DELIVERING NEW MINE COUNTERMEASURE CAPABILITIES TO THE RSN

GOH Yong Han, LAM Su Ying Audrey

ABSTRACT

Any mine incident in the Singapore Strait would severely impact Singapore's economy. As such, the Republic of Singapore Navy (RSN) Mine Countermeasure Vessels (MCMV) form the mainstay of the Singapore Armed Forces' underwater mine countermeasure capability. The Bedok-class MCMVs of the RSN were operationalised in 1995. In 2009, a modernisation programme was introduced to upgrade the MCMVs' mine countermeasure capabilities so as to enhance their mine hunting and neutralisation rate. This article discusses the threats which sea mines can pose, the project and technical challenges in delivering the mine countermeasure capability to the RSN, and the system engineering based approach adopted by the project management team in overcoming these challenges.

Keywords: mine countermeasure, mine hunting, mine disposal

INTRODUCTION

A nondescript cargo ship traverses the Strait of Singapore and releases a cylinder discreetly into the water. Later, a Republic of Singapore Navy (RSN) Mine Countermeasure Vessel (MCMV) RSS Bedok is performing a routine survey when its mine hunting sonar[1] detects a cylindrical object lying on the seabed. A lightweight underwater inspection vehicle is deployed remotely to investigate and visual confirmation via its fibre-optic link shows that the object is indeed a sea mine.

This information is sent back to the Maritime Security Task Force Headquarters and patrol vessels are dispatched immediately to cordon off the affected area. RSS Bedok then launches a lightweight expendable mine disposal vehicle which detonates the mine safely.

This is a hypothetical but possible scenario that the RSN Mine Countermeasure Squadron may face in their mission to keep the Strait of Singapore safe for shipping.

The MCMVs play an important role in the maritime security of Singapore by ensuring that its surrounding sea lanes and the Singapore Strait are free and open to international shipping. The laying of mines by potential adversaries or terrorists in the Singapore Strait or in our sea lines of communications could lead to port closure, which would result in direct trade losses amounting to more than S$2 billion daily[2].

THE SEA MINE THREAT

Sea mines are explosive devices placed in water to destroy surface ships or submarines (Wikipedia, n.d.). They range from bottom mines, moored mines, drifting or floating mines to limpet mines attached directly to the hulls of targets. Sea mines are laid and left to wait until they are triggered by the approach of, or contact with, an enemy vessel. The sea mine is a lethal weapon that dates back to the mid-19th century. They are low-cost weapons which are extremely difficult to detect, identify and destroy, presenting a significant threat even to the most sophisticated warships today. Figure 1 shows a picture of a British Mk 14 sea mine. Sea mines have evolved over time from the early low-cost contact mines to modern influence mines with magnetic, acoustic and pressure sensors. Advanced influence mines with modern signal processing

Figure 1. British Mk 14 Sea Mine (© Oxyman / File:British Mk 14 Sea Mine.jpg / Wikimedia Commons / CC BY-SA 3.0)

capability can be triggered by pre-determined logic or pre-programmed characteristics of a particular class of ship or submarine's signature.

The Committee for Mine Warfare Assessment of the US Naval Studies Board (2001) describes the strategic use of mines in the denial of passage through confined waters and the entry or exit of ports of coastal nations. Mines are asymmetric weapons and can influence a war campaign greatly. For example, in World War II, mining by the Allies achieved some remarkable successes. During the Atlantic War lasting five years, the Royal Air Force (RAF) flew 20,000 mine-laying sorties, sinking 638 ships with the loss of 450 aircraft. In comparison, RAF bombs and torpedoes sank 366 ships over the same period with the loss of 857 aircraft. During the Tanker War[3] in 1988, the guided missile frigate USS Roberts was heavily damaged by a drifting Iranian mine and the US Navy spent more than US$90 million to repair the damage (see Figure 2). In the 1991 Gulf War, Iraqi mines hindered US amphibious assault planning and heavily damaged two US warships, preventing them from further operations. For inferior forces, mines are particularly valuable to defend against a superior naval force. Sea mines are available widely and are often more difficult and time-consuming to neutralise than air and missile threats. Since World War II, 14 US Navy ships have either been sunk or damaged by mines, as compared to only two which have been damaged by air or missile attacks.

DELIVERING NEW MINE COUNTERMEASURE CAPABILITIES TO THE SINGAPORE NAVY

The RSN's four Bedok-class MCMVs were acquired from Sweden and commissioned in 1995. In view of their ageing systems and the advent of new technologies, DSTA embarked on a modernisation programme for the MCMVs. This programme commenced in 2009 with the installation of an advanced and integrated mine countermeasure combat system, comprising a Mine Information System, Hull Mounted Mine Hunting Sonar (MHS), Towed Synthetic Aperture Sonar (TSAS) and Expendable Mine Disposal System (EMDS) (see Figure 3). The approaches taken by the DSTA project management team (PMT) to deliver these new capabilities successfully are described in the following sections.

