From a submarine point of view

HDW GROUP

KOCKUMS

Two of a kind.

Fast.

Silent.

Air independent.

Lethal.

Masters of their element.

Our experience from 85

The ability of a submarine to remain undetected is by far its most important feature. Kockums is a world leader in the field of submarine stealth.

years under water

The "Svärdfisken" and "Tumlaren" were submersibles with very restricted performance in both underwater endurance and manoeuvrability. Underwater navigation was entirely confined to dead reckoning and observations at periscope depth.

When the shot that started the First World War was fired in Sarajevo in 1914, Kockums was taking its first steps into submarine technology. The 252-tonne "Svärdfisken" and "Tumlaren" submersibles marked the successful development of conventional submarines.

Since then Kockums has been intimately involved in developing the Swedish submarine fleet into an efficient and powerful force. Kockums has designed many submarines and, after the Second World War, has developed a larger number of submarine classes than any other shipyard in the world.

Kockums has also created many innovations in submarine technology, such as:

1963 One-man ship control console

1968 Hull form with high underwater performance and X rudders

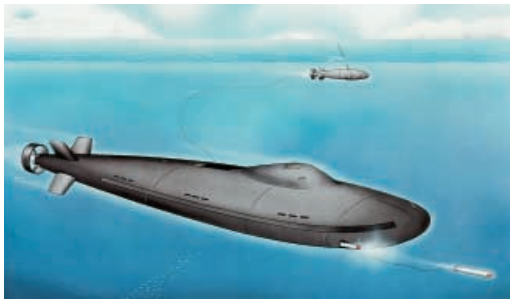
1974 Silent solid-state, low-speed propulsion control system

1974 Ship control, combat system control and weapons launcher control by digital computer

1989 Air independent propulsion (AIP) system

Kockums now has a leading position among the world's submarine shipyards. The Swedish Gotland class and the Australian Collins class are indisputably the world's most advanced conventional submarines in their classes.

The lines of today's and tomorrow's submarines reveal that they are built to travel under water. Sophisticated sensors provide comprehensive information on what is happening outside the hull.



Invisibility is a complex

Action without being seen - submarine tactics in a nutshell.

A submarine disappears from sight when it dives, but it can still leave a trail of sound, heat, sonar reflections and magnetic anomalies.

For the submarine to remain concealed, all of these signatures must be minimized. Submarines from Kockums are built in accordance with the very latest in stealth technology. Minimal signature is the underlying concept.

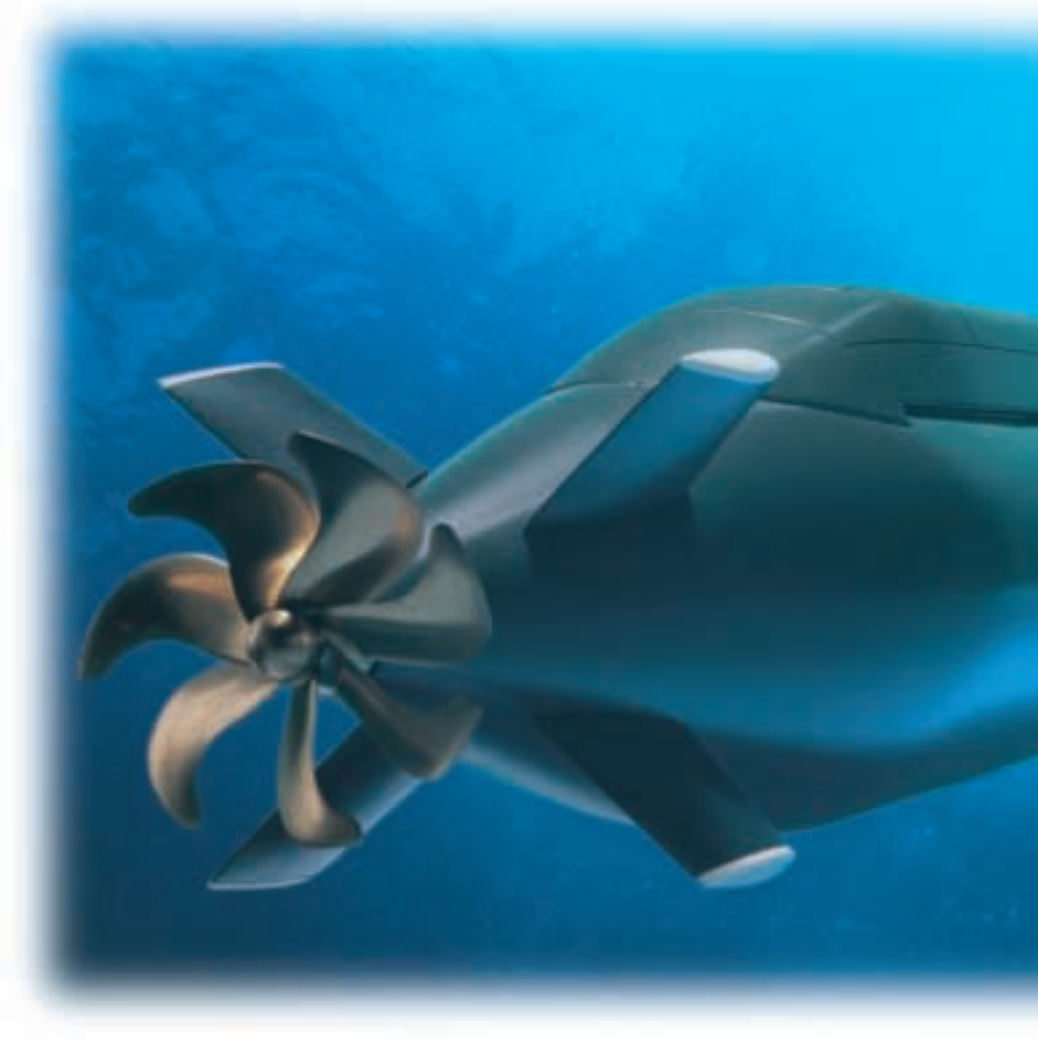
Silencing the submarine

All emitted sound that can be detected by enemy hydrophones must be suppressed.

