Kockums

The VISBY Class Corvette

Defining Stealth at Sea

Surface Vessel Division

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Stealth:

The act or characteristic of moving with extreme care and quietness, esp. so as to avoid detection.*

*The Collins Concise Dictionary of the English Language

STEALTH TECHNOLOGY

The Visby corvette's deceptive paint scheme.

Stealth technology (more formally called Low Observable Technology) aims at minimizing a vessel's transmitted and reflected energies – heat, light, sound, electric potential, and electromagnetic radiation – to deny an opponent the opportunity to locate, identify, track, and attack it. Stealth technology makes full use of aggressive architecture, controlled reflection and absorption, colour variation, machinery isolation, ordnance concealment, shielding, and electronic countermeasures (jamming or false imaging) to mask a vessel's very existence.

We tend to think of stealth as a relatively new idea – developed for modern aircraft such as the B-2 bomber introduced in 1988. In truth, stealth is an instinctive human practice that appeared early in history. Millennia ago, "hunter-gatherers" wore facial and body paint, feathers, tree branches, animal skins, or anything else to help them fade into the background and not alarm foe or animals they sought.

DISGUISE

Disguise has always been an essential aspect of warfare. Soldiers don camouflage suits; aircraft are painted in irregular patterns and colours to blend into the land when seen from above, and the sky from below; warships are camouflaged in patterns that blur their outlines against sea and sky.

In today's warfare there is essentially no place to hide. The ancient human senses have been made largely obsolete by an astonishing array of passive and active detection devices: radars, optics and cameras, infra-red (heat) sensors, sound-detecting systems and sonars, electromagnetic radiation and pressure detectors, and other remote sensors beneath, on, or high above the land and sea.

Modern tanks, armoured vehicles, and an increasing number of warships have faceted, angular forms rather than rounded ones, to reduce their radar signatures. Angular, faceted, stealth aircraft such as the American F-117A have proven their ability to evade modern electronic "eyes and ears".

STEALTH COMES IN SEVERAL LEVELS

Stealth comes in several levels. At the first level, low signatures (the recognizable signals a vessel emits and reflects) improve the performance of on-board sensors – with no local interference caused by shipboard components sensors are better able to "read" the local situation.

At the next level, low signatures are more easily concealed by active or passive countermeasures – jammers, chaff, or flares.

Finally, if signatures are reduced sufficiently to approach the environmental background, a vessel is not easily detected – as when its radar signature is reduced into the "sea clutter" and it produces no distinct "blip." (Though stealth is quite effective, it can't eliminate that blip entirely: The radar image of an F-117A, which is 19.4 meters long and weighs 23 625 kilograms, is said to equal that of a 1.5-centimetre, 6-gram bumble bee!)

On Visby, great lengths have been taken to control the Radar Cross Section (RCS) signatures of all exterior items: Angled hull surfaces and special reduced reflecting coating systems, concealed weaponry and deck gear housings, non-reflecting window glass etc.

THE VISBY

The Visby corvette is flexible and multi-mission capable and can be assigned a broad spectrum of missions, including:

- Surface Combat
- Anti Submarine Warfare (ASW)
- Mine CounterMeasures (MCM)
- Mine laying
- Air Defence
- Surveillance and Patrol Service
- Escort Duty
- Search and Rescue (SAR)
- Civilian Support
- International Operations

Visby was conceived while the Cold War was still "hot," and Sweden was engaged in mine countermeasures and antisubmarine operations close to home. Its mission was defensive: to ward off potential interference to the East, and to keep Baltic waters safe for commercial shipping – to strengthen Sweden's hand in its own shoal-water, island-filled environment, by enhancing what has traditionally been called Sweden's "littoral know-how".

EXTREME LITTORALS

That know-how dovetailed perfectly with the broad international shift away from open-sea naval operations, toward actions in more contained and difficult environments. In littoral waters, piloting and navigation difficulties, and the opponent's proximity, increase a combatant's risks, so these waters have since gained the urgent-sounding name "Extreme Littoral" – defined as a high-threat environment that places additional demands on a vessel's efficiency, performance, and survivability.

