Barracuda

France is one of the very few countries in the world with the capacity to design, build and deploy nuclear-powered ballistic-missile and attack submarines. France's four Le Triomphant-class ballistic-missile submarines (SSBNs) were commissioned between 1996 and 2010 and studies are now under way to replace the fleet by 2030. The first three vessels in the class have been upgraded to the standard of the fourth, Le Terrible, with a new combat system, an improved sonar suite and new-generation M51 ballistic missiles to replace the M45.

Nuclear-powered attack submarines (SSNs) are also the focus of an ongoing programme, with the first-of-class Barracuda SSN, Le Suffren, scheduled for delivery to the French Navy in late 2017. The Barracuda contract, awarded in 2007, calls for the delivery of six SSNs, the fourth of which was ordered in 2014. Construction of Le Suffren is now approaching completion and the new-generation submarine is scheduled to begin sea trials in late 2016. Meanwhile, the hull of the second-of-class Duguay-Trouin, and half of the hull rings for the third-of-class Tourville, have been completed.

The Barracuda-type SSNs are being built to replace the Rubis-class boats which entered service in the 1980s. Bigger, more powerful and quieter than their predecessors, they will be able to dive deeper while providing the capabilities needed to operate in the shallower waters of the littoral. These highly automated submarines will have a reduced complement of just 60. The Barracuda propulsion system (based around a nuclear reactor developed by AREVA TA) will use steam turbines coupled to generators driving an electric propulsion motor, thereby minimising the vessels' acoustic signature.

Barracuda-class submarines are designed to respond to evolving threats and meet new operational needs as part of combined international naval and air operations demanding high levels of interoperability.

Le Suffren and its sister ships will benefit from the latest technological advances, particularly in terms of electronics and acoustic discretion. Examples include a new-generation SYCOBS integrated combat management system, a state-of-the-art sonar suite from Thales (including bow and flank sonars and a mine avoidance sonar), and two new Sagem non-hull-penetrating optronic masts, one for surveillance and the other for attack. The impressive weapons payload will include four tubes for F21 heavyweight torpedoes, Exocet SM39 anti-ship missiles, and MdCN naval cruise missiles, the latter providing a deep-strike capability against even hardened land targets. The Barracuda design is also optimised for deploying and supporting special forces, with onboard accommodation for 15 commandos, and will have space behind the sail to attach a 15m dry deck shelter (DDS). This mobile pod can be used to store special forces equipment such as mini-submersibles, underwater propulsion vehicles and foldable inflatables. «

» **DISPLACEMENT:** 5,300 t

» **DIMENSIONS (m):** 99.5 x 8.8

» **SPEED:** 25 kts

» **ACCOMMODATION:** 60 (+ 10)

» **WEAPONS:** 20

- 4 x torpedo tubes (533 mm)
- MdCN cruise missiles
- SM39 Exocet missiles
- F21 torpedoes
- A3SM (Mica missiles)

DCNS's Cherbourg shipyard

SMX Ocean

SMX Ocean, the new ocean patrol submarine concept from DCNS, incorporates all the innovations that have emerged from the company's R&D programmes in recent years. Unlike previous concept ships unveiled by the shipbuilder, construction of the SMX Ocean is already technically feasible because the new submarine relies entirely on mature, proven technologies.

The SMX Ocean is a very large submarine, with a displacement of 4,700t that ranks it alongside France's future SSN fleet in terms of size. DCNS based the design on the Barracuda-class submarine, leveraging the development effort deployed on that programme – so much of the detailed design work has already been done. As a result, construction of a boat inspired by the SMX Ocean could get under way at short notice if a naval customer were to formally express an interest.

The French engineers working on the SMX Ocean project have pushed the capabilities of a conventionally-powered submarine to the very limit. The result is a vessel that is unique in terms of range and operational capabilities. The SMX Ocean is designed for missions lasting up to 90 days – twice as long as the Scorpene – and boasts a continuous transit speed of 14kts, which is faster than any conventional submarine has achieved so far. DCNS can offer this performance by drawing on its latest innovations in propulsion systems. In addition to six 1250-kW diesel engines, the SMX Ocean is equipped with two fuel cell systems and three lithium-ion batteries. This state-of-the-art air-independent propulsion (AIP) system allows the submarine to complete two week-long submerged transits and remain submerged for one month after arrival in-theatre.

With its ability to cross the Atlantic six times over, the SMX Ocean solves the mobility problem of conventional submarines. It has the deep-water capability needed for rapid deployment to remote theatres of operation, combined with the advances in acoustic discretion achieved with the Scorpene, one of the world's quietest submarines. As well as a new 360° bow sonar with optimised signal processing, the SMX Ocean also has flank arrays and a towed sonar array with a new reeling system that allows it to be stowed on the stern portion of the hull when not in use.

