NAVY 2000

Symposium 7- 8th June 2000

in Karlskrona, Sweden

The VISBY class corvette
– a vital asset in future maritime security

VISBY
ROYAL SWEDISH NAVY

SYMPOSIUM PROCEEDINGS

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Foreword
– Navy 2000 Symposium Proceedings

The launch and namegiving ceremony of the corvette Visby in Karlskrona, 8 June 2000, was a major milestone in the development that began 15 years ago and gave as the result a ship that, with new technologies in many areas, will fulfil tomorrows complex military and political requirements.

This important milestone – a real Revolution in Military Affairs – called for a broader attention. Accordingly, a symposium named ”Visby-a vital asset in future maritime security”, was held 7-8 June at the Ropemakers Yard in the Naval base.

The first day of the symposium covered the development, the program, the co-operation, the contribution from the participating industries and the tasks for the Visby class corvette.

The second day of the symposium covered the Naval forces contribution to conflict prevention and crisis management in littoral areas.

We conceive the symposium to be a thought provoking and important event that will establish an important step to continue visionary Swedish thinking in maritime matters.

Thus, we hope that these proceedings from the symposium will constitute a basis to continue further development in this field.

Lars Salomonsson Claes Tornberg
Symposium Committee

PROGRAM
Wednesday 7th June

Chairman: Rear Admiral Bertil Björkman, FMV (The Swedish Defence Materiel Administration)

Co-chairman and moderator: Captain Lars Salomonsson, FMV (The Swedish Defence Materiel Administration)

1000 - 1010 **Opening remarks** pages

Speaker: Rear Admiral Bertil Björkman, FMV

The objectives of this symposium is to show how the development that began during the cold war 15 years ago, gave as result a ship that – with new technologies in many areas - will fulfil more complex military and political requirements of tomorrow.

1010 - 1030 **The development** pages

Speaker: Captain Magnus Bergman, FMV

From the beginning of this development important areas were defined to be focused on the following characteristics within the frame of cost-effectiveness: Survivability, flexibility, command & control and endurance. HMS Smyge – a stealth vessel constructed for trials and development purposes only gave positive results within 18 different areas and could immediately be implemented in the YS 2000 project.

Political changes have focused on a naval capacity with regard to security, environment, communication and rescue mission with continuous presence for flexible action.

1030 - 1050 **The Visby programme** pages

Speaker: Captain Thomas Engevall, FMV

Widely separated missions as MCM, ASW, ASuW were made possible by revolutionary composite material technology, stealth measures on ship and equipment, a very capable sensor- and sonar system integrated in a unique command and control system. A new generation of flexible weapon systems enables the ship to contribute to maritime safety on all levels of conflicts.

International aspects changed the operational profile and made the ship slightly bigger. In spite of these changes, the project economy is kept within limits of the budget.

1050 - 1120 **Coffee break**

1120 - 1135 **The stealth approach** pages

Speaker: Captain Carl Fagergren, FMV

Basic philosophy in the stealth approach is to achieve stealth in all areas and in each area with a high level of ambition to meet future threat. Two examples:

- The composite hull decreases the radar cross section, IR-signature, hydro acoustic and magnetic signatures
- The hydro acoustic prediction programme is an important tool

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1135 - 1150 The composite hull pages

Speaker: Mr Johan Edvardsson, Kockums

A continuos development of composite hull material over almost 30 years has given the Visby class corvette a FRP composite non-magnetic structure, that combines high strength, extremely lightweight, low Radar Cross Section and IR-signature. A unique production method ensures high quality to a low total cost.

1150 - 1200 Hydroacoustic prediction pages

Speaker: Mr Björn Allenström, SSPA

Working with hydro acoustic prediction in co-operation with the Swedish Navy in several projects has developed for predicting hydro acoustic noise emitted from hull as well as from propulsion.

1200 - 1300 Lunch

1300 - 1330 The ship pages

Speakers: Commander Mikael Magnusson, FMV, and Mr Karl-Erik Hallsten, Kockums

The 72 metres 600 tons vessel is a ”closed” design, where most of the equipment is concealed below weather deck. The built-in cargo deck can accommodate weapons, sonar, as well as equipment for sea rescue operations. The deep-V hull allows the ship to operate in rough weather. A two-shaft CODOG Allied Signal/MTU machinery in combination with KAMEWA water jet propulsion ensures excellent manoeuvrability and good overall economy. Altogether this means, that the crew can handle the ship for great endurance in most waters and during different weather conditions.

1330 - 1340 Water jet propulsion pages

Speaker: Mr Gunnar Styrud, Kamewa

The water jet propulsion has proved its efficiency in service with the Swedish Navy installed in small combat craft as well as in corvettes. The propulsion gives advantages in decreasing both magnetic and hydroacoustic signatures.

1340 - 1350 The underwater missions pages

Speaker: Mr Jörgen Arbholt, FMV

One of the main tasks of the Visby class corvettes is underwater warfare. It includes antisubmarine warfare as well as mine countermeasure warfare. The vessel meets high level sophisticated requirements for both tasks. The lightweight non-magnetic hull and the silent propulsion form an excellent platform for a wide frequency passive and active sonar system. The new weapon systems are lightweight torpedoes; ASW short-range missile system and disposable remote operated underwater vehicles for mine destruction. These systems integrated with the command and control system for sensor and data fusion, mission planning and control, enables the Visby class corvette to deal with the total underwater threat.

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1350 - 1400 **ROV-S** pages

Speaker: Mr Bengt Larsson, Bofors Underwater Systems

The ROV, equipped with an advanced mine hunting sonar increases both the MCM capacity and the operational safety. The vehicle has both good stability and manoeuvrability. The power plant gives the vehicle good endurance.

1400 - 1410 **ALECTO** pages

Speaker: Mr Manfred Koerfer, Saab Dynamics

This is an integrated short-range missile system for Anti Submarine Warfare as well as for Electronic Warfare.

1410 - 1430 **The sonar system** pages

Speaker: Mr Phil Dore, Computing Devices Canada

The sonar system consists of a number of both passive and active sonar, highly integrated with advanced signal processing. Passive Towed Array System, Active Variable Depth Sonar, Hull-mounted Sonar and ROV-mounted sonar give a wide frequency sonar system, which covers the requirements for a wide range of missions.

1430 - 1440 **The surface missions** pages

Speaker: Commander Jan Ericsson, FMV

Advanced passive and active sensors are integrated with a multifunction modular command and control system for sensor, data and information fusion and engagement of a new generation weapon systems as well as equipment for rescue. These systems will give the Visby class corvette a very good flexibility in different surface operations in all levels of conflict from crisis in peacetime to armed actions.

1440 - 1450 **The surveillance radar** pages

Speaker: Mr Kent Nordström, Ericsson Microwave Systems

The surveillance radar is a vital part among the active sensors on board. As a part of the stealth concept, the lightweight 3D radar with the electronic stabilised antenna is covered by a radome built in frequency-selective structure.

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1450 - 1510 CETRIS pages

Speaker: Mr Göran Birgersson, CelsiusTech Systems

The real time CETRIS command, control, communication intelligence and inter-operability system supports all kinds of missions. Tough requirements are set on the vessel's common functions: Combat management, communications, air defence and navigation capabilities.

The system is modular and open. New technologies as well as maritime strategies are possible to implement without changing the fundamentals of the system. Redundancy and flexibility, where functions can be moved between computers and operator consoles are important features.

The air defence system is a totally integrated self-defence system that dynamically, automatically and simultaneously calculates and performs hard-kill as well as soft-kill engagements.

1510 - 1520 The 57 mm MK3 gun system pages

Speaker: Mr Stefan Bergstrand, Bofors Weapon Systems

The 57-mm gun with its 3p ammunition is a flexible weapon system. It is a vital part of the air defence on board but also a tool for gradated efforts in different missions.

1520 - 1530 RBS 15 pages

Speaker: Mr Per Robertsson, Saab Dynamics

As an alternative armament to the MCM-ROV: s the ship can be equipped with SSM´s of the RBS 15 MK II class. Development for increasing range and achieving dual function has recently started.

1530 - 1615 Coffee break

1615 - 1640 Visby – maritime security pages

Speaker: Captain Göran Frisk, Swedish National Defence College

During recent years important changes have taken place in naval warfare. The cold war is over, but conflicts on different levels continue. The flexible capability of the ship makes it efficient for all levels of conflict from peace, crisis to war.

With the built-in cargo deck, which can be converted for flexible payload, a rescue force staff can use the multifunctional command and control system; the ship can play an important role in supporting civilian resources in different rescue operations.The ship's command support is an integrated part of the armed forces general command system. For far-reaching detection, identification and classification the corvette will be capable of extensive information transfers to and from other systems in the joint armed forces, national and international, as well as civilian information systems. The high endurance capability makes the Visby corvette an efficient link in joint as well as in autonomous surveillance operations.

The Visby class corvette will cover a gap in international shallow water operations. The command and control system gathers passive and active sensors and link information and compiles a track database for targets on, above and under the surface of water. The stealth characteristics and the self-defence systems give a very high survivability.

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1640 - 1700 **Naval forces – future requirements** pages

Speaker: Commodore Göran Larsbrink, Swedish Defence Headquarters

Looking into the future in the perspective of 2010 and beyond, there are a number of capabilities that have to be fulfilled:

- The naval forces will be a natural part of joint task forces, both national and international, that requires interoperability
- A high degree of operational and tactical mobility is of great importance as well as flexibility for multipurpose actions.
- The capability of being autonomous but also being a vital part of joint actions requires long range sensors above, on and under the surface of water. Covering that volume requires a balanced sensor and information handling system.
- It is a vital capability to shorten the time for the sensor-to-shooter loop, which means the need for the complete functional chain to take the advantage of the fact that ”the ship is already there”. This physical presence is also a result of endurance.
- Endurance in a threat scenario is also based on survivability. The stealth-dual capacity is in all aspects vital.

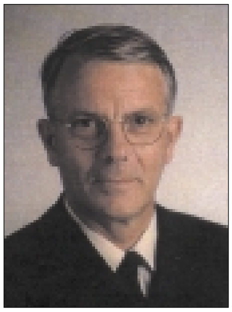
1700 - 1730 **Discussion and Close of first Day**

Captain Lars Salomonsson

Opening address

BY REAR ADMIRAL BERTIL BJÖRKMAN

Rear Admiral Bertil Björkman, Swedish Defence Material Administration



Rear Admiral Bertil Björkman's present position is Director Joint Procurement Command at the Swedish Defence Materiel Administration (FMV) in Stockholm. Prior to this he was Commanding Officer, 1. Submarine Flotilla and Director Plans and Policy at the Naval Staff.

Bertil Björkman graduated from the Royal Swedish Naval Academy in 1971 and Naval Weapon (artillery) Officer's School in 1973 and sailed during the 70's in destroyers and FPBs. He also sailed in icebreakers. After graduation from the Swedish Armed Forces Staff and War College in 1984 he served for five years in various staff appointments (mainly Plans and Policy and Budget) at the Naval Staff. In 1989 he sailed as CO of a Corvette and the year after he commanded a Corvette Squadron. After graduation from the U.S. Naval War College in 1991 he was appointed at the Swedish Armed Forces Staff and War College as Director Senior Naval Staff Course.

In 1997 Bertil Björkman was appointed as Chief Naval Materiel Command at the Swedish Defence Material Administration. During 1998, as Program Manager, he was responsible for a major reorganisation. In January 2000 he was appointed to his present position.

Bertil Björkman is a member of the Royal Swedish Society of Naval Sciences and its president since 1999. He is also a member of the Royal Swedish Academy of Military Sciences.

The defence environment has changed fundamentally since the end of the Cold War. The invasion defence structure that was justified by the cold war has now reached a turning point in the road. It is of vital importance that Sweden's geopolitical situation and the maritime issues are brought to the fore. This must be based upon the tasks for the Armed Forces, according to our new Resolution on Defence, with all that this implies, such as an increased focus on joint security. The premise is that the leading role that the Swedish armed forces, and therein the naval forces have for Swedish foreign and security policy, must become an active part of our nation' s and Europe's security concept.

Swedish security policy since the end of the cold war can be characterised as follows:

- UN membership with continued global involvement
- A strong support of UN peace-keeping operations
- Military non-alignment with European identity
- Continued involvement in OSSE
- Development of the security and defence co-operation in EU
- An increased involvement in international peacekeeping operations through IFOR/SFOR, PfP etc.
- New defence concept, from pure invasion defence to flexibility and adaptation

To develop the capability of the navy of tomorrow, there are a number of areas that appear natural to concentrate on. The transfer from a "hit and run" navy to a navy operating at sea with increased endurance, based on a corvette fleet, has to be mirrored in the exercise profiles and tactical use. Political requirements for crises management and conflict prevention capacity sets demand for a seaworthy navy with an amphibian capability for the future.

The steering principles for the development of Swedish naval defence in the new Europe are based upon the fact that the strategic focus has shifted from the Baltic Approaches to the Baltic area itself. As the dominating riparian owner, Sweden is the key to a shared overseeing above, on and under our surrounding waters of the Baltic approaches and the Baltic sea. Our national interests set demands for a naval capability with regard to security environment, communication, energy exchange and rescue mission. Continuous presence and capability for flexible action above, on, under and from the sea constitute the prerequisites for preventing international crises in our near vicinity.

The application of the stealth technology is not as easy as pie. 15 years of studies, test and trials have finally taught us that the stealth technology is not one-dimensionally attainable, i.e. what it is at all about is certainly not "bending steel" in tomorrow's threat scenario. It is an extremely complicated “science”, something that will hopefully be evident at this symposium. On the other hand, the design, combined with all the other characteristics of the platform, holds out further prospects. DBA has been made concrete! This is also something that we would like to prove.

Today, our presentations will focus on the *Visby* programme, not least the collaboration modes applied by the Navy, FMV and Industry. Furthermore, *Visby’s* role as a vital asset in maritime security will be described.

The overall objective of this first day is to describe how the development of a ship’s concept – that started during the end of the Cold War era – gradually turned into a quite new foresighted concept, a *“maritime security system vessel”*.

Now let me to introduce to you the moderator for today – Captain Lars Salomonsson.

Captain Salomonsson, assigned the FMV executive position “Head of Design”, Naval Systems, is highly qualified and suited for conducting the activities today. Not only on the grounds of his being a naval architect, but maybe primarily because he has from 1993 until quite recently been the *Visby* Project Manager. He also played a key role in the development of the test platform Smyge in the end of the 80’s and the early 90’s.

Bertil Björkman
Rear Admiral

The development

WEDNESDAY JUNE 7, 2000, 10.10-10.30 AM

Captain Magnus Bergman, FMV

Captain Magnus Bergman, Royal Swedish Navy is currently serving as Commander Programmes Management Center Naval Systems at the Swedish Defence Material Administration (FMV), Stockholm, Sweden.

Previous assignments includes duties as Head of Surface Combatant Ships Division, Head of Early Design and Systems Engineering Branch, FMV, and Deputy Commander of the Navy Shipyard at Muskö, Stockholm. He served as the Program Manager for the Test Vessel Smyge Program from early design until shipyard delivery in 1991.

He has a M.Sc. in Naval Architecture from Chalmers University of Technology, Gothenburg, Sweden. Captain Bergman is a member of the Royal Swedish Academy for Naval Sciences.

The first part of this symposium is about the development and progress in a wide range of technologies that together have formed the bases of the Visby Class Corvettes. If it had not been for this extensive and purposeful progress, it would not been possible to design and construct a ship like the one we are going to launch tomorrow.

First of all it is important to point out that this development, that in many ways can be regarded as a major step in warship design, is in fact the result of an evolution that started over 40 years ago.

The overriding consideration basis in this evolution and I guess, like in all navies of today, is cost effectiveness. Sweden gave up the blue water navy and bigger ships like cruisers and destroyers 25 years ago just because of the need for a more cost-effective fleet. We simply could not afford bigger ships due to budget cuts. Modern weapons installed on smaller ships seemed to be the solution. These ships turned out to be quite effective with comparatively high striking power although at the cost of some limited factors like survivability, flexibility and endurance *(Slide 2)*.

Ever since that time we have made big efforts in development of methods and technology to stretch these limiting factors in small warships design and operation. As the weapon systems became more and more effective the self-defence systems had to grow. This made the small warship bigger and of course more and more costly. Early in this period it became clear to us that to keep a reasonable survivability on small warships with limited weapon systems and manning you had to rely on automated defence systems. This led to the Swedish development of a highly capable C4I system with an integrated system for automatic air defence specially designed for small warship purpose.

To increase the survivability even more, the FMV started to study stealth technology. It is well known that stealth is one of the most important survivability factors in submarine design and operations. Why not use the same theory in surface warfare.

Sweden, as well as any submarine navy, has a tradition in hydroacoustic stealth development. Furthermore, hydroacoustic and magnetic signatures are vital factors in designing and operate MCM vessels. In the late 70'ies the FMV extended the stealth research and development areas and started studying radar- and IR signature control as well. The first attempt did not turned out very well mainly because of the lack of knowledge and the existing mentality that "it's always been done like this" or "we haven't done that before and we're not going to do it now either".

Some of the leading Navy officers and FMV technicians still believed in the potential of above surface stealth. The ice had to be broken.

THE TEST VESSEL SMYGE PROGRAMME – A STEP INTO THE FUTURE

In 1985 an extensive programme was started up with studies of how above surface stealth technology could be applied to our next generation of surface combatants. One of the early conclusions was that it would probably be cost effective to build a test vessel in order to evaluate the theory.

The Test Vessel Smyge programme came to reality in the spring of 1987, involving not only the FMV and the Navy organisations but Swedish industry, universities and governments agencies such as the Defence Research Institute among others. The idea was to focus all research, development and testing in one single programme.

Basically, FMV and the Swedish Navy had three main aims with the programme *(Slides 3 and 4)*:

- To test and evaluate the effects of different methods of signature reduction within a surface stealth ship
- To test and evaluate the integration of weapons and sensors in a stealth ship
- To test and evaluate surface effect ship technology.

A shipbuilding contract was signed in June 1989 and the vessel was delivered less than two years later. The sea-trials started immediately and continued until late 1994.

Tests were carried out so that individual evaluations of the three aims were possible. In that way, testing procedure guarantied that the results from the tests could be used and applied regardless if the Navy went for a monohull or a SES design for the next class of ships. This proved to be a successful strategy later on when the SES technology was considered to be too limited to meet the wide range of tactical and operational demands of the Visby class corvettes.

All the results were continuously transferred into the parallel ongoing next surface combatant development programme either as direct input to the design or as inputs to extensive simulations and studies.

During the sea-trails the technology envelope was pushed to the limit. Within the project this created a mutual feeling "that if everything is successful we have not pushed technology far enough to identify limited factors". The FMV and the Navy therefore made mistakes and found problems. Problems that were attacked by all parties and as the trails went on, solved.

