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A DRONE MOTHERSHIP: AN EMERGING NAVAL PLATFORM

Andrija Ljulj[1], Luka Mihanović[2], Zvonko Trzun[3]

[1,2,3]Dr. Franjo Tuđman Defense and Security University
E-mail: andrija.ljulj@sois-ft.hr

Abstract

The proliferation of unmanned systems, spanning aerial, surface, ground, and underwater domains, has revolutionised naval operations, creating a demand for specialised platforms to support their deployment and integration. This paper explores the emerging concept of the drone mothership, a versatile naval platform designed to carry, launch, recover, and maintain unmanned vehicles (UVs). The study synthesises insights from recent developments, existing platforms, and conceptual designs, highlighting these systems' operational advantages and challenges. By enabling the extended range and autonomy of UVs, drone motherships enhance naval capabilities in intelligence, surveillance, reconnaissance (ISR), anti-submarine warfare, mine countermeasures, and other critical missions.

Key features such as modular designs, advanced communication systems, and multi-domain support are analysed to predict their influence on future naval strategy and warfare. The findings underscore the transformative potential of drone motherships, offering strategic recommendations for their integration into modern naval fleets. Future research directions are proposed to address technical, operational, and cybersecurity challenges inherent to this paradigm shift in naval architecture.

Keywords: drone mothership, naval platform, unmanned vehicles.

1. INTRODUCTION

Over the past two to three decades, drone technology has been swift and significant advancement across air, ground, surface, and underwater domains. These developments have revolutionised various forms of warfare, including naval operations, by introducing innovative capabilities and transforming traditional strategies.

The main advantages of using drones in naval operations are:

- Drones can operate remotely and autonomously, significantly reducing the risk to personnel in dangerous operations and environments.
- They are cheaper to produce, operate, and maintain than traditional military assets.
- Drones enable efficient intelligence gathering by providing real-time imagery and video feeds, continuously monitoring the entire area of operation, and allowing for the disruption of opposing forces' activities and movements.
- Data collection can be carried out over an extended period without the risk of fatigue or decreasing readiness among the crew.
- Drone warfare is expected to evolve with advancements such as sensor miniaturisation, increased swarming capabilities, and the integration of artificial intelligence, machine learning, computer vision, and enhanced autonomy. This evolution will significantly impact naval warfare.

To further enhance the efficiency of drones in naval warfare, there is a need for a specialised platform that can host all types of drones, integrate them into a network, provide operational support, and maintain them. The drone mothership, which has emerged in the last decade, represents a new kind of naval platform unlike before. A drone mothership is a specialised vessel designed to launch, control, and support multiple unmanned aerial, surface, and underwater vehicles. These platforms serve as hosts and command-and-control centres, extending the operational capabilities of unmanned systems. They should have the necessary sensors, communication systems, modern networks, and drone deployment equipment. Drone motherships enhance operational flexibility, enabling naval forces to conduct a wide range of missions over long distances while reducing the logistical footprint of traditional naval operations.

The drone mothership concept could fill critical operational gaps in modern naval warfare and influence its strategic level. Traditional naval platforms are primarily associated with a potential risk to personnel and equipment exposed to adversary action or operating in hazardous waters that may be mined. Drone motherships can expand surveillance and reconnaissance by deploying and coordinating fleets of unmanned aerial, surface, and underwater vehicles, covering huge sea areas with minimal human intervention. This could significantly enhance intelligence, surveillance, and reconnaissance (ISR) capabilities in contested or denied waters, where traditional naval platforms may be at risk or less effective. In high-risk naval operations, such as anti-submarine warfare, minesweeping, and intelligence gathering, unmanned systems can operate autonomously and mitigate the risk to human life in hazardous zones (Savitz et al., 2013).

Another significant advantage of drone motherships is their ability to extend the operational range of unmanned systems, which typically face limitations due to constraints in battery life, fuel capacity, and the need for periodic maintenance. This is especially difficult in naval operations, where the vastness of the ocean and the distance between key strategic points can

be a significant obstacle. A drone mothership can act as a mobile base, supporting unmanned systems with recharging or refuelling capabilities, allowing them to operate far beyond their standard range. For example, a drone mothership could deploy drones for reconnaissance missions in a contested area. When those drones near their operational limits, they could return to the mothership for recharging or maintenance, effectively extending their operational duration.

Additionally, the mothership could serve as a central communication hub, amplifying the range of control signals and enhancing coordination between drones deployed over a wide area where direct line-of-sight communication is limited. In operations such as countering piracy, monitoring vast maritime borders, or conducting prolonged anti-submarine warfare missions, the drone mothership enables unmanned systems to remain in the area of operation for an extended period without returning to port. Ultimately, drone motherships can transform the limitations of unmanned systems into a strategic advantage, creating more versatile, scalable, and sustainable naval operations that can address a wide range of military challenges over extended timeframes and larger geographical areas.

1. METHODOLOGY

The rapid proliferation of unmanned vehicles has outpaced the current capabilities of traditional naval platforms to deploy, support, and maintain these systems. This gap necessitates the development of a dedicated naval platform, the drone mothership, to enhance operational efficiency and address limitations in autonomy, range, and coordination in complex environments.

This study examines the recent advancements, potential future directions, and challenges related to the technological development of drone motherships as emerging naval platforms, emphasising their implications for the future of naval drone warfare.

The methodology involves several methods:

- This comprehensive review encompasses a wide range of literature, including academic journals, military publications, industry reports, government documents, and media articles. This literature encompasses topics such as drone technology, naval operations, the capabilities of drone motherships, and their associated benefits and drawbacks.
- This comparative analysis evaluates various drone mothership platforms, their operational capabilities, and their integration with existing naval forces. Additionally, the analysis considers the broader implications for future warfare and a risk assessment related to the deployment of drone motherships, addressing technological constraints and cybersecurity concerns.
- Risk and Challenge Assessment identifies technical and operational challenges, including communication, swarm autonomy, and cybersecurity.

The paper is organised as follows: After the Introduction, the authors outline the methodology, followed by a literature review that provides a brief overview of both the historical and current perspectives on mothership platforms. Chapter 4 details the existing drone mothership platforms, including those already integrated into naval fleets, those in the design or prototype phases, and those conceptual or technical proposals. Chapter 5 offers comparative analyses, addresses future challenges, and synthesises the findings. The final chapter presents the conclusions, highlights key findings, discusses potential future developments, and explores the implications for naval warfare.

