CHALLENGES IN DEVELOPING INDIGENOUS COMBAT MANAGEMENT SYSTEMS (CMS) FOR MALAYSIAN MARITIME DEFENCE AND ENFORCEMENT SERVICES

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ABSTRACT

This study aims to discuss the feasibility of developing indigenous Combat Management Systems (CMS) for the use of Maritime Defence and Enforcement Services. The study is envisaged to identify the key success factors to realize the efforts of developing indigenous solutions in the autarky principles aligned to the aspirations sets by the authorities and buyers from the Maritime Defense and Enforcement Services. It is invented to outline the readily available technology in country to make suggestion/s to encourage the formulation of a structured tendering policy of a systems procurement to allow a true indigenous development of a CMS needs and requirements. The Royal Malaysian Navy (RMN) along with the USN are currently facing a dilemma over legacy system and modernization into standardized system and move away from 'single class of ships' combat system designs into a broader range of highly efficient mission system able to operate between flotillas, fleets and beyond. This can be attained through identifying and demarcation of the Technology Readiness Levels (TRL) of the software and hardware components used, design and development of complex system which utilizes supersets of reusables across the newbuilding program of the 15 to 5, modularly and aligned with the RMN aspirations. Commonality shall be the design theme and a specific product line requirement methodology is introduced. Furthermore, the current austerity is a valid reason for the RMN to embark 'just- in- time' on self-reliance concept. The organization is poised to upgrade its aging fleet with lesser classes known as the 15 to5 program without diminishing its primary mission capabilities and requirements.

Keywords: Combat Management System (CMS), Technology Readiness Level (TRL), Royal Malaysian Navy (RMN)

INTRODUCTION

A unique kind of combat system for each class of ships is no longer affordable for the world navies. Under stringent budgetary control, the world biggest navy, United States Navy (USN) realizes that, development of combat system computing architectures is performance limited and will be costly to upgrade especially for a single class of ships acquisition processes. Inevitably, the USN is facing intense pressure to control price escalation for combat system upgrade due to aging platforms and at the same time conduct new building that shall comply with the requirements of contemporary maritime mission requirement. In managing the various platform development challenges, while keeping costs under control, the USN must transit to managing this development within an inventiveness portfolio of vessels (Murphy, Richardson & Sheehan, 2013). Similar challenges are currently being faced by the Royal Malaysian Navy (RMN) as its current 15 classes of ships, which are mostly with an average of 30 years of age were developed as single class ships by various shipbuilders and country of origin. Inevitably, their combat systems were also developed into many forms of configuration and architectures. RMN too, faces budgetary constraints on its ship building program and has to balance their budget within an inventiveness portfolio as well. Modern surface navy does not apply techniques to adapt onto the bigger systems as most designs target specific classes of ships, such as Frigates or Destroyers. Independent conduct of requirement and design approaches varies from shipbuilding to shipbuilding. There is a need to migrate into developing highly effective and efficient operational fleet. This can be achieved through the commonality of combat system, eliminating complex family type system designs and integration. Increased the usage of common components, reduced or common facility for testing and certification are simple solutions derived from complex cross platform requirement analysis. Cost reducing factors will be

significant and could be quickly developed through reduced cost of design, development, training, maintaining and updating capabilities (Kolodgie, Shuttleworth & Albertson, 2013).

