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Future Wars Journal

UNCREWED WEAPON SYSTEMS

Edition 1

Introduction to Uncrewed Weapon Systems

"Writers of war stories, peering into the future, predict an approaching era when fighting will be done by machinery under remote control. Guns automatically operated will fire from deserted fortifications and from tanks which contain no living operators. Airplanes without human pilots will observe positions through televisors, and drop projectiles guided from a post at headquarters, many miles away. The casualties will be solely among robots of steel and copper, whose orders are conveyed to them by radio, or other subtle signalling methods. Such is the picture which is painted upon the drop curtain which conceals the next war" – Radio Craft Magazine (1931)

Uncrewed Systems

The term “drone” has been synonymous with unmanned aerial vehicles (UAV) since the fielding of breakthrough technologies during the opening strikes of the Global War on Terror (GWOT). The General Atomics MQ-1 Predator is likely the most widely known drone used by the US, next to its replacement, MQ-9 Reaper. Military and civilian audiences across the world were shocked at its ability to surveil or carry payloads over 700kms and loiter for 14 hours while carrying Hellfire missiles. Today, *drone* is now a blanket term for the many varying systems we see in the world today; Unmanned ground vehicles (UGV), unmanned aerial system (UAS), unmanned combat aerial vehicles (UCAV), remotely piloted air system (RPAS), uncrewed surface (USV) and subsurface vehicles (USSV), uncrewed underwater vehicles (UUV), No Maning Required Ship (NOMARS), one-way attack drones (OWA), quadcopters, first-person view (FPV) drones and more names flood the battlefields and social media feeds across the globe. This paper is going to breakdown a short history, general types, pitfalls, pros and cons, and current weapons fielded in contested zones and

conflict areas around the world. There are many acronyms, we will attempt to clarify repeatedly to ensure accurate understanding, please see the index if needed. The term Uncrewed is used here as it covers all bases encompassing autonomous, remotely piloted, or unmanned systems that operate in the aerial, ground, and maritime domains which would conventionally require pilots and or crew members.

Unmanned Aerial Systems

It will be surprising to most how far back unmanned aerial systems (UAS) have been used. The first recorded employment of a UAV was aerial drones used at the siege of Venice in 1845 by the Austrians. During the assault, the Austrian Navy used ~200 unmanned hot air balloons as incendiary weapons that would descend upon the defenders. A bit comical

OWA UAV Quadcopter failed to detonate of impact into Russian vehicle's windshield.

to imagine, but it shows the innovation of the human mind in warfare. Utilizing all technologies possible to gain that edge on the battlefield, it's the same for us today. Several other fascinating inventions over the decades prevailed, the fascinating steam powered No. 5 Aerodrome, the remote-controlled *Aerial Torpedoes* (remote control planes filled with explosives) of the Great War, the completely uncrewed B-17 Bombers under Project Aphrodite, and many fascinating innovations I encourage you to look up.

Today, drones have helped bridge the gap between opposing forces. Across the world, the UAV has become a staple in countless conflicts. Intelligence Surveillance and Reconnaissance (ISR) drones were once tens of millions of dollars and now a platoon could have several rapidly available ISR or strike platforms up and operating within minutes. These factors have made modern conflicts face a unique adversarial force flexibility not previously seen in history. Fascinatingly enough, to this day, the US Department of Defense seemingly only invests in the narrow section of strategic UWS, meaning high value and small numbers controlled by the higher levels of military decision-making. One of the few efforts for integrating small drones into the ranks is driven by the US Special Operations community, the Commanding General of Special Operations Command (SOCOM), GEN Fenton, has stated that "[SOCOM] is gobbling up any lessons we can learn from the wars in Gaza and Ukraine." Speaking of which, the Ukrainian conflict is one of the most heavily contested regions in the electronic warfare space and the mass use of small drones. There are ample takeaways for every war-faring nation across the world to learn.

Though the US started as the premier drone designer, many countries have altered battle fields far away from their own borders via the export of drones. Turkey's TB-2 Bayraktar, Iran's Shahed 136, Israels Harop OWA, and Chinese DJIs have shaped tactical settings for conflicts on almost every continent. China has likely affected the most conflicts via its company DJI (Da-Jiang Innovations), which supplies around 70% of commercially available drones worldwide, and 80% of the US consumer base. This is a market that is skyrocketing. The commercial drone industry was worth around $5 billion USD in 2022, this is now projected to be ~$54 billion USD by 2030. As with most things that China produces, the data is most likely being stored or scraped in some fashion which allows them to learn from technical data from drones being used across the globe, how and where they are being used to other flight metrics. You can find DJI drones being used to photograph weddings, for agriculture pesticide dispersal, and being driven into tanks with shaped charges taped to them. The speed and ease in which commercial drones can be modified has led to the widespread proliferation of the drop drone or OWA FPV (first person view) being used in conflicts from Myanmar to Ukraine. 3D printer blueprints are posted to open sources allowing any group the ability to quickly modify the DJI models to accept mines, RPG-7 warheads, or M67 Fragmentation grenades.

Russian drone Modified with rocket warhead.

Employment Methods

For both UAV and USV (Uncrewed Surface Vessels) a common tactic, and I'll assume an emerging tactic for UGVs (Unmanned Ground Vehicles), is the "Swarm" or "Flock." This technique for aerial drones is used by small and fast FPV drones fly forward towards the target location or known area of enemy activity and then land to conserve power. A "Queen" or lead drone acts as an arbiter and enables target identification, selection, and coordination for the attack drones from there. The Queen can also act as a repeater for the FPV suicide drones. As it dives on the target, many times connection is almost entirely lost as obstacles impede the line-of-sight connectivity. In order to bolster the drone's resistance to jamming or extending the range from the controller, the arbiter drone stays at a higher altitude there by assisting with the relay of a communication signal. Similarly, with USVs, an aerial platform can be used to assist in coordination or a different style USV can be used to allow for increased situational awareness or control to coordinate USV attacks into harbors or patrol ships.

