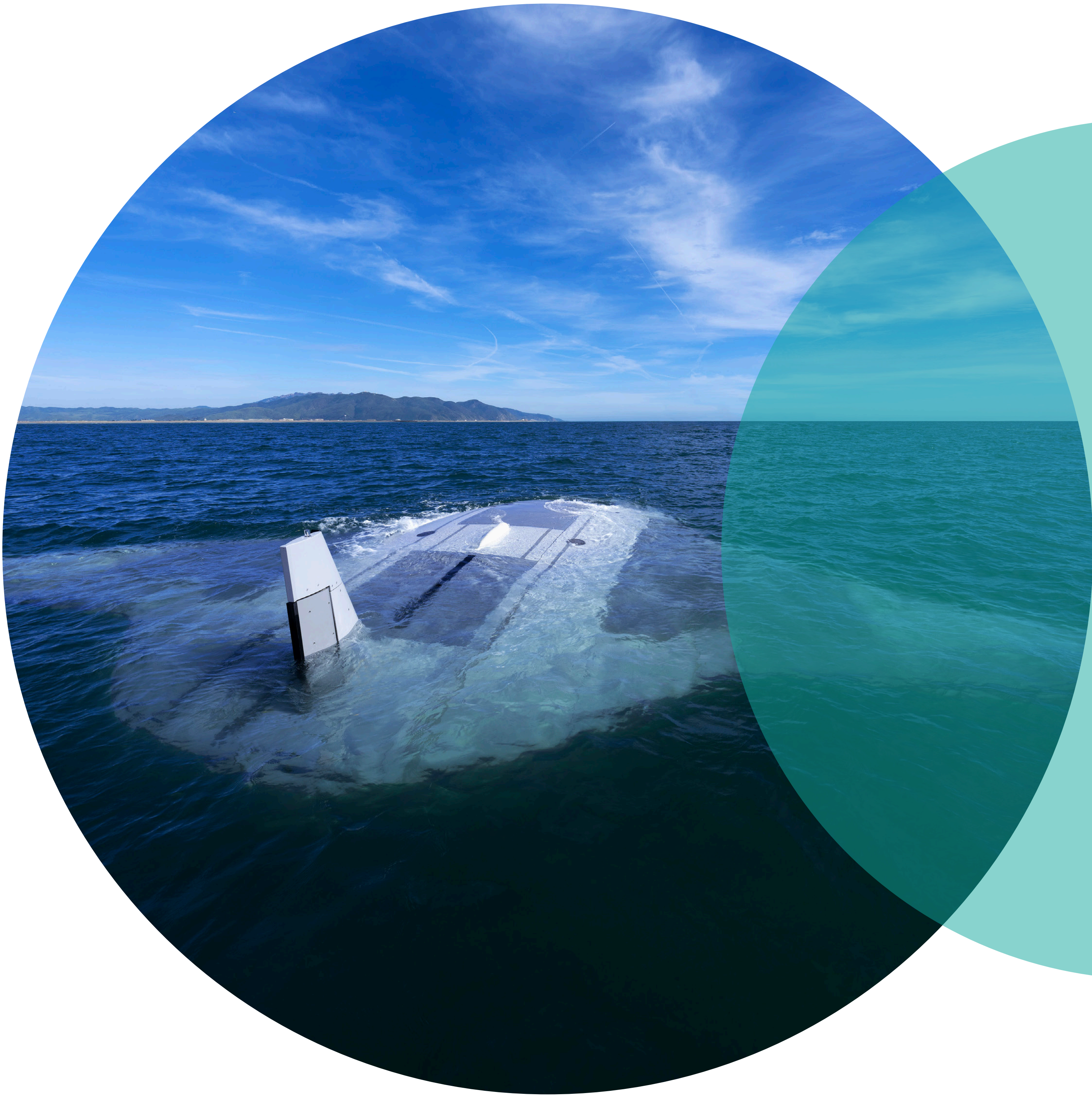
Hybrid CoE Working Paper 34

# Uncrewed maritime vessels: Shaping naval power in hybrid threat operations



Hybrid CoE

Scott Savitz – October 2024

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# Introduction

As uncrewed[1] vessels (also called unmanned vessels) and the technologies supporting them advance, they will increasingly play a role in addressing hybrid threats, namely harmful actions that combine "overt and covert military and non-military means".[2] This Hybrid CoE Working Paper discusses the current and potential impact of uncrewed maritime vessels in the context of hybrid threats. The paper begins with a brief overview of uncrewed maritime vessels, focusing on the fundamentals of how they operate given their physical environments. It goes on to discuss the history of uncrewed surface vessels (USVs) and uncrewed undersea vessels (UUVs), current developments, and various classes of these vessels. It then describes some of the ways in which they can be employed in hybrid threats, followed by a brief case study. Finally, some publicly disclosed Chinese, Russian, and Iranian uncrewed maritime vessel capabilities are characterized and potential ways of countering these threats are presented, before drawing conclusions.

1 We use the term "uncrewed" throughout this paper, although "unmanned" and "uninhabited" are also commonly used. "Unmanned" can be misleading, as it may suggest that humans are not involved with the vessel, although there are typically numerous operators, maintainers, and others who are not on board. It is also gender-specific. Since "uninhabited" has five syllables, we prefer using "uncrewed" for brevity.

2 See the website of the European Centre of Excellence for Countering Hybrid Threats, https://www.hybridcoe.fi/hybrid-threats/. The full definition from Hybrid CoE is: "The term 'hybrid threat' refers to an action conducted by state or non-state actors, whose goal is to undermine or harm a target by combining overt and covert military and non-military means."

# A brief overview of uncrewed maritime vessels

There are two main types of uncrewed maritime vessels. Uncrewed surface vessels (USVs) operate at the waterline, while uncrewed undersea vessels (UUVs) operate below it. Where there is ambiguity about whether a given vessel is a USV or a UUV, the key question is whether it maintains continuous contact with the surface. If so, it is a USV; if not, it is a UUV.