Kolodgie, Shuttleworth & Albertson, (2013), emphasize that commonality is also derived from a set of the reusable requirements across a family of surface navy mission system whereby its product line requirement is applied when the mission system is being developed. This tool vital used must first segregate common elements of functionality into a set of retained functions into a synergised set of functions unique to a particular platform type. A superset of common requirements is produced when all legacy requirements are analyzed and standardized. The beauty of this line approach method is that the product line will be reusable for future new building and program upgrading, which is withheld in a depository central for the future development of all combat system. Ever since the inception of a computerised combat system, through the SPICA M Class Project back in the 1970s, RMN has embarked on the use of Combat Management System (CMS) as the main system to conduct situational awareness of Local Area of Operations in its conduct of maritime operations. Since then, at present and beyond, the requirement of CMS equipped ships will be a relevant endeavour regardless of the types of mission challenges linked to the class of ship in the near and far future. Similar to the USN, the RMN is well-versed with the specific to class type development of CMS adapted through major shipbuilding and Ship Life Expansion Programmes (SLEP). These projects were predominantly dominated by the European Ship Building Industries and Original Equipment Manufacturers (OEMs). This is owed to that all CMS development programs are implemented via a shipbuilding program. The RMN formulates the General Staff Requirements with project teams involved in Shipbuilding Programs to supervise those requirements. The shipbuilder and its OEM partners in most cases collaborate with the RMN in developing Contract Build Specification (CBS) and its entailing sets of documentation to develop CMS utilising the technology available at that point of time. Learning from the innovation efforts taken by the leading command and control centre of the USN, it was evident that the USN experienced difficulty in cost control measures leading to the current requirement to develop command and control system that has common functionality and architecture. This means systems developer will no longer be centric on building according to Type or Class of ships. The trending CMS architectures shall be based on the common functional system like the System-of System (SoS), where CMS of ships links up with the next tier multi-level operational organizations for example the Network Centric Operation (NCO), Network Based Operations (NBO) and etc. RMN current 15 to 5 new building plans to lobby and build 20 plus ships is the textbook opportunity to develop CMS similar to the USN methodology in developing SoS. Due to the unfavourable economic situation, plus many known contractual difficulties experienced when working with foreign shipbuilder and OEM's, a game change is highly required and it is only prudent for RMN to embark on development of its own shipboard CMS indigenously. However, it is interesting to note that, at present no local industry players in the country have real hands on experiencing the indigenous development of a CMS except those involved in offset program through the previous ships new building programs.

Aim

This paper aims to discuss the feasibility of developing indigenous CMS for the use of the RMN in particular, and for the use by any Maritime Defence and Enforcement services. The study is envisaged to identify the key success factors to realize the efforts of developing indigenous solutions in the autarky principles aligned to the aspirations sets by the authorities and buyers from the Maritime Defense and Enforcement services. It is supposed to outline the readily available technology in the country to make suggestion(s) to encourage the formulation of a structured tendering policy of a systems procurement to allow for a true indigenous development of a CMS needs and requirements.

LITERATURE REVIEW

The Defense Procurement and Offsets Experience

A strong-armed force is the benchmark of a nation's power. In order to create a credible force, a country needs the backing from defence industries as well as the national defence science and technology (National Defence Policy, 2004). Self-reliance is achievable but must be developed through solidification of the local defence industry and to reduce reliance of foreign OEM's. The government of Malaysia had made various efforts to augment affiliation between local defence industry mainly to inspire the development and modernization of the defence combat systems or platforms (Roslan, Uli, Yahaya, & Nair, 2018). The Defence and Security Industry Blueprint (DESIB) purportedly, observed vital self-reliance improvement exercise through countertrades, offset program, transfer of technology,

incentive to the industries and study and development (R&D) as relevant evidences (Roslan et al., 2018). Balakrishnan (2019), introduces the mechanisms to nurture Malaysia's defence industry such as defence procurement and offsets. In order to further digest this mechanism, Balakrishan (2019) states that the defence purchases are made via defence offsets procurement, where such programs are divided into direct or indirect offsets (Ministry of Finance, 2011). This purchase concept triggers arguments between the function of offsets, whether it is a tool for enhancing and strengthening the defence industrial base, creating employment and developing human capital or the technology development itself. This idea is set against the view of offset as a non-guarantee to increase human capital capacity and technology development. Furthermore, Roslan et al., (2018) conclude that "no empirical study has been carried out to assess the impact of this defence offset procurement on the societal welfare benefit in Malaysia". It is detrimental to the defence industrialist consensus that there is no check and balance to the implementation and success of these defence offset procurement practices. Such arguments have provided vivid signals that defence offsets procurement is going into desuetude. The evolution from this old-fashioned and perhaps haphazardly implemented doctrine is obligatory in order to allow Malaysia to further progress in reaching self-reliance (Roslan et al., 2018).

15 To 5 and the Opportunities to Develop Indigenous CMS System

Maritime defence and security is about protecting the sovereignty and economic interest of one's seaward boundaries. Malaysian maritime zone spans from the Andamans seaward peninsular western seaboard all the way through Melaka Straits and across to South China Sea on the peninsular eastern seaboard and from the tip of southern Sarawak, across to the Celebes and Sulu seas off Tawau on the Sabah Northern and South Eastern seaboard. With such great area of operations, Malaysia is undoubtedly antagonized with complex and challenging maritime issues (Arof, 2008). Eastern Sabah Security Command (ESSCOM) was initiated to apprehend an escalated Sulu militant infiltration. Repeated abduction in the area including attacks on vessels were true-life actions by militants to distress the Malaysian Sovereignty. In this aspect, ESSCOM devours an immense expanse of funding, which is over RM 1.1 billion for a country that has long been stricken by economical and equipment shortfalls. Islamic State (IS) continuous presence in Malaysia also impends the need of collective maritime preparedness along the coast of Peninsular Malaysia (Koh & Lean, 2016).