On Gotland vessels, the engines and other sound-emitting equipment are carried in sound-attenuating mountings. As an example, intensive work has been devoted to minimizing the sound generated by the flow of liquids in pumps, hoses, pipes and couplings.

The silent Stirling AIP system

The AIP system of the Gotland comprises the virtually vibration-free and silent Stirling engine. The fact that the submarine can operate at great depths for long periods of time is also an important stealth factor.



The hull form and particularly the propeller design have a major influence on the noise emitted by the submarine.

Moving silently

The hydrodynamic design of the hull, rudder and propeller is of vital importance. The flow sound when the submarine travels through the water can disturb the submarine's own hydrophones and can also be heard by the enemy.

The hull design and various types of surface coatings minimize the risk of detection by active sonar.

Avoiding sonar

Active sonar is a serious threat. The main factors in avoiding detection are the geometry of the hull, fin and control surfaces, and the materials used.

An anechoic coating has a major effect on the avoidance of detection.

At Kockums, we use advanced computer programs to evaluate the anti-sonar characteristics of the vessel at the project design stage.

Counteracting magnetic field

A vessel travelling on the surface or under water gives rise to detectable local disturbances in the Earth's magnetic field.

This can be avoided by demagnetizing the ship by generating a counteracting

picture

magnetic field. On the Gotland class submarines, this counteracting field is generated by a system comprising 27 individually controlled groups of coils arranged in three perpendicular planes.

The same coil system is used for compensating for both the permanent and the induced magnetic fields.

ELF signature

Galvanic currents flowing in the hull and in the water around the hull generate underwater electrical potentials. Under certain conditions, this can cause extremely low frequency (ELF) electrical fields to be radiated into the water. Detection of the ELF signature can be prevented by short circuiting the electrical current by earthing.

Wake effects - a hydrodynamic phenomenon

When a submarine travels on the surface or at periscope depth, variations in the pressure field, vortices and the wake are detectable.

When submerged just below the surface, the submarine can generate detectable surface waves and water velocity changes. The temperature of the surface water will be altered by the wake, and this can also be detected by IR sensors or radar.

As a result of intensive work on the hydrodynamic design of the Gotland, these signatures have been reduced to a minimum.

Avoiding incident radar waves

Today's radar systems are very efficient. The head of a submarine mast must have the smallest possible geometrical size. If a snort head is used, it should be equipped with a fairing provided with facets at different angles in order to reflect the incident waves away from the radar source.

The masthead surface can also be covered with radarabsorbing material to reduce the target strength even further.

Manoeuvrability - a method for staying concealed

The concept of stealth also includes manoeuvrability. The fact that a submarine can travel and turn quickly, efficiently and quietly enables it to evade the enemy in certain circumstances.

Few submarines can match the manoeuvrability of the Gotland. This capability is a combination of hull design, location of the rudder and one-man steering.

The Gotland is also equipped with the revolutionary X rudder configuration developed by Kockums. The X rudder provides the submarine with extreme manoeuvrability and also enables it to operate very close to the seabed.

Due to one-man steering implemented by Kockums in 1963, manoeuvring the submarine below the surface has become much smoother and safer.

A submarine travelling on the surface or at periscope depth causes temperature changes and eddies in the surface water (wake) which can be detected by IR sensors or radar.

The Kockums Stirling AIP System

The submarine becomes a true underwater vessel

Battery capacity for underwater propulsion has always limited conventional submarines. Development of the snorkel in the 1940s marked a major step forward, but the submarine still had to stay just below the surface and expose the top of the snort mast.

In 1989, Kockums equipped the Swedish Navy's Näcken submarine with the world's first operational air independent propulsion (AIP) system for conventional submarines. Kockums Stirling AIP system is still the only operational propulsion system of this type.

Submerged for several weeks

The Näcken has now operated a total of 10,000 hours on its AIP system. Even at a very early stage, the technique proved to be so successful that the latest A19 Gotland submarine class is powered with Kockums AIP systems.

The system extends the submerged endurance of the submarine from a few days to several weeks, which could previously be managed only by nuclear powered submarines.

The Stirling AIP system has proved fully capable for powering submarines with displacements between 100 and 3000 tonnes.

The principle

The Kockums AIP system is based on the Stirling engine invented more than a century ago. The Stirling engine is a heat engine that serves as the energy converter in the AIP system developed by Kockums.

The Stirling engine burns diesel fuel and pure oxygen in a separate combustion chamber.

Combustion takes place at a pressure, which is higher than the pressure of surrounding sea, water, allowing exhaust gases to be discharged directly into the sea. The combustion process is continuous.

Oxygen is stored in liquid form (LOX) in cryogenic tanks. Submerged endurance is determined mainly by the amount of oxygen stored.