USVs and UUVs differ not only in where they operate, but also in their relative capabilities. Many of these favour USVs. For example, USVs are able to freely use the electromagnetic spectrum for communications, navigation, and sensing. Since electromagnetic energy rapidly attenuates below the waterline, UUVs largely lack the ability to do the same, with partial exceptions over very short ranges.[3] USVs can carry larger payloads than UUVs of comparable size, given that they do not need to fully encapsulate that payload in a watertight container. USVs can generally have higher maximum speeds than UUVs, and consume less energy at comparable speeds, since water is a much more resistant medium than air.[4] USVs also have the advantage of being able to consume energy-dense fossil fuels, since they can draw in atmospheric oxygen and release exhaust. UUVs, on the other hand, must rely on lower-density batteries for energy when they are submerged. Some can periodically surface and burn stored fuels to recharge their batteries; surfacing also provides intermittent opportunities to use the electromagnetic spectrum.[5] However, encumbering UUVs with multiple energy-storage systems limits their payload capacity, as engines take up space alongside the requisite batteries.

Although USVs have many advantages, there are two key areas in which the capabilities of UUVs exceed those of USVs. The first is stealth: a submerged UUV is very difficult to detect. Not only are they visually concealed, but they also evince relatively small signatures, even compared to submarines, which are orders of magnitude larger than even today's largest UUVs. The second advantage of UUVs is their ability to operate at variable depths. A UUV can dive to the seabed or roam anywhere in the water column. This can enable UUVs to observe, attack, or help protect undersea infrastructure to counter hybrid threat attacks or operations.

The physical environments of the two types of vessels also differ, generally in ways that require greater agility on the part of USVs. USVs need to contend with the challenges of seakeeping and weather as they roam the complex interface between air and water; this challenge becomes particularly acute at higher sea states (i.e., when seas are rough). USVs also operate in an environment more crowded with human activity. The two-dimensional surface of the ocean is full of vessels and fixed infrastructure that USVs must be able to avoid. UUVs, operating in a single three-dimensional medium that is less crowded, face lower risks in both regards.

Another key difference between USVs and UUVs is the balance between autonomy and remote control of the vessel. UUVs *must* be highly autonomous when they are submerged,

3 Scott Savitz, Irv Blickstein, Peter Buryk, Robert W. Button, Paul DeLuca, James Dryden, Jason Mastbaum, Jan Osburg, Phillip Padilla, Amy Potter, Carter C. Price, Lloyd Thrall, Susan K. Woodward, Roland J. Yardley, and John Yurchak, *U.S. Navy Employment Options for Unmanned Surface Vehicles (USVs)*. Santa Monica, CA: RAND Corporation, 2013. https://www.rand.org/pubs/research_reports/RR384.html.

4 Ibid.

5 Ibid.

unless they have long cables connecting them with shore facilities or surface vessels (in which case they are termed Remotely Operated Vessels, or ROVs). This reflects the near impossibility of precisely controlling the actions of an untethered, submerged UUV. Any electromagnetic communication underwater is confined to very short ranges, typically measured in metres. Underwater acoustic communication can be longer-range, but faces a couple of key issues. First, it typically involves very low bandwidths, and second, since sound transmission through various layers of water is complex, the range at which communications can be received and accurately decoded is variable. Moreover, while a UUV can receive acoustic communications, there are sound operational reasons for not transmitting them on a regular basis; doing so would deprive it of the stealth that is its singular advantage. An alternative way for UUVs to exchange information is to do so during brief forays to the surface, but this again exposes the UUV to detection. A stealthier approach, which has been pursued by Northrop Grumman and Seatrec, is to have the UUV periodically release buoyant "data bubbles" that float to the surface and then emit bursts of information after the UUV has had time to depart the area. These companies have also been working on aspects of undersea docking stations that UUVs could potentially use to exchange information and recharge batteries, particularly if the docking stations were hardwired to locations on land.[6]

USVs can be remotely controlled, as long as they have robust communications with the personnel exerting that control. Their lack of altitude may sometimes require them to rely on relay aircraft or even satellites to communicate with operators at a substantial distance. Another constraint on remote control includes deliberate disruption or manipulation of communication channels by hostile actors; such electronic warfare may constitute part of a set of hybrid attacks. Constant emissions of information from USVs can also make them easier for hostile actors to track, capture, or target.

Endowing USVs with a high degree of autonomy is an attractive alternative, but anticipating and algorithmically overcoming the many challenges a USV may face is far from trivial. Attempts to solve the analogous problem on land are revealing: despite various companies spending tens of billions of dollars over a decade or more, and the lucrative commercial returns for developers of fully self-driving cars, such vessels remain unavailable. At sea, the navigational problems of seakeeping and collision avoidance are hard for humans, as demonstrated by accidents such as the two collisions between US warships and commercial ships in 2017.[7] It will be difficult to teach machines to do what humans themselves are unsure about, particularly when seakeeping or collision-avoidance situations can be idiosyncratic. Moreover, an additional challenge is how to endow USVs with the ability to perform their missions

6 Xavier Vasseur, "Northrop Grumman and Seatrec Recognized for Self-Sustaining UUV Charging Station Design", *Naval News*, 6 August 2020, https://www.navalnews.com/naval-news/2020/08/northrop-grumman-and-seatrec-recognized-for-self-sustaining-uuv-charging-station-design/.

7 Kevin Eyer, "Collision Reports Reveal Bigger Issue", *Proceedings of the U.S. Naval Institute*, November 2017, Vol.143/11/1,377, https://www.usni.org/magazines/proceedings/2017/november/collision-reports-reveal-bigger-issue.

autonomously. The difficulty of this will vary as a function of mission complexity and the extent to which hostile actors are anticipated to interfere with the mission, as well as the number of potentially creative ways in which they can do so.

Given the difficulty and uncertain timelines associated with achieving full autonomy, near-term USVs will likely have some degree of partial autonomy. There are many scales that have been used to characterize degrees of autonomy; one example stems from a RAND report on USVs.[8]

- Level 0: No autonomy (fully remote-controlled)
- Level 1: Rudimentary semi-autonomy (waypoint navigation without collision avoidance)
- Level 2: Semi-autonomous (waypoint navigation including collision avoidance)
- Level 3: Advanced semi-autonomy (generates best course to target)
- Level 4: Autonomous under most conditions (application-driven)
- Level 5: Fully autonomous under all conditions (application-driven)

When analyzing how autonomous to make a USV, one positive attribute is that decisions do not need to be final. As algorithms for USV autonomy gradually improve, a vessel that was primarily remotely controlled can be transformed into one that is more autonomous, typically with only limited changes to its hardware.

