DUTCH UNDERWATER KNOWLEDGE CENTER

sinds 2004

Werkgroep van het Nederlands Marinebouw Cluster

The capabilities and participation objectives of industries in the Netherlands

A **DUKC** Report - Commercial in confidence

Executive summary

In September 2013, the Ministry of Defense (MoD)[1] announced plans to replace the Walrus Class submarines in the coming twenties. These plans included the explicit desire to collaborate with European partners. In response to the announcement the members of the Dutch Underwater Knowledge Center (DUKC) felt the need to put forward their ambition to become an integral partner in this programme and to discuss this with MoD. Subsequently it triggered this report on Participation Objectives which is based on an earlier DUKC report "Onderzeebootkennis" that was presented to MoD on 16 November 2012.

Section 3 of this report on Participation Objectives puts forward the participation objectives. It is shown that a substantial part of the design, construction and supply can be carried out by Dutch industry and research institutes. MoD has encountered a substantial knowledge drain over the past years and industry and research institutes are able to supplement these knowledge gaps through close cooperation wherever complementary knowledge exists. Section 3 spells out the ambition of DUKC members as related to the various parts of the programme.

Section 4 is an overview of the knowledge base that has been identified in the knowledge inventory of 2012 which has been updated in the course of making this report on Participation Objectives. In addition to the general submarine knowledge base, areas of excellence are identified. Based on the premise that the new requirements are for an oceangoing submarine, with the Walrus Class as a benchmark, this section also identifies some industrial capacity and capability gaps that exist today.

Section 5 deals with the need and possibilities to manage the above mentioned gaps. An estimate of the rate of increase of the engineering capacity shows that for the initial stages of the programme a sense of urgency is well noted. This urgency certainly applies to the indispensable studies following from an itemised MoD technology roadmap as well as the already defined SubMArine Research & Technology (SMART) programme. These studies are of prime importance to identify and mitigate programme risks. In addition a joint Project Definition Study (PDS) carried out in the Triple Helix[2] (gouden driehoek) is seen as the optimal way to obtain a clear understanding of a functional design specification. A PDS is not only clearly needed as a guide for the design, but will also be the point of departure for preparing production plans and the supply of subsystems and components as well as an optimal Integrated logistic Support/ Life Cycle Cost plan.

Section 6 is an overview of the organisational structures that have been considered by the DUKC members with the outcome that a Dutch prime contractor is favored. Despite this preference, in the event of a European collaboration, all organisational matters shall have to be adapted to such decision, which may include an international consortium. Irrespective of the organisational aspects, the programme offers substantial employment opportunities in the order of thousands of man years.

Section 7 addresses some related benefits of an important Dutch participation for all parties of the Triple Helix. In terms of the DIS DUKC is a (knowledge) cluster. Furthermore the joint endeavors for the new submarine greatly support the export position of the Dutch industry. Attention is given to the track record of the members of DUKC in Section 8.

The objective of this report on Participation Objectives is to discuss the desire of DUKC members to become an integral part of the Walrus Class replacement programme with MoD.

1 Nota In het belang van Nederland; De minister van Defensie Jeanine Hennis-Plasschaert.

2 Triple helix (gouden driehoek) is term used by the Dutch government for tri-partite collaboration involving the government.

DUKC is a cluster of:

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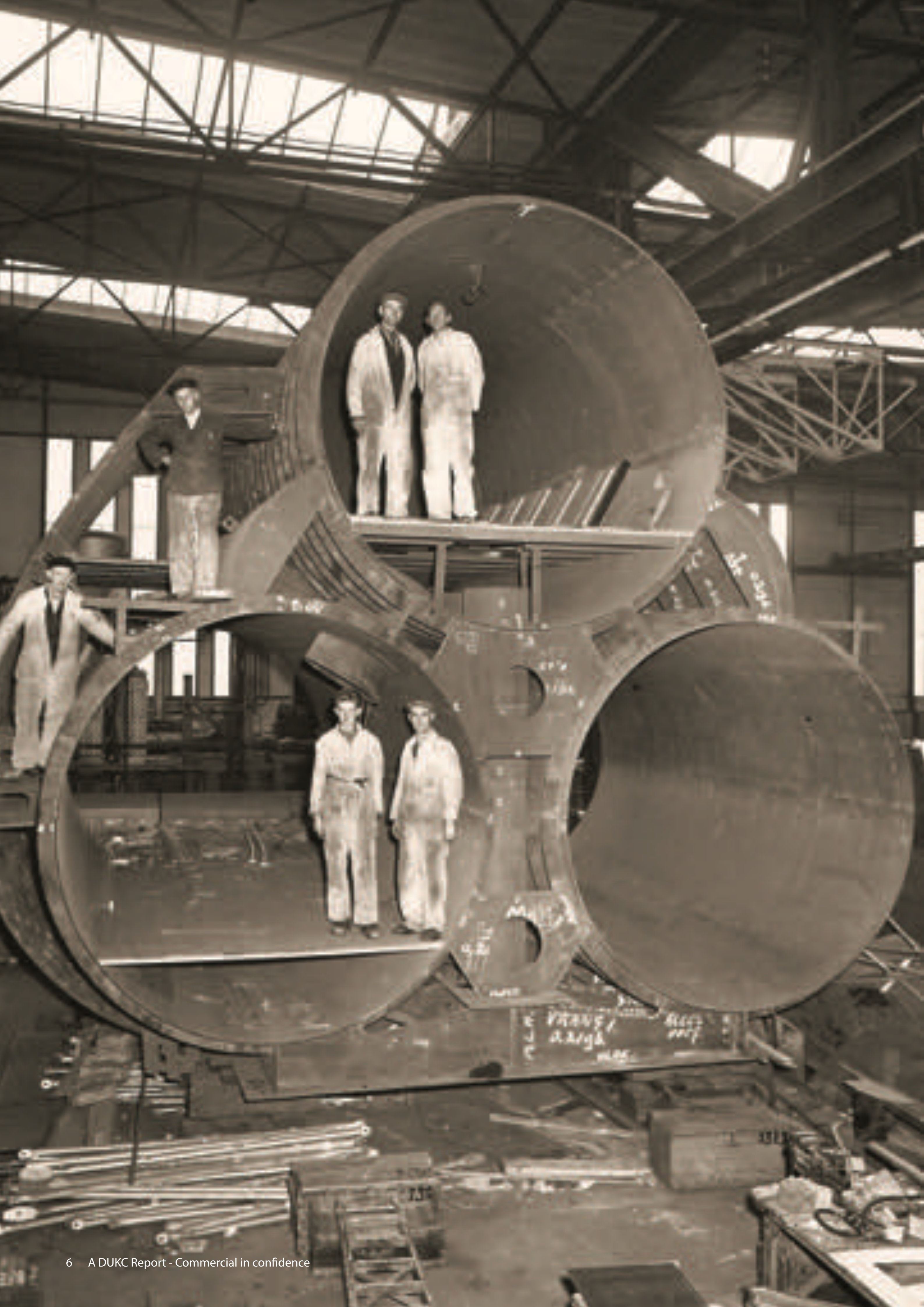


2 Introduction

Designing and building naval submarines are complex tasks that require organisations with unique skills and expertise. While recognising the importance of past experiences with the successful Walrus Class programme the circumstances for a replacement programme will be different since the objective of the Ministry of Defense (MoD) to seek collaboration with European partners will constitute a new playing field.

