THE DISRUPTOR

Director , Unmanned Systems, DASN Ships
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Making UxS a Trusted, Integral Part of the Future Hybrid Fleet

By Adm. Michael Gilday,
Chief of Naval Operations

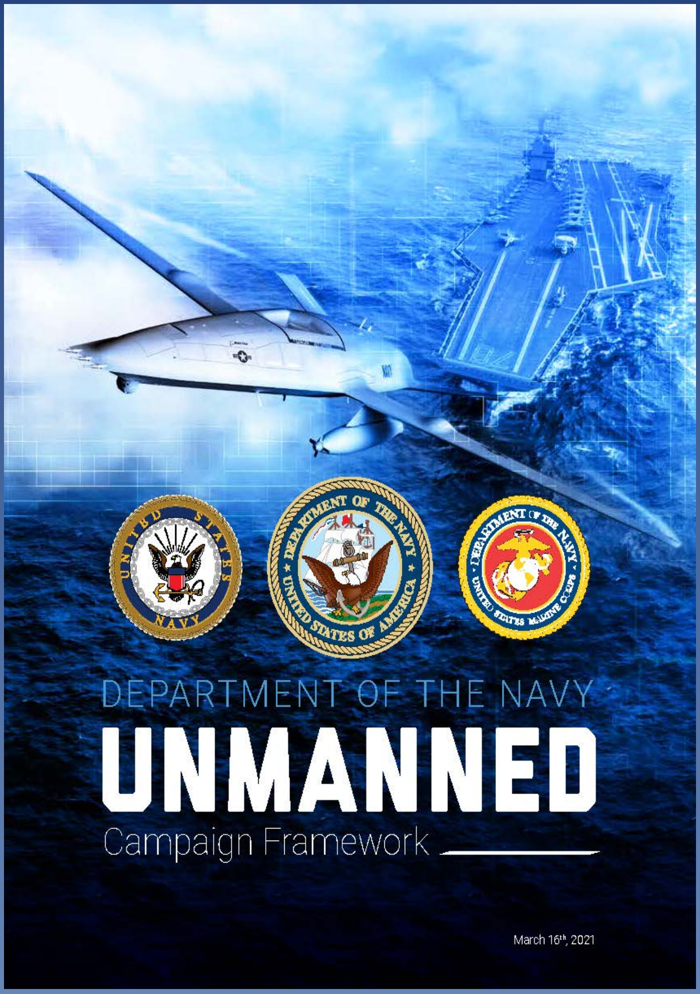
As the Navy adapts to an increasingly complex security environment, it is imperative that we understand what our future force will need to operate both in day-to-day competition as well as a high-end fight.

Unmanned systems (UxS) have and will continue to play a key part in future Distributed Maritime Operations (DMO), and there is a clear need to field affordable, lethal, scalable and connected capabilities. That is why the Navy is expanding and developing a range of unmanned aerial vehicles (UAV), unmanned undersea vehicles (UUV) and unmanned surface vessels (USV) that will play key roles as we shift our focus toward smaller platforms that operate in a more dispersed manner.

A hybrid fleet will be necessary for the Navy to meet emerging security concerns. We need platforms to deliver lethal and non-lethal effects simultaneously in all domains across multiple axes. UxS will provide added capacity in our Future Fleet — in the air, on the surface and under the water.

The campaign plan will serve as the comprehensive strategy for realizing a future where unmanned systems serve as an integral part of the Navy's warfighting team. It will be a living, iterative document that articulates our vision for a more ready, lethal and capable fleet through acceleration of critical enablers in technology, processes and partnerships.

We are mindful of past shortcomings, so therefore our approach is deliberate, but with a sense of urgency. We will address every aspect of Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, Facilities and Policy (DOTMLPF-P), identify and close capability gaps, and work to create and maintain our future naval force, together.



The Unmanned Campaign Plan represents the Navy and Marine Corps' strategy for making unmanned systems a trusted and integral part of warfighting. An Unmanned Campaign Framework document is available online at https://www.navy.mil/Portals/1/Strategic/20210315%20Unmanned%20Campaign_Final_LowRes.pdf?ver=LtCZ-BPlWki6vCBTdgtDMA%3d%3d

IBP21 Pushes the Limits of Unmanned Maritime Capabilities

By Rear Adm. Lorin C. Selby

Greetings from Southern California, where I have been watching some of the most advanced unmanned systems in the world take part in the Integrated Battle Problem 21, or IBP21. The Naval Research Enterprise (NRE) — consisting of the Office of Naval Research, the Naval Research Laboratory, the Office of Naval Research Global and PMR-51 — is directly or indirectly responsible for many of the platforms being used in this exercise, which is designed to explore how unmanned, autonomous vehicles can support the Pacific Fleet mission in its AOR.

Our Navy and Marine Corps aviation arm already enjoys a robust unmanned capability that is pushing the limits of imagination in real-world ISR operations and complex carrier operations. Now we are seeing equally encouraging unmanned capabilities joining the battle-line for the surface and undersea communities. It is great to see these unmanned platforms operating in blue water and blue skies.

In 2018, the ONR-led Sea Hunter unmanned surface vessel successfully completed an autonomous round-trip from San Diego to Pearl Harbor, Hawaii. That's a distance of well over 4,000 nautical miles, in some cases through high sea-states. Sea Hunter's sister ship, Seahawk, was delivered to the U.S. Navy just in time for IBP21, and both vessels were outfitted with payloads to perform a variety of missions.

None of this just magically happened. It took vision, substantial resources, long-term commitment and a lot of really smart people working long hours, over many a cup of coffee, to overcome enormous technical hurdles. And those folks within the NRE, working with their counterparts at the SYSCOMS, industry and academia, continue to turn scientific theories into warfighting capabilities.

But our adversaries are working just as hard. They are smart, well-resourced and they know that, to quote Sun Tzu, "victorious warriors win first then go to war, while defeated warriors go to war first and then seek to win."

We're still not where we need to be, but we're making significant strides toward Reimagining Naval Power — a phrase that's important to remember, because we need to think, act and imagine differently if we are to succeed in the future. We dare not rest on our post-Cold War laurels if we want to maintain our dominant role in the world and defend the ocean commons upon which all nations depend. IBP21 is a good, first indication that if we remain steadfast and continue to think outside the box, and frankly continue to invest sufficient resources, we will remain that dominant force.

Autonomy's time is now. Pedal to the metal. Whichever nation leads the field in unmanned capabilities, in autonomy, in AI, in manned-unmanned teaming, over the next decade, will likely chart the global geopolitical and military course for the next century. Ten years will determine the next 100.

As a nation, a Navy and a Marine Corps, our resolution is clear. In the new Unmanned Campaign Framework, acting Secretary of the Navy Thomas Harker noted: "To compete and win in an era of great power competition, the Department is committed to investing in advanced autonomy, robust networks and unmanned systems to create true integrated human-machine teaming that is ubiquitous across the fleet."