Based on the preceding discussion, Table 1 summarizes some of the relative advantages of USVs and UUVs, as well as those of uncrewed aerial vessels (UAVs).

One other set of tradeoffs needs to be considered: that between uncrewed maritime vessels and their crewed counterparts. A vessel that does not need to support humans can deliver more payload than a comparably sized crewed vessel, and has fewer design constraints. Conversely, an uncrewed maritime vessel can be smaller and perhaps stealthier than a crewed one with an equivalent payload. It may be less expensive, lacking complex systems to keep personnel alive, which may enable multiple uncrewed vessels to supplant a single crewed one. Perhaps most importantly, it can be subjected to much higher levels of risk than one containing humans, expanding the mission space. It can even be sent on a one-way mission, whereas most military forces consider it anathema to deliberately send personnel to certain death.

Uncrewed vessels are sometimes perceived as enabling hybrid threat activities with a lower risk of attribution. This may be true in some cases, to the extent that the increased stealth associated with some uncrewed vessels may reduce their likelihood of detection or capture. Some can even aim to scuttle or destroy themselves in the face of imminent danger, and may be all but irrecoverable in some marine environments. However, a captured vessel, or the remnants of a damaged one, may provide ample clues for forensic investigators. Moreover, a vessel's algorithms, or the remote operators seeking to control it, may not realize that the vessel is about to be captured until it is too late. Although there are no captured personnel whose release may require an admission of the hybrid threat activity, the other side may be able to demonstrably attribute the vessel's

8 Savitz, Blickstein et al., *U.S. Navy Employment Options for Unmanned Surface Vehicles*.

**Table 1. Relative advantages of USVs, UUVs, and UAVs**

| Attribute | USV | UUV | UAV |
|---|---|---|---|
| Endurance | Potential for days, weeks, or even months of endurance, particularly if moving slowly. | Typically limited to hours by battery life unless it also contains an engine and fuel, and periodically surfaces to recharge. | Typically limited to hours. |
| Speed | Higher than UUV, but lower than UAV. | Slow – typically a few kilometres per hour. | Fast – can be tens or hundreds of kilometres per hour. |
| Access to electromagnetic spectrum for communications and navigation | Full access, although lack of altitude may limit line-of-sight communications. | Essentially no access when submerged. | Full access |
| Autonomy requirement | Can be substantially or completely remotely controlled if communications are robust. | Untethered UUVs must be highly autonomous – remote control is not possible. | Can be substantially or completely remotely controlled if communications are robust. |
| Payload (for comparably sized vessels) | Can handle large payloads. | Limited by space. | Limited by space and weight. |
| Stealth | Can be designed for low visibility, but still less stealthy than UUVs. | Very stealthy | Generally easily detected via radar. |
| Ability to operate in three dimensions | None | Can vary depth. | Can vary altitude. |
| Challenges of physical environment | Needs to manage both seakeeping and collision avoidance on the complex, crowded sea surface. | Needs to avoid entanglement in nets or plants and collisions with seabed elevations. | Needs to avoid other airborne objects (flocks of birds, aircraft). |

activities. Nations can employ uncrewed maritime vessels in hybrid threat operations to push boundaries, testing the limits of behaviour in new ways, but they should not expect to do so with total impunity.

# History, current developments, and classes of uncrewed maritime vessels

Uncrewed maritime vessels have a long history, including their use in military operations. From ancient China to the British fight against the Spanish Armada and beyond, navies used fireships (old vessels filled with combustible materials, set alight and allowed to drift down current towards enemy ships) for thousands of years.[9] The mobile torpedoes that were first developed in the nineteenth century were arguably a form of UUV (previously, "torpedoes" referred to what are now called "mines").

The first wirelessly remote-controlled vessel of any type was a USV, pioneered by Nikola Tesla in 1898.[10] Remotely controlled, explosive-laden USVs were briefly used by German forces to target Allied shipping during World War II. Military forces have used USVs and UUVs for testing and training since the mid-twentieth century. Such systems also found niche civilian applications, notably in the offshore oil and gas industry.

Since the late twentieth century, advances in USV and UUV technologies have been outpaced by those for UAV technology. In part, this reflects the fact that the air is a simpler physical environment for uncrewed vessels: it lacks the volatility of the ocean's surface where USVs operate, while providing access to the electromagnetic spectrum that is essentially denied to UUVs. As USV and UUV technologies mature to accommodate their more challenging environments, they may achieve some degree of the ubiquity of UAV technologies in commercial, hobbyist, and military/governmental applications (including hybrid threat operations). Many of these applications are described later in this paper.

Since the turn of the millennium, there has been a proliferation of USV and UUV types, produced by many dozens of manufacturers. Companies and government agencies around the globe are designing, building, and testing these vessels for commercial, scientific, and military purposes. Analysis of sources from across the web reveals that over 250 USVs and over 200 UUVs  are currently manufactured or in various stages of development, with size ranges that span two orders of magnitude. The range of system sizes has been increasing over the last two decades. In the 2000s, experimentation and development of USVs and UUVs were largely conducted with small systems that were relatively inexpensive, easily handled, and posed limited risks to infrastructure or other vessels in the event of a collision. As the field has advanced, larger vessels are also being developed and used alongside smaller ones.

Drawing on a prior RAND report and a US Navy master plan, the vast majority of the plethora of USVs can be divided into seven classes, based on both size and specific features:[11]

9 See Ralph D. Sawyer, *Fire and Water: The Art of Incendiary and Aquatic Warfare in China*, Basic Books, 2004, and Rodríguez-Salgado, M.J.; Adams, Simon (eds.), *England, Spain and the Gran Armada 1585–1604*, Barnes & Noble, 1991.

10 See Matt Novak, "Nikola Tesla's Amazing Predictions for the 21st Century", *Smithsonian Magazine*, 19 April 2023, www.smithsonianmag.com/history/nikola-teslas-amazing-predictions-for-the-21st-century-26353702 and Savitz, Blickstein et al., *U.S. Navy Employment Options for Unmanned Surface Vehicles*.

