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Regaining U.S. Maritime Power Requires a Revolution in Shipping

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Fostering a revolution in American shipping can energize a lethargic industrial sector that is critical to the nation's defense and strengthen it so that it can sustain a wartime economy. A stronger and globally competitive maritime sector serves as a deterrent to Chinese economic coercion and military adventures. With a more robust maritime sector, American trade could proceed with greater confidence that the U.S. military can sustain combat operations on U.S.-flagged vessels. In addition to serving U.S. security needs, this shipping revolution could mitigate the environmental impacts of shipping, promote domestic production, and expand American exports to global markets, which would spur wider job growth and advance technological innovation in the U.S.

For the past 30 years the U.S. has neglected a core element of its security and continued prosperity—its maritime strength. During that period the nation gradually ceded its economic security by increasing its reliance on other nations' shipping and shipbuilding. Most concerning of these nations is China, which has relentlessly constructed a world-class merchant fleet, invested in more than 100 ports in 63 countries,[1] and achieved a commanding market share of the world's shipbuilding. This capacity has enabled a threatening rapid modernization and expansion of China's navy that will have doubled in size from 210 warships in 2000, despite purging older warships, to 400 by 2025.[2]

Meanwhile, the U.S. has ceded its naval leadership, and has failed to maintain a shipping fleet that can sustain prolonged combat operations, let alone a wartime economy. Remedying this unacceptable situation requires a rejuvenation of the nation's maritime sector. The U.S. must regain global competitiveness in shipping and shipbuilding, while ensuring that the U.S. Navy remains a credible deterrent.

FIGURE 1

Assessing New Intermodalism

STRENGTHS	OPPORTUNITIES
• U.S. leads in necessary technologies, many of which are already fully developed, including U.S. civilian nuclear power, heavy dirigibles, and drones • Public is aware of nation's logistic vulnerabilities • Regulatory work already done for drones	• Reduces shipping costs, including U.S. exports • Revitalizes rural and "rust belt" manufacturing • Provides access to more ports and inland logistic hubs without new infrastructure • Leverages Congress and Department of Defense efforts to improve naval shipbuilding and merchant marine manpower • Improves environmental footprint for merchant ships
WEAKNESSES	**THREATS**
• Limited domestic capacity to build ultra-large container ships, meaning U.S. must rely on foreign builders initially • Limited merchant mariners to man ships, labor shortages in U.S. marine sector • Technical challenge in scaling up cost-effective vertical-lift air freight	• Unfavorable and worsening domestic regulatory and bureaucratic environment • China market intervention and theft of intellectual property steals U.S. innovation unless U.S. quickly commercializes

SOURCE: Authors' analysis.

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Over the past 30 years, American shipping and shipbuilding has atrophied, yet domestic industry and capacity for innovation remain strong. This advantage needs to be pressed by focusing on restoring American maritime competitiveness. Rather than working within existing business models, a "blue ocean strategy" is needed—a revolutionary rethinking of logistics integrating a range of innovations and technologies in a novel intermodal approach—that could usher in a new era of shipping. The nation is well positioned for leadership in such an approach.

At the same time, the U.S. government must address several key military operational problems to ensure the nation's military is able to deter Chinese aggression. These military challenges must be addressed in this decade and will contribute to sustaining national security in the long term. Addressing these operational problems when joined with technological developments, such as small modular nuclear power plants for shipping,

could become the foundation of a new paradigm of intermodalism[3]—a global logistics system with greater reach, fewer intermediaries, and a reduced environmental impact.

The U.S. approach must be clear-eyed in leveraging its tremendous human capital through entrepreneurship.

The China Dilemma

American naval theorist Alfred Thayer Mahan's *The Influence of Sea Power Upon History* (1890) remains a seminal work 133 years after its publication and still influences the world's navies. One of Mahan's key insights was the interdependence of maritime commerce fleets and navies, a point that remains valid today.[4] Seeing China's progress as a naval and shipping power, one might say that it has managed to "out-Mahan" the United States through its aggressive and focused prioritization of a powerful civilian–military national maritime sector.

To compete for shipping and shipbuilding market share with Chinese corporations, such as COSCO, will require taking on the Chinese Communist Party (CCP). China's "civ-mil" fusion blends civilian activities like shipping with military needs, which has enabled a massive growth in global shipping, shipbuilding, and port operations. The risk is not just the military use of commercial ships and ports in war, but the ability to edge out market competitors and stifle any innovation that is contrary to CCP interests. Taking on a state entity with massive financial backing will be no small feat and requires national leadership.

When it comes to shipbuilding, Chinese companies enjoy healthy government backing in addition to a regulatory environment that avoids the enormous costs of U.S. environmental, labor, and special interest regulations. Between 2010 and 2018, Chinese shipbuilders enjoyed $132 billion in direct subsidies, not including vast indirect subsidies and regulations, giving them a leg up on global competitors.[5] Favorable financing and supporting government direction enabled the massive merger of COSCO Group and China Shipping Group in 2016, and then the absorption of Hong Kong–listed Orient Overseas Container Line to become today's COSCO. Such government support has created a powerful shipbuilding market that benefits from foreign orders. Surprisingly, even Taiwan's, the CCP's arch enemy, Evergreen Marine Group purchased 44 vessels from mainland Chinese shipyards in 2019. And, between 2019 and 2021, China's four main shipyards (also producing warships) had 211 new orders of which 64 percent were from overseas buyers.

TABLE 1

Costs of Deepening U.S. Port Harbors to Accommodate Large Container Ships

Port	Cost (In millions of dollars)
Port of New York/New Jersey	$2,100.0
Charleston, SC	$565.0
Jacksonville, FL	$484.0
Port of Mobile, AL	$365.3
Port of Virginia, Norfolk, VA	$350.0
Boston Harbor, MA	$306.2
Mississippi River Ship Channel	$238.0
Savannah Harbor, GA	$507.2
Seattle Harbor, WA	$61.2
Baltimore Harbor, MD	$33.0

SOURCE: Hannah Towey, "The U.S. Is Spending Billions of Dollars Deepening Port Harbors to Make Room for 'Mega' Container Ships that Are Only Getting Bigger," *Business Insider*, January 10, 2022, https://www.businessinsider.com/congress-spends-billions-deepening-port-harbors-for-mega-container-ships-2022-1 (accessed April 28, 2023).

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Trying to outcompete the CCP's government-directed and government-subsidized shipping and shipbuilding model without new thinking is destined for failure.[6] What is needed is an unleashing of innovation and unshackling of American industry to bring about a paradigm shift in the global shipping and shipbuilding market space. One way of doing this is to remove legal and regulatory impediments that handicap U.S. industries to substantially narrow the competitive gap with China. Regulations, such as the Foreign Dredge Act, that keep the nation's ports open and make new ports available for trade constrain the market for dredging.[7] Another is the redundant and politicized National Environmental Policy Act (NEPA) that creates untold amounts of red tape, which slows down or discourages maritime infrastructure projects.[8] Moreover, the Jones Act and *ad valorem* taxes on U.S.-flagged vessels for conduct of overseas ship maintenance have discouraged U.S. shipbuilders and shippers from competing in the global marketplace.[9] If pursued, policy reform needs to flow through all levels of the manufacturing supply chain, from inputs to labor and services, to final product. Without such reform, it is difficult to imagine a return to

competitiveness against China's shippers and shipyards. A deeper discussion of the CCP's state-run maritime sector and ways to secure a nascent American effort to renew its maritime strength can be found in Appendix A of this *Special Report*.

Meeting Urgent Military Needs Leads to New Commercial Applications

Americans should be concerned about the nation's maritime sector for two reasons: (1) An underperforming maritime sector makes the U.S. overly reliant on hostile nations for trade, and (2) it makes the U.S. unable to sustain a wartime military and economy. In recent years, the brittleness of American global trade networks that are stubbornly reliant on seaborne shipping were on display as ships queued at ports and store shelves went bare. Against a foe such as the CCP, the nation needs both a strong Navy today and adequate shipping in the long term.

Worsening world events serve as a reminder that the nation is not only well served by a strong Navy, but also by adequate shipping. Americans were reminded of this fact as world energy and grain supplies were jeopardized as the warfighting in Ukraine extended into the Black Sea.

It is instructive to compare the nation today with the nation at the end of the Cold War, when the nation had 636 U.S.-flagged merchant vessels, barely enough then to sustain a wartime economy.[10] Today, the U.S. has fewer than 200 ships for an economy that has since quadrupled in size.[11] Worse still, the nation's shipbuilders have built no more than 20 large commercial vessels a year since 2017, and almost all were for government agencies.[12] China, by comparison, produced more than 40 percent[13] of the world's new commercial ships by tonnage, and those same shipyards are delivering new modern warships to a fleet that will number more than 400 by 2025.[14] According to the latest U.N. report on commercial ships that displace more than 1,000 tons of water, China's 8,007 vessels are ranked second by cargo-carrying tonnage, behind Greece's 4,870 vessels. When Hong Kong is added to China, its total 9,829 vessels take the top spot. Lagging behind China by well over a million tons of cargo capacity is Japan (4,007 vessels), Singapore (2,799 vessels), and South Korea (1,680 vessels) in descending order.[15]

Conversely, the U.S. has struggled to expand a rapidly aging fleet, and since 2002 has been unable to sustain more than 300 warships.[16] In the U.S., naval and commercial shipbuilding sectors share similar skilled workforces, drawing on common skills and engineering competencies, and aside from nuclear-powered warships, share infrastructure needs, such as graving

docks, dry docks, and cranes. In sum, the U.S. maritime sector, which is important to the Navy, is in poor health. This has potentially severe consequences for the nation. Revitalizing American shipping and shipbuilding, while delivering needed naval capabilities, requires better leveraging of American ingenuity.