The SMX Ocean is designed to deliver considerable firepower, with a total of 34 weapons including heavyweight torpedoes, anti-ship missiles and cruise missiles. In addition to 533mm torpedo tubes, the vessel is also equipped with a central vertical launch module with capacity for six cruise missiles, providing deep-strike capability against land targets.

The SMX Ocean design is optimised for intelligence gathering, with a total of 8 masts housing a comprehensive array of electronic systems and equipment. A Viper multi-function buoy can also be deployed to boost the submarine's communication and surveillance capabilities while submerged. In addition, the SMX Ocean will be able to deploy UUVs via its torpedo tubes or the dry deck shelter (DDS), and even UAVs, via a vertical tube integrated into the sail, capable of launching four small A02-type UAVs which deploy their wings on reaching the surface. The UAVs, which have a range of around 50km, further enhance the vessel's surveillance capabilities, particularly in coastal waters.

Finally, the SMX Ocean is an ideal platform for special forces, in particular combat dive teams. Design features include a decompression chamber, waiting chambers, internal equipment storage, and the DDS, which can be used to store mini-submersibles, underwater propulsion vehicles, or foldable inflatables.

Crew size depends on customer needs: the vessel can accommodate up to 60 people, although a crew of just 25 is sufficient if the potential for systems automation is fully exploited. This then allows space for commandos, additional crew members, or cadets if the submarine is to be used for at-sea training. «

- **» DISPLACEMENT:** 4,750 t
- **» DIMENSIONS (m):** 100 x 8.8
- **» POWER:** 10,000 kW
- **» SPEED:** 20 kts
- **» ACCOMMODATION:** 25 (+ 35)
- **» WEAPONS:** 34
  1 x VLS (6 cruise missiles)
  4 x torpedo tubes (533 mm)
  UAVs - UUVs


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Scorpene family




Scorpene is in the process of becoming a complete family of submarines including the Scorpene 2000 ocean-going submarine and the Scorpene 1000 variant, previously known as the Andrasta class, for littoral operations.

Following the delivery of two units to Chile in 2006 and 2007, then two to Malaysia in 2009 and 2010, six Scorpene 2000s are now under construction in India and four more in Brazil. In both countries, DCNS is supporting local shipyards through technology transfer agreements. India's first Scorpene will be launched in mid-2015 and will enter service in September 2016. The Brazilian programme includes the design and construction of a complete shipyard and home base for the four vessels, scheduled for delivery between 2017 and 2021.

The Scorpene 2000 is extremely quiet and has earned a reputation as one of the world's most capable conventional submarines. Benefiting from state-of-the-art technologies, many developed for the French Navy's new SSBNs and SSNs, it features a highly streamlined hull, numerous innovations to improve acoustic discretion and latest-generation sonars. The Scorpene 2000 can be fitted with flank arrays and a towed array, which can be reeled in for operations in shallow coastal waters. Its hull now incorporates a cofferdam and two refuge compartments. The vessel is highly automated for operation by a smaller crew, and includes space for six commandos and their equipment.

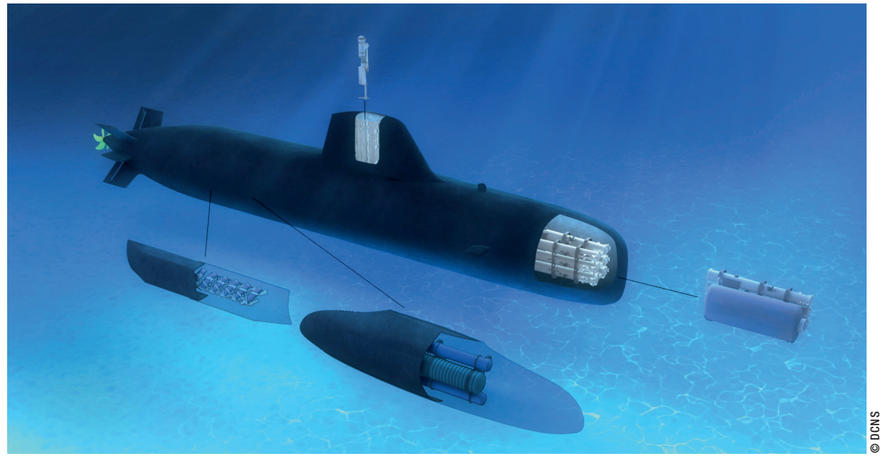
The Scorpene 2000 can readily accommodate the DCNS-designed MESMA air-independent propulsion (AIP) system or fuel cells to extend submerged endurance to around three weeks, without needing to surface or snorkel to recharge its batteries. It also features the SUBTICS combat management system and is designed from the outset to accommodate future technology insertion. For example, DCNS now offers the Scorpene 2000 with the new A3SM anti-air missile system and a surveillance UUV (unmanned underwater vehicle) option.


