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UNMANNED MARITIME SYSTEMS: THE FUTURE OF NAVAL WARFARE

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ABSTRACT

Technology has continually transformed naval warfare throughout history. Computers are now capable of performing a multitude of functions with unprecedented speed and efficiency. Furthermore, recent advances in artificial intelligence have facilitated the development of Unmanned Maritime Systems (UMSs), or 'drones', which are able to operate autonomously across all three spatial dimensions. The US and China are the world leaders in R&D, including their production versions, while India remains somewhat behind. UMSs can also be used in coordinated 'swarm' operations for greater effect. Another issue under debate is the introduction of Lethal Autonomous Weapons Systems (LAWS), which raises a number of legal and ethical issues. While the Indian Navy, along with other stakeholders, has already undertaken several initiatives to develop UMSs, a number of further recommendations are offered here for consideration as the 'way ahead'.

Keywords: Unmanned, Autonomous, Drones, Artificial Intelligence, Swarm.

INTRODUCTION

Technology has continually transformed naval warfare throughout history, turning the sea from a straightforward battleground into a domain characterised by speed, stealth, and strategic complexity. Key developments have occurred in fields such as hull forms and materials, propulsion systems, weaponry and ordnance, communications, and surveillance sensors. Naval technology has progressed from wooden ships powered by oars, through the Age of Sail and ironclads of the mid-nineteenth century, to the modern navy, which comprises vessels ranging from the largest aircraft carriers to the smallest interceptor craft. Likewise, swords and spears were succeeded by muskets and cannons, which were then replaced by large turret-mounted guns, subsequently eclipsed by missiles and torpedoes. Since the late twentieth century, computers capable of performing almost every task

previously carried out by humans have been introduced, accomplishing these far more efficiently and with fewer errors, except for decision-making itself. However, even this is changing, owing to rapid recent advances in artificial intelligence.

Development of Artificial Intelligence

Artificial intelligence (AI) refers to computer systems that can perform tasks that ordinarily require human intelligence, such as learning, problem-solving, decision-making, and perception. AI utilises algorithms and models that enable machines to process and analyse vast amounts of data, recognise patterns, and make predictions or take actions based on that information. Popular AI applications, such as GPT-4 (developed by OpenAI), Gemini (developed by Google), Grok (developed by X – formerly Twitter) and more recently, DeepSeek developed by a Chinese company, are essentially chatbots which use Large Language Models (LLMs), huge datasets and 'transformers' to churn out responses to questions posed to them, faster than any human can. These chatbots are based on 'Generative' or 'Narrow' AI[1]. The stage of 'General' AI, in which machines would, in effect, be sentient – possessing the capacity to think, feel, and perceive the physical world as humans do – has not yet been achieved.[2] Nevertheless, it is evident that AI will play an increasing role not only in civilian applications such as robotic vacuum cleaners, delivery drones and self-driving cars, but also in the military domain, specifically in the form of autonomous vessels or vehicles that can operate in all three domains: air, surface and underwater.

UNMANNED MARITIME SYSTEMS (UMSS)

Unmanned Maritime Systems (UMSs) refer to a broad category of vessels or vehicles that operate on the surface, underwater or in the air, and are termed as Unmanned Surface Vessels (USVs), Unmanned Underwater Vessels (UUVs), and Unmanned Aerial Vehicles (UAVs), respectively, depending on their operating environment. At present, most unmanned systems are operated and controlled remotely by humans, with commands transmitted via radio or satellite communications. The incorporation of artificial intelligence now enables unmanned systems to operate autonomously, without human intervention, and this transition is already underway.

Unmanned Aerial Vehicles (UAVs)

Unmanned Aerial Vehicles (UAVs), also known as Remotely Piloted Aircraft (RPAs), have been in service for the longest period. They can be either fixed or rotary-wing (single/multi-rotor), armed or unarmed, with ranges varying from a few hundred to thousands of miles, and endurance ranging from a few minutes to hundreds of hours. They can perform almost all maritime tasks that manned aircraft presently do, other than possibly air-to-air combat.

