A business case approach for maritime mine countermeasures capability replacement

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Abstract — Sea mines are cost-effective weapons to disturb sea traffic and deny access to sea. Many nations across the world have sea mines and are capable to deploy them. Mine stocks globally contain a wide variety of mine types and the technology of sea mines is still developing further. In addition, the environments in which sea mines may be encountered vary from benign to extremely challenging, making countering sea mines a very difficult task. Due to the enormous dependency of nations on access to the sea, maritime mine counter measures (MMCM) capabilities are an essential component to enable mobility at sea. Emerging new technologies such as high-resolution sonar systems, unmanned systems, and autonomy enable new MMCM concepts. In the European Defence Agency (EDA) MMCM-New Generation project, in which Belgium, Estonia, Germany, Norway, Sweden, and the Netherlands participated, these future concepts are analysed using a business-case approach. This approach considers the value of solutions expressed in terms of measures of effectiveness, the cost and the project risks associated with a capability replacement program. This paper presents the tooling developed to support the business case development and the main business case results, and potential for a common way ahead.

1 Introduction

Many European navies have a maritime mine counter measures (MMCM) capability that was acquired in the 1980's – early 1990's. The capabilities were developed for an expected lifespan of 25-30 years, meaning that nations will have to replace their current MMCM capability in the near future. In most nations the current MMCM capability consists of manned vessels that operate inside the mine field.

Future-generation MMCM will increasingly rely on the use of a new generation of high-resolution sonar systems and new possibilities offered by unmanned aerial, surface, and underwater systems. Their introduction enables new concepts that exploit these unmanned technologies which together aim to increase the effectiveness, efficiency, and safety of MMCM operations. The solution space is considered to be bounded by three main concepts of operation:

- **Hybrid**, in which the platform is capable to operate both within the minefield and at stand-off distance with organic and unmanned MMCM systems.
- **Stand-off**, in which the MMCM capability is provided exclusively by the MMCM toolbox systems which are operated remotely from a mother vessel;
- **Land-based**, in which the MMCM systems are deployed from shore.

In each concept, there are many choices related to both the platform design itself and the types and number of unmanned systems to be contained in the toolbox.

In the context of the European Armaments Cooperation Strategy, six contributing member states (BEL, EST, GER, NLD, NOR, SWE) joined in a European Defence Agency Maritime Mine Countermeasures – New Generation (EDA MMCM-NG) definition programme to investigate actual cost-effective future solutions for MMCM. This program resulted in a number of business case descriptions for national as well as common activities in which the intended outcome, investment cost and project risk are outlined. This paper summarizes the business case approach and the main results.

2 Approach

2.1 Overview

Within EDA MMCM-NG, contributing member states have defined (common) requirements for their MMCM-NG solution and derived from that a variety of scenario vignettes to reflect future operational conditions. Subsequently, an approach was developed as depicted in Figure 1 to ultimately arrive at the desired business case (BC) results. The main steps in the approach consist of:

- **Solution design and analysis:** A solution consists of both *toolbox systems* to conduct MMCM and *platforms* and/or a *land base* to operate from. The main elements are (i) types, size, and numbers of platforms, (ii) the composition of the toolbox, and (iii) the capabilities and quantities of a subset of toolbox systems that fit on an individual platform. To support the solution analysis, extensive tooling was developed or tuned to simulate and evaluate consequences of design choices and variations.

