KONGSBERG

AUV SYSTEMS

INTERNATIONAL DEFENCE APPLICATIONS

- HUGIN®
- SEAGLIDER™
- REMUS™

MAXIMIZING PERFORMANCE BY PROVIDING

THE FULL PICTURE

OUR MISSION

We shall earn the respect and recognition for our dedication to provide innovative and reliable marine electronics that ensure optimal operation at sea. By utilising and integrating our technology, experience and competencies in positioning, hydroacoustics, communication, control, navigation, simulation and automation, we aim to give our customers The Full Picture. The Full Picture yields professional solutions and global services that make a difference enabling you to stay ahead of the competition.

OUR PHILOSOPHY

Our success depends on the success of our customers. Actively listening to our customers and truly understanding their needs, and then translating these needs into successful products and solutions is central to achieving our goal.

Our people are the key to our success and we empower them to achieve. Working together in a global network of knowledge, guided by our values, engenders innovation and world class performance. Every day we have to think a little differently, because every client is unique. We aspire to translate the imagination and dedication of our staff into successful technologies and solutions. Our commitment is to add value to your operations by providing you with The Full Picture.

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Kongsberg Maritime · Document no. 420791 · November 2016

INTELLIGENT MARINE ROBOTS YOU CAN RELY ON

AUVs, also known as intelligent marine robots, have revolutionised naval exploration. Costly legacy systems and platforms are slow, heavy and have a large economic footprint. AUVs provide an automated approach to accelerate timelines and enable distributed expeditionary systems to operate from a variety of host platforms. Fast, light and precise, these modular systems remove the divers from the minefield and can be operated as organic systems.

A flexible alternative to traditional surface vessels, AUVs can glide close to the surface, dive to depths of more than 6000 meters, explore shallow waters and hover in hazardous areas where navigation is difficult. The benefits are numerous.

Kongsberg Maritime, along with its subsidiaries Kongsberg Underwater Technology, Inc. and Hydroid, Inc., produces a range of vehicle systems that can meet the demands of virtually any marine environment. The REMUS 100, part of the REMUS product line of Hydroid vehicles, was the first combat deployed AUV in history.

Kongsberg Maritime provides its customers with the most effective and efficient AUVs by incorporating the most advanced, commercially-proven technology. Today the company is synonymous with excellence in AUVs.

In addition to Hydroid's widely adopted REMUS vehicles, Kongsberg Maritime designs and manufactures the HUGIN and SEAGLIDER product lines of commercial off-the-shelf (COTS) AUVs. HUGIN boasts operational experience in both commercial and naval operations, and SEAGLIDER has revolutionised the way oceanographic data is collected by being able to complete long endurance missions.

AUV Applications

- Mine Countermeasures (MCM)
- Rapid Environmental Assessment (REA)
- Intelligence, Surveillance and Reconnaissance (ISR)
- Port Survey
- Undersea Search & Survey
- Harbour Protection Tasks & Port Clearance
- Communication/Navigation Aid
- Clearing Beachhead Amphibious Operations.

Benefits

- Reduces tactical timelines from slow, diver-centred operations to efficient, multi-aspect AUV-centred area operations
- Eliminates manned search operations in the minefield
- Increases margins of safety for divers
- Provides significant battle space coverage. Enables manoeuvre space from narrow linear lanes to tactical flexibility along the coast
- Allows for quick mission completion; timely, accurate information feedback
- Provides covert and low observable operations
- Reduces military assets required to perform mission evolutions
- Platform independent.

AUV MODELS

KONGSBERG

HUGIN®

The HUGIN AUV program started in the early '90s as a joint project between KONGSBERG, the Norwegian Defence Research Establishment (FFI), Statoil and the Royal Norwegian Navy. It has since evolved to be the most capable and successful commercial AUV in operation. HUGINs are traditionally equipped with HISAS or SSS, MBE, SBP and cameras, plus a range of environmental sensors that can all operate concurrently. Available with a range of modular payload and energy options and a world class inertial navigation system, the HUGIN AUV can run for up to 80 hours at depths of up to 6000 meters.