Homing in on One Way Attack (OWA) drones, these have increased in popularity since the Nagorno-Karabakh conflict in 2022. Two of the most prevalent are the Iranian Shahed 136 and the Israeli Harop, both of which are sold internationally and have affected conflicts across the globe. Recently the Shahed 136 has gained the most notoriety, though Iran denies it, the Shahed is blatantly being produced and used by Russia in its assault on Ukraine. The OWA is a unique class that must balance performance with price. A company must not use high-quality parts as it will be destroyed, yet the drone must make it to the target so it must be "quality enough" to survive electronic attack and be maneuverable enough to pass detection or surface to air systems. The OWA is most commonly recognized

for its swarm tactics, such as in the recent failed attack by Iran which launched hundreds of OWA UAVs in an attempt to defeat Israels air defense network.

For larger UAVs in the family of Medium Altitude Long Endurance (MALE), the classic role of flying solo or in pairs is still employed. These drones were once the most thought of system, if someone used the word drone. This group includes the MQ-1 and MQ-9 family, along with the TB-2 Bayraktar which made its fame in Nagorno-Karabakh. This conflict, though short, was a preview of conventional Large Scale Combat Operations (LSCO) warfare being mixed with modern UAV technology. The OWA Harop and TB-2 wreaked havoc against armored columns and mobile artillery positions. MALE UAVs can be employed by themselves to reconnoiter or strike deep behind denied territories or to support ground force operations providing real time intelligence and close air support. These are highly versatile platforms carrying a variety of technologies and capabilities that are interchangeable for the mission set at hand. MALEs are some of the most widely adopted UAVs across modern militaries.

A *MALE* MQ-9B SkyGuardian above UK during RAF100

A size up from there comes in the fighter sized UCAVs (Unmanned Combat Aerial Vehicles). These are generally fixed wing aircraft that can be designed to utilize artificial intelligence (AI) partially or wholly. For an example of fully autonomous designs, the MQ-28 'Loyal Wingman' is a drone being tailored for this role, crafted to integrate with the modern fifth and sixth generation air forces. This UCAV is capable of being equipped with modular sensor suites and sensor systems to enable it as a true multi-role aircraft. The idea of the Loyal Wingman is to create standoff between Western Forces and adversarial nations aircraft. Modern air superiority combat is a game of BVR (beyond visual range) engagements, or a predator and prey style, using stealth technologies and multi-domain

Boeing's MQ-28 Loyal Wingman.

communications to find targets and guide missiles fired from 20 miles and beyond to strike aircraft or targets without ever being detected. Having one or two MQ-28s per F-35 enables

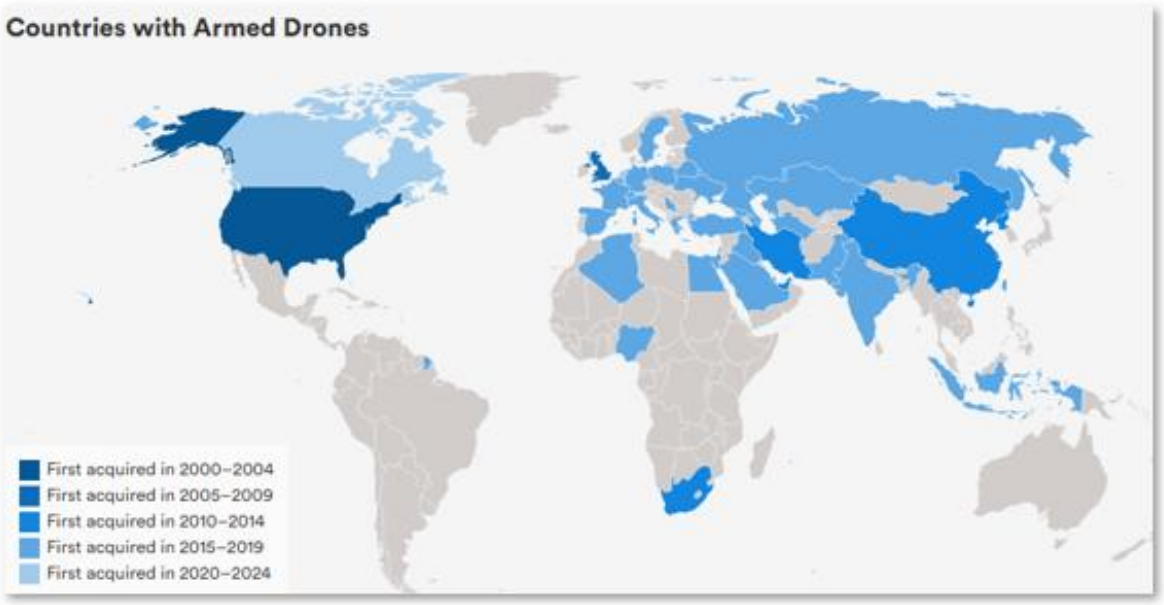
a pilot to use the drones to attack, screen, recon, or continue on the mission while enemy forces are being dealt with, this capability is an extreme force multiplier for any US fighter.

Advantages and Disadvantages

The TB-2 has fallen off as a useful platform for the Ukrainians despite its performance in the opening salvos of the Russo-Ukraine war. This was noted after an interesting incident over Kiev when Ukraine shot its own drone out of the sky after it "lost control" of the aircraft. Sure enough, the Russians successfully created a technique to hack into the Bayraktar, an interesting way to defeat the system and I would consider it almost more impactful psychologically and militarily in the long run than physically damaging to Ukraine's drone fleet. This ability to hack the drone could sell on the market or be used to barter in future geopolitical engagements. It was always assessed as a weakness for many types of drones, but it never happened in conflict until May of 2023. Besides the possibility of hacking, uplinks are the next weak point, every drone, unless fully autonomous, needs an uplink to satellites. Once considered a very secure communication technique, is now vulnerable to electronic and physical attack. ASAT (anti-satellite attack) capabilities have greatly increased with China, Russia, and the US all having weapon systems that can physically destroy or disable communications satellites in orbit.