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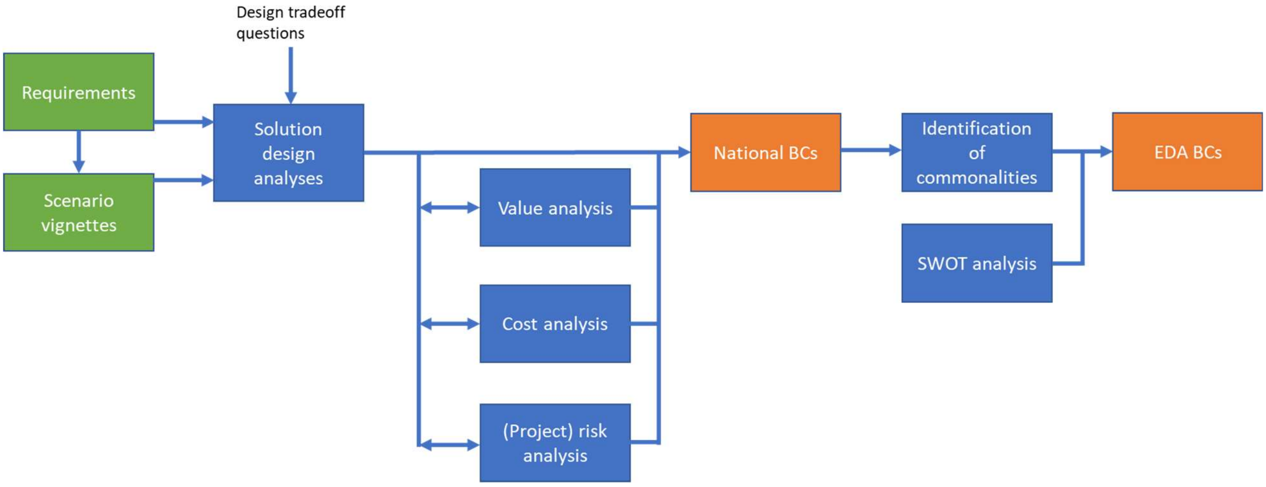

Fig. 1. Schematic overview of systems engineering process used to develop national and common EDA business cases.

- **National business case development:** The business case development follows a systems engineering approach [1]. In this approach, design alternatives consisting of combinations of platforms/land base and MMCM systems are analyzed. This analysis considers the operational value, investment cost and project risk related to the realization of each alternative, to ultimately arrive at a description of national business cases.
- **EDA business case development:** For the derivation of common (EDA) business cases, two types of analyses were conducted. The first analysis aimed to identify commonalities between the solutions of nations as a basis for common procurement. The second analysis is a so-called strength, weakness, opportunities and threat (SWOT) analysis to identify capability gaps that could be commonly addressed, or opportunities that could be commonly exploited.

2.2 Solution design and analysis

To define potential solutions for future MMCM capabilities that enable the nations to counter mine threats in relevant operational environments, the following main items have to be addressed:

- Deciding on the *concept of operation* based on national requirements;
- Articulating the descriptions of the national requirements and conditions, based on the EDA *common staff requirements* and *scenario vignettes*;
- Obtaining a selection of candidate sensor/weapon systems that are, in principle, effective in the conditions relevant for each nation;
- Developing conceivable ways of operating platforms and systems to conduct MCM tasks, which are referred to as *courses of action*;
- Defining relevant *mission modules*, which is a subset of a nation's MMCM *toolbox* used in selected missions.
- Analyzing the corresponding operational effect in these missions;
- Obtaining potential solutions for *platform designs*, capable to deploy the *mission modules* that are considered to be relevant for executing specific missions;
- Generating multiple solution alternatives consisting of a combination of platforms/land base and a *toolbox* of MMCM systems;

The solution design and analysis approach illustrates the complexity of the process to translate military requirements into a limited number of solution concepts. There are many items to be addressed, resulting in many degrees of freedom. Furthermore, the assessment should not only take current systems into account, but also systems that are in development or that should be developed. Solution design and analysis are conducted in an iterative approach in which solutions are updated based on insights derived from the analysis.

2.3 Tooling

To support the *business cases* development, the following tooling has been realised and used. With this tooling, quantitative measures of effectiveness corresponding to different solution alternatives can be derived:

- **CLIMATE-I** (Capabilities, Limitations and Maturity of Technology): this tool supports compliancy testing of system capabilities against environmental and operational conditions embedded in relevant scenario vignettes [2];
- **CLIMATE-II:** this simulation model allows to evaluate and investigate the efficiency of MMCM operations, expressed in terms of mission duration, for mission modules and their corresponding courses of action. CLIMATE-II is designed to enable the