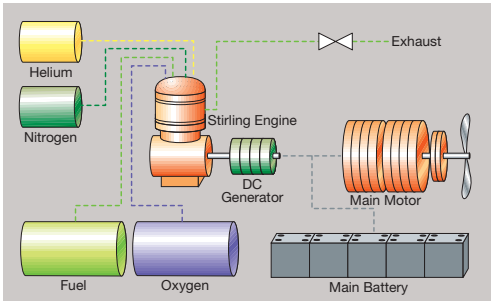
Exhaust gases from the Stirling combustion chamber are cooled, which allows waste products to leave the vessel at low temperature, thus minimizing infrared signatures.

The Stirling cycle also minimizes cyclic torque variations and ensures low levels of noise and vibration compared to those emitted by internal combustion engines. Sound signatures from submarines fitted with Stirling AIP systems are low.

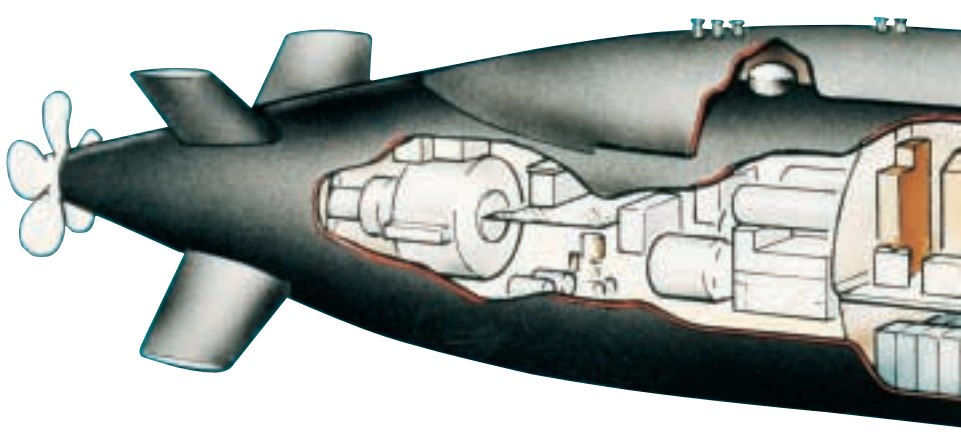
Advantages of the Stirling AIP system

- The system is commercially available. It is a mature technology, which has been thoroughly proven in operational service for a number of years.
- Its infrared signature is low.

The Stirling AIP system is a compact, stand-alone unit that can be installed in existing submarines.



The principle of integrating the Stirling AIP system into the propulsion system of a submarine.



- It is a vibration-free, silent and virtually undetectable system.
- It is a stand-alone power source in an autonomous hull module. After the oxygen has been consumed, the submarine still remains a powerful, conventional SSK.
- Initial capital investment and life cycle costs of the system are low. Fuel oil and LOX reactants are readily available commodities in most countries.

A Stirling unit being moved into the open hull section of a Gotland class submarine.

- The system is equally well suited for modernization of existing submarines as it is for integration in new vessels.
- The AIP system is a standard feature of Swedish submarines now being built. Kockums Stirling technology will remain at the forefront of proven AIP systems and will continue to be competitive in the foreseeable future.

An advanced control and supervisory system is used for both the AIP unit and the conventional electric motors and diesel engines.

Kockums weapon handling system

Designed to meet the demands of active service

Heavy torpedoes are loaded quickly, simply and safely into the tubes.

To be able to operate effectively, a warship is dependent on efficient and safe systems for loading, stowing and handling weapons.

The less complicated and more functional the system, the higher will be the combat value of the vessel.

Meeting the strictest demands

The Gotland and Collins submarine classes are equipped with Kockums weapon handling, stowage and embarkation systems.

These systems meet the strict demands of the Swedish and Australian navies for availability, reliability and ease of maintenance.

Separate assemblies

The systems can handle a wide variety of underwater weapons - torpedoes, mines and missiles. The systems are built as separate assemblies, and their operational performance can be fully tested prior to installation.

Main characteristics

- Hydraulically powered with manual back-up for quick, safe and reliable operation.
- Central control station with remote control facilities.
- Low manning requirements - highly automated.
- The entire system is included on board the submarine. A simple crane is all that is needed ashore for loading.
- High reload stowage density.
- The reload equipment is resiliently mounted for protection against shock.
- Low noise signature enables the reload equipment to be used under silent running conditions.

All that is needed ashore is a simple crane. The rest of the loading is handled by the system integrated into the submarine.

Stowing of weapons on board. A difficult job is made simple and effective.

Combat Capability

Sophisticated combination of active and passive systems

The combat system provides performance needed to meet the operational role of the submarine in a wide variety of missions - surveillance, attack, ASW missions, minelaying and special operations.

A modern combat system is integrated and comprises:

- sonar system
- periscope
- electronic support measures, radar
- command and weapon control system
- fire control solution
- navigation system
- communication system

Sonar - the ears of the submarine

As sound propagation in water is excellent, passive sonar is the foremost means of surveillance. Today's sonar is an advanced system for detection, tracking and classification of targets.

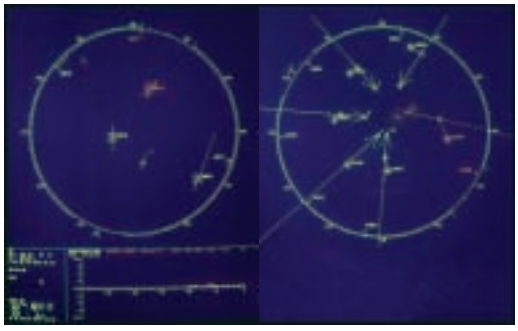
Parameters such as the number of propellers and propeller blades, type of machinery, and speed of rotation are analyzed to identify individual ships.