The conclusion synthesises the key findings from the literature review and analysis, underscoring the importance of drone motherships in contemporary naval operations. It offers recommendations for military planners and policymakers on the integration and deployment of drone motherships within future naval strategies. Ultimately, the study examines potential advancements in drone mothership technology and naval warfare, identifying areas that require further research and investigation.

3. LITERATURE REVIEW

Bradley et al. (2009) introduced a conceptual design for a mothership tailored to support unmanned aerial vehicles (UAVs), particularly in swarm operations. This concept aligns with the US Navy's potential use of UAV swarms for intelligence gathering, reconnaissance, anti-submarine warfare, search and rescue, and combat surveillance. The study outlines a feasible ship design, including its size and layout, that meets a UAV mothership's specific operational and logistical requirements. Key features of this concept include a flight deck for launching fixed-wing UAVs, a helicopter flight deck, and catch nets for UAV recovery. Further details of this concept are provided in Chapter 4.

Navalnews.com (2024) reports on the start of production for a multi-purpose ship intended for the Portuguese Navy. Constructed at Damen Shipyard Galati in Romania, the project is financed through the European Union Recovery and Resilience Facility (RRF). This multi-purpose vessel can host and operate UAVs, USVs, and UUVs. It is designed to support a range of missions, including scientific and technological research, search and rescue operations, emergency relief, maritime safety, and environmental and meteorological monitoring. It is scheduled for delivery in the year 2026.

Luck (2023) outlines the Austal "MANTA" project, a catamaran-type multi-mission ship designed for drone operations. Based on the US Navy's "Expeditionary Fast Transport" and "High-Speed Vessel" built for Oman, the MANTA platform is capable of supporting unmanned underwater vehicles (UUVs), unmanned aerial vehicles (UAVs), unmanned surface vehicles (USVs), and combat equipment. Similarly, (Sutton, 2024) provides insights into a new Chinese fixed-wing drone carrier constructed at the Jiangsu Dayang Marine shipyard on the Yangtze River. The design is based on the catamaran form, but it remains a mysterious ship since not

enough information is published from Chinese or other sources. Following the Mitchell Institute, it appears that the ship is intended as an experimental platform for developing and testing drone operations at sea.

Thomas (2024) discusses the initiation of joint Belgian-Dutch sea trials for a drone mothership, the first in a class of mine countermeasure vessels (MCMVs) named BNS Oostende. Designed for mine countermeasure missions, the ship will host unmanned aerial, surface, and underwater vehicles. Delivery is anticipated in the summer of 2025, with twelve ships planned, seven of which are currently under construction. Similarly, Suorsa and Cannon (2022) report on Turkey's plans to develop a drone carrier capable of deploying the widely recognised Bayraktar TB2 or its updated version of a fixed-wing unmanned aerial vehicle. They were converting the landing helicopter dock ship, TCG Anadolu, into a drone carrier launched in May 2019 and delivered to the Turkish Navy in 2023. The drone carrier is capable of hosting up to 80 drones and controlling 10 to 15 drones simultaneously.

Harper (2023) reports a statement by Carlos Del Toro, the US Secretary of the Navy, who revealed the US Navy's plan to develop a hybrid fleet that integrates traditional platforms with unmanned systems. Del Toro emphasised the critical need for a mothership capable of carrying and operating aerial, surface, and underwater unmanned systems to enhance the Navy's operational capabilities. He mentioned that a study is underway that will assess the necessary infrastructure for operating such a hybrid fleet, including the possibility of converting existing ships into mother ships. In the context mentioned above, the conversion of the littoral ship LCS USS Jackson into a mothership that would carry and operate air, ground, surface, and underwater unmanned systems is mentioned.

China's Navy has put a catamaran drone mothership into service as part of an experimental naval training force (Trevithick, 2022). The ship was launched in May 2021 and used to simulate enemy drone swarms and other types of naval ship threats. The ship is a replica of the model that was shown at the 2021 Zhuhai Airshow, and it is characterised by five landing pads at the bow for drone helicopters, a large open deck that is used for operating other kinds of drones, and a large tower on the top central part of the superstructure with several antennas. It is intended for the simulation of drone swarms and anti-ship and electronic warfare strikes. China has delivered a new research vessel, Zhu Hai Yun, that represents a mothership platform and will be used to experiment with and operate unmanned air, surface, and underwater vehicles for research and monitoring (Bairdmaritime.com, 2023). The mothership is versatile and capable of performing various tasks, including environmental monitoring, offshore wind farm surveillance, maintenance, and naval operations, such as countering hostile submarines and other undersea threats.

Sakhuja (2023) outlines recent advancements in the creation of a new naval platform designed to enable the command and control of multiple unmanned maritime systems, which has ultimately led to the development of drone motherships. It briefly presents the achievements of

various countries, including the US, which issued a request for information on an AttritableUxV Mother Ship at the end of 2022. Iran intends to convert two container ships into airborne drone motherships, and China's developments could be seen in drone mini-carriers and many other initiatives. Iran converted a merchant container ship into a drone carrier called Shahid Bagheri (Defence Express, 2024). The ship will be equipped with hangars for UAVs, storage facilities for weapons, and other necessary spaces for a naval vessel. It is assessed that the ship is being built for UAVs with strike and reconnaissance capabilities, such as the Mohajer-6 and Shahed 129.

The UK Royal Navy's MCM mothership can host and operate unmanned surface and underwater vehicles, whose primary mission is to counter sea mine threats (Manuel, 2024). The ship was converted from a civilian to an MCM vessel, and in addition to counter-mines, it will be used for hydrographic survey missions. The ship, named RFA Stirling Castle, will serve as the command and control centre for the autonomous operations of forward drones. Building on the experience gained from experimenting with these converted ships, the UK plans to develop a new generation of MCM platforms and acquire four such ships in the form of motherships (Navylookout.com, 2024).