The vehicle is launched and recovered using a Stinger ramp system. The Stinger extends over the stern of the ship and can be operated in Sea State 4 and up to 5 meter freeboards.

HUGIN has seen commercial operation in Europe, Africa, the Americas, Asia and Australia. It is recognized as a proven survey tool by operators offering class leading data quality and area coverage rates not seen on any other underwater survey platform. In addition, the HUGIN has provided Mine Counter Measures (MCM) and Rapid Environmental Assessment in multiple navies for more than 15 years.

HUGIN:
Flexible System with Unmatched Performance

SEAGLIDER

Rather than an electrically driven propeller, SEAGLIDER uses wings and small changes in buoyancy to achieve forward motion. This extremely efficient propulsion method results in the longest endurance of any commercial glider system - up to 10 months. Instead of using external control surfaces to affect vehicle attitude, SEAGLIDER uses adjustable ballast. The SEAGLIDER moves through water in a saw-tooth like pattern, diving to depths of up to 1000 meters. It surfaces periodically to determine its position, transmit collected data and receive commands via satellite telemetry.

Navigation is accomplished using a combination of GPS fixes while on the surface and internal sensors that monitor the vehicle heading, depth and attitude during dives. SEAGLIDER's design allows for a range of standard instruments and custom sensor packages to be developed for unique applications. SEAGLIDER's low capital cost, long deployment capacity and versatile payload capability allow collection of a wide range of high quality ocean data for a fraction of the cost of traditional collection methods. Satellite communications allow retrieval of most data in near real-time.

SEAGLIDER:
Extreme Long Endurance, Low Cost AUV

HYDROID
A KONGSBERG COMPANY

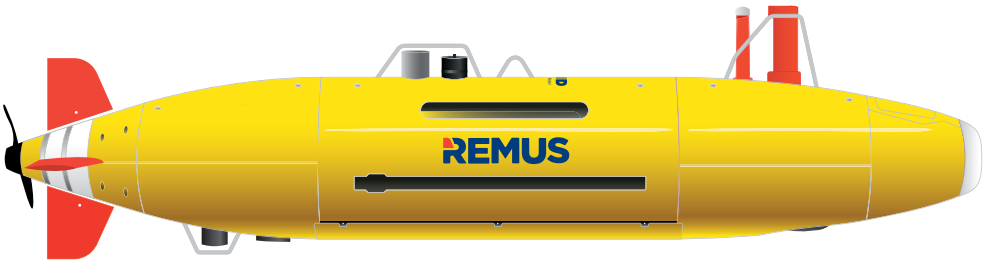
REMUS

The REMUS AUV is the culmination of 20 years of cutting-edge research and development (R&D). Utilising a powerful and versatile suite of available high performance sensors, it boasts a proven track record for highly reliable and consistent field operations in commercial applications. REMUS AUVs are offered in three vehicle classes: the lightweight, compact, man-portable REMUS 100; the highly versatile, modular REMUS 600; and the REMUS 6000, a deep-water workhorse.

All REMUS AUVs are built on a common and proven technology platform incorporating the intuitive Vehicle Interface Program (VIP). This keeps vehicle maintenance, mission planning, checkout, data analysis and cross-vehicle training seamless across the product line. The vehicles differ by size, depth, endurance and payload sensor configuration.

REMUS 100:
The Industry Standard, Compact, Man-Portable AUV

REMUS 600:
Full Capability in a Cost-Effective System



REMUS 6000:
Deep-Water Workhorse

COMMERCIAL OFF THE SHELF

Kongsberg Maritime is one of the major suppliers of high quality marine electronics in the world, with products ranging from underwater sensor systems; complex ship and process control systems for commercial vessels and oil rigs; autonomous underwater vehicles; sonars; and instrumentation systems for fisheries, naval and scientific research vessels. The products are designed, tested and manufactured to withstand tough marine environments.

