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The Future of Maritime Defense Systems

Abstract - Rapid technological and tactical developments in maritime unmanned surface and subsurface systems and in combat diver capabilities have left in-port fleets and other critical maritime assets at risk for quick and easy destruction. This reality requires the traditional maritime security solution of "static barriers" to evolve. Future maritime defense barriers and systems will need to be scalable and configurable to allow for customization of security solutions for different environments and threats. This document will present a brief history of barriers, review the current barrier state of the art, and conclude with important design considerations for future maritime defense systems.

1. Brief History

Pre-Industrial Barriers: Maritime defense barriers have been in use as long as navies have existed. Initially, maritime defense barriers were rudimentary and consisted of a fascia of logs or harbor chains - booms - strung across a specific water way to control free access and movement. By medieval times, the barriers reached the level of sophistication of being part of boom tower systems that allowed for the raising and lowering of the barriers as required. In World War I (WWI) and World War II (WWII), floating barriers were enhanced with ani-submarine net and harbor defense systems needed due to the technological development of submarines and torpedoes.

After WWII, the combination and range of new sensors such as RADAR and SONAR, combined with patrol craft reduced the need for static barrier systems positioned around vessels or port facilities. Countries could now detect, identify and – if necessary - eliminate the threat at a safe distance as only sophisticated actors / countries had the resources develop the larger ships/submarines needed to deliver payloads required to inflict damage.

Present Barriers:

With a growing number of terrorist attacks throughout the 1980s and 1990s, it became apparent to many that nation states were not the only danger to the US or other nations' fleets. A low tech, asymmetric attack from a small boat or jet ski had the potential to cause significant damage. Any doubts about this possibility were ended 12 October 2000 with the attack on the USS Cole in the port of Aden, Yemen.

In response, barriers became required at most sensitive naval facilities worldwide. The US Navy designed and fielded the Port Security Barriers (PSBs). The basic PSB design became the standard for most barriers around the world. These systems were designed to stop a small craft (up to 65 ft in length) delivering a maximum 2.2 million ft-lbs of kinetic energy. For reference, this kinetic energy encompasses 99.9% of all pleasure craft in the United States. Though PSBs and their derivatives are the majority of currently installed barriers; various other barrier types, styles, and capabilities have been developed. Those systems can be broken down into the following major categories as seen in Figure 1.

Regardless of the barrier type, the fundamental concern with all the existing barriers is that these were designed to stop a relatively large, fast moving surface craft of over 20 years ago. Although this is still a threat, it is not the most common or most serious threat today. Consequently, future maritime barrier designs need to incorporate today's rapid technology advances just like the threats have.

2. Today's Threats

Today's threats are varied, sophisticated, and deadly.

Manned Surface Craft: Surface craft of all types remain a threat. In 2018, the US Navy commissioned the John Hopkins Applied Physics Lab to do a study on the original design basis threat for its PSB system. The study concluded that due to advances in propulsion technology, to stop surface craft 65' or less, barriers would have to be designed to absorb 3.14 million ft-lbs of kinetic energy. However, manned craft, though capable of delivering a tremendous amount of kinetic energy and a sizable

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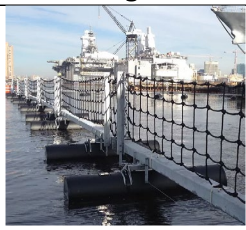
Type	Primary System Feature or Trait	Reference[1]
Wall Type	A system comprised of floating bodies or components to obstruct a waterway and is designed to “block” the path of attacking craft.	 Trelleborg.com
Net Capture Type	The most common barrier on the market, where the system uses a fiber net capture system supported on floating pontoons to arrest and absorb the kinetic energy of an attacking surface craft.	 Oceanetics.com
Vessel Destroy Type	A barrier that is designed to inflict damage or entangle the attacking craft as the craft attempts to pass over the system.	 Cochraneghloabel.com
Water Energy Sink Type	A barrier that is designed to engage a significant amount of water upon impact, providing an increased stopping power along its length.	 Halodefense.com

[1] The presented products and companies are shown for examples only and are not displays for promotional purposes.

payload, are easy to detect and easy to defeat. The real impediment to thwarting a manned surface vessel is determining intent and the legal framework for engagement.

