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DEVELOPMENT OF A PREDICTION CAPABILITY TO BETTER PROGNOSTICATE THE MATERIEL AVAILABILITY OF NAVAL WEAPON SYSTEMS

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AIM

1. This paper will give a description of a technical mean, which is able to support major planning by simulating business processes. As a project, the German Navy developed a prediction capability to better prognosticate the materiel availability of naval weapon systems, applying operational research methods. Drawing on experiences gained by the German Navy, this paper will also present findings which could be considered by the Director General Maritime Equipment Program Management as an area for further studies by the Royal Canadian Navy (RCN).

INTRODUCTION

2. In times of short resources and capacities (personnel, materiel, federal budgets) as well as increasing operational demands and very high tempo of operations, a need for careful and predictive military force planning is inevitable[1]. Available capacities need to be presciently prioritized and assigned carefully in order to enable forces to fulfill their missions and taskings; both in national defense and operations, but also with regard to training and preparation[2]. At every level (strategic/headquarter (HQ) down to tactical/squadron (SQN)) planning of force assignment and maintenance is done with best means and at best guess. But it often rests on individual experiences of subject matter

[1] Department of National Defence, *Royal Canadian Navy Strategic Plan 2017-2022*, (Ottawa: DND Canada, 2015), p. 28.
[2] Department of National Defence, *Maritime Equipment Program Business Management Rules FY 2017/18* Ottawa: DND Canada, 2017), p. 14.

experts. In current complex environments and its increasing challenges, human minds will reach their natural limits in processing multiple factor analyses and planning.

The German Federal Ministry of Defense initiated, among other things, an in-service support management based on simulation models of major business processes and on key indicators, with the aim to substantially enhance the material readiness of the German Armed Forces[3]. For this, the Bundeswehr Office for Defence Planning has been tasked, to develop a prediction capability with regard to better prognosticate the materiel availability of weapon systems. Within this framework the German Navy has chosen class K130 as a demonstrator for its related project. Operational research methods are applied in order to match maritime operational priorities with naval sustainment requirements and maintenance capabilities and capacities.

3. First, this paper will give a general, functional description of the simulation model and will explain how it works with regard to its three main processes when matching operational, sustainment and maintenance needs, followed by an overview of possible output data and results. Subsequently, a frank evaluation will be presented on the outcome, in terms of challenges, chances, potentials, and advantages. Furthermore, it will identify a gap or possible need for the RCN in this field. This will then lead to recommendations to the Director General Maritime Equipment Program Management.

[3] Bundesministerium der Verteidigung, *Bericht zur materiellen Einsatzbereitschaft der Hauptwaffensysteme der Bundeswehr 2017/Agenda Nutzung,* 2017, p. 9.

DISCUSSION

4. The German Navy project, aiming to develop and to evaluate a prediction capability with regard to the prognosticated materiel availability of naval weapon systems, has been set up in April 2018, closely, after ‘Agenda Nutzung’ (‘Agenda of In-Service Support’) and its related 13 subprojects have been initiated by the German Federal Ministry of Defense in November 2017. The German class 130 corvette, the BRAUNSCHWEIG class (K130), was selected as the Navy’s demonstrator and was foreseen as a blue-print, if the project turns out as a worthwhile outcome. A civilian contractor, IABG, was involved and tasked to determine and collect the required operational, failure and characteristic data, and to create and to model the simulation of the demonstrator. The contractor was supported by an accompanying study group of the public sector purchaser, consisting of representatives from naval in-service use and operational branches and scientific representatives from the Brandenburg University of Technology.

The Model

5. After having determined and collected the required sets of data (real data from ships, maintenance facilities, In-Service management department), they have been analysed with regard to quantity, quality, integrity and reliability of source. This analysis also served as a quality check, completed to avoid source data issues e.g. double count of data and false Meantime-between-Failure-rates (MTBF). The land based logistical support system of the class 130 is based on SAP applications, whereas the shipborne systems are not yet converted to SAP, but are intended to do in 2020. For now, there is a human interface needed to transfer data, which is mainly comprised of logistical or

technical requirements from the older onboard-systems to SAP (this function is embedded on the SQN-level, within the SQN organic support group).