The Chief of Naval Operations, Adm. Michael Gilday, noted in that same document that "there is a clear need to field affordable, lethal, scalable and connected

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On The Edge

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capabilities. That is why the Navy is expanding and developing a range of unmanned aerial vehicles (UAVs), unmanned undersea vehicles (UUVs) and unmanned surface vessels (USVs) that will play key roles as we shift our focus toward smaller platforms that operate in a more dispersed manner."

The Commandant of the Marine Corps, Gen. David Berger, has made it clear that the CONOPS are going to look very different in the near future, noting in the Framework introduction, "Concepts such as half of our aviation fleet being unmanned in the near- to mid-term, or most of our expeditionary logistics being unmanned in the near- to mid-term should not frighten anyone. Rather, these ideas should ignite the creative and cunning nature of our Marines so that our forward-deployed forces are even more lethal and useful to the joint force."

With that kind of forceful leadership commitment, and with great power competitors going all-in on unmanned systems, it's crucial that the NRE continues to sponsor the most cutting-edge research in the world. And by that, I really mean the WORLD: ONR Global is working across the globe to partner with the best researchers and discover new capabilities to support our Sailors and Marines. Its Experimentation and Analysis team has played a lead role in getting IBP21 platforms into blue water and brown mud wherever they can, taking the measure of their capabilities, discovering where they need to improve and, most important, talking with the operators about what they like or don't like. The work of engineers and scientists is critical, but ultimately it has to be useful to the E3 on the deckplate, a lance corporal in the field, or an aviator looking for a new kind of wingman.

We've done a lot of work to get this far. But this is just the beginning. Our ultimate goal is to ensure that any nation-state or non-nation-state actor with malign intent will know the line they cannot cross, because the U.S. Navy and Marine Corps have the best trained and most skillful warriors, and the tools, including unmanned, necessary for mission success.

Rear Adm. Lorin C. Selby is Chief of Naval Research.

Chief of Naval Research Rear Adm. Lorin Selby observes a Vanilla ultra endurance unmanned aerial vehicle on Pier 12 at Naval Base San Diego during U.S. Pacific Fleet's Integrated Battle Problem 21. (U.S. Navy)

Subsea and Seabed Warfare: Find, Fix and Finish – from Surface to Seafloor

By Capt. Lincoln Reifsteck

For 121 years, our Navy has jealously guarded tactical advantages in the undersea domain. To maintain that advantage, outpace threats and fully use the sea to advance U.S. objectives, the Navy evolved from seeing the manned submarine as the only factor in undersea superiority. The result today is a full-spectrum undersea warfare approach, where Subsea and Seabed Warfare (SSW) complement mine warfare and submarine warfare to control the undersea domain.

SSW uses air, surface, undersea and shore forces to employ a comprehensive portfolio of aircraft, ships, submersibles, unmanned undersea vehicles (UUVs), kinetic and non-kinetic effects, and seabed-mounted systems. Subsea Warfare extends undersea capabilities to the entire water column, protecting U.S. and allied undersea assets while countering an adversary's ability to do the same. Seabed Warfare serves an analogous function, protecting friendly seabed infrastructure and denying an adversary the advantages of the ocean floor when necessary.

This approach extends reach and persistence in the undersea. It augments elite Anti-Submarine Warfare (ASW) assets (submarines, destroyers and maritime patrol aircraft), improves battlespace awareness, and adds endurance, stealth and persistence. These systems thrive in dangerous, dull and depth-limited environments. Places where we are unable or unwilling to employ elite platforms, with lower consequences in loss of life and expense if the system is defeated, to inform the use of manned assets to achieve objectives. Employed correctly, unmanned systems will serve a wide variety of functions from environmental survey and analysis to kinetic destruction of an adversary's subsea or seabed assets, and almost anything in between.

The Navy and Department of Defense are working to identify the capabilities and effects we need, and develop doctrine, concepts of operations and employment plans to support them. Prototype systems have identified critical needs for expertise in rapid acquisition, focused tactical development and personnel mastery of new skills to support this type of warfare. They have also informed the systems roadmap ranging from niche capabilities to an integrated and ubiquitous network across Navy platforms and communities.

UUV tactics continuously evolve to satisfy offensive and defensive objectives. Offensively, UUVs are optimized to understand the environment, avoid environmental obstacles and recognize objects of interest. UUVs fix target position for later prosecution, or attack immediately. Shore-side control centers direct some UUV missions, but most missions are autonomous. The maturation of artificial intelligence and machine learning are making UUVs increasingly lethal.

Defensive missions focus on countering adversary SSW efforts. UUVs are excellent at determining changes in port approaches and chokepoints to verify harbors and channels safe following storms or suspicious adversary activity. A training mission tested UUV operators in detecting a change to a simulated harbor entrance following a storm. The UUV detected storm debris in the area and follow on data analysis proved that the debris surge posed no navigational hazard. Similar efforts have validated safe water depths outside of dry-docks at Puget Sound Naval Shipyard prior to undocking submarines and aircraft carriers.

The Navy has a single resource sponsor and a dedicated Program Executive Office to manage the acquisition of

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Devops

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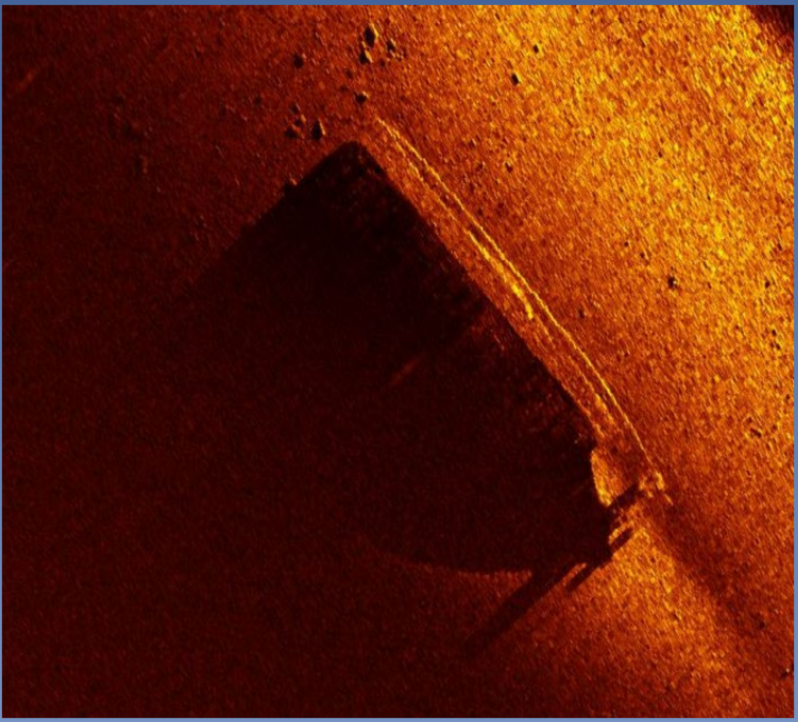
UUVs ranging in size from 50 pounds to over 50 tons. Deliveries of these programs of record have moved the SSW-supporting UUV community from small numbers of commercial and prototype vehicles to the numbers and scale that will be modular and ready to accept rapidly fielded payloads across the spectrum of mission sets.