© DCNS

In addition to the Scorpene 2000, DCNS has designed a smaller submarine for littoral operations. A development of the Andrasta class, announced in 2008 and based on the previous SMX-23 concept ship, the Scorpene 1000 has continued to evolve into a mature product that is perfectly suited to market requirements. Its design has been remodelled to improve hydrodynamic efficiency, with a more streamlined hull and reprofiled control planes. Aft, as well as the X-shaped rudder, two small horizontal winglets have been added for improved vertical plane stability. To meet operational requirements, DCNS has extended the Scorpene 1000's range from 3,000 to 4,000nm and its endurance from two to three weeks. Instead of the original 1,250kW diesel engine and emergency power unit (for auxiliaries and surface navigation), it is now powered by two diesel engines rated at approximately 500kW for improved propulsion redundancy and availability. At the same time, DCNS is working with Volvo and other engine manufacturers to offer new COTS-based propulsion options.

The Scorpene 1000 also features a fourth mast for additional sensors. As with its larger stablemate, the Scorpene 1000's bow array has been moved to the chin position, below the torpedo launch tubes. The six ready-to-fire tubes have been relocated outside the pressure hull to become an integral part of the main frame, resulting in a simpler, non-hull penetrating architecture. The tubes can deploy torpedoes, missiles or mines and are detachable for quayside reloading, without needing to bring the boat into dry dock.

The Scorpene 1000 can be used for special operations and can carry modules on either side for swimmer delivery vehicles and other equipment. These capabilities and the design's inherent displacement margin of around 10t enable DCNS to offer the Scorpene 1000 with a range of options now and in the future, including the A3SM anti-air missile system and surveillance UUVs. «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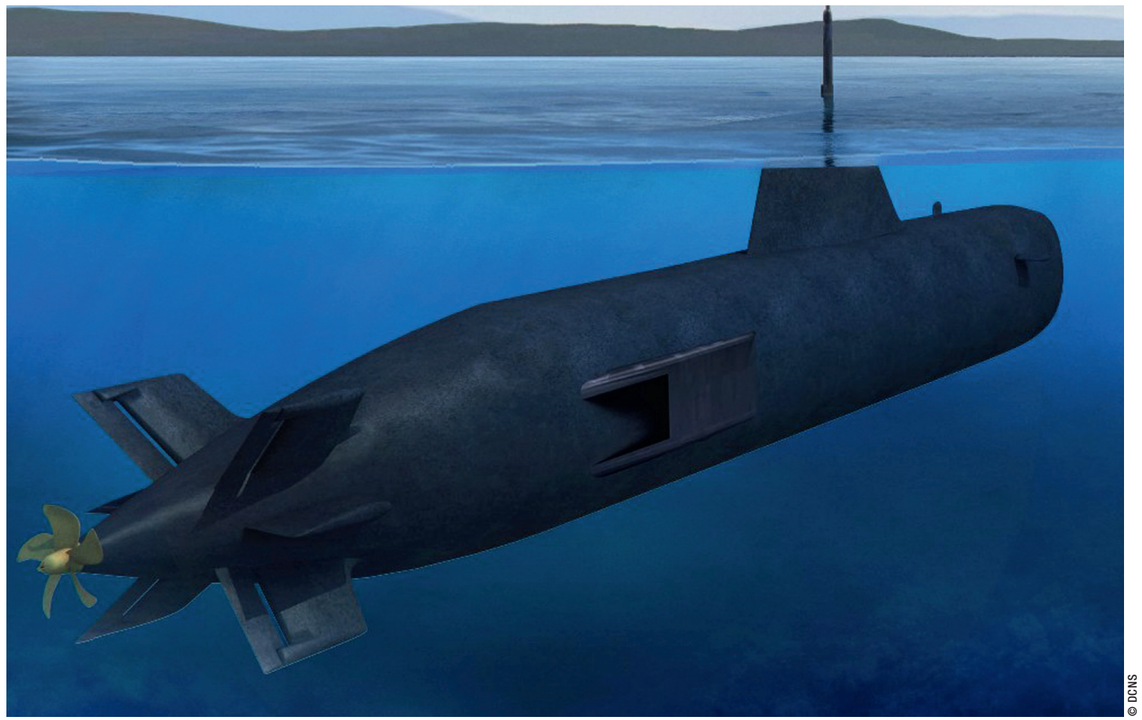
Scorpene 2000

- **» DISPLACEMENT:** 1,670 t
- **» DIMENSIONS (m):** 66.4 x 6.2
- **» POWER:** 2,800 kW
- **» SPEED:** 20 kts
- **» ACCOMMODATION:** 31 (+ 6)
- **» WEAPONS:** 18
  - 6 x torpedo tubes (533 mm)
  - MdCN cruise missiles
  - SM39 Exocet missiles
  - F21 torpedoes
  - A3SM (Mica missiles)

Scorpene 1000

- **» DISPLACEMENT:** 1,100 t
- **» DIMENSIONS (m):** 52
- **» POWER:** 1,000 kW
- **» SPEED:** 15 kts
- **» RANGE:** 4,000 NM at 4 kts
- **» ACCOMMODATION:** 21 (+ 6)
- **» WEAPONS:** 6
  - 6 x torpedo tubes (533 mm)
  - SM39 Exocet missiles
  - F21 torpedoes
  - A3SM (Mica or Mistral missiles)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Better SSK endurance

DCNS has announced new-generation fuel cells and lithium-ion batteries to extend the submerged endurance of conventional submarines.