The development of Smyge also had a very beneficial impact on the cooperative climate between the FMV, the defence industry and other government agencies. The programme was carried out in an integrated-project-team-way, and a number of inspiring meetings took place. It was very interesting to see leading academic professors meet and confront the foremen and workers at the shipyard. After the first "clash of cultures", they sat down and discussed various methods and ways to make the ship as perfect as possible.

During those four years of trials we learned that surface ships with stealth capabilities cannot be used in the same way as ships were used before. New tactics were required to make use of the full potential of new systems. This led to the initiation of extensive battle simulations. These simulations also formed the base in the tactical and operational studies that were started up. In that way, the evolution of tactical and operational concepts for the Visby Class Corvettes began already in the early 1990's.

Even though all this progress were necessary, still the most important benefit was the icebreaker-effect. The programme showed the conservatives that things really could be done in a new way. Many old and young "hard-liners" could see with their own eyes that you could run a ship like Smyge. This icebreaker-effect was necessary within the navy as well as in the design and production establishment. We proved that it is possible to design, build and operate a fully stealth surface ship and that it could be done in a cost-effective way.

YS 2000 – THE COMBINATION OF CONFLICTING DEMANDS

The concept study work for the next class of surface combatants started already in1988. This was when the test vessel Smyge was still only a blueprint and several years before the launching and test programme. The early studies resulted in three types of ships: one vessel intended for combined MCM and ASW, one smaller and one larger version of a surface combatant.

For economical reasons the three concepts melted together step by step and finally became one project. The new programme was called the YS 2000. *(Slide 6)*

The requirements were basically a combination of all three different demands without compromises. The requirements has, since that time, more or less been fixed except for the demands that were added mainly because of the changes in Swedish security policy. There was a growing need for forces with capacity for international service. This implies that we had to extend the requirements in terms of operational areas, increase the design criteria towards a much higher sea state and of course increase the endurance. Furthermore we had to add the helicopter capacity.

Finally the series of six ships have been named the Visby Class Corvettes after the decision to name the first ship HMS Visby. *(Slide 7)*

The combination of MCM, ASW and Surface attack missions might be seen as unnecessarily complex. However the potential of this littoral multi-mission capability is one important lesson from the Swedish submarine warfare during the last two decades.

In future warfare, with an enlarged and fragmented battlefield, it will be necessary to control the total under- and above water threat picture. This in combination with the potential of a network linked-up modern C4I system, will give the commanding officer flexibility to act as independently as possible.

The results and simulations show that stealth technology has proven to be an effective tool to achieve cost effectiveness. It is a way to build ships with a high degree of survivability at a reasonable cost. Stealth, combined with countermeasures, has shown to fit in a complex threat scenario, where it is hard to know who is the enemy and who is not. With a strong passive self-defence system it is possible to operate in hostile environment without first striking capacity as the main choice.

This in combination with the littoral multi-mission capability will give the joint task forces commanders a tool that can be used for brown water operations out of range of the air-protecting shield from a fleet striking force.

THE FUTURE – EVOLUTION NEVER ENDS

The research and development including concept study work for the next surface combatant has just started. Remembering that the Visby Class Corvette originally was designed in the beginning of the last decade, we now have to face the challenge to take the next step on the stairway of evolution. In our opinion the focus for the future still is: *(Slide 8)*

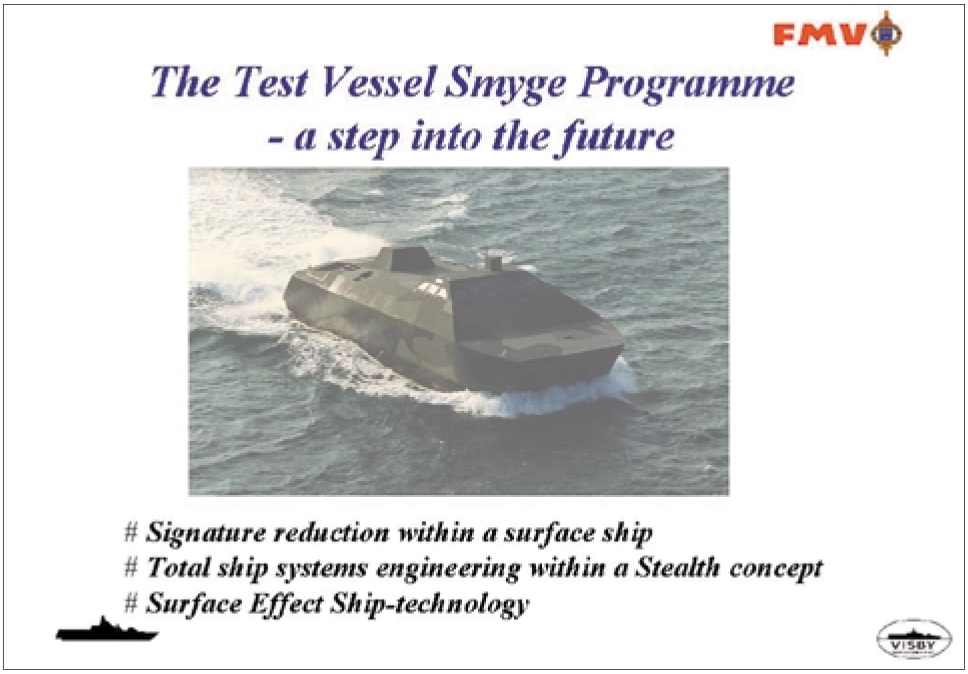
Survivability
Flexibility
C^4ISR and Network Centric Warfare
Endurance
Cost-effectiveness

Finally it is important to point out that the Visby Class Corvettes programme is much more than stealth. Stealth is just a method to bring cost effectiveness in warship design intended to meet the extremely complex and conflicting tactical and operational demands of the future. To manage in stealth design it is necessary to make progress in a wide range of other areas. Areas of technology that are not very much highlighted, but in all kinds of ways have to be there to support the stealth efforts. No chain is stronger than the weakest link.

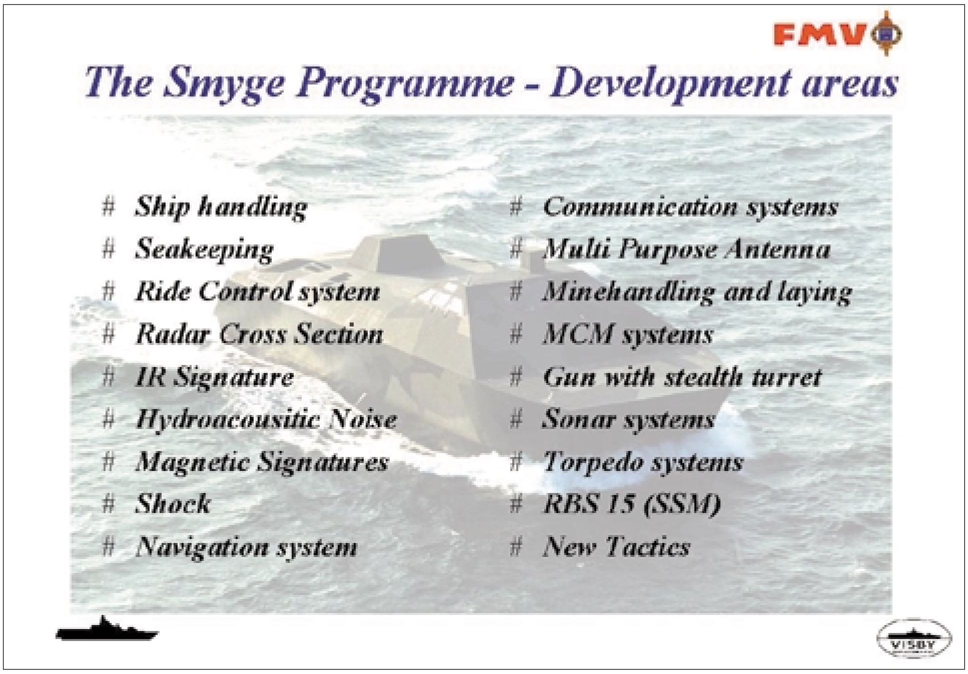
The technology that has been developed and which you will hear about later on today implies that we have created a possibility to combine the survivability, flexibility and endurance of a frigate all in the economy of a corvette sized warship. ■

SLIDE 1

SLIDE 2



SLIDE 3



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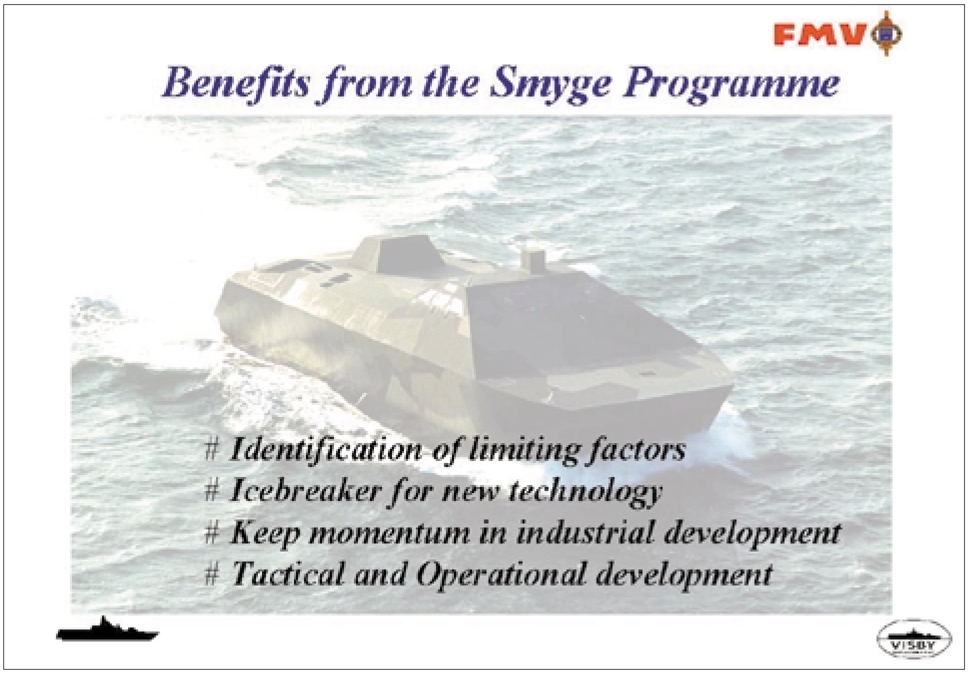

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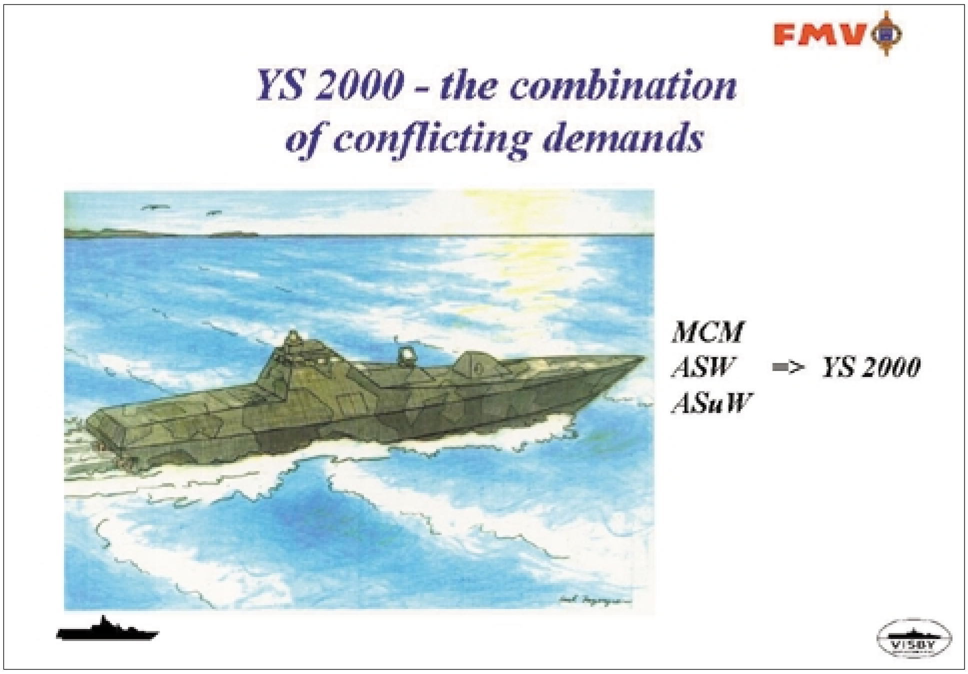
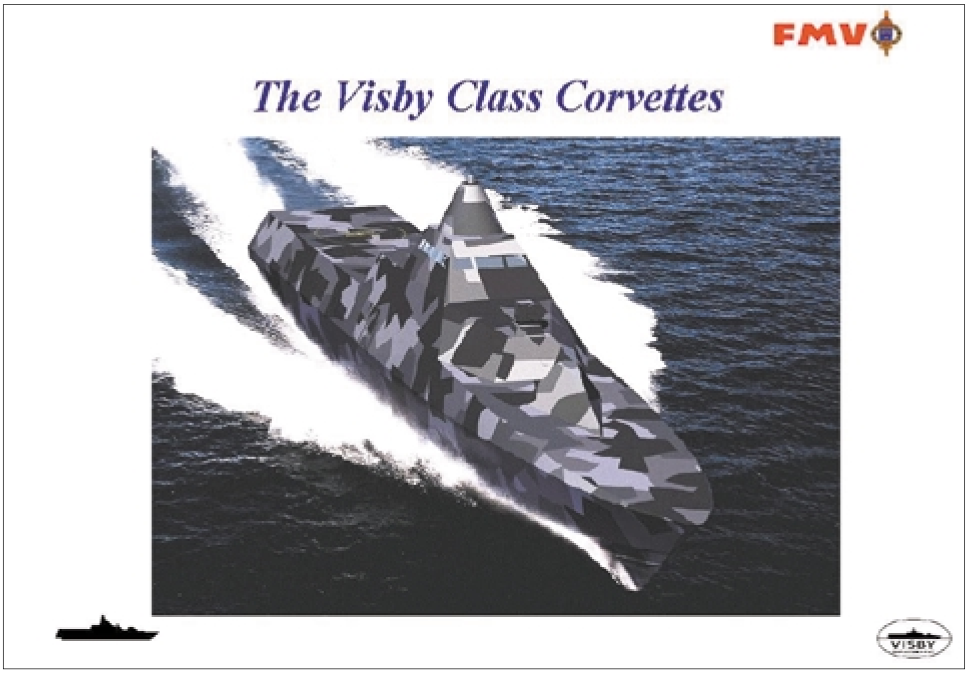
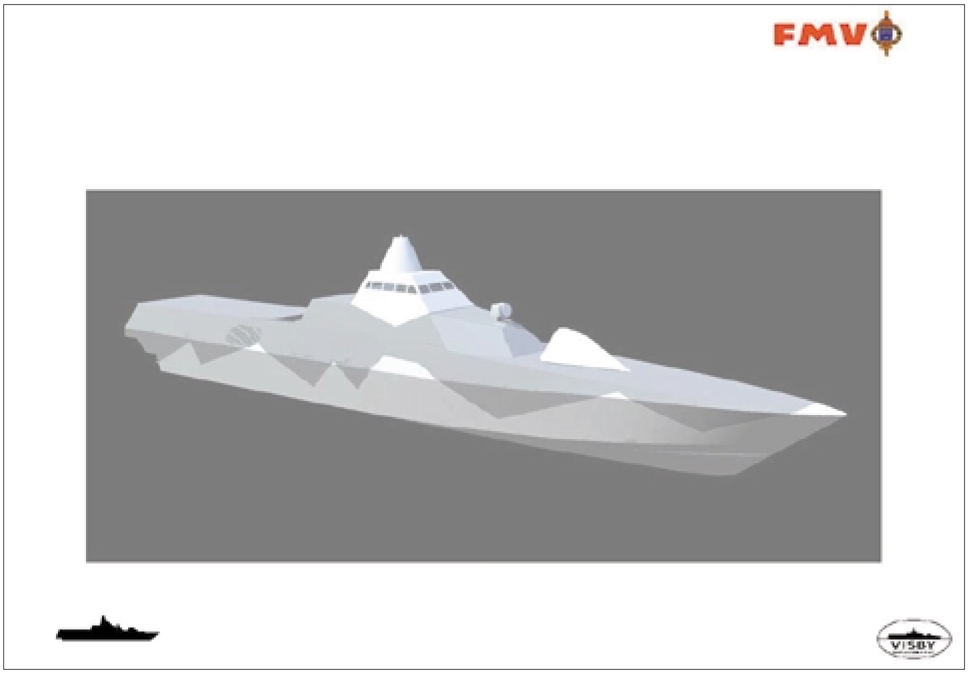


SLIDE 6



SLIDE 7

SLIDE 8



SLIDE 9

The Visby programme

WEDNESDAY JUNE 7, 2000, 10.30-10.50 AM

Captain Thomas Engevall, FMV

Captain Thomas E. Engevall, Royal Swedish Navy is currently serving as the Program Manager for the Visby Class Stealth Corvettes at the Swedish Defence Material Administration (FMV), Stockholm, Sweden. He has a M.Sc. in Naval Architecture from Chalmers University of Technology, Gothenburg, Sweden. He graduated from Naval Command College, US Naval War College in Newport, R.I., in 1997. His previous assignments include duties as Deputy Director of the Technical Department of the Swedish National Defence College, Chief Staff Engineer Swedish Fleet Staff and Commander Sea Trials unit Smyge (Sweden's stealth test ship). Captain Engevall is a member of the Royal Swedish Society for Naval Sciences and United States Naval Institute

BACKGROUND

The background for the Visby programme can be described as a large merge where the Royal Swedish Navy (RSwN) and the Swedish Defence Materiel Administration (FMV) exploited a number of technological breakthroughs in the early 1990's to combine a number of complex operational and tactical demands, in order to create one concept, the Visby corvette (earlier called Surface Combatant 2000). *(Slide 1)*

OPERATIONAL AND TACTICAL BACKGROUND

The operational and tactical background consists of a number of demands originating from;

- Tactical and operational experiences from the Swedish effort in Anti Submarine Warfare (ASW) during the 1980's and 1990's focusing on the need for sonar systems and weapon systems well adapted to the littoral and brown-water environment as in the Baltic.
- Development of MCM vessels focusing on ship systems with very low underwater signatures combined with excellent shock resistance
- Introduction of more complex and harder threat scenarios for future surface ships that had to be met.
- RSwN experiences from stealth and signature control emanating from the Test Ship Smyge (Stealth & Surface Effect) that was operated by the RSwN under FMV supervision in the early 1990's.
- Needs for a very capable C2 (Command and Control) system in order to be able to participate, and also when necessary, to lead joint and combined operations.
- Increasing focus on ability to act in a wide range of conflict roles, from support to the civil society in peacetime to full-scale military conflict.