In October 2021, The Heritage Foundation hosted William Roper to discuss the concept of "market bridges" and how they could speed up delivery of new technologies to the military. As Director of the Defense Department's (DOD's) Strategic Capabilities Office and then Assistant Secretary of the Air Force for Acquisition, Technology and Logistics, Roper had seen firsthand the challenges of market entry for new innovative companies. His concept of a market bridge is straightforward—the DOD must provide the demand by setting orders for new craft produced in a regulatory environment that is conducive for these small companies to produce innovative solutions to military needs.[17] A market bridge provides a regulatory bubble to prove key innovations that the Navy needs to actualize its warfighting concepts, while likewise advancing development of key capabilities important in a new intermodalism.

Market bridges will play a role in kickstarting a revolution in shipping, especially in overcoming prohibitive developmental costs, regulatory constraints, and capital investments for manufacturing. One path forward is by solving contemporary military problems, such as missile reloads of warships at-sea and the need to sustain expeditionary forces far from logistic hubs. These are just some of the key operational problems that the military is confronting as it thinks through what a war with China entails using concepts like multi-domain operations (MDO), distributed maritime operations (DMO), or expeditionary advance base operations (EABO).[18] All these concepts rely on independent maneuvers with coordinated effects across dispersed groups of marines, soldiers, aircraft, and ships. Solving these key operational problems was one focus of the Navy's 2022 Navigation Plan,[19] which lays out six force-design imperatives. Of these, several cross over into capabilities key for realizing a new intermodalism:

Expeditionary Logistics. Conducting expeditionary military logistics requires resupplying forward-deployed units exposed to enemy attack with limited rudimentary infrastructure dispersed over significant distances. A notable effort in this regard has been the ongoing negotiations between the Marine Corps and the Navy about the design of a small logistics ship—the Light Amphibious Warship.[20] Additionally, to minimize exposure to enemy attack (such as Chinese ballistic and cruise missiles), time in port or a fixed location during resupply operations should be held to a minimum. An

example of limiting exposure to attack occurred during the war in Afghanistan: To avoid the Taliban's ambushes and improvised explosive devices, the Navy and Marine Corps deployed autonomous K-MAX medium-lift cargo helicopters for a successful three-year resupply mission.[21] The ability to quickly move cargo from ship to shore and access remote locations with rudimentary infrastructure in a commercial context serves to open new communities to trade and industrial activity.

Resilient Logistics. Resilience in military logistics means having multiple options to re-arm, repair, and resupply ships far from major shipyards and industrial bases and doing so under threat from an enemy. To this end, since a major speech at Columbia University in January 2023, Secretary of the Navy Carlos Del Toro prioritized at-sea reload of vertical-launch systems (VLSs). This reload would enable the Navy to re-arm warships with an array of missiles that today can be done only at a limited number of ports.[22]

The DOD has also invested in additive manufacturing to alleviate reliance on long, easily interrupted supply chains by having onboard replacement parts production.[23] Moreover, additive manufacturing plants have the potential to disperse manufacturing at an industrial scale, including perhaps on massive factory ships underway at sea. As the military develops VLS reloads at sea, it can benefit development of capabilities that enable cargo transfer at sea between massive container ships and feeder vessels. Likewise, the advancement of additive manufacturing will accelerate the dispersal of production, making a new intermodalism of greater utility.

Expanded Distances. The Navy has focused substantial resources on extending the range of its weapons and on its existing aircraft. Notably, the Navy has developed the MQ-25 unmanned aircraft for in-flight refueling and surveillance missions.[24] The intent is to match, then exceed, Chinese weapons ranges. The MQ-25's development indicates an awareness that longer-range aircraft will be needed with higher fuel efficiencies. Achieving these ranges will include increased use of unmanned aircraft for a range of missions. Improvements in unmanned aircraft and engine efficiencies with longer range, especially for vertical-launch craft, will make moving cargo from massive container ships at sea inland more economically viable.

Increased Distribution. Increasing distribution will require deploying a widely dispersed fleet of platforms connected via secure communications for a unity of effect. To achieve this deployment, two related Navy efforts are necessary: development of a communications network based on the concept of Joint All-Domain Command and Control (JADC2) and large unmanned surface vessels (LUSV). In the Navy's concept of distributed maritime operations, the aim is to enable rapid response to an enemy from

numerous vectors of attack, thereby complicating an enemy's defenses. Doing so requires a resilient and reliable communications network connecting widely dispersed platforms—manned, unmanned, and autonomous. JADC2 is a program to develop a common communications network that links all U.S. military services to share remotely sensed data; a common analogy is the popular ride-sharing application Uber that connects a rider with the most suitable driver for desired destination.[25]

The other effort is development of LUSV, an experimental repurposed offshore service vessel with greatly automated and remotely monitored shipboard systems able to carry a variety of containerized cargo.[26] In July 2022, the Navy successfully tested methods of autonomous ship control of an even larger expeditionary fast transport ship, which has a ramp that can accommodate roll-on/roll-off of an M1A2 tank and 600 tons of cargo.[27] The goal of bringing the JADC2 and the LUSV together is to build a fleet connected by a resilient network that enables manned and unmanned platforms to act in concert, including for movement of materials. These military developments have utility in managing a global network of intermodal transportation across manned and autonomous platforms. Moreover, when paired with blockchain technology[28] and new cargo containers, they can offer a secure method of monitoring cargo during shipment and ease customs at more varied points of entry.

As the military pursues these capabilities, they will play a role in reimagining global logistics. However, making that connection for a greater and more impactful commercial advantage will require creating a domestic environment that is conducive to seizing a competitive edge in the maritime sector.

Domestic Shackles and Understrength Maritime Agencies

As America innovates to solve critical military operational problems, bringing those advances into wider commercial benefit will require removing a host of domestic regulatory and protectionist shackles on its maritime industry. This deregulation is imperative to promote innovation and industry and protect American intellectual and capital investments from hostile forces. Achieving all this will require a national maritime strategy focused on enhancing shipping competitiveness, while expanding access to more American ports and communities connected to global markets—not just as customers, but as producers, too. The first step involves a review of several features of America's maritime sector, the most significant being the century-old Jones Act.

The Jones Act traces its legacy to a crisis that occurred in the lead-up to and involvement in World War I. On the eve of the war in 1914, the U.S. merchant fleet carried about 10 percent of the nation's trade, with European nations conveying the remainder.[29] However, as European ships were redirected or sunk, the American merchant fleet could not sustain the nation's trade, let alone bear the demands of combat three years later when it joined the war. Wartime necessity led to a massive government shipbuilding program, delivering a large merchant fleet that predictably diminished after the war along with the Navy. However, Congress, seeking to ensure that the nation's economy and security would never again be so vulnerable, passed the Merchant Marine Act of 1920, known as the Jones Act. This act's preamble remains the best articulation of the importance of commercial shipping:

> It is necessary for the national defense and for the proper growth of its foreign and domestic commerce that the United States shall have a merchant marine of the best equipped and most suitable types of vessels sufficient to carry the greater portion of its commerce and serve as a naval or military auxiliary in time of war or national emergency.[30]

Sadly, the government protection and subsidy approach encapsulated in the Jones Act has persisted. To make up for its inadequacies, various U.S. Maritime Administration[31] programs, such as the Tanker Security Program and cargo preferences, have been enacted with little effect. Statistics speak for themselves: The 2019 Turbo Activation 19-Plus exercise demonstrated that only 64 percent of the Ready Reserve Fleet was able to deploy on time in support of national defense needs—vessels that are intended to be ready to support rapid deployment of military forces. Moreover, the average age of these merchant ships is 45 years, well over the industry end-of-life average of 20 years, and the DOD faces a gap of approximately 76 fuel tankers to meet surge sealift requirements.[32]

Administrator Mark Buzby of the U.S. Maritime Administration, responsible for ensuring sealift for the military, warned in March 2020 that the merchant fleet is likely unable to deliver in a conflict and that, with only one shipyard able to build the needed logistic ships, the capacity to shift to needed production when necessary is questionable.[33]

Attempts at reforming or repealing the Jones Act have stalled due to a powerful combination of a captive industry and its well-funded legislative support. This despite the fact that smart reform would allow access to cheaper, newer, safer, and more plentiful shipping. The issue is a complex

CHART 1

Regulatory Costs in the Manufacturing Sector

COST PER EMPLOYEE FOR MANUFACTURING, IN 2023 DOLLARS

Type of Regulation	Total Cost per Employee, All Firms	Share of Total
Environmental	$13,425	54%
Economic*	$10,178	41%
OSHHS**	$1,040	4%
Tax Compliance	$377	2%
All Federal Regulations	$25,020	

* Includes production, transport, credit, and labor regulations.
** Occupational safety and health and homeland security regulations.
NOTE: Figures have been adjusted for inflation.
SOURCE: W. Mark Crain and Nicole V. Crain, "The Cost of Federal Regulation to the U.S. Economy, Manufacturing and Small Business," National Association of Manufacturers, September 10, 2014, Table 2, p. 5, https://www.nam.org/wp-content/uploads/2019/05/Federal-Regulation-Full-Study.pdf (accessed March 9, 2023).

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one, necessitating a national maritime strategy that sets American shipping and shipbuilding on a course to global commercial competitiveness, which inevitably would make Jones Act protections unnecessary. Whichever shape a future shipping model takes, it must be able to securely transport cargo on a competitive commercial basis.

Good ideas are insufficient if regulators stand in their way. The global and domestic maritime marketplace is already difficult for new entrants, and any innovator facing hostile regulators in the U.S. may look elsewhere. To illustrate this fact, General Stephen Lyons, Commander of the U.S. Transportation Command, suggested in his 2019 congressional testimony that there is a 26-fold difference in costs to produce modern ships domestically instead of buying them from overseas shipbuilders.[34]

For example, given that China's manufacturing wages are roughly 40 percent of U.S. wages,[35] and that labor costs make up roughly half of shipbuilding,[36] only a 30 percent discount from cheaper labor should be expected, not a 26-fold difference. In other words, domestic regulations and restrictions render American shipping roughly 18 times more expensive than it should be, controlling for labor costs. It is worth noting that such self-handicapping may be similar across military procurement outside of shipbuilding.

