MAKING A DIFFERENCE THROUGH INNOVATION: MISSILE CORVETTES UPGRADE STORY

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ABSTRACT

The Republic of Singapore Navy's squadron of Missile Corvettes (MCV) was commissioned in the 1990s, and successfully upgraded from 2009 to 2013. This upgrade went beyond extending the operational lifespan of the MCVs and included an expansion of their capabilities through the application of innovative solutions. First, smart platform integration was employed to overcome the constraints imposed by the MCVs' limited deck space. As a result, maritime surveillance capabilities were introduced to the MCVs through the incorporation of an unmanned aerial vehicle. Second, innovative systems integration allowed the features of the MCVs' new sensors suite to be delivered fully. Third, new processes were established to manage work productivity and successful retention of the MCVs' still operationally capable hull. The performance of the upgraded MCVs has been verified, with the vessels having been deployed extensively in operational and search and rescue tasking, as well as in live-firings and exercises with foreign navies.

Keywords: innovation, upgrade, capability, systems integration, platform integration

INTRODUCTION

The Republic of Singapore Navy's (RSN) Missile Corvettes (MCV) were commissioned in 1990s and have served as the principal strike craft of the Second Generation RSN. As operational requirements evolved over the years, the MCVs' networking capabilities needed to be upgraded in order to remain relevant with the Singapore Armed Forces' (SAF) transformation into a Third Generation fighting force.

The MCV upgrade programme preserves the MCVs' operationally capable hull built in the 1990s, while undertaking the deliberate and thorough enhancement of their onboard combat systems to equip them with state-of-the-art capabilities (see Figure 1). The introduction of advanced surveillance, communication, as well as command and control (C2) systems has enabled the MCVs to be incorporated into the SAF-wide integrated knowledge-based C2 capabilities.

Figure 1. The pre-upgrade MCV (left) and upgraded MCV (right) sailing together. The hull and major structures remain largely unchanged, while the most observable difference is the taller and straight mast configuration where new sensors are located

SMART PLATFORM INTEGRATION

Space was a major issue for the Project Management Team (PMT) as it had to contend with the limited deck space of the 62m-long MCV. It was through smart platform integration that the PMT was able to optimise the use of the vessel's existing hull and equip it with an unmanned aerial vehicle (UAV).

Overcoming Limited Deck Space to Deliver Full UAV Capabilities

The ScanEagle UAV system is a commercial off-the-shelf (COTS) system used by overseas navies. It is typically deployed on the wide flight deck of large ships such as frigates so that its range of capabilities can be utilised fully at sea without interfering with other operations. In its standard configuration, there is insufficient space to launch and recover the ScanEagle UAV for use on smaller ships such as the MCV. Hence, the capabilities made available to such ships are limited to control and imagery, while launch and recovery can only be done either from land or from larger ships. This arrangement would greatly reduce the UAV's operational utility should it be incorporated into the MCV missions.

Enabling Efficient UAV Launch Operations

To provide the MCV with a full spectrum of UAV capabilities, the PMT conceptualised innovative means to install the launch and recovery systems of the ScanEagle UAV. For the launch system, the key challenge was to enable the ship crew to conduct a wide range of deck activities while still ensuring that the UAV could be launched safely at sea. This was an important consideration as the MCV's aft deck area supports a wide range of operations that include missile firing as well as the launch and recovery of sea boat and mooring operations. Installing the UAV launcher in its standard configuration would use up all the available deck space and prevent the undertaking of other deck operations. As such, the PMT proposed to mount a modified ScanEagle UAV launcher onto a customised turntable (see Figure 2). The turntable can be stowed to allow existing deck operations to continue unimpeded. It also enables optimal UAV launch envelope to be achieved through the controlled rotation of the launcher. The turntable performs its rotation while remaining secured on the ship's deck, thereby ensuring that UAV operations can be conducted on board the MCV safely under high sea state conditions. The customised UAV launch system has reduced the overall launch preparation time by 90%. In addition, it can be operated by a single crew member, thus reducing manpower requirement by 66%.