The members of the Dutch Underwater Knowledge Center (DUKC) have the ambition to become an integral part of a new collaborative submarine programme. DUKC acknowledges that it is important that all parties, including MoD, have a thorough understanding of the capabilities of the Dutch industry and research institutes. To be well prepared it is necessary for the industry to have a good understanding of the user's operational and support requirements for the programme. The Walrus Class' favorable operational capabilities, cost of ownership and operational availability has partly been the result of the close communication and collaboration between the MoD, the Dutch industry and research institutes in the Triple Helix (gouden driehoek). The excellent international reputation will be sustained when this collaboration is continued in a new programme.

The DUKC participation objectives are in line with the policy instruments of the Netherlands' Defense Industry Strategy (DIS) regarding the priority areas "technology, information exchange, functional specifications and market positioning".

The report on Participation Objectives presented here is an overview of the capabilities, ambitions and participation objectives of the DUKC members. The members[3] represent the present industry knowledge base, their technology portfolio and their management experience in all phases of a submarine programme, dating from their involvement with the design and construction of the Walrus Class, the Sea Dragon Class and the Project Definition Study (PDS) for the Moray Class. Recent experience has been obtained in foreign projects and the preparation and execution of the life extension programme of the Walrus Class (IP-W).

In 2012, DUKC members decided to describe the submarine knowledge base and instigated a series of interviews with industry and research institutes. This resulted in the DUKC report "Onderzeebootkennis" which was presented on 16 November 2012 during meeting organised[4] by MoD . The report presents a concise overview of the know-how and experience of the DUKC members.

The report on the submarine knowledge base was followed by an inventory of the ambitions and capabilities of the members in view of a new submarine development and construction programme. This inventory was started in 2013 through interviews with the members of DUKC. The information was reported in early 2014.

3 See Section 9 for a listing of the DUKC members

4 MoD-DUKC Kennismiddag, Prinses Juliana Kazerne, Den Haag; 16-11-2012

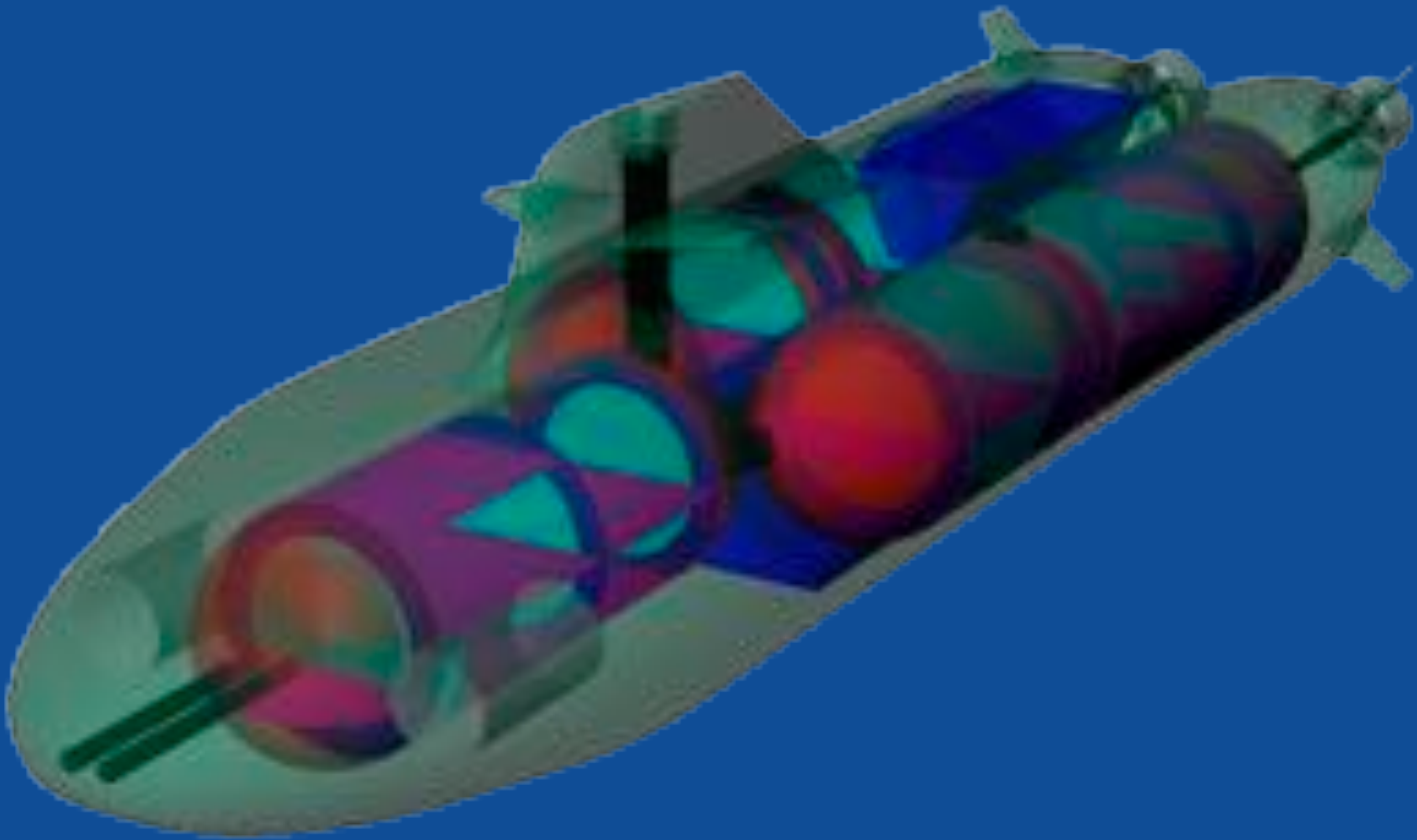
Since the announcement by the MoD in September 2013 ("In het belang van Nederland") of plans to replace the Walrus Class in the coming twenties that included the explicit desire to collaborate with European partners, the DUKC has become aware of the consequences of this MoD policy. They like to stress the opportunity for the MoD to enjoy the benefits of operational and in service support successes of the present submarine deployment when involving the Dutch industry in a new programme based on new requirements.

