Modernizing Traditional Outrigger Boat to Tactical Boat for Maritime Security in Malaysia: A Preliminary Study

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ABSTRACT

This study aimed to assess the extent to which outrigger boats developed and cultivated by coastal communities in Sabah can be used to enhance safety by various maritime enforcement agencies in Malaysia. Maritime security issues, especially cross-border threats, smuggling and encroachment in shallow waters not only demand fast assets but also have suitability in terms of functionality and adaptability to marine and coastal geographical characteristics. A paddle boat is an iconic water phrase of the coastal community that is proven to have aerodynamics, balance and can adapt to any physical condition of the waters, especially in the printed water area. To this end, this article was written to assess the extent to which this traditional design can be upgraded and modified using modern technology for the use of security forces such as ESSCOM, Marine Police (Royal Malaysian Police), Malaysian Maritime Enforcement Agency (MMEA) and so on. This study will use a qualitative approach based on Technology Adaptation Theory and Principles of Marine Engineering to assess the feasibility of integrating modern composite materials into traditional frameworks. The results of this study found that the use of these winged boats is able to improve preparedness and contribute to the success of operations to combat various maritime crimes because they are able to operate in reef areas and shallow waters that are difficult to access by large patrol boats and thus offer lower maintenance costs. Ultimately, this tactical boat innovation based on local wisdom has great potential to be developed to strengthen the country's maritime sovereignty.

Keywords: Maritime Security, Traditional Boats, Tactical Boats, Maritime Innovation and Coastal Communities.

INTRODUCTION

Southeast Asia is an archipelago region that has historically relied heavily on sea routes as the lifeblood of communication. In this context, outrigger boats emerged as one of the greatest maritime technological innovations produced by the Austronesian clump. The uniqueness of the design of this boat lies in its outrigger structure which is also referred to as wings canoe, "katik" or "katir" which are mounted on the sides of the boat body to provide exceptional stability when riding large waves without the need for a wide and heavy hull. At the regional level, outrigger boats are not just a means of transportation, but are also a symbol of man's agility in conquering the ocean thousands of years ago. In Malaysia, the culture of paddle boats is neatly carved into the identity of the coastal communities in the State of Sabah. For ethnic groups such as the Bajau Laut, Suluk, and local fishing communities, paddle boats or better known as "Bogo" are the lifeblood of daily life. The importance of this design is closely linked to the unique geography of Sabah's waters. Sabah's coastline is characterized by challenging terrain; Starting from very shallow waters, sharp rocky areas, sheltered bays, to the interspersed mangrove swamps. The nature of the outrigger boats with a low water draft allows these coastal communities to move nimbly in areas that are impossible for conventional ships to pass.

However, this geographical advantage is often exploited by maritime criminal elements such as smugglers, foreign invaders, and pirates. Maritime enforcement agencies, including the Marine Police Force (PPM) and the Malaysian Maritime Enforcement Agency (MMEA), are often faced with a dead end when chasing criminals fleeing into shallow areas or narrow mangrove areas. Existing enforcement assets are often limited by large hull sizes and the use of propulsion systems that are not suitable for shallow waters. This creates an "operational gap"

that allows criminals to evade legal action by simply taking advantage of the advantages of the seascape. In this regard, it is time for the authorities to re-evaluate the effectiveness of the use of existing modern assets. The use of large patrol boats equipped with high-power outboard engines or turbine systems may be effective on the open sea, but often fail to function optimally in tactical operations in complex coastal areas. The complete dependence on Western technology without taking into account local wisdom in maritime design needs to be reviewed. Therefore, this paper will examine the extent to which the development of a prototype safety boat based on the concept of a traditional outrigger boat can be used as a more effective alternative in dealing with the threat of maritime crime in the shallow waters of Sabah.

Research Background

Maritime security is a broad and critical concept in ensuring the sovereignty and peace of an archipelagic country like Malaysia. From a sovereign perspective, maritime security is not just the protection of physical boundaries at sea, but it also includes the control of the water space to prevent any form of foreign aggression that could threaten national integrity. Maritime peace, on the other hand, refers to the absence of threats that could disrupt the economic activities and well-being of coastal communities. According to Bueger (2015) in his study entitled What is Maritime Security? maritime security is now viewed through the lens of the "Maritime Security Matrix" which combines elements of national security, economic development, as well as the protection of the marine environment. When sovereignty is challenged by external elements, the economic and social stability of the people who depend on marine resources will also be affected. The reality is that Malaysian waters, especially in eastern Sabah, are often a breeding ground for various forms of maritime crime. Examples of crimes that often occur include smuggling of subsidised goods, human smuggling, encroachment of foreign fishermen, as well as more serious cross-border crimes such as robbery at sea and kidnapping for ransom.

These crimes occur due to several main factors, among them the geographical position that is too close to the neighbouring country and the existence of "rat lanes" in the crevices of island clusters and mangrove forests. In addition, economic factors and political instability in neighbouring regions have also led to an increase in these illegal activities, where the shallow waters of the coast are used as a protection zone for criminals to escape detection by the authorities. In an effort to address this threat, the Malaysian Maritime Enforcement Agency (MMEA) and the Marine Police Force (PPM) have carried out various operations such as “Operation Benteng” and “Operation Gasak”. However, the effectiveness of these operations is often tested when faced with tactical constraints in shallow, bay, and rocky coastal areas. The main issue faced by enforcement agencies is the inadequacy of existing assets which are mostly large patrol boats with deep water drafts. These boats are difficult to get into shallow water areas or narrow mangrove swamp areas without the risk of damage to the fan system or boat body. On the other hand, maritime criminals often use small, nimble, lightweight boats that allow them to stray into areas inaccessible to modern enforcement assets that use conventional outboard engine or turbine systems. This situation raises a fundamental question: how far is existing modern technology really capable of tackling crime in coastal areas if it ignores local wisdom in maritime design? This is where the importance of re-evaluating the potential of outrigger boats that have long been used by coastal communities in Southeast Asia, particularly in Sabah, is important. This outrigger boat has its own class due to its incredible stability even in turbulent sea conditions, in addition to having a very low water draft that allows it to move in shallow areas with ease. The development of a tactical boat prototype that combines this traditional stability with modern materials and innovative propulsion systems is seen as an urgent need to fill the existing operability gap.