The strategic background has also changed significantly and we today see a modernised Swedish National Security Strategy. The result of this is that the focus on joint (e.g. with air force and army units) and combined (international) operations is more significant. This process is in progress and it impacts such areas onboard as communications, possibility to replenish at sea and so on.

One of the starting points for the Navy in this matter was in 1993 when RSwN units participated for the first time in an international exercise, the US BALTOPS. Since then, international operations and interoperability has become one of four key mission areas for the Swedish Armed Forces. RSwN have participated in a number of international exercises and operations, the latter foremost yet in MCM operations in the Baltic States. *(Slide 2)*

MAJOR TECHNICAL BREAKTHROUGHS AND TECHNICAL ANALYSIS

In order to find a concept that answered all the demands that arouse from the operational and tactical background, RSwN and FMV had to work very hard in order to create a balance of technical and tactical solutions on a high level early in the programme. A number of technical breakthroughs were exploited and developed and FMV and RSwN also introduced necessary management processes to handle all the different questions that were expected along the development trail.

Breakthrough no 1; Introduction of the Carbon-Fibre Composite Hull Material

Perhaps the key that has enabled Sweden to develop the Visby corvette as we will se her later on during this Navy 2000 event is the choice for a composite Carbon Fibre Reinforced Plastic (CFRP) hull. Compared with traditional materials, the CFRP hull has a very good weight/strength/price ratio that does not drive overall hull cost in comparison with other materials. It also gives a hull that is light, but still has excellent shock resistant properties. This enables the ship to combine high-speed operational roles such as Anti Surface Warfare (AsuW) with MCM operational roles. The hull also insulates heat, is unmagnetic and the surfaces are very flat due to the production method. These properties are key in order to give the ship the desired stealth characteristics. *(Slide 3)*

Breakthrough no 2, A Modern C3I system in combination with active and passive sensors

The big step in developing a modern C3I system was taken when developing the SESYM system for the Gothenburg corvettes in the early 1990's. That experience now forms the basis for the C3I system on Visby. A high degree of source code etc. is reused giving us a high degree of confidence that the CETRIS system, which is the name of the C3I system on Visby, will be delivered on time and with all functionality. The CETRIS system is a real time, modular and open system where the HMI is based on Windows NT technology. This enables the Swedish Navy to integrate coming technologies and weapons systems without fundamental and expensive changes to the C3I system. FMV's ambition has been to integrate as many as possible of the ships weapon systems and sensors into the CETRIS system, thus securing a high level of freedom to adapt the CIC configuration towards different situations.. Furthermore, the system offers very good command capability in joint as well as in combined environments.

Also, in combination with the active and passive sensors on Visby, the C3I system will very soon offer Visby and her five sisters as very capable nodes in the future network that will give the Swedish Armed Forces a Dominant Battlefield Awareness (DBA) in the littoral (including the entire Baltic region). *(Slide 4)*

Breakthrough no 3, Merging of MCM and ASW systems into one

The demand for both MCM and ASW capabilities on Visby also directed the technical solutions towards new technical and tactical concepts. In short, it was a question of combining the MCM systems that exist on the Landsort class together with the ASW systems that exists on the Gothenburg class. Together with this merge it was also apparent that performance and capability had to be increased to higher levels and the integrated sonar system HYDRA was created. In building the HYDRA system FMV are using the most modern sonar technology in combination with very powerful computer resources for calculations, presentations, threat libraries etc. *(Slide 5)*

Breakthrough no 4, Dual use of some weapon systems

In order to maximise the use of available space onboard FMV have investigated the possibility to incorporate dual use for some of the weapons systems. One of the results of this effort is the rocket system ALECTO, now under development by FMV in cooperation with Saab. This system uses the same launcher and basic rocket but different munitions in order to fulfil ASW, Torpedo Counter Measures (TCM) as well as Electronic Counter Measures (ECM) missions.

Similar to the ALECTO system, the 57 mm gun developed by Bofors will be fitted with programmable ammunition. This will enhance the effectiveness of the gun system and it will provide the Gun with multi-functionality. The gun can be used as a part of the ships Air Defence towards different target types, it can be used in low level conflicts such as in embargo situations in order to threat or to stop a ship that does not follow given orders, and it can also provide fire-support to amphibious forces. *(Slide 6)*

Breakthrough no 5: Introduction of ship-borne helicopter

When it comes to interoperability and combined operations an enlargement of the ship in order to obtain the capacity to land and also to host a light helicopter in a hangar onboard was introduced rather late in the programme definition phase. This led to that the ship increased in length from 60 to 70 metres. Due to the flexibility and close cooperation between FMV and the shipyard this shift was possible to do without any significant increase in cost, keeping the overall programme budget within its earlier limits. The introduction of the helicopter function, together with landing and hangering capacity, gives a higher systems effect and opens up a number of options in using the Visby system in more operational and tactical scenarios than otherwise would have been the case.

The increase in ship size also led to better endurance and sea-keeping properties, giving an overall raise to the ships system effectiveness. *(Slide 7)*

PROGRAMME RESPONSIBILITIES

A hallmark of the Visby programme is the close cooperation that exists between the Armed Forces Headquarters (HQ), the Navy, FMV and Industry, both in the formal and in the informal sense.

The key to success in this process is to maintain well-defined responsibilities, in spite of the downsizing we now see within the Armed Forces. Within the Visby programme, several actors share the task of maintaining the definition of responsibilities. The Armed Forces HQ with the Navy, the Defence Materiel Administration (FMV), the Swedish National Defence Research Establishment (carries out applied research and studies for the total Swedish Defence) and Industry; all of them have their roles to play. *(Slide 8)*

The key to the process is a fine network of cooperation based on high knowledge and respect. The way Visby is being introduced includes representatives of all the mentioned actors, each contributing their special skills. At the same time there is a degree of competitiveness between the actors and their internal communities. As a result, sound arguments are placed on the table and unproductive infighting is kept to a minimum.

Within the Armed Forces, the HQ Steering Committee (HQSC) acts on the executive level. The HQSC are responsible for formulating all technical, tactical and economical demands on the programme. The HQSC are also responsible for formulating any modifications and/or changed requirements. In the case such a change also means that the programme budget needs to be adapted, the HQSC initiated the necessary process between the HQ and FMV.

As a working group under the HQSC a Navy Programme Supervision Committee (NPSC) exists. The NPSC consists of a chairman and a number of active naval officers. The NPSC meets regularly with FMV's programme management and with the Trials Unit in order to decide on various tactical and operationally related matters. The NPSC also has had a very important role to analyse the effects of the modified national security strategy and what new demands should accordingly be put on the programme.

For the purpose of creating technical solutions, well adapted to the needs of the operators, a traditional Trials Unit (PTK) was formed very early in the programme. One of their initial tasks was to perform tactical user analysis based on the system specifications. These user analyses were then used together with FMV knowledge and experience in writing all the different technical specifications, each of them specifically targeted at different parts of Industry. All the user analysis has thus formed a "bank" of tactical knowledge and user guidelines within the programme.

When it comes to layout, FMV have been working closely together with the Trials Unit in especially four vital areas in the ship; mooring stations, the bridge, the CIC and the Engineering Control Room. The layout in these areas have been the responsibility of the Trilas Unit, performing numerous gaming while testing layouts in different tactical scenarios for the purpose of finding the best overall layout. For the bridge, the CIC and the ECR, the Trials Unit has built full-scale mock-ups. Virtual Reality technology has also been applied by FMV and the Trials Unit in order to examine and decide colouring and illumination patterns for the CIC. *(Slide 9)*

THE WAY AHEAD

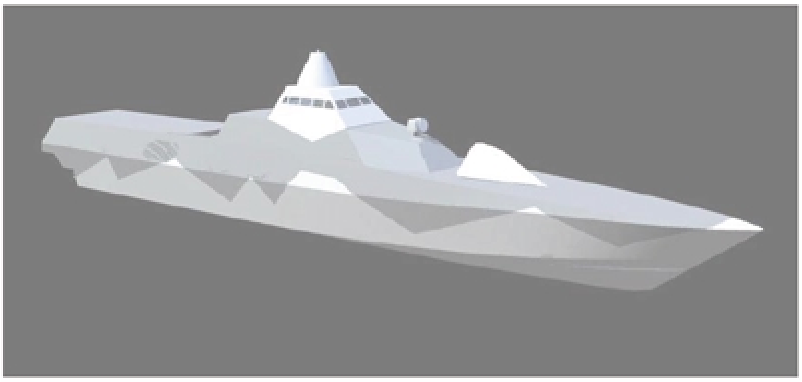
On Visby, the Programme Management has his first responsibility to make sure that the ship is delivered on time, on cost and with all demanded functionality. Up to this date all plans for time, cost and functionality are being held within the Visby programme. The upcoming seven years will prove if that statement will hold until all six ships are operational within the Royal Swedish Navy. So far it looks good. In not a long time from now, the Trials Unit, together with officers and engineers from FMV and Industry, will initiate the sea-trials and all the tactical and operational testing to be conducted.

This testing will provide the answer and the final guidelines to the Navy on how to use the ship in all the planned roles and mission types. They include:

- Mine Counter Measure (MCM) operations (alternate payload to ASuW ops.)
- Anti Surface Warfare (ASuW) operations (alternate payload to MCM ops.)
- Anti Submarine Warfare (ASW)
- Defensive/Offensive Mine laying
- Patrol service and support to the Swedish National Society in peacetime
- Escort service
- International (UN and/or NATO led) peacekeeping or peace enforcement operations. *(Slide 10)*

The trials period will also provide answers to other questions relating to future potential for the ship of the future that Visby and her sister ships Helsingborg, Härnösand, Nyköping, Karlstad and Uddevalla represent. Within FMV and RSwN we are convinced that this potential is very high. *(Slide 11)* ■

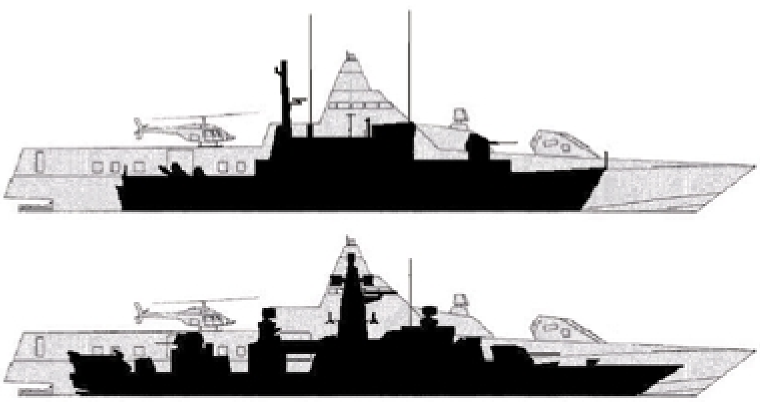
The Visby Programme



FMV

SLIDE 1

Visby, Landsort and Gothenburg



FMV

SLIDE 2

Carbon Fibre Reinforced Hull

FMV

SLIDE 3

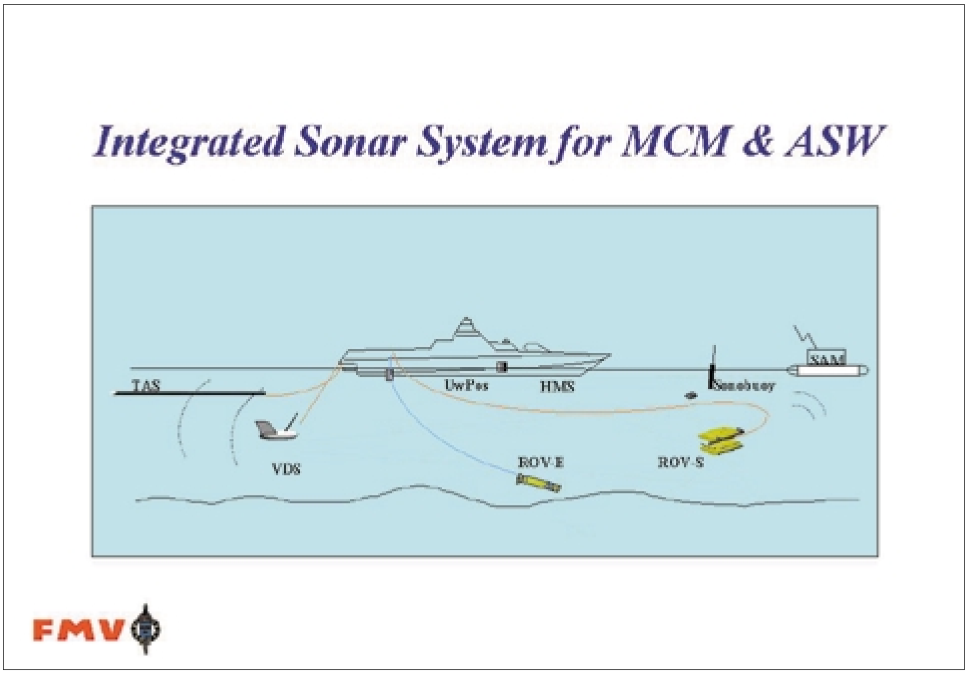
Passive Sensors

IR-sensor
Towed Array Sonar (TAS)
ESM-system

Up- and down-link capability

FMV

SLIDE 4



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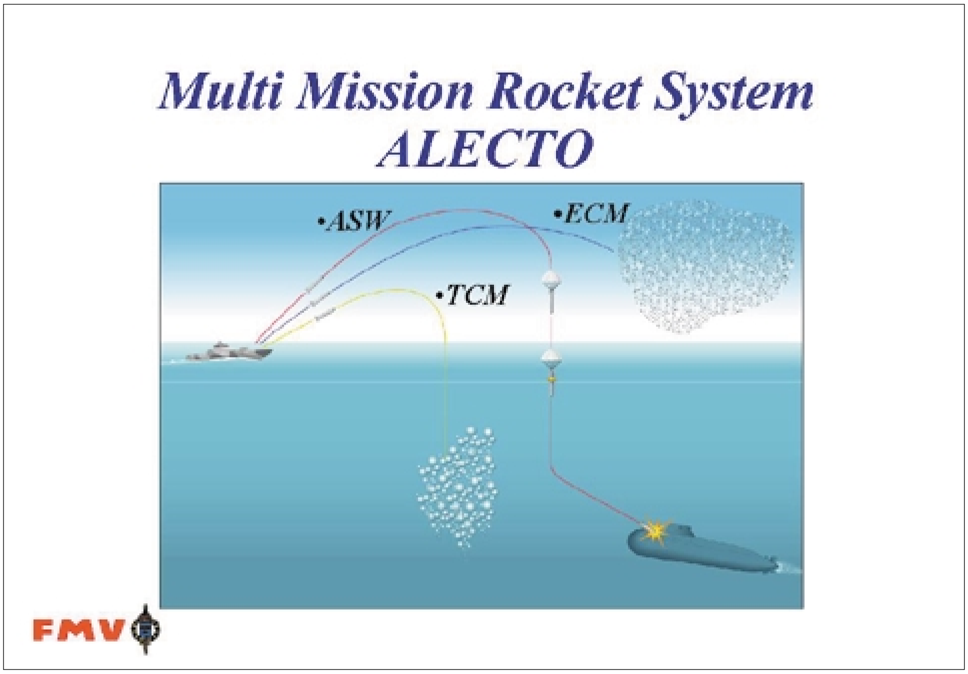

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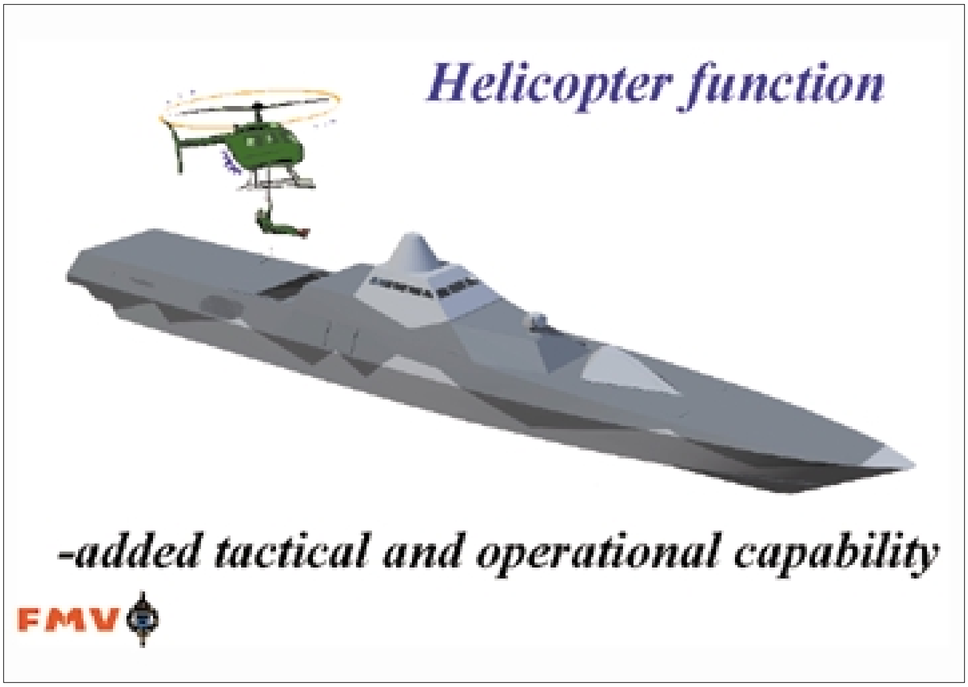

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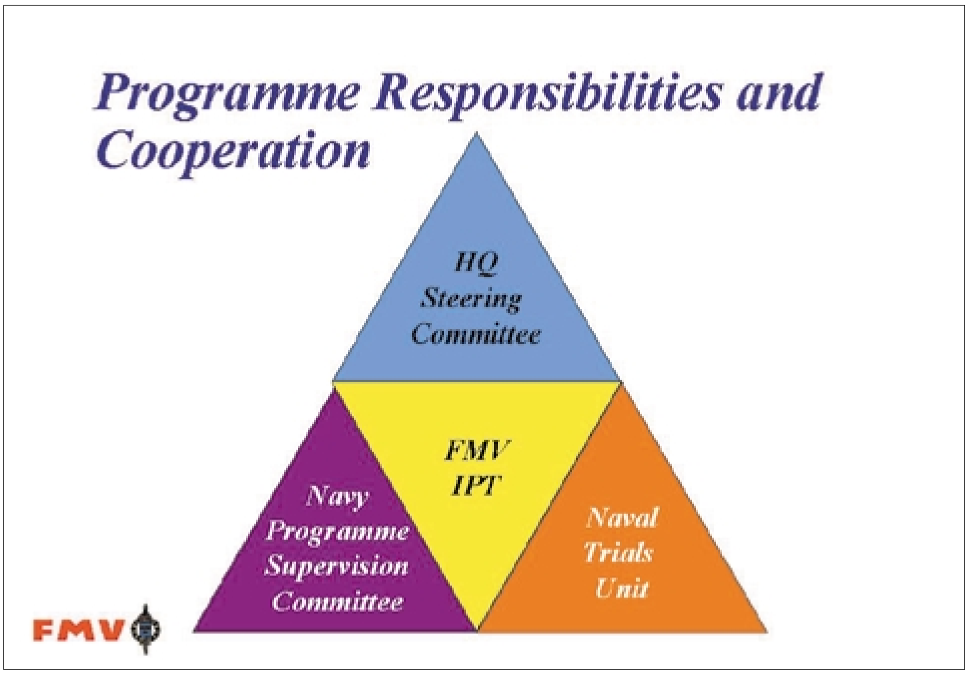