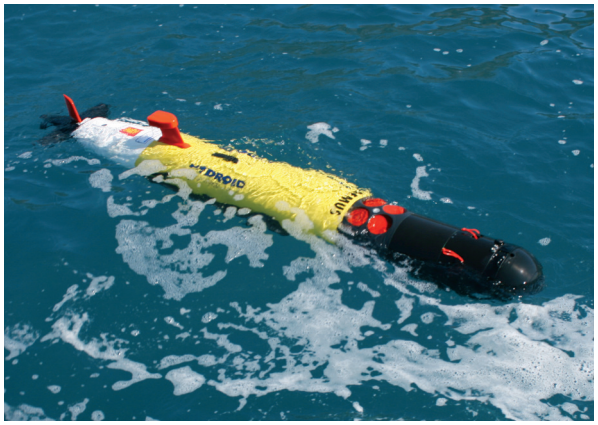
Kongsberg Maritime designs and manufactures commercial and military off-the-shelf (COTS) autonomous underwater vehicles (AUVs) and related equipment. These vehicles are in operational use in a wide number of applications including defence, hydrography and marine research. Our AUVs boast exceptional operational experience for commercial and naval operations in shallow and deep water and in arctic and tropical waters. REMUS and HUGIN vehicles have different capabilities and, as such, different applications and roles.

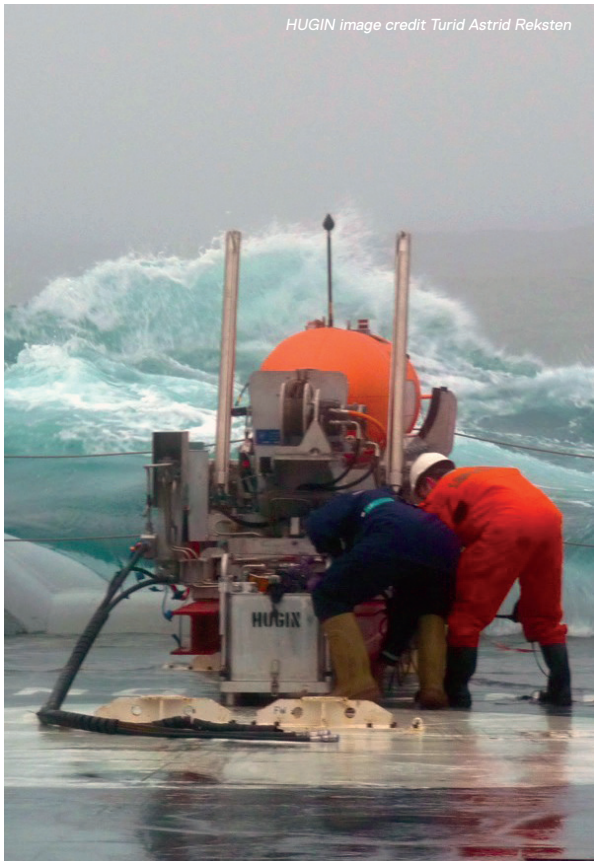
The vast operational experience is continually used to improve the quality and robustness of the vehicles, ensuring that customers benefit from the latest improvements and developments.

REMUS and HUGIN product lines allow Kongsberg Maritime to offer customers a full AUV product range and system solutions, strong worldwide customer support, product commonalities and the benefit of strengthened research and development through product synergies.

As a COTS manufacturer, Kongsberg Maritime runs a 24 hour on-site support service centre year round. Our first priority is to support our AUV customers and ensure that our AUVs are always operational. We also offer support and training programs.

We are a committed, reliable, dependable and long term partner for navies seeking superiority in the underwater battle space.