Advantages of UAVs are force flexibility and reduced risk to forces when employing these weapon systems. The ability for a platoon or company to have drones that can detect enemy movements even just an hour or two ahead of time could guarantee victory for an otherwise possible defeat. Intelligence always needs updating, and these varying drones could greatly change how conventional militaries train and fight in the future. The cost

variables in destroying expensive weapons systems with cheaper platforms is not only a real economic challenge but a psychological defeat as well. In the case of the Red Sea, the US Navy is spending millions of taxpayer dollars to destroy a several hundred to a few thousand-dollar drone. This cost imposition is not tenable in the long run. Accuracy and precision in not only reconnaissance but in real time artillery updates. Artillery is the king of battle and in modern conventional conflicts, the first to get accurate rounds on target is usually the victor of the battle, especially in counter battery fire. In later articles we will discuss more of the UGV (Unmanned Ground Vehicles) and USVs (Uncrewed Surface Vessels), both of which also have their set place on the battlefield along with disadvantages and advantages. There are dozens of other UAVs out there which would take up pages and pages to describe unique facets of each, with this and all the other editions, there is much missing, but I implore you to continue studying on your own.



Map from NewAmerica.org showing historical acquisition of armed drones.

Unmanned Ground Vehicles

UGVs did not get as early of a start as the aerial systems, but still, a fascinating history shows the brilliant minds of many engineers across the world. In 1931, a man named Nagayama took a small Fordson tractor and built a small armored remote-controlled tank designed for mine clearing or transporting supplies, unfortunately, it was not adopted by the Imperial Japanese Army, but the design did inspire a later Type 98 RC engineer vehicle which was used. Word War II saw the introduction of several UGVs that saw combat.

(Left) Nagayama RC Tank. **(Right)** German Goliath.

The more likely known UGV from the 1940s is the *Leichter Ladungstrager Goliath* or just "Goliath." This was an unmanned demolition vehicle that was designed off a French idea of the *Crocodile Schneider Torpille Terrestre* otherwise known as the Land Torpedo Crocodile Schneider. These were driven towards their target (Trench or defensive structure) carrying ~130lbs of explosives, once having arrived at its point it would be detonated. The other tank used in combat was the Russian TT-26 TeleTank. A Remotely

piloted tank with a turret that contained machine guns or even flamethrowers. These Teletanks were employed with very little success but as we look at the totality of time that the technology had been around, it was a bold endeavor to implement them among the ranks of Russia's tank battalions. UGVs progressed slower than their aerial counterparts, many innovative ideas but not much coming into full fruition. We get a semblance of modern comb disposal drones in the '70s, the British Morfax "Wheelbarrow" EOD bot was used in the disposal of bombs in Northern Ireland, the wheelbarrow had almost 400 of its own destroyed in bomb-defusal operations. Many incredible designs deserve your time and review, the CIA's autonomous land vehicle in the '80s to the remote tanks and High Mobility Multi-Wheel Vehicles (HMMWV) with mounted machine guns and other Remotely Operated Weapons Systems (ROWS).

Boston Dynamics Atlas Robot

During the US war on terror, aerial drones reigned supreme in supporting ground operations. There was really no need to design and employ a capable ground system to fight in these regions as the opposing forces had very little anti-air capability, thus all logistics and combat support could be provided by the top-notch aerial platforms. This fact did not completely stop the design of UGVs wheeled, tracked, or walking drones as seen with Boston Dynamics Atlas biped or Cheetah Quadruped drones.

Most of these humanoid designs are still decades away from usable employment in austere conditions, but the wheeled and tracked vehicles have not only transformed to robust logistical hauling and weapon system carrying platforms, but they have also finally been implemented into actual combat in the Russo-Ukraine war. The small FPV and drop drones have been far more famous for their role on the frontlines but UGVs are becoming more common as of the recent months.

Russian litter drone evacuating a wounded Russian soldier across an open area.

The most common for the Ukrainians would be a mine laying wheeled vehicle that can drive out into roads and drop anti-tank mines or be loaded with explosives and driven to key points, much like the Goliath of WWII, and then detonated destroying the fortification or key terrain. The Russians are using their “Courier” UGV in a multitude of roles. We mostly see them armed with AGS-17 30mm Automatic Grenade Launchers, or the

Russian 12.7MM NSV machine gun but they can be mounted with even Electronic Warfare systems or Kornet anti-tank guided missiles (ATGM). The famous debut of such systems was captured via Ukrainian ISR drones spotting the *Couriers* attacking Ukrainian positions in Berdychi near Avdiivka, Ukraine. This is an extraordinary event; it is the first combat where both sides employed only UWS (uncrewed weapons systems). Though small in scale, it shows the technological innovation of both sides along with their ability to employ them in the ever-changing modern conflict.