Conversely, while U.S. regulations handicap domestic shippers and shipbuilders, foreign government intervention and subsidies often present considerable advantages to competitors. The CCP's government direction and support to its shipbuilders and shippers is the largest threat. (See Appendix A for details on addressing this threat.)

Today the nation is in a dilemma similar to that of 1914, but the nation lacks urgency in addressing this danger. Unlike the breakneck, inefficient World War I government shipbuilding program, a far better approach would be to regain global maritime competitiveness that would benefit the U.S. in peacetime as well. This would not require overturning the Jones Act, but it would make it redundant over time since a competitive American shipbuilding industry would not need such protection.

Of paramount concern is that America's principal maritime competitor is China, which also poses a significant military threat. CCP control, subsidies, and a willingness to use all national resources to gain a market advantage represents a potent challenge. As China prioritized a dynamic whole-of-government approach to building a globally dominant maritime sector, the U.S. has done little more than navel-gazing in the midst of policy paralysis. Overcoming these challenges with leadership is just the first step; attracting new talent to the maritime sector and creating market space for even a rudimentary novel concept of intermodalism will be critical.

A Blue Ocean Strategy to Reset Global Logistics Using American Ingenuity

Regaining America's maritime competitiveness will require policy and industry leaders to break long-standing, often politically entrenched norms and implement a coherent, modern, competitive national maritime strategy. The primary task is to create a domestic landscape that can foster a sustainable competitive advantage in American shipbuilding, shipping, and logistics. In the near term, however, fostering stronger cooperation with allies (such as Greece, Japan, and South Korea) can help to satisfy some clearly defined national shipping needs in wartime.

Setting these conditions for a successful revolution in shipping does not mean "out-performing" the principal threat: China's heavily subsidized and government-directed shipbuilding and shipping industries. Rather, it means changing the paradigm of modern logistics. In short, the nation should pursue a well-known management approach called a "blue ocean strategy"[37]—a multifaceted approach that creates new market space rather than continuing to compete in a conventional way. Achieving this goal

will require American leadership in devising novel, cutting-edge means of moving cargo, rethinking shore-to-sea connectors, and dispersing production by leveraging emerging technologies like additive manufacturing. In short, the U.S. must sidestep the current China-dominated model of shipping and its associated shipbuilding.

Innovative U.S. leaders have acted similarly before. Two innovations perfected in the U.S. shortly after World War II still shape global shipping: modular ship construction and containerization of cargo. Modularization proved critical in World War II by rapidly connecting dispersed U.S. factories. This is a technique used now at all competitive shipyards and taken to colossal scale in China. One factor in this loss of global competitiveness was organized labor's early resistance to modularization, which led to the erosion of U.S. commercial shipyards' market share.[38] While China's cheap labor is becoming less cheap, it is still about half as expensive as that of skilled machine operators in the U.S.[39] However, labor costs are only part of the equation; regulations and red tape at home are an existential risk to American competitiveness.

The other American innovation that revolutionized shipping was cargo containerization. This technique was novel, and unlike modularization in shipbuilding, did not run into effective labor union resistance. It succeeded because containerization was a novel intermodal approach that offered greater efficiencies and security of cargo, which contributed to the rise of today's just-in-time logistics.[40] Containerization was the brainchild of Malcom McLean who in 1956 used a repurposed wartime tanker to move 58 truck trailers. After some trials and errors, this novel intermodal approach has become the dominant means of maritime trade.

At this point, it should be clear that the principal U.S. competitor is the CCP and its state-controlled maritime sector. It should be equally clear that regaining American maritime power will require contesting the CCP by fostering U.S. strengths in innovation and pursuing a blue ocean strategy to rejuvenate U.S. maritime power through a revolution in shipping. The elements of a new intermodalism are present today, and if brought together in the right way could spark a revolution in shipping.

The Vision of a New Intermodalism

Being the first mover offers advantages that the nation can turn into a lucrative business, attracting Americans to become merchant mariners and shipbuilders once again. To be successful, this new intermodalism must connect new centers of industry and customers that are far away

from existing connectors (such as airports, highways, and ports) in a more dispersed global trade that benefits far more Americans. Achieving these new connections is no simple task, and as McLean did in 1956, it will require a demonstration of the approach's viability. To get to that point first requires a workable vision that includes a way ahead for its adoption.

As a viable approach, this new intermodalism addresses three fundamental realities of profitable shipping:

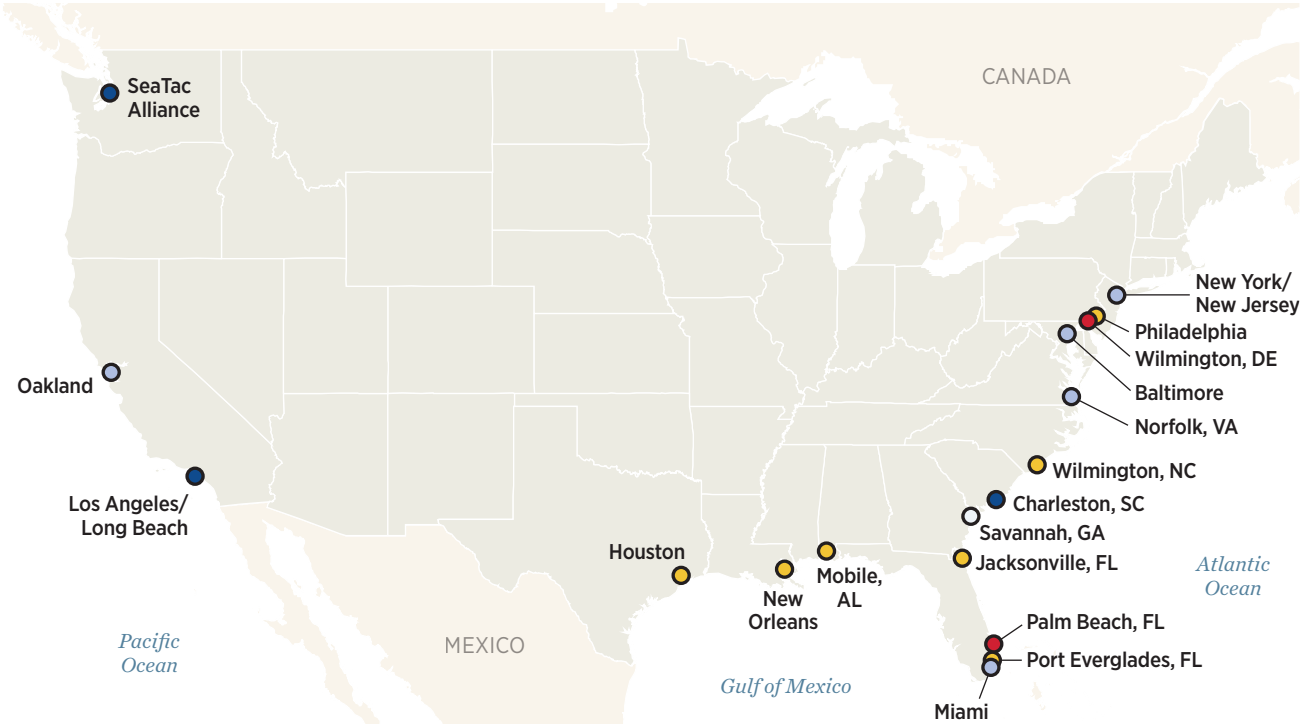
1. **Less time in port.** Shippers must reduce the time ships spend in port while maximizing overall capacity for revenue-generating freight, at minimal overhead costs (such as port fees and longshore labor). Daily port-related fees are significant and increase the longer a ship remains in port. Additionally, these fees can rise as ships age and require more frequent maintenance. The goal would be to optimize a ship's deadweight tonnage use for greatest ship productivity.[41]

2. **More trade pathways.** Shippers and port operators must increase the number of ports and alternative transit paths to improve resilience against costly port or overland disruptions (such as natural disasters and regional conflicts).[42] The importance of alternative transit routes was made explicit when the Suez Canal was blocked by the ultra large container vessel (ULCV) *Ever Given* in March 2021 for almost a week, holding up 10 percent of global maritime trade at a loss estimated at $10 billion per day and causing prolonged shipping delays.[43]

3. **More cargo throughput.** Shippers, port operators, and shipbuilders must increase the system throughput for cargo-carrying vessels to truly take advantage of economies of scale to reduce per unit cost for voyage. Any marginal increases in the economies of scale gained by larger ship capacity must be matched by improvements to intermodal throughput rates—meaning more crane, truck, and rail chassis. Merely increasing ship capacity dramatically reduces the number of ports in which the large ships can call; and the benefits of larger cargo volume can be neutralized by the increased time to load and unload cargo. This is already being witnessed as container ships grow to massive proportions, in a so-called "post-Panamax syndrome" named after ships too large to fit through the original Panama Canal.[44]

MAP 1

How U.S. Ports Can Currently Accommodate Large Container Ships



Category	Capacity in TEU*	Mean Low Water Channel Depth, in Feet
Panamax or less	4,200	Less than 38 feet
Panamax	4,500	39–40 feet
Post-Panamax I	6,000	41–45 feet
Post-Panamax II	8,000	46–48 feet
New Panamax	12,000	49–50 feet
Post Panamax	16,000	51 feet and above

* TEU refers to twenty-foot equivalent unit, which is a measure of volume in units of twenty-foot-long containers.
SOURCE: Jean-Paul Rodrigue, "Channel Depth at Major North American Container Ports," Hofstra University, Department of Global Studies and Geography, https://transportgeography.org/wp-content/uploads/Map-North-America-Container-Ports-Depth-1.pdf (accessed April 28, 2023).