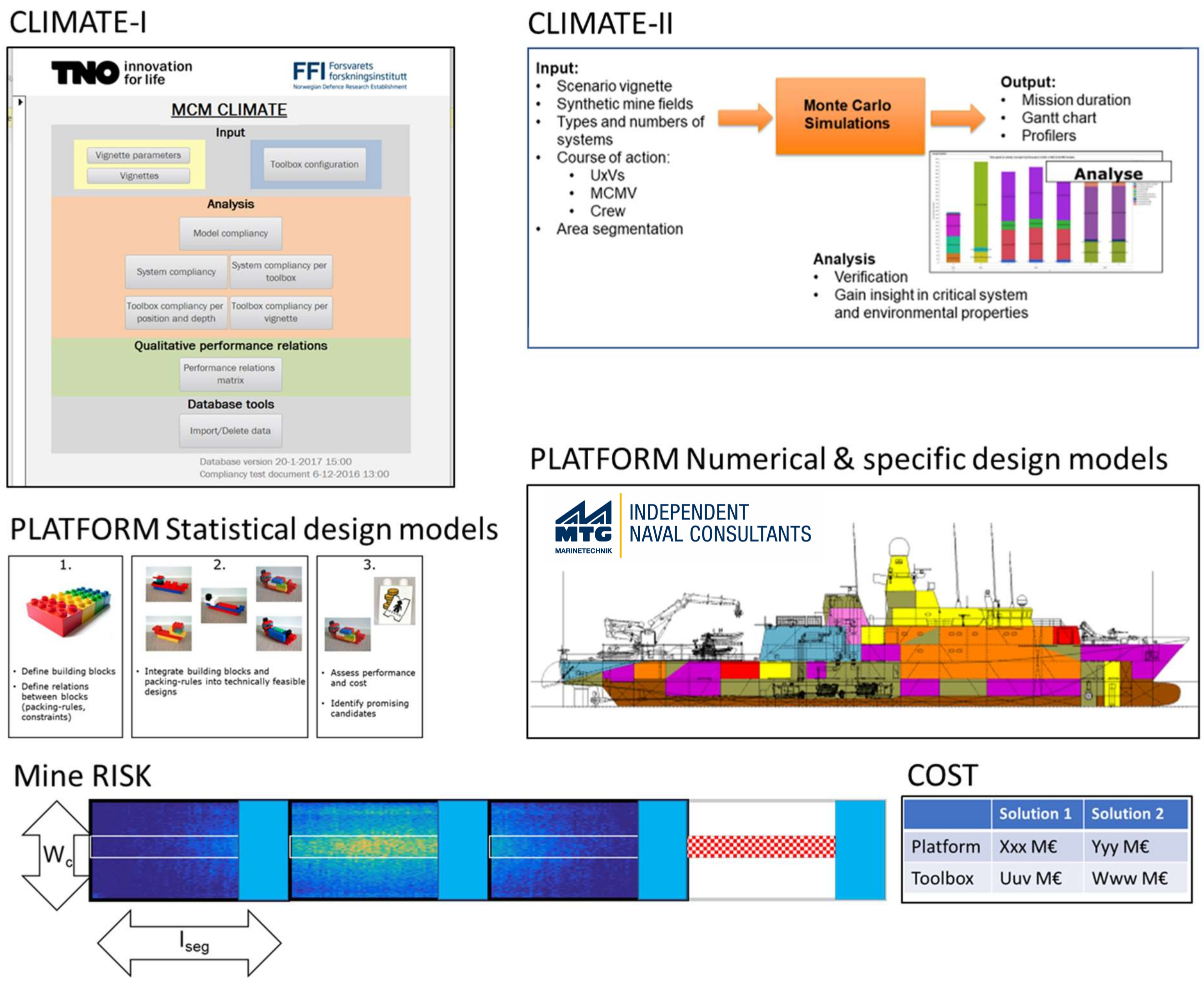

Fig. 2. Iconic view on the various models and tools that were used to assist in the design of MMCM-NG solutions.

investigation of the sensitivity of mission modules to variations in composition, system properties, and system performances in different operational environments. In addition to mission duration, the activity times of all systems are logged. This enables the identification of performance bottlenecks in a toolbox and aids the selection of efficient combinations of systems [3];