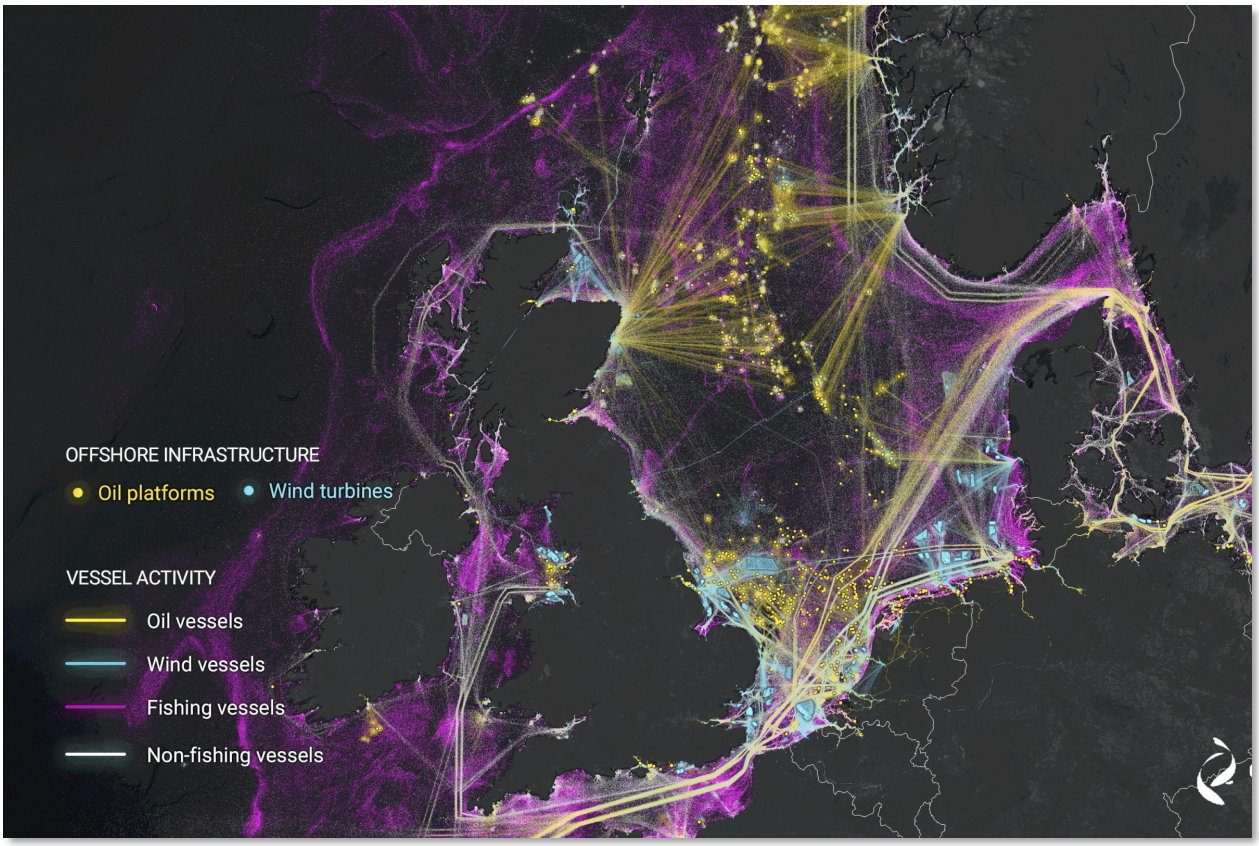
Ukrainian Drone footage on March 29th, 2024, capturing two Russian UGVs operating in Ukraine.

Like its aerial and maritime counterparts, there are benefits and weaknesses when utilizing UGVs. As above with the casualty evacuation photograph, a drone could keep more soldiers in a fight or execute tasks that are too dangerous for an individual to carry out, thus reducing loss of human life such as sabotage missions or explosive ordinance disposal. The UGV platforms can carry equipment needed for soldiers in the field or be mounted

with weapons systems and sensors to increase the ground forces situational awareness and capabilities. Mounting communications systems and sensor suites can help interface the platoon/company with the modern-day network-centric warfare state we find ourselves in, allowing for real time battle space awareness and information with near or far friendly forces. Some pitfalls of the UGV are that it is still vulnerable to electronic warfare, many UAVs can be set with a predetermined location if a loss of communication occurs, UGVs could do the same but without automated driving capabilities it would most likely find itself stuck somewhere. Which leads us to the next point, mobility. Though many contract companies tote high speeds and perfect accuracy with the sales pitch, rough terrain and complex urban environments greatly reduce the range and effectiveness of the system. Size and capacity of the UGVs will create variables in the range, but estimations for fully electric vehicles are about 20km distance, while diesel hybrids can reach over 100km. When operating in urban areas, tall buildings can block signals and debris/terrain can greatly hamper the UGVs mobility on the battlefield. As Artificial Intelligence and sensors advance, it may make the UGV a much more capable vehicle over more complex and longer distances. UGVs will be evermore utilized as the Russo-Ukraine war carries on, and the militaries around the world will watch and learn.

Uncrewed Surface/Underwater Vessels

The recent events of pipelines and undersea cables certainly reveal that offshore infrastructure vulnerability is at an all-time high. The reality that there is no solid indication or discovery of a means or manner in which it was destroyed is a testament to modern technology's both ability and inability. Remote power stations, undersea cables, and energy platforms were once thought secure due to the location or depth of the



Map generated from Space Based Systems analyzing vessels and platforms of the North Sea

structure, thinking that modern detection abilities would locate enemy vessels before they could destroy the critical assets. Without any defensive capabilities, the modern era of USV and UUVs now threaten nearly all of these assets by their low profile undetectable means of payload delivery.

As we've shown with UAVs, Uncrewed surface vessels (USV) have been around far longer than one may think. In the US Civil War, ships loaded with explosives were then sent into enemy harbors. Before that, ancient naval warfare would light ships on fire and have them drift into enemy fleets. Undersea drone technology is a bit more recent; Uncrewed Underwater Vessels (UUVs) were first used for military purposes to disable mines in the port of Um Qasr, Iraq in 2003. Besides these rare occasions, many of the sea-borne drones were used for exploration and research so it was a resounding wake up call to many in 2023 upon seeing ships of the Russian Black Sea Fleet being repeatedly sent to the bottom of the sea by a multitude of OWA and missile platforms USVs. As a whole, most sea drones are used for intelligence surveillance, and reconnaissance (ISR), mine-hunting, anti-submarine warfare (ASW), communications relay, surveying, and maintenance/sabotage of sea-based infrastructure. Let's discuss the types and employment tactics of modern USVs and UUVs.