Container shipping has been successful because it eased logistics and port operations while also increasing the security of cargo. Before container shipping, cargo was handled in bulk and repacked for movement off the pier leading to high pilferage and breakage. This problem was overcome by packing cargo in containers that a truck would move from the pier quickly

to its next destination. By conceptualizing shipping with the movement off the pier, container shipping represented an early step toward intermodalism—the transfer of cargo across various means of transport. The next era in intermodalism will be possible if several key technologies emerging now are employed in a new global logistics network. Five elements of this potential brave new intermodal world are (1) distributed production, (2) new cargo containers, (3) multi-mode transportation, (4) diversified port operations, and (5) massive cargo ships that hardly ever make port calls. An overview of these five elements follows (with a more detailed discussion in Appendix B):

1. Distributed Production. Logistics, no matter how modern, is about moving cargo. This means that several elements will persist: cargo-carrying platforms, the cargo container, sources of production, and the customer. Two developments are quickly altering the landscape of today's logistics networks: intelligent networks and additive manufacturing. Additive manufacturing uses seven techniques to "print" products, using digital blueprints to build layer-by-layer complex components across a variety of materials, including metals. Additive manufacturing does so with less waste and has enabled the production of intricate and lightweight parts not possible with traditional milling or casting. This technology has the potential to massively distribute points of production. Realizing its potential, the Navy first installed an additive-manufactured metallic critical part in one of its aircraft in July 2016 in a successful proof of concept and since May 2017 has focused on certifying additive manufacturing in operational (at-sea) settings.[45]

2. New Cargo Containers. Container shipping is widely recognized as one of the most transformative technologies in the history of shipping. A new intermodalism will likewise be reliant on new thinking about the simple container. Although the shipping container transformed the way the world trades more than 60 years ago, it has not been meaningfully updated to optimize modern trade. In fact, with container-volume utilization hovering around 65 percent, shippers often pay to move nothing but air in mostly empty containers.[46] Given the U.S. trade imbalance, volume utilization on the backhaul is often far lower. Optimizing container design for contemporary trade flows presents a considerable business opportunity. Moreover, limited container supply can hold up trade as demonstrated during the COVID-19 recovery when containers stacked up in China, delaying U.S. exports. The situation is made worse by the near-complete Chinese monopoly on container production, making developing and fielding a superior, scalable alternative by America and its allies a priority.[47]

3. Multi-Mode Transportation. During the COVID-19 pandemic, keeping truck drivers on the road proved critical to keeping stores stocked, until the recovery began in 2021, exposing a lack of drivers. (See Appendix B.) The Department of Transportation monitors congestion on the nation's roads, using a measure of travel time reliability to assess adequacy of the nation's roads. These reports, dating to 2010, have logged the average time that drivers are stuck in congestion to be four hours and 27 minutes.[48] So far, new roads seem to be keeping up with demand, but this congestion is costing trucking companies and commuters alike—$869 per commuter in 2022 ($81 billion total).[49]

Despite potential bottlenecks on the nation's roads, trucks will remain indispensable to moving cargo, but new unmanned drone and vertical-lift technologies could alleviate some of the burden on roads and greatly expand access to new locations. Additionally, shifting a greater share of domestic cargo to the sea and river networks will alleviate the driver shortage, minimize wear and tear on road and trucks, and increase demand for American maritime jobs. However, emerging technology, such as advanced lighter-than-air dirigibles and electric vertical take-off and landing (eVTOL) aircraft systems present an opportunity to reduce legacy operational expenditure barriers to such transport of cargo considerably.

The Navy has already demonstrated the ability to deliver a 50-pound cargo between ships 200 miles apart at sea using a Blue Water Drone prototype in 2019.[50] This capability is just what the Navy needs for 90 percent of its ships to carry cargo weighing less than 50 pounds. Commercially, however, these drones would have to be substantially scaled up to be useful.

A potential scaled-up solution is a prototype dirigible designed for cargo transport between ship and shore. Dirigibles are attractive as they are more fuel efficient than helicopters and have the potential for greater carrying capacity with less environmental impact.[51] In June 2022, Air Nostrum purchased 10 helium-lofted and electrically propelled dirigibles reportedly capable of moving 100 passengers up to 249 miles at 80 miles per hour (mph).[52] Lockheed Martin's LMH-1 dirigible can carry 21 metric tons of cargo at 77 mph for 1,400 miles.[53] The airship company Aeroscraft claims that its working prototype rigid dirigible can be scaled up to carry 66 metric tons of cargo up to 3,100 miles at a speed of 120 mph.[54] Cost-effective vertical lift offers the potential to connect cargo flows to and from ships with more locations closer to rail and logistic hubs, with less time in port, or avoiding port holding areas altogether.

4. Diversified Port Operations. Cargo's time on a dock can be reduced by increasing port cargo-handling infrastructure or by diversifying the

MAP 2

Opportunities for New Intermodalism

With rail, roads, and airports nearby, two dozen cities and ports on the West Coast of the U.S. could provide maritime shipping destinations currently available only to much larger ports.

SOURCE: Authors' research.

number of locations where smaller volumes of cargo can be handled. Throughput can be maximized by tackling the principal bottleneck, which is often the ship-to-shore transport. The heavy vertical lift mentioned previously can contribute, but avoiding ports altogether is not viable. Transshipment at sea offers a way to address the limits of massive new container ships to enter most ports.

Solving the challenge of keeping two ships stable enough to transfer twenty-foot equivalent unit (TEU) containers at sea also has military utility. Moving TEUs this way from massive container ships without coming to port requires smaller feeder vessels. Designing such a feeder vessel could spin off current designs for a light amphibious warship (LAW) and LUSV, the latter of which is basically an automated offshore support vessel. Such stability between ships at-sea is not a far-off development; it is a capability already used by support vessels that service offshore wind farms and oil rigs. Moreover, the Navy's *Spearhead*-class expeditionary fast transports (EPF) and experimental autonomous LUSVs have shallow drafts, which would be ideal for feeder ships with the cargo capacity that would open trade to previously inaccessible ports. This capability would provide greater logistical resilience with more secondary ports to which cargo can be moved with minimal new infrastructure.

5. Massive Stay-at-Sea Container Ships. The current champion of container ships can carry 24,004 TEU. Built in China, it is the beast *Ever Alot* measuring 1,312 feet in length and 201 feet in width, with a 55-foot draft. This immense size limits where the container ship can dock.[55] Carriers are ordering these gargantuan ships from Asian shipyards because the shippers are able to reduce the delivered cost per TEU with economies of scale. At the same time, clean-energy goals, such as IMO 2020, which mandate ever more stringent emission rules, are having significant design implications for future vessels and their energy sources.[56] Today, marine diesel remains the primary fuel for large commercial maritime vessels, but environmental and energy-efficiency concerns could ultimately lead to increased demand for maritime nuclear power.[57] Developments in other alternative fuels, such as clean hydrogen and liquid natural gas (LNG), remain viable alternates, but are not as "green" or low-carbon emitting as nuclear power, and ships so powered would still need frequent port visits to refuel.

Developments in small modular reactors offer a solution, possibly powering massive merchant ships with the greenest of energies, potentially without the need to refuel during the life of the ship. To build such vessels in the U.S. today would at first be constrained due to a shortage of

infrastructure. To overcome today's limited capacity, for example, of very large shipyard graving docks, vessels purchased on the open market could be modified in the U.S. These ships could be back-fitted with small modular nuclear reactors that provide electrical power and propulsion via electric-drive motors. The modularity of new small modular nuclear reactors conceivably eases the process of back-fitting. Once U.S. domestic production capacity matures, new massive container ships could be designed to incorporate these nuclear power plants, and, if needed, designed to ease refueling. This is not science fiction; nuclear power has been used on commercial shipping before. Under President Eisenhower's Atoms for Peace program, it was done with the nuclear-powered passenger and cargo ship *Savannah*. (For a discussion of the lessons of the *Savannah* and how modern commercial nuclear propulsion could be achieved with electric-drive technology, see Appendix B.)