The US Navy is investigating the possibility of using underwater drones integrated with submarines to enhance anti-submarine warfare capabilities (Farley, 2024). In this new concept, UUVs would be used in combination with torpedoes, and submarines would deploy UUVs for detection and targeting, effectively turning submarines into drone motherships. Utilising artificial intelligence and underwater communication technologies would significantly extend the operational reach of submarines and enhance anti-submarine warfare capabilities. The reference (Caleb, 2022) reports the statements of US Navy officials, who announced that US submarines will gain new capabilities, allowing them to launch and recover medium-sized UUVs, such as Razorback vehicles. That way, every US Navy submarine could potentially serve as a drone mothership. It will enhance anti-submarine warfare capabilities by utilizing UUVs, allowing a network of sensors to be deployed against opposing submarines. US MoD responsible for the Navy conducting market research regarding the development of unmanned small combatants in the form of Attritable UxV Mother Ship (AUMS) as a solution for deploying large numbers of UxVs to an area of operation in a contested environment (Maritime-executive.com, 2022). The project is currently in the research phase, and there is a possibility that the contract for the AUMS system will be awarded in mid-2026.

A concept warship, the UXV Combatant, designed for the UK Navy by BVT Surface Fleet, would possess characteristics of a drone mothership capable of operating unmanned aerial, surface, and underwater vehicles (Slideshare.net, 2015). Following this reference development, the UXV Combatant was a design study, and the UK MoD had no plans to acquire such vessels before 2030 due to other purchase priorities, such as the Type 26 frigate.

Singapore shipbuilder ST Engineering Marine began building the first Multi-Role Combat Vessel (MRCV) for the Singapore Navy in October 2022 (Asianmilitaryreview.com, 2024). The ship will operate as a drone mothership capable of carrying and launching unmanned aerial, surface, and underwater vehicles.
The concept of a drone mothership is not unique to the Navy, but also applies to other services. The paper (Asian Military Review, 2024) provides information from India about the larger hexacopter, a mother vehicle that can carry multiple small child drones. The child drones or swarms of drones carry explosives and conduct kamikaze attacks on the predefined target using artificial intelligence. A similar development is ongoing in the Russo-Ukraine war, where both sides use drone mothership platforms to carry smaller drones to the area of operation and release them to conduct their missions.

The report by Calvano et al. (1995) presents a system engineering concept for the development of a mothership carrying multiple surfaces and aircraft as part of the Total Ship Systems Engineering program's educational process. It covers the development of required operational capabilities for motherships and daughter crafts, as well as threat assessment through the development of operational scenarios. The second stage involved the preliminary design of the mothership alternative chosen for further development. This project can be considered a precursor to the concept of a drone mothership, which was later developed.

The study by Kouriampalis et al. (2021) provides an analytical perspective on the design process of a drone mothership that accommodates unmanned aerial, surface, and underwater vehicles while supporting their operations. The study examines various options to support the proposed approach without aiming to develop concrete technical solutions. It aligns with the recent goals and intentions of Western navies to develop the capability to deploy unmanned vehicles from surface ships.

Sakhuja (2020) provides an in-depth analysis of recent developments and trends in the reconfiguration of naval fleets, emphasising the concept of a drone mothership as a central component in the future structure of naval forces. The work summarises drone mothership trends in Western and Asian Navies that are planning to build new ones or reconfigure existing ships for that purpose. In his work, the author concludes that, due to limited resources and current trends in unmanned systems development, the Indian Navy should consider converting its existing platforms to drone mothership platforms.

Vavasseur (2019a) details the US Navy ship *Spearhead*, which conducted experiments in 2019 involving multiple unmanned aerial and underwater vehicles. These experiments were aligned with global trends, demonstrating the use of surface naval ships as drone motherships for the operation of unmanned vehicles. The Russian Navy conducted experiments using UAVs, USVs, and UUVs from its Project 22350 Admiral Gorshkov-class frigate as a drone mothership (Vavasseur, 2019b). The same source states that a series of ships of this class will host and operate the Orlan-10 UAV, which has a range of 120 km, an endurance of 14 hours, an

operational ceiling of up to 5,000 meters, and the capability to transmit video signals to a hosting station on the ship.

Scipanov and Totir (2023) analyse the development of naval tactics throughout history and conclude that, at present, technology has surpassed tactics, particularly with the introduction and proliferation of drone warfare across all domains. The authors argue that to implement these new tactics, there is a need for new platforms that can effectively project these emerging capabilities. For the naval domain, they propose the development of a new type of naval ship in the form of a drone-carrying platform. Their conclusions and proposals align with the focus of this paper, which examines the current development of an emerging naval platform: the drone mothership.

4. CURRENT DRONE MOTHERSHIP CONCEPTS AND TECHNICAL SOLUTIONS

This chapter introduces several notable drone mothership platforms selected from the projects discussed in the previous chapter. The primary objective is to showcase a variety of approaches, including new concept projects, newly constructed platforms, and platforms converted from existing ships. The information presented here is intended to provide a solid foundation for the comparisons and analyses conducted in Chapter 5.

The primary requirements for the UAV-M (UAV Mothership) in the paper by (Bradley et al., 2009) were to accommodate 100 small UAVs and 12 larger rotorcraft UAVs. Figure 1 illustrates the 3D design concept of the UAV-M mothership, while Figure 2 depicts a longitudinal cross-section of the hull used to store the UAVs. The design represents the concept of a drone mothership that will serve as a naval base for unmanned aerial vehicles. Additionally, it should carry five SH-60 Seahawks helicopters. Other essential requirements include operability in Sea State 5, a fully electric propulsion system, a range of 4,500 nm at 11.32 m/s (22 knots), meeting naval classification standards, and survivability characteristics equal to those of a naval combatant. The requirements regarding the launch and recovery of aerial vehicles were based on the operating scenarios. The UAV-M concept features a monohull form with a spacious helicopter landing deck and a starboard superstructure. Helicopters are stored aft below deck, while UAVs are stored forward below air launchers under the flight deck. Fixed-wing UAVs are launched by compressed air catapults and recovered by 10m x10m nets.