Figure 1: Illustration of the design of the outrigger boat Traditional

Source: Modified from Philippine Statistics Authority (PSA), Department of Tourism (DOT) Philippines and "Contribution of artisanal fisheries to Philippine economy", "Island hopping tourism impact Philippines" and Google. (2026). Bangka: The architectural and cultural pulse of the Philippines Image generated by AI. NotebookLM.

To study the effectiveness of this prototype development, the most suitable research methodology is a mixed-method approach involving hydrodynamic technical analysis and qualitative field studies. This research will involve observing the mobility of outrigger boats in the field, conducting interview sessions with the seafarer community and maritime operations officers to understand the real tactical requirements. From a theoretical point of view, this study will use Maritime Safety Theory by Christian Bueger which emphasizes the importance of Maritime Domain Awareness. Additionally, a study by Germond (2015) in The Geopolitics of Maritime Security proves that the effectiveness of enforcement is highly dependent on the asset's ability to dominate challenging geographic spaces. Germond found that without assets that are "compatible" with the sea's landform, a country's sovereignty in coastal waters will remain fragile. Ultimately, the integration of war boat design into modern maritime security assets is not just a cultural conservation effort, but a strategic shift in defence engineering. Understanding that Sabah's complex geography requires a more "organic" approach, the development of this prototype is expected to empower enforcement agencies in carrying out the task of chasing and eradicating crime in critical zones that have been considered safe areas for criminals.

This study is expected to open up space for more sustainable and effective local maritime innovations in safeguarding the sovereignty of the country's waters. In examining the foundation of this prototype development, a study by Bueger (2015) entitled What is Maritime Security? provides an important basis by stating that maritime security is a hybrid concept that requires integration between national security and operational capabilities in challenging areas. Furthermore, Germond (2015) through his writing The Geopolitics of Maritime Security: The European Union's Maritime Strategy found that the effectiveness of maritime enforcement is highly dependent on the ability of assets to adapt to specific geographical environments, where failure to adapt technology to the terrain of the sea will create space for transnational crime. In terms of technical stability, a study by Suman Sharma (2017) entitled Design and Development of Outrigger Boats for Artisanal Fishermen emphasised that the use of beds or wings on boats not only increases static stability but also allows boats to operate in unpredictable wave conditions with minimal water draft. In addition, Zulkhairi and Azman (2018) in their study Local Wisdom in Traditional Boat Technology in Malaysia found that the design of traditional boats such as “lepa” has a high hydrodynamic value which is often overlooked by modern engineers in building patrol boats.

Moving on to the threat aspect, a study by Sakhuja (2011) entitled Confidence Building from the Sea: An Indian Perspective explains that maritime crime in shallow coastal areas requires highly capable and low-profile assets to avoid detection by enemy radar. Next, operational practices by enforcement agencies were studied by Mohd Ariff (2019) in MMEA Operational Challenges in Sabah Waters which found that the main issue of failure to pursue criminals in mangrove areas is due to conventional boat propulsions that are often stuck on mangrove roots and sellout. A study by Viggiani (2020) entitled Advancements in Small Craft Technology for Coast Guards found that the use of modern composite materials in small boat designs can increase speed without sacrificing the stability required by the security forces. Meanwhile, Hamzah (2016) through his writing Maritime Security in the Straits of Malacca stated that the cooperation of coastal communities is the key to security, but he also suggested that the enforcement assets used should have similar characteristics to local boats in order to operate without geographical limitations.

Furthermore, a study by Beltrame (2012) titled Archaeological and Technical Study of the Outrigger Boats proved that the winged design is the answer to the stability of narrow long boats, making them an ideal platform for weapon stability. Finally, a study by Nasir (2021) entitled Patrol Boat Innovation for Shallow Waters concluded that the "biomimicry" approach or imitating natural designs and traditions is the best way to overcome navigation constraints in areas full of natural obstacles such as coral reefs. Most previous studies have either focused on the sociological aspects of coastal communities, the archaeology of boat design, or simply touched on the issue of maritime security on a macro basis without providing specific technical solutions. This study is different from the previous study because this study is not just a documentation or analysis of winged boats

cultivated by coastal communities but will develop a prototype of a tactical boat using this outrigger boat to be adapted and used as a tactical boat for the use of maritime enforcement agencies in Malaysia.

Tactical Bot Prototype Development

In general, there are two (2) approaches that can be used in developing a tactical boat for the use of maritime enforcement agencies in Malaysia if you take into account the various strengths and weaknesses that exist. The first feasible approach is to fully develop a modern prototype of a tactical boat especially in terms of its structure, building materials, operating system. This means that the prototype of this tactical boat only borrows the concept of outriggers, no longer applies the physical construction of the existing traditional outrigger boat and will certainly involve a large amount of funds to develop it. The second approach that can be considered if the first approach above involves high costs is to maintain, adapt, design and modify only the design and physicality of the existing traditional outrigger boats, using a combination of modern and traditional materials, the design is adapted to the needs of the waters, the construction and maintenance costs are cheaper and so on.