As Assistant Secretary of the Navy for Research, Development & Acquisition, James Geurts advised the UUV community to apply 'just enough rigor' to the acquisition process to ensure safety for the users and host submarines and ships, but not be overly bureaucratic in the review of every minor adjustment made to payloads. The parameters that mission sponsors and payload developers use to ensure immediate approval and fielding of payloads is led by Naval Undersea Warfare Center Keyport. Co-located with Unmanned Undersea Vehicles Squadron ONE (UUVRON-1), the "Keyport Homeport" is a single source for maintenance, engineering testing and payload integration, and hosts UUVRON-1's Unmanned Operations Center (UOC) to monitor and control vehicles during training, and afford reach-back and over-watch support for vehicles operated forward.



Sidescan sonar of a bottomed submarine. Notice the shadow of the rudder and propeller. (U.S. Navy)

By 2024, UUVRON-1 will have more than 150 Sailors and dozens of UUVs. Recently established detachments in Little Creek, Va., and Port Hueneme, Calif., meet employment needs and foster collaboration with Explosive Ordnance Disposal, Naval Special Warfare and Surface Warfare partners. These relationships enable rapid improvement in capabilities and techniques, capitalize on lessons learned and identify personnel needs for the future.

SSW partners have conducted numerous peacetime missions to search for lost submarines, validate harbor bathymetry, conduct sensitive operations and complete dozens of training missions in waters of the coasts of Washington, Hawaii and Virginia. They have worked on tactical development exercises for harbor defense, capability development for delivery and recovery from various surface and submarine platforms, locally developed and produced payload capabilities, and have conducted important surveys to monitor for changes at key strategic locations to assure that unknown changes have not occurred.

Subsea and Seabed Warfare has evolved rapidly, and the communities that have equities and expertise in the undersea fight have built enduring relationships to improve tactics, techniques and procedures. In the growing field of unmanned vehicles, we are advancing our expertise and technological capability to maintain and dramatically increase the U.S. Navy's SSW advantage. Revolutionary acquisition practices, "just enough rigor" in the acceptance of risk in UUV payloads, and establishment of demanding personnel requirements have us well positioned to push our unmanned communities to be nimble, lethal and critical to dominance in the undersea element of Great Power Competition.

Capt. Lincoln Reifsteck is commander, Submarine Development Squadron FIVE.

Assured Autonomy: Realizing the Potential of Unmanned Systems

By Cara LaPointe, PhD

Unmanned systems have the potential to fundamentally transform how we operate across the naval enterprise in every domain. Increased intelligence and autonomy are key to realizing this potential. Teaming the best of intelligent autonomous systems with the best of people will yield revolutionary capability and performance.

We do not yet have all of the tools to ensure that intelligent autonomous systems will always be safe, reliable, secure, predictable and ethical when they are integrated into unconstrained and often complex human ecosystems. There remains a critical need to develop tools that can be used throughout the life cycle to better design, develop, operate and protect these systems.

While increased intelligence is the key to achieving transformation impact at scale with unmanned systems, it also presents challenges. These include:

- **Intelligent Autonomy:** Brittle algorithms can be reliably effective in narrow circumstances, yet fail catastrophically and without warning under other conditions. The lack of transparency, explainability and auditability can hinder effectiveness or appropriateness of intelligent autonomous systems for some missions.

- **Data Management Systems:** There is a deficit of robust ubiquitous data collection and management systems to ensure we have the high-quality data needed to create effective autonomous systems.

- **Digital Infrastructure:** Extensive digital infrastructure is needed to ensure autonomous unmanned systems can be seamlessly integrated into complex ecosystems. This digital connective tissue includes everything from communications and command and control to interoperable system architectures.

These are complex and interrelated challenges that cannot be solved in isolation. We need to address them from a strategic and holistic view that takes into account their interdependence: How do the technology, the ecosystem and the policy and governance interact with one another?

To secure our communities and nation broadly, we need to use a holistic framework to drive enablers that will make these systems resilient against attack or failure, whether from adversaries, coding errors or other risks. It is an audacious goal, and success is critical for our nation. It will require advanced research, partnerships

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There remains a critical need to develop tools to ensure that intelligent autonomous systems will be safe, reliable, secure, predictable and ethical when they are integrated into human ecosystems. (Johns Hopkins University Applied Physics Laboratory)

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and collaboration across sectors — government, military, academia and industry key among them.

Building the Tools of Assurance
In order to meet this need, Johns Hopkins University has stood up the Johns Hopkins Institute for Assured Autonomy (IAA), led by the Applied Physics Laboratory and the Whiting School of Engineering. Covering a broad spectrum, we're approaching assured autonomy from a holistic perspective where we are developing the technology itself, its ability to seamlessly integrate into ecosystems and the policy and governance that regulates it. Among our major initiatives, we are forming partnerships with stakeholders across sectors and convening top experts for assuring the autonomous world. IAA is also uniting researchers across the university, leveraging advanced research and real-world applications of technology in practice. Our research projects span a range of applications.

Creating Robust Design Processes for Autonomous Unmanned Systems: As we develop intelligent autonomous systems such as unmanned surface vehicles, we need tools to make sure that as we update and improve the software we are not introducing additional bugs or causing potential failure. This research maps and compares two versions of autonomy software, enabling test engineers to ensure that more "mature" releases do not produce failure modes.

Securing Systems Against Visual Sensor Attacks: In image recognition sensors of intelligent autonomous systems, deep learning (DL) systems can be vulnerable to malicious attacks. This research will identify system vulnerabilities and deficiencies, which in turn will be leveraged to improve system robustness. It is poised to have far-ranging impact, not just improving the accuracy and resilience of image recognition algorithms, but also increasing the reliability of autonomous systems that use DL for sensing and decision-making.

Deconflicting Autonomous and Manned Airspace Operations: The air above us is increasingly congested with a range of systems — legacy manned systems, remotely operated systems and unmanned aerial systems (UAS), from unmanned rotorcraft to fixed-wing aircraft. Many unmanned systems are small and don't show up on military radars. But the military needs to understand the physical arena and keep situational awareness on all vehicles in all our physical domains — space, air, land and water. Traffic management systems need to deconflict friendly and adversarial assets in and across domains. This research is developing and evaluating prototypes of traffic-management systems to safely oversee these systems.

