UNMANNED UNDERWATER VEHICLES (UUV) BASED ON MINE COUNTER MEASURERS

Submitted By:

Lt BGMB Dissanayake

Lt Ricardo Costa

Guided by:

Lt Cdr Sumit Rathore

ANTI SUBMARINE WARFARE SCHOOL

INS VENDURUTHY, KOCHI, KERALA, INDIA

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CHAPTER I

INTRODUCTION

Aim

1. The aim of this study is to examine mine warfare with a view to exploring the various UUV based Mine Counter Measures by different countries of the world.

History

2. A naval mine or sea mines in the sense a self-contained explosive device which is lying in navigable waters with the intention of destroying or damaging enemy submarines and surface vessels. It is also defined by NATO as “an explosive device lay in the water, on the seabed or in the subsoil thereof, with the intention of damaging or sinking ships or of deterring shipping from entering an area”. Thus, the sea mine can be employed to restrict enemy access to vulnerable areas as well as to confine the enemy into certain locations.

3. The first use of mine warfare occurred around 1585 in Belgium during they were fighting against Spain. After few years in 1776, an American scientist who name David Bushnell, introduced the first concept of mine warfare to the world by introducing “Bushnell’s Keg”. The new sea mine was approved for use against the British fleet during 1777 by General George Washington to destroy the enemy ships during the American Revolution war. The mine consisted of a wooden keg filled with gunpowder and fitted with a primitive contact fuse as well as floating wooden bodies. Although, the mine was not very reliable not successful, it turned out to be an effective psychological deterrent to the adversary during the war.

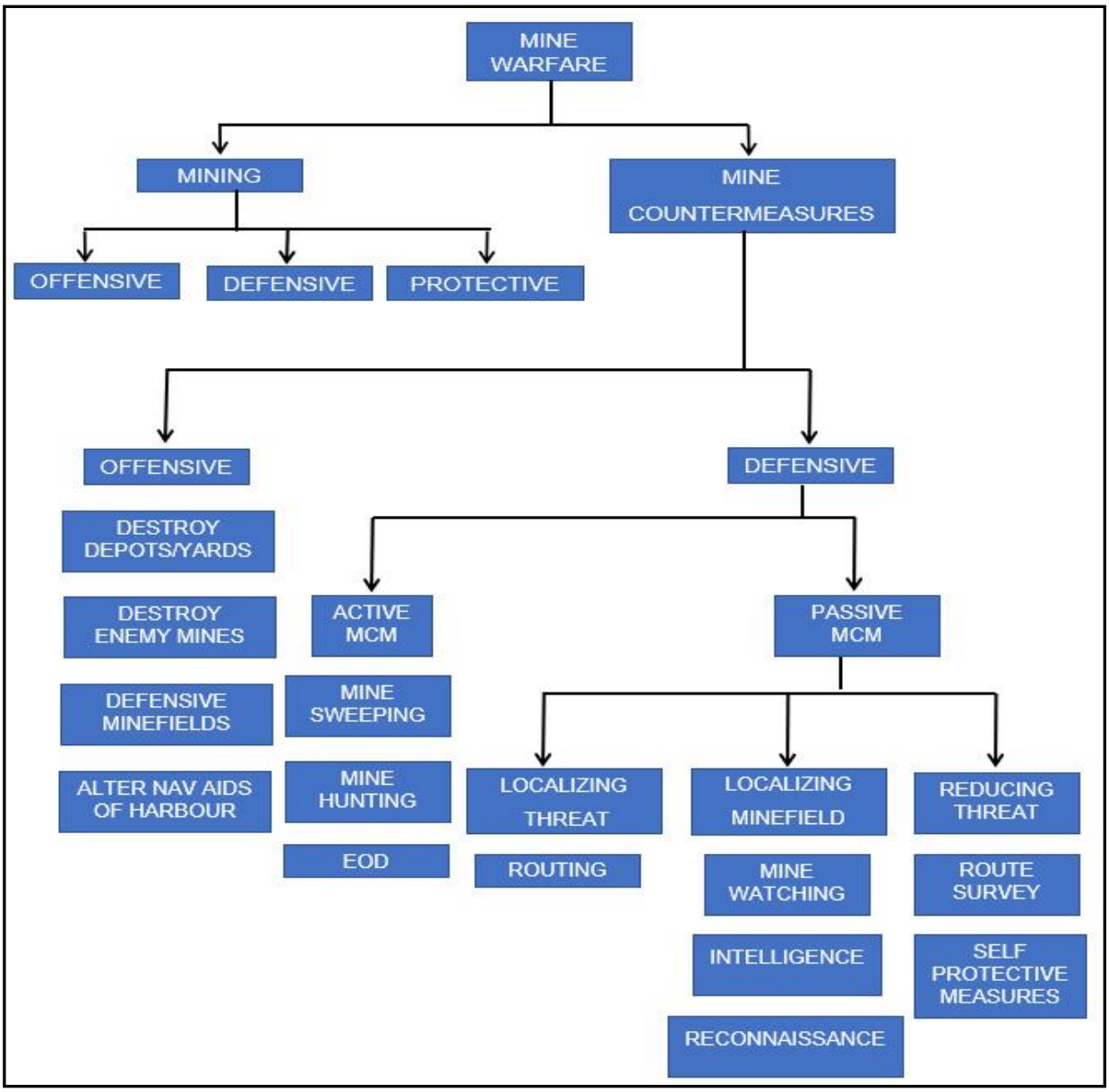
4. Robert Fulton invented several sea mines during 1797 to 1812. But his mines unable to convince the major sea powers like USA, UK, and France. Samuel Sommering from Russia able to detonate the first electrical mine and thereafter his experiments caught by Barron Pavel Schilling. After many experiments Russia able to deploy first contact mine against British during Crimean war during 1853 to 1855. During 1842 in USA Samuel Colt developed first electrical firing mine and during American civil war 1862 to 1865 it mostly used. They developed a contact mine call ‘Singer’ also.

5. Sea mines were also successfully employed during the Russo-Japanese War from 1904 to 1905. Both nations were well equipped with contact mines and

mine layers. Due to Russians laid mines in open sea many neutral merchant ships were damaged and this issue lead the forming of Hague convention in 1907.

6. During WW I, Allies laid about 70000 mines in 230 nm between Orkney Island and Norway coast and it is the biggest mine field ever in history. During this time British developed first influence ground mine in 1917 and German use Submarines as mine layers for the first time.