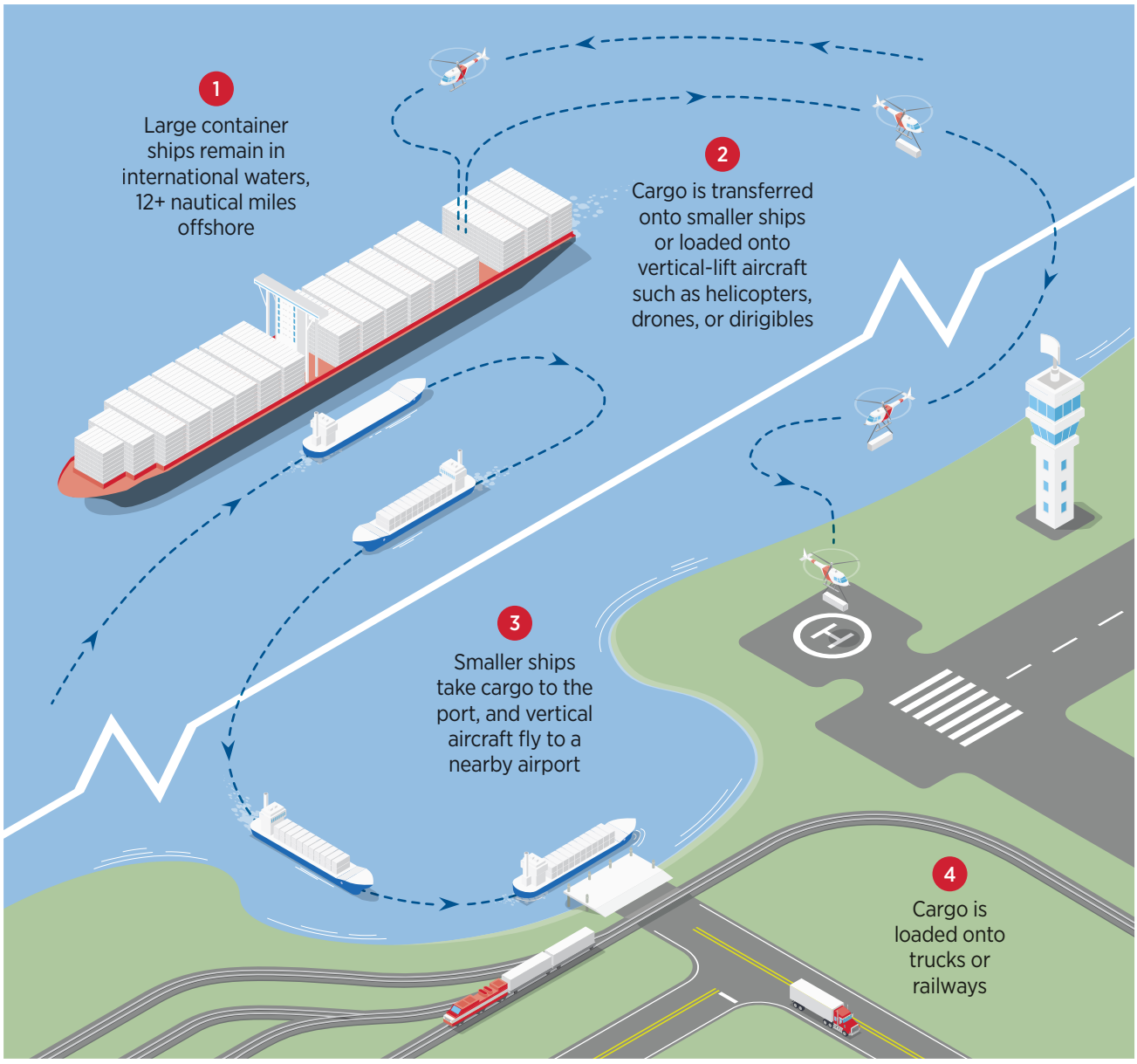
To achieve cost advantages from cargo-carrying economies of scale, massive ships will be needed. Using nuclear power for propulsion serves both to meet carbon-emission green energy goals, while freeing ships from the need for frequent refueling, thereby enabling them to stay at sea for very long durations while crews rotate to shore. Most important, perhaps, is that nuclear propulsion enables sustained higher-speed ocean transits, effectively increasing overall cargo throughput. While competitors are forced to constrain their steaming speeds to meet emissions requirements, higher-value cargo could find its way aboard nuclear-powered high-speed cargo ships to help to drive down inventory-carrying costs. Regulatory uncertainty for this bold new future is, however, a real factor. Employing nuclear power on commercial ships will require new port–state permissibility and the establishment of Emergency Planning Zones to set standoff distances from population centers in the event of nuclear incident. While entry to some ports would be desired, moving cargo from these ships miles offshore using dirigibles and cargo-carrying feeder vessels minimizes the number of ports where these arrangements would be required.

This new intermodalism vision includes massive stay-at-sea high-speed nuclear-powered container ships that can meet and exceed environmental standards for shipping. These ships would be serviced by feeder vessels and an array of vertical-lift aircraft to move cargo to and from shore, often many miles inland away from ports and nearer to logistics hubs or production sites. Several key technologies to realize this new intermodalism would be matured initially while meeting several key operational problems for the military.

FIGURE 2

The Concept of New Intermodalism

As maritime container ships grow larger, fewer ports will be able to accommodate their requirements for water depth, crane sizes, and offloading areas without incurring massive construction costs. One solution is to offload ship cargo without going to port.



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Kickstarting the Revolution in Shipping

Development of new methods of shipping and shipbuilding will be a key element of a new intermodalism, but not the only one. These engineering advances will be in tandem with the need to attract the workers to build, maintain, and run these new machines and get the concept to sea. Such a novel approach will need to bring together experts in finance, nuclear engineering, unmanned systems, education, and manufacturing. In the business world, start-up companies have benefited from so-called incubators that specialize in bringing diverse expertise and capacities together in one place to accelerate innovation and foster young companies. Inspired by business incubators, a similar approach can foster the early development of this new intermodalism while also attracting new entrants to the maritime sector and as merchant mariners.

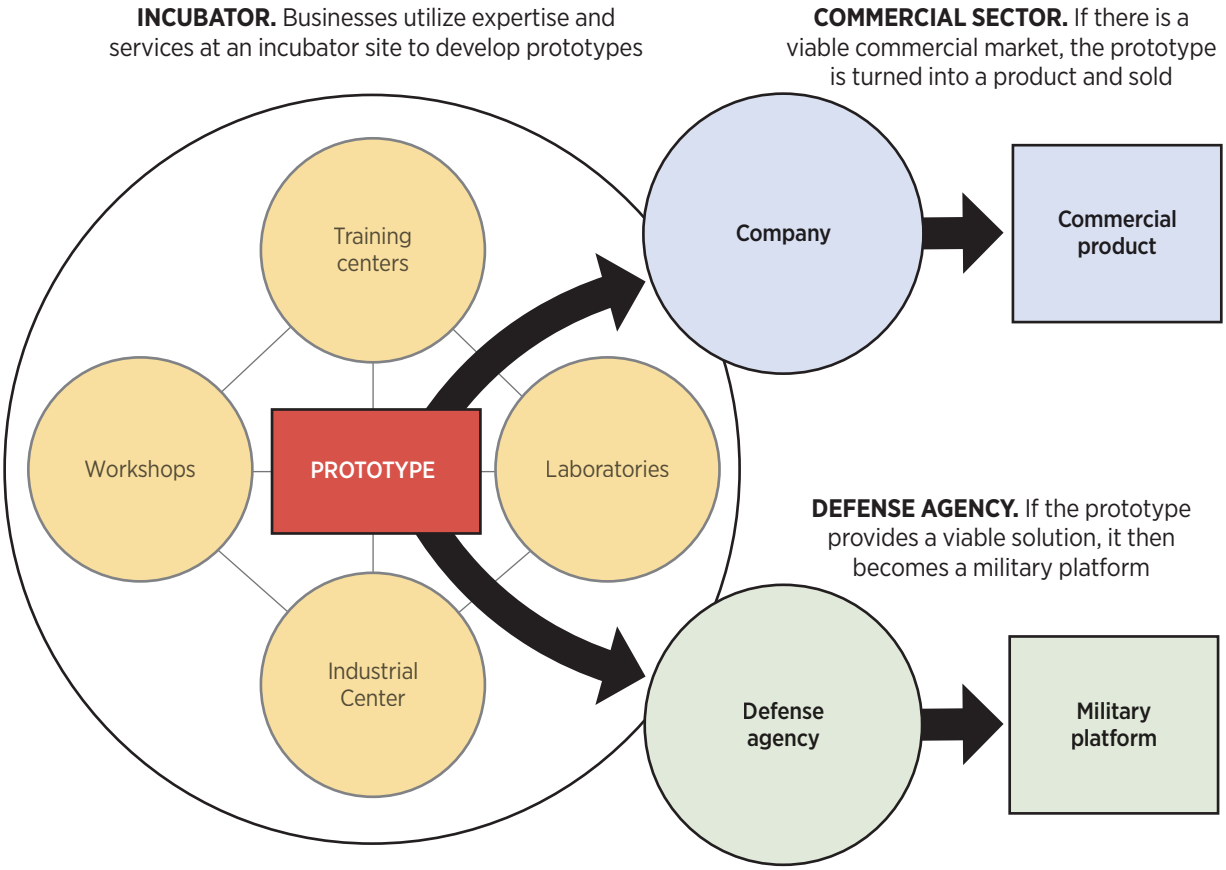
The DOD is attempting something like this. In 2015, the Defense Innovation Unit (DIU) was established to accelerate adoption of commercial and dual-use technology to solve military operational challenges.[58] The DIU solicits commercial venders to provide solutions on contract, by leveraging authorities for rapid prototyping using "Other Transaction" authorities.[59] Unlike narrowly focused business innovation incubators, the DIU has been broadly focused on a range of technologies and does not consider the commercial application of developed prototypes. The result has been a predictable and correct criticism of the DIU—that it fails to adopt at-scale new technologies that offer a return on investment to commercial participants. It is a sentiment echoed by Mike Brown in a 2022 interview at the end of his four years as Director of the DIU.[60] Then, again at a 2020 Aspen Security Forum that included the Secretary of Defense, Shield AI chief executive officer Ryan Tseng captured the sentiment: "The DoD and the national security sector need to find a way to allow companies to generate returns for their investments in innovation.... Without the right incentive structure, little will get past research and development and prototype grants."[61] An intermodal innovation incubator can avoid the shortcomings of the DIU by focusing narrowly on military maritime operational problems that can transition to commercial application. Additionally, unlike the DIU, accelerating innovation in new prototypes, as well as support for scaling up production would be enabled by co-locating research, production, and training facilities.[62]

Then, as the innovation incubator begins to deliver results, there will be a need for greater access to places with the associated infrastructure and platforms—albeit with comparatively less investment than port expansion

FIGURE 3

Creating a Defense Department Innovation Market Bridge Incubator

The business world has long used an "incubator" to provide services to benefit start-ups. The Department of Defense could embrace this concept to produce prototypes, assist DOD procurement processes, and enter the commercial sector for appropriate innovations.



SOURCE: Authors' research.

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and new intermodal connectors like roads, railways, and airports. The sites for new investment should take a page from the Trump Administration's "opportunity zones" program. These were created in 2017 and intended to attract investment to economically distressed neighborhoods by providing investors a way to invest profits while avoiding capital gains taxes.[63] A similar approach could be applied to communities that would host nodes of the new intermodalism—such as ports and distribution centers. Infrastructure investments would, in turn, be incorporated and stocks offered as an added incentive to investors. If they existed today, a beneficiary of such intermodal

opportunity zones would be the investors in the Port of Ponce, Puerto Rico. Scale AI has invested $2 million to turn the port into a smart port lab to mature technologies that could be used at other ports.[64] Technologies to be matured there include AI-enabled document processing, route optimization, object recognition, computer vision, and remote operations.