Ensuring Safe Interactions Between Humans and Robots: For mobile robots to navigate safely and follow social norms in indoor human spaces, they need to anticipate people's navigation and interaction. Just as important is the ability of a robot, operating in a social setting such as an office or hospital, to consider the impact of its actions on humans. Researchers are modeling dynamic social settings, developing more intuitive robot navigation and deploying the autonomous agents to a test environment.

Increasing Transparency and Explainability: Intelligent autonomous systems that are interpretable by humans, or can explain their decisions, help engender trust in the technology and increase usability. This work promises to significantly advance the field of explainable intelligence, ultimately allowing us to leverage intelligent autonomous systems across a broad range of missions for which transparency is a critical requirement.

Through these and other projects, we are developing tools for testing, evaluation, monitoring and governing of intelligent autonomous systems for better results across the life cycle — from design through protection, from concept through policy and governance. At the end of the day, it's about managing the intersections between these systems and people. We will only then be able to realize our full transformational potential by creating safe, reliable, secure, predictable and ethical intelligent autonomous systems.

Cara LaPointe, PhD, is co-director of the Johns Hopkins Institute for Assured Autonomy, and Assured Intelligent Systems Program Manager at the Johns Hopkins University Applied Physics Laboratory.

New Digital Processes Will Transform C³ Systems

By NUWC Division Newport Public Affairs

An area that stands to benefit greatly from digital transformation is unmanned systems (UxS) and the command, control and communications (C3) systems that allow operators to interact with them. How this transformation will occur includes the employment of new processes that signal a cultural shift for the research and development (R&D) community.

The new processes use Continuous Integration and Continuous Deployment (CI/CD) to streamline tasks and requirements in a cost-effective manner. This approach will combine artificial intelligence (AI) and machine learning (ML) with existing systems and the new services-based architecture applications under development today. The functions of the watch-floor operator will be streamlined where data will be automatically gathered, distilled and presented in a user-friendly interface to allow for fast, informed and accurate decision-making.

Why is this important? In a word: Scale. A regional Command Task Force watch-floor has its command and control and Common Operation Picture to keep track of all Navy assets and missions in the area. Like air traffic control, operators make sure the command structure is being followed. There is a hierarchy and a known quantity of people and vessels. When unmanned systems are added to the mix, the operational environment becomes significantly more complex.

Future missions will have many vehicles and systems coming into the Fleet at a rapid pace. If watch-floor manning is already a challenge, monitoring additional UxS traffic may become untenable. The amount of data being collected from unmanned systems will likely overload the watch-floor and operators may struggle to maintain situational awareness.

Understanding the struggles and challenges of watch-floor operators is essential for building the future Fleet. Digital transformation will help mitigate this problem.

During an Association for Unmanned Vehicle Systems International (AUVSI) conference in 2020, Vice Adm. Jim Kilby, deputy chief of naval operations for Warfighting Requirements and Capabilities (OPNAV N9), spoke about the technology needed to help operate UxS.

"Those enabling technologies are the Naval Tactical Grid. The ability to network and control all those unmanned vehicles is significant and important," Kilby said. "We view the world in the future of distributed maritime operations as a place where an air vehicle might have control of a surface vehicle and have to pass that control to a manned surface vessel or this unmanned operations center of the future.

"The ability to have a single control station that allows us to do that seamlessly will help us with training and the advancement and update of our systems in the future," he said.

At the same conference, Capt. Pete Small, program manager, Unmanned Maritime Systems (PMS 406), noted, "We'd like to have one interface that can support our family of unmanned systems, whether that's the surface domain or the undersea domain."

That "one interface" is the Common Control System (CCS), the operator software used to plan, execute, monitor and analyze missions that is being developed by Navy program offices and the Office of Naval Research for their portfolio of unmanned systems. It enables the future C3 for UxS. CCS not only allows for the rapid integration of new UxS capabilities, its construct reduces

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Signals

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cost and redundancies in software development. With the adoption of "DevSecOps" (development, security, operations), as new capabilities are added by individual efforts in the CCS community, the rest of the enterprise benefits as those capabilities can be shared and accredited for use.

DevSecOps is the concept of baking in cybersecurity practices into every step of the software development process. With DevSecOps, software engineers establish a "security as code" culture and collaborate on a common goal with cybersecurity teams. In order to eliminate the gaps that once existed between the information technology and cybersecurity communities, DevSecOps is intended to quickly deliver cyber-safe code. Stove-piped tasking is replaced with continuous inter-team communication and security requirements are instilled from software development to delivery.

The Integration: RAIL
The Rapid Autonomy Integration Lab (RAIL) is the Navy's pilot program for autonomy development. The RAIL provides the digital engineering infrastructure, tools and processes to rapidly develop, test, certify and deploy new autonomous capabilities. It will help scientists and engineers test and integrate advances in autonomy software with existing unmanned vessels.