INVISIBILITY

A warship's survivability can be built on one of two premises: "Invincibility" or "Invisibility." For nations with deep pockets and imposing military budgets "Invincibility" is the chosen high-ticket objective. For countries with more limited materiel resources, the more affordable choice must be "Invisibility," to which stealth is the obvious path.

The Visby corvette will be assigned a broad spectrum of missions related to mines, submarines, surface combat, surveillance, escort, civilian support, search and rescue, undersea and air defense. It will likely join in cooperative international operations. The Visby is considered to be the first vessel with high operational versatility and fully developed stealth technology, and is deemed the multi-purpose surface combatant of the future.

Visby's stealth characteristics came about through meticulous planning and analysis. Visby's visual details are minimal – no stacks, exposed weapons, or the usual clutter of deck gear and anchors. Everything possible has been hidden: equipment, weapons, and active sensors (also designed for minimal signature) are built into the structure or concealed under hatches. Antennas are flush-mounted, behind frequency-selective surfaces. Radar-absorbing material is used wherever low-signal properties are difficult to achieve. Signatures of windows, openings, and hatches are reduced.

Visby's hard-edge hull and superstructure limit radar reflection to four main directions and a single angle of elevation, by critical arrangement of their flat surfaces.

To give Visby a low infrared signature, with neither hot nor cold spots that stand out against a temperature-neutral background, the exhaust of her engines and generators is triple-cooled and exits aft, near the water's surface. Belowdecks ventilation emissions are concealed. The Visby's hull material is thermo-insulating and exterior paint is selected for optimum heat insulation as well as camouflage.

The Visby class corvettes are designed for operations in the littorals.
Here building number two, HELSINGBORG, on mission in very tight waters.

LOW SIGNATURES

The low acoustic signature is achieved first by waterjets, which generate much less propulsion noise than propellers. Propulsion diesels and gensets are double-elastically mounted to minimize transmission of noise and vibration into the hull, and are covered by sound-absorbing hoods. All other noise-generating equipment such as pumps and fans are mounted to damp out their natural vibration.

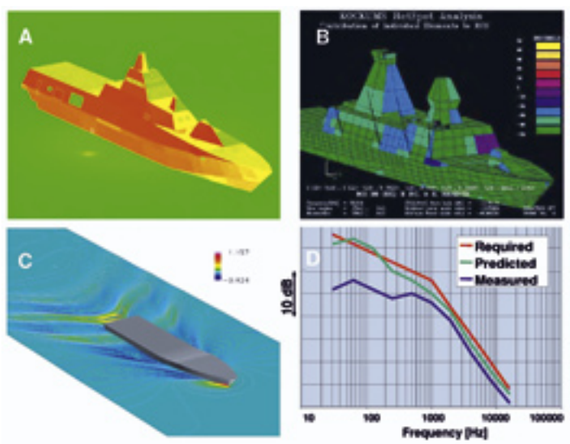
Air intakes and exhausts are designed for minimal flow noise. Fluid-filled pipes are insulated.

The hull material is non-magnetic, and standard equipment components, where feasible, are selected for their non-magnetic characteristics. An on-board degausser takes care of exceptions.

Visby's basic hull architecture evolved considerably during the research. It was originally intended to be an Surface-Effect-Ship (SES), as its prime mission was for attack as well as defence, which requires medium to high speed. But, for various reasons, the mission shifted more toward mine and antisubmarine warfare, which requires more emphasis on low and medium speed (for which the SES hullform is not so versatile).