6. In order to set up the simulation model, major business processes (MBP) and events were structured in a Conceptual Model. Afterwards, allocated MBP have been abstracted down to a functional level. These business processes are: The Annual Training and Maintain Plan ('Jahresübungs- und Erhaltungsplan, JÜEP', equivalent RCN-term Fleet Schedule) and the Medium-term Maintenance Plan ('Mittelfristerhaltungsplan, MEP', equivalent RCN-term Maintenance Schedule). Likewise, the major process of Conduct of Mission was examined, analysed, and simplified down to a functional level for an implementation into the model. This includes the subprocesses of Verification of material Readiness, Conduct of Deployment, and Failures (stochastic based occurring failures and their rectifications). Once this Functional Model was completed, it was transferred to the simulation software. This software tool, named Witness, has been developed specially to conduct dynamic simulations of industrial and logistical business processes.

7. An important part of the Functional Model were so-called Function chains. These are descriptive models of vital equipment chains of selected systems such as sensors, effectors, and main propulsion components; for example: Ship's propeller-shaft-gear-coupling-engine. Failures in theses chains occurred on stochastic events, but were based on the simulation gained MTBF. Function chains were applied in the model in order to determine whether a unit is ready to go to sea, to deploy and to define its respective readiness status. The readiness-status-systematic has been taken from the German Navy's current publication issued to determine the operational readiness status. This model deals

only with material considerations, personnel and training certifications are not aggregated. The material readiness itself fed into the MBP and were ongoing determined by the simulation model.

For the purpose of this demonstrator only selected Function chains have been implemented, but MTBF were based on processed real live data and its simulation-based extrapolation. That means that these data have to be available in applicable formats, and need to be accurate in terms of quality, reliability and quantity.

8. The simulation handles all five corvettes K130 which are currently in-service but also considers the five additional ships which are contracted and are expected to be commissioned on an annual basis, starting from 2023 onwards. When running the simulation, the first main process entities (term for unit, ship in terms of simulation) have to pass, is the so called Input-Process by feeding approximately 63 different data sets, such as status of readiness, hours of operation of several equipment, time left to next planned, deep maintenance in shipyards or arsenal. In this manner, the model will be able to establish a comprehensive status of the unit or the entity. In addition to this, data from the annual Fleet and Maintenance Schedule are also imported.

9. As a second major business process, the model produces and extrapolates generic plans; the timeframe is to be set up by the user and refers to the required timeframe of observation. The model analyzes the above-mentioned plans, and will progress it, based on the operational and maintenance inputs provided at the earlier stage. That is not artificial intelligence, but application of rules, embedded in the Functional model. The

user is also able to implement additional, new missions in order to simulate various scenarios which can then be investigated by the model.

10. Once a K130 is declared as ready to sail or ready to take part in an operation in the simulation environment, the entity will step through the Conduct of Operation business process. Herein, the model applies the Fleet schedule and the Maintenance schedule and will follow embedded mission and operation profiles. During its deployment all phases of naval operations are treated: Transit to Forward operating bases, then operational taskings itself and needed maintenance requirements. The model can also differentiate between the phases of being at sea, at anchor or in port. Because of these embedded and predetermined characteristics, the model counts the hours of operation on equipment or weapon engagements, while counting and adding rounds. The user is asked to define specific operations or training profiles by supplying information via the input window. So, the model has a quite high level of accuracy in representation of an average operation or mission.

In case a failure of equipment occurs, the model checks with its embedded Functional chains and related operational readiness status conditions, to determine whether the status of an entity has to be changed and what line of maintenance has to be applied in order to get the ship back operational ready. Also, a replacement of the unit is to be taken into account by the simulation model, valuing available hours of operations of the replacement unit by conducting the second and third MBP.

11. As the entity completes its tasking (operational, training) it will be considered by the model for further engagements or deep maintenance. By planning Fleet Maintenance,

the model considers the capacitates of the Naval Arsenal (Fleet Management Facility) with regard to workspace, stock availabilities and personnel occupations.

Results and output of a simulation's run

12. Although the simulation model and the project are in a status of a demonstrator, the output tool is able to visualize the Fleet Schedule and the occupation of each unit on a day-by-day basis, looking forward beyond the 2030 years. Also the predicted operational readiness status is given likewise. As a matter of mean, the model is able to visualize the number of used specific spare parts and sailed hours of operations.

