

Mid-Life Upgrade of the Swedish Gotland Class submarines – Adaptations securing capability today as well as transition onto the A26 submarines.

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Abstract — A general brief on principles used when preparing for and conducting the Mid-Life Upgrade on the Swedish Gotland Class submarines. The presentation will describe how the used approach has reduced costs and required resources, as well as met the aim to help the end user in the transition to operate and maintain the upcoming A26 submarines. An overview of modifications carried out as well as an update on the Swedish Stirling System will be given.

1 Introduction

The well proven Swedish Gotland Class submarines are well underway in receiving an extensive Mid-Life Upgrade. The first submarine, out of two to be modified, is to be delivered during 2019, the second in 2020.

2 Objectives of the program

- Develop and modify two submarines type A19 aiming to meet new staff requirements, retained availability and to comply with new legislature for an operational period up to 2025 (2030).
- Co-ordination with A26 shall be considered regarding design principles and acquisition of subsystems
- The task shall be carried out following "Design to Cost-principles".

3 Approach

The Program has quite a long history with the early years, *Studies/Definition 2008-2011*, used to study different concepts aiming to meet the Staff requirements as well as budgetary constraints. During the iterative process targeting a feasible cost-effective concept that could be used for the definition phase, the Staff requirements were revisited and some compromises were made.

During the *Pre-design and Design Phases, 2012-2015*, the concept was backed up with design solutions based on technical discussions and negotiations with the Main supplier as well as Sub-suppliers. A significant amount of technical solutions were brought in from the A26 Program and procurements were prepared jointly, with significant cost savings.

The on-going *Production Phase*, including Detail Design, was entered in 2015 after a re-arrangement of the ownership of the Main Contractor, now owned by Saab AB. Project closure is planned in 2020 after the delivery of the second submarine.

4 The Gotland Class, A19

4.1 The origin

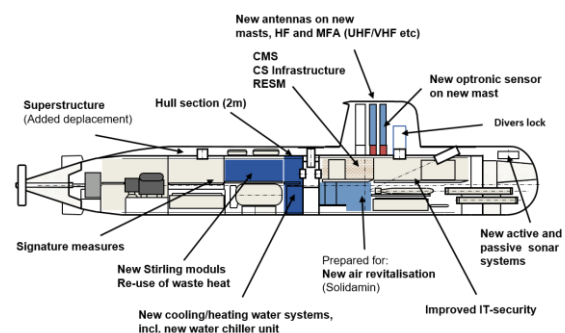
The Gotland Class was designed and built in the early 1990's. The three submarines of class, *HMS Gotland*, *HMS Uppland* and *HMS Halland* were commissioned between 1996–1998.

During the years before the MLU some major modifications were made during an upgrade of the Combat systems (2010-2013). These modifications could be seen as the first step of the MLU, even though many of the systems involved are re-addressed and further modified during the MLU.

4.2 The Mid-Life Upgrade

The MLU is quite an extensive program with many improved, as well as new, capabilities. Some major areas are;

- New sensors, navigation- and communication systems
- New combat management- and ship management systems
- Stirling Mk IV AIP for improved endurance
- Improved IT-security
- Compliance with modern rules and regulations
- Resolution of end-of-life issues



Most areas of the submarine are affected but key areas are the fin and the area just aft of the mid tank section, where

an extra hull section of 2 meter is added. Weight balance and buoyancy have been key drivers in the design. New masts and sensors in conjunction with a the added steel in the fin, related to a new divers lock for Special Forces, resulted in the need for the added displacement as well as extra keel weights.

A more thorough technical presentation will be given at UDT 2019 in Stockholm.

4.3 Commonalities with the A26 Program

The objective to share design principles and acquisition of subsystems have resulted in the following common systems, most being identical but some having a higher spec for the A26.

Combat Systems

- CS Infra Structure
- CMS
- Passive Sonar
- Active Sonar
- RESM
- Optronics
- Comms/Antennas
- Navigation
- On Board Security / IT-security

Platform Systems

- SCMS/IPMS
- Stirling (Mk IV)
- Mast System
- Tropicalisation (Water Chiller Units)
- Signature measures

An important area of co-operation is that the two programmes also share some of the personnel, both on the industry side as well as within FMV.

5 Developments considered but not included

A number of potential technologies were considered at an early stage but were rejected for different reasons. Main areas being;

- The AIP System
- The Battery System
- The Fin design

The now 30-year old AIP-System, based on Stirling engines, was challenged with fuel cell technology studies but proved in our risk/benefit analysis to be the best alternative from a total system perspective, particularly taking risk and cost into the calculation. Even though Fuel Cells have been commercially available for quite some time and a number of different FC-technologies are available, major concerns are still present regarding the supply of the hydrogen and the total system performance, including signatures.

The same applies to the battery technology. Some promising developments in battery technology were considered but showed not to be mature enough for installation within the given timeframe. Main concerns are the system complexity, temperature stability and shock resistance that has to be verified during extensive full scale testing before being an alternative on a Swedish submarine. That may still be a possible future modification though.

A lot of effort have been taken to balance the strive for new functions and new technologies with the risks and added costs involved.

Some in more depth details, including the latest developments on the Swedish Stirling System, will be given during the presentation at UDT 2019 in Stockholm.

6 Challenges

Among challenges encountered along the program most relates to introducing new technologies in an old submarine. Many constraints are at hand and quite often the work to be performed has showed to be more time consuming than starting with a clean sheet. An example of a time consuming area was the fin whereas the AIP-compartment showed more fruitful as, in this area, a “rip out and replace the lot”-approach was taken. A challenge when planning the production was to maintain the access to the submarine open as major work was done in the fin as well as around the hull opening for the extra hull section, affecting both entrances at hand. Another area that has shown to be challenging is the process to integrate, test, rectify, re-test and verify a large number of sub-system software on-board in a short time frame while maintaining a high level of IT-security.

7 Summary

Two of the Gotland Class Submarines are well under way through their Mid-Life Upgrade. Delivery to the Navy will take place in 2019 and 2020, respectively. The submarines will benefit from extensive modifications consisting of a balance between newly developed state of the art technology and carefully evolved improvements to sea-proven and well performing equipment.

The Gotland Class subs will continue to be the workhorses of the Swedish Navy until at least 2030, possibly beyond that after a Lifetime Extension. Along the road they will be accompanied by the A26 submarines that will arrive in the mid 2020th with crews already being familiar with some of their equipment from the Gotland Class.

Author/Speaker Biographies

Hans Egonsson is a Naval Architect and an ex-Submariner in the Royal Swedish Navy. He started his career onboard submarines of the Sjöormen and Västergötland Class, then moved on for a Master degree in Naval Architecture. Naval postings thereafter include Staff-Engineer within the 1st Submarine Flotilla, an exchange-posting in Australia and the Naval Staff Programme at Swedish National Defence College, before moving on for a career within FMV. At FMV, for the last 17 years, Hans has held a number of positions as a Senior Engineer and Program Manager and is currently the Program Manager for the Mid-Life Upgrade of the Gotland Class Submarines.