US Sail Drone with TF-59 in the Red Sea

Sail drones and other subsurface vessels have made a rapid shift from explorative use to military employment in a short period. Uncrewed ISR surface vessels are predominantly wind-propelled and solar powered capable of operating for periods of three to twelve months at sea. Most range from 20 -70 feet in length and are capable of

carrying a wide variety of sensors to remote areas. Usually used for ISR, Measurement and Signature Intelligence (MASINT), and gathering data from the objects, atmosphere, or subsurface/ocean floor mapping. In recent months the US has employed a great number of these in the Red Sea and in the South China Sea. These greatly improve situational awareness around the important Carrier Fleets and Surface Action Groups for very little cost, around $500K. USVs used for mine laying or ASW are much larger than these ISR sail drones, some reaching +130ft. Most of the successful USVs currently being employed are being designed and built by Ukrainians. These small low profile speed boats are being packed with 1000 – 2000lbs of explosive and driven in swarms at high speeds towards Russian ships patrolling or in harbor. As of March, ’24, 16 Russian vessels have been sunk and 6 damaged from Ukrainian OWA USVs, these 22 ships make up approximately 25% of the Russian Black Sea Fleet. These are impressive results from a country that does not have a navy. Though these have been the most combat effective due to their small radar cross section and speed, China, Russia, and the US are still developing larger craft with either vertical launch systems (VLS) or remotely operated weapon systems (ROWS). These crafts are larger and have a variety of propulsion systems. Many of these larger systems are in the testing phases. Such as the US Sea Hunter, a large surface vessel used for ASW that has been

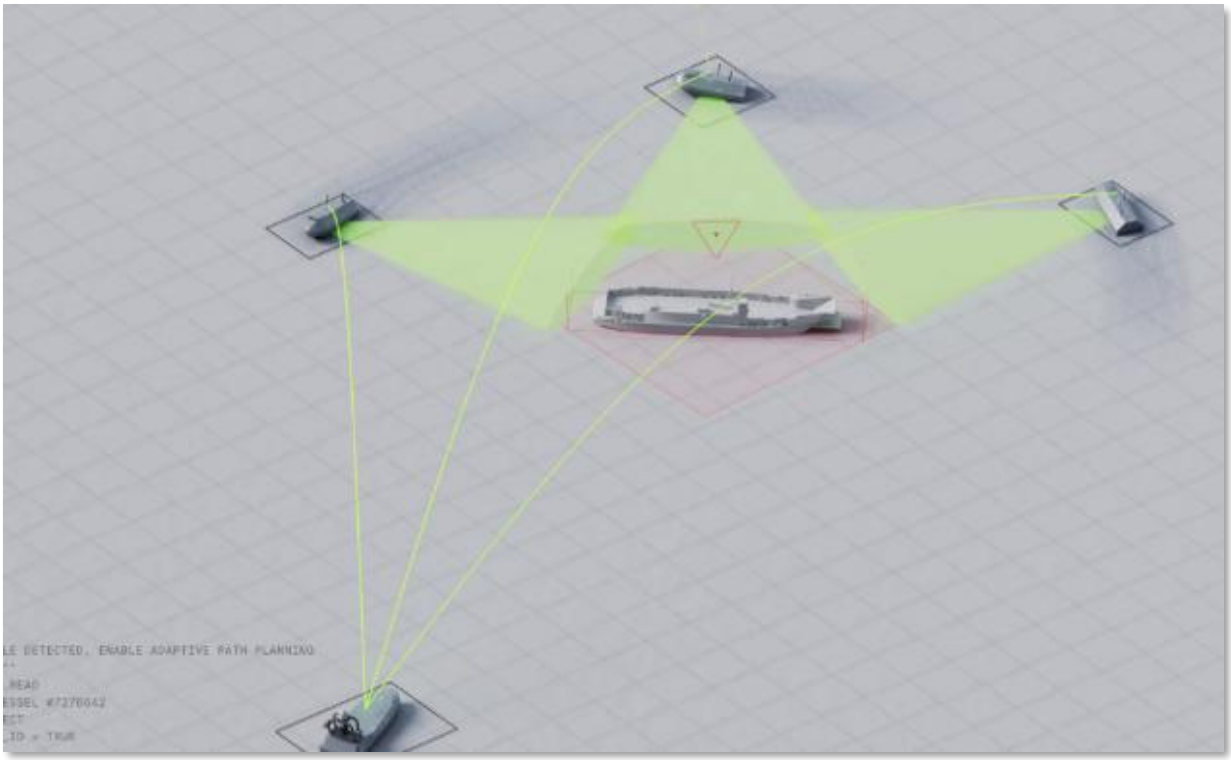
Chinese PLA-N JARi USV launched in 2019.

undergoing trials since 2016. The US defense industry is extremely optimistic of future military contracts as of the recent congressional requests from the US Navy to fund over half a billion dollars into not only USV and UUV technology but LUSV (Large Uncrewed Surface Vessels) and XLUUV (Extra Large Uncrewed Underwater Vessels). The LUSV is defined as a vessel upwards of 300 feet in length and a 2000-ton displacement, making it a large enough option to carry various weapon systems that enable participation in surface warfare actions. XLUUVs are thought to be the size of a "Subway Car" according to congressional documents. The DoD (Department of Defense) is looking for this vessel to deliver multiple payloads, specifics were not mentioned though this could be a variety of sea-floor mines or other weapon systems we may not know of.

The uncrewed systems give an air of ultimate perfection for sea warfare, no crew to feed or uphold morale during long deployments, smaller cross sections decreasing chances of detection, yet still allowing for the use of high-power weapon systems to engage in surface and subsurface combat. Unfortunately, there are some limitations. Power generation and storage are particularly challenging, especially for long-duration UUVs. Most UUV can rarely continue operations over 24 hours which forces the drone to be retrieved by manned vessels and charged. Another UUV and USV challenge is communication, though mainly autonomous, the vessels will need to communicate and that is a challenging task. For example, even the lowest radio waves rarely pass 20 meters in depth beyond that they are distorted, attenuated, or slowed. For surface vessels, accidental, active, and passive jamming can render the drone inoperable. US Sail drones have ended up washing ashore at times seemingly from accidental loss of communication, most likely not intentional. Towed arrays can be employed, but that also increases the signature of the

vessel. ISR Surface drones, generally unarmed, are completely helpless to some actor attempting to destroy, capture, or exploit the vessel. This instance happened in 2016 when a Chinese PLA-N (Peoples Liberation Army – Navy) vessel seized a US USV and eventually returned it to the US stating it was a "navigation hazard."