This program not only lowers development costs, it speeds the integration of new systems to the Fleet. In this scenario, the RAIL is the software factory integrating the apps (services) that are traveling along
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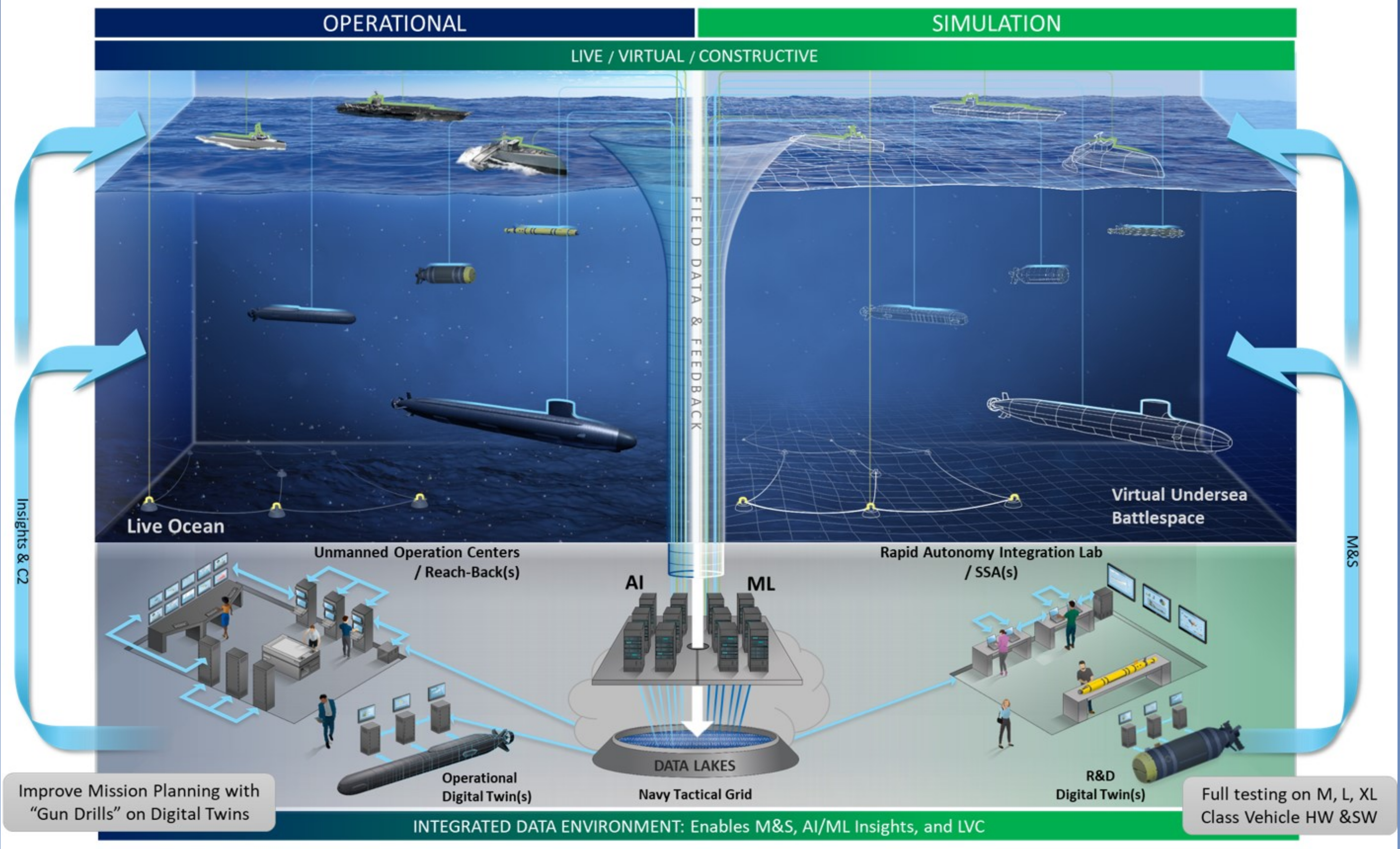

As illustrated above, pairing a strong simulation environment with DevSecOps and the Rapid Autonomy Integration Lab enables operators to run the equivalent of "gun-drills" for unmanned maritime systems. (U.S. Navy)

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a conveyer belt and being verified and validated at each stage.

If developers are using DevSecOps and the RAIL, they are doing the testing and getting the user feedback from operators. When paired with a strong simulation environment that is seamlessly integrated with the Live/Virtual/Constructive (LVC) environment, this enables the operator to run the equivalent of "gun-drills" for UxS. In addition, the concept of DevSecOps, combined with the tools at the enterprise level, lets developers experiment freely to see what works and what doesn't, and allows developers to fix any component that slows the system rather than taking the entire system offline to fix a single problem.

Culture shift for the R&D community
The UxS community can employ these processes to quickly provide watch-floor operators with the tools and information they need to do their jobs more efficiently and with greater accuracy. The culture shift comes as the R&D community adopts a new way of developing these systems.

The first step is understanding that the UxS community, and the Navy, is undergoing a transformation to allow for the expansion of new capabilities. The R&D community continues its mission of integrating AI/ML into future systems to give operators the tools they need without overwhelming them. At the same time, it cannot forget the systems that already exist.

It is important to note that as new systems are being developed, the goal is not to supplant established systems but rather incorporate them, help them evolve and carry out their mission. In order to be successful and expedient, there must be a way forward for existing programs of record that are not slated to change.

An example is to leverage the work done by the LVC community to bridge the gap between established operational systems and bring those capabilities to the RAIL using common communication protocols, according to Keith Wichowski, an engineer who led development of a C3 program at the Naval Undersea Warfare Center (NUWC) Newport Division and worked closely with fleet operators at the Unmanned Undersea Vehicles Squadron One to build the tools they need for working with UUVs and distributed systems.

"Systems that support UxS need to have common data structures, make use of LVC data, have both hardware and software in the loop, employ DevSecOps, AI/ML insights, common data lakes and the RAIL," he said. "Then, all of this data needs to be fed into distributed systems and incorporate logistics. Operators need to know what systems are fielded in the area. The success of these systems and the information they provide rely on a lot of things working together. Operators need to readily access information and that information must be human readable and machine usable."

While continuing to support the existing user base, current C3 products are working to extract the most successful components and convert them to services that can be leveraged by CCS and the Unmanned Maritime Autonomy Architecture community to enhance warfighter capabilities and provide interfaces that are intuitive, informative, distributed, scalable, manageable and fast.

Future state
As a use case for employing DevSecOps, CCS and RAIL, the UxS community is uniquely positioned for success because its systems are relatively new. As the culture shift and digital transformation take hold, other systems may follow. For developers, the shift will include the concept of Infrastructure as a Service. Ideas conceived on a laptop can transition to a rack of servers and then quickly scale to be a part of a global system. Ultimately, future software will incorporate multi-modal infographics and intelligent agents. Systems will be fast-acting, distributed, capable and integrate contextually relevant AI/ML insights for mission applications.

Knowing what works from a design sense and then knowing what is possible from a technical perspective is the key. "Operator feedback is the critical piece," Wichowski said. "In the end, there is always a human making the decision to push the button based on the information he or she was provided."

Naval Air Force Atlantic Demonstrates Cargo UAS prototype

By Commander, Naval Air Force Atlantic Public Affairs

Naval Air Force Atlantic conducted a test of a logistics unmanned air system (UAS) prototype over Naval Station Norfolk, Va., on Feb. 21, 2021. The long-range cargo transport, dubbed Blue Water UAS, is designed to operate with Naval Forces that typically operate in heavy winds over open water and require aircraft to land on pitching vessels at sea.

The technology demonstrator vehicle can operate in some of these conditions and further development will be required to meet the full Naval requirement.

"The Ford Blue Water UAS supply demo is a first step in revolutionizing logistics support to maximize operational availability and lethality for these critical capital assets," said Capt. John Bush, director, Aircraft Material and Engineering, Naval Air Forces Atlantic.

The proof-of-concept test was successfully conducted by transporting lightweight logistical equipment from the Mid-Atlantic Regional Maintenance Center (MARMC), Naval Station Norfolk, onto USS Gerald R. Ford (CVN 78) while the Ford-class aircraft carrier was in port.

"This UAS demonstration leverages cutting-edge technology to enhance our logistical efficiency across the Naval Air Force," said Rear Adm. John F. Meier, commander, Naval Air Force Atlantic. "We have come a long way in integrating unmanned systems in Naval Aviation and the lessons learned today will help to accelerate this capability to the fleet."

Historic data from Navy casualty reports show that warships that move to non-mission capable or partially mission capable status often do so due to logistics issues like the need for electronic parts, 90 percent of which are logistical deliveries weighing less than 50 pounds.