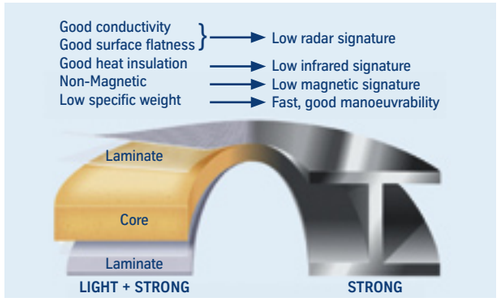
Visby's hullform is therefore a variation on a well-proven planing monohull, optimized for seaworthiness, stability, course-keeping, and manoeuvrability. It is specifically designed for waterjet propulsion, with fixed fins for directional stability.

The underbody has a fine "V" entry for slicing through waves, a variable-deadrise bottom geometry, squared bilges, and a deep spray chine forward. This form was chosen over the typical round-bilge patrol-boat form because it meets the unequivocal demand for radar-stealth geometry. And, in combination with its waterjet propulsion, produces a reasonably low pressure signature and minimal wake and spray.



Example of signature analysis on VISBY type designs. A: IR analysis. B: RCS hot-spot analysis. C: Wave pattern using Fluent (CFD). D: Radiated noise.

The vapour plume from diesel / gas turbine water cooled exhaust gases feigns the vessel's true location to infrared sensors on incoming threats.



Carbon fibre's excellent properties

High-tech in Carbon fibre: Water jet intakes and ducts are bonded to the hull, as all longitudinals and bulkheads, and form a homogeneous structure of enormous rigidity.

CARBON + CODOG

CONSTRUCTION

Visby's construction consists of 100-percent carbon fibre skins over a foam core (manufactured in a vacuum-assisted infusion system). This has excellent fire-containment properties.

With application of approved non-blistering paint, and insulation as required by the International Code of Safety for High-Speed Craft, the material conforms to International Maritime Organization requirements for limiting toxicity in case of fire.

For stealth, Carbon fibre inherently shields against a wide range of electromagnetic signals.

In areas of high stress concentration, such as the gearbox mountings, titanium reinforcing inserts are laminated into the composite.

MACHINERY

The machinery to drive the Visby is a combined diesel or gas turbine (CODOG) system, provided by Vericor Power Systems. Four Honeywell aeroderivative TF 50 A gas turbines (totalling 16 000 kW shaft output) and two MTU 16V 2000 N90 diesels (totalling 2 600 kW) are alternately connected to twin Cincinnati MA-107 SBS gearboxes driving the pumps of two 125 SII KaMeWa waterjets.

The diesels sustain Visby at 15 knots for long duration, while the turbines kick in when she has to do 35 knots or better.

At speed, steering is done by the azimuthing waterjet buckets; in close-quarter manoeuvring the jets are assisted by a 125-kW HRP 200-65 Holland Roer Propeller bow thruster.

Gas turbines (top, left) and the encapsulated diesels (top, right), deliver power to the water jets as required (below)