11 See US Department of the Navy, *The Navy Unmanned Surface Vehicle (USV) Master Plan*, 9 November 2004, and Savitz, Blickstein et al., *U.S. Navy Employment Options for Unmanned Surface Vehicles*.

- Environmentally powered USVs that are a few metres in length, and derive energy from their environment. These typically have long endurance and are useful for collecting data; they can be thought of as self-relocatable, slow-moving sensor buoys. An example is the Wave Glider USV by Boeing, which harvests both solar and wave energy.[12]
- X-class USVs are a few metres in length and are not environmentally powered. They have limited endurance, ranges, payloads, and seakeeping capabilities. An example is the Mako Jet Ski USV by AEVEX.[13]
- Snorkeler USVs are envisioned as being between 7 and 12 metres in length, with only a combined snorkel/antenna protruding above the surface. These could provide some of the stealth associated with UUVs, but as USVs, they could use both fossil fuels and the electromagnetic spectrum.
- Harbour USVs are in the order of 7 metres in length, and are not snorkelers. They typically have greater speed, endurance, range, and payload than snorkeler counterparts of comparable size, but lack the same degree of stealth. An example is the U-Ranger MS, made by L-3 Calzoni.[14]
- Fleet USVs are close to 11 metres in length (and are not snorkelers), providing more endurance, range, and payload than harbour USVs. An example is the Common USV made by Textron Systems, which is used for naval mine countermeasures, among other missions.[15]
- Medium USVs are between 12 and 50 metres in length. An example is the 42-metre Sea Hunter, which was developed by the Defense Advanced Research Projects Agency (DARPA) to track submarines.[16]
- Large USVs are over 50 metres in length, such as the US Navy's Overlord class (which varies between 60 and 90 metres), developed by Austal. These are full-fledged ships designed to operate without personnel.[17]

Similarly, UUVs can be characterized based on their size. Size not only correlates with endurance, range, and payload, but also with how these devices can be transported, handled, launched, and recovered. The following classes are based on a US Navy report to the US Congress:[18]

12 "Wave Glider", Liquid Robotics, undated, https://www.liquid-robotics.com/wave-glider/overview/.
13 Howard Altman, "Mako is a Jet Ski Turned into a Weaponized Drone", *The War Zone*, 9 May 2024, https://www.twz.com/sea/mako-is-a-jet-ski-turned-into-a-weaponized-drone.
14 "U-Ranger", Naval Drones, undated, http://www.navaldrones.com/U-RANGER.html.
15 "CUSV", Textron, undated, https://www.textronsystems.com/products/cusv.
16 Defense Advanced Research Projects Agency, "ACTUV 'Sea Hunter' Prototype Transitions to Office of Naval Research for Further Development", 30 January 2018, https://www.darpa.mil/news-events/2018-01-30a.
17 "Ghost Fleet Overlord Unmanned Surface Vessels", Naval Technology, undated, https://www.naval-technology.com/projects/ghost-fleet-overlord-unmanned-surface-vessels-usa/.
18 Chief of Naval Operations, *Report to Congress: Autonomous Undersea Vehicle Requirement for 2025*, Undersea Warfare Directorate, 18 February 2016, UNCLASSIFIED. As of 14 March 2024: https://news.usni.org/wp-content/uploads/2016/03/18Feb16-Report-to-Congress-Autonomous-Undersea-Vehicle-Requirement-for-2025.pdf.

- Small UUVs, less than about 25 cm in diameter, are readily portable by one or two people ashore or on a vessel. An example is the REMUS 100 by Hydroid, with a 19-cm diameter.[19]
- Medium UUVs, with diameters in the 25–50 cm range, require some handling equipment. They can be launched either from the shore or from a vessel. An example is the Bluefin-12 by General Dynamics, which has a 32-cm diameter.[20]
- Large UUVs, with diameters ranging from 50 cm to 2 metres, require substantial cranes. They may be launched either from the shore or from a large vessel. An example is the Marlin Mk II by Lockheed Martin, with a 1.5-metre diameter.[21]
- Extra Large UUVs, with diameters exceeding 2 metres, require very large cranes. These can generally only be launched from the shore, unless deployed from a large commercial cargo ship with ample deck space. An example is Boeing's Orca XLUUV, with a diameter of 2.6 metres.[22]

19 "REMUS UUVs", Huntington Ingalls Industries, undated, https://hii.com/what-we-do/capabilities/unmanned-systems/remus-uuvs/.
20 "Bluefin-12 Unmanned Underwater Vehicle (UUV)", General Dynamics, undated, https://gdmissionsystems.com/products/underwater-vehicles/bluefin-12-unmanned-underwater-vehicle.
21 "Marlin", Lockheed Martin, undated, https://www.lockheedmartin.com/en-us/products/marlin.html.
22 "Orca XLUUV, USA", Naval Technology, 19 April 2024, https://www.naval-technology.com/projects/orca-xluuv/.

# Employment of uncrewed maritime vessels in countering hybrid threat operations

USVs and UUVs have numerous potential uses in countering hybrid threat operations. The following are some of the most relevant ways in which these systems can be employed.