Recommendations for Congress and the Administration

Until the U.S. can compete globally in shipping and shipbuilding, building the Navy that America needs will face higher costs, limited industrial capacity, and potential technology constraints. All the while, transportation-intensive industries across the economy will continue to flee to countries with more favorable maritime logistics and hinterland trade connectivity. Consequently, the nation's economy will increasingly rely on the shipping of hostile nations or those of questionable reliability—while continuing the decline of the American maritime sector. This trend can be reversed by bringing together know-how from disparate technical fields and expertise to create a domestic landscape that can host a sustainable competitive advantage in American shipbuilding, shipping, and logistics. American manufacturing produces near-record amounts,[65] and this strength needs to be carried over to the maritime sector, which truly is a national strategic asset. To achieve this end state, the U.S. government should:

- **Publish a national maritime strategy.** The President should publish a national maritime strategy laying out specific tasks and those agencies and people responsible for executing it. The goal is regaining American global competitiveness in shipping and shipbuilding while meeting current military needs. Such an endeavor is long-term and requires an associated execution plan to ensure progress can be monitored. This effort should include replacing the outdated National Security Directive (NSD-28) on Sealift signed by the President in October 1989.[66]

- **Establish a maritime innovation incubator.** Congress should direct creation of a maritime innovation incubator administered by the DOD, leveraging expertise of the DIU.[67] Co-located at this site would be business and engineering support services needed by innovative start-up companies and new commercial entrants to the maritime sector, including machinery workshops and training centers. The intent is to provide an environment conducive to creating

the technologies and workforce needed for a new intermodalism, while providing solutions to relevant near-term military key operational problems.

- **Incentivize competitiveness of American merchant mariners.** Congress should authorize funds for, and the President should direct the Secretary of Transportation to establish, an advanced mariner training center and naval architecture advanced degree programs, ostensibly co-located with the maritime innovation incubator site. In conjunction with the innovation incubator, co-located training centers should provide cutting-edge education in industrial skills, advanced degrees and certifications for naval architects, and advanced operational training relevant to the new intermodalism (such as unmanned ship operations and advanced port operations). Stipends should be offered to promising candidates from the maritime sector with assurances that, upon completion, students can return to their prior employment. Congress and the Secretary of the Navy should establish a new Maritime Fellowship focusing on graduate-level education (such as naval architecture), with options for allied nations to send instructors and possibly students. Lastly, until there is a large and viable American shipping industry, a stipend should be offered to American merchant mariners serving aboard friendly foreign-flag ships to maintain relevant maritime certifications. These mariners would be obligated to recall and serve on U.S. merchant vessels in time of war. (For a deeper discussion on the limited number of U.S. merchant mariners, see Appendix A.)

- **Create new intermodal opportunity zones.** Congress should update legislation regarding opportunity zones and focus efforts on attracting investments at key waterfront and intermodal locations. These opportunity zones will form the backbone of the new intermodalism—such as ports, inland distribution centers able to be connected directly to massive container ships at-sea via heavy-lift aircraft, and smaller cargo feeder vessels.

- **Strengthen U.S. ability to combat unfair Chinese maritime business practices and incentivize U.S. shipping.** The President must direct policy changes and seek increased resourcing to agencies combating harmful Chinese maritime business practices at home and

abroad. For instance, the Federal Maritime Commission, established to protect American shippers from unfair foreign practices, should be resourced to expand its workforce to better enforce U.S. regulations and at new ports. Additionally, Congress should update existing laws for preferential sequencing port access and services for all U.S.-flagged vessels in U.S. ports and waive port fees for these U.S. vessels. (See Appendix A for details.)

Conclusion

The atrophied state of U.S. maritime logistics contributes to ongoing deindustrialization and abets significant, intensifying national security risks. Returning to America's roots as a maritime nation and manufacturing powerhouse and assisting the necessary innovations to do so in the modern era will be pivotal. Fostering an American revolution in shipping can energize a lethargic industrial sector critical to the nation's defense and render it able to sustain a wartime economy.

A stronger and globally competitive maritime sector serves as a deterrent against Chinese economic coercion and military adventures. With it, American trade can proceed unimpeded and with confidence that the U.S. military can sustain combat operations on U.S.-flagged vessels. In addition to serving American security needs, this revolution in shipping has the potential to mitigate environmental impacts, to promote domestic production, and expand American exports to global markets, which can spur wider job growth and advance technological innovation in the U.S.

Appendix A: Unleashing Maritime Market Forces and Curtailing China's Unfair Practices

Good ideas are insufficient if regulators stand in their way. The global and domestic maritime marketplace is already difficult for new entrants, and any innovator facing hostile regulators in the U.S. may look elsewhere. Overcoming these challenges with leadership is just the first step; attracting new talent into the maritime sector and creating market space for even a rudimentary novel concept of intermodalism will be critical.

Addressing the Chinese Maritime Threat

On January 1, 2017, a new Chinese law, the National Defense Transportation Law, came into effect making clear that transport and associated infrastructure was a national asset as part of civ-mil fusion policies.[68] This new law built on a 2015 regulation, Outline for Training and Evaluation of National Defense Transportation Specialized Support Teams, which mandated military training of personnel in "transport support teams" for ship, rail, air, and highway transportation.[69] Naval analyst Thomas Shugart has tracked the development of Chinese civilian car ferries for a potential invasion of Taiwan, noting that China has conducted training on retrofitted ferries able to embark tanks and has practiced the deployment of amphibious assault vehicle from these ferries while at sea.[70] The reality is that Chinese commercial ships are also military assets, and so are the crews.

If there were any doubts that Chinese commercial shipping serves the Chinese Communist Party (CCP), those doubts should be put to rest. A rare glimpse into the political life of COSCO crews was unveiled through the publication of several leaked corporate documents. These documents reflect crews attending political study sessions and corporate political training given to ship captains, and all swearing loyalty to the CCP.[71] According to these leaked documents, at least 10,000 party members and 150 senior special party cadre members are spread throughout COSCO's fleet and port operations. In fact, given troubling news of illegal overseas Chinese police stations, these documents also indicated that COSCO based 23 party members in New York and 24 in Piraeus, Greece. The implication is that far more than commercial interests are driving COSCO, and its presence overseas often serves political purposes.

COSCO has embarked on a decades-long effort to become a global leader in shipping and port operations. Today it has stakes in approximately 100 ports outside China, a third of which have hosted Chinese naval vessels. In

September 2021, Hamburg's Tollerort port in Germany became the 96th port outside mainland China with a major Chinese stake.[72] The deal gave COSCO a 24.9 percent stake in the port, over the objections of Germany's foreign office and five other ministries who were ultimately overruled by Chancellor Olaf Scholz. Scholz's argument was that Chinese money would simply go to another port in Poland if not Hamburg. The lesson is that Chinese investments in ports are not only guided by economics, but by strategic-political calculations with inherent risks to host nations.

So far, the U.S. response to China's global maritime market ascendency has been largely muted. Instead, despite ardent support for Jones Act limitations, some U.S. shipping companies, such as Matson, spend tens of millions on maintenance for their U.S.-flagged vessels in Chinese shipyards every year. The cost advantage of employing state-owned Chinese shipyards outweighs the 50 percent *ad valorem* tariff on foreign yard maintenance. This is particularly egregious given the possible counterintelligence value and the obvious deleterious impact to domestic shipyards. Moreover, the safe and timely operation of harbors is supported by duties collected for the Harbor Maintenance Trust Fund (HMTF); financing periodic dredging is required to keep ports open as silt builds up. But the HMTF has not resulted in significant improvement of shipping access or modernized harbor infrastructure. To better enforce U.S. regulations, a relatively small $6 million infusion is planned as part of the Ocean Shipping Reform Act of 2022 for the Federal Maritime Commission (FMC) to increase its staff with up to 170 new hires as it works through 200 complaints that spiked during the post-pandemic recovery and associated shipping backups at numerous American ports.[73] Lastly, increased cargo preference (such as government-impelled cargo to U.S.-flagged carriers) has been proffered as a means of sustaining a minimum of American shipping by impelling cargo financed by the U.S. government to keep these carriers financially afloat (solvent).[74] However, such assurances distort the U.S.-flagged shipping market to gravitate further toward limited government contracts, rather than gaining a competitive advantage against foreign competitors by increasing quality, productivity, and value.

Moving Away from Flawed Tools of Government

Tools that have been used to sustain a minimum of civilian shipping to meet military operational needs include cargo preference laws and stipends to support U.S.-flagged carriers and funding for the National Defense Reserve Fleet (NRDF) totaling 95 ships of varying classes as of

March 31, 2023.[75] According to the latest inventory report of August 2022, this number is augmented by an additional 59 commercially active but militarily useful vessels on retainer through the Maritime Security Program (MSP).[76] A subset of the NRDF is the military-focused Ready Reserve Fleet (RRF) that at the same time consisted of 41 roll-on/roll-off (RO-RO) ships, two break-bulk ships, and four crane ships.[77] Falling under the Department of Transportation umbrella, the Maritime Administration administers these support and readiness programs and was authorized in the National Defense Authorization Act of 2021 to establish the Tanker Security Program (TSP) to expand access to commercial U.S.-flagged tankers for war sustainment through stipends to incentivize flagging of foreign tankers.

As the law is written, this new TSP is not scalable, and while 10 ships are authorized, the reality is that far fewer tankers have been secured through the TSP. Those ships that have signed up for the TSP, according to industry experts, are doing so often while concurrently benefiting from government cargo-preference deals. The implication is that the stipend is too small—$6 million per ship maximum. When considering costs to modify commercial tankers to supply military vessels (CONSOL installation), the cost premium of an American crew, and relative market competition, the TSP is not a lucrative enough business proposition. The stipend would likely have to be above $10 million per ship, and not enough military cargo is available to make TSP participation lucrative.