7. During WW II mines use as offensive weapon rather than defensive weapon. Nearly seven lakhs of mines were laid and accounted for most ship damages. In 1940 German navy able to deploy influence mines. Both Nazi and Axis forces effectively laid the mines and information states that about 3000 vessels sunken/ damage.



CHAPTER II

CLASSIFICATION OF MINE

TYPES OF NAVAL MINES

8. Since the invention of mines by David Bushnell, many advance concepts and improvement have been achieved which has made it more sophisticated. This ranges from unsophisticated indiscriminate mines used at the early stages of mining, then to the remote detonation and the target selective capabilities of modern mines. Thus, there are various types of mines which can be categorized based on their shape, position in water, method of actuation, method of delivery, and counter measures.

a. **Shape**

As per shape there are 03 types of Mines and these shapes have been modified to reduce detection, provide stealth, accommodate the explosives, as well as to cater for the various means of actuation.

(1) **Spherical shaped mine** Due to their shapes, they are usually laid by surface ships and mostly act as floating mines.

(2) **Cylindrical shaped mine** These mines are usually placed on the seabed and can be laid by surface ships as well as by submarines.

(3) **Cylindrical round ended mine** These mines are usually made up of 2 round ends and usually laid by surface ships, as moored mines, and activated by contact or influence.

b. **Position**

Mines are also classified according to the position in water where they laid, relative to the seabed. They are three types.

(1) **Moving mine**. Moving mines are mostly lay on sea surface and works independent from the seabed as contact actuation mine.

(a) **Drifting mined** Mine is designed as positively buoyant and free to move on or just below the sea surface.

(b) **Creeping mine** Creeping mine is a buoyant mine located below the sea surface by a weight or “light sinker” which is usually in the form of a chain.

(c) **Oscillating mine** This mine has a hydrostatic depth control mechanism which permits it to rise and sink vertically, about a set depth.

(d) **Rising mine** Rising mine is a positively buoyant mine which is held under the sea surface by a sinker.

(e) **Bouquet mine** Bouquet mine consists of multiple mines attached to the same sinker by means of mooring cables.

(f) **Active mine** This mine is designed to transmitting acoustic signal towards a target and if there is a valid detection, the mine is activated.

(g) **Homing mine** Homing mine is designed to lie on the seabed or secured to a sinker and it is capable to propelled and home into its target.

(2) **Moored mine** Moored mines are positively buoyant mines held below the sea surface by a mooring cable linked to a sinker on the seabed.

(3) **Ground/Bottom mine** Ground mines are negatively buoyant mines, which are lying on seabed by its own weight.

c. **Method of Delivery**

Mines can be categorized further based on their method of delivery.

(1) **Aircraft laid mine** Mines can be laid with the use of air assets which drop them like bombs. Aircrafts are usually employed in laying offensive mines in a relatively short time, but helicopters can also be used for defensive mining.

(2) **Submarine laid mine** Usually, submarines are using their torpedo tubes, or a specially designed mine belt attached to her outer hull to lay mines. The mines are usually fired from the torpedo tubes.

(3) **Surface ship laid mine** Surface ships of various sizes or types can be engaged for mine laying, thus, enabling them to be laid covertly. They can easily carry a much larger number of mines economically, as well as position them accurately.

d. **Method of Actuation**

There are basically three methods which mines can classified based on the type of sensor mechanism or process required to activate and subsequently detonate them.

(1) **Contact mines**. The physical contact mine is the earliest known form of mine activation. It can be further divided into various sub types.

(a) **Chemical horn mechanism** This initiates the electrochemical reaction, and the explosion occurs.

(b) **Switch horn mechanism** The switch horn mechanism is designed in the form of an electric switch which is activated when the target encounters it.

(c) **Snag line mechanism**.

A buoyant line attached to one of the horns or switches which may be contact and pull by ship propellers or hull.

(d) **Galvanic action mechanism** Galvanic action mine works on the principle of electrochemistry. An electric current is generated using a copper or brass electrode on the mine and sea water as the electrolyte.

(e) **Inertial switch mine** the inertial switch mine works on the principle of friction. It comprises a corrugated tube which is compressed when a target hits the mine.

(2) **Command and control mine** These mines are designed such that it can only be detonated by some arming order initiated from the user.

(a) **Cable Controlled mines** Cable-controlled mines may be incorporated with a sensor which permits it to detect a ship or submarine and send a signal to the shore station.

(b) **Cable less Controlled mines** The Cableless Controlled mines are designed such that they do not require a cable connection between the mine and the shore station or firing platform.

