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Space Based Technologies and Capabilities of Relevance to Future of Maritime Operations

"The Navy's interest in space is long… And the Navy's interest in space is important, because without space contributions it would not be possible to conduct modern naval operations." [6]

The Past

Maritime nations have relied on their naval forces to carry out the national business on many fronts. The naval forces are unique in that aspect; they secure the seas, are diplomats in a foreign port, and provide the maritime security that is essential to the trade and commerce for most seafaring nations. I am glad to be part of this discussion today, albeit virtually, and I applaud Portugal, a maritime nation from its start, for hosting this forum to discuss our common maritime interests in the Atlantic. It is fitting that Portugal has led this initiative given its rich maritime history and the crucial role that Prince Henry the Navigator and Portugal's many courageous explorers played during the Golden Age of Discovery in leveraging the seas for trade and exploration. Initially along the coastal regions and later across the open ocean, the early Portuguese voyages depended on accurate observations of the moon, the planets, the sun, and the stars. The importance of Space in the maritime domain continues to this day. Since its beginning, the United States has also understood the crucial importance of space and the US Naval observatory has had the responsibility of providing an updated star catalog to our nation for over 200 years. Now it is mostly developed by space-based astrometric missions, one of the original space-based capabilities for maritime operations.

The Present

It is still pretty amazing that people wonder why the Navy is in the space business. How is it that the US Naval forces and others have always invested in space science and spacecraft technologies from the beginning? The primary reason is that the navy has been a disaggregated and distributed force since its inception and has had the need to communicate from anywhere around the globe and navigate with precision. Additionally, naval forces are always asked to go into areas where they may not have the full picture of what they are going into. This includes the physical picture (the geography, the terrain, the littorals), the electromagnetic picture (the signals in the radio frequency domain), and the environmental picture (the seas, the upper atmosphere weather, the weather of the heliosphere, and their impact on the propagation of radar, and radio waves). These are all dynamic aspects of naval warfare and can change drastically in short periods, and have a large impact on the ability to carry out naval operations and expeditionary

6 National Research Council, Navy's Needs in Space for Providing Future Capabilities (2005)

warfare. Study after study has noted that space is essential to maritime operations. The primary space-based capabilities that are used for naval warfare can be broken down in the ability to sense and see, communicate that knowledge proactively and with precision to all concerned for decision making, and produce the necessary effects in a precise and timely fashion thru naval platforms or other elements of national power.

Going forward the platforms and technologies that provide these capabilities will change, but the essential needs will be there. Primary amongst them is communications. The majority of the naval communications go through space-based assets. Not only the ships, airplanes, and submarines, but the expeditionary naval forces, the marines, need point-to-point communications, communications amongst mobile units, communications between mobile units and shore facilities, and broadcast communications from shore to ships and submarines. Another core space-based capability is navigation and timing- the deployed forces will always require a space-based system for providing accurate, all-weather, worldwide navigation for naval surface ships, aircraft, and submarines and precise time to synchronize operations, including cryptographic systems for secure communication and delivery of effects.

In addition to communication and navigation, space-based assets also provide maritime situational awareness. Intelligence Surveillance and Reconnaissance systems (though for naval operations, the more important systems are signals reconnaissance/ surveillance systems) along with supporting equipment, provide continuous and up-to-date information on naval targets, air targets, and land targets of naval interest. Systems capable of detecting, locating, and processing deliberate and inadvertent electronic emissions from military threats or criminal activities may be used for technical intelligence, strategic warning, and mission planning. These also include potential threats in the electromagnetic domain, electronic warfare, and increasingly cyber warfare. The ability to, detect, isolate, classify, identify, track, and assess incoming missiles and threats is critical. Additionally, we have to get this information directly to Navy tactical users (the Navy was the first, but it was adopted eventually by all the services), e.g., Global Broadcast System (GBS) using direct broadcast technology at high data rates to many users via very small terminals.

Lastly, given the nature of naval operations, there is a need for systems capable of obtaining weather information in support of naval forces "over areas void of meteorological observations." That means that space research that allows the study of the heliosphere (the sun drives all weather phenomenology on the earth) and better understanding, predicting and forecasting of the sun as it enables better forecasting of the ionosphere, the troposphere, the atmosphere, and the ocean weather. Naval forces benefit from forecasting in all these regimes, but what we have now on most of these regimes is "nowcasting". Naval forces also want up to date geodetic, geophysical, mapping, ice-reconnaissance, and sea-surface-temperature environmental data.

The Future

"The complexity of the maritime domain, which encompasses the confluence of water, air, land, as well as space and cyberspace, is infinite in its variations. As a result, operations in the maritime domain are inherently challenging."[7]

It is a fool's errand to predict the future, but there are technological trends that help guide us to get a somewhat accurate assessment of what to expect. As we look to Space and the recent acknowledgment by NATO that space itself is an operational domain, the majority of the focus, at least in the United States, has shifted to US Space Command and US Space Force. Naval officers have known for a long time that space is an operational and warfighting domain. As the barriers for access to space have gone down, there is a surge in the number of space-based platforms and access to them. The options of providers, vendors, integrators, and launchers have grown exponentially. But just like the automotive industry of the late 1800s, the aviation industry of the early 1900s, and the "dot coms" of the 1990s, not all will succeed, but the industry will grow, and the options for the users will increase.

The number of platforms (and they are all disaggregated, distributed platforms) in all domains are increasing exponentially. There is an exponential growth in undersea, surface, air, and space-based sensors, nodes, and apertures that have almost an infinite amount of data. Additionally, hybrid architectures are emerging and are augmenting dedicated military assets with commercially available data for sale to "all." The emergence of artificial intelligence (AI) and technologies where these sensors and platforms and machines are continually learning (ML) and refining the data they provide to the user is changing faster than most of us are capable of adapting. There is an increasing need to be able to turn this data into information and eventually use the knowledge for decision making. The driving forces behind these are data analytics and the application of AI/ML technologies. The challenges for the maritime forces will be how to combine this information and get it to a distributed force in relevant timelines and do so securely. There is an emerging need for data fusion and analytics to be done promptly and at scale.

The opening up of the artic presents a few additional challenges, since legacy communication systems were designed to give worldwide coverage with as few satellites as possible, and are in geostationary orbits, they provide no coverage in the higher latitudes and lack polar coverage. Huge investments are being made in proliferated Low earth orbit (P-LEO) systems, but most of them are likely not going to be of much use in the near term, for example, ship antennas are not designed for tracking LEO satellites for communications. Most ships tend to have a life of 30-50 years, the P-LEO models are in the 2-5-year technology refresh rate, how does the naval force stay abreast of this technology cycle?

Lastly, from a defense perspective, our adversaries have developed capabilities to target naval platforms. The timelines for detecting, tracking, and identifying these threats

7 Naval Operations Concept: Implementing the Maritime Strategy (2010)

leaves no option other than space-based sensors could that theoretically extend the range at which incoming missiles could be detected and tracked—a critical requirement for hypersonic missile defense. Again AI/ML technologies for autonomous tasking or onboard the platform, mission tasking, and command & control will be critical.