The A26 project: Status update at the end of the detail design phase and the way ahead towards delivery to the Royal Swedish Navy

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Abstract — Almost four year after the build contract was signed with Saab Kockums AB, the system design is finished, the final arrangement is defined and the main contractor works with detail design and construction. Also, the verification has started, with mainly Design reviews and Factory Acceptant Tests of sub-suppliers equipment, before delivery to Saab Kockums AB. In this paper, the work performed so far will be described and the how different challenges have been solved in cooperation between FMV and Saab Kockums AB. Also, the successful cooperation with Midlife upgrade of the Gotland class project will be discussed and how identified risks are handled, for example the pros and cons with using the same personnel. The way a head will be described, how the focus will move from design work to construction work, verification and also to training and education of the end user, the crews. The project has also started to identify what is needed to hand-over the submarines to the Royal Swedish Navy, with the objective to enable the Royal Swedish Navy in general and the Submarine flotilla in particular to operate the new and advanced submarine type A26 from the first day after the delivery; both from tactical, infrastructure and competences perspectives.

1 Introduction

The Swedish parliament has decided that Sweden shall have 4 operational submarines. Two existing submarines of the Gotland class is undergoing a Midlife Upgrade (MLU) to achieve a new submarine class that fulfils the operational requirements of today and extend its lifetime. In order to replace two of the other existing submarines, the government in 2015 decided to develop and procure two submarines of the A26 class, and FMV signed the build contract with Saab Kockums AB (SK) the same year, with the objectives to finalize the design, construct and verify two submarines of the A26-class.

2 Objectives

In this paper the project objectives are described and the work performed so far will be summarized and overall lessons learned will be discussed. The way ahead is discussed and some of the challenges that the project will cope with will briefly be discussed. Also, the co-operation with the Mid Life Upgrade of the Gotland class (MLU GTD) is described with all the advantages that it will give for the Royal Swedish Navy (RSwN).

3 Project A26

3.1 Project objectives

The objective with the A26 project is to develop and procure two submarines type A26. The submarines will be verified and validated before they are delivered to the Royal Swedish Navy (RSwN) 2024 and 2025 respectively. In the delivery, spares and documentation are also included. The project is also responsible to educate and train two crews. These two crews will also be the crews that operate the submarines during the verification and validation phase.

3.2 The submarines

The submarines are described in detail in other papers, and there will be only a brief description of the design in this paper. Even though the system design and room arrangement is defined, the most interesting news is that the Chief of Navy has decided the name of the submarines, HMS Blekinge and HMS Skåne.

The submarines will be 66 m long and with a width of 6.75 m which will give a displacement at approximately 2100 tonnes. The submarines are of single hull type, and will have two pressure tight compartments with a mid-tank section in between the compartments. In the mid-tank section a rescue tower is situated, which enables both free ascent and collective escape to a Submarine Rescue Vehicle, from both pressure tight compartments. The submarine is designed as an AIP (Air Independent Propulsion) submarine where the complete propulsion and energy system is optimized for covert operations without any need for using the noisy snorting machinery, when the submarine is in the operational area.

The combat system sensor suite consist of passive and active sonars, ESM-systems (Electronic Support Measure) working in different frequencies and an optronic sensor system. All different sensors and sub-systems are integrated with the Combat Management System (CMS) to allow for sensor fusion to gain the most out of the different sensors, to enable long range situation awareness used for intelligence gathering and weapon engagement.

The weapon load consist of heavy weight and light weight torpedoes, where the light weight torpedoes are handled in

the 53 cm torpedo tube with an insertion-tube to cope with the different diameters. In the bow, a Flexible Payload Lock (FPL) is also situated. The FPL, with its diameter of 1.5 meter can be used to lock in/out divers, Remotely Operated and Autonomous Vehicles or other types of loads to and from the sea volume.