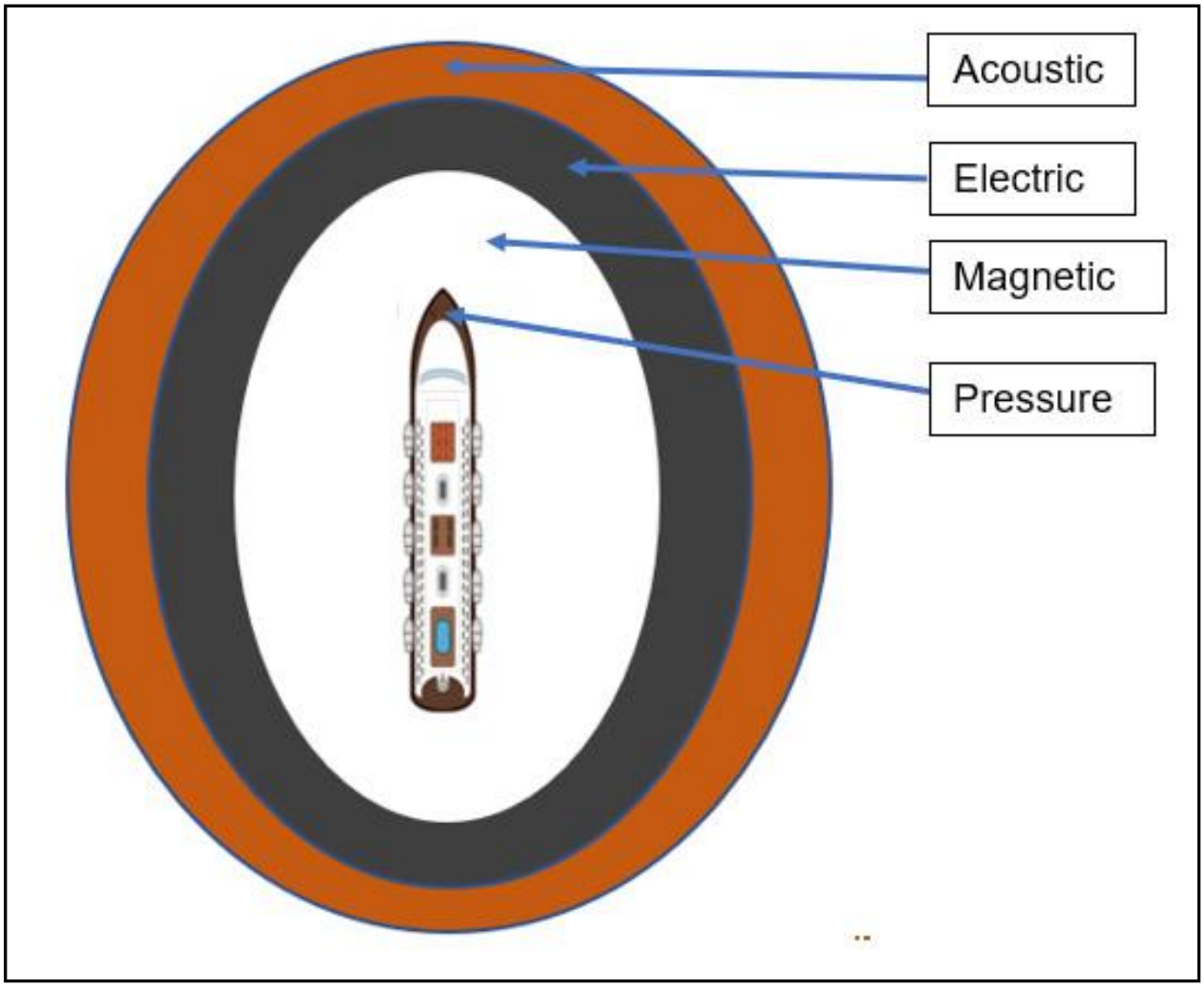
(3) **Influence signature actuation**. The influence mine is the most familiar activation method. It is designed to activate by a sensor which detects the presence of the target influence and no need to encountering it.

(a) **Magnetic mine** Magnetic mine utilizes magnetic search coils or magnetometers to detect the static field of a vessel and get activated by change in earth's magnetic field caused by vessel passing over mine area.

(b) **Pressure mine** These mines use electro-hydraulic pressure sensors to detect ship or submarine and get activated by the pressure drop associated with the passing of respective vessel.

(c) **Acoustic mine.** These mines consist of hydrophones to detect engine and propeller noise of ships and submarine. These mines activated when the noise emanated meet certain predetermined frequency and amplitude criteria that form the threshold of actuation.

(d) **Combination Influence mines.** These mines use combination of pressure, acoustic and magnetic sensors for actuation.


Acoustic
Electric
Magnetic
Pressure

CHAPTER III

MINING OPERATION

9. Mine warfare operations known to employ of various systems of mines to achieve sea power. Thus, mines, whether used offensively or defensively, may be employed by military forces to achieve a variety of objectives. Those include, blockade, preventing enemy access to an area, make psychological effect and material damage, force multiplier and personnel casualties.

Offensive mining

10. Offensive minefields are usually planted in enemy-controlled waters. This includes the mining of the enemy's waterways, harbors, and approaches. This is done with the aim of damaging enemy assets, delaying the movement of her ships, waste the enemies MCM efforts and to prevent her from receiving replenishment in war times. Offensive mining is usually carried out in war times and the execution of such in peace times will be termed as an act of war.

Defensive mining

11. Defensive minefields are usually deployed in waters which are not under enemy control, neutral waters, contested waters, international waters, or straits to intercept or deny transit of enemy forces as well as to dissuade and deter maritime operations in each area. It can also be employed to provide coastal defense, flank protection for allied forces against hostile platforms, defend SLOCs and focal points, control allied shipping and support own anti-submarine forces.

Protective mining

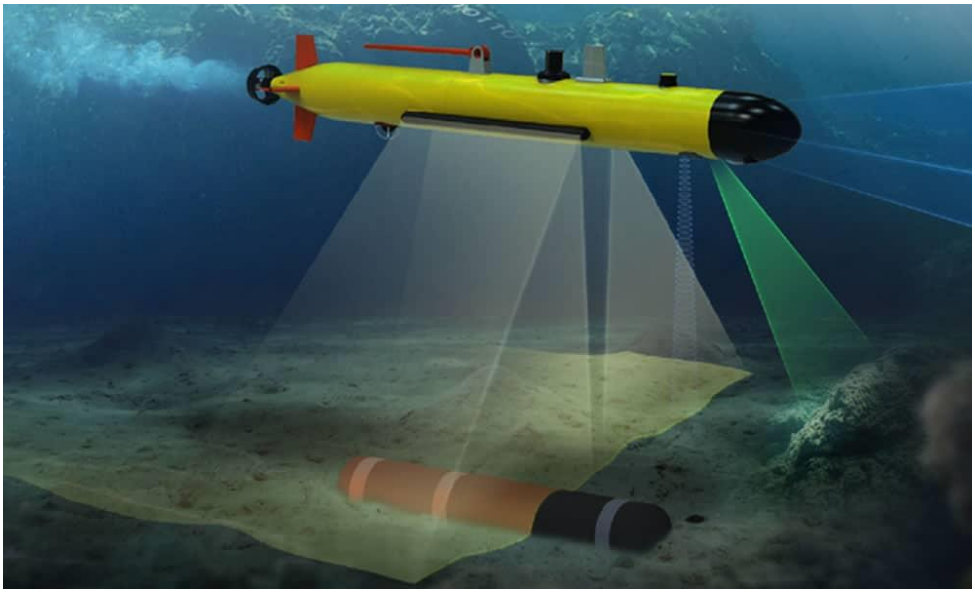
12**.** Protective minefields are usually placed in own, friendly, or territorial waters to protect own littoral areas including coastal ports, harbors, beaches, and SLOCs from hostile forces or enemy actions. It is employed to control allied shipping and choke points especially in areas of interest of the country. This includes offshore installations, oil rigs among others.

CHAPTER IV

ABOUT UUVS

What is UUV?