The principal characteristics of the UAV-M concept are:

- Length overall (LOA): 161 m,
- Waterline length (LWL): 150 m,
- Beam: 22.8 m,
- Draft: 5.3 m,
- Depth: 15.6 m,
- Total volume: 46.8 m^3,

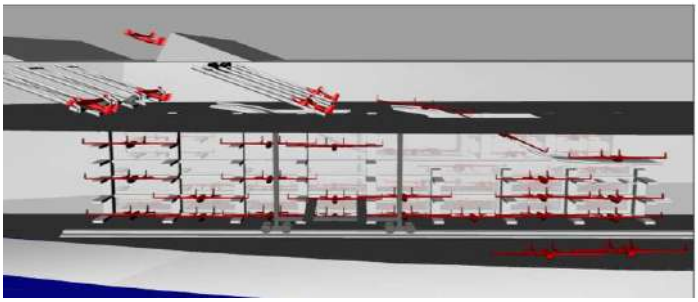
- Displacement: 11.7 mt,
- Complement: 350,
- Range: 4500 nm,
- Propulsion: 4 x Wartsilla DG,
- Power: 30 MW,
- Speed: 11.3 m/s (22 kn).

Figure 1: UAV-M concept

Source: Naval Surface Warfare Center, 2009

Several options for launching FW UAVs were considered, and the top-mounted option with six launchers was chosen (Figure 2). This solution was possible due to the spacious flight deck and reduced risk of bow slamming on big waves.

Figure 2: Storage and top-mounted UAV launchers



Source: Naval Surface Warfare Center, 2009

The UAV-M concept considered different types of hull forms, including monohull, catamaran, and trimaran. The monohull form was satisfactory, but the authors do not exclude the possibility that the catamaran or trimaran form may be used in the detailed project phase. In this concept, following the authors, all major requirements are satisfied, although the project is expected to get certain refinements in some specific areas.

The second concept of a drone mothership is related to reference (Slideshare.net, 2015) and the UK UXV Combatant project. In addition to the information mentioned in the literature review,

limited information is available about this project. Figure 3 shows the futuristic view of UXV Combatant, and the main characteristics of the project are:

- Displacement: 8000 t,
- Length: 152.4 m
- Beam: 21 m,
- Speed: 13.9 m/s (27 knots),
- Complement: 60,
- Two decks for launching drones and helicopters,
- Each deck would have a length of 50 meters,
- Electromagnetic catapult would be used for UAV launching,
- UXV would have the capability to launch UUVs,
- UXV will be able to deploy amphibious forces,
- In support of amphibious forces each UXV will be equipped with a cannon 155 mm.
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Figure 3: Futuristic view of UXV Combatant

Source: Wikipedia, 2024c.

The Multi-Purpose Ship, a drone mothership currently in production for the Portuguese Navy (Navalnews.com, 2024), is expected to be delivered in 2026. It is a multi-purpose ship capable of hosting and operating unmanned aerial, surface, and underwater vehicles. The missions range from collecting environmental data, search and rescue, disaster relief, and support to civil security authorities and defence. Figure 4 shows a computer 3D view of Multi-Purpose Ship, and the main characteristics of the vessels are taken from (Wikipedia, 2024a):

- The ship will be used for scientific and technological research, search and rescue, emergency relief, maritime safety and environment and meteorological monitoring,
- It will be equipped with laboratories for scientists,
- It will be capable of hosting and operating UAVs, USVs, and UUVs,
- Length: 107 m,
- Beam: 20 m,
- Speed: 7.7 m/s (15 kn),
- Displacement: 7000 t,
- Deck space: 650 m^2,

- Flight deck: 94 m x 11 m,
- Complement: 48 (plus 100 military personnel and 42 scientists),
- Transportation of up to 12 TEU containers for mission-specific modular systems (hospitals, hyperbaric chambers, ROV equipment),
- Two hangars for helicopters and unmanned vehicles,
- Catapult for launching drones,
- Four speed boats,
- Role 2 NATO hospital.

Figure 4: Multi-Purpose Ship (drone mothership) for the Portuguese Navy

Source: Navalnews.com, 2024.

The next drone mothership or drone carrier is a Chinese catamaran built in Jiangsu Dayang Marine shipyard (Sutton, 2024). Information about this platform is limited, and some media have speculated about its primary purpose. Figure 5 represents a model of a Chinese drone carrier, and Figure 6 provides a view of the ship's helipad rear deck. It is an experimental ship for testing drone operations at sea with the following characteristics:

- Hull has catamaran form,
- The flight deck is suitable for operating aircraft or drones with a wingspan of 20 m

Figure 5: A model of a Chinese drone carrier from Zhuhai Airshow 2021

Source: The Warzone, 2022

Figure 6: The view of the Chinese drone carrier helipad

Source: The Warzone, 2022

The reference (Shelbourne, 2022) confirmed that the US Navy unmanned surface vehicle Mariner from the Ghost Fleet Overlord program has the capability, data links, and other necessary systems to operate as a drone mothership. Currently, four platforms of this type have been built. It represents the conversion of existing offshore patrol vessel supplier projects used to support oil rigs. Although the vessels are technically uncrewed, they have a crew of six persons; all functions are fully automated, and if necessary, the crew can take control of the ship. The Ranger platform is shown in Figure 7 (Slayton, 2022). These platforms are research and development ships that will operate in conjunction with classical combat ships.

Figure 7: US Navy Ranger USV from Ghost Fleet Overlord program

Source: Slayton, 2022

The US Navy considers the littoral combat ship as a potential drone mothership for operating unmanned, surface, and underwater systems (Harper, 2023). The Independence-class is a trimaran variant of a littoral combat ship shown in Figure 8, and its main characteristics are (Wikipedia, 2024b):

- Length:128.4 m,
- Beam: 31.6 m,
- Draft: 4.3 m,
- Speed: 22.6 m/s (44 kn),
- Range: 4300 nm at 9.3 m/s (18 kn),
- Complement: 43,
- Flight deck and hangar for hosting two SH-60 or MH 60 Seahawk helicopters,
- A stern ramp for operating small boats,
- Cargo volume for small assault forces with fighting vehicles,
- Armament of Mk 110 57 mm gun and RIM-116 missiles,
- Equipped with autonomous air, surface, and underwater vehicles.