SLIDE 8

Virtual reality model of the CIC

FMV

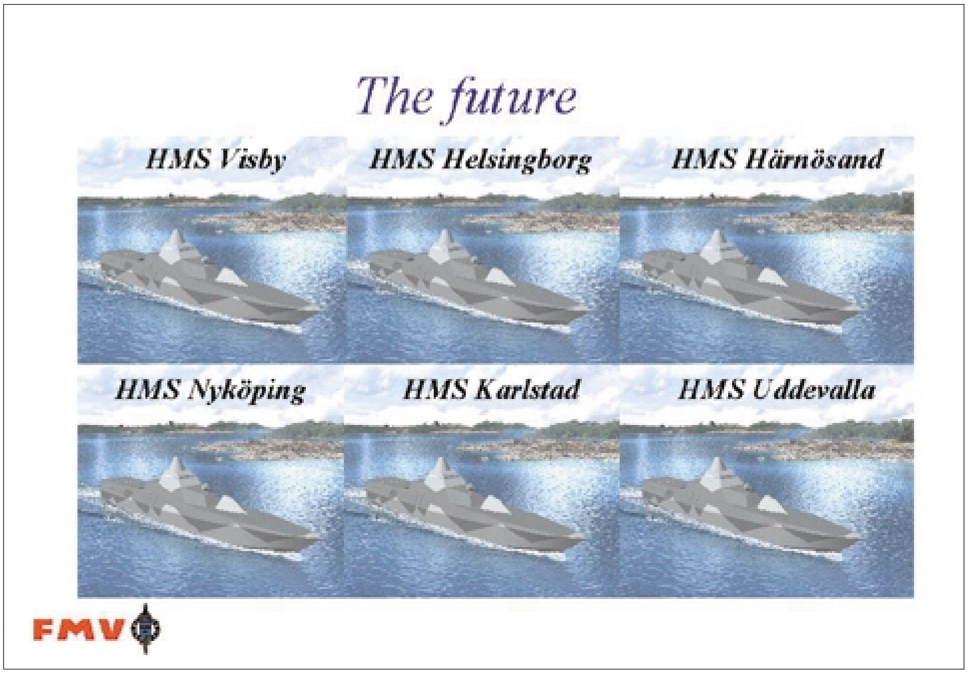
SLIDE 9

Visby's mission types

- *Mine Counter Measures (MCM) ops.*
- *Anti Surface Warfare (ASuW) ops.*
- *Anti Submarine Warfare (ASW) ops.*
- *Patrol Service and support to the Swedish National Society in peacetime*
- *Escort Duty*
- *International peacekeeping or peace enforcement operations*

FMV

SLIDE 10


The future
HMS Visby
HMS Helsingborg
HMS Härnösand
HMS Nyköping
HMS Karlstad
HMS Uddevalla
FMV

SLIDE 11

The stealh approach

WEDNESDAY JUNE 7, 2000, 11.20-11,35 AM

Captain Carl Fagergren, FMV

Captain Carl Fagergren, Royal Swedish Navy, is currently serving as Chief Engineer at the Technical Resource Centre Systems Engineering, FMV, Sweden. He has a M. Sc. in Naval Architecture from Royal University of Technology in Stockholm. His previous assignments include duties at FMV as technical manager for the test ship SMYGE, Ass. Chief Engineer at a MCM Flotilla, Test Engineer at Sea Trials Unit SMYGE (Sweden´s stealth test ship), Technical Manager/Ass PM for the Visby Class Corvette (-92 -98) and Head of the Projects Section at FMV Ships directorate. He is also a member of the Royal Swedish Society for Naval Sciences.

SIGNATURES

The Visby Class Corvette is the first naval vessel ever where stealth actions have been taken in all areas to form a totally balanced concept.

WHY STEALTH

There are two ways to achieve survivability; invincibility or invisibility.

In the early 80:s the cost for achieving reasonable survivability on a naval vessel in a scenario with an air threat was increasing rapidly (it still is). This caused us to look for alternative ways of dealing with the new threat situation. As mentioned in the earlier presentation, we decided to investigate the possibilities of a fully developed stealth ship.

The experiencies from the test ship (demonstrator) Smyge proved that stealth technology is a highly effective tool to achieve cost effectiveness on the battlefield. It also proved that if you want to reach low signature levels, stealth must permeate the entire project – from the first ideas to the construction and the trials – from the smallest antenna to the entire hull.

STEALTH AREAS

The concept of stealth technology includes everything which minimises signatures and signals with the aim of increasing the efficiency of own countermeasure systems and own sensors and hindering or preventing detection and identification.

On the Visby Class Corvette actions have been taken in all stealth areas – in the air as well as under the water – the aim being to achieve effects in all areas in question. This picture shows what we call the signature shell principle. This principle implies that in each area, the measures taken should be balanced against the expected threat, i.e. there should be no holes in the wall and each brick should be about the same thickness.

In the coming presentations we will see in more detail all the different actions taken in the areas in question and what are the tecnical solutions.

STEALTH EFFECTS ON DIFFERENT LEVELS

The first effect obtained when beginning to reduce a vessels signatures is increased peformance on own sensors, thanks to the decreased noise-level.

Going further, the next effect is that the performance of own passive countermeasure systems increases. To achieve that a certain level has to be reached; a level where the vessels reflected or transmitted energy is substantially lower than that of the countermeasure system's.

The next level to aim for is when the signatures are so low that even if it is possible to detect the ship, identification is made difficult. The highest level is to completely avoid detection. To reach the latter effects, the signatures must be about the same level as, or lower than the environmental background noise. On all levels, but particularly on the highest, environmental factors, such as weather and operational area, are of great importance.

In this picture we can see another way of expressing this. On the Visby Class Corvette, the signatures in all areas in question are kept so low that every link in the "kill chain" is affected.

THE BENEFITS OF STEALTH

What are then the real benefits of stealth? What are the properties of a stealth ship, that the commanding officer can take advantage of in a future scenario? Actually, there are quite a few and moreover, some of them might even be of vital importance. Here are some of the most important ones:

- You gain time/You are number one: The advantage of knowing where your enemy is and to get him within the range of your weapons before he does the same thing cannot be underestimated, especially in a duel situation.
- Increased survivability: The consequences of having both an active and a passive self-defence system you can count on in combination with the fact that it is hard or impossible to find you are that:
  - ÷ You don´t always have to shoot at an incoming threat
  - ÷ You have the possibility to fire as number two
  - ÷ You dare to be in dangerous places
- Stealth control: If You can contol all your signatures, if you know how stealth you are, you also know where you dare to be.
- You don´t have to be stealth: Sometimes you might not want to be stealth. That´s no problem, it is always possible to "försämra" a signature if you want to. For example: put up a radar reflector, open a few hatches, expose something hot, etc.

You can if you like sum up all this with one expression: Freedom of action! It doesn´t end with that though. It is most probably so, that in the future, if you are not stealth, you have nothing to do on the battle scene. In the next chapter I will explain why.

STEALTH IN THE FUTURE SCENARIO

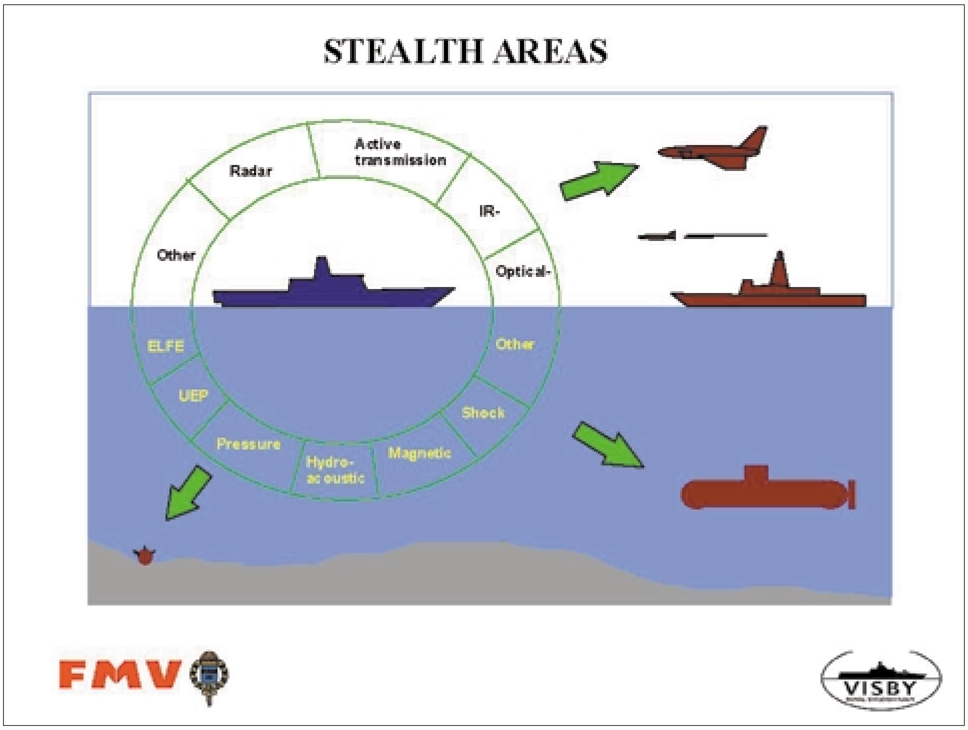
The future threat situation at sea will be more complex than ever. In the aftermath of the cold war war material is bought and sold over borders on an increasing scale. This will, among other things lead to that it will be more difficult to distinguish enemy from friend. Earlier, it was easier to connect a certain radar or a certain aircraft to a certain nation. In the future, this will not be the case. For the commanding officer the decision to engage or not (or how to engage) will be critical – he must be certain that he is not shooting at the wrong guy.

Furthermore, the ability to handle threats over a wider range of the conflict scale stresses the ability to engage gradually. Another uncertainty is that it might be difficult to understand the real risk. A situation that is defined as a low conflict, might very well imply a high risk for the specific ship. A mine in the wrong place, or an F16 at the wrong time with the wrong pilot; that is enough to create a scenario at least as dangerous as in a war situation. The difference beeing that you don´t know.

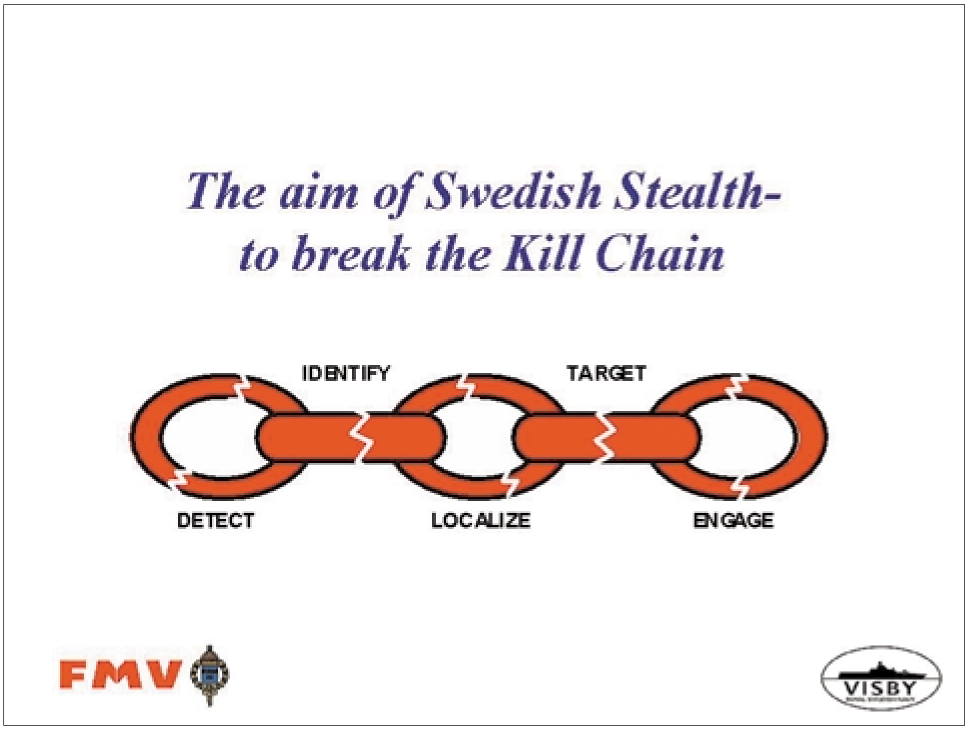
Yet another change is the shifting focus from blue to littoral and brown waters.

In all the situations mentioned above stealth is key. The ability to control all your signatures, to act without being seen or noticed in combination with a passive, but highly efficient self defence system implies great advantages. Strategic as well as tactical, but also in terms of economy. In fact it is probably so that in the future, unless you are stealth, you are not going to be invited to (or have the capability for) serious business. ■

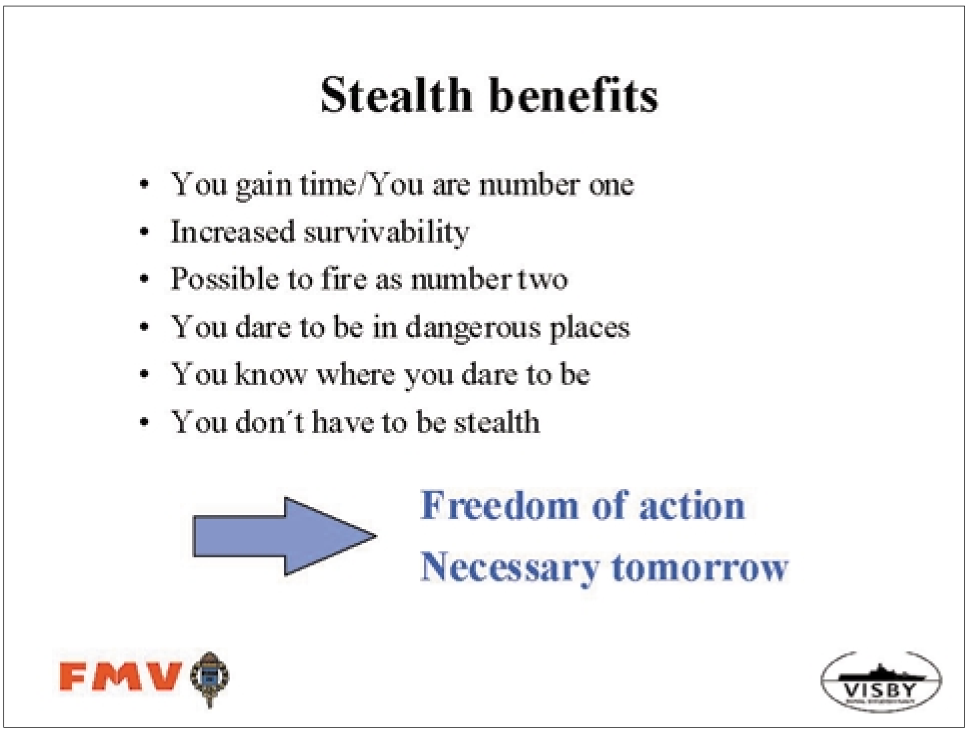
SLIDE 1: SMYGE



SLIDE 2. The swedish stealth koncept is balanced and includes all signatures



SLIDE 3. The ”Kill Chain”



SLIDE 4. The benefits of stealth

The composite hull

WEDNESDAY JUNE 7, 2000, 11.35-11.50 AM

Mr Johan Edvardsson, Kockums

Johan Edvardsson, M.Sc. Naval Architect.

Graduated from Chalmers University of Technology 1996.

During September 1998-April 2000 repsonsible for the system design of the hull structure in the Visby class corvette project.

Since April 2000 responsible for the hull production in the Visby class corvette project.

Kockums AB, previously known as Karlskronavarvet, has been producing naval vessels in glass reinforced plastic (GRP) for more than 25 years. Traditionally the hulls have been built as one piece in GRP-sandwich, using the hand lay-up method.

Designing and constructing Visby forced Kockums to think in new directions that led to a unique hull.

It is the combination of three main areas that make the hull unique

1. the material concept
2. the manufacturing method:
3. the sectional building technique

THE MATERIAL CONCEPT

The Visby hull is built as a sandwich structure using carbon fibre reinforced plastic (CFRP) laminates on a PVC core material.

The advantages of using this material concept are numerous. The major advantages are:

1. High stiffness/weight ratio.
2. Flat panels. Flat panels are one of the conditions for creating a low Radar Cross Section (RCS).
3. Non-magnetic material.
4. Shock damping capacity. The CFRP-sandwich structure has excellent energy absorbing capacity that means that the structure can resist shock, such as that induced by a mine explosion.
5. Thermal insulation. The sandwich has very good insulation properties. This is important from an IR-signature point of view as it prevents the surface of the ship from being heated up by internal heat sources.
6. Low maintenance cost. As there is no corrosion on a CFRP-hull compared to a steel hull, there is only a small need for maintenance. It means that the Life Cycle Cost (LCC) for a CFRP-hull is low.

THE MANUFACTURING METHOD

Constructing a large composite ship like Visby demands a rational manufacturing method. A lot of effort has been spent on developing a method adapted to our own needs. The method, named KVASI, is an infusion method developed for both flat and curved sandwich structures.

The advantages of the KVASI-method are:

1. Higher fibre content compared to hand lay-up, for lower structural weight.
2. Very flat panel surface. Important for the RCS.
3. No emission. As the KVASI-method is a closed process, a purifying plant can take care of all of the styrene emissions produced during manufacturing. This means a better environment, both locally, inside the workshops, and global.
4. Less man-hours per m^2 sandwich-panel produced.

THE SECTION BUILDING TECHNIQUE

Composite ships built by Kockums previously had the hull and superstructure built together as one piece before outfitting. For the Visby hull, sectional building was found to yield several advantages during the construction planning phase.

It ended up in a hull consisting of four main sections, fore, mid, aft and super structure. Each section is divided into several subdivisions.