The Walrus Class, as presently upgraded in the life extension programme, is seen as a benchmark for the new submarine capability. This benchmark is to be improved upon in a functional, practical and cost-effective way. That means that the new submarine is likely to be an oceangoing long-range submarine for climates from arctic to tropical conditions. A desired 2025 state of technology, especially regarding Platform- and Combat Management Systems (PMS, CMS), shall bring new operational benefits and may, at the same time, be a means to reduce the crew size. CMS communality with the surface ships shall help to reduce development costs and support future job rotation. Furthermore it enables introducing HR requirements into the design of workstations and the layout of the operational spaces. In addition it seems likely that training and simulation facilities can be (partly) shared with those of surface ships. Satellite communications and network enabled capabilities are regarded important to enhance the operational capabilities, with a particular focus on IRS[5] tasks.

A Walrus like hull size should facilitate habitability for special forces operations and all their equipment. The habitability as such shall be equal to the benchmark to suit expeditionary operations. The application of new materials shall be subject to further investigation to enhance maintainability.
The Walrus signature shall be improved upon where sensible and feasible. Apart from the traditional torpedo weapons, other lighter, defensive weapons should be considered.
A high availability and low Life Cycle Cost / Cost of Ownership are regarded to be a design criterion. International reports consider the current Walrus Class and the Dutch in service support as very competitive in both availability and sustainability. The aim is to continue or even improve this favorable position.

For domestic naval ship design and build programmes, the collaboration between MoD, industry and research institutes in the Triple Helix has been best practice and is recommended for future Naval projects. This practice is also promoted by all DUKC members to be adopted for a (European) collaborative submarine programme. The Dutch industry follows and supports the defense policy that has been laid down in the DIS. It offers MoD a concept for efficient communication regarding all relevant topics and enables the industry to be an informed partner in all phases of the programme. Both elements are seen as a contributing to risk reduction and efficient programme development.

5 Intelligence, Reconnaissance and Surveillance



REACH: A Submurged Remote Sensing Reconnaissance System; Prins,C.A., etal.; UDT2008

3 Participation Objectives

3.1 Overall participation objective

The ambition of industry and research institutes, not yet considering any international restrictions, is to maximise their participation and to achieve synergy between the parties involved.

In alphabetic order the participation objective of the individual DUKC members is focused on:
Airborne: to design and produce composite submarine structures, propeller shafts and propellers.
De Regt: to be the supplier of custom engineered special cables.
DSNS: to be the engineer, integrator and builder of the submarines for the MoD
Imtech: to be the architect/designer, supplier, system integrator and maintainer of (electrical) propulsion, power supply and distribution, energy management, platform automation, steering and stabilisation control system, integrated navigation and communication systems and HVAC.
Loggers: to be designer and supplier of spring mounts for shock protection and noise reduction.
MARIN: to be expert advisor on hull resistance and propulsion, maneuvering and hydrodynamic noise. Also for hydrodynamic predictions, maneuvering simulations through calculations, CFD simulations and model tests, simulator models and full mission simulators, full scale trials.
Nedinsco: to be the supplier of high quality machined parts primarily for (optronic) periscopes.
Nevesbu: to be the engineering manager and design authority and to make the integrated design.
Novek: to be the supplier of water chillers and diesel engines.
Rexroth: to design and produce complete systems for payload handling and actuation of moving parts such as hydroplanes and masts.
Thales: to be the designer and producer of a CMS and provide SEWACO[6] system integration.
TNO: to be the expert advisor on signature management, Human Factors, manning concepts, structural analysis and shock, sonar processing and CMS / PMS integration.
Verebus: to provide the ship system ILS services.

Figure 1 shows the programme areas where the members of DUKC desire to participate in accordance with their competence. The matrix represents the added value in management, engineering, production and supply activities, subdivided in non-recurrent and recurrent programme activities.

6 Sensors, Weapons, Command

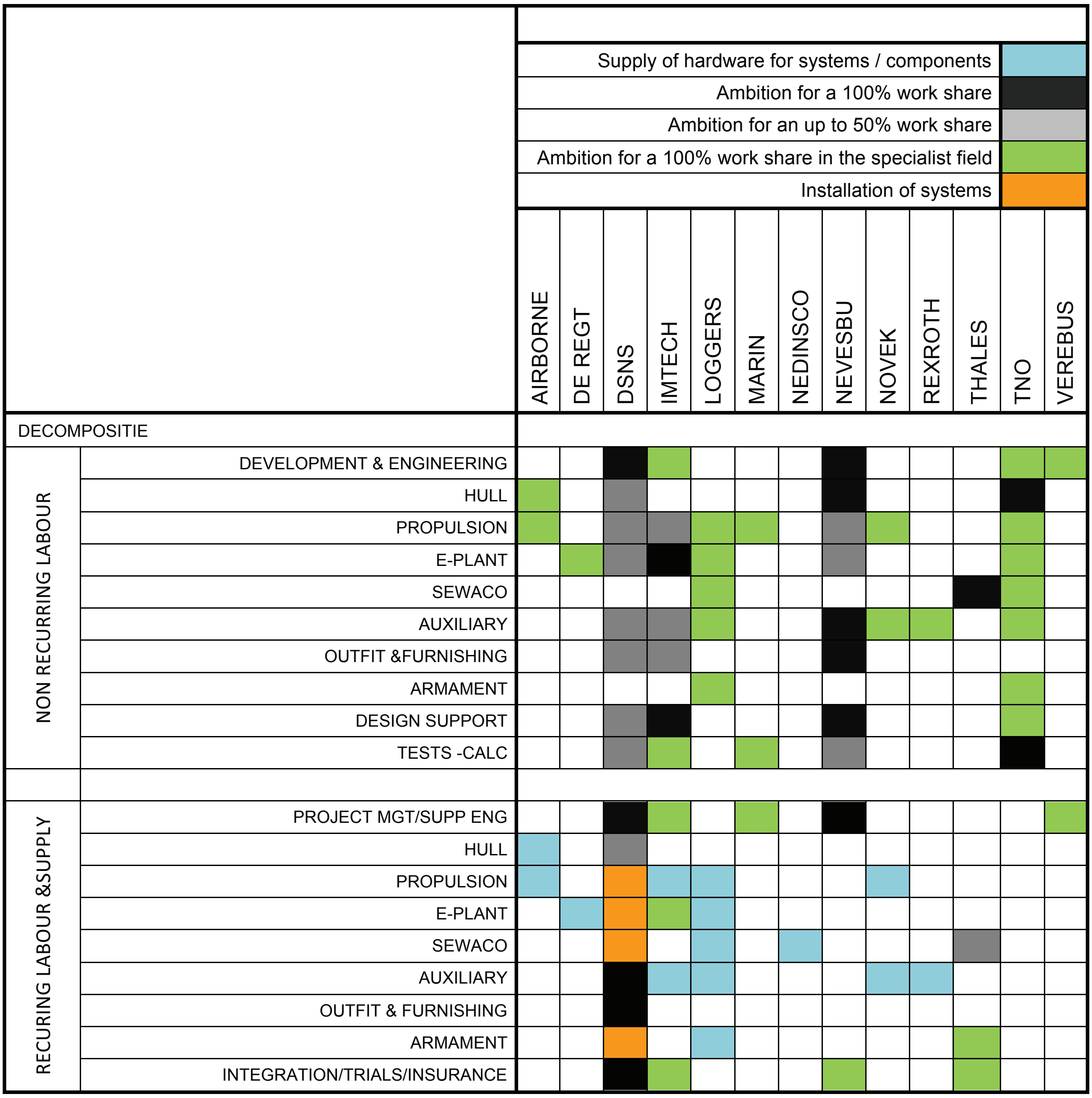


Figure 1

DUKC members represent a broad knowledge base and expertise including an integration capability at a ship system level. For the Non Recurring Labour the DUKC members are confident in their ambition to fulfill all tasks as required for all subjects apart from armament. For the Recurring Labour & Supply DUKC members realise that their participation share will not cover each and every component or subsystem.