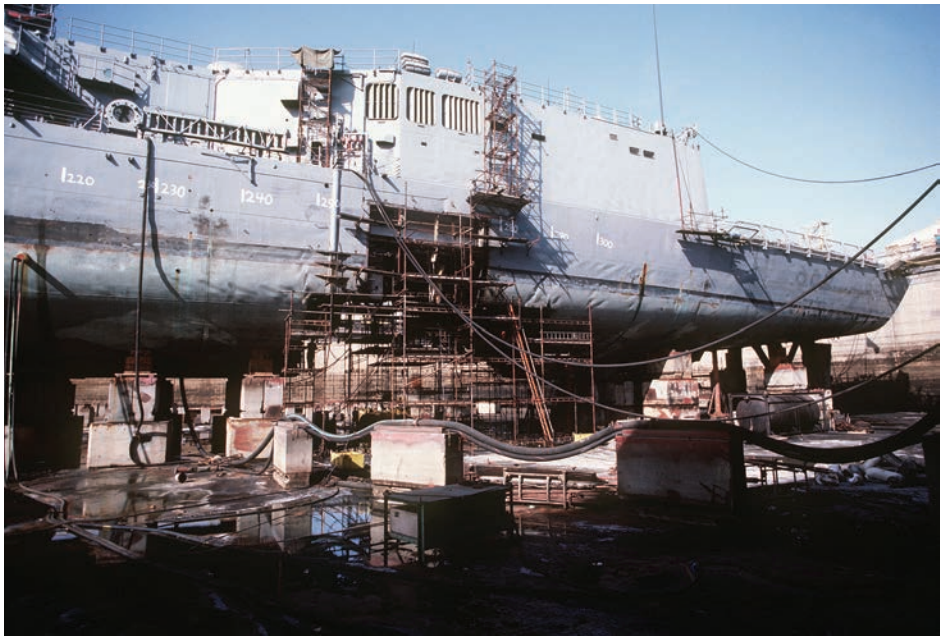


Figure 2. The eight-metre hole in the hull of guided missile frigate USS Roberts caused by an Iranian M-08 mine (© Mussi / File:Ffg58minedamage2.jpg / U.S. Navy / ID:DNST8902266 / Public Domain)

Figure 3. New mine countermeasure systems installed

Managing a Complex Upgrading Project With a Lean PMT

The conventional approach to managing a Life Extension Programme (LEP) of a naval vessel of such complexity is to form a core integrated PMT of more than 10 engineers to oversee major combat, platform and shore systems. The PMT adopted a prime contractor approach to minimise the size of the team after a careful study. The prime contractor supplied the majority of the systems, installed and integrated them with existing systems, and was responsible for the performance of the total system. This allowed a core PMT of half the typical size to manage the entire LEP.

Managing Developmental Items During Contracting

During the tender exercise in 2008, all submitted proposals had some key systems that were still in the high risk development phase due to the demanding technical performance specifications of the tender. By applying the procurement principles of competition and value for money, the PMT employed competitive bidding exercises and included contractual clauses to protect our interests in the event of possible failure of the developmental systems. This ensured the tender returns would be cost effective, with acceptable risk management measures put in place by each of the tenderers.

Achieving Cost Effectiveness During Contracting

The PMT had originally mandated all tenderers to engage the original designer of the MCMV as the platform consultant to oversee the platform modification works as a risk mitigation measure. Subsequently, the PMT conducted a thorough technical risk assessment and explored engaging an alternate platform consultant with the tenderers to achieve greater cost effectiveness. The PMT conducted detailed ship surveys on each MCMV, reviewed the existing documentation and drawings, and determined that minimal platform modifications were required. All required information could also be obtained through measurements. By systematically going through the risks of modification and integration, the PMT selected an alternate platform consultant with experience in managing MCMV platform upgrading and achieved further cost savings. With the added risk assessment and management processes put in place contractually and through project milestone review meetings and progressive monitoring, this approach led to the effective and successful execution of the programme.

Managing Integration Risk With Legacy Systems

The delivery of the upgraded programme capability was heavily dependent on the successful integration of the existing systems with the new systems. This is a more complex task compared to new-built programmes as some of the information required for integration is not available for some legacy systems. To mitigate this risk, pre-condition assessments (PCA) were performed to establish and record the baseline configuration of the ship through a series of inspections and tests. This enabled the reconstruction and extraction of missing information. At the same time, the PCA served to verify the legacy systems' performance and interface specifications to facilitate integration with the new systems.

