USE AND REGULATION OF AUTONOMOUS AND EXPERIMENTAL MARITIME TECHNOLOGIES

Testimony of

Michael Gordon Johnson

Marine Engineer

Founder & CEO of Sea Machines Robotics, Inc

of Boston Massachusetts

before the

Subcommittee of Coast Guard and Maritime Transportation

Committee on Transportation and Infrastructure

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Opening

Chairman Webster, Ranking Member Carbajal, and Members of the Subcommittee, it's with sincere gratitude that I've been invited to submit testimony with my perspectives on the purposes and value of innovation in the maritime industry and specifically marine autonomous technology as it applies to surface operating vessels.

By way of additional background, I am a degreed marine engineer, and I held an engineering officer's license in the United States Merchant Marine before moving into ship repair and shipbuilding. I've managed vessel projects in many nations and was a Vice President of Project Management at Crowley Maritime and Vice President of Operations at Crowley's affiliate Titan Salvage. I have extensive experience in designing solutions for and leading teams in complex marine projects. After owning a marine project management company which mostly focused on offshore installations, I founded Sea Machines Robotics Inc. (Sea Machines) in 2017 to build autonomous technology for the marine sectors. Sea Machines sells products to domestic and international customers and has served multiple U.S. Government departments and agencies.

Introduction

The 21st century is the era of self-sensing and self-determining advanced automation, also known as autonomy. It's taking robotics and non-mechanical machines beyond the low-level and prescriptive tasks of the last century, enabling exponentially higher productivity and machine value to society. Autonomy is already active and growing in capability in general computer processing systems, data processing, medical diagnostics, aircraft and spacecraft control systems, agriculture, and warehouse logistics and now emerging in automobiles, trucking, and maritime.

Industry Facts

The maritime industry does everything on the water-covered surface of the Earth, and that's almost three-quarters of it. It operates the largest machines built by humankind and facilitates most global trade. And licensed mariners, notably some of the best trained professionals of any industrial space, maintain these powerful machines and pilot them in the Earth's most dynamic and forceful environment. The industry is a leading contributor to our nation's economy and according to the U.S. Bureau of Economic Analysis and NOAA the marine economy accounted for 1.9% of our nation's GPD in 2021 or $432 billion. To put that in perspective, that's 2.5 times the reported output of America's farms in the same year. They further report that the marine sector provides 2.3 million jobs with an average annual salary of $81,000 which is 13% above the U.S. national average in the same year. Leading subsectors include marine tourism and recreation, national defense & public administration, offshore minerals, and marine transportation & warehousing.

Even though the marine industry contributes more to the U.S. economy than arts and entertainment, or utilities, or even modern data processing, it seemingly operates under the radar of most and receives comparatively little public attention.

Problem from the Macro Economic Perspective

The United States no longer holds the leading or influential position in the global maritime industry, the exceptions being the shrinking global presence of the US Navy and Coast Guard and some financing centered in New York City.

As the world's largest economy and the only world superpower, the United States has many reasons to maintain an influential stake in all industries that are key to global progress, economic value, and international politics.

The United States emerged mostly unscathed from the last global war. And as a capital-driven nation eager to rebuild the global markets and hence customers, while pushing back against a new potential foe, we spread our capabilities, our products, and our values across most of the world's nations, and built a castle of confidence in our strength that upholds the U.S. dollar as a current leading standard of world trade and leading reserve currency. This ensures the value of the dollar, giving our citizens at home a quality of life and security that we've come to expect. But leading positions are always subject to erosion, especially in a world that has seen continuous development for almost 80 years enabling a near leveling of lifestyles and quality of competitive capabilities and products across the world.

There are other nations, growing potential superpowers, that as competitors can surpass and displace the United States, which if this happens may critically impact the value of the dollar and risk shrinking our economy and our internal standard of living. In the last century we've seen such collapses of global position and national economy in the United Kingdom and the Soviet Union among others. Absent of major wars that can reorder global positions, the key to competitive economic fortune and global leadership comes from the combination of four elements.