The Netherlands has a mature infrastructure of suppliers of (sub)systems and components for the national and international maritime market. Next to the larger companies that act as (sub)system integrators, there is a number of Small and Medium-sized Enterprises (SME) that act as re-sellers or manufacturers of components. Although most of these are primarily oriented towards the civil market their skills often extend to the technologies required for Naval projects including submarines.

(Sub)system integrators and several lower-tier suppliers are represented in DUKC. Together they cover diverse areas such as composites, shock mounts, chilled water plants, hydraulic systems, umbilical's, optics, et cetera. They aspire to contribute their current products but are also keen to enter emerging areas of interest to expand their field of expertise. Examples are launch/recovery systems for manned and unmanned systems.

The above participation objectives will include state-of-the-market products as a baseline. However, new requirements, LCC challenges, developments in production methods and techniques, available materials, health monitoring, et cetera may stimulate innovation in specific areas. As part of the participation objectives such innovation opportunities shall be brought forward at an early stage in order to weigh the benefits of further exploration.

It is well understood that international cooperation will demand a careful selection and trade-off of participation opportunities, obliging MoD and Industry to be well prepared.

3.2. Design and Engineering

The participation ambitions include the full range of the general design and engineering assignments as required for an oceangoing submarine. The requirements envisaged for the new submarine make it likely that there will be areas of technological evolution and innovations where expertise has been available for many years.
These are:

- Signature management
- CMS and PMS and their integration in combination with Human Factors with the potential of manning reductions
- Hull form design and propulsion
- Special materials such as composite propellers Pressure hull design
- Energy Storage + Integrating ship's automation
- Drive and Control technology for actuation of moving parts

Such expertise is available to investigate the effectiveness of applying state of the art (COTS/MOTS) technology or develop innovative solutions in close cooperation with MoD.

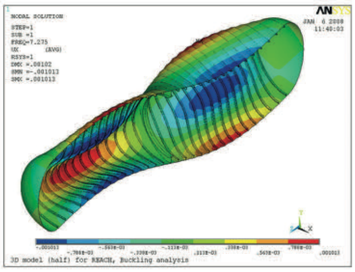
3.3. Production/assembly/delivery

Participation in system assembly and component installation as well as cable routing, piping and ducting involves a large part of the building activities. It may be assumed that pressure hull sections are procured from a foreign supplier. On this basis installation and assembly work of the complete submarine can be carried out domestically.

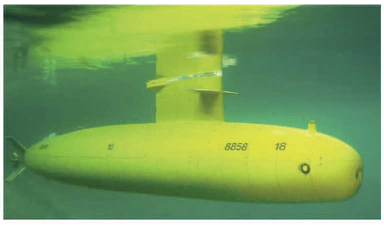
The supply of subsystems and components is subject to the availability and the acceptability of the use of COTS/MOTS items versus innovations or modifications of such products. The decision to use COTS/MOTS items will depend upon the specific functional requirements (e.g. for noise and shock). The choice made will have consequences for the design and affect maintainability and cost of ownership. The instruments published in the DIS document (especially "Industriële participatie") obviously support useful domestic innovative efforts.

4. The industrial knowledge base

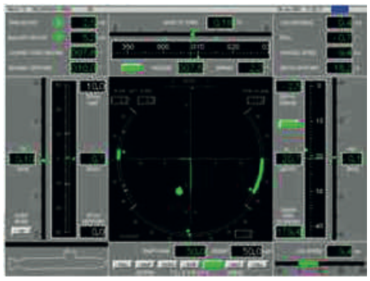
The report[7] "Onderzeebootkennis" provides detailed information about the type and level of expertise of the members of DUKC, as well as the areas where know-how is lacking.
The report identifies a number of clusters of expert knowledge. The clusters represent key



Buckling analysis of pressure hull



Hydrodynamic testing free running submarine model



Display submarine autopilot

submarine technologies shared within the industrial knowledge base in the Netherlands. It is therefore relevant to mention these expert capabilities of the Dutch industry with a view on the decision making of the foreseeable programme and its execution.

- Pressure Hull Design
- Hydrodynamic resistance and powering
- Platform System architecture (integration and design)
- Integrated Platform Management & Automation systems
- Combat Management Systems
- Design to Human Factors
- Signature Management
- Battery and Energy Management Systems

These clusters of expertise constitute areas where further innovative steps forward can be made. An early start of research and development programmes assure that the results are available in time for application in the submarine design.

To develop an affordable submarine that can be operated efficiently and maintained at reasonable cost knowledge of operation, maintenance and crew training as well as the design of critical systems such as automation, hydraulics, steering systems, weapon storage and reloading systems, etc. is essential. The DUKC members are capable of providing the appropriate knowledge as required.

For ship design it is important to have the knowledge to integrate systems and components into a complete and safe ship system. System integration is a critical aspect of submarine design and risk reduction. This capability is required in particular because of the demanding limited design- and build margins of a submarine. This knowledge and know-how forms a prominent part of the DUKC submarine knowledge base.

7 DUKC-R-2012-N01 rev. F-1; 30-01-13; Onderzeeboot kennis deel 1 – kennis inventarisatie

The DUKC report "Onderzeebootkennis" uses the work breakdown structure (SWBS) as a basis for the description of the know-how, skills and facilities held by the members of DUKC. In the report, detailed information is provided up to the fourth level of the work breakdown structure. In total the knowledge level for 180 subgroups was reported. The categories are: no knowledge – basic knowledge related to surface ships – basic submarine knowledge – expert submarine knowledge.

Figure 2 shows the average knowledge level among the DUKC members for the main groups. The relevant SWBS groups used in the report "Onderzeebootkennis" are mentioned in the upper left quadrant. Averaging has the result, in some instances, that expert knowledge found for a sub group may not be evident in the main group in Figure 2. The knowledge for each main SWBS group is plotted against the level of expertise (knowledge level) (x-axis) and knowledge spread (number of DUKC members with knowledge) (y-axis).