- **Environmental characterization.** The enclosed seas that flank Europe are complex and dynamic, with highly localized conditions that are evolving due to climate change.[23] The ability of USVs and UUVs to gather data on the physical environment, such as the character of the seabed, detailed bathymetric data, and layers or gradients within the water column, can greatly assist in countering hybrid threats in the maritime domain. Using uncrewed vessels for this purpose can reduce costs and risks relative to performing the same tasks with crewed surface vessels or scarce submarines. Long-endurance USVs – such as the Wave Glider – can be particularly useful for discerning environmental changes over multiple months. Harbour or Fleet USVs can collect environmental data in coastal environments, while Medium or Large USVs can be employed further offshore. UUVs can help to precisely measure the seabed and different parts of the water column. Small or Medium UUVs can be launched from the shore or crewed vessels to conduct short-range missions, while Large or Extra-Large UUVs can be used for longer-range operations.
- **Intelligence, surveillance, and reconnaissance (ISR).** To counter hybrid threats, NATO nations need to know what hostile actors are doing. For example, it is important to be aware if another nation is sending divers or UUVs to tamper with the undersea infrastructure of NATO nations. Again, using uncrewed platforms can reduce costs, mitigate risks, and lessen the need to use crewed vessels that are in high demand for other missions. NATO nations could use different classes of uncrewed vessels to monitor threats in different physical environments, as described above with respect to environmental characterization. UUVs could also be used to precisely emplace and retrieve devices that collect information for later recovery. For example, a device that collects video when triggered by nearby activity could aid in the forensic reconstruction of attacks. In some cases, visible ISR capabilities – such as sensor-studded Large USVs – may help deter clandestine activities, since the would-be perpetrators know that they will be caught. In other cases, it may be desirable to conduct ISR without being seen, in order to catch the perpetrators in the act. UUVs and low-visibility USVs, such as snorkelers or Wave Gliders, can provide excellent platforms for stealthy observation, from the seabed to the surface. Obviating the need to transport and support humans also minimizes the size and detectable signatures of the vessel compared to its crewed counterparts.
- **Search and rescue.** While air platforms are best suited to the search aspect of this mission, USVs can play a central role in the actual rescue. Deploying Fleet, Medium, or Large USVs into roiling seas or hostile waters can enable conscious personnel to clamber aboard and be taken to safety, while minimizing the risk to additional personnel. To reduce

23 Scott Savitz and Isabelle Winston, *A Brief Naval Overview of the Baltic Sea Region*, RAND Corporation, PE-A2111–1, June 2024. As of June 13, 2024: https://www.rand.org/pubs/perspectives/PEA2111–1.html.

rescue timelines, some rescue USVs can be pre-deployed to waters where they may be needed, anchoring themselves until directed to identified locations. Some rescue technology has existed for over a decade; the Emergency Integrated Lifesaving Lanyard (EMILY) USV has long been used by beach lifeguards to rescue swimmers.[24]

- **Protecting ships and infrastructure.** NATO nations could use Harbour and Fleet USVs to provide security buffers around key assets and to target or block threat vessels on command. For example, the Protector USV by Rafael Advanced Defense Systems has been used by the Singaporean and Israeli forces to protect against small boat attacks for over a decade.[25] Its mobile sensors also provide security forces with additional situational awareness.
- **Ramming ships.** NATO nations could use USVs in standoffs to counter aggressive actions that fall short of full-scale war. Chinese vessels have repeatedly rammed other nations' ships during hybrid threat or "grey zone" incidents in the South China Sea in an attempt to dominate the waterspace; Russia and other nations may follow suit at some point. Having a group of Fleet USVs designed by NATO nations for ramming, and explicitly not containing explosive payloads, could help deter such action.[26] Hostile behaviour could be met with a proportional response that would pose limited escalation risks. A key challenge would be to convincingly communicate to rival nations that these USVs wholly lack explosives.
- **Hosting/supporting other uncrewed vessels.** Medium or Large USVs can be used to launch UAVs, UUVs, or smaller USVs. This would enable these vessels to operate where they are needed, overcoming limitations in range and endurance. Large or Extra-Large UUVs could also launch others, in cases where stealth is critical and the inherent limitations of UUVs are not.
- **Naval mine countermeasures.** Minelaying has long been a part of hybrid threats, with Iran and Libya laying mines in critical waters while disclaiming responsibility. NATO can use USVs and UUVs to help mitigate the threat. Fleet USVs and Small and Medium UUVs are already being used to detect naval mines, limiting the need for personnel to enter the minefield. Fleet USVs also sweep mines, meaning that they drag gear behind them that causes influence-sensitive mines to detonate prematurely. In the future, large, high-signature USVs filled with buoyant materials could be used to sweep mines and further reduce risks.[27] Mine countermeasures can be conducted in peacetime, as well as in war, either to clear historical ordnance (e.g.,

24 See "Beach EMILY", *Emily Robot*, undated, https://www.emilyrobot.com/emily.

25 "Protector Unmanned Surface Vehicle (USV)", *Naval Technology*, undated, https://www.naval-technology.com/projects/protector-unmanned-surface-vehicle/.

26 Scott Savitz, "Revive the Ram", *RealClearDefense*, 22 June 2023, https://www.realcleardefense.com/articles/2023/06/22/revive_the_ram_942314.html.

27 Such ships could generate additional signatures, such as a substantial pressure drop, that are hard to achieve with smaller vessels. See Scott Savitz, "Rethink Mine Countermeasures", *Proceedings of the U.S. Naval Institute*, July 2017, Vol. 143/7/1,373, https://www.usni.org/user/login?destination=/magazines/proceedings/2017/july/rethink-mine-countermeasures.

World War II mines ensconced from the central Pacific to northern Europe) or to address threats from covert minelaying.

- **Anti-submarine warfare**. NATO nations face a continual threat from hostile submarines infiltrating their waters for observation or clandestine attacks.[28] Distributed, relatively inexpensive, long-endurance USVs (such as the Wave Glider) can be used to detect potential submarine signatures across wide areas. Upon detection of a signature, they would cue other assets to respond. Some of those response assets could themselves be Fleet, Medium, or Large USVs with advanced sensor suites to classify and identify the contact as a hostile submarine. Similar approaches could also be used against hostile UUVs, although the smaller size and signatures of UUVs would make them harder to discern than crewed submarines.

28 A spectacular demonstration of this was the "Whiskey on the Rocks" incident when a Soviet Whiskey-class submarine ran aground near a Swedish naval base in 1981 (although Sweden was not a NATO member at the time). This incident gained notoriety because of its public visibility, although it was presumably not the only time that Soviet or Russian submarines infiltrated other nations' waters. See Laura Pineschi and Tullio Treves, *The Law of the Sea: The European Union and its Member States*, Martinus Nijhoff, 1997, p. 517.

