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An Update on Core Technologies

By Robert D. Holzer

The U.S. Navy's plans to develop advanced and diverse fleets of unmanned surface and undersea vehicles and vessels clearly demonstrate the service's growing interest in this emerging area of naval warfare. Unmanned systems will play a significant role in the future of surface and undersea warfare. Fifty percent of the new ships identified in the Navy's Surface Capability Evolution Plan (SCEP), which lays out the four major shipbuilding pillars for the future, will be unmanned vessels. Likewise, the Navy's submarine force envisions manned submarines deploying and operating with growing numbers of extra-large unmanned vehicles that independently deploy from pier-side in future operations.

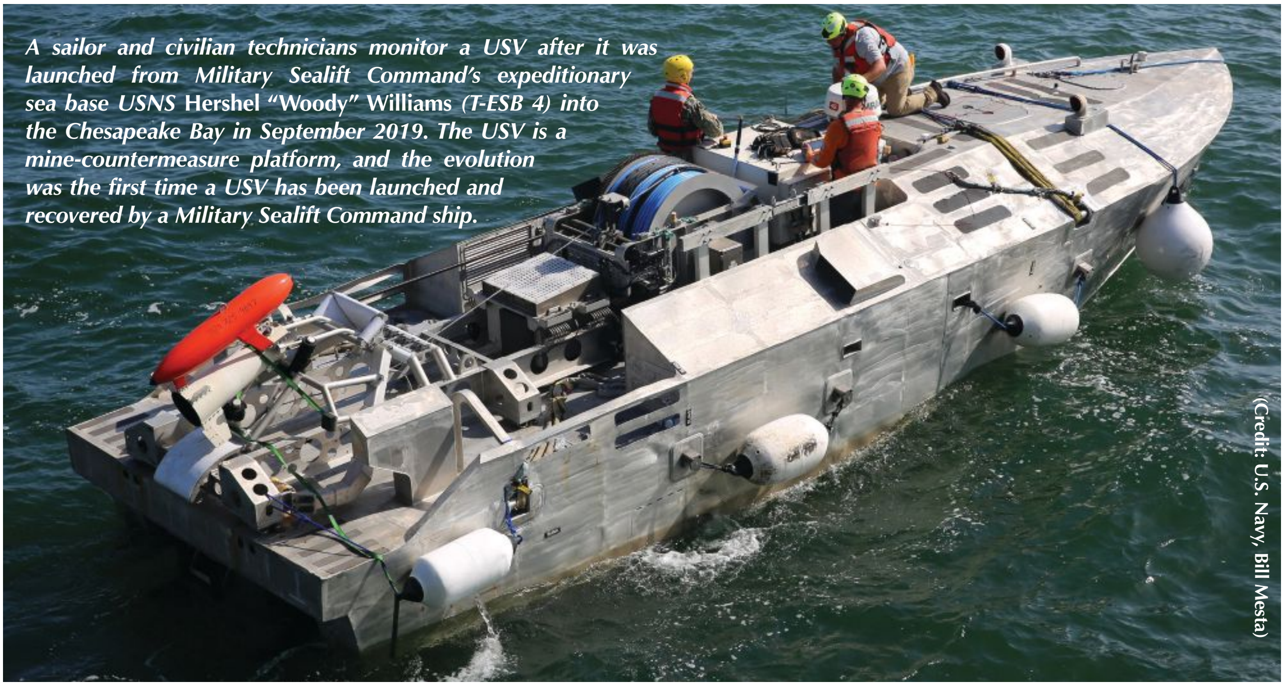
The emphasis on autonomous maritime systems could be as historically important for the future Navy as the service's investment in the nascent field of naval aviation proved to be in the early 20th century. Significant increases in funding, as evidenced by the dramatic total sought for unmanned maritime systems in the Navy's fiscal year (FY) 2020 budget request—about $400 million was initially requested for two large unmanned surface vessels to be purchased in 2020—show the important bet Navy leaders are placing in the unmanned arena.

Unmanned Umbrella

Over the last several years the Navy has been developing and refining its "family" approach to the acquisition of unmanned surface vessels (USVs) and unmanned undersea vehicles (UUVs) as the breadth of both portfolios continues to grow. This framework has proven to be an effective mechanism for clearly articulating how each of the portfolios will change over time and how

A view of the UUV Knightfish being recovered by Military Sealift Command's expeditionary sea base USNS Hershel "Woody" Williams *(T-ESB 4) while the ship was at anchor in the Chesapeake Bay in September 2019. Knightfish is a mine-countermeasure platform, and the evolution was the first time a UUV was launched and recovered by an expeditionary sea base.*

(Credit: U.S. Navy, Bill Mesta)



A sailor and civilian technicians monitor a USV after it was launched from Military Sealift Command's expeditionary sea base USNS Hershel "Woody" Williams *(T-ESB 4) into the Chesapeake Bay in September 2019. The USV is a mine-countermeasure platform, and the evolution was the first time a USV has been launched and recovered by a Military Sealift Command ship.*

(Credit: U.S. Navy, Bill Mesta)

each new system "fits" into their respective "families." Currently there are more than a dozen separate USV and UUV programs under development or in acquisition across the Navy. The majority of these unmanned programs are under the management of the Navy's Program Executive Office for Unmanned and Small Combatants (PEO USC), which was officially established in March 2018, at the direction of James Geurts, Navy acquisition chief. The PEO's Unmanned Maritime Systems office (PMS 406) is responsible for the day-to-day program development, management and oversight of the USV and UUV portfolios.