13. The technology advance allowance plan MCM operations and implement tactical decisions which reduce the risk of operating in mined waters and increasing the reliability of that intelligent systems. Such technologies are usually designed to be multipurpose, based onboard ships, helicopters, or shore stations. Unmanned underwater vehicles (UUV), sometimes known as underwater drones, are submersible vehicles that can operate underwater without a human occupant. These vehicles can be divided into two categories, remotely operated underwater vehicles (ROUVs) and autonomous underwater vehicles (AUVs). ROUVs are remotely controlled by a human operator. AUVs are automated and operate independently of direct human input.



The History of UUV

14. Underwater vehicles were first invented in the 1950s. Their design enabled them to carry out missions for the Navy and research colleges. In the 1960s, technology continued to advance. This allowed an underwater vehicles to even retrieve a lost nuclear bomb. The retrieval occurred off the coast of Spain and remained secret for many years. Since the 1970s, commercial industries began to use them in earnest. Underwater vehicles even saved the crew of a wrecked submarine during the 1970s. Droves grew in demand for their effectiveness and ability to do things no human could. The finding of the Titanic by Robert Ballard required a new type of ROV. They developed this machine with help from the Navy. The latest version enabled the discovery of the famous wrecks of the Titanic

and Bismarck. In the 1990s, new vehicles models could now disable mines and do other duties that once relied on human divers. During 2000s saw a massive boost to underwater drones. The reason behind this was the improvement of the lithium-ion battery technology.

15. As this method of energy storage improved, so too did the construction of UUVs. In decades past, a UUV would require a tremendous tether and a full research ship to deploy. In the 2000s, it became possible to deploy them off much smaller vessels. Since then, UUV usage has continued to grow. Underwater drones get used by industry and military missions around the world.

UUV related applications and missions

a. Intelligence, Surveillance and Reconnaissance

ISR is important not only for the traditional purpose of intelligence collection, but also as a precursor and enabler for other missions and applications of UUVs. The ISR mission area encompasses collection and delivery of many types of data, intelligence collection of all types, target detection, localization and mapping. UUVs are uniquely suited for information collection due to their ability to operate at long standoff distances, operate in shallow water areas, operate autonomously, and provide a level of clandestine capability not available with other systems

b. Mine Countermeasures

MCM mission requirements are driven by the need to rapidly establish large, safe operating areas and transit routes and lanes. Seven to ten days is emerging as the requirement to complete all MCM operations in specified areas, but clearly, quicker is better. The objective of this MCM capability is to create areas of operation that are clear of sea mines without requiring manned platforms to enter suspected mined areas and to shorten MCM timelines.

c. <u>Inspection / Identification</u>

This mission stems from the need to efficiently inspect ship hulls and piers

for foreign objects, such as an explosive device, to keep harbors and choke points safe. Currently, hull and pier inspection is generally both time and manpower intensive. Preparing a ship for divers may take several hours, and it requires coordination, as some damage control systems may have to remain on-line. Searching for unexploded ordnance that is typically time fused is particularly hazardous to divers. Use of an unmanned vehicle can reduce the risk to divers by providing precise location of suspicious objects, while relieving the divers of the tedious search process in cluttered environments.

d. Oceanography / Hydrography

All maritime platforms manned and unmanned, surface, air and undersea can gather oceanographic/hydrographic data to varying degrees in parallel with their other missions. Dedicated oceanographic/ hydrographic operations occur worldwide; these operations will be augmented by UUVs operating from survey ships and ships of opportunity that may be used as a platform for plug and play unmanned systems.

Advantages of UUVs

a. Compared to deploying divers, underwater UUVs are quite safe. Those who operate the UUVs can sit in the safety and comfort of a control room. Using UUVs can also increase the safety of divers who are accompanying them, by keeping a steady eye out for any potential danger.

b. Another key advantage of using UUV is the time they can stay underwater. Scuba tanks last for one hour in water that's not deep or choppy. While some tanks arrangements can prolong this, the more activity the diver must do, the more oxygen they use up.

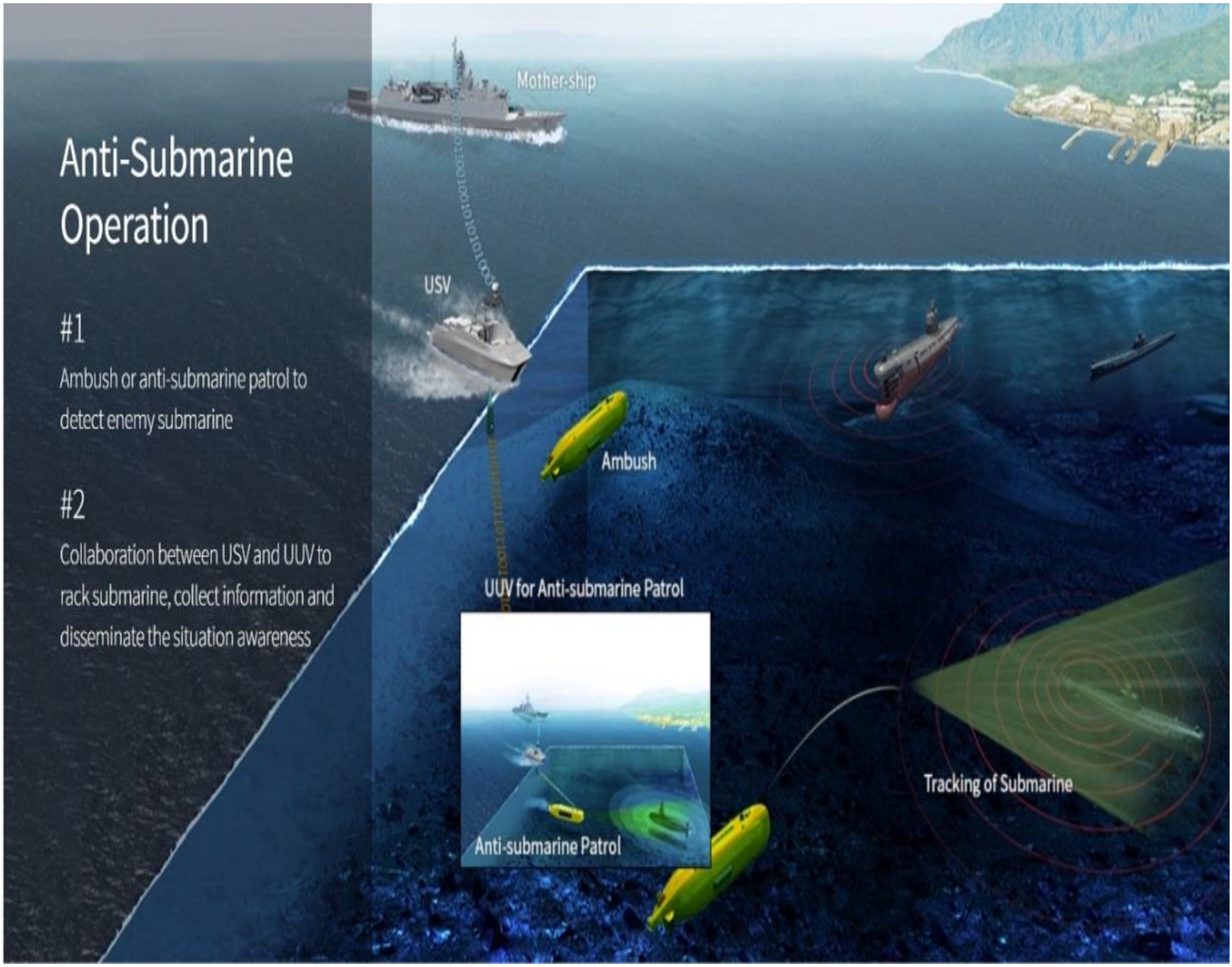
c. UUVs don't need oxygen and operate off battery power. This allows them to stay functioning for hours on end without the need to recharge. This can provide a worksite with constant monitoring, and UUVs can check far more of a pipeline or the seafloor than a diver could ever hope to.