Delivering Improved Mine Hunting Capability

Underwater mines are located using sonar which is traditionally a slow and tedious process. With the advent of new technologies, e.g. the synthetic aperture sonar (SAS), mine hunting can be performed better and faster. The principle of SAS is to combine successive pings[4] along a known track coherently in order to increase the resolution of the azimuth direction (along-track). Hansen (2011) explained that with this increased "synthetic aperture" length, the sonar is able to obtain higher resolution images with respect to conventional sonar processing.

The coverage rate for a TSAS is about five times faster than the legacy hull-mounted MHS. This is achieved due to a higher survey speed and wider sonar swath widths (see Figure 4). Being hull-mounted, the one-sided MHS array limits the MCMV speed during survey, while the TSAS is a two-sided array able to cover more area, and can be towed at a higher speed to achieve a much higher coverage rate. In addition, the TSAS provides significantly higher resolution for improved classification capability[5]. The new TSAS also offers an automatic detection and classification capability to ease the operator's workload in mine detection and classification.

Compared to the previous sonar system which was hull-mounted and not towed, the PMT conducted an extensive safety review on the procedures provided by the contractors for the launching, recovery and towing operations. All the emergency safety features of the TSAS, such as emergency surfacing, cable breaking tensions and emergency stops, were individually analysed during design reviews and tested thoroughly during sea acceptance tests to ensure safe operations. The launch and recovery procedures were also improved and simplified through numerous sea trials.

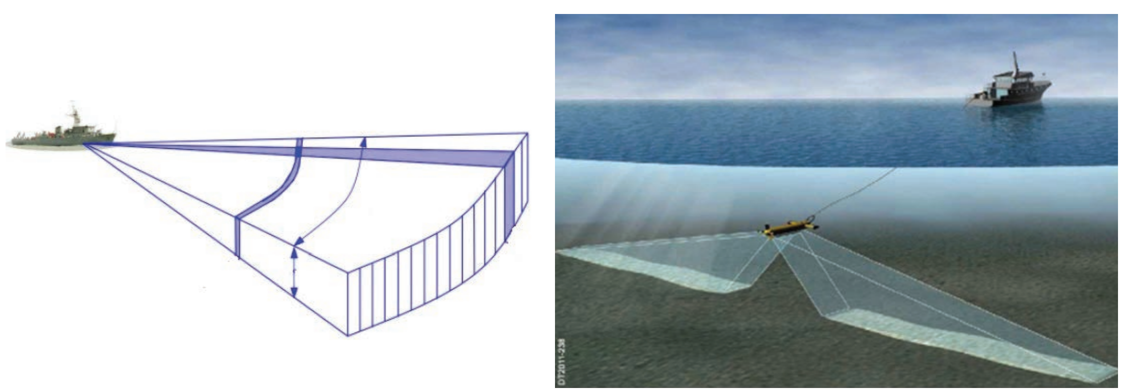
Delivering Improved Mine Neutralisation Capability

The mine disposal system (MDS) has been used by the RSN for mine neutralisation since 1995. The vehicle used in the MDS weighs about 900kg and requires a crane and handling system for launching and recovery during mine neutralisation missions. As part of the MCMV modernisation programme, a new EMDS was acquired and installed on board the MCMVs.

The K-Ster[6] EMDS is capable of identifying and neutralising mine-like objects to support the mine clearance operations of the RSN. It is a remotely operated vehicle that consists of a lightweight vehicle and supporting shipboard systems. The vehicle has two configurations – the K-Ster Inspection for identification of mine threats, and the K-Ster Combat for neutralisation of mines. The expendable K-Ster Combat vehicle is designed to neutralise a mine with a single shot (see Figure 5).

This vehicle has led to vast improvements in mission effectiveness as it is lightweight, simple to operate and easy to deploy. At 50kg, it is less than 10% the weight of the previous MDS vehicle, and its lighter weight simplifies the launch and recovery process. It is estimated that the operation time per mine is reduced by about half. Equipped with just a small charge, the vehicle is designed with a tiltable warhead, sonar, sighting laser, video camera and searchlights to locate and attack mines accurately and efficiently.

The K-Ster Combat vehicles are stored in the EMDS magazine on board the MCMVs. To minimise manual handling of vehicles, the PMT worked closely with the prime contractor to design a set of customised jibs and fixtures to facilitate a more efficient transfer of K-Ster Combat vehicles.