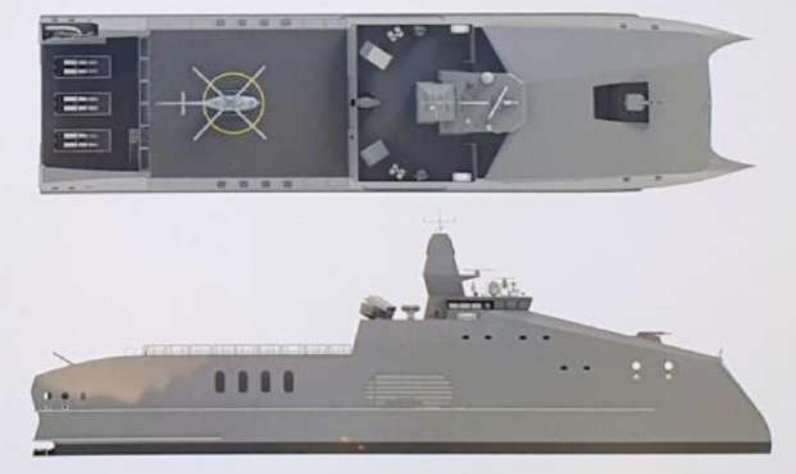
Figure 8: USS Independence platform

Source: Wikipedia, 2024b

As mentioned by an Australian company in Luck (2023), the concept of a drone mothership is called MANTA (Multimission Autonomous Network Transporter - Armed). The top and side view of a computer model of MANTA concept is shown in Figure 9. It is an advanced catamaran-type concept designed to counter current and future threats, serving as a multi-purpose platform that focuses on drone operations and multiple missions. The main characteristics of the concept are:

- Length: 78 m,
- Beam: 19.3 m,
- Complement: 20 + accommodation for 30 additional personnel,
- Max. speed: 15.4 m/s (30 kn),
- Range 2700 km at 6.4 m/s (12.5 kn),
- Propulsion: 4 x 4300 kW diesel engines + four water jets,
- Containerised and modular weapons,
- Helicopter and helicopter-drone landing deck,
- Self-defence capability,
- Launchers of Harpy-type loitering munitions,
- Spike NLOS-type strike missiles,
- 35 mm autocannon on the foredeck,
- Multi-mission bay for operations of UUVs.

Figure 9: Austal MANTA concept of a drone mothership



Source: Luck, 2023

The main characteristics of the Iranian drone carrier (Defence Express, 2024) are based on a civilian container ship. Significant modifications were made to the ship, particularly the reconstruction of the flight deck, which was installed at an angle, while the original superstructure remained unchanged. The ship has a length of 240 meters, a beam of 32.2 meters, and a flying deck length of 170 meters. The ship under reconstruction is shown in Figure 10.

Figure 10: Iranian drone carrier "Shahid Bageri"

Source: Defence Express, 2024

In April 2023, Turkey unveiled its amphibious assault ship, a drone carrier designed to carry and operate light aircraft and military drones. The drone carrier, TCG Anadolu, is 230 meters long and 32 meters wide and can accommodate combat helicopters, aerial unmanned surface vehicles, and 94 army vehicles, including 13 tanks. The ship entered service in May 2023 (Thedefencepost.com, 2023). Turkey drone carrier TCG Andaolu is shown in Figure 11.

Figure 11: Turkey drone carrier TCG Andaolu

Source: Thedefencepost.com, 2023

As mentioned in (Thomas R., 2024) and (Groizeleau, 2019), a joint Belgian-Duch project of MCMV drone mothership was developed and is in the sea trial phase. This project represents a completely new approach to conducting MCM missions in the future. The platform will host USVs and UUVs designed to perform the hazardous task of detecting, identifying, and clearing sea mines. The mothership platform will stay away at a safe distance from the sea minefields. This new concept of MCM operations provides higher efficiency and safety for the crew embarking on a drone mothership. The computer model of MCMV drone mothership is shown in Figure 12. The main particulars of the platform are:

- Length: 82.6 m,
- Beam: 17.0 m,
- Displacement: 2800 t,
- Range: > 3500 nm,
- Complement: 63,
- Embarkation capacity: 2 SOLAS 7m RHIBs,
- Handling equipment: Two side launch and recovery systems, 15 t and 3 t cranes.

Figure 12: Belgian-Duch Oostende MCM drone mothership

Source: Thomas, 2024

UK MCM Sterling Castle joined the UK Navy and will replace classical counter-mine ships. It represents a mothership that can operate unmanned surface and underwater vehicles for mine clearance. UK MCM Stirling Castle mothership platform is shown in Figure 13. The main characteristics of the UK MCM Stirling Castle (Manuel, 2024) mothership platform are:
- Length: 96 m,
- Beam: 20 m,
- Displacement: 5840 t,
- Complement: 42.

Figure 13: UK MCM Stirling Castle mothership platform

Source: Manuel, 2024

5. ANALYSES OF CURRENT DRONE MOTHERSHIP AND CHALLENGES

The analysis of current project concepts and technical solutions is based on data and criteria collected in Table A1. The criteria are listed in the first row of Table A1 from column 3 up to column 10. It represents the available technical and operational data regarding project concepts, newly developed designs, built ships, and drone mothership platforms based on the conversion of existing merchant or naval ships. There are eleven different projects: three conceptual

designs that did not undergo the detailed design process, four represent newly developed and built platforms, and four involve converting existing ships into drone motherships (column 3 in Table A1).

The first concept design, dated 2009 and developed by the US Naval Surface Warfare Centre, provides a valuable assessment from that perspective on how drone warfare might evolve in the future and offers a technical solution through a new drone mothership platform. The second concept design (UXV Combatant), dated 2015, lacks sufficient details; however, it appears that the project was relevant to the UK Navy, although it was not further developed due to current priorities surrounding the development of the Type 26 frigate. The third concept project is Austal's MANTA project. This project differs from the previous two because it is a concrete project that was actively promoted on Austal's website, indicating a high likelihood that it could evolve into detailed design and production. It is based on an existing Austal auxiliary naval ship project. The authors believe this concept closely aligns with the current requirements for effective naval drone warfare.

The second project group is related to newly developed and built platforms. The Portuguese Navy's multi-purpose ship seems to be the most versatile drone mothership, as it includes capabilities for all drone domains: air, surface, and underwater. It represents an excellent platform for drone operations and experimentation. It is assessed that lessons learned and experiences gained from operating this platform can be easily transferred to pure naval operations. The Chinese drone carrier lacks sufficient open-source information. It appears to have the same purpose as previous similar projects, and the Chinese Navy is expected to benefit from research and gaining experience in naval drone operations.

The US Navy's Mariner vessel, part of the Ghost Fleet Overlord project, has the capability, along with the other three vessels of this class, to serve as a drone mothership. However, it serves multiple roles and is also an unmanned surface vehicle. The primary purpose of a drone mothership is to conduct research and experimentation in naval drone operations. It is assessed that, in the near future, this project will further evolve into an enhanced drone warfare platform.