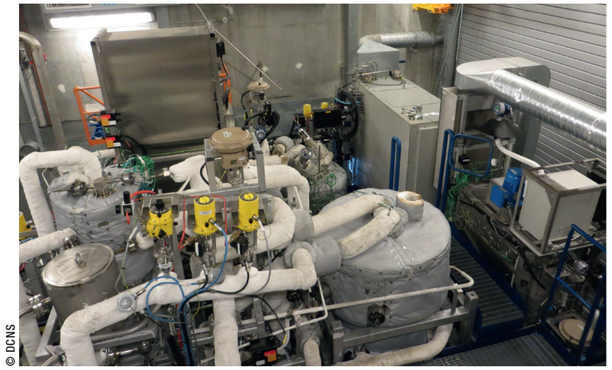
Following a ten-year R&D programme, DCNS has announced the FC 2G second-generation fuel cell. Like Mesma*, the group's first – and still actively marketed – air-independent propulsion system, the FC 2G module is packaged as a dedicated 8m-long hull section or 'plug' suitable for either new-build submarines or modernisation programmes. The design can be tailored to any hull of at least 6m in diameter, including Scorpene and SMX Ocean, without compromising the submarine's dive capabilities or acoustic discretion. After extensive testing over the last few years with a full-scale demonstrator that has logged several thousand operating hours, DCNS can now guarantee a submerged endurance of at least three weeks.

In technological terms, the FC 2G module combines two key innovations. First, the module produces hydrogen for the fuel cell from diesel fuel by hydrocarbon reforming. To preserve the submarine's acoustic discretion, process gases are expelled directly into the sea where they dissolve instantaneously. The second innovation is a patented system that produces air by injecting nitrogen into oxygen from the module's storage tank. This air reacts with hydrogen in the fuel cell to yield electricity plus water.

DCNS's FC 2G concept offers important advantages over competing systems using external hydrogen storage tanks, which pose significant problems due to their weight and refuelling difficulties. Current-generation fuel cells also use pure oxygen, which increases wear factors and means that filters and membranes need to be replaced at regular intervals. According to the design team, the French system offers improved performance and intervals between major overhauls five times longer than competing technologies.

DCNS has also announced new-generation lithium-ion batteries offering a week's submerged endurance thanks to their increased capacity. Like the Mesma AIP and the FC 2G fuel cell, the batteries are packaged as a dedicated hull section or 'plug' that does not require any changes to the submarine's power architecture. The diesel generators are still used to charge the batteries and the batteries to power the electric propulsion motor. The original lead-acid batteries can also be retained, in which case they are connected to the submarine's power distribution network, but not the EPM. In addition to increased submerged endurance, the new-generation lithium-ion batteries offer improved response to power ramp-up and variations as well as deep discharge. Overall, the new batteries allow a submarine to maintain a submerged speed of 12kts for 24 hours, marking a significant new milestone in SSK performance. «

* Mesma AIPs have been operational aboard DCNS-designed Agosta 90B submarines operated by the Pakistan Navy since 2008. They are also available as an option for Scorpene submarines. Mesma uses a steam turbine powered by burning either ethanol (Agosta 90B) or diesel fuel (Scorpene) with oxygen stored in a cryogenic tank to offer two weeks' submerged endurance.



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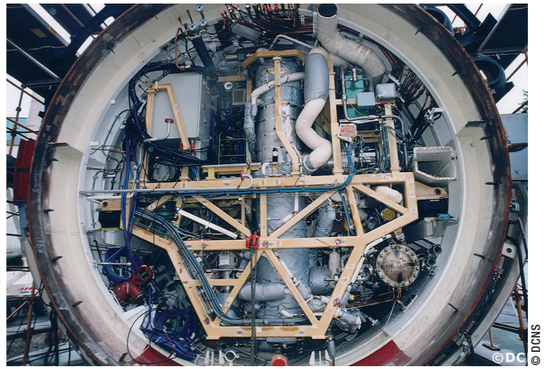

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Multifunction buoys

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DCNS has developed a multifunction buoy to boost a submarine's communication and intelligence-gathering capabilities while submerged. This new solution is especially suited to operations in high-threat littoral environments, where it is particularly important for submarines to monitor the surface situation and communicate with HQ without being detected. The multifunction buoy system also contributes to submarine safety when surfacing.