The knowledge level is "1" if there is an expert member or a cluster of members with expert knowledge in each of the sub-groups. The knowledge spread is "1" if 50% of the members have sufficient knowledge for all sub-groups.

The upper right quadrant in Figure 2 represents groups with a high level of expertise, spread over a large number of DUKC members. The lower right quadrant of the graph represents groups with a high level of expertise but where fewer members are involved. The lower left quadrant of the graph represents groups where knowledge is limited and only available at few DUKC members. The knowledge spread is no direct indication of manpower capacity. The spread only indicates the number of DUKC members involved.

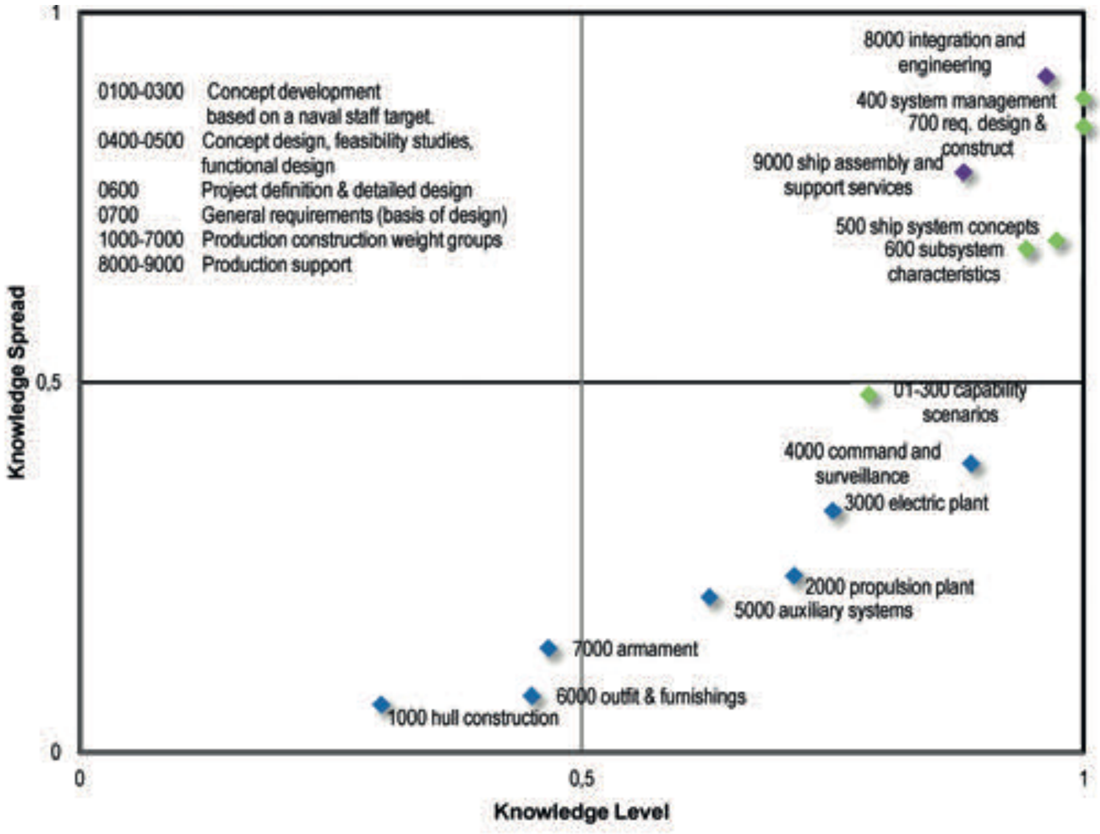


Figure 2: Average knowledge level among DUKC members

Concept development, concept and basic design and project execution (groups 0100-0700) are indicated by green markers. The production groups (1000-7000) are indicated with blue markers. The Production support groups (8000-9000) are indicated with a purple marker. The DUKC members represent an industrial knowledge base with the capabilities to execute the prime tasks of a submarine replacement programme.
Adequate knowledge is available for base of design, concept development, design and engineering, engineering management and production support. This includes design integration and fulfilling the task of design authority.

Concept development based on operational scenarios (groups 0100-0300) is a key MoD responsibility. The DUKC members have sufficient knowledge however to assist and support the MoD in this task.

It is expected that the design authority will support the prime contractor to select and procure major components for the propulsion plant, electrical plant and auxiliary systems groups from international OEMs.

The MoD is leading in specifying and selecting the command and surveillance group. DUKC knowledge is complementary to this MoD responsibility easing the required MoD manpower capacity.

Expert knowledge exists for system assembly, system installation and outfitting and furnishings for surface vessels. For the submarine-specific applications, international partnering is a logical backup.

Armament systems will be procured from international OEMs, but integration know-how is available which might require some updating. The know-how of fabricating and assembling the weapon storage systems is available.

To sum up the DUKC members represent a strong knowledge base. For the concept development, concept and basic design and project execution (groups 0100-0700) and production support groups (8000-9000) the existing strong knowledge base needs to grow in capacity. International partners can strengthen the submarine specific experience for the production groups (1000-7000).

The lower quadrants of Figure 2 show some areas where knowledge has to be enhanced or manpower capacity has to be increased.

4.1 Industrial Capability Gap

Although the knowledge base shows ample coverage of the general subjects of submarine design there are some specific knowledge gaps as seen in Figure 2.

In some areas the basic knowledge has to be updated in the initial stages of the programme. A technology roadmap and the SMART programme are identified by the stakeholders in the Triple Helix as a means to gain more in-depth knowledge. Subjects noted as such are in integral life cycle costing, design production know-how in relation to practical design philosophies, weapon handling, et cetera.

There are excellent capabilities (MoD, research institutes, industry) in the areas of integrated platform management, automation, CMS and human factors. But it is necessary for MoD to formulate a design philosophy for both SEWACO and the platform systems to express the level of their ambition in the Manning and Automation domain. This information is in fact part of the Basis of Design and is needed at an early stage of design activities to make use of the (unique) opportunities for innovation. Although it is not directly a capability gap, it is important, time critical knowledge and a precondition for (even) an (initial) effective and efficient design process involving many systems.

