Linking reliability engineering with supportability for enhanced operational availability

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Abstract — This paper will elaborate on a mission-oriented approach used to develop new and upgrade existing systems to meet the operational needs, threats and requirements from future submarine operations. It will provide an insight into the strategic importance of connecting operational availability with supportability and cost effectiveness.

1 - Introduction

A submarine fleet is an extensive investment for any Navy and therefore the Navy should require a good return of investment in form of optimal availability and cost effectiveness.

Sweden is one of the few countries in the world that has the capability to develop, design, construct, operate and maintain AIP submarines, and this with a relative small defence budget. This is mainly due to the following factors:

- A design method with balanced requirements stated from operational needs, threat and operational environment – a mission oriented approach
- A submarine enterprise, where the different stakeholders have complementary competences and assets for the complete life cycle of the submarine.
- A design that takes the demands and needs for production and maintenance into account [1]

2 - Approach

Acquisition of a submarine is a delicate balance between whole life costs, risks and operational performance, which forces the parent Navy to choose a procurement strategy

The balanced method is to base the design on a proven (High TRL) solution, which can be evolved further in order to maintain the competitive edge but still be able to keep project risks and costs at reasonable levels.

With a mission-oriented approach [2] complemented with parallel system development it is possible to integrate new and improved technologies at justifiable risk levels [3]

2.1. Modular Design

The Blekinge class submarine (A26) is a development of the successful Gotland class submarine (A19), with optimized performance in areas, such as:

- Communication, Command and Control
- The Sensor-Suite
- Endurance
- AIP-Capability

The Blekinge class submarine (A26), while developed for the Swedish Navy, is designed for operations in littoral and blue-water areas worldwide in all kinds of environment, from tropic to arctic, and in all levels of conflict, from peace to war. A key factor in the design of the Blekinge class submarine is the modularity and flexibility in the design [3]. Margins for future upgrades are defined in a number of areas and specific systems.

The submarine is also prepared for later addition of systems and/or equipment that for various reasons may not be implemented initially. Additionally, with the Blekinge class a new maintenance plan is introduced (Fig 2.) in order to optimize the operational availability of the submarines [4].

To integrate new systems and functionalities into a submarine project, the solution in Sweden has been to have parallel system development projects, not directly coupled to a specific submarine project. Within a development project, a new system can be promoted, tested and verified, and when it reaches its target Technology Readiness Level (TRL), it can be incorporated into either an existing or new submarine project.

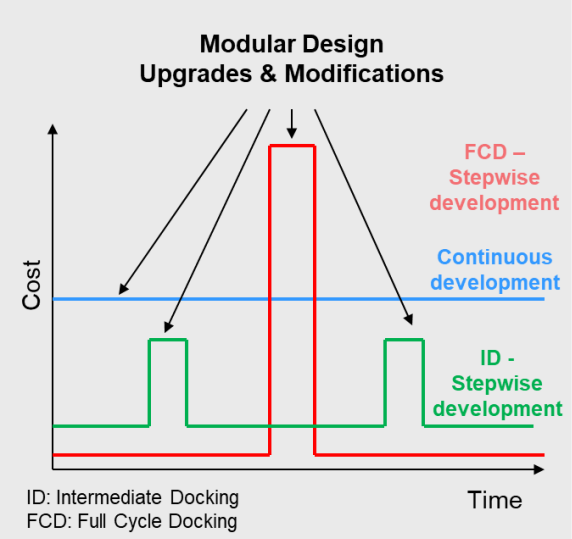

Fig. 1. Upgrades and modifications is introduced at the ID and FCD maintenance availabilities.

The ambition is not to have a large midlife upgrade on the Blekinge class. Instead, upgrades and modifications are budgeted and planned for the ID and FCD maintenance availabilities (Fig. 1).

2.2. Availability and Maintenance Planning

The Swedish Navy have a maintenance plan with yearly intermediate docking (ID), and a full cycle docking (FCD) with general overhaul after six years (Fig. 2). An intermediate docking takes about 10 weeks and a FCD is about one year.