Development of a Modern Outrigger Boat Prototype

The development of this tactical boat prototype began with a design philosophy that combines the hydrodynamic stability of the traditional outrigger boat of the Sabah community with the needs of modern paramilitary operations. Technically, this design maintains a long, tapered main body to reduce water resistance, while the two outrigger structures on the left and right sides act as dynamic stabilizers. The technical drawings of this prototype show the main body made of Carbon Fiber Reinforced Polymer (CFRP) to ensure maximum structural strength at the minimum weight. The use of this CFRP is critical to ensure that the boat's water draft remains below 0.3 metres, allowing it to glide over coral reef areas and mangrove swamps without touching the seabed. The wing structure is designed with a hydraulic adjustment system that allows the wings to be pulled close to the hull when passing through narrow passages in mangrove forests, and repositioned when high stability is required for interception operations or during the use of light weapons systems on deck. By modernizing the traditional outrigger design into tactical security prototypes, security agencies can close this critical "operability gap" through several innovative enhancements as follows:

- Ultra-Low Water Draft for Shallow Navigation: By constructing the long, narrow main body of the boat from lightweight Carbon Fiber Reinforced Polymer (CFRP), modernized outrigger boats can maintain a water draft of under 0.3 meters. This incredibly low draft allows security forces to seamlessly glide over coral reefs and shallow mangrove swamps where conventional large patrol boats cannot safely operate.

- Exceptional Stability for Weapon Platforms: The defining feature of outrigger boats—the side "wings" or outriggers provides extraordinary hydrodynamic stability, even in rough and unpredictable seas. This distinct stability ensures that the boat can serve as a reliable and highly stable platform for light weapons and precise interception operations.

- Adaptable Hydraulic Wings: To solve the issue of navigating tight spaces, modern tactical outrigger designs incorporate a hydraulic adjustment system. This technology allows the outrigger wings to be retracted tightly against the boat's hull when moving through narrow mangrove channels, and extended again when high stability is required in open or turbulent waters.

- Stealth Capabilities and AI Navigation: These prototype designs integrate an "AI Tactical Navigation Brain" connected to lidar and sonar sensors, which can map the seabed in real-time (real-time bathymetry) to safely guide the boat through unmapped shallow areas. Furthermore, they feature hybrid propulsion systems that utilize water jets for high speed and silent electric motors for stealth mode. This stealth capability is crucial for covertly tracking and surprising smugglers during night operations.

- Agility and Cost-Effectiveness: Embracing this "biomimetic" approach mimicking traditional, environmentally adapted designs—results in highly aerodynamic and agile vessels. They are specifically tailored to the local maritime landscape and offer lower maintenance costs compared to maintaining large conventional patrol boats.

Ultimately, blending the traditional maritime wisdom of the outrigger design with modern paramilitary materials and Artificial Intelligence empowers security forces like ESSCOM to effectively pursue and neutralize criminal threats in hard-to-reach coastal zones that criminals previously used as safe havens. Artificial Intelligence (AI) and modern materials are transforming traditional maritime technologies by merging historical, localized vessel designs with advanced engineering and digital capabilities. This modernization is primarily evident in the upgrading of traditional outrigger boats into highly capable tactical vessels, as well as the enhancement of port logistics. Here is how these technologies are applied:

Integration of Modern Materials

- Carbon Fiber Reinforced Polymer (CFRP): Traditional outrigger boats, which natively feature a long, narrow hull and stabilizing side wings, are being modernized using CFRP.
- Optimized Weight and Navigation: Utilizing CFRP provides the maximum structural strength at the lowest possible weight. This modern material innovation ensures the boat maintains a very low water draft of under 0.3 meters. As a result, the vessel can easily glide over sharp coral reefs and navigate tightly woven mangrove swamps without touching the seabed or risking damage.
- Hydraulic Systems: The traditional outrigger wings are upgraded with modern hydraulic adjustment systems, allowing the wings to be pulled close to the hull for navigating narrow mangrove channels and extended outward for high stability during interceptions or when using light deck weapons.

Implementation of Artificial Intelligence (AI)

- The "Tactical Navigation Brain": AI is integrated into these modernized traditional boats to serve as a central navigational intelligence system connected to lidar sensors and obstacle-detecting sonar.
- Real-Time Bathymetry: The AI system is capable of mapping the seabed in real-time. This allows it to recommend the safest routes through extremely shallow or complex waters that lack complete nautical charts.
- Smart Hybrid Propulsion: AI also controls the vessel's hybrid propulsion system. It can seamlessly switch between water-jet propulsion for high-speed pursuits and a silent electric motor for covert intelligence gathering or stealth operations at night.
- Supply Chain and Port Modernization**:** Beyond the vessels themselves, AI is being paired with 5G technology to modernize maritime infrastructure. This includes integrating AI into the Malaysia Maritime Single Window (MMSW) and logistics tracking tools to maximize the fluidity and efficiency of the maritime supply chain

The integration of Artificial Intelligence (AI) technology is the main pillar that distinguishes this prototype from conventional patrol boats. The installed AI system serves as a "Tactical Navigation Brain" connected to lidar sensors and obstacle detection sonar. This technology is able to map the seabed in real-time (real-time bathymetry) and provide recommendations for the safest route in shallow areas that do not have complete nautical charts. In addition, the AI also controls a hybrid propulsion system consisting of a water-jet propulsion engine for high speed and a silent electric motor for espionage operations. According to a study by Viggiani (2020), the use of smart propulsion systems in small boats not only increases fuel efficiency but also allows security forces to conduct operations in stealth mode, an element that is indispensable in combating smuggling crimes at night

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Figure 2: Prototype Modern Tactical Bot

Sources: NotebookLM. (2026). Traditional Wisdom, Modern Defense: The Tactical Outrigger Prototype & Bangka Architectural Pulse. Image generated by AI.