d. Deploying UUV doesn't require expensive insurance and contracting costs. Some UUVs can be deployed by a single individual off of any boat. You don't need to have a crew or an expansive team to operate them, thus reducing operating costs considerably.

e. Main concepts of MCM operations using UUV systems are to reduce threats for the naval fleet through employing a robust, highly autonomous vehicle unit, which is capable of engagement and execution of mine sweeping or neutralization procedure.

f. The neutralization procedure entails either moving the mine out of the original place or precise delivery of the charged device to blast previously localized

mines, in volume, drift, floating, and bottom mines in the deep and shallow water zones.



CHAPTER V

USE OF UUVS IN MODERN NAVIES

AN/ASQ-235 Archerfish Airborne Mine Neutralization System (AMNS).

16. The Airborne Mine Neutralization System known as AMNS, is the U.S. Navy's standard for airborne mine clearance system which operate as remotely, expendable, device. AMNS neutralizes moored and bottom mines while operating from sea and land-based on MH-60S helicopters. By using helicopters as a central platform, mine clearance has become safer. Mines are first identified by the AN/AQS-20A sonar system or other mine countermeasure assets. The AMNS then identifies the location of the mines and neutralizes the target. AMNS consists of the following removable mission equipment,

a. Launch and Handling System
b. Common neutralizer vehicle
c. Common console display
d. Carriage, Stream, Tow and Recovery System

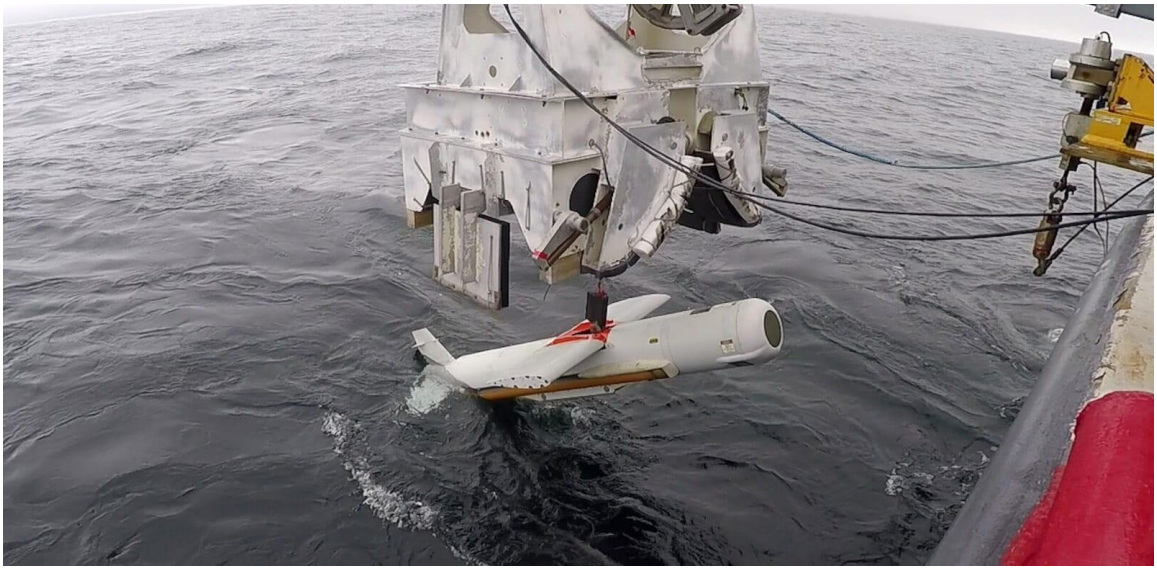
17. The mine neutralization begins with the deployment of the Launch and Handling System (LHS) from the MH-60S helicopter. Because it's compatible with MH-60S mechanical and electrical interfaces and supports easy on/off kit reconfiguration, the LHS is easily deployed from the aircraft. The highly effective LHS integrates many diverse high-tech capabilities into a single system, including a stable platform from which to launch the neutralizer vehicle.

18. The neutralizer vehicle is released from the LHS under the control of the sensor operator on the aircraft. The operator guides the lightweight (15.5 kg) and highly maneuverable vehicle to the target location using on-board sonar. After the target is viewed and positively identified with an on-board video camera, the operator fires an armor-piercing warhead from the vehicle to neutralize the mine. The neutralizer's state-of-the art electronics and sensors also provide a robust,

high-speed fiber optic data link, track responder and echo sounder. An inert unit with strobe light, acoustic beacon and recovery section is used for training.

AN/AQS-20C Mine hunting sonar.