The first generation of UAVs operated by the Indian Navy were the Israeli IAI-built Searcher and the larger Heron, contracted in 2002 for maritime surveillance of coastal areas. These were launched from a naval air station and could operate up to 160 nautical miles (nm) when controlled from a shore station known as a Ground Station Control System or GSCS; but this range could be almost doubled by deploying a specially equipped ship known as an Advanced Ship Control Station or ASCS[3].

Almost 20 years later, in 2020, the Indian Navy leased two long-range, unarmed High-Altitude Long-Endurance (HALE) Sea Guardian MQ-9A UAVs from the US to expand its surveillance activities over the IOR[4]. This has now been followed by the signing of a $3.5 billion deal in Oct 2024 to acquire 31 highly advanced and armed MQ-9B UAVs, having an endurance of 40 hours, of which 15 will be for the Indian Navy and 8 each for the Indian Army and the IAF[5].

The Indian Navy also acquired two indigenously made Medium-Altitude Long-Endurance (MALE) UAV Drishti 10 Starliner – a variant of the Hermes 900 – developed by Adani Defence & Aerospace, with technology from Elbit Systems, Israel. It has 36 hours of endurance and can carry a 450 kg payload. Unfortunately, one crashed off Porbandar on 14 January 2025, while undergoing user trials[6].

Another such indigenous MALE UAV, the TAPAS-BH-201 (Tactical Airborne Platform for Aerial Surveillance-Beyond Horizon-201), designed by DRDO and manufactured by a BEL-HAL consortium, was also under consideration, but later rejected as it did not meet the Navy's standards[7].

All these UAVs, however, are land-based and cannot operate from ships. Consequently, in June 2022, the Indian Navy issued a Request for Information (RFI) for the procurement of 40 Naval Ship-borne Unmanned Aerial Systems (NSUAS). Options under consideration include the Boeing ScanEagle/Blackjack, as well as other platforms such as the Israeli Maritime Heron and BlackEagle 50,

the AR-3 and AR-5 made by Tekever, a UK/Portugal-based firm, and the US-made MQ-8B Fire-Scout NRUAV[8]. Additionally, two indigenous collaborative projects are under evaluation: the IAI-HAL VTOL Naval Rotary Unmanned Aerial Vehicle (NRUAV), a jointly developed rotary-wing UAS project to mount IAI's Helicopter Modification Suite (HeMoS) on HAL's Chetan (upgraded Chetak); and the RUAV-200, a coaxial, rotary-wing, fuel-engine UAS jointly developed by HAL and IIT[9]. Although ship-launched UAVs do not have the range or endurance of the land-based ones, they offer the advantage of being deployable at short notice to provide surveillance in the vicinity of the launch platform.

UAVs can be either unarmed or armed, when they are referred to as Unmanned Combat Air Vehicles or UCAVs. They have been used on a number of occasions during armed conflicts between conventional adversaries such as the 2020 Nagorno-Karabakh war between Armenia and Azerbaijan, the ongoing Russia-Ukraine war, by militant organisations such as the Yemen based Houthis to attack merchant ships in the Red Sea, and by nations such as the US and Israel to carry out targeted attacks on high value terrorist groups.

UAVs were also extensively used during the recent short conflict between India and Pakistan in the wake of the Pahalgam terrorist attack that took place on 22 April 2025, which led to India launching Op SINDOOR on 07 May 2025. India used the Israeli Heron Mk II, the DRDO-developed TAPAS-BH-201 (formerly known as Rustom-II), as well as the Hawk, Scout and Eagle UAVs made by a Chennai-based startup, Zuppa Geo Navigation Technologies, for surveillance and early warning. In addition, several Loitering Munitions (or Kamikaze Drones), such as the indigenous Nagastra-1, JM-1, ALS-50 (made by Tata Advanced Systems Limited), SkyStriker (manufactured by Alpha Design Technologies in collaboration with Israel's Elbit Systems), and the Israeli Harop were used to target Pakistani positions. On its part, Pakistan employed more than 600 UAVs, primarily of Chinese and Turkish origin. These included the Turkish Bayraktar TB2 and indigenous Shahpar IIs for surveillance, and the Chinese Wing Loong and CH-4, as well as the indigenous Burraq armed drones for targeted attacks[10].