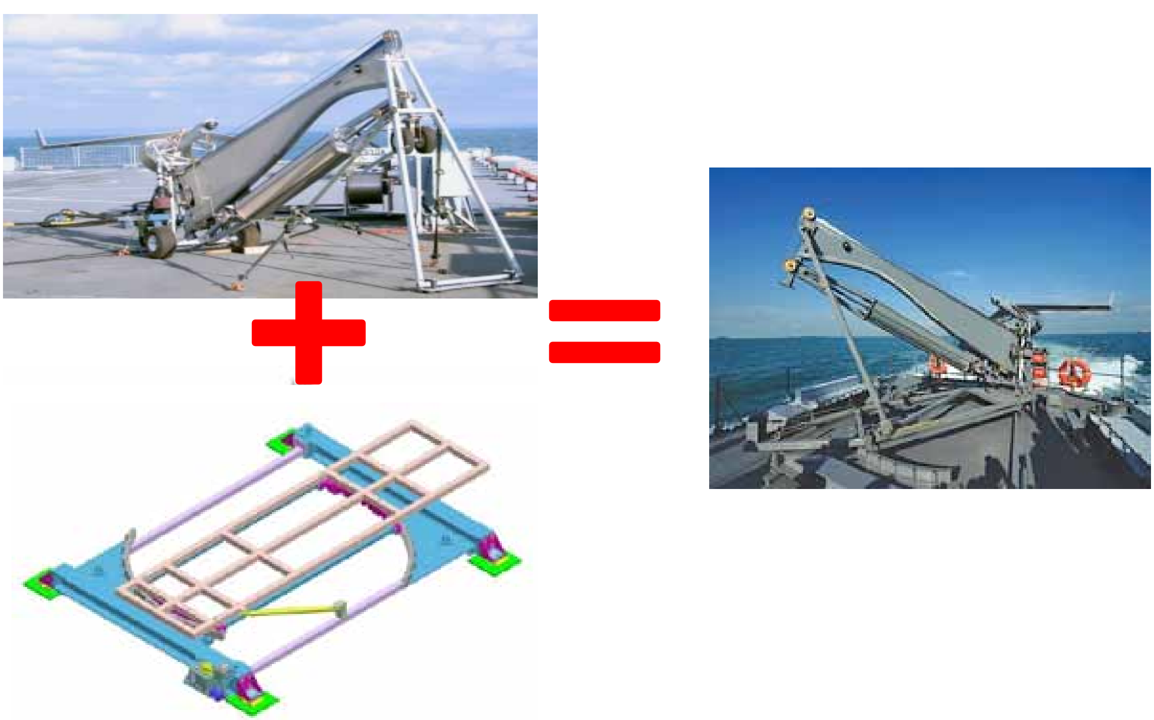

Figure 2. (a) The launcher in its original configuration and the UAV turntable concept
(b) The modified UAV launcher mounted on the turntable on board the MCV

Enabling Safe UAV Recovery Operations

The ScanEagle UAV is recovered in flight using a skyhook arrestor. The skyhook system – which in its original design requires an area of $25m^2$ – was re-engineered such that it can be extended to recover the UAV and retracted for stowage within a reduced space of $10m^2$ (see Figure 3). This reduces the amount of space required by the UAV recovery system by more than 50%. However, the lack of open spaces on deck poses a potential safety risk during the recovery of the UAV. The PMT hence programmed the UAV to maintain an angle away from the ship as it flies towards the recovery system, thereby enhancing the safety of recovery operation on board the MCV.

INNOVATIVE SYSTEMS INTEGRATION

As the SAF transforms into a Third Generation networked fighting force, enabling interconnectivity among its various assets is essential. Therefore, a key element of the MCV upgrade programme was to ensure that the MCVs would be able to interoperate closely with other assets to achieve higher operational synergy. To that end, the PMT carried out the integration of advanced sensors and C2 systems on board the MCVs.

Reconceptualising Mast Layout: Optimised Sensor Suite to See Farther

In the pre-upgrade MCV, the arrangement of the sensors on its mast was optimised to reduce the impact of electromagnetic interference. The PMT applied new electromagnetic interference management techniques to further mediate the MCV's electromagnetic environment and facilitate the incorporation of advanced sensors into a straight and taller mast (see Figure 4). The new sensor suite allows the upgraded MCV to sense targets at farther distances.