To ensure a high standard of sonar performance, platforms and equipment are resiliently mounted, and inherent noise of the submarine is restricted to an absolute minimum.

Periscope and other masts are exposed above the water surface for the shortest possible time.

Periscope for visual information

Gotland class submarines are equipped with a high-performance combined surveillance and attack periscope. The image intensifier in the periscope makes it possible to detect ships at night, even if they are blacked out and a long distance away.



Data from sensors is compiled into simple and clear displays on operators' monitors to show, for instance, the positions of the surrounding vessels and the course of torpedoes launched against the targets.

ESM reveals incident radar waves

Electronic support measures (ESM) are used mainly for obtaining early warning when the submarine is travelling just below the surface. The ESM mast is hoisted for only 30 seconds, and the signals received are then thoroughly analyzed.

The submarine's own radar system is used primarily for navigation in peacetime conditions.

Tactical information and control

Since the submarine uses only passive sensors, the combat system employs an advanced target motion analysis algorithm for calculating target factors (distance, speed and course) by using measured bearings of the target. The system then delivers accurate values of these target factors within a few minutes, and is also capable of detecting any manoeuvres executed by the target.

Sensor information, such as target and environmental data, is gathered by the command and weapon control system and is then presented as a tactical display.

The system is controlled from three common multi-function consoles, and provides the means for tactical data management, threat evaluation, attack planning and weapons engagement.

Torpedoes, mines and missiles

The heavy torpedo is the main weapon of the submarine. Several torpedoes can be launched and wire-guided simultaneously. A homing device is switched on when the torpedo has entered the target area.

Gotland class submarines can also be used for concealed minelaying operations, and can be equipped with various types of missiles.

Torpedo 2000 from Bofors Underwater Systems. This high-speed, long-range, low-noise, deep-diving, wire-guided and homing torpedo is a formidable weapon against both surface targets and submarines.

Navigation systems

A submerged submarine cannot update its position by using a global positioning system (GPS) fix or by other observations. The navigation system instead uses data from the navigation sensors (Doppler log, electromagnetic log, gyro compass and inertial system) to calculate its position, course and speed.

Gotland class submarine

A conventional submarine with unconventional performance

The nerve centre - control room of the Gotland.

Gotland class submarines - the Gotland, Halland and Uppland - are the latest additions to the Swedish navy submarine fleet, and are also the world's most modern non-nuclear powered submarines.

The Gotland is designed principally for operating in Swedish waters. Anti-shipping operations, ASW missions, forward surveillance, special operations and mine-laying tasks are typical missions, and Gotland class submarines can carry a powerful array of wire-guided and homing torpedoes, missiles and mines.

Designed for AIP

The Gotland is the world's first conventional submarine designed from the start to incorporate an AIP system. This, combined with low underwater signatures and target strengths, provides the ultimate in underwater stealth.

Needs a small crew

A very high degree of automation and remote control enables the Gotland to operate with a relatively small complement of only 25 men. In addition to minimizing operating costs, this also enables crew accommodation of a high standard.

Automation and remote control features in no way compromise the underwater safety of the vessel.

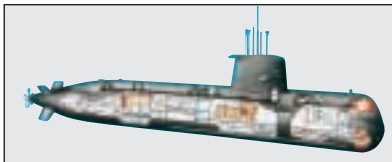
The Combat System

Detection, identification, weapons launching and control at distances well beyond the horizon are carried out by the Combat System.

All weapons can be launched in quick succession and can then be guided simultaneously toward individual targets.

The Combat System includes an effective sonar suite with circular, intercept and flank arrays.

The Gotland also has extremely high shock resistance, enhancing survivability of the class.



Technical data

Hull	Single
Displacement	1490 tonnes
Length	60.4 m
Beam	6.2 m
Torpedo armament	Four 53 cm bow tubes Two 40 cm bow tubes
Propulsion	Single-shaft diesel-electric and Stirling AIP
Surface speed	10 knots
Crew	25

Independent operation

The Gotland can operate independently of any major infrastructure facilities ashore. Fuel oil used is widely available, and reload of weapons can be handled by means of only a small crane ashore. This gives the Gotland class a very high operational value.

Unique features

The Gotland class has a number of unique features, including systems for emptying the ballast tanks, the X rudders, high electrical efficiency and a high standard of safety.

Collins class submarines

The choice of the Royal Australian Navy

The operator at his control panels in the diving and safety station on board HMAS Collins.

In competition with designs from Great Britain, Germany, France, Italy and Holland, the Kockums type 471 was selected in 1987 for Australia's new submarine project.

Designed by Kockums the six Collins class submarines are being built by the Australian Submarine Corporation of Adelaide, South Australia. The company is owned jointly by Kockums and two Australian companies. Kockums currently has a 49% holding in the company.

The Collins class submarine operational requirements called for a long-range, multi-mission patrol submarine capable of both short-duration coastal missions, and long-duration open ocean defensive and offensive operations for up to 70 days.

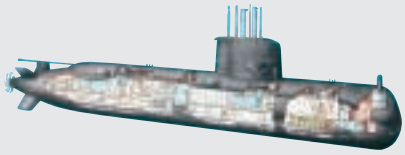
Largest in the world

Collins class submarines have all the attributes expected of a state-of-the-art conventional submarine, including high manoeuvrability, low signature patterns, high firing rates, and excellent shock endurance.

With displacement of 3000 tonnes, the Collins class is the largest conventional submarine in the world.

An effective weapon ...

The submarine can carry a substantial weapons load, and can accommodate a mix of torpedoes, missiles and mines.