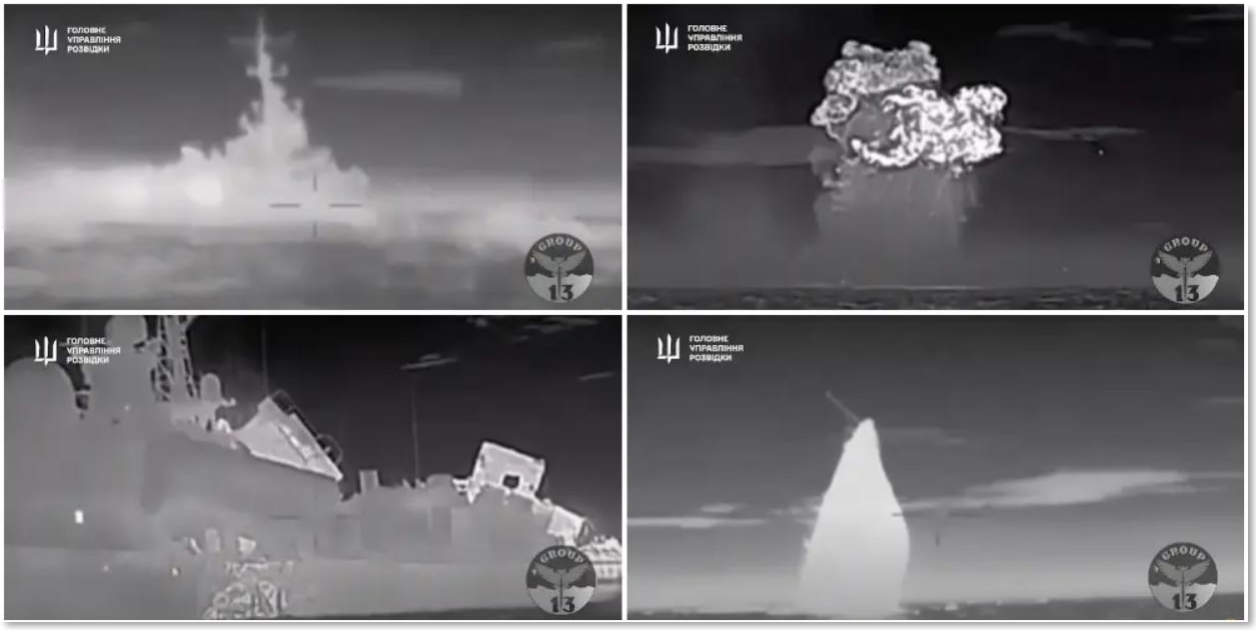
The PLA-N is the USs' main competitor in the field of USV and UUV development. They have multiple small to medium size vessels that are also in varying levels of testing. The Chinese, learning from the Ukrainians, are developing advanced sensing techniques and capabilities to detect small OWA USVs. This strategy is an attempt to protect their naval infrastructure and vessels with what they call a multi-domain three-dimensional approach. The three-dimensional perimeter defenses include point defense, floating barriers, and electronic warfare to disable enemy attack boats and drones. China, understanding their threat, also sees the strengths in such vessels. Autonomous swarm



Rendering of Autonomous Drone concept using Saronic USV Technologies.

vessels able to

communicate and share information could rapidly overtake multiple vessels. If an operator is merely using an infrared camera searching for ships, it would be fairly inefficient, increase a drone's size and sensor suite and allow it to communicate with not only other OWA or aerial assets and you have a very formidable swarm. Even with rudimentary swarm capabilities, we have seen success time and again of the Ukrainian USVs attacking both harbors and patrol ships. It is an attack type that navies across the world will have to rapidly develop defenses against.

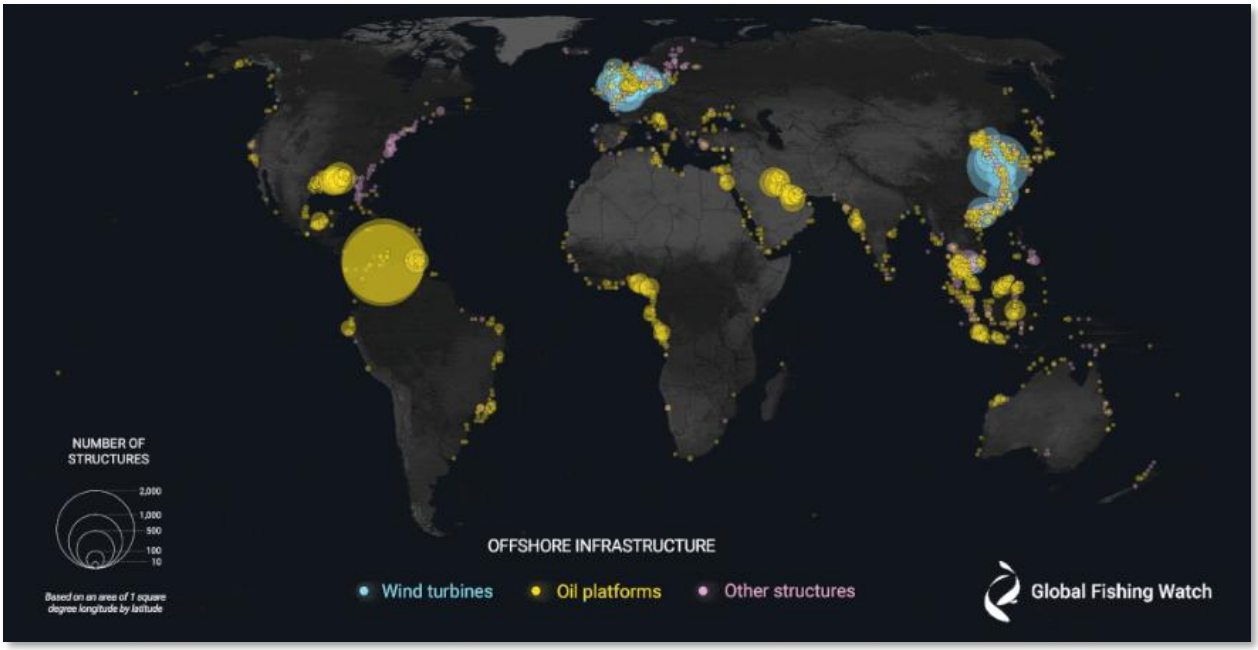


Ukrainian USVs attack against the Russian Corvette Ivanovets.