Most recently, on 01 June 2025, Ukraine carried out an audacious and well-planned attack using 117 drones on five Russian air bases – Belaya, Dyagilevo, Ivanovo Severny, Olenya, and Ukrainka – deep inside the latter's territory. The aim of Operation SPIDER WEB, as it was called, was to target the Russian Air Force's long-range aviation assets, specifically strategic bombers and early warning aircraft. The drones were covertly transported to their launch areas concealed

within trucks, which were driven by Russian nationals unaware of their cargo. Ukraine claimed to have destroyed 41 Russian aircraft in the operation, although this number is contested by Russian authorities[11].

Unmanned Surface Vessels or Vehicles (USVs)

Unmanned Surface Vessels (USVs), commonly referred to as drone boats or ships, have both civil as well as military applications. In the civil sector, there is much debate regarding the concept of Maritime Autonomous Surface Ships (MASS), but several legal and regulatory challenges need to be addressed before they can freely operate on the oceans[12]. Other civil applications include oceanography, hydrography, and environmental monitoring.

Military applications of USVs include ISR, communication, MCM, ASW and logistical support. They have also been used in conflict for targeting enemy ships, notably during the Russia-Ukraine conflict when Ukraine executed a USV assault on Russian naval vessels at the Sevastopol Naval Base on 29 October 2022[13] and at Novorossiysk in Aug 2023[14]. More attacks in 2024 targeted Russian landing craft in Crimea[15]. The Houthis have also used autonomous USVs (as well as drones) to target merchant ships in the Red Sea in the past year[16].

Major navies are developing USVs of various sizes to perform specific roles. The US Navy, for example, has deployed the *Sea Hunter* and *Sea Hawk*, both Medium Displacement USVs developed by DARPA and placed under Unmanned Surface Vessel Division One (USVDIV 1)[17]. Their primary roles are ASW and ISR. The US Navy is also developing even bigger USVs, such as the Large USV (LUSV) of 1000-2000 tonnes and the Medium USV (MUSV) of 500 tonnes[18].

China presently appears to be producing USVs at the same rate at which it is building warships. It started out with the 15-metre, 20-tonne *JARI* launched in 2021[19]. This was followed by a 200-tonne trimaran designed by Zhejiang-based Beikun Intelligent Technology, which was launched in 2019 and undertook sea trials in 2022[20]. Then it unveiled a 280-tonne USV called *Thunderer A2000* at the World DefExpo in Riyadh in February 2024[21]. Most recently, in November 2024, China unveiled the '*JARI-USV-A* of 420 tonnes, with a length of 58 m, a maximum speed of 40 kn and a range of 4,000 nm.[22] The majority of USVs – especially the later ones – are based on trimaran hulls, similar to the US *Sea Hunter*.

India is some way behind the US and China, but has taken several steps to develop indigenous USVs through both startups as well as established defence shipyards and manufacturers. One of these is the *Matangi* Autonomous Surface Vessel developed by a Pune-based startup, Sagar Defence Engineering Pvt Ltd. This is a high-speed (50 kn), autonomous USV, equipped with a 12.7mm stabilised remote-controlled gun. It successfully completed an 850 nm autonomous passage in 2024. The Navy plans to acquire 12 such USVs for coastal and lake operations, including patrolling the Pangong Tso lake in Ladakh[23]. Sagar Defence has also entered into a collaboration with Liquid Robotics, a company owned by the aerospace giant Boeing, to co-develop and co-produce USVs. It is expected that this would be the Wave Glider, which is powered by wave and solar energy and can remain on task for several months at a time[24].