Even though the A26-class submarine is a development of the successful Gotland class submarine (A19), the performance is enhanced in many areas such as:

- The sensor-suite
- Communication
- Command and control
- Flexibility
- Endurance
- AIP-capability
- Signatures
- Fire Protection
- Capability to withstand shock
- Living environment for the crew
- Increased capabilities for underwater work and Special forces

The degree of shock resistance is very high on the A26 submarine. Through the use of advanced numerical tools, shock performance is assessed and the requirements on system and component level are generated. Together with platform mounting of systems and components, a high resistance level is achieved at reasonable cost. The use of platform mounting of systems will imply that the shock requirements for systems and components can be less stringent, compared with systems and components mounted directly on the pressure hull structure. Platform mounting will also give lower acoustic signatures and it will also imply that the construction cost will be lower, since a lot of the systems and components can be mounted and tested outside the submarine. After completion of tests and verifications, the platforms are elastically mounted in the pressure hull sections, which then are welded together.

In order to achieve a cost effective maintenance concept and maximized available mission time for the submarine, the Integrated Logistic Support work has been taken into account early in the design work. Customer requirements are set for different ILS related areas early in the development phase. Example areas are; availability, Mean Time Between Failure and Mean Time to Repair and time to perform completion of storage, crew size, onboard training facilities and documentation. These requirements, set on the complete submarine, are then allocated, by the main contractor, to the different systems and components in the early stages of the system design, and then handled during system- and detail design, to ensure they will be fulfilled.

In the end, this will provide a submarine with high availability, for example by having overhaul every 2nd year and major overhaul every 8th year, without increasing the time needed for each overhaul. Implementing condition based maintenance (CBM) system will give the possibility of identify needs for preventive maintenance tasks at an early stage resulting in an undiminished availability.

From a tactical perspective, short stand-off times in harbour/bases is important, and for the A26 submarine, the submarine will be able to refill its storages, such as fuel, LOX, weapons and other supplies during one working-day.

Also, to reduce the Life Cycle Cost many systems are common between the MLU GTD class submarines and the A26 class submarines, which is described in next section.

3.3 A26 and Midlife upgrade of Gotland class

Since the MLU GTD and A26 projects run in parallel, although with different project times and different phases, there was an opportunity to develop and procure different systems to be used in both submarine classes. Example of systems are the Stirling system, Optronic sensor system, Water Chiller Units, Ship Control and Monitoring System, ESM-system, communication antennas, masts, CMS and sonars. The procurement costs is lower, since the Non-recurring cost is shared, and in addition, the total Life Cycle Cost will be lower, since RSwN can use the same stock of spares for both submarine types. Also, upgrades will be done for four systems instead of two, Land Based Training Site can also be used for training and education for both submarine classes etc.. For the A26 project, this also means that for some systems that will developed and used, the technology is already proven, since it is installed in the MLU GTD class submarines. For the submarine officers and seamen, it will be easier to change between the two classes, since a lot of the systems are common, which is favourable when you only have 4 submarines in total.

Figure 1. The A26 submarine

3.4 Lessons learned so far and the way ahead

Lessons learned from other projects are always of great interest. Since a submarine is one of the most complex vehicles that are designed and operated today, the author believes that they are (more or less) of the same kind, regardless of the project, as long as we talk about a project with the objective to develop and construct advanced vehicles. Below are some of the lessons learned are listed:

- It is very important to have a management team that have deep understanding of submarine design and the relation and balance between different capabilities, key areas and systems
- The system engineering process must be adapted and customized, since a submarine is a very complex vehicle and has limited available space. This can be concluded in two sentences;
    - The devil is in the details
    - A submarine should be as small as possible
- Today, many favour early verification using drawings and design documents, with the justification that then you know what you get and that it will save money to verify early. The authors experience is that it is more cost effective to work close to the suppliers during the complete design work to ensure that the interpretation of requirements is agreed and that you know what you get, and that it is more efficient to verify the requirements in real life; FAT, HAT and SAT, although some requirements are hard to verify in real life, such as collapse depth
- To design and build a submarine that fulfil all the operational requirements, such as shock, signature, onboard security, sonar range etc. and at the same time is user friendly, fulfils requirements for maintainability and cost effectiveness during the complete life cycle is not possible without a close cooperation between the different stakeholders. Those stakeholders are
    - The end user
    - The procurement agency with both management- technical- and commercial teams
    - The main supplier and sub-suppliers

The majority of the above lessons learned are the same as for earlier Swedish submarine projects, and we have an organization and processes that both are adapted to the challenges, even though the organization, process and how to interact between the different stake holders has to be tailored for this project, as well for others.