Significant programs in the USV segment include the Large USV (LUSV), which is a new FY 2020 program; the Medium USV (MUSV); and the Mine Counter-Measures USV (MCM USV). In the UUV segment, the Orca Extra Large UUV, the Snakehead Large UUV and the Knifefish mine-hunting UUV are the dominant programs. All of these USV and UUV efforts are either well along in development, in low-rate production or gearing up for production in the near term. None of the programs listed above are mere PowerPoint fantasies.

LUSV is truly a bold departure. The Navy intends to rapidly procure 10 or so ships based on commercial shipbuilding standards and outfit them with autonomy software for navigation and vessel operations integrated with remotely operated standard Navy combat and missile systems. Using a novel approach, these ships will develop the concept of operations for large USVs and conduct experimentation with various technologies and systems, which is not how traditional acquisition usually works. With the LUSV, the Navy is seeking to rapidly accelerate the fleet's learning and interactions with large unmanned systems by procuring an initial tranche of vessels to conduct serious and sustained at-sea experimentation.

The Orca Extra-Large UUV is already under contract to Boeing to build five systems based on the company's Echo Voyager UUV design. The initial production run of these extra-large UUVs begins delivering in 2021. Each Orca is more than 80 ft. long, contains a large payload bay and will deploy from pier-side to conduct autonomous missions that could be months in duration.

The future operational and mission success of the Navy's unmanned USV and UUV fleets hinges heavily on the technical maturity and expansion of a core set of critical technology enablers. These are the essential technology building blocks that will drive the Navy's expansion into the unmanned maritime domain. The Navy is currently making healthy investments in each of these technical areas. The list of critical technology enablers includes: autonomy and precision navigation; platform integration; endurance; payloads and sensors; and command, control and communications.

Autonomy is arguably the most salient of the technology enablers since it is the linchpin to unlocking the full potential for conducting long-range and high-end missions for unmanned naval systems. Autonomy is what enables USVs and UUVs to execute missions successfully. It is the special sauce that opens the operational aperture to allow unmanned systems to navigate for days, weeks or even months on open-ended missions. Autonomy, using secure communications, allows sailors to launch all types of payloads from these vehicles and ensure they are successful. Given its significance to the future capability enhancement and expansion of both USVs and UUVs, the Navy's acquisition community intends to speed autonomy development by using an innovative two-pronged strategy.

Unmanned Maritime Autonomy Architecture

The first piece of the process is the development of the Unmanned Maritime Autonomy Architecture (UMAA). The purpose of UMAA is to define standards for how different pieces of autonomy, called services, can interface with one another. It is not to define autonomy technology itself. This is a cardinal point. Autonomy services examples could be: mission autonomy, payloads, navigation, or ship-to-ship or ship-to-shore communications. How these services are developed and how they interact with one another determine the defining characteristics of the vehicle's autonomous behavior. Because UMAA defines how these different services will interface, new and updated software or services can be easily inserted into existing solutions to improve USV or UUV capabilities. In addition, since the services are common across multiple autonomy solutions, they can be reused.

Each of these are separate and distinct elements within any USV or UUV's autonomy architecture. UMAA seeks to allow any of these disparate elements of a USV's or UUV's autonomy to be upgraded or replaced without having to simultaneously upgrade or change every other piece of the USV or UUV's overall architecture. UMAA seeks to do away with the "big black box" of autonomy and move to a modular architecture that is not dependent on any single company or approach. By standardizing how each of these separate elements of autonomy talk to each other it allows the rapid upgrade and refresh of critical new technology without having to upgrade the entire system's architecture.

The intent with UMAA is akin to what the American automobile and aerospace industries experienced during their rapid development in the early decades of the 20th century. Car and airplane manufacturers quickly realized that instituting a system of standards and relatively interchangeable parts that applied to their respective industries would help fuel their growth and expansion. Now in the 21st century, as the U.S. Navy moves aggressively into the new and expanding domain of unmanned surface and undersea vessels, there is a need for a similar, but bold, form of system standardization. Today, however, the standards will apply to computer architectures and autonomy and not the spare parts and avionics that the aviation industry had to create. The future growth and evolution of unmanned systems in the Navy could well hinge on getting this critical process right.

To help ensure UMAA's success, the Navy is seeking information, insights and innovative ideas from a wide swath of industry and academia. PMS 406 has issued a Request for Information on UMAA and has held a series of Industry Days with interested government, industry and academic organizations. The Industry Days provided an opportunity for PMS 406 to solicit new ideas and broaden the discussion on UMAA to determine what areas of USVs and UUVs are ripe for the application of common interfaces and standardization.