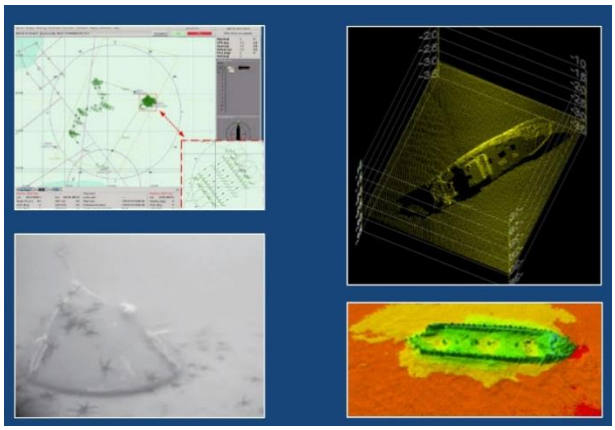
19. The AN/AQS-20C mine hunting sonar system is the U.S. Navy's latest mine hunting technology, which is integrated into the littoral combat ship mine countermeasures mission package. Its advanced signal processing and computer algorithms offer real time, computer aided detection and classification against a full spectrum of mines in deep and shallow waters. The AN/AQS-20C system is made up of four sonars that operate together to detect, classify, and identify mine like objects from the near surface of the sea to those on the sea floor in a single pass. It is made up of a pair of multi-function, side look synthetic aperture sonars capable of providing acoustic identification in all water conditions. It also has wide band forward looking sonar which simultaneously hunts mines and digital gap filler sonar that detects mines directly under the towed body. The system employs high-resolution sensors to provide a clearer and more definite picture of the environment. Aside this, the advanced automatic target recognition and high resolution, acoustic identification feature enables it to easily identify contact and enhances its ID capability without the electro-optic sensor. The system can be deployed from helicopters, surface vessels, boats, and USV as well as being paired with the barracuda mine neutralization system.



Integrated Mine Countermeasures System (IMCMS).

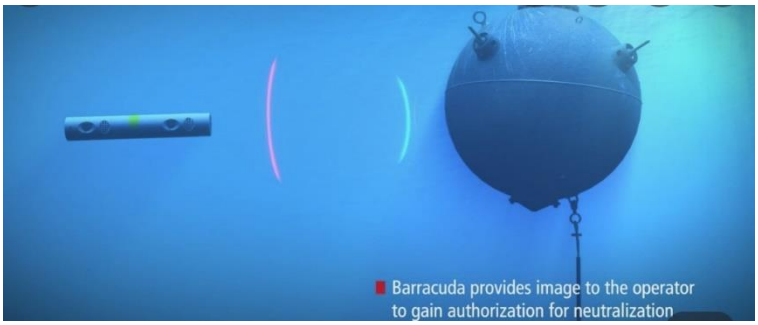
20. The Integrated Mine Countermeasures System (IMCMS) makes use of sensors systems and USV's and UUV's combining mine hunting and minesweeping to achieve effective neutralization of mines. A mobile variant of the IMCMS is being developed which will permit mine countermeasures on naval

vessels on foreign mission. This can then be carried on board the ship, in containers, to protect the safety of personnel and material.



Barracuda Mine Neutralization System.

21. Barracuda is a semiautonomous, expendable mine neutralizer vehicle, capable of neutralizing shallow water mines also. It is composed of a communications buoy, an extremely mobile vehicle propulsion system, the communications buoy links the vehicle operating below the surface and the mothership. It also assists in precise navigation for the vehicle while operating underwater. Barracuda can be deployed by MCM USV, helicopter or any ship capable of deploying A-Size sonobuoys. It can also be coupled with the AQS-20 sonar to provide a much faster MCM operation. It is equipped with electro optical sensor for homing and target tracking. After the target acquisition, the operator uses both sonar and optical sensors to position the vehicle to destroy the mine.



UAQS24B Unmanned Mine Hunter.

22. The UAQS24 system employs a high-speed synthetic aperture radar sonar for real-time, long-range detection, localization, and subsequent classification of bottom and moored mines. The system can be integrated with MCM USV or helicopters, to obtain a real-time transmission of all the AQS-24 data transmitted to a remote sonar operator either onboard a surface vessel or in a

shore station. The operator can then commence real-time mission analysis (RTMA) of the recorded data. This reduces the time lapse between the detection to engagement, as well as facilitate the reacquisition and identification of bottom mines. It is currently in use by the Australian, US and UK Navy.

CHAPTER VI

MODERN TRENDS IN UUVS

23. While the mines are evolving, the MCM efforts are following these advances. So, the Industry and countries are always developing new capabilities against the most sophisticated types of mines.

a. <u>UK Maritime Mine Counter Measure System (MMCM) / FRANCE Future Mine Warfare System (SLAM-F).</u>

(1) The UK MMCM/FRANCE SLAM-F is completely autonomous MCM system based on the mother ship concept developed by Thales for UK and France. Each set of MMCM consists of:

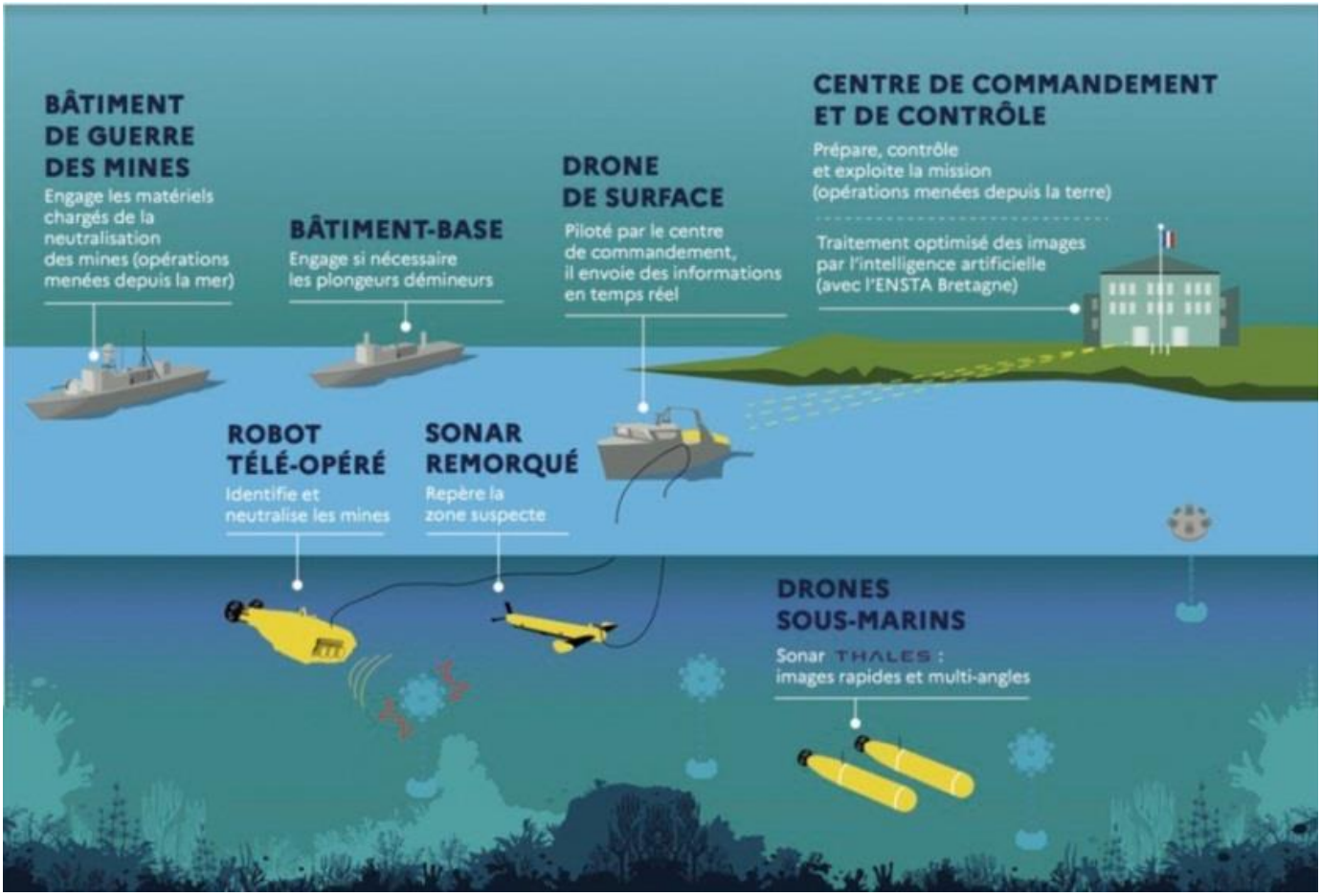
(a). A portable operation center including Mission Management System and Mi-MAP software for post mission analysis.