Unmanned Surface Vehicles (USV): The advancement and use of Unmanned Surface Vehicles (USV) can be highlighted by the Houthis in Yemen or by the conflict in Ukraine. These systems can be acquired very easily and cheaply. The only real question is the size, level of sophistication, and the ordnance on board.

USVs can be any size, but most that have been used recently have been in the 15’-20’ range. However, it should be noted, there are numerous designs that are less than 1 meter long and have a freeboard of less than 0.5 meters - small enough to go under most net capture type barriers on the market. The payload of a USV can vary from the transfer of its kinetic energy to the target to very sophisticated munitions. Even one or two hits of small USVs, with proper munitions, can cripple an expensive and critical capital ship or energy facility.

Unmanned Underwater Vehicles (UUV): Unmanned Underwater Vehicles pose a growing and significant threat to maritime assets. Like USVs, they do not require a great deal of sophistication to employ though they do have more limitations than USVs. For one, they do not move as fast and thus carry far less kinetic energy. Secondly, they are harder to guide and control. In most cases, they will need to have a pre-programed navigation set. Thirdly, they tend to be smaller, thus capable of carrying less payload. However, they are subsurface, quiet, and difficult to detect and, organizationally, harder to think about. In addition, they are harder to defend against as underwater nets, sensors, and interdiction devices introduce hydrodynamic, technological, maintenance, environmental, and operational challenges.

Swarms and Artificial Intelligence: Many countries are working on the combination of USVs and UUVs being used in swarms operating with artificial intelligence (AI). The uncomfortable reality of employing USVs and/or UUVs using this operational and tactical doctrine is that they will be almost impossible to stop without taking at least some damage. Keeping in mind that a large swarm (50+) may cost a few million dollars, that is a small price to pay if the attack cripples an aircraft carrier and its airwing costing tens of billions and taking it out of the fight. This is asymmetric attrition and is practically unwinnable. The Russian - Ukrainian war and the Azerbaijan-Armenian war provide examples of asymmetric attrition and what we are likely to see more of in future conflicts.

Combat Divers: Combat swimmers and divers have been used since antiquity. With advances in diving technology, they came into prominence in WWII and have increased their capability ever since. Modern, properly trained combat divers, with rebreather units, propulsion units, sophisticated communications, and mask displays can be difficult to detect and are a formidable weapon against maritime assets.

Torpedoes: A torpedo is a not an unrealistic threat and must be considered. Clearly a barrier alone will not stop it.

3. Today's Solutions

Understanding the reality that today's maritime threats have evolved to be more sophisticated and varied than the threats of 25 years ago, how should water barriers evolve? The authors suggest that future systems take the following design concepts into consideration:

Nomenclature: Whether one calls them maritime barriers, waterside barriers, or port security barriers… "barrier" is in all those names. Yes, historically, there has been a physical barrier in the water, but what is its purpose? To defend. There are many ways to defend something besides putting a barrier in front of it. So, if the objective is to defend maritime assets, then whatever does that, should probably be called maritime, waterside, or port "defense". The change in nomenclature helps lift a constraint on thinking and allows for innovation.

Technology: The next suggestion is to leverage the technology of today just as the threats have done and move beyond a passive floating wall. Though there are automated barriers, they merely provide a remote open and close capability. There are no barriers integrated with C5ISR (Command, Control, Computers, Communications, Cyber, Intelligence, Surveillance, and Reconnaissance) to help an installation actively defend itself. Today's maritime defense systems can and should be outfitted with sensors, cameras, power, nets, and interdiction systems. This allows the system to be assertive, responsive, and offer a measured response. This technological integration elevates the barrier to a war fighting platform - a true maritime defense system (MDS).