The lesson learned regarding the optimum time for verification is for sure made in other projects as well. For the A26 project, this view has changed during the time frame of the project. The main reason is that a submarine is a very complex system, with many dependencies between different subsystems, and if you perform early verification, for example a design review or test on test site, you will not test the component or system in its correct environment.

4 The way ahead

The construction work at the shipyard in Karlskrona is ongoing. At the moment, sections of the pressure hull are welded and some of the platforms are constructed. Also, a lot of sub-systems and components have arrived to SK facility. FMV is present at the shipyard performing quality controls. In comparison to other Swedish military ship projects, a Swedish submarine project does not use a classification society, and thereby must perform some of that work ourselves.

We have also started the verification of the submarines, with the main focus on design reviews and FAT. Design reviews are preferable performed for requirements that cannot be tested in real life. FAT is performed at the sub-suppliers premises, and are performed before the sub-suppliers deliver the systems to SK. For more advanced and important systems, FMV participates at the FAT.

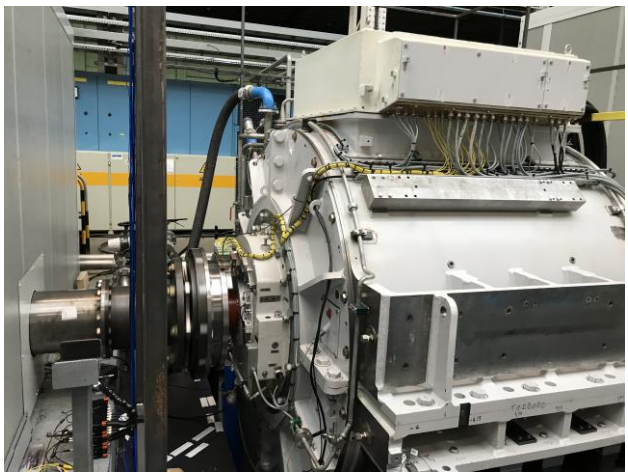

Figure 2. Picture from the FAT for the propulsion engine system for A26

In order to deliver the submarines to the 1st Submarine flotilla, and that the flotilla is prepared to operate the A26 submarine class, FMV is conducting an early planning to identify tasks that so far haven't been taken care of. One area that is already covered is training of crew members and maintenance personnel, where we at the moment are working with the detailed planning. In this planning, a given step is to finally decide how the crew will look and what kind of basic education they need. A finding was, not surprising, that technicians need a deeper knowledge in IT-systems and data networks.

In the early planning for handover to the RSwN, some areas where identified such as:

- Piers are adapted due to physical dimensions of the A26 submarines.
- New shore connections for power and communication
- The RSwN need an organization to take care of the A26 Material Safety Quality Program
- The RSwN needs to start new courses for new sensor types

At the start of the early planning work of the delivery of the submarine system to the end user, there were arguments that it was too early. The result so far indicates the opposite.

5 Summary

To design, build and verify a complex vehicle such as a submarine is a challenge, which require skilled competences of the different stakeholders to manage the different risks and different design areas. Even though the A26 submarine is one of the most modern submarines in the world when it will be launched, a lot of the different technologies used in different areas on-board are proven, due to the commonality with MLU GTD class submarines.. New capabilities are added in comparison to existing submarines, such as the Flexible Payload Lock, which will enable to lock in and out different types of vehicles, equipment and divers to and from the submarine.

The lessons learned so far shows that it is important to have a management level with a deep technical understanding, that processes and organizations must be adapted to the different projects and challenges, and that the close cooperation between the end user, the procurement and design agency and the suppliers are very important. Also, in order to be successful, start to work with the handover process to the Navy as early as possible.

Author/Speaker Biographies

Dr Fredrik Hellstrom is the Project Manager for Project A26/Next generation submarine at FMV. Dr Hellstrom has a background from the Royal Swedish Navy, where he served as an engineer, obtained a degree of M Sc in Naval Architecture at KTH and other different military educations. In addition to the educations mentioned, Dr Hellstrom has a PhD in fluid dynamics.