The European nations like France, Italy, United Kingdom and Germany were dominant in the maritime shipbuilding segment since the 1970's. Due to disparities in origin, there was no common electronics and system suite familiar to the users. The 'cut-throat' trending market encourages platform suppliers to include 'mix and match' solutions customized in special ways to meet the customer's commonality need. Their approach promotes the reduction of dependability risk of the customers, but at the same time fashions complications in systems integrations challenges. Hence, after-sales life cycles support implications are deemed inevitable primarily in the logistical facets as emphasised by Koh & Lean (2016). Koh & Lean (2016), argue that MAF introduction of the China's naval build purchase is an old story in the region. Thailand has two major naval building experiences from China namely Chao Phraya Class frigates (Jianghu III/IV) of whose content is 100% Chinese and Jianghu-based Naresuan Class Frigates, which were outfitted with mainly European gadgets. The Chao Phraya was criticized for being inferior in quality and reliability and the latter taking lesser critics distinctively. In the current state of austerity, defence allocation for the MAF budget continues to decline. The evolving defence challenges like ESSCOM and IS threaten in a vast maritime space.

This calls for a new means of supply source to counter and cope with the 'mix and match' practice at the same time. Logistics will continue to constitute long term challenges with the 15 to 5 Armada Transformation Program. The plan envisages reduction of 15 classes of vessels into 5 classes, transition of old to new procurement in stages whilst maintaining the critical mass. The government's focus on maritime assets to coffer the East Sabah and IS threat rather than on war doctrine calls for less budget. Hence, cheaper solutions will be the demand of purchase, which is less expensive yet effective and fit for operations of vessels. Comparatively, Malaysian current purchase of arms from China is regarded as non-affiliation to the Chinese Government but rather suiting Malaysia's current day to day cost savings effort to control profligacy as experienced with the European purchases, whilst maintaining law and order at sea. It also reflects the behavior of Malaysian Armed Forces defence procurement exercises as again a non-starter in self-reliance efforts. There was no observation made on the impact of offset procurement on the societal benefits in Malaysia (Roslan et al., 2018). This matter is exacerbated by national budgetary constraints and less sophistication of assets to meet the stringent Maritime security requirements (Koh & Lean, 2016). It is thus prudent for Malaysia to embark on indigenously developed solution to save

money and spend it for the benefits of the societal economy (Roslan et al., 2018).

Commonality and Importance of System-of-Systems Approach in developing Indigenous CMS

Limitations in cross platform requirements have commanded silo development of systems requirement that offers no cross reference between platforms despite common operational needs. This happens as a result of the inevitable when cross reference analysis between platform system's requirement never existed, leading to independent silo development, which was further aggravated when it was found there were similar systems requirement being developed uniquely. This has led to 'stove-pipe designs' whereby things are done in total seclusion leading to advantageous redundancy being neglected. Design by type is to be blamed for these wastages of efforts plus no particular attention considered for a larger family system. This concludes that even the USN neglected the advantages of commonality when conducting the requirements development and design approaches from a newbuilding to the other. Contrarily, commonality is a true proponent to pave ways of creating highly effective and efficient operational task force. The USN's System of Systems is defined as "SoS and is used to describe an integrated force package of interoperable systems acting as a single system to achieve a mission capability" (Smith, 2013). When introduced amongst combat systems, it can reduce the complexity of designing family type of systems and more importantly the platform and combat system integration challenges. These further escalates into setbacks of missing out potentials in endorsing commonality and the overall possession cost gain factors by having commonality. A greater potential in substantial cost savings by reducing cost in training, development, production, training, maintaining and updating will benefit the fleet in substantially upgrading of its capabilities (Kolodgie, Shuttleworth & Albertson, 2013). Kolodgie, Shuttleworth & Albertson, (2013), also state that "a combat system product line develops commonality" as it is derived through the identification of the common set of reusables, which are placed under a larger set of reusables. Reusable here is defined as all-encompassing combat system components and software applications constituting the functional behavior expressed as services, tasks and function required for system to perform.