The Belgian Duch MCM platform is a real drone mothership. However, it is focused solely on one naval mission, mine countermeasures (MCM). This project represents one of the most effective implementations of naval drone warfare, and it is anticipated that it will further enhance and likely gain additional capabilities, such as the use of unmanned surface vehicles (USVs) for ISR, ASW, surface warfare, and other missions.

Converting a US Navy Littoral Combat Ship into a drone mothership seems like a great idea, but it has not yet been confirmed whether it will actually take place. Another issue with this idea is that several ships of this class have already been retired due to technical problems, making the proposed conversion a potentially very challenging task. The idea to convert this

ship into a drone mothership reveals a strong need within the US Navy for such a versatile platform that could elevate naval drone warfare to a higher level.

The conversion of the UK Navy's supplier ship to the MCM Sterling Castle highlights the urgent need to develop a naval drone warfare platform for mine countermeasures (MCM) use. It has already been confirmed that the experience of using this platform has been beneficial for the UK Navy. At the same time, plans are underway to develop a new platform that will address some of the technical disadvantages of the converted ship. This demonstrates the firm intention to develop a drone mothership platform further.

The Iranian conversion of a container ship into a drone carrier is the most unexpected and unusual approach. However, it demonstrates Iran's intention to enhance and extend its capabilities in the domain of naval drone air warfare. The primary benefit of this conversion is its low cost; however, the project is still far from achieving full operational capabilities and must demonstrate its feasibility in real-world operations.

The Turkish conversion of the Spanish landing helicopter dock, TCG Andaolu, has been completed and delivered to the Turkish Navy. This conversion differs from the previously mentioned ones in that it involves a newly built ship whose design is based on another vessel. This project is being developed at the right time and will likely reveal its potential in future naval drone operations of the Turkish Navy.

The drone mothership type of platform (column 4 in table A1) is based on domains (air, surface, underwater) that the platform supports. It can be concluded that six platforms support two domains, three support all three domains, and three support only one domain. This suggests that there is no uniform approach and that platforms differ significantly in this area.

Regarding hull types (column 5 in Table A1), most platforms are monohulls; two are catamarans, and one has a trimaran hull. Catamarans and trimarans have certain advantages over monohulls. They have spacious decks suitable for placing and operating aerial drones. Additionally, they can achieve higher speeds, improved fuel economy, enhanced stability, and better seakeeping characteristics in higher sea states. Such platforms are expected to prevail as a drone mothership in the future.

Regarding hull materials (column 5 in table A1), steel and Aluminium alloys prevail. Aluminium alloys are primarily associated with US Navy platforms constructed by Austal, a specialist in building ship hulls from aluminium alloys. Drone mothership platforms are expected to use aluminium alloys and composite hulls to get lower total weights. Those hulls are expensive and demanding for production. However, they offer several advantages, including lower weight and maintenance, good corrosion resistance, and a balance of strength-to-weight, which leads to higher efficiency.

The propulsion systems (column 6 in Table A1) vary; diesel engines are used alone or in combination with gas turbines (TCG Andaolu) and electric motors (Belgium Duch MCMV). The propulsors are water jets for high-speed platforms, electric pods, and fixed-pitch propellers (Belgium Duch MCMV). It is assessed that drone mothership platforms will utilise electric pod propulsion in combination with diesel engines, as this trend has already emerged from the analysis.

The ship's main particulars, such as ship length, width, draft, and height, are shown in column 7 in Table A1. Platforms' length varies from 59 m (US Navy Ranger) to 240 m (Iranian drone carrier). It is also characteristic of ship width, draft, and height, as some platforms are designed from scratch, while others already exist, and some are converted from existing ships. Therefore, presented platforms vary significantly in size, displacement, and main particulars.

Analysing the speed (column 8 in table A1) of platforms, it can be concluded that it diverges in the range from 7.72 m/s (15 knots) (Belgian Duch MCMV) up to 22.64 m/s (44 knots) (US Navy combat littoral ship). The speed mainly depends on the type and mission of the drone mothership. Lower speeds are acceptable for MCM missions, but higher speeds are preferred for platforms that operate UAVs, USVs, and UUVs. It is also worth mentioning that Al alloy platforms generally have higher speeds due to lower weight. The main geometric characteristics vary significantly, which is expected given the different origins and intended uses of the selected platforms. Future drone motherships are anticipated to be similar in size to multi-purpose corvettes and even the frigate class of naval ships.

Due to the high level of automation in drone motherships, the complement is expected to be as small as possible. In the long term, the platform is likely to be unmanned or have a minimal crew that would take control of the ship if necessary. Although a drone mothership offers numerous advantages in naval drone warfare, several challenges must be overcome, as outlined in the following text. It is a challenge to maintain reliable communication simultaneously between the mothership and numerous drones. The drones communicate with the control station on board, and a large swarm of drones might potentially overload the communication network, leading to delays and data loss.

Swarm management onboard a drone mothership involves coordinating large numbers of unmanned systems to operate harmonised and efficiently in complex environments. This requires advanced algorithms for real-time communication, data sharing, and task distribution, enabling drones to work together in sync while responding to changing operating conditions. The challenge is to ensure seamless communication between all units, especially in environments where signal interference, electronic warfare, or communication blackouts might occur. Additionally, managing the autonomy of numerous drones simultaneously without causing conflicts or collisions requires highly sophisticated systems for path planning, dynamic decision-making, and adaptive mission reconfiguration.

Another issue is related to the levels of autonomy within the swarm and the extent to which humans should intervene. The autonomy of unmanned systems onboard a drone mothership is decisive in enhancing operational efficiency and minimising human intervention. The systems with the highest level of autonomy are often equipped with advanced AI and machine learning algorithms, enabling them to perform complex tasks such as navigation, target identification and tracking, and decision-making without direct human control. Such a level of autonomy allows unmanned systems to operate independently across vast areas, respond to dynamic environments, and conduct missions with minimal supervision, making them highly effective for prolonged operations in contested or denied regions where human involvement may be limited or risky. Implementing this requires sophisticated algorithms for drone coordination, path planning, and decision-making.

The next issue is how to provide power management, drone battery charging, and replacement to smooth operations and achieve efficient energy use. A drone swarm generates vast amounts of data; therefore, the mothership requires sufficient capacity to process and analyse this data in real-time.