Most of these vessels, much like aerial drones, are being designed with the thought of long-range, lone, autonomous operations along with supplementing existing manned fleets and capabilities. As technology progresses, we will see innovations that continue to shock the world with both surface and subsurface vessels. The rise of Medium and Large USVs will lead to not only advanced military tactics, but I can foresee law enforcement activities adopting systems as well. Drones of all types are slowly being integrated more

into a law enforcement capacity, and I see no reason why USVs or UUVs can bolster detection and interdiction in the national waters of the US or the high seas between the Middle East and the African East Coast where drugs are in constant flow. If war erupts in the future on a larger scale, the use of solo USSVs could also be leveraged to conduct succesfful harrasment of logistics and shipping. We need only look to the successes of the German U-Boat from World War I and World War II to see the capabilities that hard to detect vessels can play in hampering Sea Lines of Communications (SLOCs).

US Navy Sea Hunter MUSV (Medium Uncrewed Surface Vessel


NUMBER OF STRUCTURES
2,000
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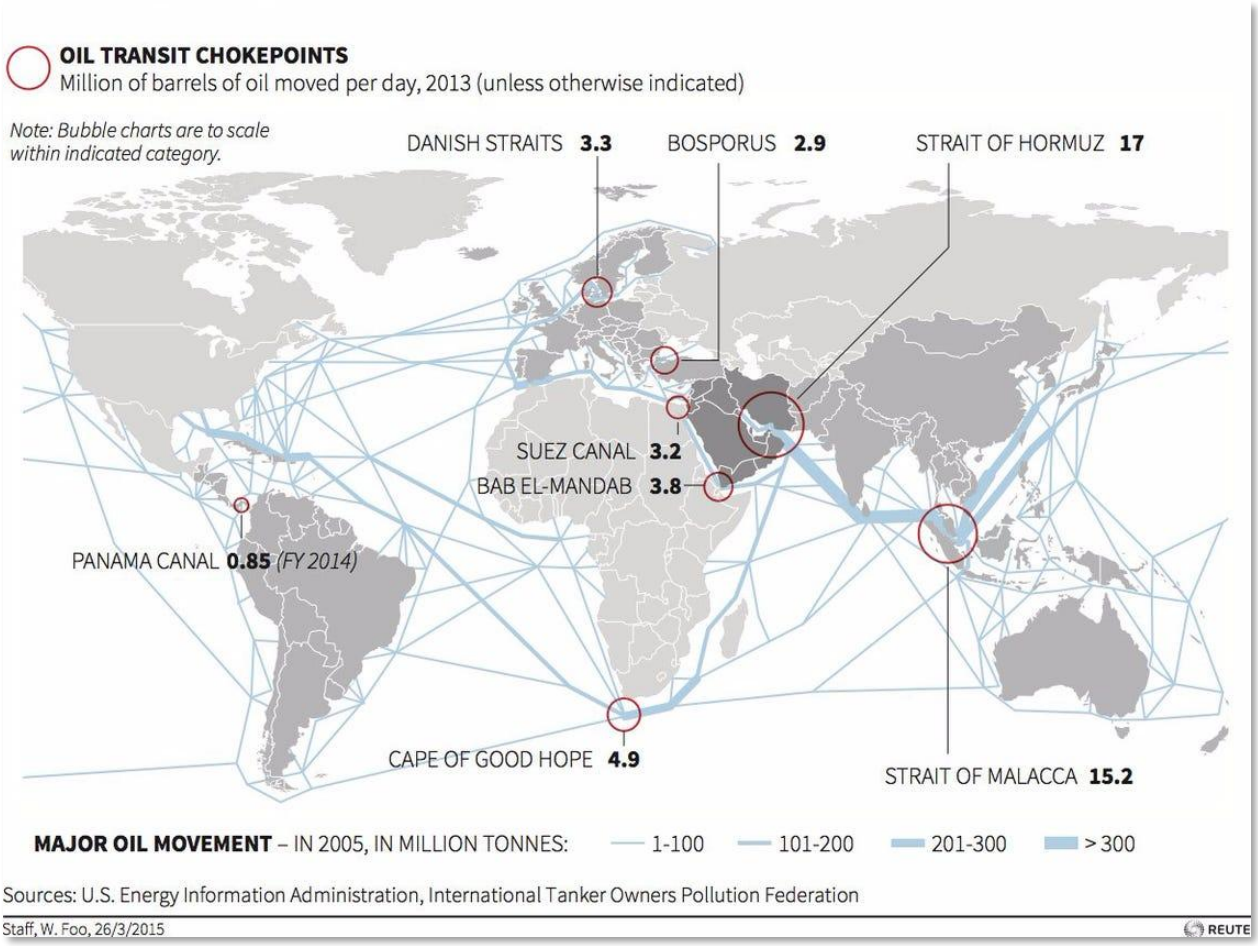
Based on an area of 1 square degree longitude by latitude
OFFSHORE INFRASTRUCTURE
Wind turbines
Oil platforms
Other structures
Global Fishing Watch


OIL TRANSIT CHOKEPOINTS
Million of barrels of oil moved per day, 2013 (unless otherwise indicated)
Note: Bubble charts are to scale within indicated category.
DANISH STRAITS 3.3
BOSPORUS 2.9
STRAIT OF HORMUZ 17
SUEZ CANAL 3.2
BAB EL-MANDAB 3.8
PANAMA CANAL 0.85 (FY 2014)
CAPE OF GOOD HOPE 4.9
STRAIT OF MALACCA 15.2
MAJOR OIL MOVEMENT – IN 2005, IN MILLION TONNES:
1-100
101-200
201-300
> 300
Sources: U.S. Energy Information Administration, International Tanker Owners Pollution Federation
Staff, W. Foo, 26/3/2015
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Index