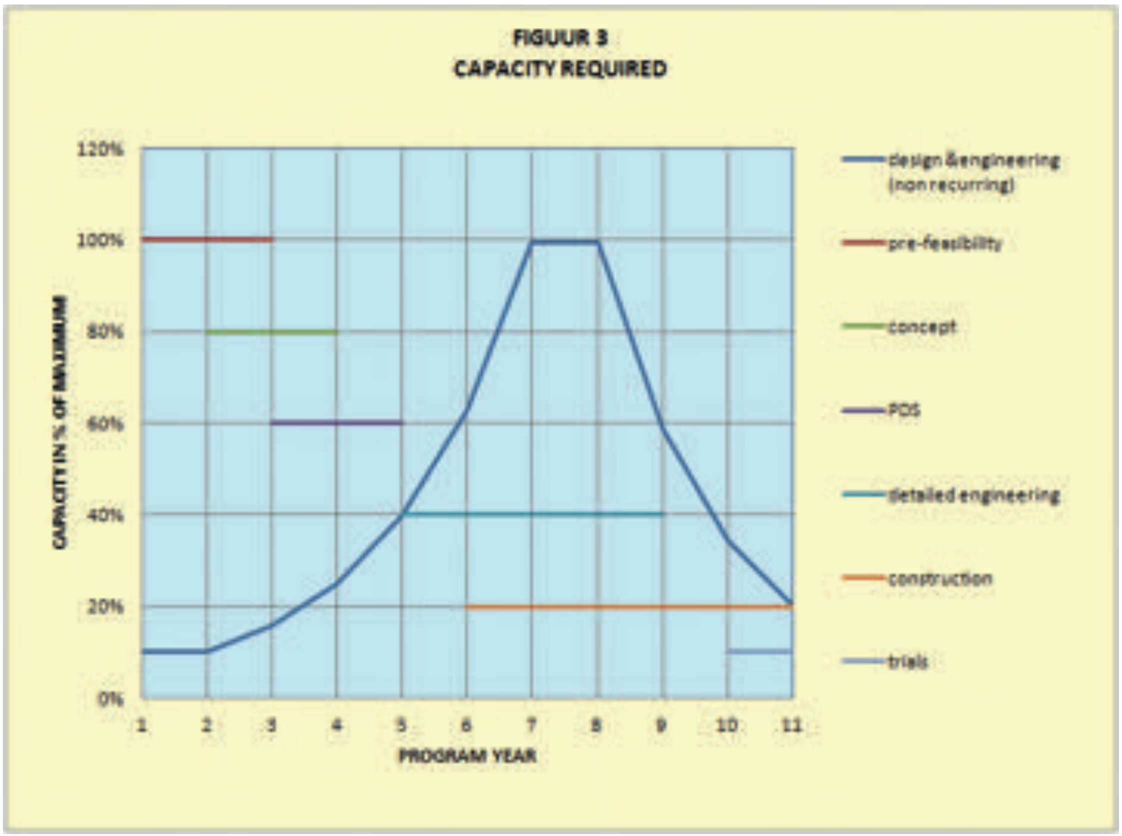
An important design effort for any future capability can be expected in the field of efficient use of energy, energy generation and energy storage. The management of energy is the enabler and limiting factor for endurance – both in time and range. It is necessary to decide on these issues at an early stage of the design and even better in the phase of formulating and discussing (final) requirements.
Although general knowledge is available, a thorough effort must still be made to review recent technical developments and alternatives regarding their feasibility and consequences for the design. Developments in energy generation, Air Independent Propulsion (AIP) systems, storage in battery systems and means to save energy during operational use have to be integrated in a balanced configuration with regard to individual systems and their interaction. Consequences for ship safety, battery management and PMS shall be accounted for during all design phases.

So, to be able to achieve the design targets general knowledge is not sufficient. It is necessary to augment specific and up-to-date knowledge about related issues.
It is essential that MoD's knowledge is used during the design and specification phase, in order to be able to build a submarine that can observe an operation and support cycle that allows for maximum operational availability.

Experience in pressure hull fabrication and the related manpower capacity is limited whereas experience in non-pressure hull fabrication is available. International partnering is a logical means to overcome this knowledge gap.

4.2 Engineering Capacity Gap

Based on the ambition of MoD to replace the Walrus Class in the twenties an approximate division in programme phases is outlined in Figure 3 including the growth and subsequent decrease of the engineering capacity that is to be expected during the programme.



One year from the onset of the programme the growth curve would require a 60% increase in capacity per annum. This puts some pressure on the effort to effect the inflow of engineers. The RAND[8] report found that "the average mentoring of 3 new hires to 1 experienced worker" is quite acceptable, which is a 40% growth rate. It may be remembered that it takes up to 3 years for the new hire to become independent. The much higher growth rate, directly from the start, as detected here is reason for concern. There seems to be almost no time for a gradual build up, while this start up phase (pre-feasibility) is the period to become aware of risks that may develop later in the programme.

8 Australia's submarine design capabilities and capacities, chapter 7, pp 101-109; published 2011 by the RAND Corporation.

Bron: AudioVisuele Dienst Defensie (AVDD)

5. Managing the Gap

The overview of Figure 2 shows an average high level of knowledge and capacity available for design and engineering. There is also substantial expertise in naval ship construction. There are some gaps in the present capacities and capabilities varying with the specific topics. In some instances there is a need to address some knowledge gaps. The knowledge gaps are described at the end of Section 4 and below under the heading "Knowledge development in the pre-definition phase".

5.1 Capabilities

5.1.1. Design & Engineering

The capabilities as well as some gaps to overcome among the DUKC members are presented in Section 4, Figure 2.

5.1.2. Knowledge development in the predefinition phase

There are knowledge gaps to deal with, as summarised at the end of Section 4. Some of them are in the realm of typical military issues such as operational experience, armament, and confidential aspects like signature management. The practice of collaboration between the parties in the Triple Helix will prove to provide synergy of a combined, complimentary knowledge base. To make the necessary progress in PMS and CMS systems as mentioned in Section 4, close cooperation in the Triple Helix is essential for industry and research institutes to understand the Manning and Automation philosophy in the Basis of Design.

SMART[9]. MoD has generated a study plan for the future underwater capability – named SMART – for further investigation and study in the run up to a Walrus Class replacement programme. Members of DUKC have been invited to participate in these funded, preparatory studies based on MoD's SMART initiative. Five of these joint study projects are contracted at this time.

Technology Roadmap. Industry is aware of the areas where design and engineering knowledge gaps require further attention in preparation for the design phase. The road map acknowledged in the Triple Helix concerns topics such as: design tools, submarine production know how, integral lifecycle costing, Manning & Automation know-how, some weapon handling know-how.

Outline design. DSNS has taken the initiative for a conceptual outline design exercise. Nevesbu is technical project manager; Thales and Imtech participated as well.
A first phase of this conceptual design has been completed.

9 Study plan for the future underwater capability as a replacement of the Walrus class submarine, Input for SMART (SubMArine Research & Technology)

5.1.3. Project definition study

DSNS has expressed a desire to carry out a joint PDS in collaboration with DMO. A PDS is an important tool to establish a clear picture of the MoD functional requirements, the systems and critical components to fulfill these functional requirements and, importantly, establish risks and critical factors in the early stages of the programme. Major gaps, if any, in the knowledge base or the design and manufacturing expertise will be identified during the PDS. It is critical to defining the technical-functional specifications; it may be expected that MoD will not be in a position to develop detailed technical plans as they were used to in past programmes. The PDS will benefit from the good practices established over the years working together in the Triple Helix.