Another indigenous USV project, which is presently under trials, is the 15 metres Autonomous Fast Interceptor Boat (A-FIB), developed by the Weapons and Electronics Systems Engineering Establishment (WESEE)[25], in collaboration with Bharat Electronics Limited, and built by Goa Shipyard[26]. Similarly, L&T Defence showcased its '*Vega*' USV in May 2024 at its Kattupalli Shipyard,[27] while Cochin Shipyard Ltd is working on a USV Project termed '*Swayat',* which is expected to commence trials in 2026[28]. However, except for the *Matangi* USV, other projects are still in the prototype/technology demonstration phase and are small craft (15-20 metres in length).

Unmanned Underwater Vehicles or Vessels (UUVs)

Unmanned Underwater Vessels (UUVs), also known as underwater drones, are submersible vehicles that can operate underwater without a human occupant on board, using sensors, cameras, and other equipment to perform various tasks.

There are two main categories of UUVs: Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs). ROVs are tethered to a surface ship and controlled by human operators in real time via a cable that transmits power and data. AUVs, on the other hand, operate independently, following pre-programmed instructions or adapting to their surroundings using AI and onboard sensors[29].

UUVs have a wide range of civil and military applications. Navies can deploy them for tasks like mine detection, ISR and for attacking enemy surface ships – either

for suicide attacks or as loitering munitions. In scientific research, they explore deep-sea ecosystems, map the ocean floor, or monitor environmental changes. The oil sector uses ROVs for inspecting underwater infrastructure like pipelines, cables, or oil rigs, and they have also been used in search-and-recovery missions, such as locating shipwrecks or downed aircraft.

UUVs being developed by the US include the Extra-Large Unmanned Undersea Vehicles (XLUUVs) through Boeing's 'ORCA' project, having a range of 6500 nm,[30] the Boeing *Echo Voyager* UUV of 50 tonnes[31], the Northrop Grumman *Manta Ray* UUV,[32] as well as a host of small and medium UUVs too numerous to list.

China has been researching UUVs since the 1980s, starting with the Shenyang Institute of Automation and Shanghai Jiao Tong University's development of HR-01.[33] China's largest UUV is the *HSU-001*, designed for ISR during long-endurance patrols.[34] The UUV-300 series includes the 300CB for ISR, minelaying and for deploying smaller UUVs; and the *300CD,* which can carry a torpedo[35]. It is also working on the CSSC-705 XLUUV (similar to the US Navy's Orca)[36] and the *Haishen (Poseidon)* series Medium UUVs.[37] Ukraine has developed several UUVs for suicide missions against Russian vessels in the Black Sea. These include the *Marichka*, 6 metres in length with a range of approx 1000 km,[38] and the *Toloka* Series (TLK-150, TLK-400 and TLK-1000) varying from 2.5 to 12 metres in length[39].

As regards India, there are several UUV projects under development in both the public and private sectors. The first of these is the High Endurance Autonomous Underwater Vehicle (HEAUV) being developed by the Naval Science and Technological Laboratory (NSTL), under DRDO. It is a mini-submarine-like AUV designed for long-endurance missions, including ASW and MCM[40].

India is also developing its own XLUUV through DRDO with L&T Defence as the likely private industry partner. The vessel is expected to be 50 metres in length, having a displacement of up to 300 tons and with a 10-tonne payload capacity. The intended roles include ISR, ASW, ASuW, and mine warfare. It may feature two torpedo tubes and mine-laying capabilities, powered by Li-ion batteries or a fuel cell-based AIP system, giving a 45-day endurance, max speed of 8 knots, and cruising speed of 4 knots. The Indian Navy plans to procure 12 XLUUVs. The project is in the feasibility and design phase[41].

Other UUV projects under development are as follows: -

(a) **Underwater-Launched Unmanned Aerial Vehicle (UL-UAV).** There are two concurrent projects, the first of which is being developed by L&T in collaboration with NewSpace Research & Technologies (NRT) and the second by Sagar Defence Engineering, under contract by DRDO. The L&T project (also called SLUAS) would be a hybrid UUV-UAV system designed to be launched from submarine torpedo tubes to enhance the submarine's situational awareness with real-time visuals[42]. Sagar Defence's version includes an intelligent swarm of drones with AI for mine detection and payload delivery at 60-metre depths[43].