Cybersecurity is one of the challenges because autonomous and remote unmanned vehicle operations open the possibility of cyber-attacks. Opponents or other malicious actors could potentially utilise the system's disadvantages to control or disable unmanned vehicles, posing operational and security risks.

Launching and recovering many drones from a mothership is a considerable challenge, especially in high-sea states. The last one concerns the maintenance of drones to ensure smooth operations during extended missions. The mentioned challenges are related to operating a swarm of drones and can be considered general challenges in drone mothership operations. Many significant ongoing efforts within the scientific community are focused on overcoming these challenges, so it can be expected that they will be considerably mitigated in the years to come.

Human nature tends to resist the introduction of novelty, and this is also the case with unmanned vehicles and drone motherships. The primary reasons for resistance are related to the reduction in personnel and the new knowledge required to operate and maintain unmanned vehicles. It is expected that it will influence the delayed integration of unmanned vehicles and drone mothership platforms into naval forces. Currently, unmanned systems operate in combination with classical weapons. However, considering the recent experience of using unmanned vehicles in military operations, their impact on military thinking, and the necessity to adapt military strategies and plans accordingly, the ratio of unmanned vehicles and drone mothership platforms is expected to be higher in the near future.

6. CONCLUSION

In recent decades, the number of unmanned vehicles, particularly unmanned aerial vehicles (UAVs), has significantly increased for both civilian and military applications. These vehicles

are cost-effective, widely accessible, compact, and equipped with advanced sensors. When networked, they become high-value assets for nearly all armed forces. Their integration with artificial intelligence, including machine learning, computer vision, and other algorithms, enhances their capabilities, transforming them into powerful military tools.

Deploying and operating those drones in an area of operations requires a platform capable of carrying, supporting, and maintaining them. That is where a drone mothership comes into play. This paper analyzes current developments regarding the emergence of a new naval platform, a drone mothership that can extend naval drone warfare capabilities. A drone mothership hosts various types of Unmanned Vehicles (UVs) depending on the mission, launches and retrieves them, and provides a control station, which is essential for the command and control of UVs, networking them, and enhancing naval drone warfare in this way.

It is evident from the analysis in this paper that there is a strong drive to develop and operate drone mothership platforms. As discussed throughout the paper, this emerging platform is taking shape through conceptual designs, newly built ships, and the conversion of existing vessels. The majority of the analysed platforms are used for research and experimentation, leveraging motherships in conjunction with unmanned vehicles (UVs). Some platforms are versatile and capable of operating various types of UVs, while others specialise in specific tasks, such as mine countermeasures (MCM) or aerial UV operations. In addition to surface motherships, there is an intention to convert submarines into UUV motherships.

The concept of a drone mothership is not limited to naval forces but is also being explored by other branches of the military. In the Ukraine-Russia conflict, relatively large aerial drones have emerged that can carry smaller suicide attack drones. These larger drones serve as transporters, provide communication capabilities, and extend the operational range of smaller UAVs.

Recent reports from Ukraine indicate the deployment of high-speed unmanned vessels, which serve as mother platforms to carry multiple unmanned aerial systems (FPV drones) for offensive operations against high-value targets on the Crimean Peninsula. This setup allows attack FPV drones to operate at longer distances with the support of the mother platform. This example highlights the growing trend of innovative applications of mother ships in real-world operations.

It can be concluded that this phase of drone mothership development is experimental. With a high level of certainty, very soon, there will be a proliferation of drone motherships that will change the way and nature of conducting military operations. Searching for an optimal drone mothership will undoubtedly be a demanding task for ship designers, and it will involve numerous challenges, some of which were mentioned in the previous paragraph.

The findings of this study underscore the significance of recent developments in naval warfare, which is particularly relevant for naval strategists, military planners, and policymakers. These

changes represent a technical revolution driven by unmanned surface vehicles, which are compact, cost-effective, and as capable as their traditional counterparts. To further enhance their effectiveness across all domains, such as air, surface, and underwater, it is essential to consider the development of a new naval platform: the drone mothership. This platform, functioning as a base station, would significantly strengthen the capabilities of naval drone warfare. Given current trends, it is anticipated that many nations will seriously consider integrating naval drone warfare and the drone mothership concept into their future navy modernisation plans. Ultimately, the authors believe this trend will extend beyond the maritime sector and influence other military branches, including the Army and Air Force.

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LIST OF ABBREVIATIONS

AUMS - Attritable UxV Mother Ship
CHN – China
EU RRF – European Union Recovery and Resilience Facility
FPV – First Person View
FW UAVs – Forward UAVs
ISR – Intelligence, Surveillance, Reconnaissance
LCS USS – Littoral Combat Ship US Ship
LOA – Length Overall
LWL – Length of Waterline
MANTA – Multi-Mission Autonomous Network Transporter (Armed)
MCM – Mine Countermeasure
MCMV – MCM Vehicle
MRCV- Multi-Role Combat Vessels
NATO – North Atlantic Treaty Organization
POR – Portugal
RHIB – Rigid Hull Inflatable Boat
ROV – Remotely Operated Vehicle
SOLAS – International Convention for the Safety of Life at Sea
TEU- Twenty-foot Equivalent Unit
UAV – Unmanned Aerial Vehicle
UAV-M – UAV Mothership
UK – United Kingdom
US – United States
US MoD- US Ministry of Defence
USV – Unmanned Surface Vehicle
UUV – Unmanned Underwater Vehicle
UV – Unmanned Vehicle

Appendix A: Comparison of Drone Mothership Projects: Characteristics and Specification

Table A1: The main characteristics and comparison of selected drone mothership projects
Source: own

	Project	**Concept; New built ship; Conversion/ Main mission**	**Mothership type platform**	**Hull type/ Material**	**Propulsion plant**	**Main particulars**	**Speed [m/s]/ [kn]**	**Complement**	**Range [nm]/ Autonomy [days]**
1	Naval Surface Warfare Center project	Concept/ Military UAVs swarm operations	UAVs mothership	monohull / steel	4 diesel engines+ 2 pod electric propulsors 30 MW	LOA=161m LWL=150m B=22.8 T=5.3 m H=15.6 m Dis=11693 t	11.3/ 22	350	4500/ -
2	UXV Combatant	Concept/ UAVs and UUVs operations; amphibious operations	UAVs/ UUVs mothership	monohull / steel	-	L=152.4 m B=21 m Dis=8000t	13.9/ 27	60	-
3	MANTA	Concept/ Multiple drone's missions	UAVs/ USVS/ UUVs mothership	catamaran/ Al alloy	4x4300 kW diesel engines+ four water jets	L=78 m B=19.3 m	15.4/ 30	20+30	2700/ -