Technical data

Hull	Single
Displacement	3000 tonnes
Length	77 m
Beam	8 m
Torpedo armament	Six 21-inch bow tubes
Propulsion	Single-shaft diesel-electric
Surface speed	10 knots
Crew	42

A full suite of acoustic and other sensors is integrated into an innovative combat system produced by Boeing (initially by Rockwell International) to provide simultaneous processing capabilities for a large number of targets and guided weapons.

... and a comfortable ship

Due to the high degree of automation and remote control, the ship's complement is only 42 men. Comfortable accommodation is provided for the crew, including individual bunks in cabins, a central galley and three mess areas.

Modular construction

The intelligent way of building a submarine

When Kockums launched modular construction methods in 1967, they were heralded as a revolution in submarine building.

Individual sections are completely fitted out before being joined together as a complete submarine. This method of construction enables individual sections to be produced at different locations, provides vastly improved access to each section during the fitting-out work, and reduces time needed on slipways or in graving docks.

Completed before the sections are joined together

Individual components and items of equipment are assembled into larger units, are mounted on platforms and are completed before being installed in the appropriate sections of the vessel. Before the completed platforms are installed, the open sections of the vessel are fitted out to the maximum extent possible.

All platforms are supported on resilient mountings. The greatest possible use of platforms protects equipment against shocks and provides enhanced noise attenuation.

The submarine is built as a number of open, free-standing sections for exceptional ease of access.

A fully assembled platform is installed in one of the sections.

All main sections of the submarine are fitted out concurrently. After the sections have been joined together, the submarine is finally fitted out, the batteries are moved on board, and the vessel is transferred to the launching site.

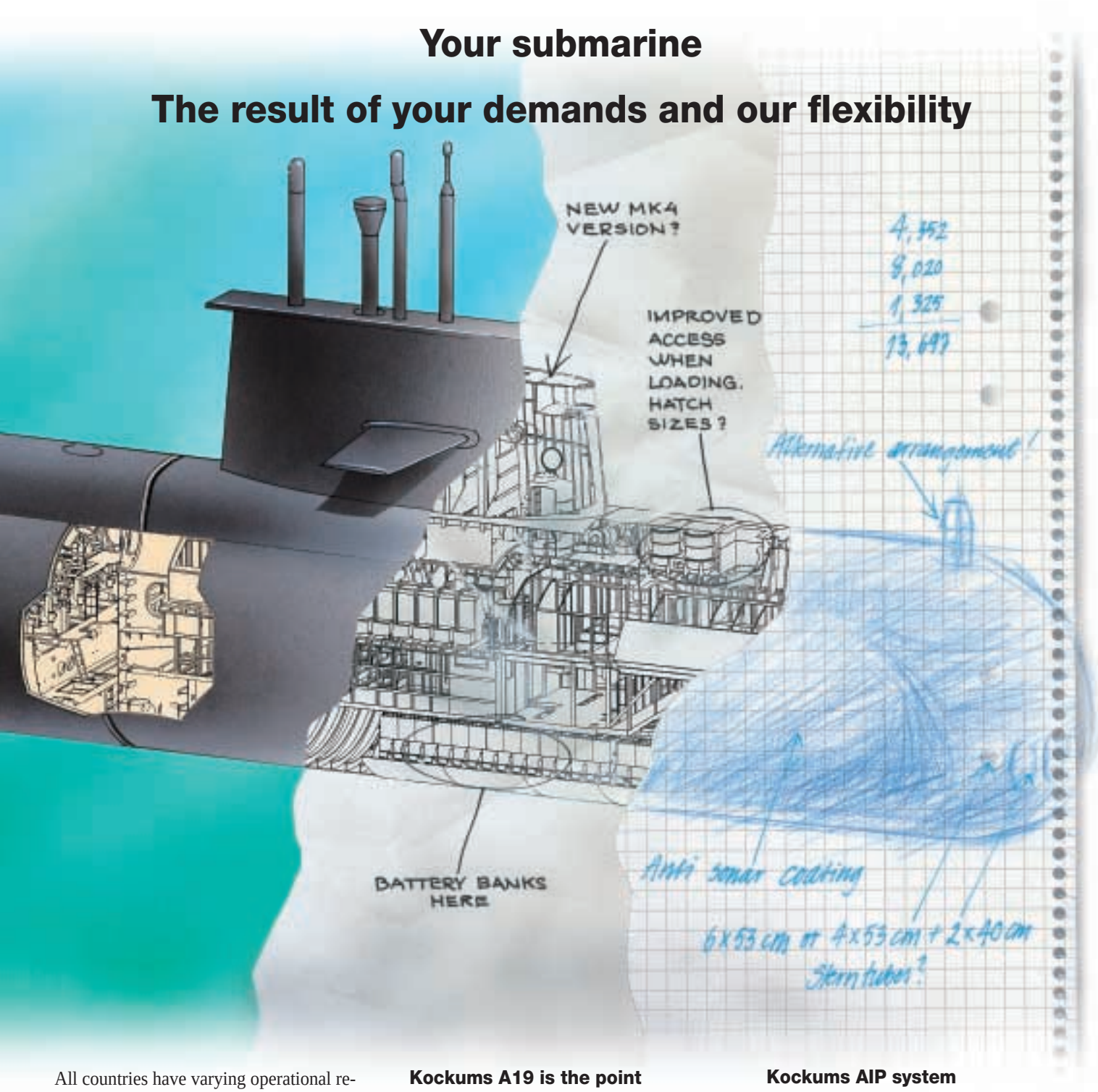
Numerous advantages

- Construction lead times can be reduced. More personnel can work efficiently on open sections than in a completed submarine hull.
- Improved access offers better scope for quality inspection.
- Items for which delivery time is long can be installed in an open section at a late stage, without limitations caused by hatch sizes, confined passages, etc. Delays in one section will not affect other sections.
- Improved accessibility makes it easier to design compact installations.
- If necessary, the sections of the hull can be moved to a workshop for machining instead of the work having to be done on site. This ensures improved accuracy and reduced manual work.