Figure 3. (a) The UAV recovery system in its original form, with its outriggers and wheels outlined in red
(b) The reconfigured skyhook (without outriggers and wheels) on board the MCV

Figure 4. The pre-upgrade MCV with its slanted mast (left) as compared to the upgraded MCV with its straight mast (right)

Enhanced C2: Delivering the Capability to Decide Faster

Although the legacy C2 system has served the RSN well, its limited processing capabilities were one of the key considerations that drove the SAF to pursue a new and upgraded Combat Management System (CMS). The new CMS was developed indigenously by DSTA and DSO National Laboratories. Integrated into the MCV, the CMS comes with a decision support engine for data fusion, identification and threat evaluation to accelerate the compilation of a comprehensive tactical picture and flag out suspicious contacts. Compared to its predecessor, the CMS is able to handle significantly more tracks as it utilises Ethernet LAN instead of serial links, thus enabling data transfer at higher speeds. This enhances the richness and timeliness of the information presented to the MCV's command team.

However, the limited size of the MCV's Combat Information Centre meant that the Commanding Officer could not be equipped with a console and had to rely on his operators for information. This proved to be disruptive and limited the effectiveness of the command team. The PMT hence developed a touchscreen for the CMS that was mounted onto the Commanding Officer's chair, enabling ready access to key information and mitigating process inefficiencies (see Figure 5). As a result, the Commanding Officer can act more decisively and quickly to enhance mission effectiveness.

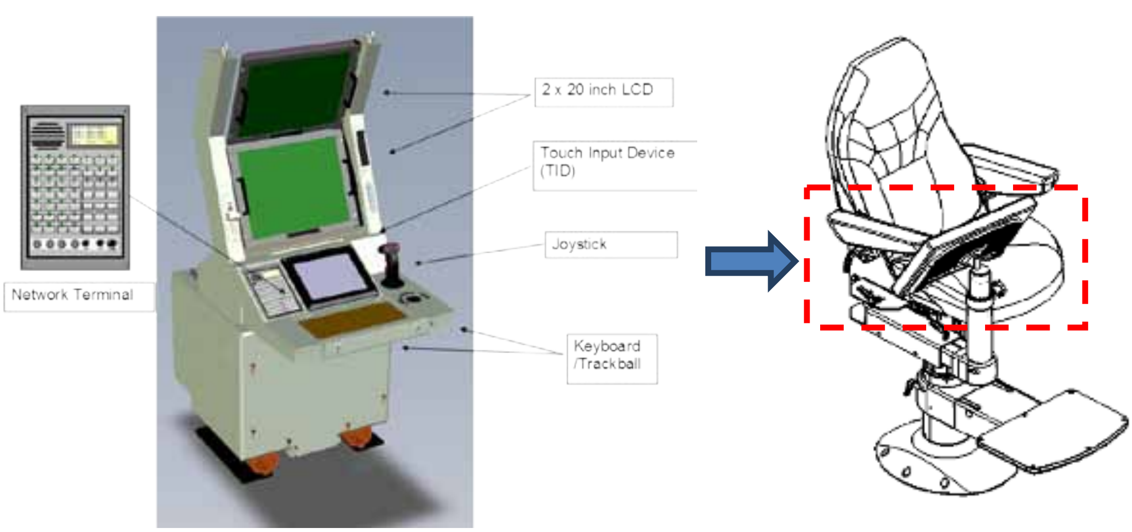

Figure 5. The CMS touchscreen allows direct access to combat information

PROCESS INNOVATIONS

The PMT also displayed innovation in managing work productivity and optimising the capabilities of the MCVs amid a tight schedule.

Improving Productivity Using Key Performance Indicators

The upgrade of the operational MCVs meant that time was of the essence as the traditional approach of sequential platform upgrade would incur an unacceptably long operational downtime. To minimise this issue, the MCV upgrade programme was planned on an overlapping schedule which required careful allocation of resources through monitoring of Key Performance Indicators as there were instances where multiple ships were undergoing upgrades. The upgrade was eventually completed three months ahead of schedule.

Optimising the Capabilities of the Platform

Using Technical Budgets to Manage Platform Impacts

The cornerstone of the MCV upgrade was the retention of the operational capabilities of the existing vessel. However, this also meant that the upgrade had to be done within the constraints imposed by the existing hull. To ensure the successful integration of new combat systems into the hull, the PMT established a process of assigning technical budgets such as space, weight, electrical power and cooling capacity for each system. These budgets were managed closely and reviewed by the PMT at each major milestone, hence allowing it to manage the platform budgets effectively.

Fully Realising the Available Technical Budgets from Existing Hull

Older systems on board the MCVs had to be removed so as to create the capacity for new systems to be incorporated into the vessels. To ensure the timely and correct removal of the older systems, the PMT developed a Removal Control Document (RCD) to help identify, document, verify and remove the older systems from the ship. The RCD records all system information at a component and sub-component level, including the action to be taken (i.e. remove, retain or relocate). This provided good visibility of the overall system architecture and traceability of the actions taken, resulting in the comprehensive and efficient removal of the older systems on board the MCVs. This process has subsequently been adopted in other naval upgrade programmes managed by DSTA.