(b) **L&T's AUV Family (*Adamya, Amogh, Maya*).** This is a series of AUVs of varying sizes and dimensions. *Adamya* is the largest, with a length of 5 metres, an operating depth of 500 metres and an 8-hour endurance at 4 knots. The payload can be customised for ISR and MCM[44].

(c) **AUV-150 Series.** This project is being developed by the Central Mechanical Engineering Research Institute (CMERI), with NSTL and industry contributions. It would be a family of AUVs, designed for coastal security and scientific missions. The AUV-150 is 4.8 metres long, displaces 490 kg and can operate up to a depth of 150 metres with a 4-knot speed. It is equipped with sonar, cameras, and sensors for MCM, seabed mapping, and environmental monitoring. NSTL has designed a 1.7-tonne AUV, which it tested off Visakhapatnam at a depth of 500 metres. It can carry a 500 kg payload for ISR, sensor deployment, and ammunition delivery. The Navy plans to acquire 10 such platforms[45].

(d) **Neerakshi.** This project is being undertaken by GRSE in collaboration with Aerospace Engineers Pvt. Ltd., under DRDO oversight. It would be a lightweight AUV, 2.1 metres long, displacing about 45 kg, primarily for mine detection and underwater surveys. One prototype is undergoing user trials[46].

(e) **ULAUV.** The IN also floated an RFI on 01 July 2024 for development of an Underwater Launched Autonomous Underwater Vehicle (ULAUV).[a] The roles would be ISR and MCM and it would be carried to the target area by an underwater platform (likely submarine).[47]

a not to be confused with the ULUAV mentioned in sub para (a) above.

Drone Swarms and Carriers

While UMSs for support missions like ISR and intelligence gathering can operate alone, their threat increases significantly when used in 'drone swarms' in offensive missions against various targets. The large number of drones can overwhelm defences, even if some are intercepted. Due to limited endurance, individual drones are likely to be transported in larger platforms such as the Chinese '*Zhu Hai Yun*', the world's first drone carrier of 88 metres capable of carrying up to 50 smaller underwater, surface, and aerial drones for coordinated missions. The ship was built by Huangpu Weichong Shipyard and launched in May 2022[48].

More recently, in Dec 2024, China launched the Type 076 *Yulan*-class amphibious assault ship at the Hudong Zhonghua shipyard. It has a length of 260 metres and a displacement of 50,000 tonnes and is also capable of being used as a drone carrier, especially for large UCAVs[49].

China has also unveiled a new class of heavy UAV called *Jetank,* described as a "swarm carrier" at the Zhuhai air show on 17 November 2024. It is built by AVIC, China's state-owned aerospace corporation, with a maximum take-off weight (MTOW) of 16 tonnes, a payload capacity of 6 tonnes and a wingspan of 25m. It has eight hardpoints for weapons and a "mission module" that can be configured for a range of functions, including airlift, air drop, strike and countermeasures deployment. The aircraft is reportedly remotely piloted, rather than autonomous, but can carry several smaller drones, which can be deployed in swarms[50].

Operation Spider Web, carried out by Ukraine against Russian air bases, has shown, firstly, the potential threat that even short-range UAVs used in swarms can pose to seemingly well-defended military bases or other targets, when deployed with ingenuity and innovation; and secondly, the disproportionate amount of damage they can cause vis-à-vis their own cost. While Ukraine used trucks as 'drone carriers', it is quite likely that we will see UMSs being transported through the medium of the sea as well as by air and deployed in the vicinity of their target, which could include naval bases, in future conflicts.

Consequently, advanced nations are developing countermeasures to neutralise drone swarms which could include kinetic interception weapons, directed energy weapons, as well as jamming and GPS spoofing. During the Op SINDOOR conflict, India was able to intercept almost all Pakistani UAVs using its Integrated Air Command and Control System (IACCS) and Air Defence Control &

Reporting System (or Akashteer)[51], using interceptor missiles such as S-400, Barak-8, Spyder and Akash; as well as the Low-Level Air Defence (LLAD) Network comprising L-70 guns[52]. However, using expensive interceptor missiles to bring down relatively cheap UAVs is not very cost-effective, which makes it imperative to find more efficient counters. The US is developing the 60 KW `Helios' (High Energy Laser with Integrated Optical-Dazzler and Surveillance) while Israel is similarly deploying a 100 KW `Iron Beam' laser. India has also tested a 30 KW laser-based drone countermeasure system termed Laser-DEW Mark-II(A)[53].