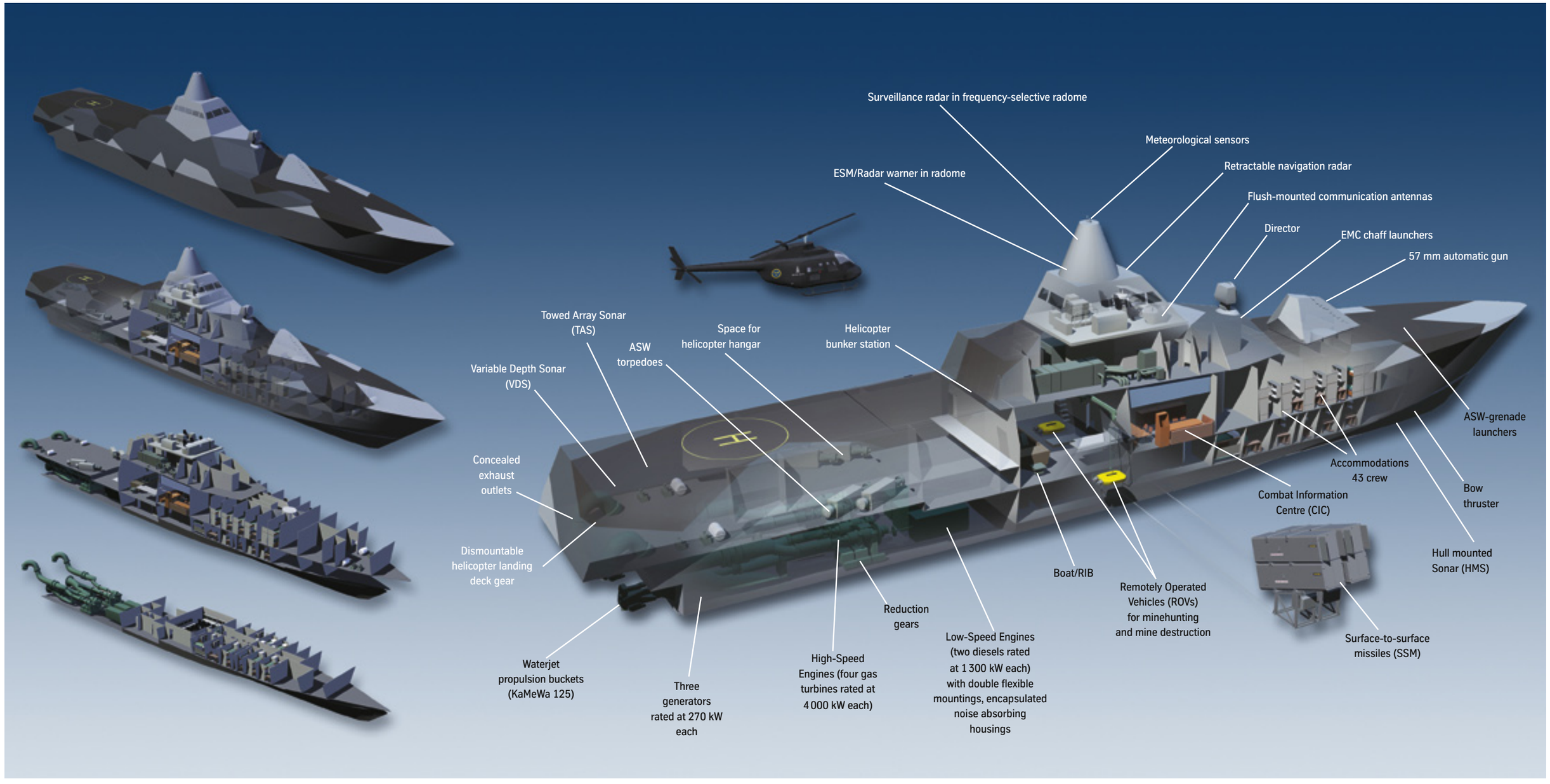
EQUIPMENT

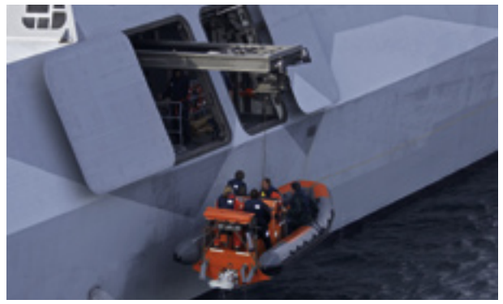
MINE COUNTERMEASURES
The Visby is equipped with myriad machines and systems ready to fulfill her missions, one of which is mine countermeasures. For this, Visby has active and passive sensors that detect, classify, and home-in on mines. A remote-controlled Double-Eagle Mk III underwater vehicle (ROV-S) is guided well ahead, at appropriate depth, where high-resolution sonar and television cameras identify and locate mines long before the vessel reaches them. The mines are then destroyed by an expendable Atlas Elektronik Seafox ROV-E. (Visby is also equipped with mine rails, mine-launching gear, and computer capability to set minefields and register mine locations.)