The VIPERE multifunction buoy from DCNS eliminates the need to come up to periscope depth. It can be deployed when the submarine is stationed off a coastline or moving at low speed. The 1m diameter, 1.6m tall buoy is connected to the submarine by a fibre-optic cable for real-time data transmission. Depending on customer needs, VIPERE can be supplied with a range of payload options: communication equipment, a satellite positioning system for recalibration of inertial platforms, AIS, electronic warfare equipment, such as a radar warning receiver, or an electro-optical system with TV/IR camera for day/night surveillance.

The VIPERE system has been successfully completed proof-of-concept testing, including deployment, operation and recovery of a prototype buoy with four full HD micro cameras for panoramic surveillance, a GPS/AIS receiver and antennas, plus a positioning system. One priority has been to ensure that this capability in no way compromises the discretion of the host submarine. The reeling system, for example, is integrated into the sail or fairing on the deck, thereby maintaining the hull's hydrodynamic characteristics. The design of the buoy itself has been optimised to avoid any wake pattern caused by the traction effect on the cable at the start of the recovery phase. In addition to its conical shape, it also has small wings to speed the dive phase of a deployment sequence, which need to be as short as possible to avoid detection. Only the top part of the buoy (a few tens of centimetres) is visible above the surface. The buoy remains static while stationed on the surface for about 15 minutes, while the submarine continues to travel forward at a speed of 4kts.

With recent advances in miniaturisation, the VIPERE system can carry multiple sensors. And DCNS engineers believe that further miniaturisation will soon make it feasible to deploy communication antennas, optronic sensors and a geopositioning system on a single buoy at the same time. Several buoys with different capabilities can also be deployed simultaneously, depending on the size of the submarine. «

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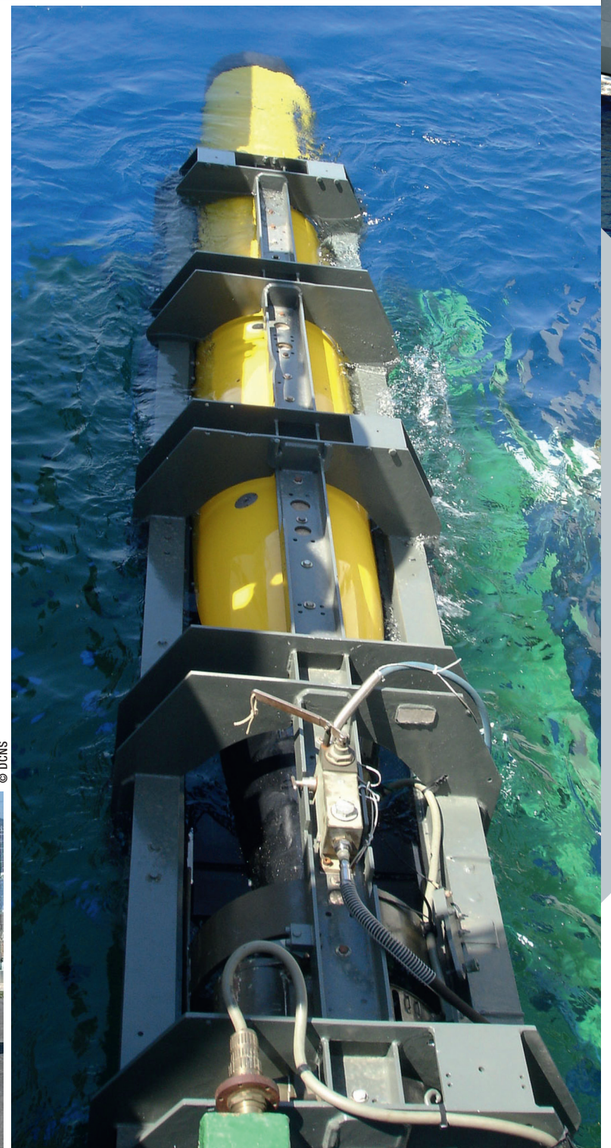
UUVs

In the not-too-distant future, submarines will routinely deploy unmanned underwater vehicles to enhance their surveillance capabilities. However, the launching and, more importantly, recovery of these devices remains challenging. DCNS is a trailblazer in this field. The company recently completed its first-ever tests of a UUV launch and recovery system with the host vessel under way. In July 2014, a series of tests involving a freely manoeuvring Ifremer-designed Aster X UUV and a mobile recovery platform validated this innovative concept. The overall aim is to develop a UUV the same size and weight as a heavyweight torpedo so that it can be launched from the host submarine's torpedo tubes. After completing each mission of the latest trials, the UUV proceeded to the rendez-vous and located the approaching platform with a long-range acoustic guidance system that uses short bursts of low-level sound to minimise the risk of detection by enemy sonars. With both host and UUV manoeuvring continuously, an optical system switches on automatically the instant the host comes within visual range, then guides the UUV to dock with the host's docking structure. The trials were performed with the UUV moving 2kts faster than the submerged platform. A safety system automatically suspends the sequence if any of the approach parameters indicate a risk of damage. In such cases, the UUV moves away and then comes back for a second attempt.