The final operation consists of joining the sections together as a finished hull.

Your submarine

The result of your demands and our flexibility



All countries have varying operational requirements, and defence strategy considerations are different. Accordingly submarines of different countries will differ to a greater or lesser extent.

A cooperative process

Kockums does not build standard submarines. Every submarine is the result of close cooperation with the purchaser. We decide jointly everything from the displacement and dimensions of the submarine to specific weapons and command systems.

Kockums A19 is the point of departure

Our point of departure is the very latest in technology, which is now the export version of the Gotland - the Kockums type A19.

The A19 represents a careful balance between cost and performance, and can meet all operational requirements the customer may make on a medium-sized submarine.

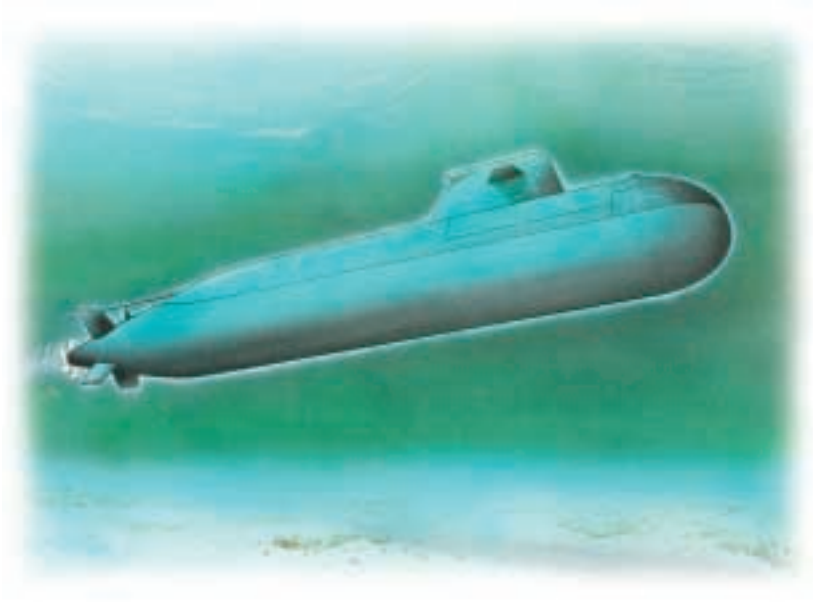
Kockums AIP system makes the A19 extraordinary

Submarine weapons and command system are determined on the basis of the customer's operational requirements and existing infrastructure. The A19 is a very flexible platform that can carry a wide variety of systems.

The propulsion system is based on advanced diesel-electric machinery. Stealth properties and underwater endurance can be dramatically improved by the Kockums Stirling AIP system.

Kockums in the future

At the leading edge



The "Viking" inter-Nordic development project is aimed at refining the stealth properties of submarines.

The Swedish defence industry has been at the leading edge of technology since the Second World War. In marine engineering, this has been demonstrated by a long succession of innovations, particularly in the latest Gotland and Collins class submarines.

Developments are forging ahead. Kockums is now working intensively on the next generation of submarines scheduled for launching just after the turn of the century.

The custom-made concept

Our intention is to make the next generation of submarines an international project by cooperative arrangements with potential client countries. This demands a flexible design concept, since the requirements of individual countries will differ somewhat.

Further refinement of stealth technology

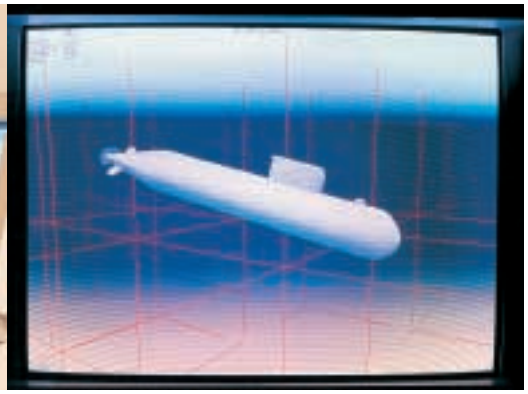
A great deal of work is being devoted to refining the stealth properties of submarines. Hull form, materials used and acoustic damping are important elements in this respect.

Entirely new designs are also being developed. As an example, a small "micro-submarine" which is very difficult to detect and is controlled by the mother ship is being developed to supplement the submarine's own sensors.

The micro-submarine detects various signals and undertakes visual reconnaissance while the mother ship waits at a safe depth.