The navigation system takes input data from the log, gyro, and Global Positioning System (GPS) satellites, and computes an extremely accurate plot. At slow speed, the automated diesel propulsion, guided by more precise Differential GPS, closely follows a preset track or – by dynamic positioning with waterjets and thruster – holds the vessel stationary for mine work. The automation minimizes human error and reduces crew work-load, improving safety.

ANTI-SUBMARINE WARFARE (ASW)
The main submarine detection sensor is a Hydroscience Technologies passive Towed Array Sonar (TAS) with hydrophones. It is towed up to 1 000 meters astern to avoid turbulence or interference from the ship, and can also detect surface vessels running beyond the range of Visby's radar. For anti-submarine work, Visby also uses a towed dual-frequency Variable-Depth Sonar (VDS). Once the TAS detects a submarine, VDS fixes its position and aims selected weapons at it. A hull-mounted sonar helps classify submarines or detect mines. If the target is lying on the seabed, the ROV-S can also identify it. A Hydra multi-sonar suite from General Dynamics Canada integrates data from the towed-array, variable-depth, and hull-mounted sonars, and data from the ROVs. An Underwater Environmental Monitoring system supports the Hydra in mission planning.

Visby corvettes are equipped with several anti-submarine weapon systems, beginning with four fixed





Visbys' boats, RIBs, ROVs etc. are stored behind flush fitting hanger doors, and launched from telescopic gantry cranes

HELSINGBORG and VISBY at flank speed of 35+ knots. In order to render themselves detectable for Radar in friendly waters, both vessels have reflectors set astern of the bridges. The railings and life rings, detrimental to the RCS, are only rigged on non-hostile missions when maximum stealth is not of importance.

SELF-DEFENCE ON THE VISBY

40-cm tubes for firing Type 45 wire-guided torpedoes with active/passive homing devices. There is a supply of depth charges as well as a suite of ASW 127-mm rocket launchers (which also can dispense torpedo countermeasures, or launch confusion materials such as chaff or infrared decoy rounds).

AIR DEFENCE

The Air Defence System – incorporated into the Cetris C3 system automatically controls hard-kill or soft-kill engagements, coordinating sensors, weapons, and manoeuvres. Its active element is a Bofors 57-mm 70 SAK Mark III general-purpose gun with fire control, automated to reduce reaction time, for example, in an attack by sea-skimming missiles. The gun cupola forms an integral part of Visby's stealth superstructure, until the moment it engages a target, when the gun fires programmable ammunition in complex patterns, selecting the ammunition mode at the moment of firing.

ELECTRONIC SUPPORT MEASURES

Visby is equipped with an Electronic Support Measure (ESM) sensor system, the Condor Systems CS-3701, that permits surveillance across the radar spectrum. A Communication ESM (CESM) to cover radio signals and an Infra-Red Search and Track (IRST) enhance surveillance capability. To maximize stealth by operating in electromagnetic "silence", all three systems are passive – they emit no signals. This enables a vessel's commander to capture a picture of the surroundings, and to decide what signatures to show. (Some radars and infrared tracking systems can "see" a stealth vessel to a limited extent, so it is imperative that Visby's command always be aware of their own signature, to control the tactics of a situation.)

RADAR SYSTEMS

Not everything can be made passive and invisible. Visby has active radars – an Ericsson Microwave Systems Sea Giraffe AMB C 3-D surveillance radar, a Therma navigation radar, and a Saab fire-control radar, to assist weapons in destroying incoming missiles.

RADIO COMMUNICATIONS

Radio communications and other essential emissions are, wherever possible, transmitted in selected sectors, highly directionalised, and even bounced off the ionosphere to limit detection to a very small field and to confuse opposing surveillance systems by denying them sources to home in on.

MISSILES

The Visbys will not initially be fitted with an air-defence missile system. But space has been allocated for Surface-to-Air Missiles (SAM). Up to eight Saab RBS 15 Mk II (later Mk III) anti-ship missiles can be installed instead of, or combined with, mine-countermeasure equipment. In order to assure stealth, SAM or SSM systems will function in a "fire and forget" mode – without continual radar guidance that project a detectable signature toward the threat.

