THE IMPACT OF NEW TECHNOLOGIES FOR NATIONAL DEFENCE: AN ANALYSIS OF CURRENT AND FUTURE DEPLOYMENT OF UNMANNED MARITIME VEHICLES

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ABSTRACT

New technologies have long played a part in defining the security landscape, and leadership in technological innovation has been a crucial national defence asset for most nations. The marine environment, both on the high seas and underwater, has been the proving ground of many increasingly autonomous technologies such as Unmanned Maritime Vehicles, (UMVs). The present study analysed both current and future deployment of UMVs vis-à-vis the impact of new technologies for national defence. The present study analysed issues associated with the deployment of UMVs for enhanced national defence in the maritime domain. The study adopted the field survey research design by conducting interviews and administering questionnaires to 3 groups in the Nigerian Navy technical units. The study revealed the effects of UMVs on national defence in the maritime domain. The effects include Intelligence Surveillance and Reconnaissance (ISR), Mine Counter Measure (MCM) and anti-submarine warfare. The challenges associated with the deployment of UMVs were identified as accidental attacks and unintended interactions, cycle of measures and counter measures as well as environmental protection. Furthermore, the study proffered strategies to mitigate the challenges of employment of UMVs for national defence. These strategies include development of new curriculum, redesigning programmes to suit multi-vehicle control and finally the need for proficient testing and validation of new technologies.

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INTRODUCTION

New technologies are technologies whose development, practical application, or both are still largely unrealized, such that they are figuratively emerging into prominence from nonexistence or obscurity. These technologies are generally new but also include older technologies that are still relatively undeveloped in potential. New technologies are often perceived as capable of changing the status quo. It is characterized by radical novelty, relatively fast growth, cohesion, prominent impact and uncertainty and ambiguity [1].

According to Bitzinger [2] national defence includes the needs of, and the planning and preparedness to meet, essential defence, industrial and military emergency, energy requirements relative to the national safety, welfare, and economy, particularly resulting from foreign military or economic actions. The author further posited that national defence could be attained when there is an effective advancement in technologies, R&D and the right processes employed. Bitzinger [2] asserted that national defence is measured against technology availability, R&D capability and economic viability. Bitzinger's view captures the vital elements of national defence which include technology availability, economic viability as well as R&D capability.

New technologies have long played a part in defining the security landscape, and leadership in technological innovation has been a crucial national defence asset for most nations. The marine environment, both on the high seas and underwater, has been the proving ground of many increasingly autonomous technologies such as Unmanned Maritime Vehicles, (UMVs) which form part of the Unmanned Maritime System (UMS). UMS refers to all systems, subsystems, associated components, vehicles, equipment and logistics for the operation of Unmanned Vehicles. These vehicles can be operated on the surface or underwater and may be remotely operated, partially or fully autonomous [3].

New technologies in marine environment are expected to have major impact on the development of societies and contribute positively to national defence [4]. These technologies are widely incorporated into a lot of systems, which means, they can influence vital elements of national defence capabilities and national security such as counter-terrorism and counter insurgency operations. The present study is focused on current and future technology for UMVs vis-à-vis the impact of new technologies for national defence.

METHODS

Research design

The study adopted the field survey research design. Field survey involved the conduct of interviews and administrating questionnaire with stakeholders and experts in the field. The study also administered copies of the questionnaire and interviews of subject matter experts and stakeholders on a sample drawn from the population. The research design also incorporated nature of research and level of research. The nature of research was applied research employing empirical approach. The data employed for this research was an integration of quantitative and qualitative data. The data were collected and analyzed in relation to new technologies and national defence in maritime environment. This was achieved through the collection of data from primary and secondary sources. The level of research adopted was descriptive approach. This was used to analyze collected data, without manipulating the environment. Descriptive approach was also used to describe how new technologies has impacted on national defence in the maritime environment.

Sources of data

The research data were obtained from both primary and secondary sources. The primary data for this study were obtained through questionnaires and unstructured interviews with subject matter experts on mechatronics, robotics and AI. Furthermore, data were obtained from officers at the Nigerian Naval Engineering College (NNEC) Sapele. The sources of secondary data included published and unpublished materials such as books, journals, newspapers, official publications, seminar and conference. Others are papers, lectures, policy papers, magazines and the internet. Additional secondary data were also obtained from the libraries of the Ejiga library at the Armed Forces Command and Staff College (AFCSC) and National Defence College (NDC).

Population and sampling design/ technique

The population and sampling design for the study included population of the study, sample of the study and sampling technique. The total population was estimated at 500. The research adopted a purposive sampling method to select 3 groups in the Nigerian Navy technical units. The 3 groups are NNEC Sapele, Fleet Support Group West (FSG W) and Fleet Support Unit Warri (FSU W) which comprise of students, instructors, technical personnel and administrators. This ensured that relevant features like service and the degree of involvement of respondents in administration, operations and technical training activities were considered. This is to meet the necessary requirement for external validity of the research. The sample size was calculated using Slovin's [5] formula as,

$$\frac{N}{1 + Ne^2}$$

where: n is the sample size, N is the population size, e is the margin error and 1 is a constant value. Using a population size of 496 with a confidence level of 95 per cent and error margin of 5 per cent, the sample size, n is estimated at 221.