Joining composite sections together is much more complicated than joining steel sections. The method used is developed by Kockums and based upon the KVASI vacuum-infusion method. ■

Visby Class Corvette - A Ship With A Unique Hull

The material concept

The manufacturing method

The sectional building technique

SLIDE 1

The Material Concept - CFRP-sandwich

High stiffness/weight ratio

Flat panels ⇒ Low RCS

Non magnetic material

Shock damping capacity

Thermal insulation - IR signature

Low maintenance cost ⇒ low LCC

SLIDE 2

The Manufacturing method - KVASI

Karlskronavarvet Vacuum Assisted Sandwich Infusion

3 / 2000-05-15

KOCKUMS

SLIDE 3

Advantages using the KVASI-method

Higher fibre content ⇒ Lower weight

Very flat panel surface ⇒ Low RCS

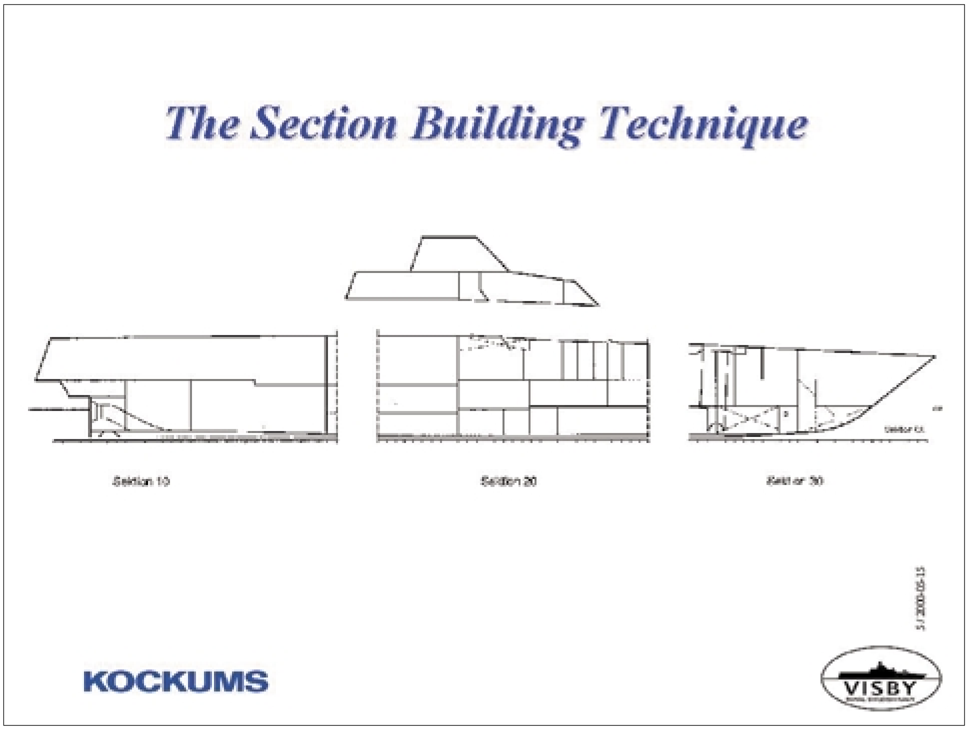
No emission ⇒ Better environment

Less man-hours

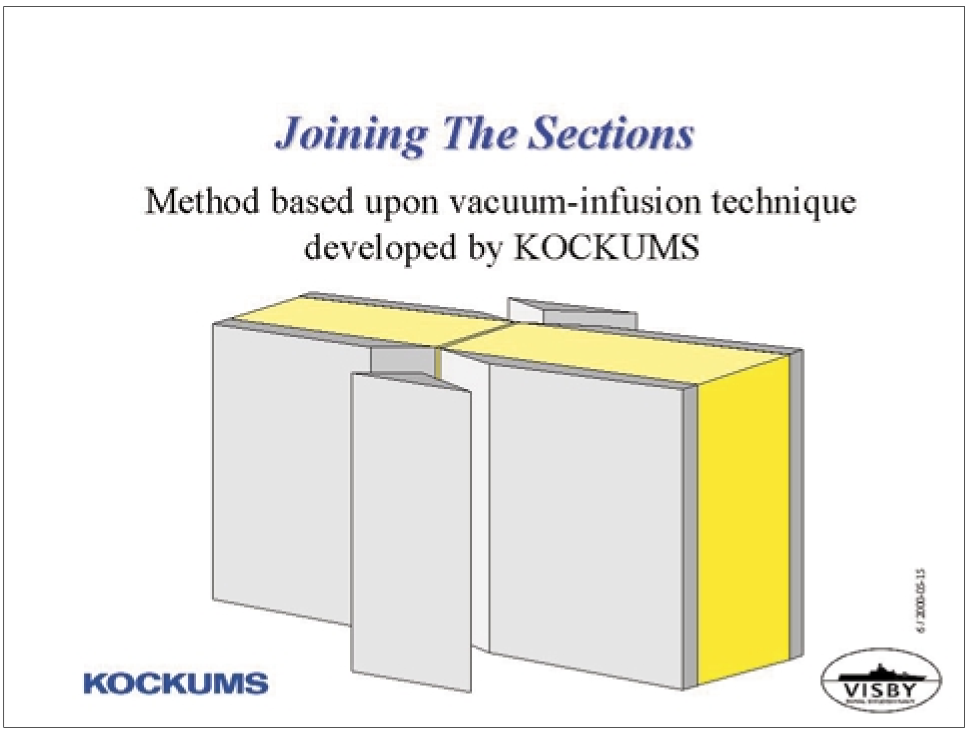
4 / 2000-05-15

KOCKUMS

SLIDE 4



SLIDE 5



SLIDE 6

Hydroacoustic prediction

WEDNESDAY JUNE 7, 2000, 11.50-12.00 AM

Mr Björn Allenström, SSPA

Mr Björn Allenström, Director Hydrodynamics Development

He received his M. Sc. degree in Naval Architecture in 1976 at Chalmers University of Technology and has since then, except for two years, been employed at SSPA.

SUMMARY

SSPA has a long and successful tradition of co-operation with the Swedish Defence Materiel Administration and the Royal Swedish Navy on a number of projects in the hydroacoustic field. Together we have built up an unique competence and experience in predictions of hydroacoustic performance of surface vessels and submarines.

The hydroacoustic signature is one of the most important signature parameters in ASW (Anti Submarine Warfare) and a comprehensive view is a vital qualification in the acoustic design of a modern vessel. SSPA Sweden AB has long experience in predicting passive and active signatures for surface vessels, submarines and torpedoes. Onboard noise, underwater radiated noise and air borne radiated noise must be considered when a complete acoustic analysis is performed. The underwater radiated noise can be used for detection, localisation and classification of the vessel. In harbours and archipelagos the air borne radiated noise might be an annoyance for people. Here we will focus on the radiated underwater noise.

INTRODUCTION

Propulsion, machinery and transmission are major sources of noise on a ship. For HMS Visby the waterjet propulsion system was chosen to keep the radiated propulsion noise low. The development of YS 2000, as it was called during the development phase, began in the late 80's with the development of the experimental patrol craft HMS Smyge. The tests in SSPA's laboratories and the sea trails provided the project team of YS 2000 with important information.

Hydroacoustic predictions are carried out by commercial and/or in-house developed computer programs. For low frequency assessments FEM (Finite Element Method) together with BEM (Boundary Element Method) are a powerful combination.

The main noise sources onboard a ship are:

- engine exhaust
- engine air intake
- radiation from hull vibrations caused by the engine or the transmission
- radiation from hull vibrations caused by pressure pulsation from the propulsion
- ventilation fans and compressors
- activity of the crew
- loading and unloading systems may cause noise in terminals and harbours.

Most of these noise sources give direct or indirect radiated underwater noise. Radiated noise from the waterjet will be discussed in the next chapter.

Hull flow excited noise may be a source of noise in cases like for high speed crafts, underwater vehicles and self noise of own sonar. To keep the flow noise low the flow design of the underwater body (hull, apertures, inlets, outlets, edges, etc) is of great importance. To avoid design solutions with poor flow noise performance, CFD programs (such as SHIPFLOW) are useful tools in the design work.

RADIATED NOISE EMANATING FROM THE WATERJET

The excitation level of the noise radiated from the propulsor is mainly determined by the following parameters:

1. The geometry of the propeller or, in the waterjet case, the rotor and stator and the clearance between them.
2. The mean thrust and rpm of the propeller (rotor).

3. The velocity distribution of the inflow to the propeller (rotor).

Numerous evaluations of full-scale noise measurements from different types of naval ships (read surface vessels and submarines) indicate that the indirectly radiated noise, at least at low frequencies (say one to ten times the blade frequency), may determine the resulting noise level.

The resulting radiated noise can be calculated by coupled finite element (FE) and boundary element (BE) analysis. However, this modelling is a complicated task that is particularly difficult to perform at an early stage of a project. Thus semi-empirical methods for the radiated noise based on full scale measurements from ships of similar types and the experience base at SSPA have been developed. For YS 2000 such calculations of the radiated noise from the waterjet propulsion system were carried out.

MACHINERY AND TRANSMISSION NOISE

Propulsion, machinery and transmission give tones in the noise spectrum. It is important to avoid pure tones or at least reduce them to a minimum. As every naval operator knows pure tones in the spectrum provide excellent opportunities for classification of the vessel. Tones in the propulsion and machinery frequency register travel long distances in the water and they may also disturb the ship's own sonars.

The exterior air borne noise is today probably of most importance for the ship's crew and people in the archipelago. It is important to achieve a comfortable interior noise level for the crew. High noise levels are annoying and result in radiated underwater noise as well. To keep both the interior and the exterior noise low it is essential to take not only the noise sources but also the different transmission ways in to consideration.

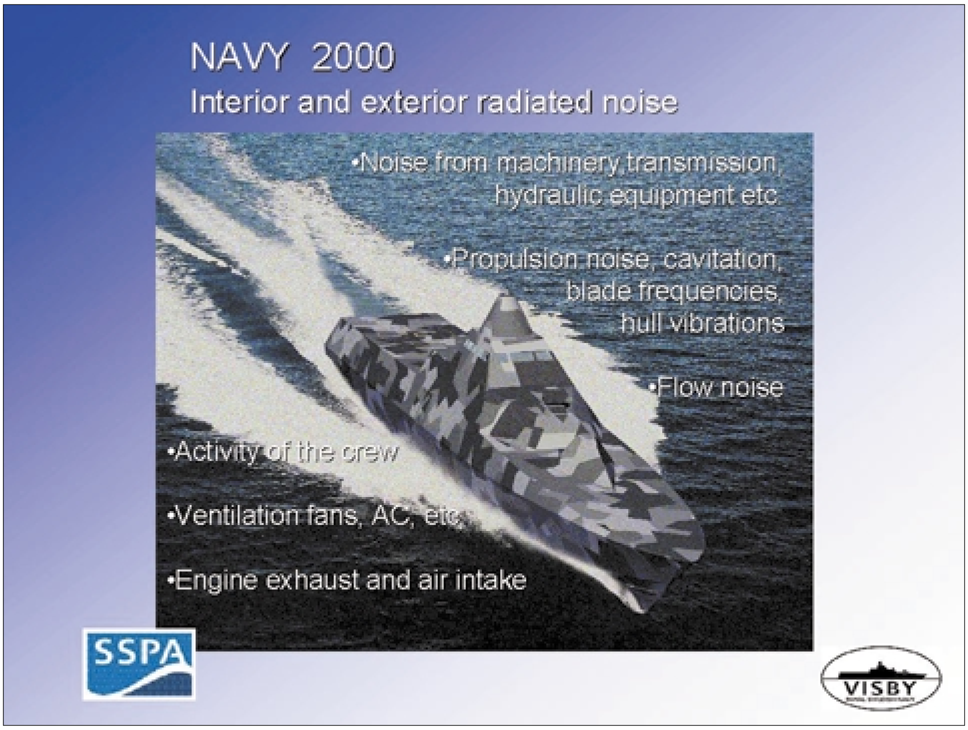
The software SuShi (Submarine and Ship Acoustics), developed in house by SSPA, has been a valuable tool for evaluating the noise signature of YS 2000. In the project phase different design solutions of machinery-isolator-foundation system and propulsion system were investigated. Maximum allowed vibration and pressure pulsation levels for equipment such as hydraulic pumps and motors have been calculated starting from the underwater noise requirements. Requirements on pipe flange vibrations and pressure pulsations in the hydraulic pipes have also been calculated.

CONCLUSIONS

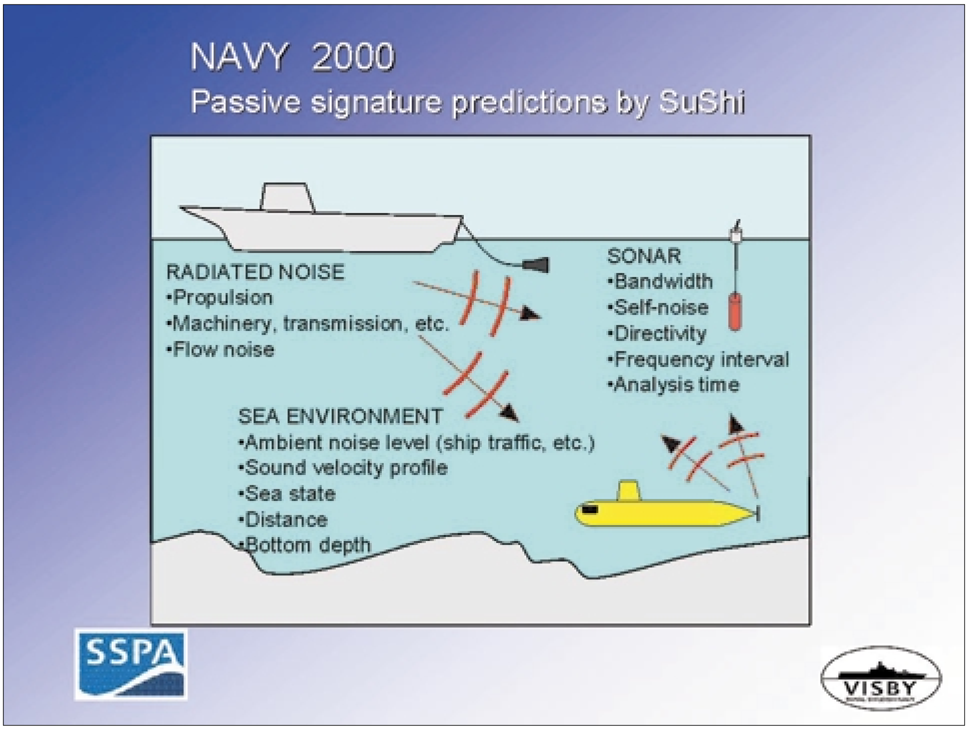
HMS Visby, with the silent waterjet propulsion system together with all the efforts put into noise and vibration design of machinery and transmission system, has very good potential to be a low noise radiation ship.

In the future the underwater radiated noise will still be one of the most important signature parameters of a naval vessel. We are convinced that new technologies such as active noise and vibration control will be used much more than today.

Environmental parameters such as onboard noise and air borne radiated noise will be even more important in the future. Therefore a comprehensive acoustic view is important when the design is performed. ■



SLIDE 1



SLIDE 2

Figure 1 *For naval vessels radiated noise is one of the most important stealth factors and it must be considered at an early project stage. One problem is how to predict it and another is how to assess it. Acoustic echo target strength is another important factor to be taken into account in an early project stage. The software SuShi (**Su**bmarine and **Shi**p Acoustics), developed in house by SSPA, is a very useful tool for both passive and active predictions. The sea environment with sound transmission loss and background noise together with the detection capabilities and self-noise levels of the sonars give the detection distance of the own vessel. The noise prediction methods are semi-empirical, i.e. they are based on theoretical methods correlated with data measured in model and full scale conditions. In this figure the most important parameters are described. The program has been developed in close co-operation with the contractor, the Swedish Defence Materiel Administration.*

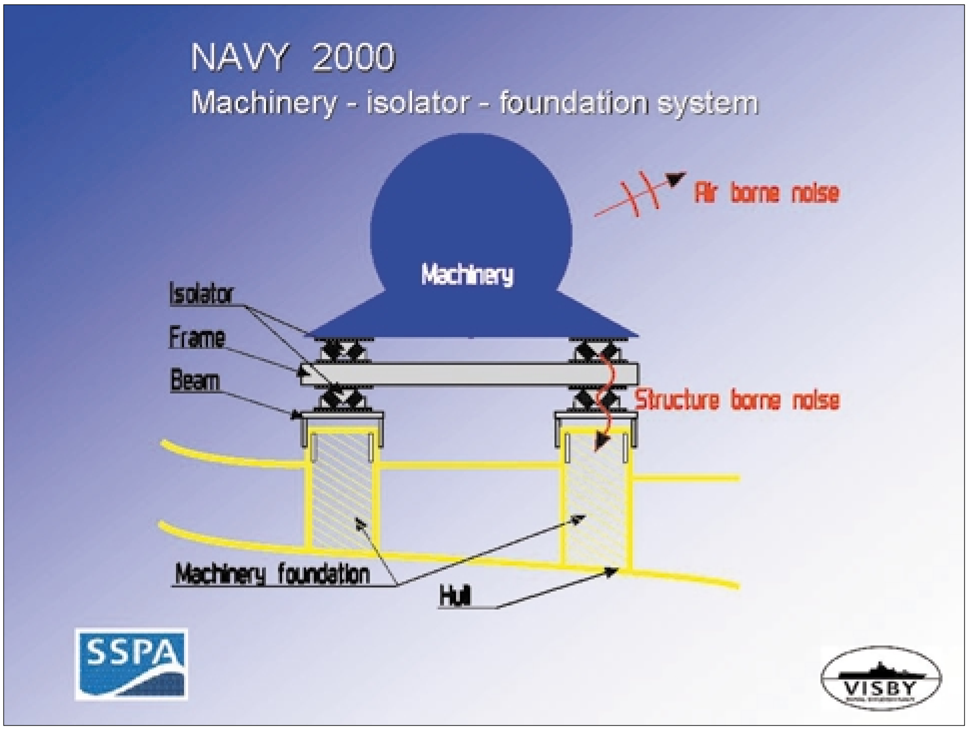


Figure 2 *The machinery-isolator-foundation system must be well designed to keep the radiated machinery and transmission sound low. Dynamic FEM-analyses of YSB's machinery foundation were performed in an early project stage to investigate different design solutions. Stiffness, losses and mass are important parameters for the foundation. Other transmission ways such as hydraulic pipes shall be attached to the ship structure with soft elastic mounts. Flexible pipes shall replace pipes close to the vibrating machines.*

SLIDE 3

The ship

WEDNESDAY JUNE 7, 2000, 13.00-13.30 PM

Commander Mikael Magnusson, FMV

Commander Mikael Magnusson works at the Defence Materiel Adminisration Technical Resource Centre Marin Technology. Present work is Contract Manager for the contract with the Ship Yard.