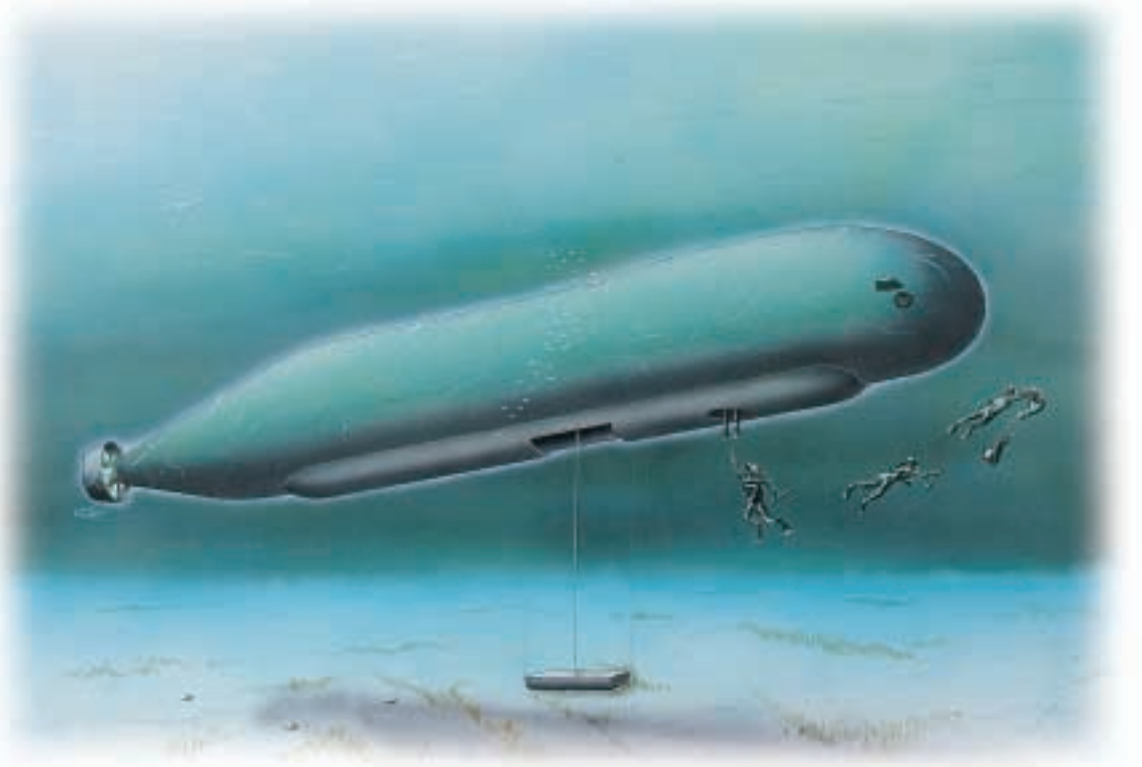
Second generation AIP system

Further development of the Stirling AIP system also contributes to enhancing stealth properties of submarines through extremely silent operation, and by virtually eliminating the need for surfacing. Depending on



The Kockums SubTrainer is an advanced simulator for submarine manoeuvring. It can be used for training, for analysis of sea trials or for sessions aimed at trying out extreme and abnormal manoeuvres.

An important element in development work: testing resistance of various materials to underwater explosions.



The Sea Dagger mini-submarine is of unique design, incorporating a replaceable centre section. Different modules can be used for the centre section, such as for transporting attack divers, for reconnaissance duties or for traditional attack missions.

operational requirements, the next generation of submarines will have an upgraded Stirling AIP system as the primary source of propulsion.

Unaffected by a direct hit

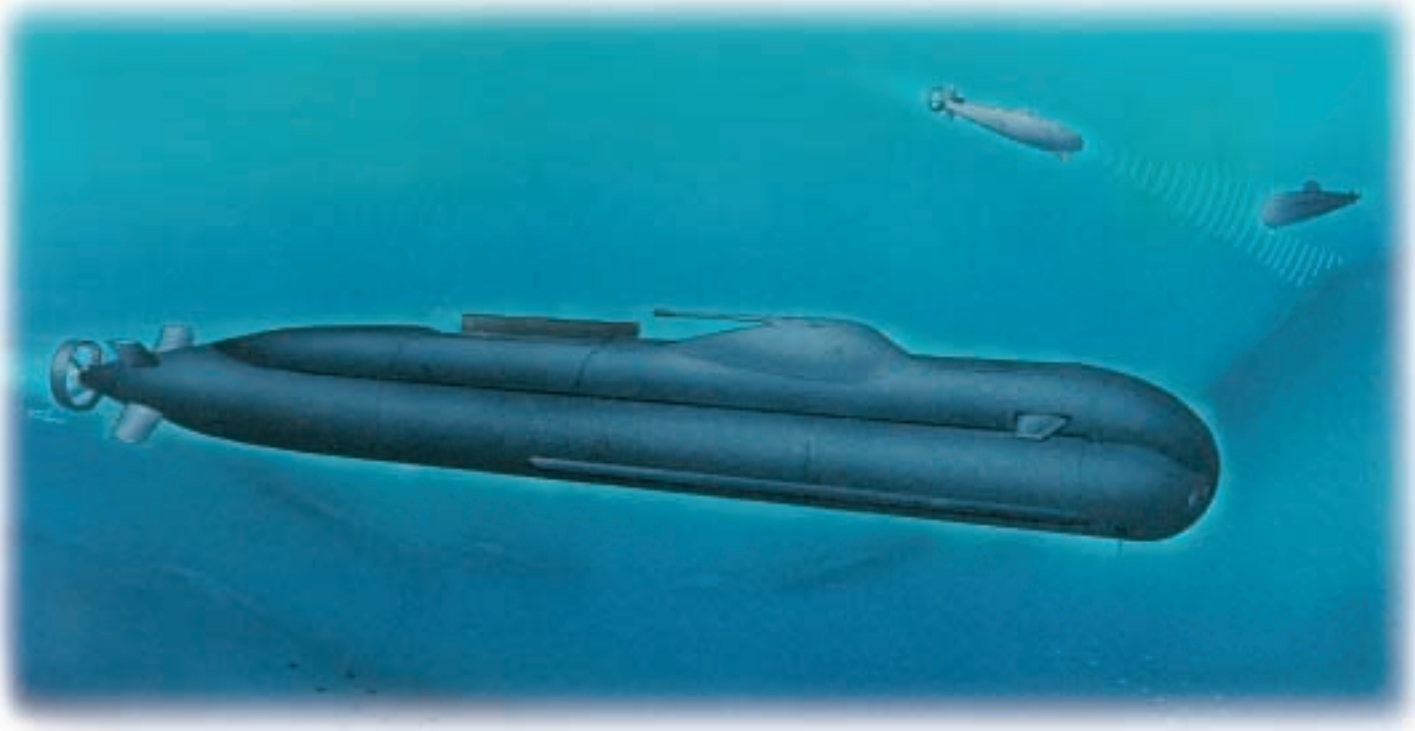
Kockums is conducting advanced research into the strength of hulls. New technology will enable submarines in the next century to survive a direct hit by today's conventional weapons.