The study adopted the non-probabilistic purposive sampling technique. The strength of this sampling technique is that it allows for opinions of professionals and authorities in the field of study. However, the weakness of the technique is that it targets a particular group of the people. Some of whom may be difficult to locate and interview for the purpose of the study. Such weakness was eliminated through verifications from 2 or more sources and references. The technique was also complemented with questionnaire that was administered to other stakeholders.

Methods of data collection

The methods of data collection that were adopted for the study include the field method and document analysis. The field method of data collection involved the use of questionnaires and interviews. Copies of questionnaire were administered to obtain data on respondents' views and opinions on different aspect of emerging technologies as they impact on national defence. This method enabled a thorough interrogation of the view and analysis of Naval engineering officers on employment and impact of UMVs on national defence.

Secondary sources of data were collected through print and electronic media and analysed using the archival library search. This proved very useful in clarifying the basic concepts and other aspects of new technologies and national defence that primary sources could not provide. This ensured that sufficient literature was obtained on employment of UMVs for national security to either reinforce or disprove the primary data.

Instruments of data collection

The instruments used for data collection in the field were the questionnaire, research notebooks and interview guide as well as interview summary sheet. The questionnaire, attached as Appendix 1, consisted of 27 items divided into 5 sections. Section A was on respondents' personal data, Section B was on the variables; new technologies and national defence. Section C was on the main research questions on the issues and challenges. Section D was on the main research question on the impact of UMVs on national defence while Section E was on the main research questions. The questions which consisted both open and close ended questions were structured to capture attributes of the variables and the objectives of the research. The close ended questions were provided with 3-scale responses. The interview guide at Appendix 2 was also used to aid data collection during interviews. A total of 10 questions, were open ended to allow for in-depth discussion. It further enables follow-up questions on possible areas of interests not covered in the questionnaire.

Methods of data analysis

Data from the unstructured interviews, questionnaire and secondary sources were subjected to qualitative and quantitative analyses. Content analysis and themes were used to analyze data from secondary sources. These were useful in clarifying basic concepts of new technologies and national defence as well as validating primary data. Data obtained from questionnaires were analyzed quantitatively using descriptive statistics with the aid of Statistical Package for the Social Sciences (SPSS) Software, version 25. This enabled the profiling of trends of data on new technologies and national defence in the maritime domain.

Information and analysis of the sample

The information and analysis of the sample on this section includes sample size and attributes of respondents. These are discussed subsequently. Based on the sampling techniques, the sample size for the study was calculated as 221. Accordingly, 250 copies of the questionnaire were physically distributed to NNEC Sapele, FSG (W) and FSU (W). The returned rate of the questionnaire represented 88.4 per cent validity. Thus, the high return and validity rates authenticate the reliability of the research process.

The highlights of the sample attributes cover gender and age as well as profession and years in Service. In terms of gender, 212 respondents (95.9 per cent) are male and 6 (2.7 per cent) are female, whereas 3 respondents (1.4 per cent) gave no response as to their gender. This indicates a vast majority of males over females. The data on age of the respondents covers 10-year brackets ranging from 21 years to over 50s. The largest age bracket was the 31 – 40 years, which registered 104 respondents (47.1 per cent). The smallest age bracket was 50 and above with 17 respondents (7.7 per cent). These are shown in Tables 1 and 2.

Table 1: Respondents' Views on Gender

SERIAL	RESPONSE	FREQUENCY	PERCENTAGE	REMARKS
(a)	**(b)**	**(c)**	**(d)**	**(e)**
1	Male	212	95.9	
2	Female	6	2.7	
3	No Response	3	1.4	
	Total	**221**	**100**	

Table 2: Respondents' Views on Age

Serial	Response	Frequency	Percentage	Remarks
(a)	**(b)**	**(c)**	**(d)**	**(e)**
1.	21 – 30	56	25.3	
2.	31 – 40	104	47.1	
3.	41 – 50	35	15.8	
4.	51 and above	17	7.7	
	Total	**221**	**100**	

The attribute of occupation covers 2 categories, namely; profession and years in Service. Profession as the largest category was the military profession (navy) with 186 respondents (84.2 per cent). The civilian category responded with 35 respondents (15.8 per cent). In terms of years in Service, the respondents were categorized in 3 brackets ranging from 0 years to over 20 years. The largest group was those who have served for 0 – 10 years with 164 respondents (74.2 per cent). The smallest group was 11 years and above with 57 respondents (25.8 per cent). These are shown in Tables 3 and 4.