Requirements of Unmanned Maritime Systems

As the foregoing paragraphs would have clearly brought out, Unmanned Maritime Systems come in a variety of shapes, sizes, ranges and control methods. Their area of operations can vary from a few feet from a control platform, as in the case of ROVs, to a few thousand miles away from base. However, all UMSs share some requirements to carry out their mission successfully.

(a) **Propulsion Systems.** UMSs use propulsion systems that are most suitable for their operating environment, designed range and endurance, as well as mission requirements. These could be either conventional fossil fuel engines, electric motors, hybrid systems, or those using renewable sources (solar, wind, waves). Recently, a Chinese company, Betavolt, has tested a battery the size of a coin using a radioactive nickel isotope (Ni-63), which is claimed to provide power for up to 50 years[54]. While this would not be powerful enough to propel UMSs, in the future, battery packs with multiple, larger cells, along the lines of EVs that will be produced, may do so.

(b) **Defect Rectification.** Just as in the case of manned vessels, UMSs too may face technical problems during a mission, such as machinery breakdowns, power disruptions or sensor malfunctions, which could be caused by weather, environmental factors or enemy action. This would require the UMS to undertake diagnostics, reboot the operating system, carry out defect rectification or change over to backup or emergency systems. Remotely controlled UMSs could be fed commands by the operator to achieve these tasks. However, autonomous systems would need to undertake all these without any human input.

(c) **Navigation Systems.** Long-range UAVs and USVs would have to use satellite systems like GPS to ensure safe navigation. This could be supplemented by inertial navigation systems (INS) for redundancy in environments where GPS signals may be either jammed or spoofed by the enemy. UUVs would be primarily dependent on INS as well as more advanced techniques like Doppler Velocity Log (DVL) and Simultaneous Localisation and Mapping (SLAM)[55].

(d) **Collision Avoidance.** UMSs – especially USVs – would need to ensure collision and obstacle avoidance in restricted waters or busy shipping lanes through a combination of radar, LIDAR and regular cameras, analogous to self-driving cars.

(e) **Sensors and Payloads.** UMSs would have to carry sensors and weapons appropriate to their mission configuration. These too could be affected by weather, environmental factors and enemy action and, consequently, autonomous vessels need to have defect rectification procedures built into their software – along with a self-destruct mechanism (such as opening seacocks), which operates after a certain time out - to avoid an armed USV, for example, turning into a floating, unresponsive Unexploded Ordnance (UXO) that is a hazard to surface vessels.

(f) **Connectivity.** UMSs – except for UUVs – would need high-bandwidth satellite or radio links to allow real-time data relay to and from their control station or base. UUVs may – depending on their role – also need some form of connectivity, to get the latest inputs from their control station, as well as to relay back ISR information relevant to their area of operation, which would mean they would periodically have to come up to or just below the surface to raise a satellite or radio mast. There must also be a provision for an autonomous fallback mode to activate if communication is lost, ensuring that the vessel either returns to base, holds position (and is recovered) or self-destructs.

(g) **Hull and Structural Design.** UMSs must be able to withstand waves, wind, and weather, depending on the environment that they are operating in (air, sea or underwater). Such platforms would be constructed from lightweight composites or aluminium to reduce fuel consumption, resisting corrosion and yet robust enough to withstand rough weather and wave action.

(h) **Mission Planning.** Routes to the mission area, speed, patrol patterns and payload deployment will need to be pre-defined and fed into the software for autonomous vessels. UMSs must also be able to coordinate their operations, both with friendly manned ships or other unmanned systems, as the situation demands via networked command.