HUGIN image credit Turid Astrid Reksten

PRODUCT LINE

How to select the right product for you.
The HUGIN and REMUS family is comprised of a wide range of vehicles with varying capabilities. The REMUS 100 is a man-portable system capable of quickly and covertly being deployed from small, rigid-hulled inflatable boats (RHIB). The HUGIN and REMUS 6000 vehicles are capable of reaching the deepest regions of the world's oceans with a range of sensors to accomplish diverse mission objectives.

Our AUVs are ideally suited for a wide range of applications, from very shallow water mine countermeasures to search and survey applications in the deep ocean. All of our AUVs can be equipped with a wide selection of sensors including acoustic and optical imaging, bathymetry and environmental data collection.

The REMUS vehicles can operate a wide selection of sensors depending on customer requirements including Synthetic Aperture Sonar (HISAS), Sidescan Sonar (SSS), Bathymetry (MBE), optical and chemical sensors. The HUGIN has a very high resolution Synthetic Aperture Sonar (HISAS), Multibeam Echo Sounder (MBE), camera and sub-bottom profilers making it uniquely suited for large area MCM operations.

The smaller systems can be deployed using standard shipboard handling equipment. The larger systems are deployed with Launch & Recovery Systems (LARS) specifically designed for the system. The LARS enables AUVs to be deployed in open water and rough weather conditions without the need to put a small boat in the water. The LARS also enables operations on vessels of opportunity.

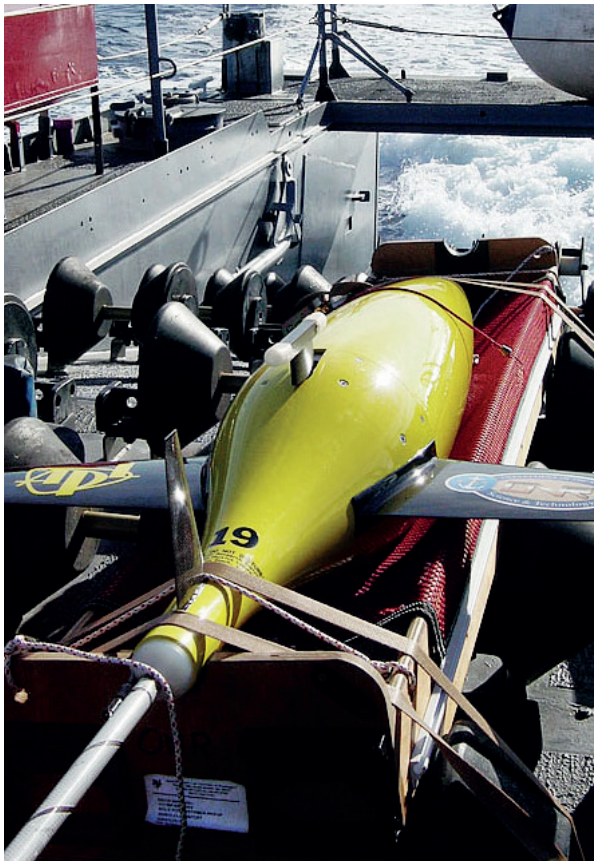


Photo courtesy of the Italian Navy

APPLICATIONS COMPARISON

KONGSBERG

HUGIN®

6000 m Operating Depth
Up to 80 Hours Mission Duration

- Most successful commercial AUV
- HISAS or SSS, MBE, SBP, Camera, turbidity and CTD sensors – standard
- Simultaneous sensor operation for multipurpose missions
- Obtain comprehensive data sets in a single dive
- Sensor integration with the vehicle's navigation systems
- Swappable batteries
- Launch and recovery using a Stinger ramp system
- Operation in conditions up to Sea State 4
- Vehicle, equipment & LARS easily installed in DnV containers on ships of opportunity
- Additional options available