A logistics unmanned air system (UAS) prototype, called Blue Water UAS, approaches to deliver cargo on the USS Gerald R. Ford's (CVN 78's) flight deck during a Feb. 21 supply demonstration. (U.S. Navy)

Currently, aircraft like the MH-60 helicopters and MV-22 tilt-rotors fly these missions.

Blue Water presents an opportunity to cut the cost and inefficiency of these flights.

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Understanding the Environment Key to Advancing Application of UUVs

By Rear Adm. John A. Okon

Naval Oceanography has operated unmanned underwater systems for more than 20 years to help define, predict and exploit the water column, ocean bottom and sub-bottom in support of naval operations. Leveraging both government and industry research and operations during that time, Naval Oceanography's technology has advanced from the original Seahorse, a 28-foot-by-38-inch diameter Autonomous Underwater Vehicle (AUV) in 1990, to today's fleet of nearly 200 Littoral Battlespace Buoyancy Gliders (LBS-G), and AUVs ranging from REMUS 100-meter, 600-meter and 2,500-meter vehicles to full-ocean-depth, 6,000-meter vehicles.

While technology and innovation continues to advance applications for unmanned underwater vehicles (UUVs) in naval and joint warfighting at a blistering pace, one constant remains: the impact of the environment on autonomous vehicles and the need to better know, understand and predict the ocean and maritime environment. If you plan to operate UUVs, you better know the environment in which you intend to operate.

Plan to deploy and recover your underwater vehicle at a certain location and time? Did you take into account internal currents, internal waves, salt- or fresh-water lenses, cold and warm core eddies, biofouling, underwater obstructions? If not, decades of real ocean experience indicate that your probability to deploy, operate and recover your vehicle successfully is low.

As outlined in the recently released Department of the Navy Unmanned Campaign Framework, unmanned systems are a key component in the successful execution of current and future Distributed Maritime Operations (DMO). Our Navy is making significant investments in UUVs and recognizes the necessity to account for the ocean environment in all phases of UUV development, including initial design to operations to increase lethality, capacity, operational tempo, deterrence and readiness.

For the Navy to successfully deliver new unmanned capabilities, we must build upon past investments in command and control, automation and machine-to-machine learning. We must also acknowledge the importance of the ocean's internal structure and processes on UUVs and their autonomy. As an early adapter and operator of unmanned systems, Naval Oceanography's longstanding partnerships leveraged

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Naval Oceanography's fleet today includes nearly 200 Littoral Battlespace Buoyancy Gliders (LBS-G) and Autonomous Underwater Vehicles (AUVs) ranging from REMUS 100-meter, 600-meter and 2,500-meter vehicles to full-ocean-depth, 6,000-meter vehicles. (U.S. Navy)

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"The sea is selective, slow at recognition of effort and aptitude, but fast in sinking the unfit"
— Felix Reisenberg

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intellectual capital in industry, academia and government to innovate and transform new technology into operational advantage.

Through machine learning and deep understanding of the ocean, we pushed the original operational construct of 10 LBS-Gliders to one Glider Pilot to 50:1 in 2019. We are seeking to increase efficiencies to 100:1 in 2021. How can this be achieved? Through centralized command and control and development and implementation of new automation/autonomy tools for use in our ocean models.

Over the last decade, Naval Oceanography's unmanned vehicles have traversed more than 50,000 miles with 17,000 hours of total data collection time. Collocated with the Navy's world-class global and tactical ocean numerical prediction, the Navy's Glider Operation Center has command and controlled hundreds of LBS-G glider deployments over more than 370,000 miles, and logging more than 1.2 million hours deployed. This extensive operational experience is foundational and demonstrates a deep understanding of how maritime unmanned systems operate, particularly in the areas of navigation, autonomy and mission duration, and which will be built upon to accelerate further adoption throughout the Fleet.

As we develop a roadmap to bring the Unmanned Campaign Framework to life, we should not navigate alone in any aspect of unmanned systems. We should leverage current capability while acknowledging and including the realities of the physical environment into our decision cycles. If we do not recognize this reality we risk running afoul of the old adage: remember the sea is selective, slow at recognition of effort and aptitude, but fast at sinking the unfit.

Rear Adm. John A. Okon is commander, Naval Meteorology and Oceanography Command/Task Group 80.7, and Oceanographer of the Navy

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"Carrier logistics is a complex and diverse problem set," said Capt. Paul Lanzilotta, Gerald R. Ford's commanding officer. "Sometimes getting a small part delivered to the ship has a big impact on the availability of an embarked system or aircraft. Having UAS like Blue Water may improve our ability to quickly meet specific logistics needs where payload and ship's location permit."

The Naval Air Warfare Center Aircraft Division (NAWCAD) will continue to work with its industry partners to enhance the UAS in-house with developments like folding wings for better handling and ship storage, and consider alternative air vehicle designs with advanced propulsion systems to provide greater range and payload performance, optical and infrared collision avoidance and landing systems, and navigation systems not only dependent on GPS.

"Developmental platforms like our Blue Water UAS are important for exploring opportunities to maintain a competitive edge with top-tier technology and improve the logistical support of America's Sailors and Marines," said NAWCAD Commander, Rear Adm. John Lemmon.

Blue Water UAS can operate from both the ship and the shore. It requires minimal maintenance and control stations are small – about the size of a shoebox or small suitcase – netting near zero infrastructure.

Experimentation with the fleet will continue throughout 2021. The results of the experimentation will help the Navy decide whether to transition the technology to support fleet initiatives.

International Cooperation in the Era of Unmanned

By Andrea Bell-Miller

As we enter a new era of digital revolution and innovation, the U.S. Navy's long-held technical advantage is under threat. We are in many ways clearing the scoreboard. The scale and pace of autonomy-related investments internationally far exceed any one nation's capacity to compete on all fronts. Partners and allies must collaborate in order to maintain the operational advantage and sustained strategic advantage.

Synergies across the acquisition spectrum, innovation ecosystems, and science and technology communities all facilitate the development of joint solutions. These have the potential to go beyond interoperability and lead to interchangeability on Day Zero of any conflict – Interoperability to Interchangeability (I2I) being the gold standard for coalition operations to deliver a force that is greater than the sum of its parts.

However, there are challenges to overcome and subtleties that go beyond pure defense. But the desire from the very top has begun to thaw what was once considered a "frozen middle," and suddenly those involved in international cooperation have been energized and called upon to deliver results – at pace!

In terms of unmanned systems, many consider the NATO Maritime Unmanned Systems Initiative (MUSI) to be an exemplar, multi-national effort. At the 2018 Defense Ministerial in Brussels, former Defense Secretary James N. Mattis, along with counterparts from 12 other nations, agreed to sign a Declaration of Intent to work together to develop maritime unmanned systems. Over the past two and a half years, it has grown to 17 nations and very soon will include Estonia, forming a team dedicated to development and delivery of these systems.