# Case study: The use of USVs and UUVs in a hybrid threat scenario in the Baltic Sea

Russia has been engaging in various types of hybrid threat operations and periodic outright warfare since the turn of the millennium. Its massive cyberattacks against Estonia in 2007 and around the globe since then, its manipulation of other nations' political systems, and its use of unidentified personnel or proxy forces have been punctuated by full-scale wars in Georgia, Ukraine, and elsewhere. In general, relatively little of this hybrid or full-scale warfare has had a maritime bent. While it has used naval power against land targets from Syria to Ukraine, all of its post-Soviet conflicts have been land-centric, and Russia has always been much more of a land power than a naval one.

However, as Russia's land forces continue to be degraded by their Ukrainian counterparts, it may choose to emulate its partner in Beijing and conduct more hybrid threat activities at sea. A prime locale for this is the Baltic Sea region, where numerous small NATO states are heavily dependent on the sea, and either border Russia or are closer to it than they would like. Estonia, Latvia, Lithuania, Denmark, Sweden, and Finland all depend heavily on commercial maritime traffic and undersea cables to sustain their economies. (These are also important for Poland and Germany, which are also NATO members, but these two nations are less maritime-dependent.) If Russia were to threaten or actually start a war, NATO nations would also need to move military forces across the Baltic to the Alliance's easternmost front.

Russia lacks the ability to exert control over the Baltic Sea: its entrances are controlled by NATO members, as is every shore of the sea except for two small slivers belonging to Russia. The formidable naval capabilities of Sweden and Finland have just been added to the NATO Alliance, and the navies of NATO's Baltic nations are backed by allies throughout Europe and even in North America. However, future Russian hybrid threat activities could achieve some level of sea denial or help Russia to exert coercive pressure against littoral nations. For some of these activities, malice may be difficult to prove, and the attacker may even claim a degree of plausible or implausible deniability. For example, Russian and Chinese ships appear to have deliberately severed undersea cables and gas pipelines in the Baltic during October 2023.[29] In other cases, being overt is the point: in May 2024, Russia proposed expanding its maritime boundaries in the Baltic Sea into its neighbours' waters, unsettling them; the Lithuanian and Finnish foreign ministries cited this as a "hybrid threat operation" and "hybrid influence".[30] In the future, Russia may also seek to harass other Baltic nations' shipping, fishing vessels, or even coastguard or naval ships. China's bullying of its neighbours in a similar fashion has helped it to achieve greater influence over the South China Sea, and it has faced few consequences for its actions. Russia could even covertly lay mines from ostensibly civilian vessels in the approaches to other nations' ports. When damage occurred, Russia could implausibly deny involvement, perhaps claiming that the resulting explosions were due to World War II ordnance that had somehow been moved and reactivated.

29 Eric Tegler, "Investigating the Chinese Ship That 'Accidentally' Hit Undersea Lines", *Forbes*, 29 November 2023, https://www.forbes.com/sites/erictegler/2023/11/28/investigating-the-chinese-ship-that-accidentally-hit-undersea-lines/?sh=3d9cd68040bf.

30 "Russia May Try to Redraw its Boundaries in the Baltic Sea", *Maritime Executive*, 22 May 2024, https://maritime-executive.com/article/russia-may-try-to-redraw-its-boundaries-in-the-baltic-sea.

In the event of sustained Russian attacks against infrastructure or harassment of vessels, NATO nations could use USVs and UUVs in many of the ways outlined in the previous section of this Working Paper, such as monitoring infrastructure. Recurring NATO surveys of the seabed and infrastructure could also reveal whether Russia had clandestinely deployed devices for ISR collection. NATO nations could recover, analyze, and publicly reveal these devices. Detailed knowledge of the evolving physical environment could also aid nations trying to detect Russian submarines conducting ISR in their waters. Submarine detection requires an exquisite knowledge of local conditions and how they vary over time, shaping the propagation of underwater sound.

In addition, NATO nations could use USVs and UUVs to collect environmental data periodically and extensively, providing information that would help to expedite any necessary mine countermeasures. After an incident of suspected or actual mining, all of the pre-existing seabed detritus that was detected by minehunting systems could be readily ignored, enabling personnel to focus exclusively on the newly laid mines. Thorough characterization of localized currents and the composition of the seabed would also reduce timelines for minehunting. USVs could also assist in minesweeping, if this approach – more expeditious but less thorough than minehunting – were chosen. Some of these USVs might be small vessels towing gear that emits acoustic and magnetic signatures similar to those of a ship, while others could be larger vessels filled with buoyant material to enable them to withstand mine damage.[31]

NATO nations could employ USVs and UUVs to conduct ISR in their waters and international thoroughfares. Specifically, USVs could serve as offshore, relocatable, sensor-laden assets that would continually monitor and document Russian activities. These USVs could even host UAVs, providing additional altitude and speed to see further or take a closer look. Being able to unequivocally show what Russian vessels are doing would be useful in combating Russian disinformation campaigns. In addition, USV-based detection of incipient Russian activities could aid in enabling response assets to rush to the scene. At the same time, NATO UUVs could closely monitor undersea infrastructure to detect signs of prior tampering, or Russian vessels or divers actually conducting such tampering. Complexes of fixed sensors to detect underwater intrusions into nations' port facilities could be complemented by USVs and UUVs full of sensors that would respond to possible alarms.

As mentioned above, ramming USVs could also be used in maritime confrontations. Russian vessels may choose to menace other nations' ships by threatening to ram them or actually doing so, but they are likely to want to limit escalation risks, precluding them from shooting. A well-placed swarm of NATO USVs purpose-designed for ramming could help to deter Russian vessels from attacking, while making it clear that NATO nations' response would not escalate beyond the level of the Russian vessels' own threats.