Table 3: Respondents' Views on Profession

SERIAL	RESPONSE	FREQUENCY	PERCENTAGE	REMARKS
(a)	**(b)**	**(c)**	**(d)**	**(e)**
1.	Military	186	84.2%	
2.	Civilian	35	15.8%	
	Total	**221**	**100%**	

Table 4: Respondents' Views on Years in Service

Serial	Response	Frequency	Percentage	Remarks
(a)	**(b)**	**(c)**	**(d)**	**(e)**
1	0 – 10	164	74.2%	
2	11 and above	57	25.8%	
	Total	**221**	**100**	

RESULTS AND DISCUSSIONS

Effects of UMVs on national defence

A wide range of increasingly autonomous UMV military systems are already deployed in the maritime environment for a variety of missions including ISR, MCM, and anti-submarine warfare. These effects are discussed subsequently.

Intelligence, Surveillance and Reconnaissance

UMVs systems enable States to monitor activities of interest and potentially hostile actions over areas that could not be easily covered by human operators. UMVs can be deployed on missions such as port surveillance, fleet protection and supply delivery. Recent developments in swarming capabilities open realistic possibilities for automated ship protection and area denial, where autonomous surface vehicles operate in defensive postures yet could have offensive capabilities. Increasingly autonomous UMVs are also of interest for coastal monitoring, anti-piracy and counter-narcotics operations, as well as wide area searches, such as for Malaysian Airlines flight 370.

According to Savitz [6] the military unmanned vehicles sector is increasingly being dominated by unmanned surface vehicles, as a number of missions can be easily carried out at relatively low cost and equivalent reliability. UMVs are expected to become a key part of the US Navy fleet in the future due to the urgency attached by the navy for meeting the rapidly evolving military threats from countries such as China. The US Navy aims to shift towards a distributed fleet architecture that includes more unmanned vehicles to support manned surface combatants and is aiming to introduce them into service quickly. The navy plans to deploy large UMVs mainly for anti-surface warfare and medium UMVs for ISR and electronic warfare.

Table 5 show respondents' views on UMVs being increasingly used for ISR as an effect of UMVs on national defence. Accordingly, 175 of respondents agreed that UMVs can be performing ISR more effectively than man systems. Also, 37 respondents disagree and 9 respondents were indifferent. Hence, employment of UMVs for ISR mission has positive effect on national defence and security.

Table 5: Respondents' Views on Diffusion into New Environment

SERIAL	RESPONSE	FREQUENCY	PERCENTAGE	REMARKS
(a)	**(b)**	**(c)**	**(d)**	**(e)**
1	Agreed	175	79.2	
2	Disagreed	37	16.7	
3	Undecided	9	4.1	
	Total	**221**	**100**	

Fletcher [7] asserted that unmanned vehicle systems play a key role in many of the ISR tasks. They are an effective means of deploying surveillance sensors at sea, providing the data required for comprehensive situation awareness and understanding. Various communications modes are facilitated with vehicle systems, be it underwater or over the horizon, providing connectivity without exposing platforms to hazardous situations. He further stated that vehicles are also key in cross platform integration, bringing shore-based data to offshore platforms and vice-versa. Therefore, compatible and integrated systems are essential for the continued evolution and performance of these missions. These would ensure effective gathering of information and efficient integration of platforms.

Mine Counter Measure

UMVs can be deployed on missions such as MCM. MCM is the process of neutralizing sea mines to a degree that the mines do not impair the ability of ships to transit sea lanes safely. Mines vary widely in explosive yield, actuation mechanism, placement (in the water column or at the bottom of the sea), and ocean conditions in which they operate (e.g., turbidity, bottom-scouring, and sediment movement). Some mines are tethered in the water column and may have a contact actuation mechanism that is, they detonate upon contact or may be actuated by acoustic, magnetic, or pressure influences or a combination thereof. Other mines are on the ocean bottom and actuate only through an influence or combination of influences.

According to Fletcher [7], Operation Iraqi Freedom in 2003 saw the first use of autonomous underwater vehicles for mine warfare operations in Umm Qasr Harbour. Most unmanned underwater systems require some level of autonomy due to the fact that standard methods of navigation such as GPS do not work underwater. He affirmed that today's unmanned vehicle systems are showing increasing levels of autonomy, enabling them to perform complex missions with minimal human intervention. Autonomy is of particular importance for many MCM roles, where it is critical that the vehicle system be able to function independently, minimizing the risk to manned platforms. In this regard, the researcher conducted a field survey to ascertain the performance of UMVs in MCM missions as shown in Table 6.