FORM FOLLOWS FUNCTION

COMMAND, CONTROL, COMMUNICATIONS
Visby is equipped with the Saab Cetris for Command, Control, and Communications. This directs the combat management, air defence, and navigation functions, enabling Visby to assume tactical command of a vessel group. Command and Control and weapons systems feature surveillance radar, electronic support system with radar warning device, fire-control direction, and navigation. It is also fitted with Infra-Red scanning, missile control and, later, radar-jamming.

The Command Support is also integrated into the Swedish Armed Forces' common command system, thus is capable of full exchange of information among the Swedish Air Force airborne FSR 890 surveillance radar and the multi-role JAS 39 Gripen aircraft.

It should be obvious that the Visby corvette is a classic example of Louis Sullivan's famous, and oft-repeated, 1896 injunction: "Form ever follows function." That is, there is no device aboard Visby that has no function, and its form is conceived solely to execute that function. Although the corvette's form is not totally invisible, it is very difficult to detect.

An opponent can only "see" a Visby close up, which is too late, as her command and crew have already had time to exercise their options. Visby's motto might be: "We see them before they see us."

Visby's 43 officers and conscripts live in quarters that are minimalist with absolutely no compromises to deter her and her crew from its missions.

HELICOPTER
Although corvettes don't usually carry one, the Visby is designed to accommodate a helicopter – the Agusta Bell A109 (HKP-15 to Swedish Armed Forces). The helicopter lands, takes off, and refuels on the upper deck, and stows in a belowdecks hangar (where the alternate medium-range, vertical-launch air-defence missiles would be).

The helicopter can be used for sensor deployment, transport, mine detection and destruction, search and rescue, medical evacuation, radar reconnaissance, anti-submarine action, and environmental inspection, and it can map the seabed with deep-penetration lasers. The chopper could also be fitted with missiles and targeting equipment for laser-guided weapons.

At 35+ knot speeds, a Visby is quickly re-positioned. In addition to her inherent stealth properties, sheer speed makes it very difficult to track and detect a Visby operating in the littorals (top).

Minimalistic design below deck: Wardroom and cabin (far left).

The bridge's high vantage point is ideally located for visual sea surveillance (left).

The CIC: state-of-the-art (right).

VISBY MAIN TECHNICAL DATA

MAIN PARTICULARS

Length over all:	72.7 m
Length between perpendiculars:	61.5 m
Beam:	max. 10.4 m
Draught:	approx. 2.4 m
Displacement, fully equipped:	approx. 640 tons
Speed at full displacement:	35+ knots
HULL	Carbon fibre sandwich
CREW	43

CODOG PROPULSION CHAIN:

2 KaMeWa waterjets, twin gearboxes	
4 Honeywell gas turbines, 4 000 kW each	16 000 kW
2 MTU diesel engines, 1 300 kW each	2 600 kW

MISSION EQUIPMENT, EFFECTORS AND SENSORS

1 Saab Double-Eagle Mk III with Sonar (ROV-S)
1 Atlas Elektronik Seafox Mine Disposal Vehicle (ROV-E)
1 Hydroscience Technologies Towed Array Sonar (TAS)
1 GDC Variable Depth Sonar (VDS)
1 GDC Hull Mounted Sonar (HMS)

1 Bofors 57-mm Mk 3 General Purpose Gun
with Saab CEROS 200 Fire Control Radar System
8 Saab RBS15 Surface-to-Surface Missiles (SSM)
4 Saab 40-cm ASW Torpedoes
ASW rockets
Decoy Dispensers
Mine Rails

Saab 9LV Cetris Command, Control and Communication System
Ericsson Sea Giraffe AMB 3-D Surveillance Radar
Condor CS-3701 ESM System

TOMMOROW'S VISBY

HMS VISBY experienced her first trials at sea on 6 December 2001 and entered navy service in 2005, with the last of her sisters set to be on duty by 2007. The Visby was designed for the Swedish littoral. But, despite Sweden's continued abstention from the "ocean option", its navy is likely to be called on to join others in military or security operations in waters farther from its traditional dominion. This has given impetus to the Visby of tomorrow, or the "Visby Plus."