Ensuring the Performance of the Upgraded MCV

The removal of older systems and the installation of new systems, especially on the MCV's main deck and the mast, resulted in changes in the vessel's weight and centre of gravity. The PMT closely tracked these changes and validated the data via inclination experiments that allowed the confirmation of the design weight and centre of gravity.

The structural strength of the MCV was also another aspect that was affected by the changes in weight and its distribution. The introduction of new and heavier systems such as the skyhook meant that greater stress was placed on the existing structures. The PMT thus carried out global and local strengthening of selective structural members to ensure that the vessel could accommodate its new enhancements without compromising safety.

Additionally, the PMT managed the weight distribution of the new systems carefully to minimise the impact of the increased weight on ship speed by keeping the location of the MCV's longitudinal centre of gravity (LCG) as consistent as possible. The final weight and the LCG achieved were within 1% of the designed value. To quantify any potential impact, speed trials were carried out before and after the upgrade. The results showed that there was no appreciable change in the ship speed after the upgrade.

To ensure that the upgraded MCV would continue to perform well at sea, model testing was carried out by the PMT to examine the ship's sea-keeping behaviour. The data gathered was then translated into load conditions and operating limits within which the ship crew could safely and fully exploit the ship's abilities. The data also led to the conclusion that the ScanEagle UAV system could be operated in the required sea state so long as the ship is moving within a certain speed boundary. This helped the ship's operators to understand the operational limits and include these considerations into their operating procedures (see Figure 6).

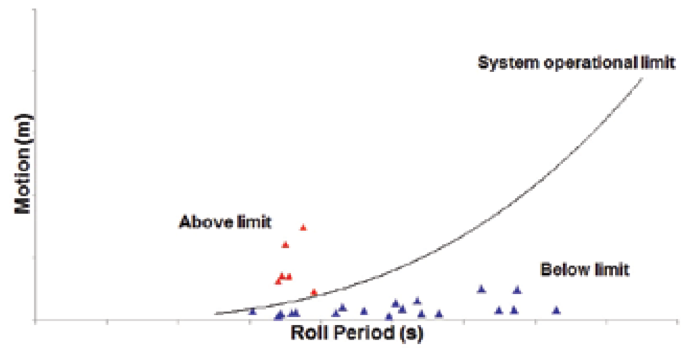

Figure 6. Sea-keeping data used to determine ship operational limit for UAV recovery

CONCLUSION

The MCV upgrade programme provided a unique opportunity for the PMT to innovate and deliver a wider range of capabilities that have enhanced the operational effectiveness of the MCVs. The innovations not only impacted individual system performance, but also enhanced the performance of the vessels' integrated systems that enable the ship to see farther and facilitate faster decision making. Since 2013, the upgraded MCVs have contributed to national and international security through operational and search and rescue tasking, as well as its active participation in live-firings and exercises with foreign navies.

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BIOGRAPHY

CHUNG Kam Sam is a Head Capability Development (Naval Systems) who oversees the development of special craft projects. He has taken on various roles over the course of the Missile Corvette (MCV) upgrade programme. These include carrying out technical assessments and managing the delivery of all platform modifications as Platform Manager as well as overseeing the entire MCV upgrade programme as Programme Manager. Kam Sam has also worked on the Republic of Singapore Navy's stealth frigate and patrol vessel programmes. He was part of the teams that won the Defence Technology Prize Team (Engineering) Award in 1996, 2007 and 2014. Kam Sam graduated with a Bachelor of Engineering (Mechanical Engineering) degree from the National University of Singapore in 1991.

WIBAWA Martin Sulaiman is a Project Lead (Naval Systems) currently managing the retrofit of a commercial vessel to be used as a training asset for National Servicemen. He was previously in charge of managing the MCV's structural and hydrodynamics performance. A recipient of the DSTA Scholarship, Martin graduated with a Bachelor of Science in Engineering (Naval Architecture and Marine Engineering) degree from the University of Michigan, Ann Arbor, USA, in 2008. He further obtained a Master of Science (Naval Architecture and Marine Engineering) degree from the Massachusetts Institute of Technology, USA, in 2010.