Such a PDS could be set up shortly after the release of the DMP-A document. For the proper execution of a PDS, it is important to have a close cooperation between industry and MoD/End user. This may be realised through a joint defense-industry Integrated Project Team. The objective is to achieve a good understanding about the operational and maintenance philosophy of the MoD, to best design the platform and SEWACO system, in recognition of the operation and maintenance cycle philosophy and the crew planning and training.

5.1.4. Construction

Naval construction in the Netherlands is of a high standard delivering quality products to the MoD that are cost-effective in operation and maintenance. Nevertheless construction of the last submarines has been some years in the past and that know-how will have to be upgraded. This is most eminent for the fabrication of the pressure hull. It is expected that know-how can be supplemented by hiring experts abroad and/or by fabricating test sections. Investment in production facilities for pressure hull fabrications may not be practical, so the pressure hull (sections) might be designated for procurement abroad.

As with their international counterparts, the size of the (accessible) submarine market and the investment required generally keeps the lower-tier suppliers from establishing a dedicated MOTS product line. Instead they rely on the modification of suitable COTS components, or make a custom design on the basis of customer requirements. This has a number of effects that have to be taken into account, not only for the production/assembly/delivery phase but also for the exploitation phase.

- The nature of the requirements will guide the manufacturer's decisions for a modest modification versus a complete re-design. Two-way communication with the spec setters is needed at an early stage.
- Development, prototyping, testing for either "specials" or modified COTS items require lead times in terms of years. If specific non-civil requirements are to be met, these should be stated early in the programme.
- It will be necessary to establish the LCC-parameters anew for modified or custom-designed components.
- Supplementation of stock supplies shall remain possible throughout the system lifetime.

Attention needs to be given to reproducibility and obsolescence for modified or custom-designed components.

Given the potential impact of the above considerations on development lead time, cost and operational effectiveness, it is recommended that the areas that may be affected are identified at an early stage.

5.2. Capacities

To organise an expert design workforce with roots in the present knowledge base it is not necessary to have the full staff required for the detailed design and construction present at the initial phase of the project. Detailed design and construction are several years ahead in the planning.

The present "generation" of engineers is well motivated to accept the challenge and to share their knowledge and experience. This intrinsic motivation is a key success factor and the present generation will be able to pass on their experience to the new inflow of staff. There is time to manage the gap, but it is also time to act now, provided a clear view of the programme is evident.

As shown in Figure 3, for a programme of about 11 years from stating the requirement to commissioning of the first boat, the manpower requirements for design and engineering will peak around the 6th to 7th year.

The present "generation" of experts and senior engineers constitutes the nucleus of the engineering staff. Increasing their numbers over the initial years of the programme can still be planned in an orderly fashion. This incoming staff can well be mentored by the experienced workers.
The bulk of the more junior personnel can be more flexibly staffed from a market resource that is expected to be larger. However, this workforce has to be assembled and should assimilate all the technology required for this particular programme stage by stage when a clear roadmap to the main programme becomes available.

For construction and supply of systems and components there is more time to anticipate capacity shortages.

Although this does not mean there is no need for urgency. The timetable, especially regarding the technology roadmap in the pre-feasibility phase, is coming under stress.

6. Organising the programme

6.1. Prime contractor

There is a consensus among the members of DUKC that a Dutch prime contractor is the more desirable way to manage the new submarine programme. DSNS has expressed their ambition to be that prime contractor ("bouwmeester") as engineer, integrator and builder. It would also be in line with the practice of Naval shipbuilding for previous MoD programmes as well as for export projects.
To organise the programme several options for organisational structures have been discussed among DUKC members.

- Prime contractor structure with subcontractors ("bouwmeester").
- Consortium of the main participants, who are collectively responsible, and subcontractors.
- A form of collaboration where participants are responsible for their own contribution.

The majority of the members of DUKC interviewed for this purpose are of the opinion that a programme structure with a Dutch prime contractor would put them in the best position to achieve their participation objectives. Also, the working relations from past projects are a good starting point to organise the industrial collaboration for the new submarine programme.

6.2. Consequences of European collaboration

With the industry's objectives clearly stated above, it is also obvious that the industry is well aware of the consequences of a possible MoD decision to collaborate with other European navies and the importance of the operational aspects this has for the MoD.

In line with the best practice of the Walrus Engineering Support Project (WESP) organisation, DUKC prefers to initiate a joint PDS early in the DMP-A phase carried out by MoD, the industry and research institutes. This would involve Dutch expertise, identified as centers of excellence, to mitigate programme risks.

International collaboration is not new for naval ship design and construction. It will not be difficult, therefore, to adjust to the circumstances and requirements of the new submarine programme. It is appropriate to state the Dutch industries objective to be regarded as a knowledgeable partner in such a programme.

6.3. Employment opportunity

A new submarine programme will provide substantial employment opportunities to this country. These will cover a range of skills: Project management, design and engineering and production support. The life-time in service support period requires engineers and craftsmen as well as other technical trades with years of maritime experience. For a programme of this magnitude thousands of man-years are involved.

Especially with the safety culture of submarine design in mind, there will be a need for innovative solutions inherent to the development of a new class of submarines. The technologies that will be applied and the resulting solutions will have spinoff effects for other (maritime) industry sectors.

Even though a collaboration between the MoD and other European partners will result in shared work, it will also be beneficial to the Dutch industry and research institutes due to larger programme scope. It provides challenges for new technical jobs and sets up proper infrastructures to accommodate the programme.

7. Benefits of "Dutch content"

7.1. DIS

The DIS objectives support the work share ambitions presented in this report on Participation Objectives:

"Based on the operational interests and needs of the armed forces, the Defence Industry Strategy (DIS) aims to position the Netherlands' Defence- and Security-Related Industry (NL DTIB) and knowledge institutions in such a manner that they can make a high-quality contribution to the Netherlands security, whilst also operating competitively in the European and international markets and in supply chains."[10]

A few aspects of Dutch content are mentioned below.

7.2. Cost of ownership of the current Walrus class submarines

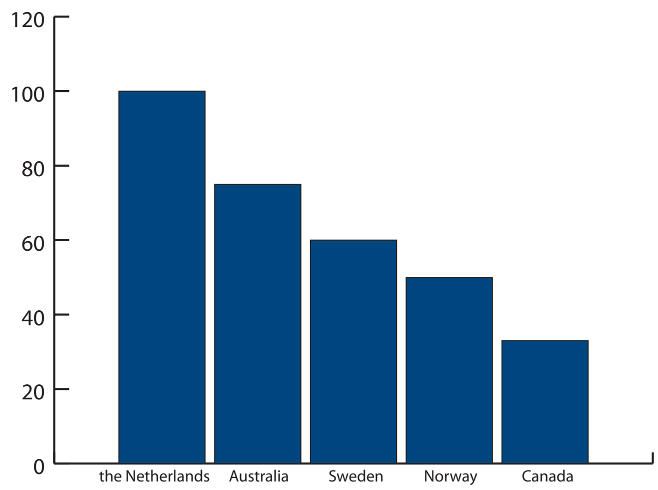
The high standing international reputation of MoD regarding high availability and low in service support costs of the Walrus Class is served by the practice of collaboration of the MoD with industry and the research institutes.