At Kockums development is going ahead on larger versions of Visby, designed in accordance with Det Norske Veritas Naval Rules, with a variety of equipment options aimed at the international market. The Visby Plus has been programmed to reduce production costs, even as it will have full stealth technology. Its design takes a modular approach to simplify customization, including weight and volume reserved for future modifications.

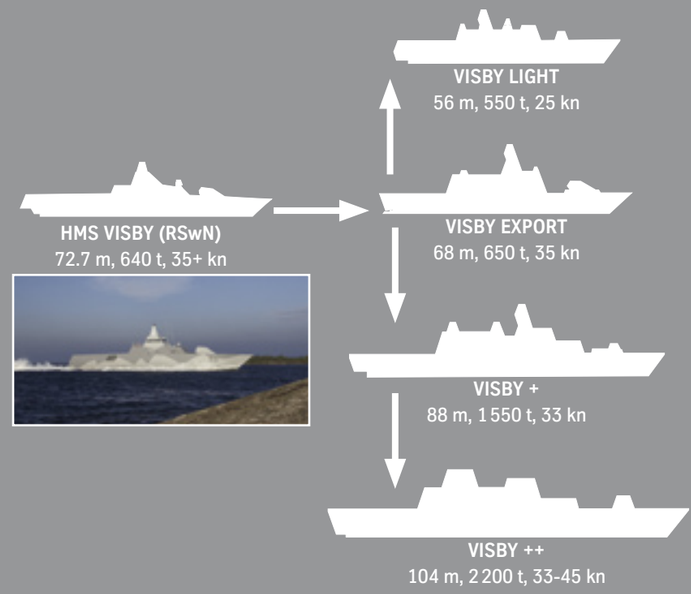
The initial Visby Plus carbon-fibre cored composite model is 88 meters LOA, with 1 500 tonnes displacement. Its prime functions will be anti-submarine warfare, surface attack, air defence, training, and patrol. According to preliminary calculations, when compared to a conventional propeller-driven steel vessel, with an aluminium superstructure, funnel exhausts, and non-stealth weapons and sensors, the new design will have the following considerable gains:

- A lower profile for a reduced visual signature
- A lighter, more shock-resistant structure
- A lower displacement and draft, requiring less engine power
- Reduced fuel consumption, hull maintenance, and operating costs
- Lower hydroacoustic, magnetic, infrared, and radar signatures.

The new corvette will have berths for 71 crew, a helipad and hangar, two universal cranes and two ship's boats. The propulsion will be four diesel engines of about 7 400 kW driving four waterjets. The engine room will be set aft, to leave appreciable volume amidships for operations. An integrated system will control, monitor, and provide support for navigation, propulsion, electrical power, peripheral systems, ship safety, fire protection, and damage control. Weapons and command-and-control systems will be NATO-compatible.

Credits: The writing for this brochure has been taken from the book ON THE CREST OF A WAVE, produced by Jack A. Somer and Peter Neumann. Interior photographs by Peter Nilsson, exteriors by Peter Neumann.

THE VISBY FAMILY



VISBY EXPORT STEALTH CORVETTE
Length 68,3 m · Beam 12,3 m · Draught 2,4 m · Diplacement (full) 650 t
Speed at full displ. 35+ kn · Range at 15 kn: 2 500 nm · Endurance approx. 21 days

VISBY+ STEALTH CORVETTE
Length 88,0 m · Beam 15,0 m · Draught 3,2 m · Diplacement (full) 1 500 t
Speed at full displ. 33 kn · Range at 14 kn: 3 000 nm · Endurance approx. 21 days