(j) **Launch and Recovery.** Except for long endurance UMSs, other vessels would need to be transported to the target area by a drone carrier. Even smaller navies like Iran and Turkey have adapted existing ships as drone carriers. Iran has converted a container ship, the *Shahid Bagheri*, while Turkey has converted an amphibious assault ship, the *TCG Anadolu*.

(k) **Personnel and Training.** Operators of manned UMSs require specialised training through simulators and live exercises for navigation, sensor monitoring, payload deployment and troubleshooting. Autonomous vessels would require fewer operators, mainly for monitoring ISR data.

(l) **Compliance with IML.** Operations by UMSs in territorial seas or airspace of an adversarial nation will simply not be permitted during peacetime. Some countries may still resort to covert deployment of stealthier platforms such as UUVs for intelligence collection, but if these are detected by the littoral nation, it may lead to a diplomatic incident. During war, as seen in the Russia-Ukraine conflict, there are no such niceties.

Lethal Autonomous Weapon Systems (LAWS)

Some of the advanced militaries are also developing so-called Lethal Autonomous Weapon Systems (LAWS) or more commonly 'killer robots.' They will use AI and advanced algorithms to identify, track, and engage targets, which may include human targets, without human intervention. These systems can operate independently, making decisions to apply lethal force based on pre-programmed rules or real-time data analysis, such as sensor inputs from cameras, radar, or other detection mechanisms. LAWS may also include loitering munitions that wait in an area until they find a valid target to attack based on a preprogrammed algorithm. The concept raises significant ethical, legal, and strategic questions. While human oversight via satellite/radio is feasible for USVs and UAVs, it is nearly impossible for UUVs once submerged. Proponents argue that LAWS could reduce human

casualties by keeping soldiers out of harm's way and improve precision in targeting. Critics, however, warn of risks like unintended escalation, lack of accountability, and the potential for machines to make life-and-death decisions in unpredictable scenarios. There's also the fear of an arms race or these systems falling into the wrong hands.

Internationally, there's an ongoing debate about regulating or banning LAWS. The United Nations has hosted discussions under the Convention on Certain Conventional Weapons (CCW) since 2014 through a Group of Governmental Experts (GGE), but no binding agreement exists yet due to differences between the three major powers – the US, Russia and China. India is a High Contracting Party to the CCW and has actively participated in the global discourse on LAWS at the GGE. As the GGE chair in 2017, India played an instrumental role in the GGE agreeing on the 11 guiding principles on the use and development of LAWS[56]. To comply with this Convention, LAWS must distinguish between combatants and non-combatants across various scenarios (Geneva Conventions First Additional Protocol, Arts 48, 51(2), and 52(2)) and also adhere to norms of proportionality and avoid unnecessary suffering (Arts 35(2) and 57(2))[57].

UN Secretary-General António Guterres has argued that LAWS should be prohibited under international law due to political and moral concerns. In his 2023 New Agenda for Peace and again in January 2024, the Secretary-General and the International Committee of the Red Cross called for UN member states to negotiate a new international treaty to ban and regulate LAWS by 2026[58]. On 02 Dec 24, the UNGA adopted a resolution on LAWS as one more step towards the formulation of a treaty, with 166 votes in favour, 3 opposed and 15 abstentions. Notably, while the US voted in favour, both China and India abstained, while Russia voted against it.[59]

Ultimately, just as in the case of nuclear weapons, LAWS will create a world with 'haves' and 'have-nots,' with the 'haves' justifying their possession and use as being in their national security interests. Unlike nuclear arms, however, it is very likely that LAWS will be used in future wars as well as in OOTW scenarios.

WHERE DOES INDIA STAND?

IN Integrated Roadmap and Vision Documents. Countries like the United States and China already have a head start over India in the research and development of

unmanned and autonomous vessels/vehicles. The Indian Navy has acknowledged the challenge and taken steps to develop such platforms indigenously, utilising the combined talents of DRDO, expertise within the Services, academia, established defence contractors as well as startups throughout the country. Another noteworthy achievement by the *IN* is the release of the Integrated Unmanned Roadmap (2021-2030) by the RM in October 2022, followed by the *IN* Vision Document for Unmanned Systems by the Hon'ble PM in July 2022. These guidance documents provide details of unmanned systems that the *IN* envisages to induct by 2030, as per a phased timeline, which would help industry partners to synchronise their development efforts with the Service[60].