To assess the feasibility of this project, a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis needs to be thoroughly examined. The main strength of these boats lies in their exceptional stability and navigational capabilities in extreme waters that are unattainable by existing safety agency boats. The uniqueness of the winged design ensures that the armament platform remains stable even in rough sea conditions, which according to Beltrame (2012), is the main advantage of catamaran or outrigger type boats. However, the disadvantages identified are the high initial development costs due to the use of carbon fibre materials and the integration of complex AI systems. In addition, the wide design of the wings may make it difficult to store on board existing carrier carriers if it is not equipped with an efficient folding wing system. From an opportunity point of view, this prototype has great potential to be used as a standard asset for Special Operations Forces in border areas such as the Eastern Sabah Security Zone (ESSZONE). This innovation also opens up space for the local defence industry to export shallow water boat technology to other island countries facing similar geographical challenges. However, the threat to watch out for is the speed with which criminals adapt to new technologies as well as the risk of electronic system failure in a corrosive saltwater environment if maintenance is not carried out to strict standards. Overall, the development of this prototype is a proactive step that responds to the recommendations of Nasir (2021) on the need for biomimicry and adaptive asset innovation for the local maritime landscape to ensure that the country's sovereignty continues to be protected from increasingly cunning threats.

Table 1: SWOT Analysis of Tactical Boat Prototypes

CATEGORY	ANALYSIS FACTORS	DETAILED DESCRIPTION
Strength	Stability & Navigation	Has exceptional stability in extreme waters and is able to access shallow areas that existing assets cannot pass through.
	Armament Platform	The winged design ensures the stability of the weapon platform even in rough sea conditions (Beltrame, 2012).
	Material Innovation	The use of carbon fibre provides an optimal strength-to-weight ratio and low water draft.
Weakness	Development Costs	The high initial cost of procurement of raw materials (carbon fibres) and the integration of Artificial Intelligence

		(AI) systems is estimated to cost around RM3 million per boat.
	Space Constraints	The wide physical design can make it difficult to store on an aircraft carrier without an efficient folding wing system.
Opportunities	Asset Standardization	Potentially become a standard asset of special operations teams in critical areas such as ESSZONE, Sabah.
	Global Markets	An opportunity to export shallow water boat technology to other island countries with similar geographies.
	Maritime Sovereignty	Empower border control through "biomimicry" innovations that are adaptive to the local landscape (Nasir, 2021).
Threats	Criminal Adaptation	Maritime criminals may adapt their tactics or technology quickly to cope with the capabilities of new assets.
	Environmental Factors	High risk of electronic system failure due to saltwater erosion if maintenance protocols are not strictly adhered to.

. **Development of Hybrid Tactical Boat**

The development of a prototype of a hybrid outrigger boat is a proactive step taken to enhance the capabilities of existing traditional outrigger boats. By definition, hybrid cantilevered boats refer to the harmonious integration between the use of conventional building materials that are traditional in nature and the application of modern material technology that is of higher quality and has better durability. This innovative approach aims to maintain the aesthetic value as well as stability of traditional designs while at the same time improving the durability and operational efficiency of the boat through the use of the latest materials of better quality. In terms of the combination of building materials, the hybrid concept in this project focuses on the strategic use of materials according to the specific functions of each boat component. Conventional materials such as “cengal” or “meranti “hardwood are often used to build the main frame or interior structure to maintain the original flexibility and preserve the traditional characteristics of the boat. Meanwhile, from the point of view of using modern materials, materials such as Fiberglass Reinforced Plastic (FRP), epoxy resin, and aluminum are applied to coat the hull of the boat as well as build the outrigger components. The integration of these modern materials offers significant advantages in terms of better water resistance, reduced overall weight of the boat, as well as high resistance to decay processes.

Figure 3: Illustration of a Double-Outrigger Boat

Sources: Horridge, A. (2015). The prahu: Traditional sailing boat of Indonesia. Oxford University Press. Also see Manguin, P. Y. (2012). Austronesian shipping encounters the Indian Ocean: The Ship Archaeology Record. Oxford Centre for Maritime Archaeology.

Traditional boats known by various local names such as “Bangka” in the Philippines, “Jukung” in Indonesia and Malaysia, as well as “Baroto” are symbols of maritime greatness in the Southeast Asian region. These water vehicles serve extensively in the daily lives of the community as a primary tool for fishing, essential transportation between islands, as well as supporting various economic activities along the coast. From a heritage perspective, these boats have deep cultural significance as they symbolize the height of navigational skills and carpentry expertise inherited by the Austronesian people. The uniqueness of this boat also lies in its construction technique which still retains its traditional characteristics, namely by using natural rope tying techniques and utilizing natural materials such as bamboo to build a bed that serves as a balance of stability in the ocean.

Table 2: Summary of the Background of the Swinging Boat

CATEGORY	REFERENCE DETAILS
Local Names	“Bangka” (Philippines), “Jukung” (Indonesia), “Bogo” (Malaysia)
Main Functions	Widely used for fishing, inter-island transportation, and coastal activities.
Cultural Significance	Symbolizes the navigational and carpentry skills of the Austronesian people.
Construction Techniques	Using natural rope tying techniques and natural materials such as bamboo for “katir”.