SEAGLIDER

1000 m Operating Depth
Up to 10 Months Mission Duration

- Low capital cost – a fraction of traditional methods
- Extremely long deployment time
- Versatile payload capability for collection of a wide range of high quality ocean data
- Robust design reduces the chance of missions being aborted before completion
- Large variable buoyancy allows for operation in a wider range of water densities without requiring constant adjustment of the static ballast
- Satellite communications provide retrieval of most data in near real-time
- Able to be piloted from virtually anywhere in the world via satellite and Internet connection

MCM	Route Survey	—
	Mine Detection	—
	Mine Classification	—
	Mine Identification	—
	Automated Target Recognition	—
	Change Detection	—
	Counter IEDs	—
REA	Area Survey	—
	Bathymetric Survey	—
	Environmental Survey	Environmental Survey
ISR	Area Survey	—
	Charting	—
	Change Detection	—
SAR	Asset Location	—
	Identification	—

HYDROID
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REMUS 100

100 m Operating Depth
Up to 12 Hours Mission Duration

- Low logistics, two-man portable
- Size and weight allows for economical overnight shipping
- Simple deployment/recovery
- Full suite of standard sensors for almost any subsea application
- New sensors being integrated on a continuous basis
- Modularity provides for multiple missions from the same vehicle
- Proven ten year track record of reliability
- Intuitive, easy-to-learn vehicle interface program (VIP)

REMUS 600

600/1500 m Operating Depth
Up to 45 Hours Mission Duration

- Industry-leading mid-weight AUV
- Built on success of REMUS 100
- Increased size & power capacity allow power-hungry payloads to meet customers' increasing mission demands
- Increased depth rating allows for greatly increased operational scope
- Fully modular for a wide variety of customer-configured payloads.
- Hull sections designed for ease of separation for vehicle re-configuration, maintenance and/or shipping
- Thousands of mission hours logged to date

REMUS 6000

6000 m Operating Depth
22 Hours Mission Duration

- A deep-water workhorse at depths up to 6000 meters
- Versatile design allows long mission durations in shallow littoral areas
- Configurable to include a wide range of customer-specified sensors
- In-field configurable to meet specific and varied mission requirements
- Simple to operate with the same leading-edge technology as the REMUS 100
- Roll on/off launch and recovery system (LARS) designed to be installed easily off the stern or midship of a vessel of opportunity

MCM	Route Survey Mine Detection Mine Classification Mine Identification Automated Target Recognition Change Detection —	Route Survey Mine Detection Mine Classification Mine Identification Automated Target Recognition Change Detection —	— — — — — — —
REA	Area Survey Bathymetric Survey Environmental Survey	Area Survey Bathymetric Survey Environmental Survey	Area Survey Bathymetric Survey Environmental Survey
ISR	Area Survey Charting Change Detection	Area Survey Charting Change Detection	Area Survey Charting Change Detection
SAR	Asset Location Identification	Asset Location Identification	Asset Location Identification

AUV SYSTEM HIGHLIGHTS FOR NAVAL OPERATIONS

Mission Planning and Operation Systems
All HUGIN and REMUS AUVs are equipped with highly intuitive mission planning and operation systems which greatly simplify mission planning, vehicle checkout, vehicle operation and data analysis. Key functionality includes:

- Integrated text editor for construction of the mission plan
- Map view illustrating the planned mission for review
- Automatic error checking performed on all aspects of the planned mission, with warning messages that appear if any mission parameters are incorrect
- Testing of important sub-systems such as the propulsion motor, rudders and emergency systems
- Monitoring and displaying data from the vehicle and support systems
- Input, sanity check and transmission of operator commands
- Training simulation mode
- Mission replay mode

Post Mission Analysis
Some navies have preferred systems for payload processing and post mission analysis. Our AUVs can interface to these systems.