Table 6: Respondents' Views on Effect of UMV in Mine Counter Measure

SERIAL	RESPONSE	FREQUENCY	PERCENTAGE	REMARKS
(a)	**(b)**	**(c)**	**(d)**	**(e)**
1	Agreed	211	95.5	
2	Disagreed	6	2.7	
3	Undecided	4	1.8	
	Total	**221**	**100**	

Table 6 indicated that 95.5 per cent of the respondents agreed that the autonomous UMVs would perform incredibly well in MCM mission. Also, only 2.7 per cent disagreed and 1.8 per cent was indifferent. This result reinforces the impact of UMVs in MCM missions for enhanced national defence.

Anti-Submarine Warfare

Anti-submarine warfare (ASW) operations generally focus on deterring and eliminating enemy diesel-electric submarines from transit routes and protecting High Value Units (HVUs), such as amphibious warfare ships and logistics ships. In view of the national defence and security challenges in the littorals, ASW is critical to establish and maintain a highly effective ASW capability. The ASW techniques that we use today are mostly effective, but it is important to explore new technologies and techniques such as potential UMVs solutions.

According to Naval Drones [8], research is underway to increase autonomous functions of UMVs for more complex operations. For example, the Defense Advanced Research Projects Agency programme "Anti-Submarine Warfare Continuous Trail Unmanned Vessel" (known as Sea Hunter) attempts to detect and track quiet diesel electric submarines for several months at a time. In order to perform this mission, the system will need to demonstrate several facets of advanced autonomous operation, including autonomous compliance with maritime laws and conventions for safe navigation, unmanned system management for operational reliability, and autonomous interactions with an intelligent adversary. In order to ascertain the effectiveness of the UMVs in ASW, Salim [9] used an agent-based simulation platform known as Map Aware Non-Uniform Automata (MANA) to model the ASW effectiveness of UMVs while considering their advantage of long on-station time and disadvantage of low speed (as compared to helicopters). A generic scenario was created to allow experiment with potential UMVs capabilities in ASW missions. The modelling first focuses on building an existing ASW screening scenario in MANA. In this scenario, two frigates with hull-mounted active sonars were positioned on the inner ASW screen and two ASW helicopters with active dipping sonars were positioned on the outer ASW screen to protect an HVU from submarine attacks. This baseline scenario provides a standardized benchmark on current ASW performance. In this regard, the researcher conducted a field survey to ascertain the effectiveness of UMVs in ASW operations. The result is as shown in Table 7.

Table 7: Respondents' Views on Effectiveness of UMVs in ASW Operations

SERIAL	RESPONSE	FREQUENCY	PERCENTAGE	REMARKS
(a)	**(b)**	**(c)**	**(d)**	**(e)**
1	Agreed	197	89.1	
2	Disagreed	18	8.1	
3	Undecided	6	2.8	
	Total	**221**	**100**	

Table 7 above indicate that 89.1 per cent of the respondents agreed that UMVs are very effective in conducting ASW operations. Also 8.1 per cent disagreed and 2.8 per cent were indifferent. The result reinforces that UMVs impact positively on ASW operations for national defence and security.

Presentation of data on challenges to employment of UMVs for national defence

The challenges of employment of UMVs for national defence and security are accidental attacks and unintended interactions, cycle of measures and counter measures and environmental protection. These challenges are discussed in the subsequent paragraphs.

Accidental attacks and unintended interactions

Mechanical failures, malfunctions or mistakes are inevitable. When these unfortunately occur, will the fact that the system was operating autonomously create greater tensions. The deployment of a highly autonomous system outside of communication range and outside of an active conflict could lead to an accidental attack on or collision with a military object of another country. Although the object might be a legitimate target in wartime, an unintended attack in peacetime or in a period of tension could trigger retaliation, escalation and incite a broader conflict.

Singh [10] was of the opinion that around 90% of global trade is carried out by maritime shipping. Hence, nations will need to consider industry and commerce as important stakeholders in the consideration of weaponized autonomous UMVs. Consequently, an accidental attack on a civilian vessel by an autonomous UMVs might alter public perception of the reliability and safety of these systems as well as whether they are an impediment to freedom of navigation.

The result of survey on accidental attacks and unintended interaction is as shown in Table 8. From the response, 10.4 per cent disagreed that deployment of UMVs in the maritime domain could bring about accidental attacks and unintended interaction with other neutral vessels transiting within the deployment area. About 85.5 per cent, however agreed, while 4.1 per cent were undecided.

Table 8: Respondents' Views on Accidental Attacks and Unintended Interactions of UMVs in Maritime Environment

SERIAL	RESPONSE	FREQUENCY	PERCENTAGE	REMARKS
(a)	**(b)**	**(c)**	**(d)**	**(e)**
1	Agreed	189	85.5	
2	Disagreed	23	10.4	
3	Undecided	9	4.1	
	Total	**221**	**100**	

Smarting from the foregoing, majority of the respondent agreed that employment of UMVs for national defence of the maritime environment could bring serious accidental and unintended interaction with vessels transiting on safe passage. The result of the survey was corroborated by Wrobel *et al.* [11] stated that the occurrence of navigational accidents can be expected to decrease with development of UMVs. However, the extent of consequences resulting from non-navigational accidents can be expected to be much larger for the UMVs when compared with conventional vessels. Therefore, accidental attacks are a major concern for employment of UMVs for national security and defence of the maritime environment.