Altogether, the existing maintenance plan is adequate and the Gotland class submarines have an optimal availability in general, but in order to meet the requirements on the Blekinge class a new maintenance plan has been developed.

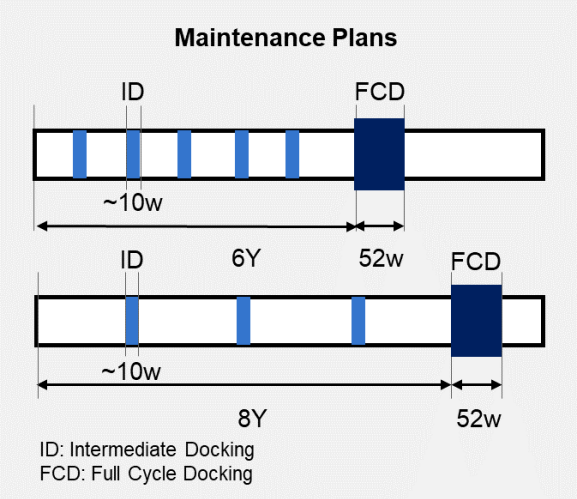

Fig. 2. Comparison of Gotland and Blekinge maintenance plans

This new plan will increase the operational availability with 14 % i.r.t. Gotland Class and result in a theoretical operational availability of more than 80%.

2.3. Cost Effectiveness and Reliability

Cost effectiveness and Life Cycle Costing trade-off analysis is driven by reliability (i.e. how much performance can you get for your money?)

Reliability [*R*] is driven by number of failures, and tells information about the failure-free interval (i.e. how many failures can you afford?)

Operational availability [A_o] is driven by time lost, and tells information about how you use time (i.e. how much can you afford to spend to avoid failures?)

Both reliability and operational availability are described in percentage values and early analysis is critical for reductions in life cycle cost and trade-offs in performance or system effectiveness (Fig. 3)

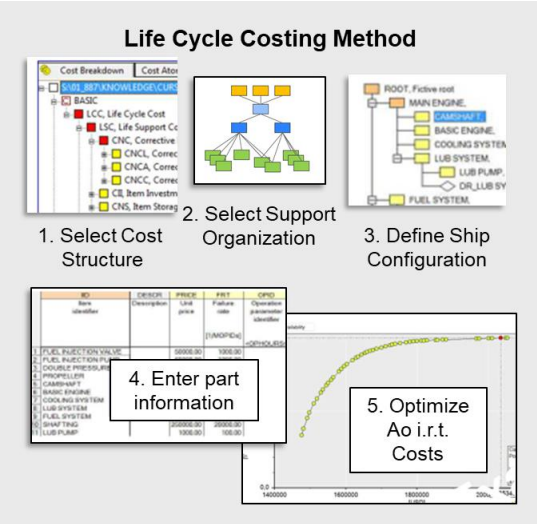

Fig. 3. Life Cycle Costing method for analysing operational availability, Ao, and cost efficiency

3 - Conclusion

Today's naval procurement is a balance between new and proven design solutions where low project risk, shorter lead times and cost effectiveness are some key factors. With the requirement driven mission-oriented approach, it is possible to define the range of conditions on availability, supportability and affordability. Moreover, it is possible to align stakeholder requirements with system development and assess the design maturity with reference to trade-offs in performance and efficiency

References

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Peter Anbring serves as Senior Logistics Engineer with focus on dependability in the Blekinge project. Anbring served as ILS Deputy Project Manager in the Singaporean Obsolescence Replacement Programme from 2013 to 2015 and as ILS Deputy Project Manager in the concluding part of the Northern Light project from 2013 to 2014.

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Tomas Ternström serves as ILS Manager Naval Support Solutions since 2012. He has been a Senior Logistics Engineer at Saab Kockums since October 2006. Ternström served as ILS Manager Gotland Class CMS upgrade from 2009 to 2011 and as ILS Manager on various upgrades to the Gotland Class submarines between 2006 and 2008