Before he has been working for NSWC Combatant Craft Department (CCD) in Norfolk for 13 month between 1997-1998. He has been working as a Squadron Engineer for the Gothenburg Class Corvettes and before that a Test Engineer for the Smyge.

He graduated from the Royal Swedish Naval Academy in 1987. The same year he started at Royal Institute of Technology in Stockholm.

He graduated in 1991. In April 2000 he was promoted to Commander.

The Visby Class Corvette is designed to meet the new requirements of the littoral water challenges.

This means that she is a multipurpose ship with substantibility and seaworthiness to cope with a wide range of tasks.

FLEXIBILITY

The vessel has a built-in cargo deck and a weapon deck with capacity to carry weapons, sonars as well as equipment for sea-rescue operations. *(Slide 1)*

There are many advantages:

- Working areas protected from the weather
- Extensive endurance feasibilities
- Feasibilities to carry out missions in rough weather conditions
- Most of the ship's armaments are hidden, which makes it difficult for an observer to determine their mission.

(Slide 2)

The aft part of the cargo deck is hosting the underwater sensors like the Towed Array Sonar (TAS), the Variable Depth Sonar (VDS) and the Anti Submarine Warfare (ASW) 40 cm torpedoes.

The front part of the cargo deck can be used either for a helicopter hangar or the coming Sea To Air Missiles (SAM).

The weapon deck may be used for different equipment due to the current operating mode. The same space can host the Sea To Sea Missile (Rb 15 Mk II), or Mine Counter Measures (MCM) equipment such as Remote Operating Vehicles (ROVs), and additionally be reserved for sea-rescue operations.

Furthermore, as a notice before seeing the hangar: a helicopter can take off land and refuel on the upper deck.

All this together provides for an excellent flexibility, resulting in a rapid reconfiguration of the ship, dependent on her next mission.

PERFORMANCE CRITERIA

Important criteria are endurance, shock resistance, low signature, performance in high seastate, but also a capability to operate in shallow waters, the latter criterion causing a few restrains on the ship's dimensions.

The use the composite carbon-fibre structure for hull and superstructure has made an adequate reciprocal adjustment of these criteria possible.

The non-magnetic, strong and lightweight hull has allowed for a deep-V hullform which gives the Visby Class Corvette excellent seakeeping performance for a ship of her size.

The Combat Information Centre, the Engine Control Room and the Bridge, the work stations of most crew members, are all located near their physical training centre, thus creating the best possible PT environment.

The ship is equipped with a two-shaft Combined Diesel Or Gas turbine (CODOG) machinery in combination with waterjet propulsion, diesels for low speed and gasturbines for high speed. This ensures an excellent flexibility and a sound economy in all respects.

There are auxiliary facilities onboard, a bowthruster for manoeuvring in harbour areas.

The selection of a low-speed machinery and the waterjet have been made for the purpose of offering excellent manoeuvrability in Mine Counter Measure (MCM) operations as well as providing for good endurance and very silent operational modes at low speed.

In all, these technical solutions give the crew what is needed to operate the Visby with good endurance in most waters and under different weather conditions.

STEALTH DESIGN *(Slide 3)*

The Stealth design has been and still is one of the main criteria of this project.

In order to reach the lowest possible Radar Cross Section (RCS), the hull needs large, flat surfaces and sharp edges.

Everything which does not necessarily have to be mounted on the outside of the ship has been integrated, made hoistable/retractible or been hidden behind hatches, like sensors and weapons.

The surveillance radar has been positioned behind a frequency selected surface. *(Slide 4)*

You may call this a “closed design”, aiming at meeting the requirement of the RCS.

For the purpose of granting the vessel a low IR-signature, gas turbine exhausts and exhaust-pipes are concealed in hidden outlets in the stern, close to the water surface.

Generators and low speed diesels have been mounted double-elastically under noise-hoods to obtain low noise radiation internally, externally and hydroacoustically.

MARITIME SECURITY

To conclude, the ship is a maritime security vessel, designed for littoral water operations, thus not provided with international blue water capacity – but enabled to meet the requirements within the Baltic and international operations in littoral areas. ■

FLEXIBILITY

The vessle has a built-in cargo deck and a weapon deck with capacity to carry weapons, sonars as well as equipment for sea-rescue operations.

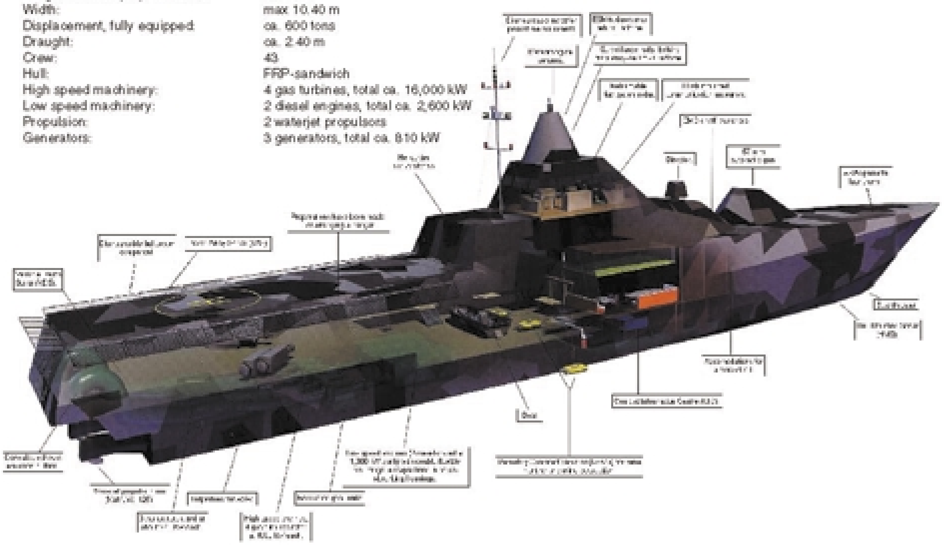
The advantages are many:

- Weather protected working areas
- Allows great endurance
- Opportunity to carry out missions in rough weather conditions
- Most of the ship's armament are hidden, which makes it difficoult for an observer to determine its mission

SLIDE 1

Visby Class Corvette - main technical data

Length over all:	ca. 72 m
Length between perpendiculars:	61.50 m
Width:	max 10.40 m
Displacement, fully equipped:	ca. 600 tons
Draught:	ca. 2.40 m
Crew:	43
Hull:	FRP-sandwich
High speed machinery:	4 gas turbines, total ca. 16,000 kW
Low speed machinery:	2 diesel engines, total ca. 2,600 kW
Propulsion:	2 waterjet propulsors
Generators:	3 generators, total ca. 810 kW



SLIDE 2

Radar Cross Section

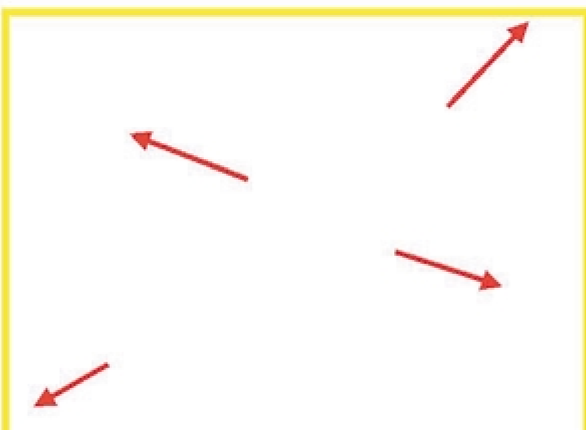
controlled reflection

- # *Careful design (flat panels, few angles, low height)*
- # *Optimised material in hull and production of hull*
- # *Hidden installation of all main equipment, inlets/outlets*
- # *New methods to perform weatherdeck activities*
- # *Gun in new type of turret*
- # *Antennas flush mounted, hoistable*
- # *Use of RAM when necessary*

FMV

SLIDE 3

STEALTH - Radar cross section



Reflection minimized to 4 main directions and elevation angle

FMV

SLIDE 4

Mr Karl-Erik Hallsten, Kockums

Mr Karl-Erik Hallsten graduated from Chalmers University of Technology in 1967 with and M.Sc. in Naval Architecture and started his career as a hull designer of large tankers and gas carriers at Kockums.

He moved to Karlskrona and Karlskrona shipyard in 1979, where he held several positions.

As a planning manager he was very much involved in the construction of HMS Smyge, the first stealth vessel. He has been project manager for building the submarine section.

Before he became project manager for the Visby Class Corvettes he was responsible for the Gothenburg Class of Coastal Corvettes.

NAVY 2000 – THE SHIP (KAB)

HMS Visby is so far one of the biggest ships built in fibre reinforced plastic and definitely the biggest one built in carbon fibre reinforced plastic.

The size of Visby forced us to reconsider the construction technique. Due to the size of Visby, the hull had to be built in four sections. To meet the stealth requirements, the number the hatches shall be as few as possible and of course the hatch size should be as small as possible. The limited number of hatches and our reluctance to make temporary openings in the hull during the outfitting period means that we can't employ the normal procedures for outfitting a complete ship. Instead we are doing a major part of the outfitting work in the four hull sections, before the sections are joined together. We are convinced that this will reduce the total number of man-hours for the outfitting.

When talking about stealth there is a tendency to focus on the radar cross section. Of course, the radar cross section is a major component in the total stealth concept. We have put in a lot of advanced engineering work to reduce and minimize the other signatures, such as the hydroacoustic, magnetic, noise and IR-signatures. A good example of what we have been doing is the propulsion system. As mentioned earlier, we use CODOG-machinery. For speeds up to 17 knots we use the two diesel engines. These are of course double elastic mounted, with a sound insulation cover, and water is injected in the exhaust pipe to reduce the IR-signature. The engines are modified to reduce the initial magnetic signature. They are demagnetizied and, to further reduce the magnetic signature, we have installed a local degaussing system.

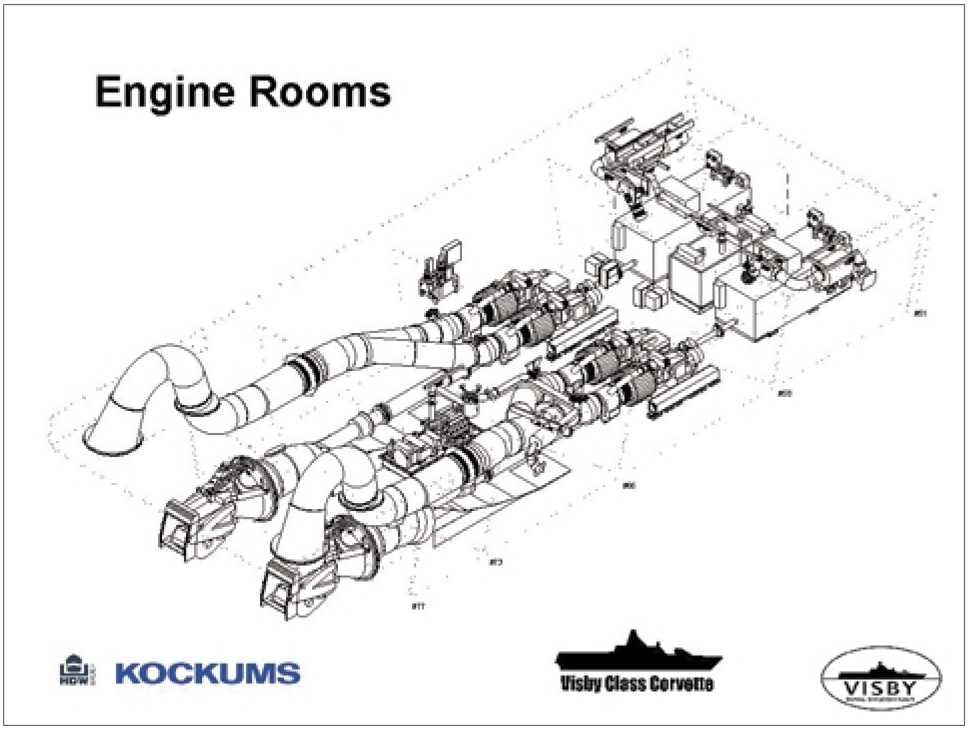
We use four Gas Turbines from Honeywell, previously known as AlliedSignal, for high speed propulsion. The two main gear boxes are supplied by Cincinatti Gear. The same stealth techniques are applied to the high speed machinery as for the low speed machinery. We employ double elastic mounting, water injection and magnetic treatment/compensation. We have also have been able to reduce the noise levels somewhat.

The same technique applies to the generator set as to the low speed and high speed machinery.

The gas turbines are directly mounted on the main gearbox. The diesel engines are connected to the gearbox through a shaft made of composite.

We have designed a special shafting from the gearboxes to the water jet units system made of composite.

The expression "Details can be the devil" is really true of the stealth area. You have to cover all aspects and all areas and I am convinced that we are building a unique product which we will be very proud of in the future. ■



SLIDE 1

Water jet propulsion

WEDNESDAY JUNE 7, 2000, 13.30-13.40 PM

Mr Gunnar Styrud, Kamewa

Mr Gunnar Styrud graduated from Chalmers University of Technology as a Naval Architect and Marine Engineer in 1977. He was then employed by the Öresundsvarvet shipyard and was engaged with projects and design.

During the period 1980-1987 he was employed by Det Norske Veritas in Oslo and was mainly dealing with noise and vibration analyses and measurements for ships and offshore platforms.

In 1987, he moved back to Sweden and joined Kamewa, and has been working with development and special projects since then.

Mr Styrud currently leads the project team developing the large "size" 325 water jets for FastShip Inc.

INTRODUCTION

The propulsion system for the Visby class corvettes is the latest outstanding result in a long tradition of successful cooperation between the Swedish Defence Material Administration, Kockums, the Swedish Navy and Kamewa. Previous water jet installations of note include coastal corvettes, Smyge and Combat Vessel 90.

Water jets from Kamewa are now established as the natural choice when looking for a propulsion system for high-performance navy vessels. Today, more than 660 navy vessels and other craft around the world are equipped with water jets from Kamewa (180 with the Kamewa stainless steel series and 480 with the FF-jet series).

WATER JETS – A COMPARISON WITH PROPELLER PROPULSION

Top speed and fuel consumption

The Kamewa mixed flow impeller offers an efficiency exceeding 90 %, the frictional boundary layer on the ship's bottom is effectively taken advantage of, the interaction between the hull and the water jet is favourable at high speeds and the absence of shafting, rudders etc reduces hull resistance. These factors favour water jets. On the other hand, a water jet installation is heavier than a propeller installation, causing an approximately 2% increase in displacement for the same payload.

As a rule of thumb, an optimised jet installation requires less power than a propeller version in the speed range above 20-25 knots. The diagram below shows trial results with a vessel first equipped with propellers and then retrofitted with Kamewa water jets.

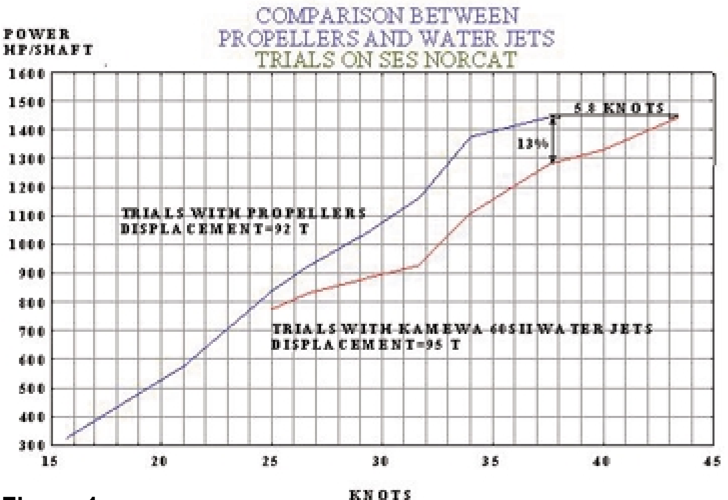


Figure 1

As mentioned above, the Kamewa mixed flow pump has high efficiency. However, it is equally important that the maximum efficiency occurs at a combination of head and flow rate that promotes high system efficiency. Figure 2 provides a comparison with another more axial pump design.

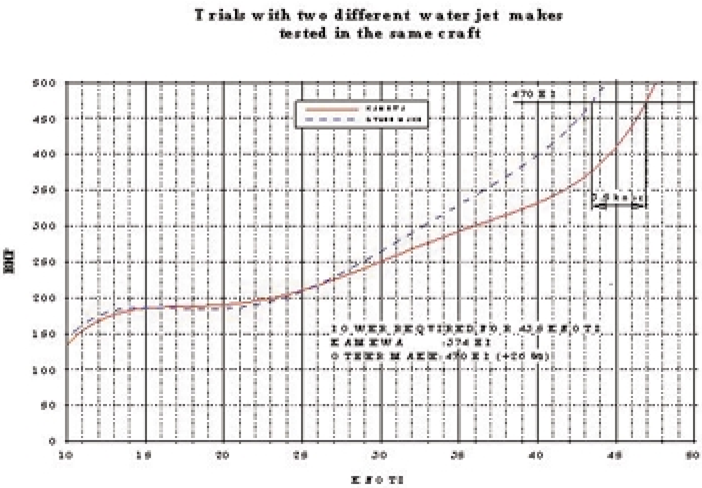


Figure 2

Manoeuvrability

A water jet unit creates side forces by deflecting the jet sideways. Compared to a rudder/propeller the generated side forces are 2-4 times higher. This results in quicker turns and about 50 % smaller tactical diameters, demonstrated by the trial results shown in figure 3.

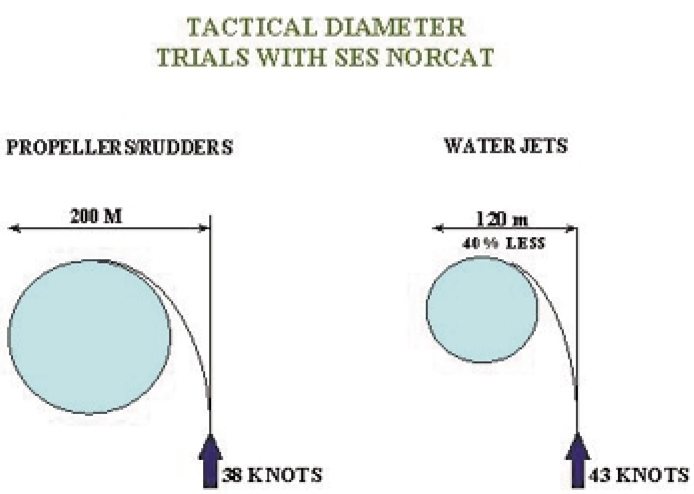


Figure 3

Reversing forces are created by deflecting the jet in a forward direction, as shown below.