31 See Savitz, "Rethink Mine Countermeasures".

# Chinese, Russian, and Iranian USV and UUV developments

Open Chinese publications indicate substantial interest in using USVs and UUVs militarily – notably for ISR and launching weapons – as well as for civilian applications, but there has been limited public reporting on existing or projected capabilities.[32] An exception is China's well-publicized Jiangsu Automation Research Institute (JARI) USV, a medium-class USV measuring 15 metres in length. The JARI USV is claimed to be capable of launching torpedoes, rockets, guns, or missiles.[33] Based on social media and commercial satellite imagery, China may have another medium USV that is designed to resemble the US's 42-metre Sea Hunter.[34] For decades, China has had military ROV systems, and perhaps some untethered UUVs. The *Global Times*, a Chinese government mouthpiece, described a "robo-shark" in 2021, which it claimed was useful for both ISR and anti-submarine warfare.[35] The robo-shark USV looks very much like an actual shark, but it is unclear whether this design reflects attempts to improve capabilities by emulating nature, or is simply an attempt to make the USV appear more menacing in photographs. It is unclear to what extent, if any, Chinese uncrewed maritime technology has incorporated features from a US oceanographic UUV that was briefly grabbed by a Chinese warship in 2016, only to be returned several days later.[36]

For Russia, as with China, there are some glimpses of uncrewed maritime vessel capabilities. Russia unveiled its first publicized USV in 2021, which appears to be designed for civilian purposes. Called the Pioneer-M, it is supposed to travel up to 800 km autonomously over periods of up to five days. Academics and others are also pursuing additional USVs for dredging, icebreaking, and cargo delivery.[37]

Russian sources indicate that the Soviet Union pursued UUVs as far back as the 1960s.[38] More recently, in the early 2000s, Russia's Institute of Marine Technology Problems (IMTP)

32 Michael S. Chase, Kristen Gunness, Lyle J. Morris, Samuel K. Berkowitz, and Benjamin Purser, *Emerging Trends in China's Development of Unmanned Systems*, Santa Monica, Calif.: RAND Corporation, RR-990-OSD, 2015.

33 *Navy Recognition* website, September 2018, https://www.navyrecognition.com/index.php/news/defence-news/2018/september-2018-navy-naval-defense-news/6515-aad-2018-china-s-csoc-unveils-jari-unmanned-surface-combatant-usv.html; Fergus Kelly, "China Launches JARI Combat Drone Boat", *The Defense Post*, 23 August 2019, https://www.thedefensepost.com/2019/08/23/china-jari-combat-drone-boat-launched/; *Navy Recognition* website, August 2019, https://www.navyrecognition.com/index.php/news/defence-news/2019/august/7411-china-launches-world-leading-jari-unmanned-warship-usv.html.

34 H.I. Sutton, "New Intelligence: Chinese Copy of U.S. Navy's Sea Hunter USV", *Naval News*, 25 September 2020; H.I. Sutton, "Chinese Testing Experimental Armed Drone Ships at Secret Naval Base", *U.S. Naval Institute News*, October 11, 2021.

35 Ryan Fedasiuk, "How China Is Militarizing Autonomous Underwater Vehicle Technology", *The Maritime Executive*, 22 August 2021, and Kris Osborn, "The Chinese Navy Is Building a Robo-Shark", *The National Interest*, 10 July 2021.

36 Mark Katkov, "China Returns U.S. Navy Drone Seized in South China Sea", *National Public Radio*, December 20, 2016.

37 TASS, "Nauchno-Issledovatel'skoye Sudno 'Pioner-M' Spustili Na Vodu v Peterburge [Research Vessel 'Pioneer-M' Launched in St. Petersburg]", 24 September 2021, https://tass.ru/obschestvo/12499301.

38 Sergey Ptichkin, "Podvodnyye Lodki-Roboty Uzhe Nesut Sluzhbu v Glubinakh Mirovogo Okeana [Robotic Submarines Already Serve in the Depths of the Oceans]", *Rossiyskaya Gazeta [Russian Gazette]*, 27 June 2021, https://rg.ru/2021/06/27/podvodnye-lodki-roboty-uzhe-nesut-sluzhbu-v-glubinah-mirovogo-okeana.html.

developed the deep-diving Klavesin-1R UUV, capable of going as deep as 6 kilometres. Since then, the Russian Navy has used at least three UUVs – the Klavesin-1R, the Klavesin-2R-PM (by Rubin Design Bureau), and the MT-2012 Galtel (by IMTP) – to locate undersea objects and conduct research.[39] Russia has an exclusively military UUV called the Surrogat; as its name suggests, it is a decoy for Russian submarines, aimed at distracting anti-submarine forces.[40] The Nerpa UUV was developed for underwater reconnaissance and combat operations.[41] The submarine-launched Poseidon UUV, expected to be acquired by 2027, will be nuclear-powered and can be equipped with nuclear weapons.[42] The Poseidon's alleged ability to silently and autonomously zoom across thousands of kilometres at speeds of 100 km per hour, among other capabilities that have been attributed to it, suggests that its features have been greatly exaggerated or simply fabricated.[43] Russia also plans to develop and acquire at least one civilian UUV, the Iceberg, which will conduct oil exploration and drilling, including under Arctic ice.[44]

Iran has also developed USVs, including both the Shark 33 and the Ya Mahdi, since at least 2010. Both can be filled with explosives to target ships, while the Ya Mahdi may be able to launch weapons. The Shark 33 was likely used by Iran's Houthi allies in an attack on a Saudi frigate as far back as 2017. The Houthis have also attempted to use explosive-laden USVs to target ships in the Red Sea since the Israel-Hamas war began in 2023, although most of their attacks have employed missiles or UAVs. Iran also appears to have provided the Houthis with an explosive-laden UUV that can also target

39 Kirill Ryabov, "Osnovnyye Otechestvennyye Razrabotki V Oblasti Avtonomnykh Neobitayemykh Podvodnykh Apparatov [Main Domestic Developments in the Field of Autonomous Unmanned Underwater Vehicles]", *Voennoe Obozreniie [Military Review]*, 13 September 2021, https://topwar.ru/186977-osnovnye-otechestvennye-razrabotki-v-oblasti-voennyh-anpa.html; Roman Kretsul and Aleksey Ramm, "Muzyka Voln: Podvodnyy Dron 'Klavesin' Ispytayut Na Dal'nem Vostoke [Music of the Waves: Underwater Drone 'Klavesin' Will Be Tested in the Far East]", *Izvestiya [News]*, 7 September 2021, https://iz.ru/1218017/roman-kretcul-aleksei-ramm/muzyka-voln-podvodnyi-dron-klavesin-ispytaiut-na-dalnem-vostoke.