Way Ahead. The *IN* Unmanned Roadmap and Vision Statements do indeed have ambitious objectives. However, it would need to be seen whether actual outcomes match the objectives set out. As would be realised from the foregoing paragraphs, the US and China are already bringing out productionized small, medium and large UMSs depending on their envisaged roles. Meanwhile, indigenous Indian UMS projects comprise mostly small platforms, while large UMSs for the Indian Navy are stuck at a 'feasibility study' stage. Unless we accelerate our R&D and manufacturing processes, both in terms of hardware and software development, the gap between us and the advanced navies will keep growing. Some of the suggested steps that the Govt and the Indian Navy need to implement are listed below: -

(a) Increase the R&D budget significantly. This is presently just around 0.6% of our GDP[61] and needs to increase to at least 2.5%. By comparison, the US and China spend about 3.4% and 2.7% of their already large GDP on R&D, respectively[62].

(b) While Indian shipyards have developed considerable experience and expertise in designing and building ships, the development of the software and algorithms which control an autonomous UMS for mission accomplishment will be a significant challenge which would require bringing together the best and brightest minds that can be found in academic institutions, IT companies and entrepreneurial startups.

(c) Autonomous UMSs – especially those likely to be deployed at extended ranges – also require extensive testing, static and dynamic user trials under all possible scenarios to bring down the margin of error during deployment to the bare minimum. If at some point, the Indian Navy does

decide to go in for armed UMSs, even more care needs to be taken towards developing the algorithms for mission accomplishment, especially those which would make decisions on target engagement.

(d) As of now, there does not appear to be any IN project to design and construct a specialised 'drone carrier'. It is, however, understood that the Multi-Purpose Vessel (MPV)[63] as well as the Landing Platform Dock (LPD),[64] both of which are presently under construction, will be able to deploy drones. Nevertheless, as more of our indigenous UMS projects transition from prototypes to production versions, the Navy should initiate the process of designing a dedicated drone carrier, preferably one capable of carrying all three types of UMSs.

(e) Drone swarm countermeasures such as the Laser-DEW Mark-II(A) also need to be adapted for fitment on naval ships and integrated into the AIO.

(f) Along with the induction of the platforms, the Indian Navy would also need to formulate operational doctrines, tactics, Standard Operating Procedures, maintenance and refit philosophies, training curricula, logistics and spares supply chains to ensure that all the UMSs that are being inducted are optimally deployed, operated, maintained and serviced. This may also call for changes to naval formations from IHQ MoD (Navy) to the Command HQs to Fleets, Submarine Squadrons, Air Stations, and Training Institutes, to add directorates and sections, specifically to handle UMSs.

CONCLUSION

In conclusion, history has shown how quickly technology can become obsolete; battleships were once seen as the prima donnas of world fleets until aircraft carriers made them virtually obsolete during WWII. Today, major navies including the US, China, Russia and India continue to invest in conventional platforms while at the same time developing small, medium and large UMSs to perform different roles.

Unmanned systems offer cost-efficiency, stealth, and expendability, making them ideal for niche or high-risk roles. Conventional warships, however, still provide

unmatched firepower, versatility, and strategic presence. The future, therefore, likely lies in hybrid fleets where both coexist – unmanned systems handling the "dull, dirty, and dangerous" tasks, while conventional warships remain the symbol of naval power.

Finding the optimum balance between manned and unmanned platforms, which will ensure the maximum bang for the buck, should therefore be foremost in the minds of our naval planners, especially considering our limited defence budget. Furthermore, while there may be some collaboration with foreign companies, as the Sagar Defence-Liquid Robotics project, the majority of development work needs to be indigenous, which is where the Indian Navy's recent initiatives such as 'Supporting Pole-vaulting in R&D through iDEX, NIIO and TDAC (SPRINT)' working together with other Government agencies such as DRDO, academia, PSUs and the private sector can really bring about results.

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