1) Security, Order, and Trust
2) Culture that Encourages Merit and Elevation of Position
3) Open Market Economy
4) Technology Innovation

The United States does well against primary competitors in the combined value of the elements 1-3, but as we've transitioned into generations of leadership, both in business and government, that are guided less by long-term developmentalism and more through a lens of short-term finance, our nation has taken the eye off the strategic innovation ball. And because of that, competitors that, frankly, have learned from the United States, have a focused innovation strategy of such determined force that they seem to overcome their weakness in elements 1-3.

Natural Progression of Technology

It's easy for most Americans to overlook the fact that we live on a water-world. For over 3,500 years, the leading intercontinental nations, societies, and empires of each period were also dominant on the seas. Across 95% of that time, up until the mid-19th century, the highest technology was always in ships. But the 2nd Industrial Revolution (Industry 2.0) brought new fields such as electricity and assembly line manufacturing that cultivated immense economic value that by the time of Industry 3.0 maritime had become relegated to a lower return commodity driven sector.

And now today, autonomous technology is a key aspect of the 4th Industrial Revolution, which is continuing an ever-growing shift of both manual and cognitive effort from human to machine. Technologies in Industry 4.0 also include networked data-driven systems, Internet of Things (IoT), machine learning, and artificial intelligence (AI). However, it's difficult to see ways that these technologies can be applied generically across key industries. Meaning that one can innovate and build autonomy or AI for the automotive sector without much of it being applicable to aerospace or maritime.

Advancements from Autonomous Control

Advanced control systems have already been deployed in other vehicle sectors. From advanced flight control fly-by-wire systems in aircraft that began to enter the market in the 1980s to active driver assistance systems in cars and trucks that started to emerge in the early 2000s. And while there are many different capabilities to these technologies, the primary purpose is to increase safety by eliminating human operator errors and improve productivity and efficiency through precise data-driven control.

Marine autonomy is the innate technical progression after 20th century automation, yet the power and capability of it is an exponential step. Where automation is a singular process, often *if-this-then-that* control, autonomy is a comprehensive compute engine completing a larger complex process, like a full voyage, by prioritizing sensor data and weighing decisions to provide a desired outcome.

And that's valuable because the industry and its mariners today are handicapped by continued use of last century's technology and methodologies. Accident rates, both in commercial and recreational vessels eclipse most other moving vehicle industries, on time arrival rates that match airlines of the 1970s, and unoptimized operation of the world's cargo ships which are said to emit 3% of humanity's annual greenhouse gas.

Sector Challenges

Accidents

According to Allianz and other sources such as the Japan P&I Club, on average approximately 2% of the global commercial fleet (vessels of 100 gross tons on greater) is involved in a non-machinery related major navigation incident or accident annually. In 2022, Allianz/Lloyds List reports 1,554 non-machinery related incidents and accidents in their tracked 58,000 vessels, of which 280 were vessel-to-vessel collisions and 209 were groundings. Japan P&I, latest data being 2016, tracks a fleet of 2,333 ocean going vessels reported 53 collisions and groundings, or a 2.2% rate.

2.2% is around the same rate as automobile accidents in the United States (2.4% of U.S. car fleet is calculated to have been involved in an accident in 2017) but a more appropriate comparison would be to airliners due to that sector being a professionally operated. Airlines in 2022 reported 39 accidents from a global fleet of 23,513 active aircraft or 0.17% rate; therefore, commercial maritime has an incident and accident rate 13 times commercial airlines.

Efficiency & Resource Use

Cargo ships are already around 2 times more fuel efficient per cargo ton compared to trains and 20 times versus average trailer-trucks but this is all due to size and quantity of cargo being moved by one vessel.

The approximately 58,000 commercial ships of the world burn around 350 million tons of fuel per year, **which is equivalent to 115 days of all oil consumption of the United States.** These vessels are said to emit 3% of society's global greenhouse gas emissions, which if the sector was a nation would rank No. 6 as an emitter.

It's believed that after power plants and aviation, cargo ships are the 3rd most concentrated source of greenhouse gas emissions, and therefore improvements that reduce fuel burn, can make a significant impact in reducing emissions in a short period of time when deployed across the fleets.

New technology brings great opportunity for improvement. Autonomous control systems, due to their more precise data-driven control and real time route optimization have the capability to reduce fuel usage, with presumed reductions up to 25% or more. Along with reducing emissions, this reduces operational costs and the U.S. Government is one of, if not the largest, buyer of petroleum products with the Department of Defense spending over $9 billion annually on fuel.