Due to pump characteristics, a water jet unit will not over-torque the engine, irrespective of shaft rpm, ship speed and reversing bucket position (see below). This means that full engine power is available for manoeuvring which gives stopping and acceleration capabilities similar

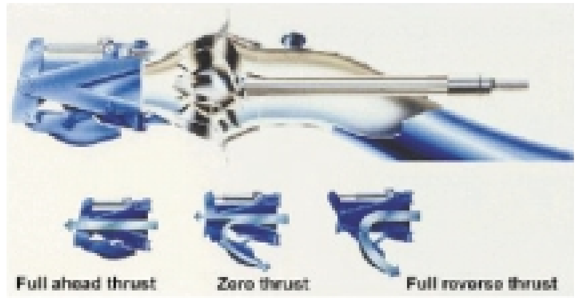


Figure 4

to those of a controllable pitch propeller installation.

Manoeuvring in congested areas, such as harbours, is further facilitated by the fact that ship speed can be steplessly reduced to zero by putting the reversing bucket in an intermediate position.This can be done with the engines running at constant rpm and constantly clutched in. In this way, strains on the engines, coupling and gear are minimised.

Water jet engine interaction

When a fixed pitch propeller is rotating with constant shaft speed, power absorption is strongly influenced by changes in the ship speed. This means that the engines are frequently overloaded during acceleration, in rough sea conditions etc. For instance, an MTU16V 595 TE70 engine can deliver its MCR power between 1700-1800 RPM. If the gear ratio is selected to allow the engine to run at 1800 RPM at, say, 42 knots, the engine will be overloaded if the ship speed drops to 38 knots due to rough sea conditions, high load, hull fouling etc.

A water jet unit has quite different characteristics in this respect, as its power absorption at constant RPM is insensitive to ship speed. This protects the engines from overload and also enables simple and efficient multi shaft installations as in the 90 m, 40+ knot car ferry Aquastrada. The Kamewa 100SII wing jets are driven by diesels and the Kamewa 180B centre jet by a 22100 BKW LM2500 gas turbine.

During harbour manoeuvring and slow speed cruising only the wing jets are in operation. In this mode, the diesels deliver 3565 BKW at about 1730 RPM. During normal operation, with the centre jet at full power too, the ship speed is about 44 knots but the wing diesels can still deliver their 3565 BKW at only a slightly higher shaft speed. See figure 5. Thus the engine RPM will vary a mere 2.5%, preventing overload, which in the long run will reduce engine wear.

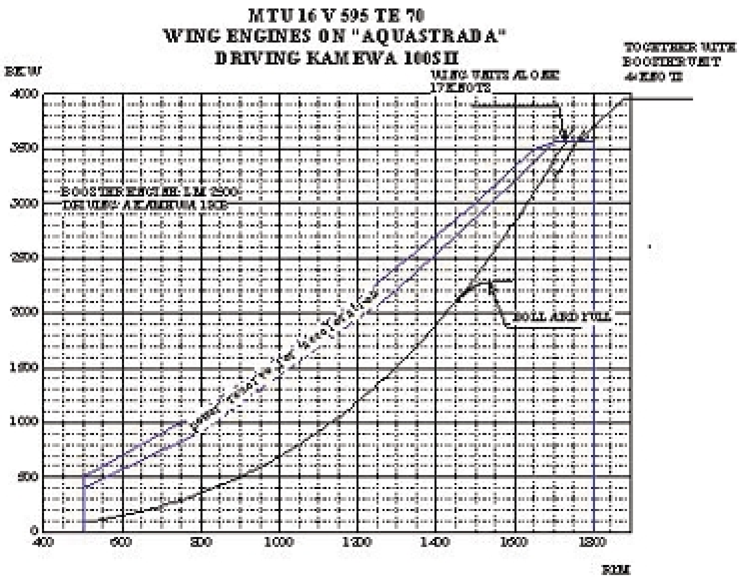


Figure 5

Inboard noise

The main reason for the low hydroacoustic noise generated by a water jet unit is that it transfers a minimum of vibrations to the hull structure.This also contributes to a reduction in the inboard noise level.

On two occasions, vessels have been converted from propellers to water jets – permitting a direct comparison. In the first case – a 150 ton Navy fast patrol boat – the crew reported a pronounced reduction in noise and vibration levels from low patrol speed and upwards. The other case is the 95 ton passenger ferry described earlier.

Noise reduction following the installation of the water jets is shown in figure 6.

Propulsive efficiency

The propulsive efficiency is defined as h_p, the effective power/input power to the pump shafts. On a full scale installation the effective power is based on predictions using a model basin and the pump power is preferably measured by strain gauges on the pump shafts.

h_p can be further split up as $h_p = h_{pump} * h_{rel. rot} * h_{hull} * h_{jet}$. Among these partial efficiencies the last two, h_{hull} and h_{jet} , depend on the specific loading of the water jet, i.e. how much power is absorbed at a given ship speed. The higher the specific load, the lower the efficiency. The shape of the resistance curves and Kamewa's policy in water jet size selection usually results in reduced specific loading with increased ship speed. As can be seen in the diagram below, this means that efficiency increases with the ship's speed.The effect of increased specific load can be seen when Aquastrada shuts down the 180B centre jet and runs on the two 100SII wing jets alone, at about 19 knots – and when the FPB goes from three-shaft operation to two-shaft operation at about 21 knots. The fact that some trials are run at maximum displacement and some at design displacement adds to the spread in the graph, due to the same reason.

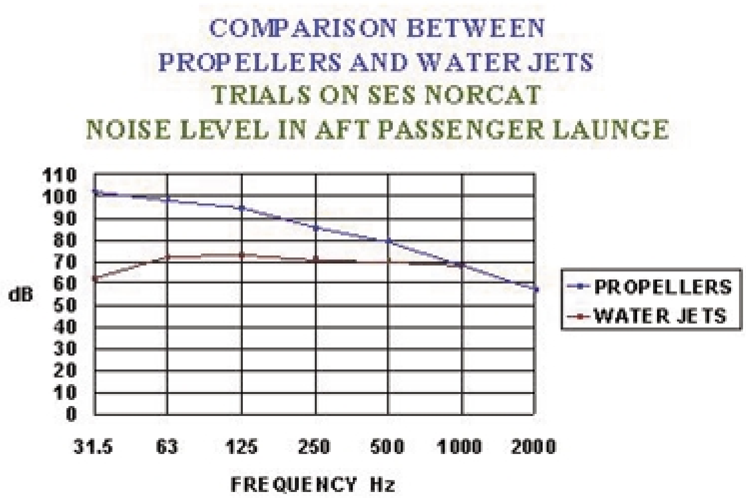


Figure 6

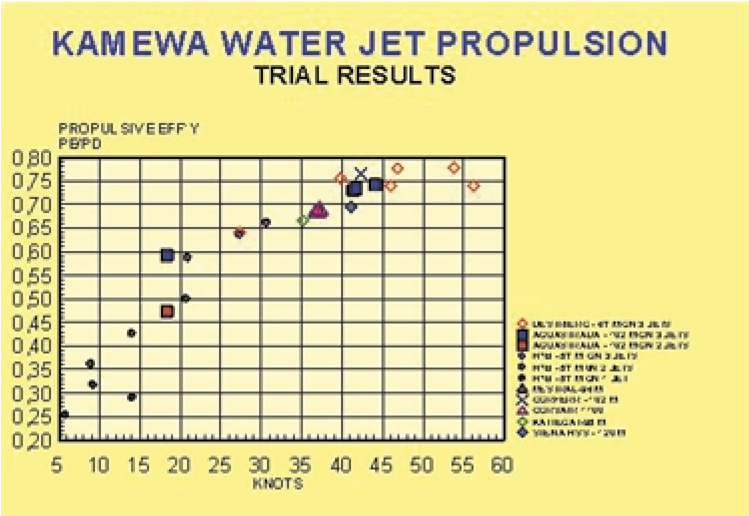


Figure 7

VIBRATIONS

Like all rotating machinery, the impeller creates pulsating forces. These forces are transferred to the hull structure, mainly by pressure impulses in the inlet, and by varying thrust and torque in the impeller shaft.

Kamewa has devoted much effort to minimising the generated impulses and thus to reducing vibrations and structure-borne noise on board. Military craft also benefit from this, as the hydroacoustic created noise can be kept very low.

The vibration levels in transom and inlet tunnel depend not only on pressure fluctuations within the inlet tunnel and varying thrust, but also on local resonance phenomena. This means that the vibrational characteristics of different vessels can vary considerably, even if the water jets produce the same vibrations.

To minimise impulses from the shaft, it is important to design the inlet so that the water inflow to the impeller is as uniform as possible. The fact that the Kamewa standard design incorporates a six-bladed impeller, combined with eleven vanes in the flow straightener, also contributes to low levels.

WATER JETS FOR YS 2000

The water jets delivered for HMS Visby are the first units fully developed to an individual customer's specifications. Mos of the development, in cooperation with FMV and the shipyard, has been conducted subsequent to signing the contract.

Special requirements for this order

The combination of three different requirements - low magnetic signature, low shock resistance and reduced weight – has been a real challenge for the design team. The low magnetic signature requirement means that standard high tensile duplex stainless steel cannot be used. Yet the weight had to be reduced.

The hydro-acoustic noise levels are reduced compared to the noise levels of our standard water jets. This reduction has been achieved by further optimisation of inlet duct, impeller and guide vane chamber, combined with elastically mounted bearings.

The Kamewa performance guarantee is another requirement that is now quite common for demanding orders.

Finally the feed back system has been modified in order to meet the loads caused by ice as well as EMP. ■

The underwater missions

WEDNESDAY JUNE 7, 2000, 13.40-13.50 PM

Mr Jörgen Arbholt, FMV

Mr Jörgen Arbholt, Principal Technical Officer at FMV has since 1998 been Project Manager for the HYDRA Multi Sonar System to the Visby Class Corvette program. Jörgen Arbholt has worked with Sonar Systems since 1989 and been involved in all of the Swedish Navys Submarine programs since then. Jörgen Arbholt has a Master of Science in Computer Science.

In 1995 Jörgen Arbholt received a scolarship from the General Inspector of the Navy for his work on the Submarine Sonar Systems

The underwater threat in shallow water is a complex combination of small submarines, mines, homing torpedoes, detection devices etc. To meeat he littoral water challenges the ship can counter these threats with combination of Anti-Submarine Warfare (ASW), Mine Counter Measure (MCM), Underwater Defence (UwD), underwater signature etc.

The main tasks are not completely separated, but interact in functionality. Some of the sensors should be used for more than one main task. Other equipment, hardware and software functions can also be common.

ANTI-SUBMARINE WARFARE

The ASW System is divided into ASW Command & Control system and the ASW Sonar system. The ASW Command & Control system 9LV CETRIS is integrated with the Hydra Sonar System through an high speed data link.

The tasks for the ASW systems are to detect, classify, locate and monitor for threat such as, submarines and submersibles, moving, hovering or lying on the bottom, in order to provide:

- Support for attack with own ship's ASW weapons
- Guidance for co-operating units, ships and/or helicopters

The demand for parallel active/passive ASW is very important. The sonars must be able to carry out active/passive detection and classification simultaneously

Tactical Conditions ASW

The environmental conditions have influenced submarine tactics in the Baltic which consequently are built on the following backbones:

〈 A submarines best protection in the Baltic is, beside being submerged, to go with low speed and take advantage of all the possibilities that the hydrography and the bottom topography gives. A usual and effective way to avoid ASW units is to manoeuvre to achieve a nil doppler situation, hover or lay still on a bedrock bottom.

Active ASW

Active ASW missions will be carried out either as escort missions or as patrol missions. The main sensor is the VDS which is the search sonar for long range detection, tracking and localisation of moving and stationary targets.

The VDS System shall also be able to classify bottom laying submarines.

A typical weapon against moving targets is the ASW Torpedo (Torpedo 45 or 62) or the ASW short range missile system (ALECTO) and against a submarine laying on a rough bottom is the ROV-E.

Passive ASW

Passive ASW are normally carried out with one individual surface unit working with a TAS in a separate area. TAS is the main sensor, but sonobuoys are also used.

The passive detection can be in broad band noise, narrow band noise or transients. The TAS is able to do passive ranging.

Analysis of narrow band signature of the actual target, and comparison is made with reference targets stored in a database system.

The Swedish ASW Torpedo system or ALECTO, which will be the weapon used, can operate on passive sonar information . The torpedo is equipped with an active/passive homing device and is wire guided (optical fibre) which includes an advanced communication link to/from the ship.

The TAS search phase is normally carried out in low speed with the VDS launched in stand-by, ready to transmit in order to very fast get an accurate position on the target if the TAS gets a short distance contact. This is very important in order to save time between first contact and weapon launch.

MINE COUNTER MEASURE

The modern mine threat consist of a mixture of old tethered contact mines and modern multisensor influence mines including self-propelled variants.

To counter that mine threat Visby's MCM system is designed to counter all types of mines well, outside mine's dangerzone.

The ship is designed to minimise her emitted underwater signatures, acoustic, pressure, magnetic, electric and seismic. Her low under water signature gives her the possibility to operate in very shallow waters

The MCM weapon suite is to a very great extend remotely operated both, in mine hunting mode using ROV and mine sweeping mode, using sweeping drones. Both tasks can be carried out simultaneously

The versatile sonar system is able to scan the whole water column for mines, from the surface down into the bottom mud. The system includes propelled variable depth sonar (PVDS), hull mounted sonar (HMS), and side scan sonar

In search mode the self-propelled sonar is deployed well ahead of or beside the ship so the minimum detection range is well outside of a mines danger area.

The PVDS gives the operator the possibility to choose the optimum depth for the sonar to achieve best possible detection probability

The sonar data is distributed to the command and control system where the targets are presented as a part of the recognised maritime picture.

Through the C3I system the operator will also get his reference data, technical, tactical and environmental as well as different support tools.

To destroy the identified mine an expendable ROV is used. A mine disposal vehicle can also be used.

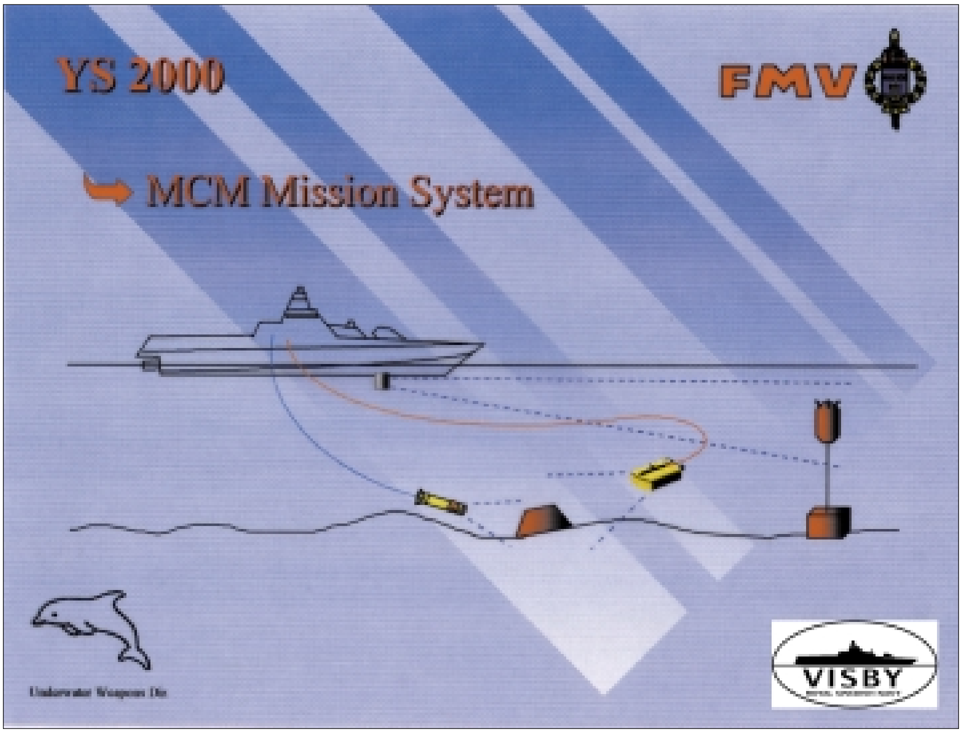
The minesweeping drones are programmed controlled and monitored from the ship.

Lead through operations is an essential part of the area control mission in mine infected areas.

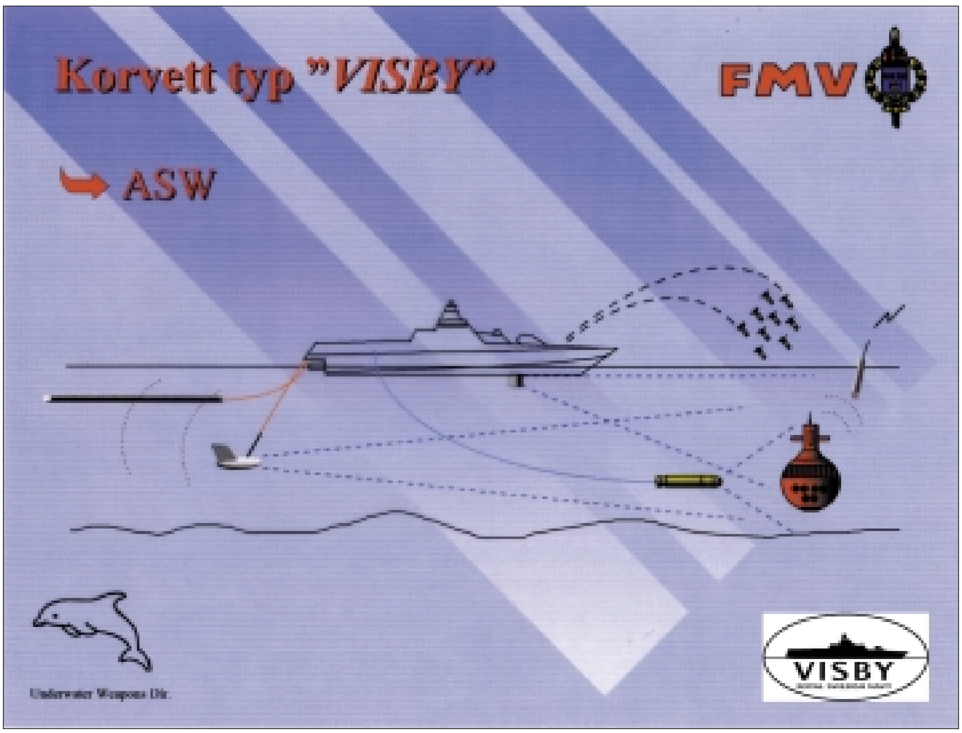
By the use of the C3I system and her sweeping drones Visby can provide a good protection for transiting ships.

Visby is unique as a MCMV with self-defence capability against all known types of threats.