To realize the development of this prototype, several key material requirements have been identified to ensure the quality of the construction. The use of high-quality wood is still required as the basic structure, while fiberglass and resin are widely used for exterior finishes to ensure that the boat is waterproof and durable. Next, industrial-grade PVC or aluminum pipes are used specifically to build outrigger structures so that they remain lightweight yet strong enough to withstand water resistance. In addition, the use of hybrid or electric engines was introduced as the main purpose system to reduce dependence on fossil fuels, in addition to the application of anti-fouling paints to prevent the growth of marine life on the bottom of the boat. In terms of design, this boat retains the distinctive feature of using outriggers on both sides to provide maximum stability especially when the boat is faced with strong waves in the open sea. The hull of the boat is designed with a sharper V-shape at the front to allow it to cut through water more efficiently and quickly. The integration of modern materials in this design allows the boat to be more aerodynamic and lightweight, while the use of modular components on the outriggers makes the maintenance and replacement process even easier in the event of any damage in the future. The development of this boat has also proven to be very cost-effective from a long-term economic point of view although the initial cost may be a bit high due to the use of modern material technology. Maintenance costs can be drastically reduced because modern materials are not easily rotted or attacked by termites when compared to boats made entirely of wood. Additionally, fuel efficiency can be improved as the lighter weight of the boat directly reduces the workload of the engine. This precise combination of materials ultimately guarantees a longer lifespan of the boat before any major repairs need to be made.

Figure 4: Anatomy of a Single-Outrigger Canoe

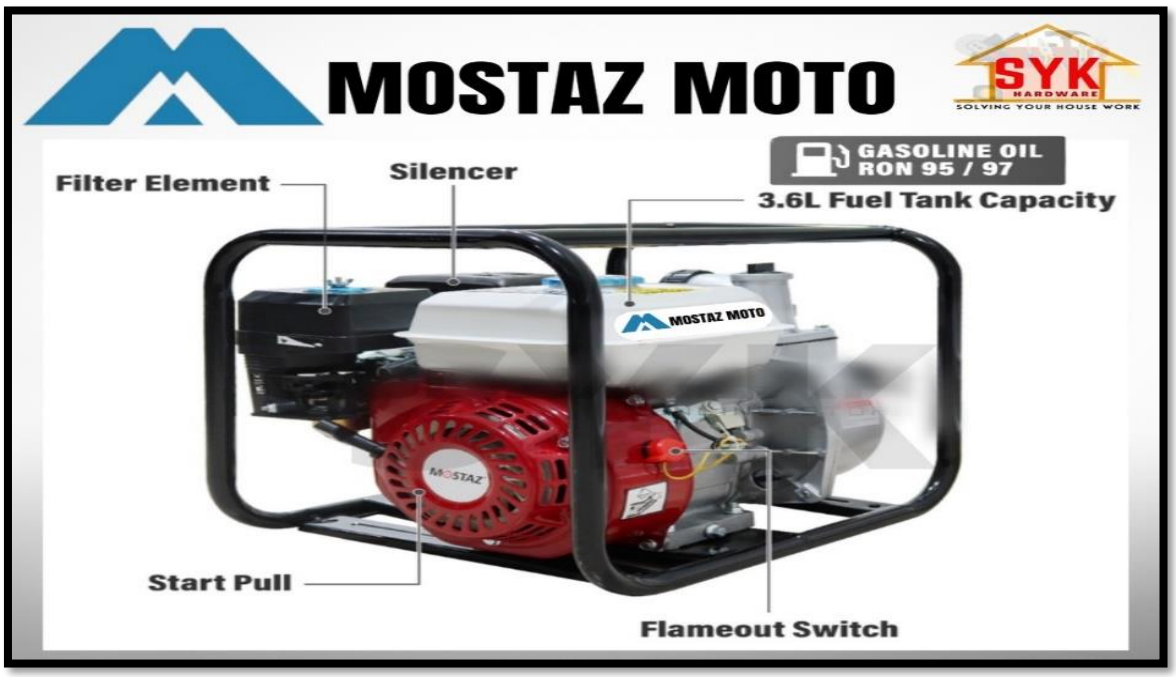
Source: Modified from NotebookLM, Google. (2024). Anatomy of a traditional outrigger canoe. https://notebooklm.google.com/. Image generated by AI. NotebookLM.

The Use of Multi-Purpose Stationary Engines in Modern Industry

A stationary engine refers to a type of engine whose frame is designed to remain in one place or not moving while it is in operation (Abdullah, 2021). This device has a significant difference from the vehicle engine because its role is not to move the engine body itself, but rather it is used as the main power source to drive various stationary equipment or other machinery that requires mechanical energy. According to Hassan and Rahman (2020), the main purpose of using this engine is to supply power to industrial and domestic machines such as electricity generators, water pumps, grinding machines, as well as machinery in factories. Based on a survey of maritime culture in Southeast Asia, this boat is unique in that it does not use conventional marine outboard engines, instead relies on multi-purpose gearbox engines such as those produced by the Briggs & Stratton or Honda brands. According to Smith (2022), these engines are categorized as small internal combustion engines that are designed to operate in a fixed position or are mounted on mobile equipment to provide consistent mechanical power. The ability of this engine to work in a wide range of environmental conditions makes it a top choice for the agricultural, construction, and domestic use sectors worldwide.