(b) Two Unmanned Surface Vessels (USV).

(c) USV 1 equipped with a volume search towed array sonar and one UUV/AUV equipped with the SAMDIS sonar and responsible for detecting, classifying, and locating the mines.

(d) USV 2 equipped with a ROV, the Multi-Shot Mine Neutralization System which neutralizes the detected mine.

(2) The system is designed to operate remotely and stay out of the mine field using unmanned systems. Thus, it is remotely controlled from the operation command center via a secure communication system. The operation command center which can be located ashore or on the mother ship can control up to three systems in parallel at sea.



b. <u>The Unmanned Influence Sweep System (UISS).</u>

(1). The Unmanned Influence Sweep System (UISS) is a self-propelled, semi-autonomous surface vessel developed by Textron Systems for the US Navy. The UISS is designed to be integrated with the LCS as part of the mine countermeasures mission (MCM) package. The system includes an MCM USV, an unmanned surface sweep system (US3), and a sensor package. The US3 includes a magnetic field generator, an acoustic generator, a power system, and other associated equipment.

(2). The UISS will provide an unmanned, off-board minesweeping capability in littoral areas. It is designed to enable mine clearance in sea lanes, fleet operating areas, straits, choke points, and amphibious objective areas. The UISS carries a range of sensors to sweep magnetic, acoustic, and magnetic-acoustic combination mine types. It can be fitted with payloads such as side-scan sonar, non-lethal weapons, mine neutralization, and intelligence, surveillance, and reconnaissance (ISR) sensors.

(3). The UISS USV is driven by a diesel engine. The vessel has a maximum range of 140km and can endure at sea for more than 20 hours. It has a towing capacity of about 4000lb (1,814.36g) while travelling at a speed of 20kt.

CHAPTER VII
RECOMMENDATIONS

24. Based on our study we come up with few recommendations which may immensely help to make more advance UUVs in future. Those Key defense and technology trends impacting the UUV are,

Modularity

25. The concepts of modularity and flexibility are supported to reduce both the time and cost of modernizing in service ships and adapt to future uncertainties. Navies consider modular systems as a means to deliver capability, which is leading to a growing demand for modular UUVs designed for multi missions. Companies, therefore, are designing their UUVs in the modular structure, allowing new technology to be embarked quickly without costly modifications to the host platform.

3D printing

26. 3D printers have already proved their worth in the aerospace and defense industry, which requires precision engineering to produce high specification parts. Aerospace in particular has seen some of the highest adoption rates across all industries, and the largest players are now transitioning from prototyping to parts manufacturing. Some companies and universities are looking to leverage 3D printing technologies for manufacturing UUVs.

Processor chips

27. Microprocessors serve as the control centers for unmanned vehicles, providing a platform for control and communications software that integrates with collision avoidance sensors, high-definition cameras, and other sensors. Advances in chip design, driven in large measure by the mobile phone industry, are leading to smaller chips with higher performance and lower cost, which in turn helps to drive down the manufacturing cost of unmanned vehicles. Chip manufacturers are expanding the capabilities of system on chip components to combine multiple sensing and processing elements on a single chip.

Artificial intelligence

28. The growing volume of data gathered by unmanned vehicles will create demand for increasingly sophisticated analysis of the data. Unmanned vehicles solutions need to make use of the latest data analytics technologies to effectively process incoming sensor data and draw meaningful conclusions.

29. Additionally, AI enables ‘continued learning’ for unmanned vehicles through machine learning techniques to enable complex capabilities such as autonomous navigation and obstacle recognition and avoidance. The industrial sector is already proving to be a significant market for unmanned vehicles with AI capabilities, while

the service sector companies are also vying for AI-enabled unmanned vehicles to develop new business models.