Autonomy Integration Lab

The second prong of the Navy's autonomy strategy for unmanned maritime systems is the development of an Autonomy Integration Lab (AIL). The purpose of the AIL is to serve as a rapid pipeline to get new software quickly to the unmanned fleet, reducing traditional software deployment timelines of months and years to days, hours, or even minutes. It will do this by employing modern DevOps culture and processes to automate the required performance testing, cyber hardening and software deployment for new software. The automated tests not only speed up the development process but build more visibility, assurance and, ultimately, trust into the software—a crucial element if the Navy is going to fully embrace unmanned technology. Establishing this key process will help speed the application of UMAA across the entire Navy unmanned systems enterprise.

The AIL will not develop actual software itself. Instead it will work closely with third-party software developers, such as commercial developers and Navy warfare centers. The AIL will receive those services, test them and integrate them with current solutions, providing a secure and fast pathway to seamlessly push new and updated autonomy services to the Navy's fleet of unmanned vehicles. UMAA will be a key enabler for the AIL, reducing a lot of the intensive upfront work typically required with integrating software produced by different companies or developers.

Endurance

Significant progress is also being achieved in the other key technology-enabler areas over the last year, including batteries, sensors and communications.

To boost endurance, the Navy is working multiple efforts to develop and implement more energy-dense power solutions to increase the capability of the entire unmanned systems portfolio. Near-term efforts are focused on establishing efficient and technically acceptable requirements for testing rechargeable lithium-ion battery systems; establishing updated, informed submarine "hostability" requirements; and developing propagation-resistant battery architectures to enable safe integration and deployment from Navy platforms.

Significant progress has been made recently by adopting a more balanced approach focused not only on prevention of battery casualties, but also on detection and mitigation. This effort is coordinated across multiple program offices and Navy labs, has the endorsement of the NAVSEA technical community and is informed by close collaboration with the automotive industry and NASA. The Navy has committed to lithium-ion battery technology for UUV programs intended for submarine integration in the next several years.

In parallel with these near-term efforts, the Navy is continuing to invest in other energy-dense technologies. In addition to focusing on UUV-centric energy efforts, additional research work is required to develop hull, mechanical and electrical solutions to support the long-range deployment of USVs without onboard operator monitoring and intervention.

Payloads and Sensors

In developing payloads and sensors, there is significant interest in enhancing the warfighting capabilities of unmanned vehicles using a mix of unique and complex payloads to effectively support a broad range of missions. Current mission sets include intelligence, surveillance and reconnaissance; mine countermeasures; electronic warfare and others. PMS 406 and the Advanced Undersea Systems program office (PMS 394) have established a Payload Integration Group (PIG) to develop, maintain and oversee a standard, rapid and cost-effective payload integration process for both USVs and UUVs. Establishment of the PIG helps to streamline efforts across multiple organizations, enhance commonality of systems between USVs and UUVs, and ensure the development of modular payloads capable of being used by either surface or undersea systems.

Command, Control and Communications

Similar to efforts underway in autonomy, the Navy is working to define and standardize the architectures and interfaces for command, control and communications in order to deliver unmanned maritime systems that can be rapidly and effectively integrated with and operated from fleet units. The unmanned aviation community has already adopted a Common Control System in their unmanned aerial system portfolio to provide commonality, interoperability and multi-domain mission management. Other agencies and warfare domains have been working on unmanned control architectures for a number of years.

PMS406 is leading another Integrated Product Team to leverage the good work already done and identify the specific maritime domain components and interfaces required for Common Control System-compliant solutions that will integrate with surface, submarine and aviation assets. PMS 406 is working with Naval Air Systems Command, Naval Information Warfare Command, PEO Integrated Warfare Systems and PEO Submarines to define government-managed, open-architecture control solutions compatible with existing fleet command-and-control systems.

The key to success is to ensure all the concept lightning bolts in PowerPoint slide decks actually work without the use of numerous specialized and proprietary control interfaces.

Experimentation and Testing

While much of the current autonomy and enabling technologies work is focused on the medium-future horizon, the state of USV and UUV development is not stagnant. A fulsome experimentation and testing program is emerging that will provide ready vehicles for transitioning successive iterations of autonomy software for at-sea testing.

The Navy established a UUV Squadron, based at Keyport, Washington, in late 2017 to begin experimenting with prototypes of large UUVs. This work focused on developing procedures for how to move these large systems, how to put them into and out of water, maintenance routines and other logistical processes. This testing and experimenting continues apace.

To jump-start experimentation with medium and large USVs, the Navy established a new Surface Warfare Development Squadron (SURFDEVRON) in May 2019 at San Diego. The Defense Advanced Research Projects Agency-developed Sea Hunter unmanned vessel, which has been successfully conducting transits between San Diego and Hawaii, was scheduled for transfer to the SURFDEVRON in October 2019. Two more experimental large USVs will also eventually transition to SURFDEVRON to accelerate fleet experimentation with unmanned systems and develop concepts of operation. **ST**

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