We need fast adoption of these systems into the existing force structure, we need to be able to think beyond just interoperable to I2I in order to maximize impact. The United States and its allies recognize that operational experimentation is key to accelerating these systems into the hands of the warfighter. As the U.S. Unmanned Campaign Framework suggests, "test a little, learn a lot."

MUSI, in its short existence, has delivered the world's largest operational experimentation exercise involving maritime unmanned systems (Recognized Environmental Picture, Maritime Unmanned Systems, or REPMUS) in 2019 and is leading the planning for the next two major events, REPMUS 21 and Dynamic Messenger Series 2022.

REPMUS 21 will take place off the Troia Peninsula, Portugal, on Sept. 21. The United States and the United Kingdom will be leading I2I experimentation in accordance with the Chief of Naval Operations/First Sea Lord Combined Seapower Strategy. Specifically, in the development of interfaces between the Common Control System/Maritime Autonomous Platform Exploitation (CCS/MAPLE) for cross-domain command and control (C2) of unmanned systems (UxS).

This experimentation will decentralize traditional UxS management processes and enable dynamic resource reallocation among nations to meet specific evolving tactical needs while optimizing these broad military objectives:

- Enabling allied systems to pass/receive information between disparate commands to greatly expand the operational viewpoint with a complete tactical picture extending well beyond the current view.

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International

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- Integration of Transfer of Tactical Control capability to effectively share multi-national unmanned vehicle resources when needed to execute mission objectives.

MUSI is the technical sponsor for developing the standard for C2 of multi-domain UxS. Defining and agreeing to C2 standards will naturally lead to I2I, irrespective of national C2 systems or the plethora of ground control stations on the market. In addition to the acceleration and I2I efforts, MUSI, in response to NATO's No. 1 maritime priority, has created an Anti-Submarine Warfare Barrier (using MUS) NATO Smart Defense Project to tackle the ASW threat posed by a resurgent Russian submarine force. This project is the fastest developing Smart Defense project at NATO.

More broadly, and with a little help from the MUSI Innovation Advisory Board (composed of professionals from all sectors such as author Peter W. Singer, Estonian Finance Minister Keit Pentus and Sparkcognition CEO Amir Hussain), the MUSI is developing concepts to tackle wider issues in the maritime and bolster all the levers of power. The Digital Ocean is the latest to permeate the community and result in collaboration that could be game changing for the allies.

A U.K. Royal Navy unmanned Pacific 950 Rigid Inflatable Boat patrols the harbor near Troia, Portugal, during an unmanned systems trial as part of REPMUS 2019. (NATO)

The Digital Ocean looks to exploit new technologies to enable detection and identification of activities in, on and under the ocean globally. Every system from the seabed to space that can transmit and receive data is a potential situational awareness asset. The United States is ahead in this area and the "Ocean of Things" features prominently in the U.S. Unmanned Campaign Framework. But international team work will make this dream work.

Due to the challenges resulting from COVID-19 travel restrictions, international participation in a Live, Virtual and Constructive (LVC) environment was initiated that not only de-risked future operation exercise events but facilitated transatlantic technical development of I2I, passing missions from a control station in the United States to an unmanned system in the United Kingdom.

We will be utilizing the Naval Integrated LVC Environment (NILE) that capitalizes on a wealth of components and capabilities across the naval research and development establishment, including testbeds, hardware-in-the-loop emulators, constructive simulations, trainers and ranges. NILE is an enterprise endeavor intended to serve a broad range of stakeholders and use cases including experimentation, capability development, mission engineering, test and evaluation, and war gaming.

The primary function is to enable end-to-end, mission-based contextualization. International LVC work is only just beginning and this area has much potential looking to the future.

So, as the world begins to open back up over the course of 2021 and 2022, developments, concepts and design principles will be put to the test by allies, with the United States leading. In the next three-to-five years we should see these systems combine with conventional forces to deliver a truly revolutionary warfighting capability on the international stage. In the words of one of the MUSI founders, "much good lies ahead."

Andrea Bell-Miller is International Director, PEO Unmanned and Small Combatants

MCWL's Ground Robotics Work Paved the Way for Joint Successes

By Dr. Matthew Foglesong

The Marine Corps Warfighting Laboratory (MCWL) identifies, develops and delivers innovative capabilities for warfighter assessment and experimentation in support of the Marine Corps future force design and development activities. One focus area of development and assessment is the use of robotic and autonomous systems to help enhance the capabilities and survivability of our warfighters.

The key to efficiently developing and fielding the most effective unmanned ground vehicles (UGVs) for the Marine Corps greatly depends on close collaboration and integration with the other services and defense agencies.

Early robotics and autonomous system development at MCWL yielded initial successes, which had lasting effects. The early 2000s saw the development of the Dragon Runner, which demonstrated the potential for how UGVs can reduce the risk to warfighters on the modern battlefield. Dragon Runner was basically a self-contained, rugged and remotely operated vehicle with some sensors and manipulators.

But it had serious drawbacks. The system could not readily share sensor feeds with other units, and Marines could not pass control of the Dragon Runner from one team to another. This was due to the immaturity of the system, but also because interoperability had not been designed into the system.

Beginning in 2009, MCWL initiated an eight-year off-road autonomy and perception algorithms development effort that resulted in the Ground Unmanned Support Surrogate (GUSS). GUSS added autonomy to existing Internally Transported Vehicles (ITVs) and prototypes of the Polaris MRZR All-Terrain Vehicles. This effort proved that fully autonomous UGV technology was mature enough to achieve a level of manned-unmanned teaming that could potentially revolutionize ground operations.

Early robotics and autonomous system development at the Marine Corps Warfighting Laboratory demonstrated the potential for how unmanned ground vehicles can reduce the risk to warfighters on the modern battlefield. Here, a Marine operates a Dragon Runner at Marine Corps Base Camp Pendleton, Calif. (U.S. Marine Corps)

GUSS demonstrated that UGVs no longer required a Marine to control every move of the vehicle remotely. Instead, a Marine operator could give GUSS a destination and the robot would find its way autonomously. GUSS could also follow in trace of a Marine or convoy autonomously.

While a Marine prototype and experimentation effort, MCWL's S&T Division shared results of multiple assessments and experiments with Army counterparts conducting similar UGV S&T efforts. The emergence of multi-service UGV efforts, not all of which were coordinated, led to the formation in 2016 of the Joint Ground Robotics Integration Team (JGRIT). Primarily an Army and Marine Corps team, the JGRIT sought to address UGV limitations and interoperability issues.