We offer the post mission analysis (PMA) software suite which provides a wide range of options, essentially covering:

- Navigation post-processing for increased position accuracy (NavLab)
- Bathymetric processing, quality control, mosaicing, layering to charts and 3D view generation
- Side scan sonar processing
- Synthetic aperture sonar processing REA applications
- Automatic target recognition and other specialised functions for naval mine countermeasures

Launch and Recovery Systems
One of the main challenges with AUV operations is recovery in open and rough seas. The REMUS 600/6000 and HUGIN have dedicated Launch and Recovery Systems (LARS) that have proved their efficiency and reliability in harsh operations over the years.

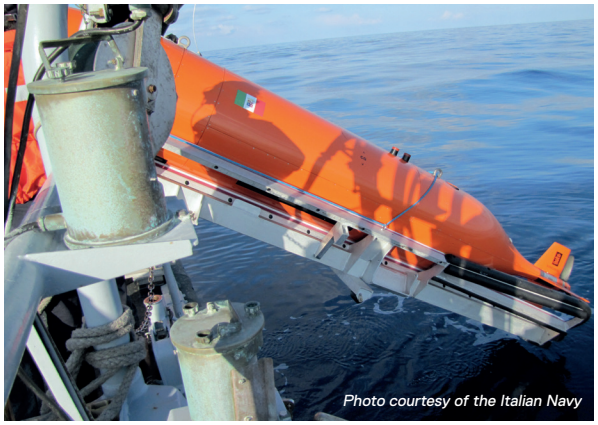
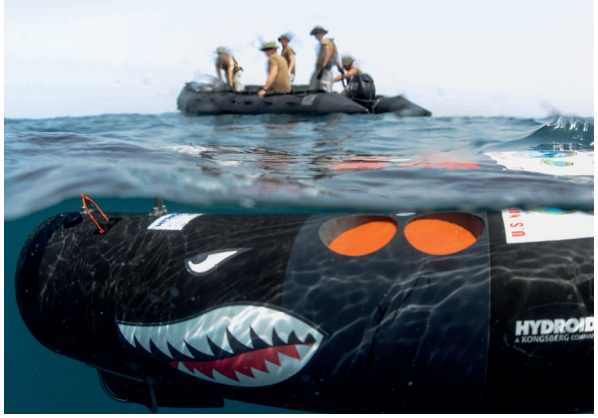


Photo courtesy of the Italian Navy



System Overview
KONGSBERG and Hydroid offer full picture solutions. These include:

- Mission planning systems
- Launch and recovery systems
- Communication and localisation equipment
- Navigation equipment
- Docking systems
- Post-mission analysis
- Spare part package
- Maintenance equipment
- Training systems.

SYNTHETIC APERTURE SONAR

Transformational changes in warfare over the last two decades have increased the need for very high resolution imagery and high area coverage rates in MCM operations. The shift towards expeditionary warfare means that route survey data will often not be available. Being able to separate mines from mine-sized rocks is crucial. Modern mines and improvised explosive devices (IEDs) are difficult to classify (or even detect) with traditional sonars.

KONGSBERG's high resolution interferometric synthetic aperture sonar (HISAS) provides a resolution of better than 5x5 cm over a swath of several hundred metres (speed and water depth dependent), capable of covering more than 2 square km per hour with sonar imagery allowing classification of modern mines and IEDs. This makes the system ideally suited for large area MCM operations. Compared to a traditional high frequency side scan sonar, HISAS typically reduces the MCM survey time by a factor of 3-6. The superior data quality and availability of additional products such as SAS bathymetry will also allow more reliable mine classification with fewer false alarms. This will, in turn, reduce time consumption for reacquisition, identification and disposal.

HISAS 1030 has been used operationally on HUGIN AUVs by Navy customers since 2008. HISAS systems have been used to detect and classify thousands of mines, often in areas that were previously deemed impossible to explore. An upgraded version, HISAS 1032, and the recently introduced HISAS 2040 is now available on all of our vehicles, and offers real-time processing and sonar quality assessment, higher performance and much lower power consumption - all in a considerably smaller form factor.