Integration of systems

Sensors, command and weapon systems are steadily being improved and refined. Due to integration of the systems and extremely high sensitivity of sensors, tomorrow's submarines from Kockums will be extremely effective warships.

As always, experience and methods used by Kockums to produce cost-effective designs will be the underlying concepts.

Future submarines will be equipped with an independent, remotely controlled "micro-submarine" that moves many of the sensors, such as the periscope and sonar, to a safe distance from the mother ship.



Kockums – at the forefront of naval technologies

Submarine systems

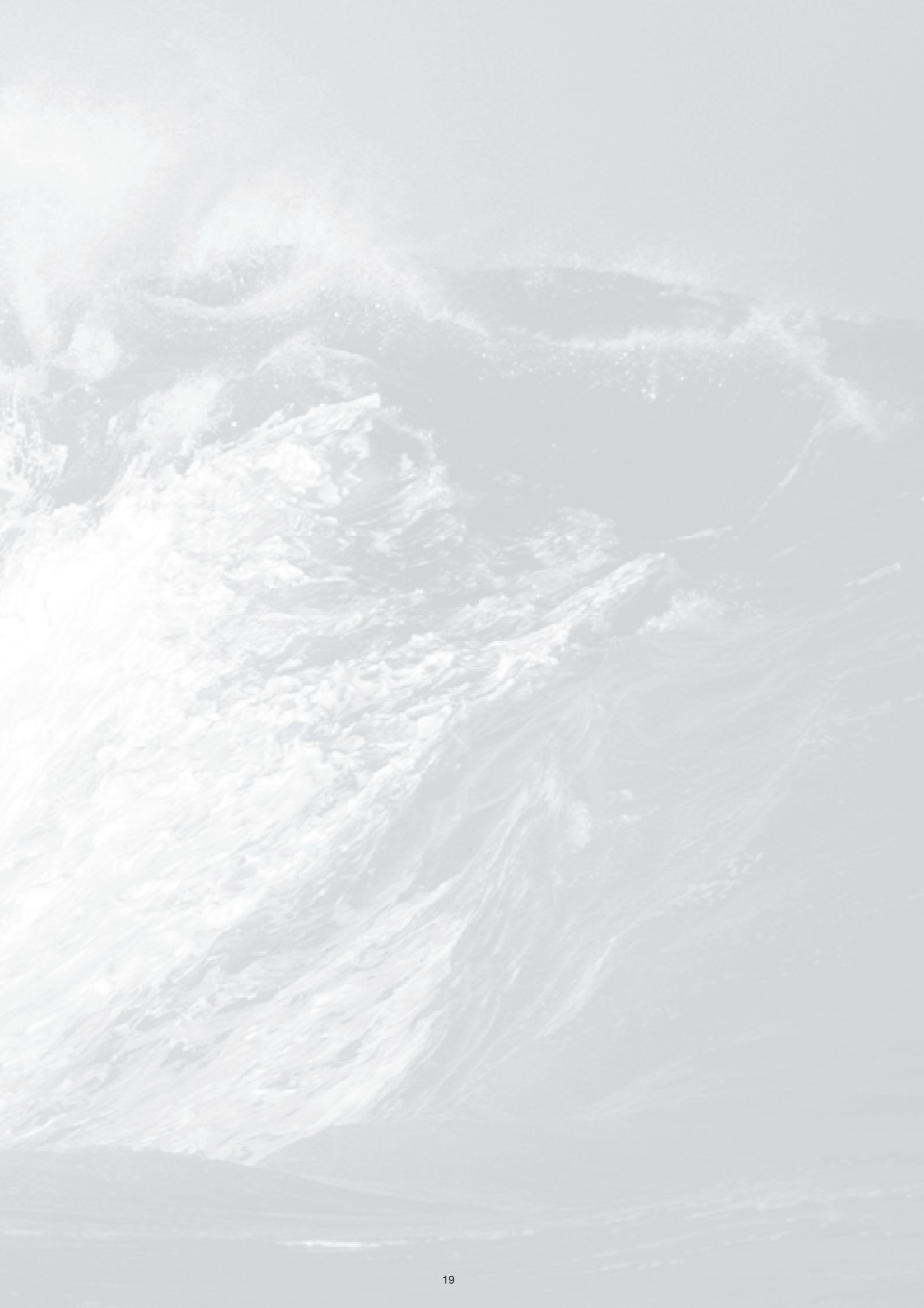
Surface vessel systems

Stealth technologies

Mine countermeasures systems

Subsmarine rescue systems

Stirling engine systems



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