Cycle of measures and counter measures

A wide range of countermeasures can be conceived for hijacking or interfering with UMV systems. As seen throughout history with other technological advances in warfare, a cycle of measures and counter-measures can be expected that will require continuous investment and improvement of the systems. The more autonomous and sophisticated a system, the more the system will rely on its software which will be a critical point of vulnerability. Thus, weaponization of increasing autonomous UMVs will fuel cyber operations to exploit such vulnerabilities.

Solnør *et al.* [12] stated that UMVs are vulnerable to passive and active cyber-physical attacks that can be used for industrial espionage and hijacking attempts. Since attackers can use hijacked vehicles as weapons in terrorist attacks, ensuring the secure operation of such vehicles is critical to prevent the attacks from causing dire financial consequences, or worse, the loss of human lives. He emphasized that high-level descriptions of vulnerabilities and attacks, and the true impact of the described attacks remains unclear.

An illustration of the respondents' view is as shown in Table 9 and Figure 9. From the respondents representing 76.0 per cent agreed that cycle of measures and counter-measures that will require continuous investment and improvement of the systems is expected with UMVs while 19.0 per cent of the respondents disagreed and 5.0 per cent were not sure. This indicates that cycle of measures and counter measures may hinder the employment of UMVs for national defence in the maritime domain.

Table 9: Respondents' Views on Cycle of Measures and Counter Measures in Protecting UMVs in Maritime Environment

SERIAL	RESPONSE	FREQUENCY	PERCENTAGE	REMARKS
(a)	**(b)**	**(c)**	**(d)**	**(e)**
1	Agreed	168	76	
2	Disagreed	42	30.8	
3	Not sure	11	5	
	Total	**221**	**100**	

Solnør *et al.* [12] emphasized that cyber-attacks against equipped UMVs may lead to catastrophic accidents and political tension. A malicious actor may endanger the confidentiality of UMVs by capturing and disclosing sensitive data. This has further declined the potentials of UMVs employment for national defence.

Environmental protection

Increasingly autonomous systems operating for extended time spans in remote areas will require a long-lasting energy source. Systems with low manoeuvrability require significantly less energy and considerable research is underway on sustainable energy sources such as harnessing ocean currents. Highly manoeuvrable systems will require significant energy resources from batteries, diesel or gas.

The UN Convention on the Law of the Sea notes the requirement that States Parties "protect and preserve the marine environment", as well as "take measures to prevent, reduce, and control marine pollution from any source". More generally, States have the obligation to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or areas otherwise beyond the limits of its national jurisdiction. An important consideration is what will happen to autonomous weaponized UMVs at the end of their active life. Will there be an obligation for a State to recuperate them when their missions are completed? Depending on their energy source and payload, are there environmental concerns that arise from malfunctioning or unrecoverable objects? Due to the potential for catastrophic environmental consequences, as a precautionary measure, should autonomous_nuclear-powered UMVs be pre-emptively banned?

Even if autonomous UMVs were able to allay all of the concerns and challenges mentioned above, a range of risks and policy issues would remain. While these are not unique to the maritime environment, they are worthy of mention here as maritime autonomy is developing so quickly. In order to ascertain the perceived environmental concern among technologists and technicians in the maritime environment, a survey was conducted and the respondents' views are at shown in Table 10. In the survey, 173 respondents representing 78.3 per cent agreed that environmental protection is a serious concern towards deployment of UMVs for national defence, while 18.1 per cent of the respondents disagreed and 3.6 per cent were not sure. This indicates that environmental protection has remained a concern towards employment of UMVs in the maritime domain.

Table 10: Respondents' Views on Environmental Protection Issues towards Employment of UMVs in Maritime Environment

SERIAL	RESPONSE	FREQUENCY	PERCENTAGE	REMARKS
(a)	**(b)**	**(c)**	**(d)**	**(e)**
1	Agreed	173	78.3	
2	Disagreed	40	18.1	
3	Not sure	8	3.6	
	Total	**221**	**100**	

Strategies to mitigate the challenges of employment of UMVs for national defence in the maritime domain

The strategies to mitigate the challenges of employment of UMVs for national defence are development of new curriculum to produce technologically educated personnel, navies need to programme their operations, units and systems to suit multi-vehicle control and proficient testing and validation institute to test the new technologies. The proffered strategies were subjected to Suitability, Acceptability, Feasibility and Ethics (SAFE) test as indicated in Appendix 3.