This results in higher operational availabilities than achieved by other navies.

The same can be said for the expenses of the in-service support of the submarine Classes of the RNIN. Recent comparison of the upkeep costs of the Walrus Class with those of the RAN and the RCN have confirmed this trend.

The communication within the Dutch submarine community (Navy as well as industry) is open. Lines of communication are short and the people involved are well capable and highly motivated.

A submarine programme under Dutch design and construction with substantial



average amount of days at sea per submarine each year

10 From 'The Netherlands' Defence Industry Strategy', 10 December 2013, page 3.

11 Source www.marineschepen.nl

participation of the Dutch industry and research institutes will be advantageous to continue the successful operation of a new submarine and should consolidate the achievements of high availability and low in service support costs.

7.3. Export position

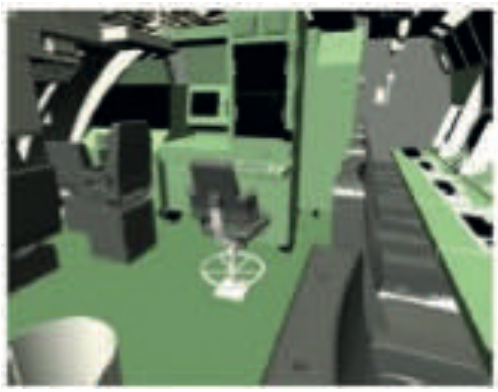
A substantial participation for industry and research institutes in the new submarine programme will not only contribute to employment in the Netherlands, but it will also strengthen their export position. It is relevant to note that a submarine programme embraces the priority areas mentioned in the DIS:

- Integrated system design and development
- Sensors, C41 and automation
- Advanced materials and components
- Simulation and simulators in support of training
- Electronic and information protection/armament

8. Track record

Life Extension Programme Walrus (IP-W)
In response to the MoD requirements six members of DUKC, five industries and one research institute, joined in a collaboration establishing an independent, integrated engineering team called WESP to support the MoD for the design of the IP-W modifications. The study allowed for speedy and efficient communication between WESP and the MoD. More importantly the study was an effective exercise in risk reduction and had the same effect as a PDS will have for a much larger project as a submarine design. The implementation of the modifications started in 2013 and will last for several years to modify the four submarines.
The IP-W project involves:

- Adoption of a new Combat Management System and redesign of the Central Control Room accordingly
- The integration of an optronic periscope and mast
- The integration of a Satellite Communication system and mast
- Rearrangement of the electronics and radio room as well as other areas to accommodate new electronics hardware.



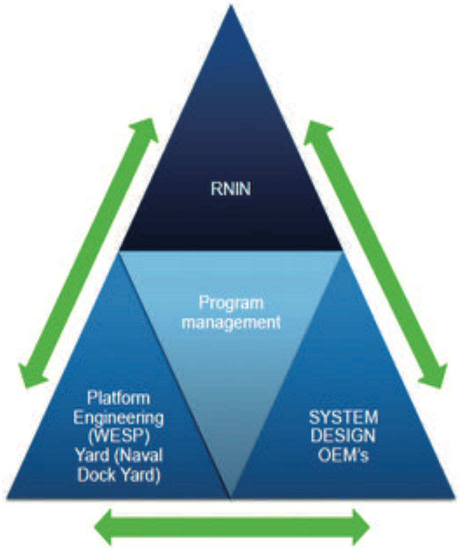
Redesign of Central Control Room

The requirements and specifications for the team evolved as more details became available and were discussed under well-regulated but short lines of communication between WESP and the MoD.

Integrating Optronic Sensor in existing sail structure

The mottos for the WESP team were:

- Do not change the design philosophy of the Walrus class and base the design on the original requirements and design rules.
- Apply an integral "system approach" to achieve a harmonious design
- Develop the engineering effort from generic to detailed design.



MoD declared the results of WESP, with respect to the technical outcome as well as its managerial aspects, a great success.
The approach enabled MoD to act as a Smart Buyer. Important technical choices were made at an early stage, thereby reducing project risks. The engineering method had a beneficial effect on costs.

Bron: AudioVisuele Dienst Defensie (AVDD)

9. Company references

The current members have ongoing domestic orders as well as international projects.

Airborne	(Composite propellers, domestic and international projects)
De Regt	(Umbilical cables and pressure tight connectors)
DSNS	(World Class supplier of naval ships, domestic and foreign projects)
Imtech	(Walrus, Sea Dragon and Moray Class and foreign submarine projects, IP-W)
Loggers	(Shock spring mounts, domestic and foreign projects)
MARIN	(Walrus Class incl. hydrodynamic support for Walrus operational issues; Moray Class and foreign submarine projects, IP-W)
Nedinsco	(periscope parts, navigation systems international projects)
Nevesbu	(Walrus, Sea Dragon and Moray Class and foreign submarine projects, IP-W)
Novek	(Sea Dragon Diesel Generator Sets, replacement of Walrus chilled water plants, chilled water plants for domestic and foreign projects)
Rexroth	(Walrus, Sea Dragon and Moray Class and foreign submarine projects)
Thales	(Walrus, Sea Dragon and Moray Class and foreign submarine projects)
TNO	(Walrus, Sea Dragon and Moray Class and foreign submarine projects, IP-W)
Verebus	(Walrus, Sea Dragon and Moray Class and foreign submarine projects, IP-W)

10. Abbreviations

AIP	Air Independent Propulsion
C4I	Command, control, computers, computing & intelligence
CFD	Computational fluid dynamics
CMS	Platform and Combat Management Systems
COTS	Commercial off-the-shelf
DIS	Defense Industry Strategy
DMO	Defence Materiel Organisation
DMP	Defense material process
DMP-A	Defense material process - phase A: Setting the requirements
DUKC	Dutch Underwater Knowledge Center
DVI	Defensie- en Veiligheidsgerelateerde Industrie
HR	Human resource management
HVAC	Heating, ventilating, and air conditioning
ILS	Integrated Logistics Support
IP-W	Life extension programme of the Walrus Class
IRS	Intelligence-Reconnaissance-surveillance
LCC	Life-cycle cost
MoD	Ministry of Defense
MOTS	Military off-the-shelf
OEM	Original equipment manufacturer
PDS	Project Definition Study
PMS	Platform and Combat Management Systems
RAN	Royal Australian Navy
RCN	Royal Canadian Navy
RNIN	Royal Netherlands Navy
SEWACO	Sensor Wapon systems and command systems
SMART	Submarine Research & Technology
SME	Small and Medium-sized Enterprises
SWBS	work breakdown structure
WESP	Walrus Engineering Support Project

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