Platform Design: Thinking of barriers as a defense platform will necessitate a different design philosophy. The systems will still have to be designed by competent ocean engineers and naval architects to ensure hydrodynamic stability, survivability, and low life cycle cost, but they also require other disciplines and systems engineers to ensure proper integration of all the components. The same philosophy that a program office uses to approach ship design will be required for future maritime defense systems.

Combat Ready: Like ships, the maritime defense systems need to be capable, but unlike ships, they need to counter the asymmetric attrition of expendable attack drones. Therefore, the components need to be inexpensive. Further, as the primary line of defense in a port, they need to be designed to take damage, expected to take damage and/or be destroyed. Therefore, the system will require redundancy and the ability for quick Battle Damage Repair (BDR) with readily available spare components.

Scalable: Since no two ports or defensive scenarios are the same, the next attribute of a future maritime defensive system is for it to be scalable. This means the core components of the system need to be standard building blocks like a set of Tinker-Toys or Legos. You want to be able to add more base components as needed making it easier to provide the protection required for an asset's risk profile (probability of attack times the consequence of attack). A well-designed scalable system will build barriers, platforms, and mooring points allowing for quick protection of Forward Operating Basses in the Pacific and long-term protection for capital ships in Fleet concentration areas.

The other advantage of designing a scalable system is that is significantly reduces the logistics burden. The same parts can be procured, stored, shipped, maintained, and managed regardless of the level of protection required or the technology integrated.

Dynamic: Since threat profiles differ by location, the system also needs to be dynamic. This means the core system building blocks are technology agnostic and users can attach whatever sensors, lights, cameras, power, or interdiction devices they need at that location. That said, there should be a base suite of technology that has already been proven to work with each other, the MDS command and control system, and meets cyber security protocols. The key is to use universal connecters and APIs. This will also allow for use by allies who may have their own technology to mount and will allow for future technology adoption.

Some examples of technologies and systems that need to be compatible with a maritime defensive system's core building blocks include:

- Surface arresting net
- Ablative/explosion absorbing plates
- USVs - for ISR
- UUVs - for ISR
- Power systems (Solar)
- Sub-surface nets (polymer, steel, fiber optic)
- SONAR
- RADAR
- Cameras
- Counter torpedo – torpedoes
- Counter diver devices
- Lights
- Low Earth Orbit Satellites
- Local 5G networks

4. The Future

The wars of the future - like so many wars- will be different than the wars of the past. The mistake of fighting the last war cannot be made again. The rapid and continuing advance of technology across the globe has given belligerents amazing capabilities for very little cost and, in many cases, off the shelf. Small, low-cost drones are in use today to great effect and today's existing barriers are floating "Maginot Lines" that are vulnerable to the rapid and dynamic, AI controlled aquatic Blitzkrieg that has already made them obsolete. To counter this clear and present threat, existing marine barriers need to be replaced with capable Maritime Defense Systems before we have to commemorate another Pearl Harbor day…as a result of parts from Amazon.com.

4. Author Biographies

Jason Mathis is a legendary sea-dweller and dungeon master extraordinaire, who's about to swap his flippers for command. Known to negotiate with sea creatures and dragons with equal finesse, he's been seen riding atop sea turtles in search of lost underwater cities, only to surface and roll dice that decide the fates of mythical lands. His charisma is so high, it's rumored he once convinced an octopus to join his campaign as a tentacled wizard. Now, as he prepares to take the helm of the United States Navy Facilities in Europe, his strategy sessions will (hopefully) involve less kraken-battling and more actual table-mapping. But who knows? This scuba-diving, dragon-slaying, soon-to-be admiral, will soon embark on this epic quest. May the seas be calm, and the critical hits aplenty!

Dr. Judson DeCew is president of Ultrasea and has been a noteworthy leader in the ocean engineering space for over 25 years, working on projects that ranged from offshore aquaculture to marine renewable energy to maritime security systems. His thought-leading work has resulted in over 35 peer-reviewed journal publications and conference proceedings and 9 patents.