The standard instrumentation on a HUGIN for MCM also includes a high-resolution optical camera. With the use of in-mission HISAS processing, automated target recognition (ATR) and rerouting, this allows the vehicle to perform detection, classification, reacquisition and optical identification of mine-like targets in the same mission, providing further time savings.

HISAS 1032 image of a shipwreck from the Skagerrak chemical munitions dumpsite. Image by Roy Edgar Hansen, © Norwegian Coastal Administration and Norwegian Defence Research Establishment (FFI)

VEHICLE SAFETY FEATURES

Health Monitoring
HUGIN and REMUS AUVs have core systems designed to monitor the status and operation of essential components. Health monitoring includes batteries, motors, sensors and communications as well as conditions such as depth and water ingress.

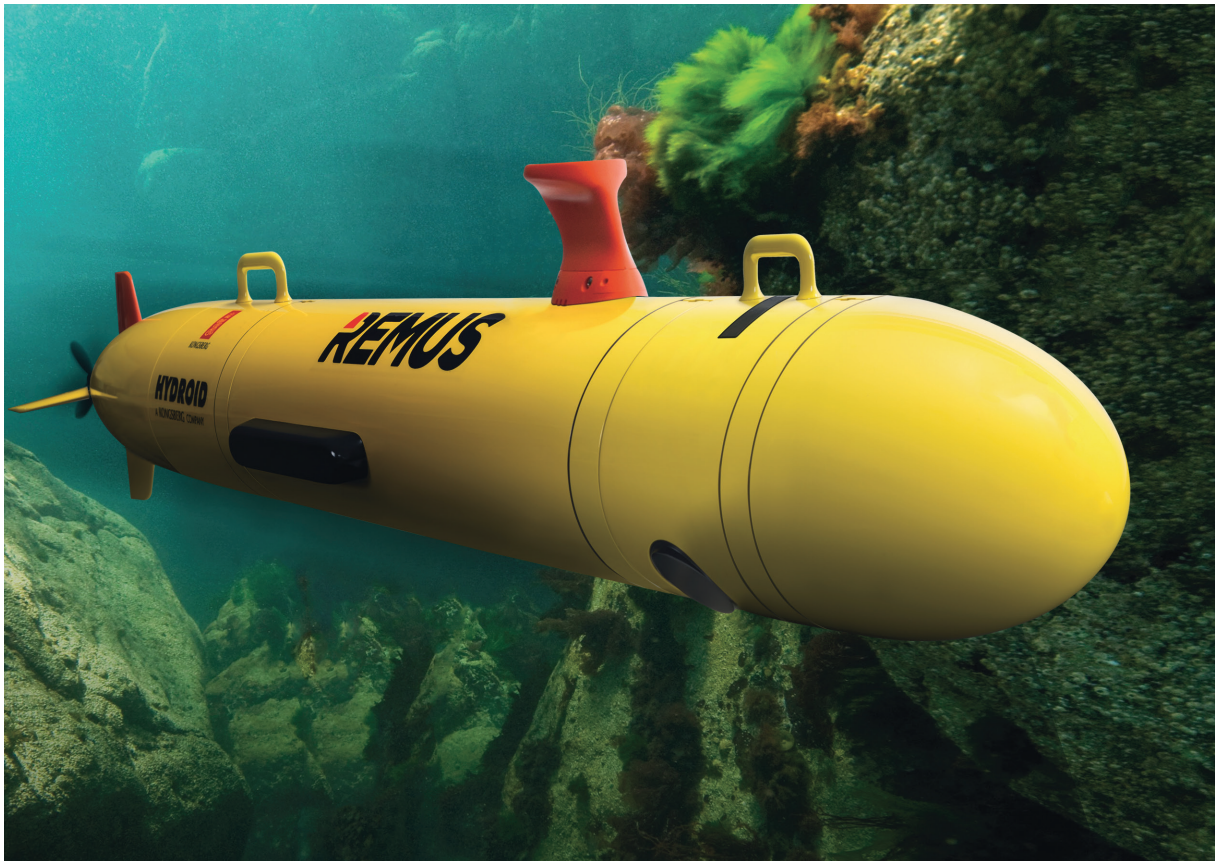
If an abnormality is detected, an alarm is raised. During supervised missions, this will be transmitted to the operator enabling them to decide if the vehicle should return from its mission. When the vehicle is operating autonomously, the response to an alarm is determined by the preselected response listed in the mission plan. This could include an emergency abort to preserve vehicle security.