Development of new curriculum to produce technologically educated personnel

There will be a need to develop new training curriculum to produce technologically educated and AI calibrated personnel. Currently, majority of the applications of AI to naval operations are dependent on a human operator, making human-machine calibration immensely important. Naval combat systems only perform analytical functions in a combat scenario, whereas the final decision of engagement rests with the commander. Therefore, there is the need to ensure new specialist training curriculum for naval and coast guard personnel to ameliorate the challenge associated with the employment of UMVs for national defence.

Navies need to programme their operations, units and systems to suit multi-vehicle control

In an era that precedes man-machine teaming in lethal engagements, navies need to programme their operations, unit and systems with all prospects, no matter how remote they may seem. Naval operations through information management systems are to enhance and influence the decision-making process of the commanders. The AI software gives command the ability to monitor concurrent combat situations and duly utilise the naval assets at their disposal. These systems are combined with hardware to fully transform naval manoeuvres. The AI systems can reduce fatigue and greatly boost the operational proficiency of sub-surface commanders who often engaged in dull operations that require patience, skill and navigational expertise, and above all, the ability to react to sudden changes in combat situations.

Proficient testing and validation institute to test the new technologies

First time users of UMVs must anticipate a debugging and calibration period during which the system's actual capabilities and limitations are determined. Automation in these systems should not be taken at face value (i.e. it's always right), it can lull operators into a false sense of security with result that will not make checks that would otherwise be advisable. Another barrier to the development and deployment of such systems are their vulnerabilities from countermeasures, some of which have already been created. Additionally, the functioning of unmanned vehicles in GPS-denied environments, either due to constraints of bathymetry, or GPS jamming by enemy forces, raises serious concerns about how such systems would work uninterrupted. Non-GPS based guiding systems and anti-jamming protection software will need to be included in the research and development process and likewise proficient testing and validation institute to test these new technologies.

Prospects for improving the impact of new technologies for national defence in the maritime domain

The prospects for improving the influence of new technologies for enhanced national defence are proposed integration of NNEC as engineering campus for International Maritime University (IMU) and sustainment Admiralty University of Nigeria (ADUN). These prospects are discussed in the subsequent paragraphs.

Proposed integration of Nigerian Naval Engineering College into Engineering Campus for International Maritime University

The efforts of the NNEC authority towards ensuring full accreditation by the NBTE as well as approval by the National Universities Commission (NUC) to run university programmes appear to be yielding results. In August 2015 a team from Hellenic Educational Limited (HEL) representing University of Nicosia, Cyprus visited the NNEC Sapele. The visit was to inspect the College facility with a view to firming up modalities to integrate the College as an engineering satellite campus for the proposed IMU in Delta State. To this end, NBTE and NUC were invited for accreditation inspection of the programmes in the NNEC Sapele.

The equipment and training facilities at the NNEC Sapele are to be upgraded for technical training of the NN personnel as well as the new IMU. Also workshops and laboratories in the College are to be upgraded. Apart from this, the College would run specialised professional courses such as Automobile and advanced training courses. These courses are specially designed to meet the Service requirements. Therefore, the proposed integration of NNEC Sapele into an Engineering Campus if pursed to fruition holds prospect for technical training of the NN personnel for enhanced operational effectiveness.

Sustainment of Admiralty University of Nigeria

The sustainment of ADUN Admiralty University of Nigeria will enhance local training of NN officers and personnel. ADUN was conceived to expand the frontiers of knowledge for the growth and development of humanity, meet the training needs of the NN along with those of sister services. This is in addition to reduce travel abroad for training and the pressure it imposed on foreign exchange as well as to improve technical training and enhancing operational effectiveness of the Nigerian Navy.

It is believed that ADUN will deliver undergraduate, graduate, post-graduate degree and certificate programs in 9 faculties on 4 campuses and its main campus in Ibusa as well as additional campuses in Lagos, Sapele and Calabar. Equally, it offers a non-traditional teaching and learning environment in line to the best educational practices as experienced by students at some of the best universities in the United States and Europe. Thus, the sustenance of the ADUN would greatly improve technical training for enhanced operational effectiveness in the Nigerian Navy.

CONCLUSION

This research focused both on current and future technology for unmanned maritime vehicles vis-à-vis the impact of new technologies for national defence. The study revealed the effects of UMVs on national defence in the maritime domain. The effects include ISR, MCM and anti-submarine warfare. For ISR effect, 175 (79.2 %) of respondents agreed that UMVs can be performing ISR more effectively than manned systems. Also, 37 (16.7%) respondents disagree and 9 respondents were indifferent. Hence, employment of UMVs for ISR mission has positive effect on national defence and security. Additionally, 95.5 per cent of the respondents agreed that the autonomous UMVs would perform incredibly well in MCM mission whilst 2.7 per cent and 1.8 per cent disagreed and indifferent respectively. This result reinforces the impact of UMVs in MCM missions for enhanced national defence. On ASW, about 89.1 per cent of the respondents affirmed that UMVs are very effective in conducting ASW operations whereas 8.1 per cent disagreed and 2.8 per cent were indifferent. The result reinforces that UMVs impact positively on ASW operations for national defence and security.