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DoD UxS

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Through the combined efforts of MCWL and the JGRIT, the Forward Robotic RSTA Experimentation and TTP (FERRET) system and an unmanned systems common controller, the Tactical Robotic Controller, were developed. The Joint S&T program explored semi-autonomous behaviors for Reconnaissance, Surveillance and Target Acquisition (RSTA) for UGV assets, the integration of autonomous capabilities with robotics controllers and the understanding of human-machine interaction on the battlefield.

The MCWL Expeditionary Modular Autonomous Vehicle (EMAV) was created using the knowledge derived from Army and Marine Corps UGV efforts. The EMAV became the Marine Corps' first fully autonomous and adaptive UGV. Leveraging the autonomy hardware and software developed for the GUSS project, EMAV includes a modular payload integration architecture that provides the ability to rapidly change payloads for a variety of missions across multiple warfighting functions.

EMAV is capable of remote-controlled or autonomous operations and provides combat forces with a highly mobile, air-transportable, multiple payload UGV for use at tactical levels. The vehicle also had the capability to off-board stored electrical power.

In March 2018, the U.S. Army Futures Command Ground Vehicle Support Center hosted a Robotics Rodeo. In this demonstration, the EMAV outperformed all other UGVs in its size/weight category. MCWL, with support from Pratt & Miller Engineering, entered the EMAV as a contender for the U.S. Army Robotic Combat Vehicle – Light (RCV-L) Program. These collaborative efforts led to the down-select of EMAV as the RCV-L vehicle of choice for further experimentation, and tactics, techniques and procedures and standard operating procedures development.

While the U.S. Army pushes ahead with capabilities documentation and development, the Marine Corps is continuing with multi-mission payload development, warfighting integration and manned-unmanned teaming experimentation. Long-term success, however, will depend on cross-service coordination and free sharing of data across the services and their developmental partners.

In order to drive down costs, reduce developmental risk, explore new avenues and ensure the development of a common lexicon, the Marine Corps and the Army owe it to the enlisted operators of tomorrow's UGVs to pave this road together.

Dr. Matthew Foglesong is Robotics Branch Head at the Marine Corps Warfighting Lab.

The Marine Corps Warfighting Laboratory leveraged the autonomy hardware and software developed for the Ground Unmanned Support Surrogate project, at left, for the Expeditionary Modular Autonomous Vehicle, at right. (U.S. Marine Corps)

Will the 'real' game changer please stand up?

By Dorothy Engelhardt

In early January 2020, the first cases of COVID were reported in the United States. By spring, our world had changed dramatically as the death toll continued to rise with no known vaccine able to combat the virus.

COVID-19 became a forcing function for our pharmaceutical industry to band together and commence a race against time. By way of brilliant scientists, aided by technology and pressing global needs, vaccines were researched, tested and manufactured for widespread use in record time.

However, it would be the vaccine distribution and logistics system that would languish behind, because we weren't organized for the scale required for nationwide implementation. Many of you are thinking, what does this have to do with unmanned systems? What did COVID teach us about technology and distribution?

It is abundantly clear that technology is moving at a speed that we are unfamiliar with. As a result, we need to change our traditional organizational and business models in order to better facilitate fielding of emergent technologies and capabilities.

Now is the time to think seriously about how the Navy and Marine Corps should be organized to leverage

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The medium displacement unmanned surface vessels Seahawk, front, and Sea Hunter launch April 20 for the U.S. Pacific Fleet's Unmanned Systems Integrated Battle Problem (UxS IBP) 21. (U.S. Navy)

Message In Code

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a more autonomous world — an operating environment composed of autonomous ships, aircraft, undersea vehicles. We must also think anew about the key role manpower will play and the new and different types of supply chains required to sustain these new autonomous capabilities.

What new operating and support constructs are needed to develop, build, operate and sustain unmanned capabilities that are going to be heavily reliant on autonomy software? The naval enterprise should begin exploring a Digital Maturity Model for unmanned systems that maximizes Live, Virtual and Constructive, DevOps and Sandbox(s) based on virtual twins and are collaborative across both government and industry. This approach leads to a more agile and responsive enterprise to make better use of disruptive technologies and continuous improvements to enduring capabilities.

Using LVC will also lower the cost of experimentation and accelerate learning, testing and iterating, and it will facilitate faster transitions to the fleet than using traditional models. This approach will take time to fully implement, but using both unmanned systems and autonomy architectures as pathfinders, we will be able to jumpstart the understanding of network demands; determine what new business process models need to be implemented to go faster; figure out what new standards and interfaces need to be implemented to protect industry IP; and understand what the

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An unmanned Boeing MQ-25 T1 Stingray test aircraft, left, refuels a manned F/A-18 Super Hornet, June 4, 2021, near MidAmerica Airport in Mascoutah, Ill. This successful flight demonstrated that the MQ-25 can fulfill its tanker mission using the Navy's standard probe-and-drogue aerial refueling method. The MQ-25A will be the world's first operational carrier-based unmanned aircraft and provide critical aerial refueling and intelligence, surveillance and reconnaissance capabilities. (U.S. Navy courtesy of Boeing)

Message In Code

A Vanilla ultra endurance land-launched unmanned aerial vehicle operates April 24 during UxS IBP 21. (U.S. Navy)

An MQ-9 Sea Guardian unmanned maritime surveillance aircraft system flies over USS Coronado (LCS 4) April 21 during UxS IBP 21. (U.S. Navy)

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government needs to retain ownership of to continuously improve capabilities.

I think of Tesla's model where its cars are continuously updated with new software designed to make the engines run more efficiently, extend existing battery life or enhance the navigation system. Now imagine Navy aircraft, ships and undersea capabilities being able to execute similar software updates to continuously improve warfighting capabilities without being operationally "downed" or taking their capability off line.

I can imagine an autonomous ship transmitting a request to a supplier to repair or replace a part that is nearing the end of life cycle, and the supplier alerting its distribution center to automatically send the part to the port or location of the USV in preparation for installation. This is a long game, and one that requires the Navy and Marine Corps to own its technical baseline and interfaces in order to keep pace with technology, but we must take the first step and organize for it.

Dorothy Engelhardt is Director of Unmanned Systems, DASN Ships.

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Sapere aude

Greetings readers. I hope you enjoyed the kickoff edition of **THE DISRUPTOR**. We are always open to new ideas or additional topics and issues to highlight, as well as suggestions on how to continue improving **THE DISRUPTOR**. Collectively and collaboratively, we are building the Navy's unmanned systems community of interest from the ground up! Please reach out to me at **dorothy.engelhardt@navy.mil**, or Rob Holzer at **RHolzer@gryphonlc.com** with suggestions on future article topics or new directions to explore.

THE DISRUPTOR is produced by the Director, Unmanned Systems, Deputy Assistant Secretary of the Navy Ships. This document has been approved for public release and distribution is unlimited. Design and layout by Peter Atkinson and Whitney Whiteside.