(a) (b)

Figure 4. (a) MHS transmission pattern (b) TSAS transmission pattern

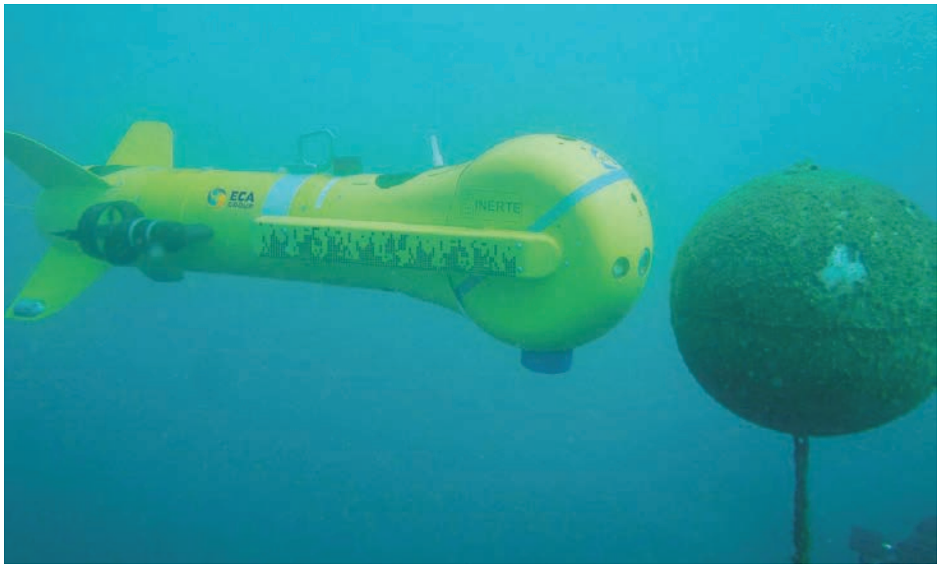


Figure 5. K-Ster vehicle approaching a target

The RSN is the first navy in the world to conduct live-firing using this vehicle. As this is a new weapon system, there were no previous firing templates or references. The PMT collaborated with the RSN to develop test scenarios and safety firing templates. Subsequently, with the knowledge gained from the first firing, the PMT worked out a new weapon danger area template which significantly reduced the safety radius compared to the first firing. This achieved further cost savings in terms of assets and time required for safety clearance.

In addition, over the several sea trials and live-firing, the PMT enhanced the preparation procedures progressively, and implemented additional instrumentation to further automate the pre-launch process. These served to reduce the preparation time needed before each firing.

CONCLUSION

Through the application of the system engineering based approach, the PMT had successfully completed the MCMV modernisation programme for the RSN in 2014 in a cost-effective manner. This has resulted in new and enhanced mine countermeasure capabilities to keep Singapore's sea lanes mine-free and safe.

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ENDNOTES

[1] Sonar stands for sound navigation and ranging, and is a technique that uses sound propagation to detect objects on or under the surface of the water.

[2] Singapore's total trade in 2013 was S$980 billion based on the Ministry of Trade and Industry figures, of which about 80% or S$784 billion was transported via seaborne means.

[3] The Tanker War refers to the anti-shipping campaigns during the Iran-Iraq War (1980-1988). In 1981, Iraq initiated attacks on ships to weaken Iran's warfighting capability, starting with ships carrying military supplies to the ground war front and subsequently attacking merchant ships carrying Iran's exports. Iran retaliated in a similar fashion, attacking ships belonging to Iraq's trading partners and to countries that supported Iraq's war effort. In 1987, the US joined the war upon Kuwait's request to offer protection to Kuwait's tanker fleet. With US warships patrolling the gulf, Iran started to sow the gulf with anti-ship mines. This resulted in several US ships being damaged by Iranian mines, including the guided missile frigate USS Samuel B. Roberts (FFG-58) in April 1988.

[4] The transmission of sound waves underwater is commonly referred to as pings.

[5] With the higher resolution, better classification is achieved as there are more pixels associated with the object under investigation to compute its size and shape more accurately.

[6] The K-Ster EMDS is a product of ECA Robotics, France.

BIOGRAPHY

GOH Yong Han is a Programme Manager (Naval Systems) managing the Mine Countermeasure Vessel (MCMV) upgrade programme. He has worked on the Challenger-class submarine upgrade, undertaken defence R&D at DSO National Laboratories and managed research and technology projects at the Ministry of Defence before assuming his current role. A recipient of the Public Service Commission Scholarship, Yong Han graduated with a Bachelor of Engineering (Electrical Engineering) with First Class Honours from the National University of Singapore (NUS) in 1997. He further obtained a Master of Engineering (Electrical Engineering) degree from NUS in 1998 under the NUS Research Scholarship as well as a Master of Science (Electrical and Computer Engineering) degree from the University of California, San Diego, USA, in 2007 under the DSTA Postgraduate Scholarship.

LAM Su Ying Audrey is a Systems Architect (DSTA Masterplanning and Systems Architecting) currently supporting the masterplanning and operations concept formulation with the Singapore Armed Forces. She was previously a Senior Engineer at Naval Systems Programme Centre, where she led the delivery of several naval systems, including naval guns on the Formidable-class frigates and the new mine countermeasure combat systems in the MCMV upgrade programme. Audrey graduated with a Bachelor of Engineering (Mechanical Engineering) degree and a Master of Science (Industrial and Systems Engineering) degree from NUS in 2004 and 2007 respectively.