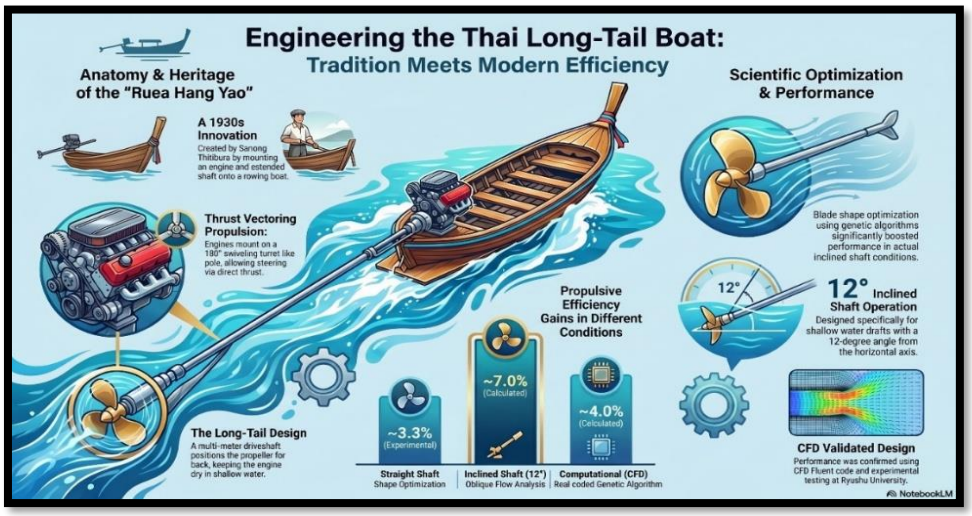
The Briggs & Stratton brand is often associated with the development of durable horizontal and vertical shaft engines for site care equipment such as lawn mowers. Miller and Davis (2021) stated that Briggs & Stratton's innovations in popularizing overhead valve (OHV) configurations have improved fuel efficiency and reduced carbon emissions compared to older flat-head engine designs. In addition, the use of aluminum materials in their engine blocks allows for a better power-to-weight ratio, thus facilitating the operation of equipment driven by such engines. Next, Honda has set the industry standard with their GX engine series which is known for its low noise levels and high reliability. Based on a study by Jones (2023), Honda Combustion Technology allows for a more perfect combustion process, which not only improves torque performance but also extends the life of the engine. Honda's engine superiority is often seen in the heavy construction sector, such as in ground compactors and electric power generators, where operating stability at high rpm is critical to avoid mechanical failures at the project site. Overall, the evolution of multipurpose stationary engines reflects advances in mechanical engineering that prioritize energy efficiency and engine survival. As Brown (2020) argues, competition between brands such as Briggs & Stratton and Honda has driven innovations in electronic ignition systems and automatic speed control systems that make modern engines more user-friendly.

Figure 5: Pump Boat Engine



Source: SYK Hardware. (2009). Mostaz Moto 3.6L Gasoline engine specifications https://www.sykhardware.com.my/mostaz-moto-gasoline-engine.

Figure 6: Thai Long-Tail Boat Illustration Engine



Source: Modified from Google. (2026). Engineering The Thai Long-Tail Boat: Tradition Meets Modern Efficiency, Notebooklm. Https://Notebooklm.Google.Com/

The process of installing this engine on a wheeled boat is done by a very simple but effective inboard drive method. The engine is placed horizontally on a wooden frame in the centre of the hull to ensure a balanced distribution of weight, which is then connected directly to the long iron shaft without the use of a gearbox system. This shaft penetrates the bottom of the stern of the boat through a watertight hole that is usually bushed with grease and rags to prevent leakage. Directional control is done via a steering stick that is connected directly to the steering blade behind the fan, creating a direct transmission system where the fan will continue to rotate once the engine is started. From a technical point of view, the long and narrow design of the boat is very suitable for the placement of the engine in the central part as it lowers the centre of gravity and increases the stability of the boat when going through large waves with the help of a bed or outrigger on both sides. Additionally, the low maintenance costs and widespread availability of parts in rural areas make this engine a top choice for fishermen over expensive specialty marine engines. Therefore, the integration of these engines not only provides sufficient purpose power for daily activities, but it also reflects the ability of coastal communities to adapt onshore machinery for use in challenging oceans.

SWOT Analysis of Tactical Bot Prototype Development

The development of a prototype of a tactical boat based on an outrigger boat is a strategic step that can be evaluated through SWOT analysis to understand the potential and challenges in strengthening the country's maritime security. This analysis covers the aspects of strengths, weaknesses, opportunities, and threats that surround the asset's innovation. Strengths The main strength of this prototype lies in its exceptional stability and navigation in extreme waters. This traditional adapted design allows the boat to access areas of shallow waters that are impassable to existing assets. Additionally, the winged or outrigger design acts as a highly stable armament platform, allowing operational accuracy to be maintained even in turbulent sea conditions. Technically, material innovations such as the use of carbon fibre provide an optimal strength ratio, thus maintaining low water draft for agile movement. However, there are some constraints identified, especially in terms of development costs. The initial cost of procurement of sophisticated raw materials as well as the integration of complex Artificial Intelligence (AI) systems requires a high financial investment.