As explained, the ability to clear ports of cargo is vital, and rail transport still serves a critical role. But after a decade of cost cutting, U.S. rail carriers have too few engines driving fewer, but longer, double-stacked trains that are degrading rail lines not updated for the heavier loads.[78] This development is encouraged by regulations that discourage capital investments while layering additional requirements that may not ensure adequate safety, making disasters, such as the train derailment in East Palestine,[79] more likely. These are pressures that percolated to a near national rail strike that could have cost the nation $2 billion daily.[80] The U.S. needs a shipping strategy that includes enhancing transportation competitiveness and attractiveness of American ports connected to global markets.

Making the Jones Act Unnecessary

Congress has created several mechanisms for ensuring that the nation can meet its military sealift needs. Despite the repeated testimonies by successive DOD Transportation Command Commanders citing the criticality of recapitalizing the RRF, the issue has been a political football passed

from Administration to Administration, remaining unresolved. Plans to help the U.S. shipbuilding industrial base and to bolster U.S. sealift capacity and reliability by replacing decrepit vessels has also fallen flat. Attempts to purchase modern domestically built ships came to a halt following congressional testimony that it would cost 26 times as much to build each vessel domestically than to purchase used foreign-built alternatives.[81] Limited American shipyard capacity has been squeezed to the brink of starvation and places emphasis on winning higher value naval combatant contracts, further constraining the lower-end sealift construction base. As this dying RRF fleet gasps its last breaths and Beijing continues to build out its maritime logistical prowess, the American approach must change.

The reality is that the Jones Act has failed to meet its stated intent. Due to a captive market, dominated by a small handful of politically connected shipowners, the domestic blue-water fleet that the Jones Act sought to bolster has instead relegated itself to carriage of only the most inelastic cargo where no other alternatives exist. Because of market distortions that it has caused, U.S. commercial shipyards have become upwards of 60 percent less efficient than overseas shipbuilders and are producing ships of limited value to the Navy's logistic needs at a 700 percent price premium.[82] The most modern, productivity-enhancing capital improvements, such as automated welding systems prevalent in leading shipyards globally, remain elusive to most domestic shipyards. Moreover, American carriers are punished with an *ad valorem* tax when conducting maintenance overseas at more modern and cost-effective shipyards, a vestige of the Tariff Act of 1930 (though this does not stop American carriers from doing maintenance overseas given the considerable savings over domestic shipyard work).

Another failure has been ensuring an adequate number of available and certified U.S. mariners that would be needed in a sustained crisis. While testifying before Congress in March 2020, former Maritime Administration head Rear Admiral (ret.) Mark Buzby, drew attention to the inability to train and attract U.S. merchant mariners with viable jobs.[83] Another study from 2016 found a shortage of well above 15 percent of needed crew members (a gap of approximately 2,000 trained and physically ready people), who today have an average age of 47.[84] While some experts have voiced serious concerns about this study, there is a consensus among experts that the nation has a problem ensuring that it has sufficient merchant mariners.

The Jones Act fleet has a significant capability problem. Spanning decades, a lack of competition has driven the fleet into a deadweight-tonnage composition reflective of supply chains that have no alternatives. Now, the vast majority of fleet capacity is dedicated to domestic petroleum

movements that do not have pipeline alternatives. This lack of fleet diversity presents a considerable challenge to the broader strategic mobility systems needed today and that Mahan envisioned for powerful navies bolstered by robust merchant marines. Because the Jones Act fleet has retreated into these most inelastic domestic supply chains, repurposing tonnage for wartime use would deplete domestic energy security. For this reason, it is unlikely the Jones Act fleet would play a meaningful DOD role in support of wartime strategic mobility.

The Jones Act intended in its several minor updates since 1920 to ensure that U.S. shipping remained competitive, carrying a majority of American seaborne commerce. At a minimum, the act attempts to maintain competitiveness by requiring that all shipping between U.S. ports be conducted on domestically flagged, crewed, and built ships. The reality is that today's domestic fleet is commercially uncompetitive and unable to sustain distant military operations away from American shores. Any meaningful reform must make the commercial competitiveness of a U.S.-fleet a principal objective.

An undersized American maritime sector severely constrains the nation's ability to mobilize for war, to sustain a wartime economy, or to sustain a warfighting fleet. The result is a weaker deterrence to China, opening Americans to economic coercion. During the 1991 Gulf War, 13 foreign-chartered vessels refused to enter the war zone, delaying delivery of military materials. If a major war occurred in 2020, military sealift would have had to include a combination of domestic shipping, America's allies, and contractual obligations with third parties to meet the need for 19.2 million square feet of cargo capacity and 86 tankers.[85]

An interim solution would be to relieve treaty allies from the restrictions of the Jones Act and allow Japan and South Korea to conduct shipping between U.S. ports. Waiving the Jones Act limits on ships built and registered in allied countries would avoid subsidizing Chinese shipyards and instead contribute to the allied shipbuilding industrial bases. This could be achieved by incentivizing allied shipping and overseas maintenance. As part of the deal, stipulations could be included that allied commercial ships employ a certain number of U.S. merchant mariners and conduct some repairs and improvements in American shipyards.

Waiving allies from Jones Act restrictions is only temporary until policy can support and American ingenuity delivers a new competitive intermodalism. If successful, a larger, more competitive fleet would also facilitate a modal shift of domestic freight to the water and expand transportation-intensive American manufacturing industries.

Facilitating Growth of a New Intermodalism with Intermodal Innovation Incubator Zones

An important advantage of the business incubator is proximity to various enterprises and associated business services. Geographic proximity of such business support services, such as financing and groups of small enterprises involved in developing various elements of the new intermodalism, will be critical. This enables cross-communicating engineering and technical developments, such as between nuclear-powered massive container ships with another group developing feeder vessel stability systems. This approach could also accelerate development of shared technologies and access to common resources, such as machinery shops and welders. The organizing principle for this innovation incubator would be the development of a viable new intermodalism.

Given the imperative of the military to be postured for a war with China, this incubator would first focus on developing several key militarily useful capabilities, such as the VLS reloads at sea. Initially, the incubator, while focused on developing solutions to VLS reloads at sea, would also look for ways to apply such developed technologies to shipping and shipbuilding. As prototypes are developed and operated, the lessons learned will inform the training of the workforce that builds, operates, and maintains them. Co-locating training centers with the developers would create a rapid feedback loop informing the training of associated workforces.

An additional task of such an incubator is to encourage personnel to enter the maritime sector. This will require attracting a younger population with offers of meaningful work and advancing in exciting new fields with lucrative careers. This cannot be a ground-up approach, and leveraging the workforce of today will be necessary to benefit from the decades of collective experience in shipyards and operating ships. To do this, a co-located training center focused on advanced naval architecture education, modern shipyard industrial techniques, and operational mariner proficiencies will be needed. However, getting shipyard workers and naval architects to leave their jobs for the prospect of improved skills will require arrangements that benefit them as well as their employers. One way to do this is to create a program modeled on the Fulbright[86] and Mansfield[87] Scholarship programs that focus on exposing U.S. participants to international institutions and new ways of doing business. A new maritime fellowship for aspiring maritime professionals and skilled industrial workers could be offered. This would bring together experts and skilled shipyard workers from around the nation and some allied nations to share best practices, study, and advance relevant

new processes and technologies, such as unmanned ships. Another element of this training institution would focus on the operators.

The U.S. currently has a deficit in able merchant mariners, and increasing their number means providing options for pursuing lucrative careers at sea. If a "sustained crisis" were to occur, the number of required U.S. mariners (many approaching retirement age) would fall short. Addressing this shortfall is the duty of the Maritime Administration, which has tried to use student incentive payments to pay for college with associated obligations to serve in the merchant marine.

However, without a viable industry to work in many potential takers have forgone the $12,000 per year scholarship offered. While more is needed to entice people to become merchant marine officers, more is also required to attract and retain more shipyard workers and the crews of modern merchant ships. Doing this will be necessary to sustain American shipping and shipbuilding. In addition to increased scholarships for college, longer associated service obligations (currently only three years) and new stipends targeting skilled laborers are needed to entice the next generation of shipyard workers with its much-needed cutting-edge technical skills.

Additionally, until American shipping returns with a new intermodalism, career options will be needed to ensure that enough American merchant mariners retain the skills required for operating at sea. One way of doing this is to offer salary offsets to those working for allied nations' shipping companies to allow them to keep their mariner certifications current while accepting competitive-but-lower wages from foreign shipping companies. Eventually, these mariners would return to be trained at, and eventually take over the ships of, a future American shipping fleet.

Appendix B: Elements of the Next Intermodalism

Five elements of this potential brave new intermodal world include distributed production, new cargo containers, multi-mode transportation, diversified port operations, and massive cargo ships that hardly ever make port calls.

Distributed Production

In January 2021, the Defense Department doubled down and committed all services to adopting additive manufacturing and identified eight U.S. firms as additive manufacturing innovation institutes to help to bring this technology to the military.[88] The implications to global supply chains are immense, opening new markets and centers of production. However, connecting these new centers of production requires a secure method of communication and tracking and decision assistance, and the new technology of blockchain offers a solution.

While famous for their application to cryptocurrencies, blockchains offer dramatic improvements in logistics and manufacturing, too. They do this by effectively automating the verification and communication of data, while cheaply offering increased security, transparency, and accountability. In simple terms, blockchains are decentralized registers of transaction data that function like a traditional database but can cheaply encompass a massive network to track the movement of cargo. Because blockchains natively operate across borders and languages and can use customizable permissions and rules, when paired with verifiable, immutable data inside smart cargo containers, the combination can ease customs processing and security of sensitive or perishable cargo. These features offer important safeguards against human error, fraud, illicit use, and corruption. Blockchains are already being widely researched and implemented in at least 65 industries, including shipping, logistics, manufacturing, insurance, and national security applications.[89]

Because of their potential in these areas, blockchains attracted $25 billion in venture capital investment in 2021, up 713 percent from the previous year.[90] Paired with a powerful artificial intelligence (AI) decision-assistance program, the potential of adaptive-predictive logistics chains becomes more possible. Given the CCP's demonstrated history of usurping critical first-mover status in emerging technologies, the U.S. must guard its advances.