The following central questions can be answered by the model, by pre-configuring the model and setting up the simulation-run correctly by the user:

- What is the tendency of available ships in a concrete timeframe or moment in time in general or with a discrete operational readiness status?
- Are the available maintenance capabilities sufficient in order to reach the demanded readiness status of a specific number of ships?
- Which parallel measures have to be taken to reach improvements in the maintenance sector and what interdependences might occur?
- Which recommended actions will lead to an optimized materiel availability of naval weapon systems?

Evaluation on the project and its outcome

13. The model was scientifically validated and verified by passing the stress tests, which were developed by the accompanying study group (German Naval Headquarters,

Brandenburg University to Technology).[4] It also proved its sufficient accuracy in the representation of the system described. First use as a 'hot run' was conducted in the course of a comprehensive test series of the new main in-service support management concept, related to the 'Agenda Nutzung'. The simulation results were presented on MoD level as part of the force planning group of the new outlined concept.[5]

14. As a result, the German Navy deems the project to be an astonishing, successful outcome and to a certain extent, as disruptive, by applying operational research methods and technical support measures. Advantages are seen in the analysis of parallelly interacting factors and parameters aiming to predict and enhance the materiel availability of naval weapon systems. Materiel availability trends can be predicted with regard to future in-service use and operational demands. The German Navy also sees planning advantages, when human capacities of thinking and intelligence are reaching its limits. Challenges are seen in the availability of sufficient data sets[6]. At the moment, they are assessed as limited sufficient with regard to quantity, quality and integrity. Improvements are expected when the class 130 has transferred to shipborne SAP applications. Additionally, an organizational element with specialists has to be founded and implemented in the In-service support branch. This element has to apply, to maintain and to develop the simulation models.[7]

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[4] German Navy Headquarter, *Final Report on Development of a simulation-based prediction capability for the materiel availability of Navy ships*, p. 2, 2019.
[5] *Ibid*, p. 3, 2019.
[6] *Ibid*, p. 4.
7Ibid, p. 4.

Gap and possible advantage for the Royal Canadian Navy

15. The RCN is not a newcomer with simulation-based appliances. Several individual projects were conducted in the operational and maintenance field. For example, one project dealt with the estimation of the number of required surface ships in order to fulfill current operational demands, applying mathematical methods and software support for a multi-parametrical examination. Two further projects dealt with the optimization of the maintenance of RCN submarines and of the Arctic ships. Civil contractors are engaged in the development and in engineering of these maintenance-optimizers (Babcock, Thales). Several inhouse tools are used by the naval maintenance branch to achieve an internal planning support, when coordinating and assigning internal capacities, for example inside the RCN Fleet Maintenance Facilities. Another project, sponsored by the Assistant Deputy Minister for Materiel (ADM (Mat)), utilizes the Monte-Carlo-Simulation to optimize operational needs and aspects.

16. All RCN projects are already bringing together subject matter experts (SME) and are working towards the long-term goal to enhance the operational readiness and availability of RCN fleet units by optimizing operations and maintenance matters, but should still be considered as silo-system solutions. Since, they are unable to operate with any other system, this means they are closed off from other IT-systems. A project similar to the one the German Navy has conducted recently could bring together the already existing functional experiences from several silo-systems within one solution or model. This should be interfaced and connected with shipborne applications such as SAP for logistics and maintenance needs.

CONCLUSION

17. This paper has given an overview and a functional description of the simulation model, which was composed in the course of a German Navy project. This project has been set up by the German Armed Forces MoD in order to develop a simulation-based prediction capability for the material availability of weapon systems, aiming to enhance the overall material readiness. The simulation model proved the general feasibility of reproducing real life systems and complex processes of naval operations, engineering and logistics through Functional Models. Operational and maintenance requirements were handled simultaneously by the simulation model within its three major business processes. First utilizations of the model brought useful experiences and proper results. But it also showed current challenges with regard to the available data sets. However, the general approach and the general feasibility have been sufficiently proven. The RCN should – based on its own existing experiences in this field – proceed and spend effort in order to develop one comprehensive system. For this, the RCN could consider the gained findings by the German Navy project as described.

RECOMMENDATION

18. A clear recommendation for the RCN is to combine all existing functions and experiences of its different silo-system solutions in one comprehensive solution in order to have only one system available across the Navy and to enhance effectiveness by doing so. The German Navy's project of developing a simulation-based prediction capability could serve as an example or at least as a matter for further studies and considerations by responsible RCN representatives.

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