Maritime Applications

Autonomy transforms operations and brings forward the reliability, productivity, and precision of advanced robotics, empowering mariners to do more, do it better, with less effort and less cost. Autonomous control systems of various levels of faculty are being deployed by early adopters for both commercial and national security. And now, fueled by the prospect of opportunity and enhanced productivity, autonomy is beginning to be trialed in larger vessels that move cargo and people.

Workboats

Task driven workboats are using it for open water surveying, data collection, as well as heavy dangerous work like oil spill skimming and naval operations survey, security,

Response Boats

To improve response availability and response time autonomy systems are starting to be adopted by fireboats, lifesaving boats, and other response vessels; the technology being focused on routine or dangerous aspects of the work can enable the human crew to focus on specific complicated tasks.

Unmanned Naval and Security Vessels

Autonomy enables unmanned vessels which can provide new capabilities of persistent domain awareness or security; for example, providing a persistently patrolling sea-level sentry on watch for drug smugglers and complementing other common domain sensors or creating distributed networks of smaller naval vessels that extend the reach and support the power of the capital fleet.

Autonomous Pilot Assistance for all Vessels

The most significant benefit and uses of autonomous systems will be as advanced pilot assistance, bringing the value of onboard inherent control like that found in airliners and the ADAS systems emerging in road vehicles. It increases safety, performance, and overall efficiency of the operations. Within the next three years early adopters in sectors such as cargo ships, ferries, and yachts will begin deployments.

Infrastructure

Infrastructure provides the foundation and common tools for our economy and society to grow and thrive. And over the years the federal government has taken numerous measures to promote our

maritime sectors, from incentives to protectionism; however, both the scale and type of incentives are not aligned with the potential that can be unlocked. Along with maintenance and operational budgets for locks, navigation markers, dredging, and U.S. Coast Guard, the government has also spent about $100 million since 2010 in promotion of the U.S. Marine Highways System, or an average of $8.4 million per year, also around $20 million annually on grants to the shipbuilding sector. Most of these funds go to traditional physical assets, such as forklifts, cranes, welding machines. **This type of spending, while helpful at the micro-level, does very little to unlock the next era of maritime. The nation needs to be looking forward and invest in the digital infrastructure to stay ahead, inflate the value of the resulting products and services, and advance worker salaries.**

Marine Highway System

The Marine Highway System consists of 29 marine routes, along all coasts, major interior waterways, and around Puerto Rico, Hawaii, and other Pacific Islands. The intended reasoning behind establishing this system is well described by the Maritime Administration (MARAD), including reduction of traffic and local land air pollution within the nations roadways and land corridors, shifting hazardous cargo transit away from living areas, reducing road wear and maintenance costs, and improving transportation resiliency through alternatives. MARAD also presents the need to improve economic competitiveness by adding new freight and passenger capacities. These are all very important reasons to put focus and funding for the expanded promotion of the marine highways, but these trade lanes and passenger avenues also provide the venues to launch a new autonomy-enabled generation of technology.

Competition

Looking at competition from the national perspective, we see development from each of the following nations, ranked by a combination of focus, maturity in development, funding, and momentum.

1) **China:** Deployment of many small autonomous collaborative boats, and now autonomous 300TEU containership, the ZHI FEI, commenced regular commercial short sea operations in 2022, as well a 200-ton trimaran unmanned naval patrol vessel.
2) **Israel:** Deploying and testing unmanned patrol vessels for over 15 years.
3) **United States:** Deploying naval test boats and larger vessels, often one-off for over 15 years. Venture-backed small businesses with commercially available products. Over 20 years of underwater autonomy development and commercial business.

4) **Singapore:** Deploying unmanned vessels for testing and military patrols for over 10 years; providing R&D funding to bring forward autonomous harbor tugs.
5) **UK:** Deploying and testing multi-unit unmanned mine counter measure (MCM) & patrol vessels for over 5 years.
6) **France:** Many R&D projects including MCM vessels, patrol boats, survey craft, and oil field support vessels.
7) **European Union:** Horizon 2020 technology funding track for autonomous vessel R&D, as well as funding for remote control cargo barging on inland waterways.
8) **Norway:** Government-funded development of autonomy associated with electrical cargo short sea shipping demonstrator.
9) **Japan:** Government funded R&D programs launched 4 years ago to developed autonomous cargo ships with multiple cohort collaborations.
10) **Sweden:** Deep commercial experience in underwater and direct remote control for naval vessels.
11) **Netherlands:** Multiple leading commercial marine operating companies that are deploying autonomy in survey and dredging projects.
12) **Turkey:** Multiple speculative commercially funded patrol vessel developments.