Meanwhile, the U.S. and its allies must prioritize innovating and building market dominance in maritime blockchain technology. Furthermore, truly

opening up new logistic chains will also require a re-examination of the simple cargo container.

New Cargo Containers

Today, container shipping and airfreight rely on two common containers—the twenty-foot equivalent unit (TEU) and the forty-foot equivalent unit (FEU).[91] U.S. federal regulations stipulate weight limits for truck cargo (80,000 pounds) and rail-car cargo (286,000 pounds), which do not consider local bridge, state road, or environmental constraints. With these limits in mind, industry generally recommends that TEU containers not exceed 44,000 pounds (22 short tons), including varieties with self-contained refrigeration units for moving perishables.[92] Air freight containers come in a wide array of sizes and shapes and are most often made with lightweight aluminum. Conventional steel TEU containers do not lend themselves to multiple shipping modes like airlift, limiting their use in a future with increased air transport that potentially alleviates road and rail congestion.

In recent years, progress in the development of "smart rail cars" has been made. These "smart" cars' movement is tracked, reports sent when freight is accessed along the way, and provides monitoring of the environmental conditions in the container holding the freight.[93] Married with the technology of blockchains, shippers can receive real-time data to inform delivery schedules, prompt customs clearances, optimize transit routes, and ensure that perishable cargo arrives without damage. Returning to the humble shipping container (the TEU), three Chinese companies in 2021 manufactured 96 percent of the dry cargo containers and 100 percent of refrigerated cargo containers.[94] During the COVID-19 pandemic and the recovery in 2021 and 2022, China's "zero-COVID" policies saw frequent port disruptions delaying movement of containers, which, without U.S. container manufacturing capacity meant that cargo had to wait for containers to arrive from China, the cargo emptied, and then delivered to the shippers. The result was significant delays and a doubling of shipping rates between U.S. ports and China between April 2020 and April 2021.[95] The scarcity of containers and Chinese policy impacts provides a lesson for why more distributed manufacturing of containers is needed, as well as new designs that enable new intermodal shipping.

New containers with some level of reverse compatibility, that can be carried on massive container ships side-by-side traditional TEUs, will be needed. New air-freight-capable containers could conceivably be connected together into a TEU or FEU footprint for shipping and broken down for air

freight or smaller trucks. Another method is to use new materials, such as advanced composites, in the fabrication of shipping containers that offer greater cargo capacity with less tare weight.[96] Lastly, methods of handling these new containers on container ships will be needed to enable transshipment at sea via support ships and vertical heavy-lift air platforms.

Multi-Mode Transportation

According to the American Trucking Association, in 2022 there was a deficit of 80,000 drivers due in part to accelerated retirements during the pandemic, in a sector where the majority of drivers are above 55 years of age, and too few new hires given the difficult lifestyle and low pay.[97] Trucks carried 72.2 percent of domestic freight tonnage in 2021 on the nation's roads and transported 66.1 percent to Canada and 82.7 percent to Mexico in value of trade that year.[98] Beyond the existing deficit in drivers, meeting demand will require an additional 90,900 new drivers to be hired by 2031—all for jobs that in 2021 paid an average $23.23 an hour.[99] Even if the drivers could be found, it is an open question whether road expansion can support this expected growth in truck transport.

The military, for its part, has long had to contend with moving cargo over rough and contested terrain without roads, ports, or airfields. The helicopter proved critical in meeting this need and opened an entirely new element of naval and amphibious warfare. Helicopters were able to move between warships at sea without large flight decks, were fitted with submarine-detecting sensors and weapons, became a formidable threat to hostile submarines, and acted as combat ambulances moving wounded rapidly from the front line to medical centers. The value of these missions validated the operating costs, ranging from the legacy CH-47 Chinook heavy-lift helicopter's approximate $4,000 per flight hour at the low end, to the CV-22 Osprey tilt-rotor craft's almost $80,000 per fight hour.[100] Though the range, speed, and access to otherwise inaccessible locations are useful to the military and a great advantage, if the cost cannot be reduced, it will be problematic in commercial applications.

Air freight, conducted on fixed-wing aircraft, is the most expensive commercial means of cargo transport, relegating it to the highest-value and most time-sensitive cargos. According to several case studies carried out by the World Bank, air freight is four to five times more expensive than trucking, and 12 to 16 times more expensive than sea transport.[101] Comparing truck to rail transport, analysis of the American market points to a cost advantage to rail by a factor of three (or one-third the cost per ton

via trucking).[102] Lastly, detention and demurrage fees for cargo waiting for movement from the port holding area can average $100 per day per TEU.[103] If the cost per ton per mile of air freight could be reduced by half it would become competitive with trucking, especially over congested roadways or destinations not currently connected by rail. Short-haul air freight could then unlock potential savings by shortening the time that cargo waits in port for movement and circumvent overland road and rail bottlenecks near ports of entry.

Relative Shipping Unit Cost =

16(miles via air freight) + 9(miles via truck) + 3(miles via rail) + (miles via ship) + 100(days in port)

Cheaper to operate, high-productivity unmanned helicopter drones (such as the K-MAX) and modern dirigibles present potential solutions to otherwise untenable air freight costs. In recent years, interesting developments in piloted and autonomously piloted "air taxis" have been noted.[104] For example, widely available heavy-lift drones carrying up to 500 pounds are now price-competitive with low-end helicopters, with ongoing improvements making this even more so.[105] Moreover, the Navy has already demonstrated the ability to deliver a 50-pound cargo 200 miles to a ship at sea using a Blue Water Drone prototype in 2019.[106] For the Navy, this capability is just what is needed for 90 percent of its shore-to-ship cargo weighing less than 50 pounds. Commercially, however, these drones would have to be substantially scaled up to be useful.

Diversified Port Operations

To manage today's shipping, companies like Flexport are streamlining existing supply-chain and transport networks. It is a lucrative business line, but not revolutionary. When a container ship carrying thousands of TEUs arrives in port, it usually takes days before the cargo is on its way, and then longer still before it reaches its destination.[107] The actual time it takes is a function of crane availability and ground-transport availability for onward delivery. If the cargo within a TEU container must be further broken down for onward delivery, that adds still more time and requires warehousing, which can be in short supply. All this handling takes time and money, and reducing the need for these movements is where the next revolution in shipping resides. The key feature of Flexport's approach is getting cargo on and off the dock quickly. A new intermodalism must do this—and much more.

Conducting cargo transfers to smaller feeder vessels opens shallow water ports often without the pier space or cranes to service modern and

future container ships. After a review of nautical charts and rail and road maps between Los Angeles and the Straits of Juan de Luca to Port Angeles, Washington suggests there are at least 16 ports that could achieve greater global trade connectivity using these types of feeder vessels. Today only three geographic locales service the vast majority of West Coast American container traffic: San Francisco Bay (Oakland, San Francisco), Puget Sound (Seattle, Tacoma), and Los Angeles-Long Beach. Diversifying ports of entry would ease existing bottlenecks, while increasing trade connectivity that would benefit Americans.

Massive Stay-at-Sea Container Ships

As regulations championed by environmental activists are put in place regulating carbon emissions, shippers and shipbuilders are having to look to green-energy solutions. At the same time, the International Energy Agency has emphasized nuclear power as a viable, cost-effective green-energy production method.[108] Likewise, recent developments in small commercial reactors could usher in a renaissance of nuclear power at sea. This has been tried before, most notably in President Eisenhower's 1955 Atoms for Peace program and the related launching of a nuclear-powered commercial ship the NS *Savannah*. The ship has been anchored since 1970 and today rests in Baltimore harbor. The cost of operating and maintaining the earlier nuclear power plant and the lack of cargo-carrying capacity proved cost prohibitive and the idea failed to become profitable. That could change with new advanced small modular reactors.

On July 29, 2022, the U.S. Nuclear Regulatory Commission (NRC) approved NuScale's small modular reactor design.[109] NuScale's reactor uses passive means to cool its pressurized power plant by submerging it in water. It produced 600 megawatts of electricity in a 12-reactor module grouping. At 50 megawatts each, one or two of these cores could potentially power large container ships using already proven electric-drive methods of propulsion. Other small nuclear reactor designs potentially suitable for shipping are in the works, like TerraPower's[110] molten-salt reactor and a 15-megawatt heat pipe reactor (HPR)[111] being developed at the Los Alamos National Laboratory.

All these designs will drive electricity-generating turbines. For ship propulsion, electric drives, instead of a steam turbine attached through reduction gears to a propellor, are used. The generated electricity powers an electric motor that turns the propeller with far less penalty to cargo capacity. Electric drives are a proven design, having been used on various

warships starting in the 1930s, such as on aircraft carriers *Langley*, *Lexington*, and *Saratoga* and five battleships, such as the *New Mexico*.[112] Based on this track record and technological advances, the latest U.S. Navy warships, like the destroyer *Truxtun* in 2018, have employed these systems with favorable results, such as reduced fuel costs and ease of operations by the crew.[113] The more advanced *Zumwalt*-class destroyers have an integrated power system (IPS) that also uses electric motors rather than large and very heavy reduction gears to reduce the high speed of turbines used for generating electricity into motive force directly. The *Zumwalt*'s IPS can generate 78 megawatts of power, using only 17 of that to propel the ship at a speed of 20 knots.[114]

Electric propulsion has likewise matured in the commercial setting with recent newbuild cruise ships providing up to 20 percent fuel savings.[115] While still in development, the recent movement to prototype several small modular reactors holds promise for future maritime use. These new designs' modularity could enable the new nuclear power plants' early use in back-fitted container ships with electric-drive propulsion, and ease future nuclear refueling, if needed. Ideally, a commercial small modular reactor purpose-built for powering a large container ship would be designed for the life of the ship—approximately 20 years.

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