In addition, space constraints are an issue because the wide physical design of the boat due to the wings can make it difficult to store on existing carrier aircraft carriers if they are not equipped with an efficient folding wing system. Opportunity. From an opportunity point of view, this innovation has great potential to be used as an asset standardisation for special operations teams in critical areas such as the Eastern Sabah Security Zone (ESSZONE). In addition to empowering maritime sovereignty through a "biomimicry" approach that is adaptive to the local landscape, the project also paves the way for global markets. Malaysia has the opportunity to export

this shallow water boat technology to other island countries that face similar geographical challenges. Finally, there are threats that need to be taken into account, among which is criminal adaptation. Maritime criminals may adapt their tactics or technology quickly to outperform the capabilities of these new assets. There are also risks related to environmental factors, where complex electronic systems are prone to failure due to high saltwater erosion if maintenance protocols are not strictly adhered to.

Table 3: SWOT Analysis of Hybrid Tactical Bot Prototypes

CATEGORY	ANALYSIS FACTORS	DETAILED DESCRIPTION
Strengths	Stability & Navigation	Has exceptional stability in extreme waters and is able to access shallow areas that existing assets cannot pass.
	Armament Platform	The winged design ensures the stability of the weapon platform even in rough sea conditions.
	Material Innovation	The use of carbon fibre provides an optimal strength ratio and low water draft.
	Maintenance Costs	The use of modern materials such as FRP and aluminum in hybrid structures reduces maintenance costs as they are not easily rotted or attacked by termites.
Weaknesses	Development Costs	High initial costs for the procurement of raw materials (carbon fibres) and the integration of Artificial Intelligence (AI) systems.
	Space Constraints	The wide physical design can make it difficult to store on an aircraft carrier without an efficient folding wing system.
Opportunities	Asset Standardization	Potentially become a standard asset of special operations teams in critical areas such as ESSZONE, Sabah.
	Global Markets	An opportunity to export shallow water boat technology to other island countries with similar geographies.
	Maritime Sovereignty	Empower border control through "biomimicry" innovations that are adaptive to the local landscape.
Threats	Criminal Adaptation	Maritime criminals may quickly adapt their tactics or technology to outperform the capabilities of new assets.
	Environmental Factors	The risk of electronic system failure due to saltwater erosion is high if maintenance protocols are not strictly adhered to.

Overall, this SWOT description shows that despite the challenges in terms of cost and technicality, the potential of tactical boats to dominate difficult geographical spaces makes it a worthwhile investment for the sustainability of the country's territorial waters.The development of this prototype is not just a technical innovation, but also a proactive step in closing the operational gap in coastal areas. Despite the high development costs, the tactical advantage in dominating the shallow area and the potential use in the ESSZONE provides a strong justification to continue this project for the sake of the sustainability of the country's maritime sovereignty.

DISCUSSION AND ANALYSIS

The development of maritime assets for security agencies in Malaysia is currently at the crossroads of innovation between full modernisation and adaptation of local wisdom. Based on the study of the development of tactical boat prototypes, there are two main approaches that can be compared, namely the development of fully modern

tactical boats and hybrid tactical boats that are based on the modification of traditional outrigger boats. These two concepts offer their own advantages in addressing maritime security issues, especially in closing operational gaps in shallow and complex waters such as eastern Sabah. In terms of design, modern tactical boats are built entirely using the latest technology with a structure that borrows the concept of outriggers as dynamic stabilizers but uses advanced building materials such as Carbon Fiber Reinforced Polymer (CFRP). The use of this CFRP allows the boat to have maximum structural strength at the minimum weight, thus resulting in a very low water draft of just under 0.3 metres. Additionally, the modern boat is equipped with an adjustable hydraulic wing system as well as the integration of Artificial Intelligence (AI) as the brain of tactical navigation connected to lidar and sonar sensors.

On the other hand, hybrid tactical boats retain the physical identity of traditional outrigger boats by applying a combination of modern and conventional materials. The main frame may still use hardwoods for flexibility, but the body is coated with Fiberglass Reinforced Plastic (FRP) and epoxy resin for better water resistance. This hybrid design is more organic and biomimicry, maintaining a sharp V-body shape to efficiently cut through water while using modular components on outrigger parts for ease of maintenance. The operational suitability of these two types of boats is highly dependent on the threat profile and geography of the waters. Modern tactical boats are particularly superior in high-speed reconnaissance and pursuit operations because they are equipped with a hybrid propulsion system that combines a water jet engine and a silent or stealth mode electric motor. AI's ability to map the seabed in real-time (real-time bathymetry) allows these modern boats to safely navigate shallow areas that do not have complete nautical charts.

While hybrid tactical boats offer advantages in terms of operational sustainability in rural areas. By using multi-purpose engine engines such as Honda or Briggs & Stratton brands that are installed inboard, these hybrid boats are very practical as the spare parts are readily available. This hybrid boat is ideally suited for the day-to-day operations of agencies such as ESSCOM and the Marine Police in narrow mangrove swamp and coral reef areas due to its design that has been cultivated by coastal communities for thousands of years to cope with the challenging physical conditions of the waters. From an economic and cost point of view, there are significant differences that are decisive factors in asset turnover. Modern tactical boats require enormous funds for initial development due to the high cost of carbon fibre materials as well as the complexity of integrating electronic systems and AI. While it offers exceptional operational efficiency, the cost of its technology investment is a significant financial burden. On the other hand, hybrid tactical bots are seen as a much more cost-effective solution. The hybrid approach only involves modifications and upgrades to the existing design, which directly reduces construction costs.

Long-term maintenance costs for hybrid boats are also lower because modern materials such as FRP are less prone to rot or termite attacks than wood entirely, while the use of multi-purpose engines reduces reliance on expensive specialized marine engines. Overall, the choice between modern and hybrid tactical boats requires a balance between high-tech requirements and the realities of budget and ease of maintenance. Modern boats provide tactical advantages through electronic and material sophistication, while hybrid boats empower sovereignty through agile and effective adaptation of local wisdom. These two innovations have great potential to become standard assets in combating cross-border crime and ensuring that the country's maritime security continues to be preserved in critical zones.

