pdf.

LIST OF ACRONYMS

A2/AD	anti-access/area denial
ABLTS	Amphibious Bulk Liquid Transfer System
ARG	amphibious ready group
AS	submarine tender
ASROC	anti-submarine rocket
ATTDS	Anti-Torpedo Torpedo Defense System
bbl	barrels
C3	command, control, and communications
CHAMP	Common Hull Auxiliary Multi-mission Platform
CLF	Combat Logistics Force
COD	carrier onboard delivery
CONOP	concept of operation
CONSOL	Consolidated Logistics
CSAR	combat search and rescue
CSG	carrier strike group
DiAL	Distributed and Agile Logistics
DL	Distributed Lethality
DLA	Defense Logistics Agency
DMO	Distributed Maritime Operations
DoD	Department of Defense
EABO	Expeditionary Advance Base Operations
EMS	electromagnetic spectrum
EMW	Electromagnetic Maneuver Warfare
ESB	expeditionary sea base
ESD	expeditionary transport dock
ESSM	Evolved Sea Sparrow Missile
FLO/FLO	float-on/float-off
FY	fiscal year
IO	information operation
IPDS	Inland Petroleum Distribution System
ISR	intelligence, surveillance, and reconnaissance
JMSDF	Japan Maritime Self-Defense Force
LCM	landing craft, mechanized
LMSR	large, medium-speed, roll-on/roll-off ship
LPI/LPD	low probability of intercept/low probability of detection
LRASM	Long-Range Anti-Ship Missile
LST	landing ship, tank
MARAD	Maritime Administration
MCRS	Mobility Capabilities and Requirements Study

MFDS	Modular Fuel Delivery System
MLF	Mobile Logistics Force
MPS	Maritime Prepositioning Ship
MPSV	multi-purpose support vessel
MR	medium range
MSC	Military Sealift Command
MSP	Maritime Security Program
NATO	North Atlantic Treaty Organization
NDRF	National Defense Reserve Fleet
NDAA	National Defense Authorization Act
O&M	operations and maintenance
OPDS	Offshore Petroleum Discharge System
OPLOG	Operational Logistics in a Contested Maritime Environment
O&S	operations and support
OSV	Offshore Support Vessel
PLA	People's Liberation Army
PLAN	People's Liberation Army Navy
PNT	positioning, navigation, and timing
PRC	People's Republic of China
RAS	rearming at sea
REFORGER	Return of Forces to Germany
RF	radio frequency
RRF	Ready Reserve Force
RO/RO	roll-on/roll-off
SAG	surface action group
SAR	search and rescue
SLEP	service life extension program
SM	Standard Missile
STREAM	Standard Tensioned Replenishment Alongside Method
T-AH	hospital ship
T-AHL	light hospital ship
T-AO	fleet replenishment oiler
T-AOE	fast combat support ship
T-AOL	light oiler
T-AKE	dry cargo/ammunition ship
T-AKM	missile rearmament ship
T-AKRE	dry cargo/ammunition, resupply, ship
T-ARF	fleet ocean tug
T-ATF	rescue and salvage vessel
T-ATS	towing, salvage, and rescue ship
TLAM	Tomahawk Land Attack Missile

UAS	unmanned aircraft system
UNREP	underway replenishment
USTRANSCOM	U.S. Transportation Command
USV	unmanned surface vessel
VERTREP	vertical replenishment
VLS	vertical launch system
VTA	Voluntary Tanker Agreement
WMD	Weapons of Mass Destruction

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