To conclude, the sonar and weapon systems, integrated with the command and control system for sensor and data fusion, mission planning and control, enables the Visby class corvette to deal with the total underwater threat. ■



SLIDE 1



SLIDE 2

ROV-S

WEDNESDAY JUNE 7, 2000, 13.50-14.00 PM

Bengt Larsson, Bofors Underwater Systems

Mr Bengt Larsson has an M.Sc. degree from Linköping University.

He has worked at Saab since 1976. His speciality is stress analysis of aircraft.

Since 1988 he has worked as technical and ROV Sales Manager at Bofors Underwater Systems AB.Bengt Larsson, Bofors Underwater Systems

Mr Bengt Larsson has an M.Sc. degree from Linköping University.

He has worked at Saab since 1976. His speciality is stress analysis of aircraft.

Since 1988 he has worked as technical and ROV Sales Manager at Bofors Underwater Systems AB.

1 THE DOUBLE EAGLE SYSTEM OPERATED FROM VISBY

The ROV-S is Visby's onboard sonar system for mine detection and mine classification. The ROV-S comprises a remotely operated underwater vehicle (ROV) system, the **Double Eagle**, from Bofors Underwater Systems, and a sonar system from CDC/Reson, with the sonar array and its front electronics mounted onboard the ROV. Sonar data from the array is transmitted via a designated fibre in the ROVs tether to the sonar processing unit onboard Visby.

The **Double Eagle** is controlled either manually or in automatic mode from the ship. In its ROV-S configuration, the **Double Eagle**, has an interface to the ship's tactical system, including information from the underwater positioning system as well as to the sonar system. This enables the Mine Hunting Officer to plan for and execute automatic mine hunting operations, the ROV-S automatically following a given pre-planned track or route.

The most significant operational requirements for a ROV system during mine hunting operations are long endurance combined with high-speed performance, excellent stability and manoeuvrability, and low acoustic and magnetic signatures. The **Double Eagle** system has served for a number of years with different navies around the world, clearly demonstrating its excellence in these areas, making it the natural choice for the Swedish Navy.

During the first minute after launch from the ship, the ROV will, be controlled from a portable operator's control board on deck. The on-board operator's task is to control the vehicle and, as quickly as possible, with the vehicle, just below the surface, but still visible, reach a position approx. 20 to 50 metres away from the side of the ship and then dive. At this point, the position of the vehicle will be visible on a screen to the operator in the control room. He takes over command and directs the vehicle in manual or automatic mode to the starting point for the planned operation. The ROV is equipped with one or two transponders (normally in responding mode), for tracking by an underwater positioning system or by ship sonar.

The operator monitors ROV operation on a display, which will show specified operational and technical system parameters. The operator also monitors operation of the onboard winch and tether system. During normal operations the parameters shown are speed, course, depth, power etc. If a fault occurs, the operator is informed by both audio signal and on-screen alerts.

When the sonar system detects a target, the ROV operator can take manual control of the ROV-S at any time, stop the vehicle or direct the vehicle towards the target from different angles to obtain the best possible classification. The vehicle is also equipped with video camera(s) and can be manoeuvred close to the target for identification.

The ROV-S is supplied complete with a safe and speedy launch and recovery system.

2 THE DOUBLE EAGLE SYSTEM IN MINE HUNTING CONFIGURATION

Important parameters when using the **Double Eagle** System as a ROV-S for Mine Hunting operations are:

Manoeuvrability and stability. **Double Eagle** offers extreme manoeuvrability, permitting movement in six degrees of freedom and outstanding active controlled stability at any attitude.

Speed and endurance. **Double Eagle's** unlimited endurance ensures the best speed performance on the market today. A unique power transmission system in conjunction with optimal underwater cable technology

Reliability and maintainability. **Double Eagle** has a proven military and commercial track record. A quote from the commercial side is “6,000 to 9,000 hours use with preventive maintenance only”.

Magnetic and acoustic signature. **Double Eagle** meets STANAG 1364. Always measured during operational conditions.

Life Cycle Cost. LCC is the parameter which has been one of the strongest reasons for users to change to or use the **Double Eagle** system for military or commercial applications.

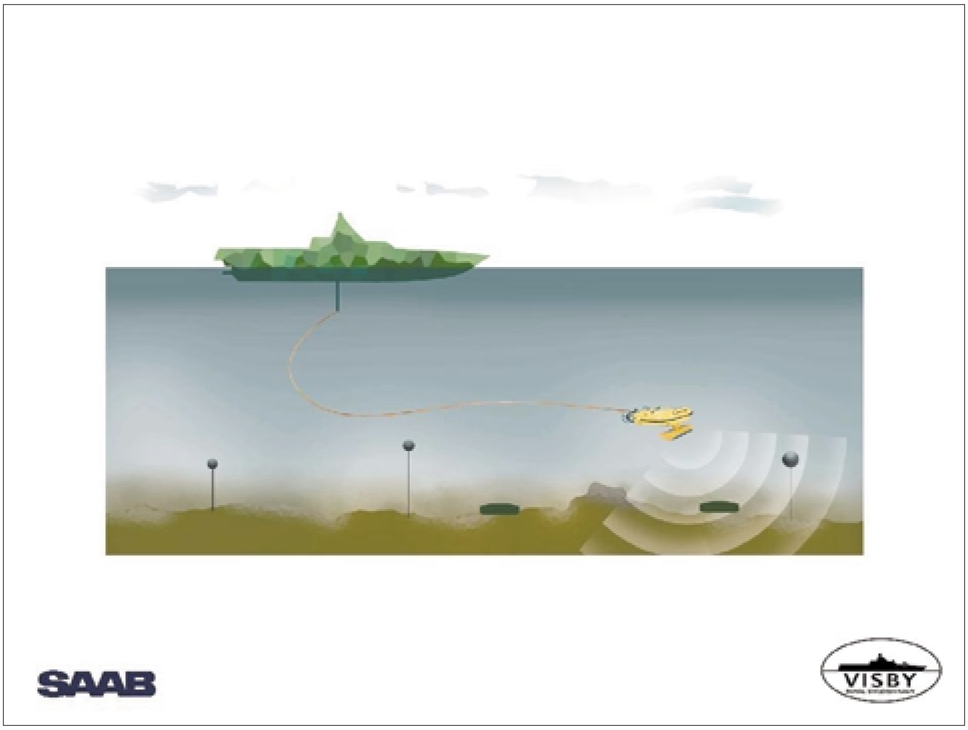
Open Interface. **Double Eagle** can adapt easily to new sensors or exchange information with other shipboard systems.

3 THE DOUBLE EAGLE SYSTEM FOR MINE DISPOSAL

The **Double Eagle** is required to operate in either Minehunting Mode (detection of targets and classification of possible mines) or in Mine Disposal Mode (identification of possible mines and disposal of mines).

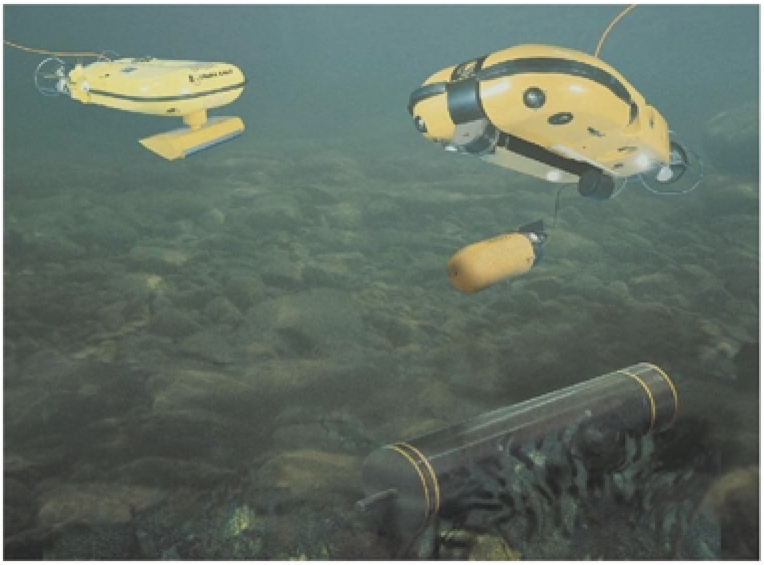
The conversion from ROV in mine hunting mode to ROV in mine disposal mode can be performed onboard ship soon after the decision has been reached. Normally, two vehicles are recommended onboard the ship. One can be in mine hunting configuration and one in mine disposal configuration. It is possible to operate both vehicles simultaneously, even when the ship is moving. The mine hunting ROV is used to find and classify the targets and, after positive classification, it adopts a safe position close to the ship or away from the mine. The mine disposal ROV then advances to relocate the target, guided by the mine hunting sonar onboard the minehunting ROV, for identification and disposal. The mine disposal ROV carries its own relocation sonar, normally an electronic scanning sonar, to ensure the best operational environment. Identification is performed by one or two video cameras, which can also include a special bomb-aiming sight to be used when dropping the mine disposal charge from a place above the target. For smaller charges, a mine disposal arm including a closeup camera for precise placement is used. Before detonation, the mine disposal ROV returns to the ship, while the ROV-S either withdraws further to continue observation or returns to the ship.

The **Double Eagle** System is so far the only system in the world with a proven track record in mine hunting and mine disposal operations. ■



SLIDE 1

SLIDE 2



SLIDE 3

ALECTO

WEDNESDAY JUNE 7, 2000, 14.00-14.10 PM

Mr Manne K.A. Koerfer, Saab Dynamics

Commander RSwN (Reserve) Manne K A Koerfer has been Sales Manager, Naval Systems at Saab Dynamics AB since the mid 90´s, with Export Market responsibility for the RBS15 Mk3 SSM system. He is also responsible for ASW marketing activities, inlcuding the ASW-601 and the ALECTO system for the Visby class stealth corvettes. He holds a degree in Mechanical Engineering and a Bachelor of Arts in Eastern European Studies and Military History from the University of Uppsala. Previous Naval assignments includes positions as Commanding Officer, ASW- and Manoeuvering Officer, and various staff positions.

SAAB ALECTO

Today's naval threat scenario is more complex then ever before. Targets are more silent, have a reduced signature and are operating longer on concealed (and littoral) missions than in the past. Operational ASW weapon systems of today severe hydro-acoustic conditions, i.e. salinity and/or temperature-stratified waters, shallow waters and targets making use of tactical advantages near the bottom. Furthermore, the torpedo threat from submarines is still very much present, as is the above water threat of Anti-Ship Missiles. The former requires some form of Torpedo Countermeasures and the latter a way of using decoy chaff as well as IR grenades. The guiding-star for ALECTO will therefore be the very short time from target detection to decision of engagement and to time to impact on target.

ALECTO MULTI MISSION WARFARE SYSTEM

The new 127 mm (5 inch) rocket-based ALECTO ASW MMW system for the RSwN *Visby* class will focus on the following three main mission profiles:

- **ALECTO ASW Anti-Submarine Warfare**, a rapid engagement of submarine targets primarily floating/ close to bottom or bottom-lying in the range interval from a few hundred meters to 6000 meters. The engagement should take place so fast that counteraction by the target is impossible. This time sequence should not exceed one minute range. In action, the primary task (ASW) is often directly followed by a secondary task (TCM). This is because weapon engagement against a submarine often results in a counter-reaction by the target in the form of a torpedo attack. ALECTO will be capable of performing one primary engagement, with a secondary countermeasure against a submarine, without reloading. It will be possible to carry out two engagements within the specified one minute range.

- **ALECTO TCM Torpedo Countermeasure**, own defence and/or unit defence. ALECTO is part of the torpedo function within underwater defense. As mentioned above, an engagement against a target will probably result in a counter attack, typically with two torpedoes at the same time, thus requiring the ALECTO system to be able to switch targets rapidly. The TCM shall be able to decoy/combat two torpedoes with conventional propulsion systems, equipped with the best target seeker technology available on the international market, on two bearings simultaneously. Underwater defense is highly time critical in order to obtain good overall system functionality. ALECTO will be capable of performing one counter-engagement, followed by an ASW engagement or a stand-alone engagement without reloading. It will be possible to carry out two engagements within a minute. ALECTO be able to fire ASW rockets and TCM rockets on different bearings at different ranges within very short time frames.

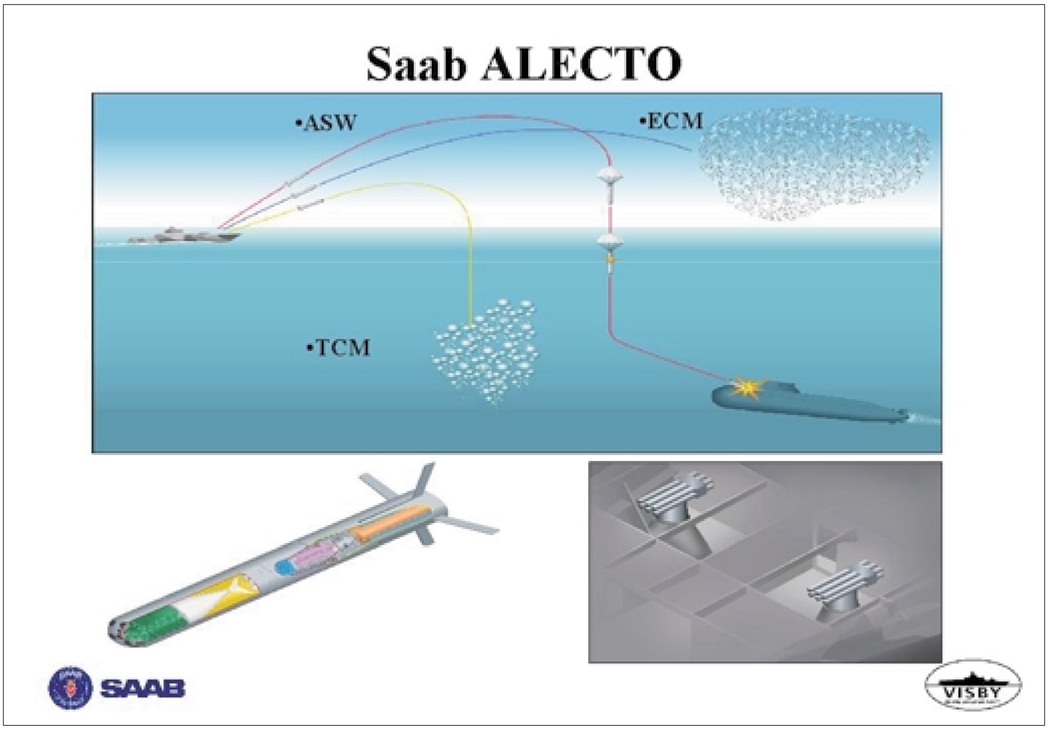
- **ALECTO ECM Electronic Countermeasure**, ASM, Attack-Missiles. When it comes to air defence, the primary functions are seduction and distraction. It will in future be possible to equip the system with an off-board jammer. The above mentioned sub-functions are valid for meeting the threat from attack- or surface-to-surface missiles. It will also be feasible to use ammunition for battle-field illumination and sonar buoys. The ground attack feature offers especially interesting opportunities for joint operation with the Marines in a littoral environment.

CONCLUSION

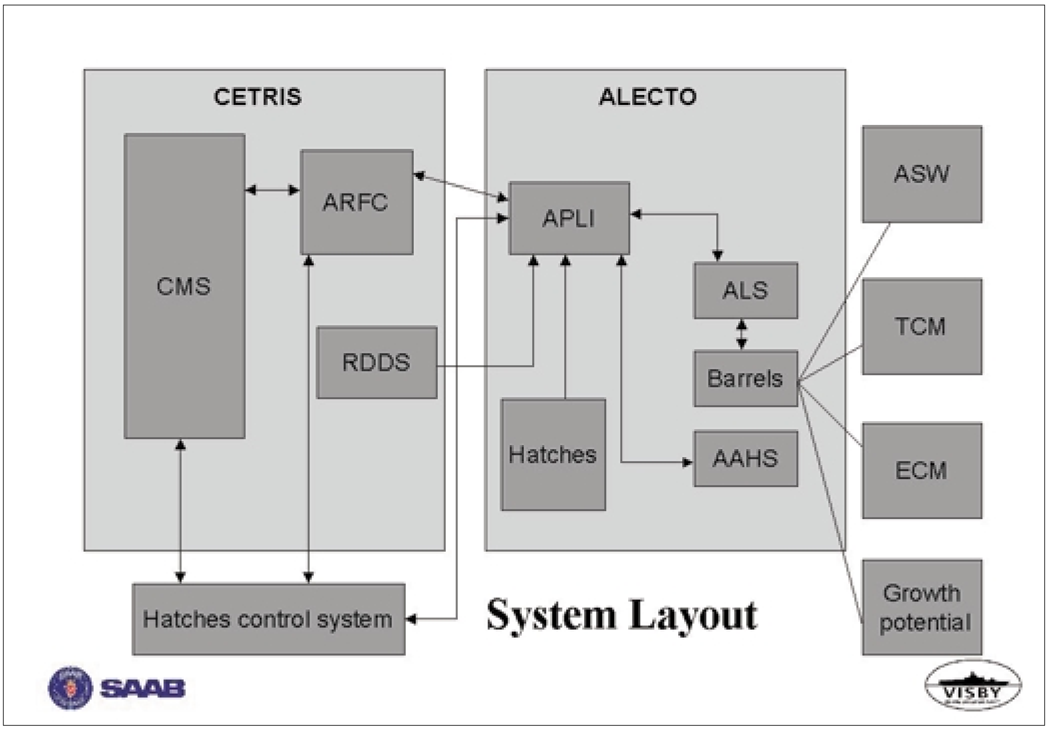
To a large extent current, Naval doctrine is based on a task force concept. *Visby* with her weapon systems, including the ALECTO MMW system, will fit nicely into this concept. The combination of signature control, multi-mission capability and state-of-the-art weapon will permit new and promising operational profiles not yet seen in surface fleets.

The ALECTO MMW System will be able to handle ASW, TCM and ECM in a single system, operated jointly by the ASW Officer, the Air Defence Officer and the Above Surface Warfare Officer. All the operators will be able to prepare individual engagements independent of each other. Engagement will be possible simultaneously and independently with both rocket launchers.

The name ALECTO derive from Greek mythology: ALECTO was one of the three furies, entranted with punishing transgressors. The Furies' main attributes were the ability to find anyone, at any location, at any time! ■



SLIDE 1



SLIDE 2

Conclusion

- ALECTO meets the related tactics and stealth concept of Visby
- ALECTO is a multimission weapon system suitable for combined operations
- ALECTO provides freedom of action and operational durability
- ALECTO can handle ASW, TCM and ECM in one single system, fulfilling requirements on cost- and weapon efficiency
- ALECTO has growth potential for firing ammunition for battlefield illumination, marine forces support etc

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SLIDE 3