Comprehensive Maritime Network

This paper has been referring to marine autonomy mainly from a vessel or fleet perspective, but the opportunity is much bigger than the operational level. Autonomy is an enabling technology that can deliver the 1+2=10 systems of systems; when fully built out it will bring forth a global connected platform, much like the internet, that ties new software applications and artificial intelligence to a major world-moving industry. For the same reasons that marine autonomy saw rapid initial adoption around the world, the domain being vast and open and suitable for even immature technology, makes an optimal environment for a fully connected active network to take shape. And whoever builds and dominates this network may take all value in a zero-sum competition.

It's Time to Act

When looking at global fleet ownership, the United States now ranks No. 14, between Taiwan and Bermuda, well below China at No. 1 with a cargo fleet value that is nearly 5x that of the U.S. And China is

pushing further ahead with government and government-backed investments both in the physical and digital infrastructure.

And while autonomy is a nascent space it's advancing quickly and other determined nations, such as China, that value its power and potential are investing heavily to take that commanding position. The United States shouldn't pass on this.

The federal government has a record of acting pro-actively to ensure new high value society-moving technologies are built and centered within our nation, from the internet to oil, from drugs to electric cars, it was members of Congress that used their voice and their legislation to bring focused attention, research budgets, steer federal agencies, or foster adoption through incentives.

Consider the example of the internet. In the 1980s, select members were actively bringing focus on the opportunities that can be had from the envisioned supercomputing network. Then in 1991 Congress delivered The High-Performance Computing and Information Act to President Bush which allocated $600 million to accelerate the development of the super-information highway. Almost immediately new companies were forming around the nation and by 2020, less than 30 years since the bill was signed, the internet directly contributed over 10% ($2.45 trillion) to our nation's annual GDP. A return on that 1991 investment like no other.

But there are also examples of new technical fields where our nation showed indifference or even stifled, from advanced high-tech and digital equipment manufacturing to aerial drones, allowing competitors to take the space.

And right now, the signal flags are snapping in the wind because marine autonomy is that next opportunity to capture immense future value for our nation and our citizens, bringing forth a digitally connected, network to machine autonomy that powers the next generations of marine fleets.

Action today is critical because competitors are clearly showing their desire, and without focusing our national lens we risk handing over the keys of the seas. The subject of marine autonomy is well known in many government departments and agencies that operate on water and some have developed strategic plans, supported by specific budget line items, that mostly include experimental roadmaps, knowledge and experience building, and industry partnering. These are all positive steps, but the reality is that leading competitors are fielding more autonomous vessels into determined active daily operations to force-forward a rate of development that cannot be achieved with a paced approach. We ask our

Congress and other agencies to take the time to understand this opportunity in marine autonomous technology and proactively do things today to shape where we want to be in decades ahead.

Conclusion

The United States marine industry is at a crossroads of opportunity on the ever-important sea lanes and open oceans.

We, as Americans, are very aware of the value that industry brings to our society through products, jobs, wages, tax base, security, and happiness. Yet the value of each form of industrial technology normally decreases with time on the market as it becomes conventional, and therefore it's paramount to maintain a continuous re-inflation of our economic value through innovation of new technologies. And I believe it's the responsibility of leaders in the United States, from government to business, from labor to social, to purposely promote and foster this.

We have a workforce and knowledge base in maritime, software, robotics and a marine infrastructure that is ripe for improvement. With the right motivations through Government focus, voice, and funding and a permissive regulatory attitude, we can release a spirit into the veins of our commercial marine industry that breaks the molds of complacency and builds new technologies that bring U.S. maritime back to the tip of the spear on all fronts. Opportunity is knocking, let us answer before it is too late.

Thank you. I wish to thank you Chairman Webster, Ranking Member Carbajal, and Members of the Subcommittee for this chance to testify before you on the subject and I will make myself available for any further needed information.