The success of these recovery tests using combined acoustic and optical guidance is an endorsement of earlier tests conducted by DCNS. In 2012, the company completed submerged UUV tube release tests followed by the surface deployment of a device equipped with an image acquisition mast. In 2013, a French SSN performed quay-side UUV tests. Now that all the building blocks of a next-generation UUV have been tested, DCNS is preparing to trial a complete UUV using a submerged submarine. Other recent developments include tests on a UUV with an electro-optical (TV/IR) system and an electronic support measures (ESM) subsystem, as well as a mechanism to reload the UUV in the torpoedo tube after a mission is completed, and a shelter-type recovery structure optimised for minimum impact on the host submarine's hydrodynamics. «



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Mine countermeasures

A revolution is under way in mine countermeasures. Fully automated systems are having a major impact on deployment doctrines and making this strategic capability accessible to larger numbers of naval forces around the world.

The greater part of world trade being transported by sea, straits and harbour approaches are strategic zones that can be easily blocked by mines or underwater improvised explosive devices (IEDs). Inherently complex and reliant on a broad range of skills and technologies, mine warfare and mine countermeasures (MCM) are in a constant state of flux. Today, MCM specialists are focusing increasingly on robotic solutions in an effort to keep personnel clear of danger zones. Unmanned vehicles are being developed to detect, classify, locate, identify and destroy underwater mines, and French companies, widely acclaimed for their expertise in this field, are playing leading roles in these developments.

The French defence procurement agency (DGA) launched the ongoing Espadon advanced study project in 2009 as part of the SLAMF future MCM programme to develop next-generation mine hunters for the French Navy. The aim is to assess the feasibility of a concept comprising a mother vessel, remotely piloted surface vehicles and autonomous underwater vehicles. The mine hunter will launch the USVs then direct them to the search area. Each USV will deploy and automatically recover a towed-array sonar and small AUVs. The companies involved include DCNS, Thales and ECA Robotics, France's leading specialist in underwater vehicles. The ECA Robotics product ranges include Alister AUVs and K-Ster ROVs and mine killers.

For the Espadon project, ECA Robotics has developed two types of AUV: a DCL type for detection, classification and location and an I type for identification. The DCL type will be equipped with the Thales-designed Samdis flank sonar to search vast areas for potential threats. When a threat is detected, the I type is called in. This unmanned system is based on the company's Alister 18 Twin equipped with a high-resolution sonar and four cameras to record images of any threats from several angles. The ultimate aim is to develop a sonar returning images that are accurate enough to replace the camera images, particularly in cloudy or turbid water.

These AUVs, along with a Thales towed synthetic aperture sonar, have been deployed for testing a large unmanned surface vehicle designed specifically for the task. The USV, called the Sterenn Du (Breton for 'black star'), was first launched in 2010. The catamaran –17m long, 7.5m wide and with a displacement of 25t – was equipped with automatic AUV launch and recovery systems. One of them is the LARS system developed and patented by ECA. This critical component comprises an A-frame designed to deploy and recover a cage accommodating the AUV. The A-frame's motion compensation system stabilises the cage in rough seas, both above and below water, thereby facilitating AUV launch and recovery from an USV designed to work in bad weather (up to sea state 4). When the AUVs return from a mission, they use a sonar to detect a cable that guides them into the recovery cage. The algorithms used to detect the cable were developed specifically for the task by ECA.

Over the past four years, the Espadon project has included numerous trials to test the feasibility of this innovative combination of USV and AUVs for mine countermeasures missions. The Sterenn Du behaved well in remote control mode, successfully deploying its towed array and the I-type AUV – both of which performed well – up to sea state 4. The first version of the DCL-type AUV was also successfully tested, and a second version developed specifically for this programme will continue its tests until 2015. It features a significantly improved sonar and processing system and improved endurance (up to 30 hours).

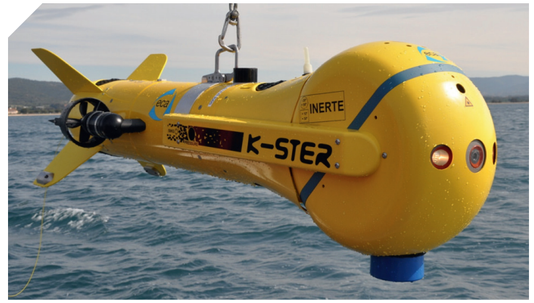
For the critical final phase, namely mine neutralisation, the USV has to deploy its mine killers. These remotely controlled robots carry a warhead that explodes on contact with the mine. ECA's K-Ster mine killers are among the contenders. These feature a tiltable warhead to attack mines accurately and efficiently even in the presence of strong currents.