AGS-17 – Automatic Grenade Launcher System (30mm, Russian)
AI – Artificial Intelligence
ASAT – Anti-Satellite Attack
ASW – Anti-Submarine Warfare
ATGM – Anti-Tank Guided Missile
BVR – Beyond Visual Range
CIA – Central Intelligence Agency
DJI – Da-Jiang Innovations
DoD – Department of Defense
EOD – Explosive Ordnance Disposal
FPV – First Person View
GWOT – Global War on Terror
HMMWV – High Mobility Multi-Wheeled Vehicle
ISR – Intelligence, Surveillance, and Reconnaissance
LSCO – Large Scale Combat Operations
LUSV – Large Uncrewed Surface Vessel
MALE – Medium Altitude Long Endurance
MASINT – Measurement and Signature Intelligence
NOMARS – No Manning Required Ship
OWA – One-Way Attack
PLA-N – People's Liberation Army Navy
RPAS – Remotely Piloted Air System
ROWS – Remotely Operated Weapons System
SLOC – Sea Lines of Communications
SOCOM – United States Special Operations Command
TB-2 – Bayraktar TB-2 Uncrewed Aerial Vehicle
UCAV – Unmanned Combat Aerial Vehicle
UAS – Unmanned Aerial System
UAV – Unmanned Aerial Vehicle
UGV – Unmanned Ground Vehicle
UUV – Uncrewed Underwater Vehicle
USV – Uncrewed Surface Vessel
USSV – Uncrewed Subsurface Vehicle
VLS – Vertical Launch System
XLUUV – Extra-Large Uncrewed Underwater Vehicle

References

Army.mil. (n.d.). *Pros and cons of autonomous weapons systems*. U.S. Army. https://www.army.mil

Arms Control Center. (n.d.). *Fact sheet: Autonomous weapons*. https://armscontrolcenter.org/fact-sheet-autonomous-weapons/

Axe, D. (n.d.). *Book review: Drone war Vietnam*. Warfare History Network. https://www.warfarehistorynetwork.com

Bard College. (n.d.). *Out of the shadows: The strange world of ground drones*. https://www.bard.edu

Bureau of Investigative Journalism. (n.d.). *History of drone warfare*. https://www.thebureauinvestigates.com

Center for Strategic and International Studies. (n.d.). *Release the robot hounds: Providing unmanned ground vehicles to Ukraine*. https://www.csis.org

Congressional Research Service. (2024). *Navy large unmanned surface and undersea vehicles: Background and issues for Congress* (R45757). https://crsreports.congress.gov

Droneii. (2023). *The drone industry's journey through 2023*. https://www.droneii.com

Drone Wars UK. (2024). *The next wave: Global military drone trends*. https://dronewars.net

Euro-SD. (n.d.). *The state of autonomy, AI & robotics for Russia's ground vehicles*. https://www.euro-sd.com

FLYING Magazine. (n.d.). *How were drones used during WWI and WWII?* https://www.flyingmag.com

Forbes. (2024). *Did Ukraine just build its first drone battleship?* https://www.forbes.com

Gage, D. W. (1995). UGV history 101: A brief history of unmanned ground vehicle development efforts. *Unmanned Systems Magazine, 13*(3).

General Dynamics UK. (2021). *MUTT unmanned ground vehicle datasheet*. https://www.generaldynamics.uk.com

Grey Falcon. (n.d.). *Nagayama*. https://greyfalcon.us

ITSS Verona. (n.d.). *The implementation of drone warfare in modern ground operations*. https://www.itssverona.it

Naval Association of Canada. (2022). *Uncrewed naval systems*. https://www.navalassoc.ca

Naval News. (2023). *World's first specialized explosive naval drone unit formed in Ukraine*. https://www.navalnews.com

Naval News. (n.d.). *Sea drone found in Black Sea is American boat with massive Soviet warhead*. https://www.navalnews.com

NOAA Office of Marine and Aviation Operations. (n.d.). *Uncrewed aircraft systems*. https://www.noaa.gov

NOAA Office of Marine and Aviation Operations. (n.d.). *Uncrewed surface vessels*. https://www.noaa.gov

Oryx. (n.d.). *List of naval losses during the Russian invasion of Ukraine*. https://www.oryxspioenkop.com

Palmer, J. (2023). *Palmer debates the ethics of drones*. Virginia Military Institute. https://www.vmi.edu

Paleofuture. (n.d.). *Remote-controlled tanks of the 1930s were supposed to save lives on both sides*. https://paleofuture.gizmodo.com

Pennsylvania State University. (n.d.). *DASH QH-50 imagery*. https://aero.psu.edu

RAND Corporation. (2024). *What Chinese navy planners are learning from Ukraine's war*. https://www.rand.org

ResearchGate. (n.d.). *DARPA autonomous land vehicle (ALV) program*. https://www.researchgate.net

Radio Free Europe/Radio Liberty. (n.d.). *How Ukraine uses obsolete Soviet grenades to destroy Russian tanks from above*. https://www.rferl.org

ScienceDirect. (2024). *Autonomy and robotics in modern warfare*. https://www.sciencedirect.com

SCSP. (n.d.). *Homepage*. https://www.scsp.ai

Sutton, H. I. (n.d.). *Covert Shores*. https://www.hisutton.com

U.S. Army. (n.d.). *ODIN: OE data integration network*. https://www.army.mil

U.S. Government Publishing Office. (n.d.). *Saildrone technical specifications*. https://www.gsaadvantage.gov

U.S. Naval Institute News. (2024). *Navy will stand up lethal drone unit later this year*. https://news.usni.org

War History Online. (n.d.). *The disastrous Operation Aphrodite killed JFK's brother*. https://www.warhistoryonline.com

War on the Rocks. (2024). *Uncrewed systems and the transformation of U.S. warfighting capacity*. https://warontherocks.com