RESEARCH FINDINGS

As a result of research into the development of tactical boat prototypes, studies have found that outrigger boats have a very high level of suitability for use in maritime security operations, especially in challenging water areas. This iconic design of the coastal community has a very low water draft, which is under 0.3 meters when constructed using a carbon fibre reinforced polymer composite (CFRP) material, which allows it to glide nimbly over areas of coral reefs, shallow waters, and mangrove swamps that are impossible for conventional ships or large patrol boats to navigate. Unique aerodynamic and balance characteristics through the use of "wings" or outriggers provide exceptional stability when wading through large waves, thus providing a fixed and stable armament platform for interception operations or the use of light weapons on deck. In terms of operational

effectiveness, these tactical boats based on traditional concepts are able to close the "operational gaps" that are often exploited by criminal elements such as smugglers and intruders who flee to narrow water areas.

This effectiveness is further strengthened by the integration of modern technologies such as tightly retractable hydraulic wing systems for navigation in narrow mangrove lanes, as well as the use of Artificial Intelligence (AI) that serves as a "Tactical Navigation Brain" to map the seabed in real-time bathymetry in areas that do not have complete nautical charts. Additionally, a hybrid propulsion system that combines a high-speed water jet engine and a silent electric motor allows enforcement agencies to conduct espionage operations in stealth mode, which is critical in combating crime at night. Studies also prove that these innovations are very cost-effective in the long run through the use of modern materials and local wisdom. The use of composite materials such as fiberglass and epoxy resin increases the boat's resistance to saltwater decay and erosion, thus drastically reducing maintenance costs compared to a fully wooden boat. The development of prototypes that adapt hybrid boat designs with simple multi-purpose gearbox engines also offers a practical economic solution due to the wide availability of spare parts and higher fuel efficiency due to the lighter weight of the boat. Ultimately, the modernization of the outrigger boat-based asset not only strengthens the country's maritime sovereignty through agile technology, but is also a strategic step that saves the country's expenditure on security asset management.

CONCLUSION AND WAY FORWARD

Ultimately, the development of tactical boats based on local wisdom through the innovation of outrigger boats is a strategic shift that can strengthen the country's maritime sovereignty. The integration of traditional hydrodynamic stability with modern technologies such as carbon fibre composite materials (CFRP) and Artificial Intelligence (AI) systems has proven to close the "operational gap" that has been limiting enforcement agencies' assets in shallow waters, coral reefs, and mangrove swamps. The boat's ability to operate nimbly with low water drafts, as well as the high stability it offers as an armament platform, makes it a more effective alternative to the use of large patrol boats that are bound by geographical constraints. Apart from the tactical advantages, this approach also offers a cost-effective solution through reduced maintenance costs and fuel efficiency, while also opening up space for the local defence industry to explore global markets with similar geographical challenges. Finally, the modernisation of this "biomimicry" asset is not just an effort to conserve maritime culture, but is also a proactive step in ensuring that security agencies such as ESSCOM, MMEA, and the Marine Police are always at the forefront in combating the increasingly complex threat of cross-border crime. By harnessing the wisdom of this Austronesian heritage, Malaysia is able to build a maritime defence system that is more organic, sustainable, and adaptive to the local ocean landscape.

The innovation of outrigger boats as a tactical asset for maritime security agencies in Malaysia is a transformative move that combines local wisdom with modern defence needs. The main direction to ensure that these innovations achieve their goals is through the transition phase from traditional design to advanced materials engineering. The use of composite materials such as carbon fibre or high-density polyethylene should be prioritised to replace wood, aiming to increase the ratio of strength to weight. This will directly give the boats exceptional agility in shallow waters and coral areas that are often blind spots for large patrol vessels, thus enabling enforcement agencies to conduct monitoring operations in previously hard-to-reach areas. Next, this innovation direction should focus on the integration of sensing technology and hybrid propulsion systems. As a tactical boat, it needs to be equipped with a thermal navigation system and infra-red sensors that allow operations to be carried out effectively at night or in adverse weather conditions. The use of hybrid engines capable of operating in silent electric mode is particularly critical in raid tactics, where agencies can approach targets without detecting the sound of conventional engines. This approach not only enhances the element of surprise in operations to combat smuggling or encroachment of foreign fishermen, but also supports the country's maritime sustainability agenda through the reduction of carbon emissions in ecologically sensitive areas.

Apart from the technical aspects, the development of operational doctrine and specialized training for maritime agency members are the main pillars in driving this innovation forward. Since the parachute boats have different operating dynamics than standard patrol boats, a new tactical training curriculum needs to be devised. This training should include fast beach landing techniques and manoeuvres in narrow spaces which are the main advantages of capped structures. By establishing in-house expertise, security agencies not only possess

sophisticated assets, but also have human resources capable of optimizing every inch of the design advantages of such boats in real-world conflict scenarios. Finally, a sustainable direction requires strategic collaboration between universities, industry, and government agencies such as the Malaysian Maritime Enforcement Agency on a larger scale. This process should move from just a preliminary survey to a field test phase in high-risk zones such as Sabah's waters. Through these tests, performance data can be collected in real-time for continuous improvement before commercialization or asset acquisition is done on a large scale. In conclusion, by combining modern engineering, sensing technology, and robust tactical doctrine, this jumble boat innovation is capable of becoming a sovereign asset that empowers the security of the country's waters in a more cost-effective and efficient manner.

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