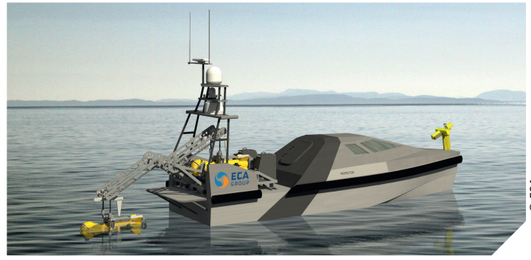
After scanning the seafloor, the DCL-type AUVs return to the surface to transmit their imagery to the mine hunter by radio, either directly or via the Sterenn Du which doubles as a communications relay. Acoustic systems are also used to communicate with the AUVs, but because the range capabilities of acoustic communications are limited to only a few kilometres, they are only used to receive AUV operating parameters (position, battery charge status, mission phase, etc.) and transmit mid-mission reconfiguration commands. For the moment, acoustic wave data rates are also too low for real-time sonar or video imagery.

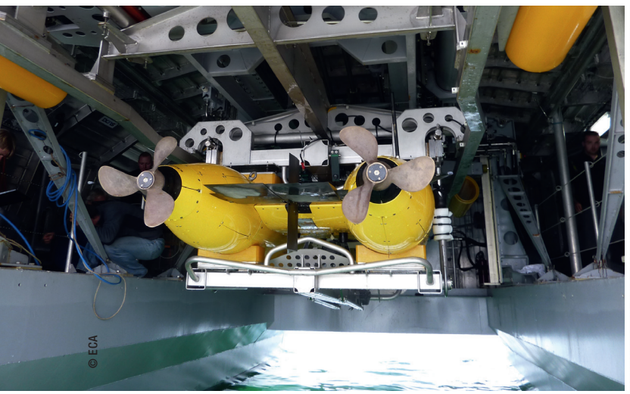
The USV will probably be deployed to a distance of around 20nm from the mine hunter, with the AUVs operating within a range of about 10nm. The mine hunter will thus be well clear of the danger zone at all times. This also has its tactical benefits, as it will facilitate covert MCM ahead of, say, an expeditionary force landing.

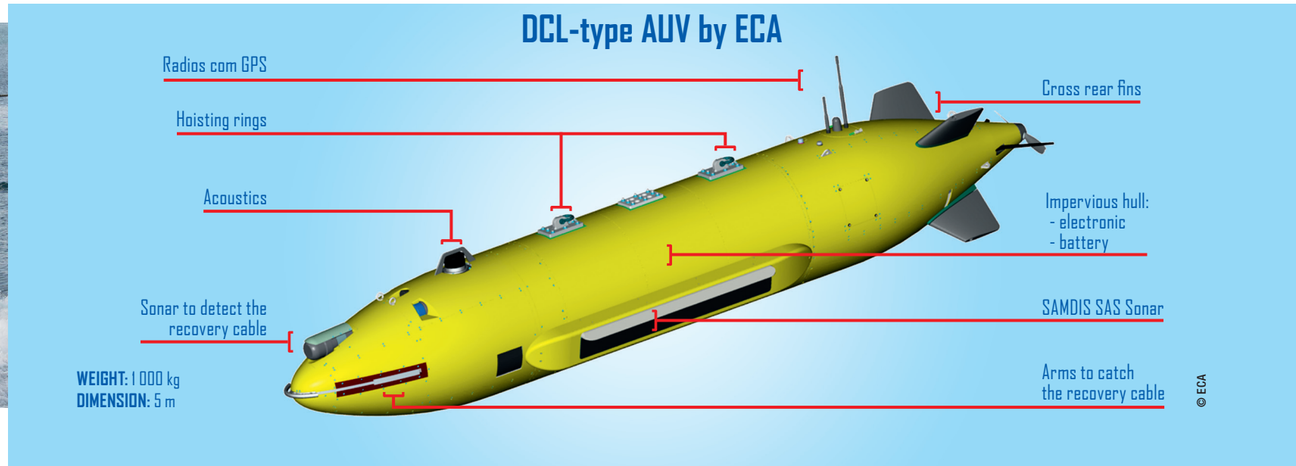
Work on the Espadon project is scheduled to continue beyond 2015 to help the DGA, the contractors and the Navy take stock of achievements before starting work on future deployment doctrines. The tests conducted using the Sterenn Du prototype will also provide input for the SLAMF future MCM programme, a Franco-British initiative that is expected to deliver a first operational capability in around 2020.