How well a function is to perform is regarded as non-functional and the question is carried through consistently across the family type of combat system of the USN. A collective set of system's requirements is added when platform unique constraints on the system's behavior in the non-functional form are introduced. This process shall establish consistent and common breakdown of the operational requirement across multiple ship classes while preserving a platform's unique requirement. Future projects shall benefit from these synergies because a common set of product line requirement with platform unique requirement is now a complete set of common set of combat systems level requirements. Together they form a superset of reusables when all existing legacy platforms requirements are studied and standardized. USN will deposit these readily applicable product line requirements for future platform and platform retrofits requirement into a centralized repository meant for combat system requirements.

Product Line Approach (PLA) is a new concept of systems development being inevitably introduced, to gain 'the best of breed'. The business models are based on the following principle:

1) Modular designs,
2) Competition and collaboration,
3) Interoperability through commonality,
4) Reusable software components, and
5) Life cycle affordability using commercial off-the-shelf (COTS) and technology insertion processes.

The USN adapted an open business process based on the principles listed above, whereby they segregated combat system design from ship design, develop modular combat system, facilitated software and hardware reuse and incorporated COTS open based components to promote ease of upgrade (Murphy, Richardson & Sheehan, 2013). Murphy, Richardson & Sheehan, (2013), introduce the challenges within the SoS method surrounding naval organizations, working with the industry, academia and politicians. Under the organizational challenges, Murphy, Richardson & Sheehan, (2013) mention about the challenging mitigating actions in organization to effectively establish requirements, budget and adoption to better replicate benefits to parallel-unified organizations. There are apparent concerns within the naval organization as a buyer; the de facto being "historical planning, funding, and acquisition execution due to the belief that organization reflects in which the environment they work. The new business open model encourages opportunities for competition and shall garner the "best of breed" choices as the industry will itself grow. Incentives like projects, rewards and future opportunities await as long as the industry becomes a willing and an effective partner. Besides that, intellectual among the academia could provide the

most benefits in the open business model challenges. Specializing in study and development, academia can provide noteworthy scholarly works worth exploring to stay at the pinnacle of technology, whilst remaining enacted. Hence, keeping academia in the development loop is critical so that future peer group of engineers can be developed and be made ready as the work-force. Partnering with the political decision makers is also the naval commitment to ensure ally and as a willing partner to synergize efforts in articulating the worthiness and choices to manage the innovative constructs.

The success of the USN SoS will be dependent on the efforts of transiting successfully the innovative efforts into the new business model relevant to the magnitude of its fleet and assets. Factual monetary gain and dynamic rapid integration are easily achievable. However, there are challenges that need to be addressed and amongst those pressing ones includes the need to transit its acquisition process, restructuring and enforcing its technical and organization to a PLA. Nonetheless, the dire need of focus on an innovative organizational structure, continuity of leadership and renaissance of government technical roles are sensible technical initiatives. Therefore, the establishment of PLA for developing reusable components that can be assembled by the platform system integrators is a centric requirement besides the need to centrally manage an intense technically inclined project such as the large scale SoS cross-platform innovativeness development (Murphy, Richardson & Sheehan, 2013).

TRL's Application in Developing Indigenous CMS

Technology Readiness Level (TRL) is a type of measurement system used to access the maturity level of a particular technology. Each technology project is evaluated against the parameters for each technology level and is then assigned a TRL rating based on the project progress. There are nine technology readiness levels (TRLs). TRL 1 is the lowest and TRL 9 is the highest (Mankins, 1995). The primary purpose of using TRLs is to assist the management in making decisions concerning the development and transition of technology Not much is publicized about TRL user community and their opinion of technique and practical encounters to the use of TRL. To compile some opinions and practical encounters feedback, a global survey was sent to known professional TRL users to categorize challenges of TRL use (Tomaschek, K., Olechowski, A., Eppinger, S., & Joglekar, N. 2016). It should be viewed as one of several tools that are needed to manage the progress of study and development activity within an organization. Some advantages of TRLs are as follows:

1) Provide a common understanding of technology status,
2) Risk Management,
3) Used to make decisions on technology funding, and
4) Used to make decision concerning transition of technology.