The challenges associated with the employment of UMVs include accidental attacks and unintended interactions, cycle of measures and counter measures as well as environmental protection. Despite these challenges there were some identified prospects for improving the impact of new technologies for national defence in the maritime domain. The prospects include increased connectivity networks and proposed law enforcement operations. Furthermore, the present study proffered strategies to mitigate the challenges of employment of UMVs for national defence. The strategies include development of new curriculum to produce technologically educated personnel, navies need to programme their operations, units and systems to suit multi-vehicle control and finally proficient testing and validation institute to test the new technologies.

REFERENCES

1. AMEER, M. (2022). Exploring Emerging Technologies for Enhanced Counterterrorism and counterinsurgency Operations in the Armed Forces of Nigeria. A paper presented at the Armed forces command and staff college on 23 February 2022.
2. BITZINGER, R.A. (2021). The Revolution in Military Affairs and the Global Defence Industry: Reactions and Interactions. Security Challenges, Vol. 4, No. 4 (Summer 2008), pp. 1-11. At https://search.informit.org/doi/abs/10.3316/ielapa.200902020 Accessed 31 May 22.
3. ESA (2023). Unmanned Maritime System. Available at https://business.esa.int/funding/invitation-to-tender/unmanned-maritime-systems-ums. Accessed 1 August 2023.
4. PURDY, E.M. (2008). The Increasing Role of Robotics in National Security. Office of the Deputy Under Secretary of Defense for Acquisition and Technology Washington United States. At https://apps.dtic.mil/sti/citations/AD1016191 Accessed on 29 May 22.
5. SLOVIN, E. (1960). Slovin’s Formula for Sampling Technique. Available at <http://www.slideshare.net/ludymae/chapter-8sample-sampling-techniques> accessed 27 March 2022.
6. SAVITZ, S. (2020). The Marine Transportation System, Autonomous Technology, and Implications for the U.S. Coast Guard. RAND Corporation.
7. FLETCHER, B. (2020). New Roles for UUVS in Intelligence, Surveillance and Reconnaissance. Space and Naval Warfare Systems Centre D744, San Diego, CA USA. P. 2-7.
8. NAVAL DRONES (2017). Exclusive Content on Unmanned Naval Systems. Available at http://www.navaldrones.com/ACTUV.html
9. SALIM, U. (2015). Effectiveness of Unmanned Surface Vehicles in Anti-Submarine Warfare with the Goal of Protecting a High Value Unit.

A dissertation submitted to Naval Postgraduate School, Monterey, California.
10. SINGH, A.P. (2021). Study on the implications of autonomous ships on maritime security and law enforcement by reviewing maritime security incidents. World Maritime University Dissertations. 1746.
11. WROBEL, K., MONTEWKA, J. & KUJALA, P. (2017). Towards the assessment of potential impact of unmanned vessels on maritime transportation safety. *Reliability Engineering & System Safety*, **165**: 155-169.
12. SOLNØR, P., VOLDEN, O., GRYTE, K., PETROVIC, S. & FOSSEN, T.I. (2022). Hijacking of unmanned surface vehicles: A demonstration of attacks and countermeasures in the field. *Journal of Field Robotics*, **39**: 631–649.

APPENDIX 1 – QUESTIONNAIRE

SECTION A

Instructions:
A. New technologies are to be considered in relation to national defence.
B. You are please kindly requested to either tick or fill the spaces provided and feel free to express your opinion in any aspect.

PERSONAL DATA OF RESPONDENTS

1. Gender: Male ☐ Female ☐

2. Age: 21-30 ☐ 31-40 ☐ ☐ 41-50 ☐ 51 and above

3. Profession: Military ☐ Civilian ☐

4. Place of Residence……………………………………………………….

5. Years in Service: 0-10 ☐ 11 and above ☐

6. Designation:____

7. Academic Qualification: Secondary ☐ OND/Diploma ☐
   BSc/HND ☐ Post- Graduate ☐

SECTION B: (Please tick as appropriate)

NEW TECHNOLOGIES AND NATIONAL DEFENCE IN THE MARITIME DOMAIN

8. Do you know the meaning of new technologies and its purpose?

   Yes ☐ No ☐ Indifferent ☐ Slightly ☐

9. Are you aware that new technologies can impact national defence in the maritime domain?

   Yes ☐ No ☐ Indifferent ☐ Fairly ☐

10. Do you agree that employment of UMVs would enhance national defence?

Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided

11. How effective are new technologies towards enhancing national defence?

Very Effective ☐ Effective ☐ Not Effective ☐

12. Do you agree that new technologies would improve national defence in the maritime domain?

Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided

SECTION C: **(Please tick as appropriate)**
This section addresses issues associated with employment of UMVs for national defence in the maritime domain.