40 RIA Novosti, "V Rossii Sproyektirovali Imitator Podlodki 'Surrogat' [Russia has designed the 'Surrogate' submarine simulator]", 1 September 2021, https://ria.ru/20210901/robot-1748093663.html.

41 TASS, "Rostekh Pokazal Prototip Podvodnogo Protivodiversionnogo Robota Na 'Armii-2018' [Rostec Unveils Prototype of Underwater Anti-Sabotage Robot at 'Army-2018']", 21 August 2018, https://tass.ru/armiya-i-opk/5475917.

42 Izvestiya, "V SSHA Yadernyy Podvodnyy Apparat 'Poseydon' Nazvali 'Oruzhiyem Sudnogo Dnya' RF [In the United States, the 'Poseidon' Nuclear Submarine Was Called the 'Doomsday Weapon' of the Russian Federation]", 12 November 2021, https://iz.ru/1249027/2021-11-12/v-ssha-iadernyi-podvodnyi-apparat-poseidon-nazvali-oruzhiem-sudnogo-dnia-rf.

43 Michael Starr, "Here's Why You Shouldn't Fear Russia's Poseidon Nuclear Torpedo", *Jerusalem Post*, 7 October 2022, https://www.jpost.com/international/article-719118.

44 Rubin Design Bureau, "Podvodnyy Robotizirovannyy Kompleks 'Aysberg' Predstavlen Na Vystavke 'Neva'' ['Iceberg' underwater robotic complex presented at the 'Neva' exhibition]", webpage, 19 September 2017, http://ckbrubin.ru/mediacentr/novosti_i_sobytija/novost/news/detail/News/podvodnyi_robotizirovannyi_kompleks_aisberg_preds/.

ships.[45] In addition, Iranian Revolutionary Guard Corps Navy forces attempted to capture a US Saildrone USV in 2022, but were thwarted. It is unclear whether this was simply opportunistic, or reflected a desire to reverse-engineer the USV.[46]

45 See "Ya Mahdi", *Naval Drones*, undated, http://www.navaldrones.com/Ya-Mahdi.html; "Shark 33", *Naval Drones*, undated, http://www.navaldrones.com/Shark-33.html; Sam LaGrone, "Navy: Saudi Frigate Attacked by Unmanned Bomb Boat, Likely Iranian", *U.S. Naval Institute News*, 20 February 2017, https://news.usni.org/2017/02/20/navy-saudi-frigate-attacked-unmanned-bomb-boat-likely-iranian; Sutton, H.I., "Notes on Emerging Iranian / Houthi Uncrewed Underwater Vehicle (UUV) Threat", 18 February 2024, http://www.hisutton.com/Iranian-Houthi-UUV-notes.html; Seth J. Frantzman, "Iran-Based Houthis Increase Sea Drone Attacks", *Jerusalem Post*, 27 February 2024, https://www.jpost.com/middle-east/article-789070.

46 U.S. Naval Forces Central Command Public Affairs, "U.S. Navy Foils Iranian Attempt to Capture Unmanned Vessel in Arabian Gulf", 30 August 2022, https://www.navy.mil/Press-Office/News-Stories/Article/3144078/us-navy-foils-iranian-attempt-to-capture-unmanned-vessel-in-arabian-gulf/.

# Conclusions

This Hybrid CoE Working Paper has described the capabilities of USVs and UUVs, as well as their advantages, histories, classes, and uses. Many of these uses could be undertaken in the context of hybrid threat operations. Above all, this paper has demonstrated the impact that these systems are already having, as well as their potential for even greater impact as technology advances and military services embrace the capabilities that they provide. Looking towards the middle of the twenty-first century, it becomes clear that nations that avail themselves of USV and UUV technologies will have a formidable advantage at sea over those that do not. Whether conflicts remain at the level of hybrid threats between peace and war, or escalate to unrestrained warfare, USVs and UUVs will play an essential role in shaping sea power for generations to come.

Given the USV and UUV capabilities of China, Russia, and Iran, other nations should expect to face threats from hostile actors using them in the ways outlined above, as well as others. The attributes that make uncrewed maritime vessels so effective also make their use by hostile actors so difficult to counter. For example, a stealthy UUV is hard to detect, while large swarms of relatively inexpensive, explosive-laden USVs can pose a threat to shipping. Fortunately, USVs and UUVs themselves can help to counter their use by hostile forces. For example, the heightened domain awareness provided by numerous USVs and UUVs can be used to help ascertain hostile actions being undertaken by another nation employing USVs and UUVs. UAVs, perhaps launched from USVs, can further enhance awareness. The close observation of ports and critical infrastructure with USVs and UUVs can reduce vulnerabilities, as described in the case study. USV and UUV capabilities can also contribute to deterrence by demonstrating options for being able to take out another nation’s commercial or military ships. This is particularly important for nations with otherwise limited naval power. As Ukraine has demonstrated, even a nation that is essentially devoid of warships can use USVs to inflict heavy damage against an adversary’s fleet, key infrastructure, and even rotary-wing aircraft. As technologies advance, USVs and UUVs may be increasingly able to launch weapons that can severely damage fixed-wing aircraft, ships, and inland targets. In future wars, USV swarms armed with projectile weapons may even battle one another.

# Author

**Dr Scott Savitz** is a Senior Engineer at RAND. Much of his research focuses on how to improve the effectiveness and resilience of operational forces through the use of uncrewed vessels and other technologies, and how to employ these systems effectively. He has developed numerous models and simulations in support of these analyses. Recently, he has led analytical efforts regarding military capability gaps in the Arctic, the impact of non-lethal weapons, and how the U.S., Japanese, and Brazilian militaries can employ uncrewed vessels. Dr Savitz has also led analyses on testing infrastructure requirements for autonomous systems and ways of improving maritime domain awareness. Previously, he provided on-site analytical support for the U.S. Navy's mine warfare command and the U.S. Naval Forces Central Command. He has led exercise-observation teams around the globe, and supported the U.S. Navy in Bahrain from 2001 to 2003, addressing political-military, counter-terrorism, and chemical/biological/radiological defence issues. He holds a bachelor's degree in chemical engineering from Yale University, as well as a master's degree and PhD in the same field from the University of Pennsylvania. He can be reached at ssavitz@rand.org.

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