TRL is complementing Manufacturing Readiness level (MRL) rather than the latter be suitable for another methodology of technology maturity (Madison et al., 2015). Hence it is imperative for a study of the TRLs levels conducted to assess how TRL can be used in the development of indigenous CMS. To propose a set of guidance documents in helping project developers to understand the TRLs in a particular field of development within the development of a CMS.

Feasibility Study

In order to ascertain the prospect of completing the CMS development successfully, a feasibility study is perceived as a suitable analysis because it takes all of a development process relevant factors into account. These shall include but not limited to economic, technical, legal, and scheduling considerations. Planning office, project managers and procurement establishment use feasibility studies to discern the pros and cons of undertaking a project before they invest a lot of time and money into it. Feasibility studies also can provide an entity's management with decisive information that could prevent them from entering into risky businesses. Promotion activity like marketing or branding is one of the most imperative sections of the feasibility study as it examines the marketability of the product or services and convinces players and stake holders that there is a potential market for the development of the CMS for the Malaysian market.

SWOT Analysis on the feasibility of developing indigenous CMS

The purpose of SWOT analysis to develop guideline and indications of a feasibility study to be conducted on the intent to develop indigenous CMS based on the SoS Open Business concept for the Malaysian Defence and Security market segments. A currents success, failure and weakness experienced by entities involved in the CMS development program is being appraised as shows in Table 1.

Table 1. SWOT Analysis on indigenous CMS

Strength	*Weakness*
• Government National Defence Policy aspirations through DESIB • National autarky needs • National IR 4.0 aspirations • Transformation programmes • TRL 7-9 available technology and COTS useable • Vast source of local human capital and talents	• Difficulty in obtaining synergy between academia, industry buyers and politicians • Differences in purposes and objectives by entities/organisations when attempting to developing TRL 1 through 9 • Congregation of the truthful human capital to initiate investment from cradle to grave is difficult to achieve
Opportunities	*Threat*
• 15 to 5 newbuilding programs • Government RnD grants • Government RnD incentives • IP development • Reaching autarky principles • Commonality of System integrates into higher system hierarchy like NCO and P4 • Just in Time development • True savings broadly	• Organisational awareness of concept and behavioural towards the notion • Foreign Industrial Players intervention • Financing and financers faith • IP retainment • Human Capital investment retainment

PESTLE Analysis to predict the external force effecting the development of the product.

Political, Economic, Social, Technology, Legal and Environment (PESTLE) analysis is an extension to the SWOT analysis to track the environment of the plan to launch a CMS development project, product or service. It is imperative as it provides a look down perspectives on a predictive atmosphere that empowers checking and tracking the contemplation of developing CMS indigenously. Some of the predictions encompass but not limited as shows in Table 2.

Table 2. PESTLE Analysis

Political	*Economic*
• Intercession of G to G commitments • The will to invest • Embargo • Export License Issues	• Project Financing • Sustenance due to austerity delays • Currency fluctuations for Imported components where relevant
Social	*Technology*
• The trust of indigenous product reliability • Gathering the correct talent • Sustaining the Correct talent	• Absence of the indigenously produced CMS sub-system, high tech Sensors and Actuators • Integration of know how • Absence of stabilised algorithms
Legal	*Environment*
• IP ownership • IPs and boundaries • The rights of Design Authority • Royalties and Commissions	• Buyers and Users • Political • Academic • Industrial • Financiers • Foreign relations policies • Market trend

CONCLUSION

There is an apparent need for the RMN to seriously plan to develop its own CMS. Learning from the intended USN's migration from class specific combat system into the innovative SoS concept, the RMN for its 15 to 5 programs, could embark on the SoS concept in stages. Commonality shall be the theme of RMN's migration to counter logistical challenges its currently facing with class specific system, which are also aging and entering obsolescent. The offsets procurement program failure in obtaining success remains uncheck since there was no empirical study made to benchmark achievements crucial to Malaysia as she needs to be able to progress on self-reliance efforts so as to progress into a real Autarky status. Technology has progress far ahead and perhaps for CMS development most of it had surpassed conceptual development level. Through a documented study, the TRLs of the technology used to develop a CMS can be ascertained and applied by buyers of CMS in the process to publish tenders. This can truly promote indigenous development of CMS as compared to defence procurement offsets purchase from foreign source. Inevitably, promoting societal

benefits especially in developing a nation geared for IR 4.0.

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