13. Do you know why it is important to control the deployment of UMVs n the maritime environment?
Yes ☐ No ☐ Indifferent ☐

14. Do you agree that the increased actors and objects in the maritime environment could be a serious challenge to the deployment of UMVs for national defence?

Agree ☐ Disagree ☐ Indifferent ☐

15. Do you agree that increased autonomy and connectivity would boost operational abilities of UMVs?

Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided

16. Do you agree that UMVs should be considered as a means of imposing law and order in the maritime domain?

Agree ☐ Disagree ☐ Indifferent ☐

17. Do you agree that spread of new and advanced technologies has led to grave concern regarding proliferation of technologies into irresponsible hands?

Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided

18. How do you rate the significance of technological realities on the security perception and defence operations of individual nations?
Adequate ☐ Inadequate ☐ Indifferent ☐

19. Do you agree that some diffusion of military technologies has become unavoidable in this IT age , thereby creating new challenges for the future of technology control?

Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided

SECTION D: **(Please tick as appropriate)**
This section covers the aspect of effects of UMVs on national defence.

20. Does technical training have effect on technical personnel proficiency in NN?
Adequate ☐ Inadequate ☐ Indifferent ☐

21. Does Technical training improve maintenance of the NN platforms?

Adequate ☐ Inadequate ☐ Indifferent ☐

22. Does technical training have effect on equipment serviceability in the NN?

Adequate ☐ Inadequate ☐ Indifferent ☐

<u>SECTION E:</u> **(Please indicate as appropriate)**

This section covers the aspect of challenges of employment of UMVs for national defence in the maritime domain.

23. Do you agree that deployment of UMVs in the maritime domain could bring about accidental attacks and unintended interactions with other neutral vessels?

Strongly Agree	**Agree**	**Disagree**	**Strongly Disagree**	**Undecided**

24. Do you agree that a wide range of measures and counter measures can be conceived for hijacking or interfering with UMV systems?

Strongly Agree	**Agree**	**Disagree**	**Strongly Disagree**	**Undecided**

25. Do you agree that environmental protection is a concern towards deployment of UMVs in the maritime environment?

Strongly Agree	**Agree**	**Disagree**	**Strongly Disagree**	**Undecided**

26. What is your overall opinion about the impact of UMVs for national defence in the maritime environment?

27. Please list other effects of UMVs employment on national defence …………..…………………………………………………………………………

APPENDIX 2 - SAMPLE OF INTERVIEW GUIDE

GENERAL

A. Impact of new technologies for national defence: an analysis of current and future technology for unmanned maritime vehicles.

B. Date of Interview:

C. Location:

INTERVIEW QUESTIONS

1. When was UMV introduced in the maritime environment for national defence?

2. Are new technologies expected to have major impact on the development of societies and contribute positively to national defence over the coming years?

3. How would you rate the existing naval capabilities in defence of the maritime domain of individual nations?

4. What would you say are the effects of employment of UMVs for national defence in the maritime domain?

5. What would you say are the major challenges militating against the employment of UMVs for national defence in the maritime environment?

6. In terms of policy provisions, would you say a specific policy is necessary for the employment of UMVs for national defence in the maritime domain?

7. In which areas have UMVs made most significant contributions since its introduction in the maritime domain?

8. What are the prospects of improving the influence of new technologies for national defence in the maritime domain?

9. What strategies would you proffer for dealing with identified challenges to the employment of UMVs for national defence in the maritime domain?

10. How do you see the impact of UMVs in the maritime environment in the next 10 years?

APPENDIX 3 - SAFE TEST CRITERIA FOR PROFFERED STRATEGIES

Serial	Strategies	Criteria				Remarks
		Suitability	Acceptability	Feasibility	Ethical	
(a)	(b)	(c)	(d)	(e)	(f)	(g)
1.	Development of new curriculum to produce technologically educated personnel.	This strategy will boost the capacity of personnel on human-machine calibration and AI	This strategy is agreeable and expected to maximize the impact of UMVs for national defence in the maritime domain.	The funding for this training could be through the defence headquarters.	The strategy is ethical as it would impact new technologies positively and by extension enhances national defence.	
2.	Programming of operations, units and systems to suit multi-vehicle control.	This strategy would ameliorate combat situations and boost operational proficiency of sub-commanders.	a. The strategy will be acceptable to all relevant stakeholders. b. It will serve as as one of the drivers of information management system for enhanced national defence.	This strategy could integrate all relevant units in the navies.	a. This strategy is ethical as it would increase the ability of navies to react to sudden changes in combat situations. b. It is durable and in line with global best practices.	
3.	Proficient testing and validation institute to test new technologies.	This strategy would mitigate the challenge of vulnerability from countermeasures.	a. The strategy is reasonable and agreeable to ministries of defence and science and technology. b. It is expected to employ modern measures of upgrading the new technologies.	The funding for this could be from budgetary allocation of ministry of defence.	It is durable and would endure long period.	