Name	Country's Operator	Manufacturer	Platform	Type of MCM	Type of Vehicle	Disposal	Single Use
AN/ASQ-235 **(AMNS)**	USA	Raytheon missiles & defense	Airborne	Mine hunting	Remotely operated	Yes	Yes
AN/AQS-20C	USA	Raytheon missiles & defense	Helicopters, surface vessels, boats, and USV's	Mine hunting	Remotely operated	No	No
INTEGRATED MINE COUNTERMEASURES SYSTEM (**IMCMS)**	USA, UK, Finland, Germany, Netherlands, Thailand, and Belgium	Atlas elektroniks	Surface vessels	Mine hunting and mine sweeping	Autonomous or remotely operated	Yes	Yes
BARRACUDA	USA	Raytheon missiles & defense	Helicopters, surface vessels, and USV'S	Mine neutralizer	Semiautonomous	Yes	Yes
UAQS-24B	Australia, USA, AND UK	Northrop Grumman	Helicopters, surface vessels, and USV'S	Mine hunting	Remotely operated	No	No
UK MMCM/FRANCE SLAM-F	UK AND France	Thale's systems	USV's	Mine hunting	Autonomous operated	Yes	No
UNMANNED INFLUENCE SWEEP SYSTEM **(UISS)**	USA	Textron systems	USV's	Minesweeping	Semiautonomous	Yes	No

30. Once go through above MCM systems used by modern navies, project highlighted and recommended 03 effective and advance MCM systems which other nations can use for MCM related operations. Those systems are categories a follow:

a. Only for detection: AN/AQS-20C is a mine hunter sonar system use by US navy and can be deployed from helicopters, surface vessels, and USV for the purpose of detection. For neutralizing the mine, this can pair with the barracuda mine neutralization system. So, sonar system has advantages of utilizing all areas by all delivery methods where ships can't operate.

b. For neutralizer: Barracuda is a semiautonomous, expendable mine neutralizer vehicle and it capable of neutralizing shallow water mines also. Barracuda can be deployed by MCM USV, helicopter or ship and it can also be coupled with the AQS-20 sonar to provide a much faster MCM operation.

c. For compact system: Integrated mine Countermeasures System is well advance, portable system comprise with mine hunting, mine sweeping, mine laying and mine neutralized capabilities. This system can operate either from land base or onboard ship also. This system is composed by Command, control and communication takes charge of the complete MCM process ranging from planning, preparation, execution of task and evaluation, reporting and documentation.

31. With the development of technology all advance navies looking towards new MCM concepts. For that it seems the necessity of establishment and maintaining an intelligence network to monitor ongoing mine developments and mine related technologies around the world. This will immensely help to overcome and go for further developments of MCM equipment and systems.

CHAPTER VIII

CONCLUSION

32. With the development of naval mine in 1776 by David Bushnell, it produced a turning point to Naval warfare, which make effort on forces to no longer must be physically present in an area of interest or operation to achieve their objective. The sea mine has proved itself to be a forceful weapon during all sea battles. Once studying history, sea mines effectively use during the American revolution, the American civil war, Russo-Japanese war, World War I and World War II etc.

33. The use of mine during these wars also paved the way for many improvements and technological advancements in its design. Such advancements have led to the developments of smart mines with anti-sweeping, anti-hunting, or anti-recovery devices. Some are even provided with stealth technology making it difficult to detect them during the mine hunting process while others have been made capable of counting the ships to explode on a specific target.

34. It may appear that mines have long been forgotten, but they're re appearance in the Red Sea in present days accompanied with verified damages has awaken nations once again to the potency of these weapons. The situation above coupled with the modern mine evolution, depicts the advanced and evolved mining capabilities possessed by navies around the world in modern days. It also describes to an extent, the magnitude of threat that sea mines constitute to safety of navigation and global shipping in present days, thus, making it necessary to have commensurate MCM to counter such threats.

35. To overcome the mine threat, it should have dedicated MCM assets that carry out mine sweeping, mine hunting and EOD operations. These operations always proved to be unsustainable and very risky, putting both materials and personnel in danger. Naval forces must wait and must put more effort on MCM operation once they meet with Mine fields or Mine like area while operate at sea. Those efforts effectively create delays on naval operations. Therefor reduce material, equipment, and human losses during vast MCM operations, it is necessary to have UUV based MCM meatheads. For that nowadays lot of advance navies use to carry UUVs, USVs ROVs and UAVs for face any mine threat during in route. These advance MCM mechanisms day to day getting modified and that equipment immensely help to reduce damage threat on material and personnel, as well as it makes MCM operations to function in smooth and accuracy level.

36. Another important invention in the modern MCM operations is the employment of LASER technology both for detection and pinpoint detonation of the mine. Consequently, the use of these modern technologies has contributed immensely to reducing the mine threat to both vessel and personnel.
It has also reduced the time on task for MCM operations with the real time transmission capabilities.

37. Finally, the future holds great expectations for naval forces when the UUV based organic MCM are combined with dedicated MCM assets. This will not only strengthen the existent capabilities but will provide for a formidable MCM force as well. Navies around the world would be left with no option than to upgrade their existent platforms and key into these emerging technologies if they must be adept to fighting in the modern days war.

38. During our study we come up with few recommendations which may help to uplift the effective use of UUVs in MCM operations, The concepts of modularity and flexibility are supported to reduce both the time and cost. Introducing of Microprocessors which serve as the control centers for unmanned vehicles and providing a platform for control and communications, collision avoidance sensors, high-definition cameras. Based on facts which include in project, it seems most of the navies in world are using UUVs for MCM operations and out of those we found that AN/AQS-20C sonar system, BARRACUDA systems and IMCMS which use by USA navy consist with more advantages and applicable than others.

39. AN/AQS-20C system consists of four sonars that operate together to detect, classify, and identify mine-like objects from the sea floor to the near surface in a single pass. The AN/AQS-20C safely and effectively supports expansive mine-clearing operations that previously required a warship manned by more than 80 sailors.

40. The Barracuda is a semi-autonomous, unmanned, underwater vehicle that identifies and destroys near surface, volume, and bottom sea mines. It can operate in shallow water, using an expendable, modular neutralizer with a kill mechanism, propulsion, sensors, and communications buoy, which transmits wirelessly back to the host ship. Initially, it will be launched from an unmanned surface vessel operating from the Littoral Combat Ship, but in the future, it is planning to launch from almost any platform with an A-sized sonobuoy launcher.

41. Integrated mine Countermeasures System (IMCMS) can utilize from land or onboard ship. System comprises with mine hunting, mine sweeping, mine laying and mine neutralized capabilities. Due to its complicated system one operator can handle this full operation and only requirement is having a space onboard ship to keep this system.

42. Consequently, the use of these modern technologies has contributed immensely to reducing the mine threat to both vessel and personnel. It has also reduced the time on task for MCM operations with the real time transmission capabilities.

43. Finally, the future holds great expectations for naval forces when the UUV, ROV and Autonomous vehicle based MCM are combined with dedicated MCM assets. This will not only strengthen the existent capabilities but will provide for a formidable MCM force as well. Navies around the world would be left with no

option than to upgrade their existent platforms and key into these emerging technologies if they must be adept to fighting in the modern days war.

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