4	Multi Purpose Ship POR Navy	New built ship/ Research; SAR; Maritime safety; Monitoring	UAVs/ USVS/ UUVs mothership	monohull / steel	6 MW+ 2 pod propellers	L=107 m B=20 m T=5.5 m Dis: 7000 t	7.7-10.2/ 15-20	48+100+42	10000/ 45
5	CHN drone carrier	New built ship/ research and experimentation with unmanned systems	UAVs/ USVs mothership	catamaran/ steel	-	-	-	-	-
6	US Navy Mariner (Ghost Fleet Overlord)	New built ship (conversion from offshore patrol vessel)/ Research and development platforms	USVs/ UUVs mothership	monohull / Al alloy	5x1491 kW diesel engines+ waterjet propulsors	L=59 m B=10 m	14.4/ 28	-	-
7	US Navy littoral ship	Conversion of existing ship/ Naval drone's operations	UAVs/ USVS/ UUVs mothership	trimaran/ Al alloy	2xMTU 20V 8000 + 2xGE LM2500 GT 4x water jets	L=128.4 m B=31.6 m T=4.3 m Dis=3055 t	22.6/ 44	43	4300/ -

8	Iranian drone carrier	Conversion of merchant container ship/ UAVs operations	UAVs mothership	monohull / steel	MAN-B&W 29800 kW	L=240 m B=32.2 m	-	-	-
9	Turkey drone carrier TCG Andaolu	Conversion of existing Spanish landing helicopter dock	UAVs mothership	monohull / steel	GE ITP LM2500+ Navantia MAN 16V32/40 2x11 MW pod	L=232 m B=32 m T=6.9 m H=58 m Dis=27000 t	11.1/ 21.5	261	9000/ -
10	Belgian Duch MCMV ship	New built ship/ Mine countermeasures operations	USVs/ UUVs mothership	monohull / steel	CODLAD 1xABC 12VDZC DG 2xABC 6DZC DG 2xMEP electric motors (1800 kW each) 2x FPP	L=82.3 m B=17 m T=3.8 m Dis=2800 t	7.9/ 15.3	63	3500/ -

11	UK MCM Sterling Castle	Conversion of existing merchant supplier ship	USVs/ UUVs mothership	monohull / steel	4x 2000 kW diesel engines + 2x azimuth trusters (2x 3500 kW)	L=96 m B=20 m T=6 m Dis:5840 t	-	100	-

Table A2. Data from Table A1 prepared in tabular form for visual presentation.
Source: own

Platform	Domains Supported	Hull Type	Speed (knots)	Mission Type
Naval Surface Warfare Center	1	Monohull	22	Military UAV Swarm
UXV Combatant	2	Monohull	27	Amphibious Operations
MANTA	3	Catamaran	30	Multi-Drone Missions
Multi-Purpose Ship	3	Monohull	15	Research/Monitoring
CHN Drone Carrier	2	Catamaran	-	Unmanned Systems Testing
US Navy Mariner	2	Monohull	28	Research/Testing
US Navy Littoral Ship	3	Trimaran	44	Naval Drone Ops
Iranian Drone Carrier	1	Monohull	-	UAV Operations
Turkey TCG Anadolu	2	Monohull	21.5	Naval Drone Ops
Belgian-Dutch MCMV	1	Monohull	15.3	Mine Countermeasures
UK MCM Sterling Castle	1	Monohull	-	Mine Countermeasures

Figure A1: Number of domains supported by drone mothership platform
Source: own

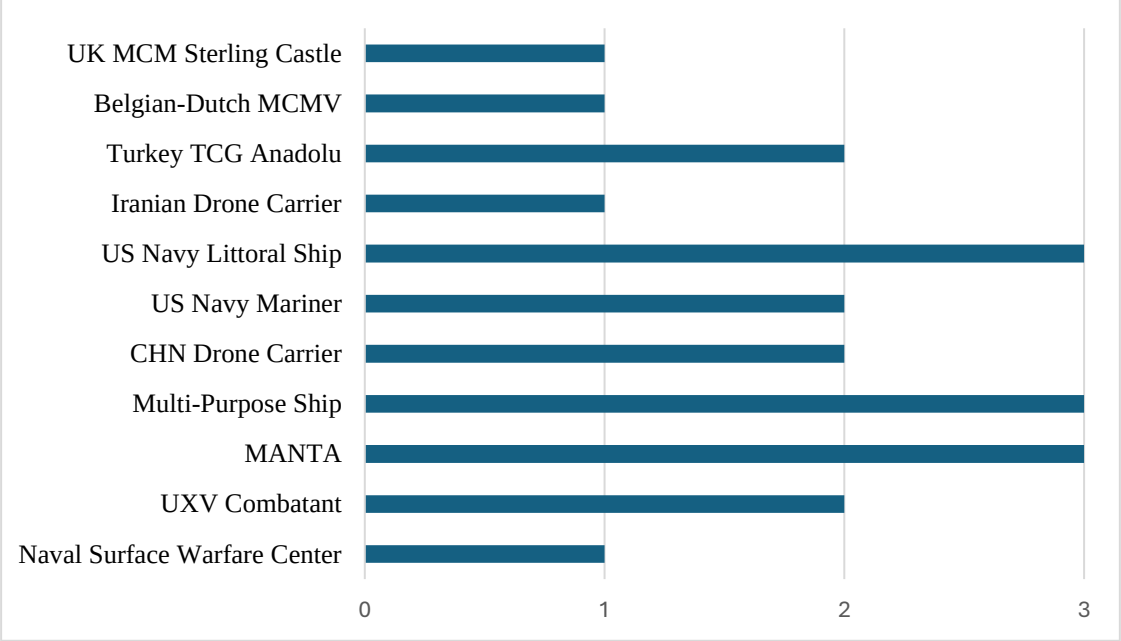

Figure A2: Hull type distribution in drone mothership platforms
Source: own