- **Mine risk;** this Monte Carlo simulation-based model enables to evaluate the mine risk for MCMVs, USVs, AUVs and the first ship in transit, having finalized the MMCM operation, depending on assumed survivability criteria [4];
- **Statistical platform design models**; this model enables to generate early stage platform design concepts satisfying different platform requirements [5]. It provides valuable insights in the consequences of combinations of different requirements on the resulting platform design;
- **Numerical and specific platform design tooling**; based on platform solution that emerge from the statistical design step, specific, more detailed designs can be obtained to elaborate subdivision of the working deck, L&R system placement, maintenance areas, platform systems and organic sensor and weapon systems. Such designs are suited to evaluate dimensions, platform stability, endurance, speed, achievable signature and shock levels, etc. Because such designs are elaborated in sufficient detail, they are also suited for cost estimation.
- **Cost modelling;** the cost model is based on information from previous ship building projects, RFI information or estimated cost for solution components that are not on the market yet. This model allows taking cost brackets and price uncertainty into account;
- **Project risk assessment**: the approach is based on the risk management guide for U.S. Department of Defence acquisition projects [6], using input provided by subject matter experts.

The results derived from the usage of the tooling mentioned above are generally used in an iterative design loop to arrive at partial solutions. This iterative approach allows to converge to solutions that are considered as viable and enables to investigate these in more detail. Another way to use the tooling is to evaluate solution concepts that were already available. Both approaches were used by the nations contributing to the EDA MMCM-NG project.

2.4 National business case development

National business case development is mainly a consolidation step after the solution design analysis phase. The main elements in the BC development are:

- First, the most important solution alternatives are established for each nation, and fundamental design trade-offs are identified.
- These solutions are evaluated by determining the value, cost, and project risk associated with the solution alternatives using the EDA MMCM vignettes from the Common Staff Requirements:
  - The value of each potential solution alternative was determined in a quantitative way in terms of a set of measures of effectiveness: operational effectiveness, efficiency, survivability, resilience and operability in waves.
  - Estimates of the total cost of the solution alternatives (including both the platforms/land-based facilities and the toolbox) were made.
  - Project risks associated with the choice for a certain solution alternative were analyzed.

2.5 EDA business case development

The objective of developing EDA business cases is to investigate whether there are collaboration opportunities for the next phase towards procurement. To support the development of EDA business cases, commonalities between the national business cases were identified, both in terms of solutions and project risk. This commonality analysis was complemented by an analysis of the Strengths, Weaknesses, Opportunities and Threats (SWOT) for the different solution concepts (stand-off, hybrid and land-based). Based on the results from these analyses, topics were selected for which it was considered of interest to develop common EDA business cases.

3 Main findings

The approach has been applied to develop national BCs for Germany, Sweden, Norway and The Netherlands. An observation of the national business cases is that the different nations have a preference for different concepts of operation (hybrid vs. stand-off), and even in the case of selecting the same concept of operation, platform design is mainly driven by national requirements. This results in different platform concepts for each nation with varying sizes and protection levels.

Despite the differences in the operational concepts, between nations, there are commonalities in the envisaged toolbox systems, especially off-board systems that offer stand-off capabilities such as USVs, AUVs and UAVs. The usage of these type of unmanned systems allows scalable MMCM solutions with an increased efficiency.

In order to achieve effective and efficient MMCM operations, it is important to tailor mission modules to the mission, environment, and threat. This requires a balance between hunt and sweep capabilities and between search, identification and disposal capabilities.

The common EDA Business cases were developed based on three types of input:

- Commonalities between national solutions;
- Commonalities between project risks in national business cases;
- Identified capability gaps and opportunities from the SWOT analysis.

The EDA MMCM-NG project provided insight in cost-effective MMCM solutions for individual nations, and revealed opportunities for collaboration between nations. Cooperation through taking up a common EDA business case is thought to lead to cost benefit, improved capabilities by capability gap resolution, or capability enhancement and/or project risk reduction.

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Robbert van Vossen received his M.Sc. degree in geophysics and the Ph.D. degree in seismology (cum laude) from Utrecht University, Utrecht, The Netherlands, in 2000 and 2005, respectively. He is a Senior Research Scientist with the Acoustics and Sonar Department at the Netherlands Organisation for Applied Scientific Research (TNO), The Hague, The Netherlands.