In addition to meeting French and British needs, this technology will also be proposed to export customers, possibly in the form of a lightweight version. Possible USV solutions also include remotely piloted RHIBs, such as the ECA Robotics Inspector, an 8.4m RHIB equipped with sonar, echo sounder and remotely controlled devices. As these systems become more compact, their deployment by smaller multi-purpose platforms, including OPVs, will become a serious prospect. «

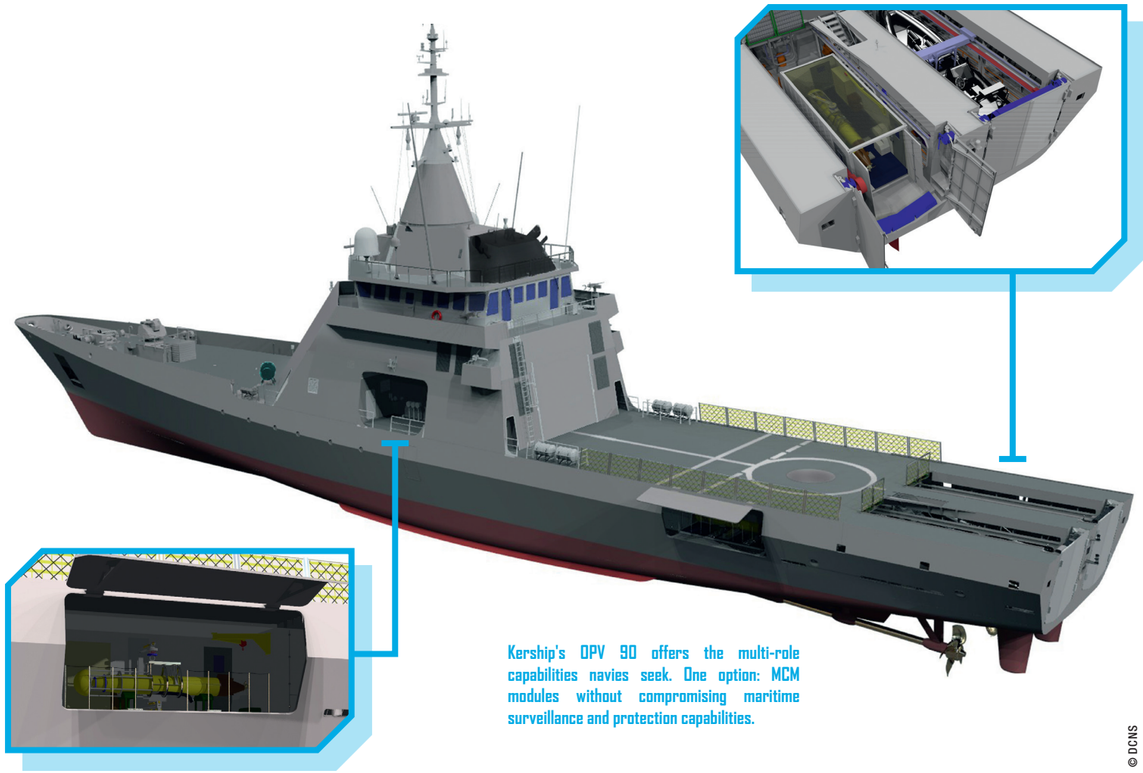








Mine hunter OPVs



Kership's OPV 90 offers the multi-role capabilities navies seek. One option: MCM modules without compromising maritime surveillance and protection capabilities.

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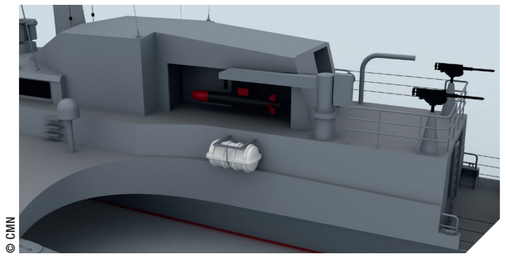

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While remotely controlled vehicles continue to gain traction in mine countermeasures, the question of what type of vessel should deploy them remains open. Whereas larger navies generally opt for dedicated MCM vessels, this solution is incompatible with the budget priorities of most naval forces.

With 50 or more fleets expected to renew their MCM resources over the coming years, the market for mine hunters is remarkably calm, in sharp contrast to the strong demand for OPVs. Responding to this emerging opportunity, several French shipbuilders now offer multi-role platforms capable of serving as both patrol and MCM units. With suitable tailoring, these concepts promise high performance and reduced costs for a wide range of missions.

One approach involves MCM modules for multi-role OPVs or corvettes. The modules may include remotely piloted semi-submersible, underwater or surface vehicles, the last deploying a towed sonar. Options for these system concepts include UAVs for use as communications relays and mission systems to manage all vehicles and process incoming data. System integration is clearly critical. Drawing on its expertise in combat management systems, DCNS proposes MCM modules tailored for use with OPVs marketed by its French joint venture Kership. OPVs from 50 to 90m in length could deploy MCM vehicles using either their RHIB ramps or dedicated deck space and facilities.

Cherbourg-based shipbuilder CMN also proposes an MCM version of its 43m, composite-hull, electric-propulsion Ocean Eagle patrol vessel. With this concept, the trimaran's modified superstructure can accommodate an autonomous underwater vehicle and eight mine killers. «