Communication and Tracking
Operators can monitor the AUV's progress and status via an acoustic or satellite link. This also enables amendments to the mission plan to be sent to the vehicle along with position updates if required. Many of our AUVs can be equipped with acoustic positioning systems that can aid the onboard navigation equipment to make the real-time position solution as accurate as possible.

Some KONGSBERG and Hydroid AUVs also transmit real-time side scan and bathymetry data back to the operator acoustically. This data is displayed on the payload computer screen to give the operations team confidence that the mission is progressing as planned and there are no gaps in the data.

When the AUVs are on the surface, they can communicate via Wi-Fi or radio with the operator. They are also equipped with GPS receivers to update the AUV position with the most accurate information available.

Emergency Localisation
To assist with emergency localisation and recovery operations, the AUVs can be equipped with emergency radio beacons, strobe lights and satellite communications. In the event of an emergency ascent, the position and status of the vehicle can be sent via the Iridium network to the operators and home base simplifying post-emergency localisation. If two-way satellite communication is enabled, a revised mission plan can be sent to the vehicle from anywhere in the world.



LAUNCH & RECOVERY SYSTEMS

The launch and recovery of an AUV is critical, as many missions often take place in rough, open waters. Multiple LARS (Launch and Recovery Systems) are offered that can meet a variety of parameters.

Stinger LARS
AUVs are normally launched and recovered using the Stinger ramp system. Capable of operating in Sea State 4, the Stinger can be installed either on an open deck, or more commonly in a container or workshop. The Stinger system is available in two lengths for freeboards of either 3 or 5 meters.

Mini-Stinger
The Mini-Stinger ramp system is a modular, transportable system designed to be used on vessels of opportunity.

The bottom section of the Mini-Stinger is flexible and has flotation built into it, providing some compensation for wave action during recovery.

Cranes
Cranes can be utilised for launch and recovery with either a hydraulic or electric saddle attachment.

LARS
This Launch and Recovery System (LARS) extends the operational weather window of our AUVs by allowing launch and recovery in sea states up to Sea State 5.

Docking
AUVs can be configured with autonomous docking capability. The systems includes:

- Dynamic Docking
- Docking Stations
- Line Capture Nose (Whiskers)
- Automated Recovery

Custom Solutions
- RIDE (REMUS Integrated Deck Equipment)
- RHIB customer developed solution

GLOBAL CUSTOMER SUPPORT

We are always there, wherever you need us. Our customer service organisations are designed to provide high-quality, global support, whenever and wherever it is needed. We are committed to providing easy access to support and service, and to responding promptly to your needs. Support and service activities are supervised from our headquarters in Norway, with service and support centres at strategic locations around the globe.

As part of our commitment to total customer satisfaction, we offer a wide variety of services to meet individual customers' operational needs. Support 24 is one of our solutions designed to give round-the-clock support. For mission-critical operations, Support 24 can be extended to include remote monitoring. We can adapt the level of support needs by offering service agreements, on-site spare part stocks and quick on-site response arrangements.

Sales & Support 24

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Global and Local Support
We provide global support from local service and support facilities at strategic locations worldwide. Service and support work is carried out under the supervision of your personal account manager, who will ensure that you receive high-quality service and support where and when you need it. Your account manager will ensure continuity and work closely with your personnel to improve and optimise system availability and performance. Under the direction of your account manager, and with a local inventory of spare parts, our well qualified field service engineers will be able to help you quickly and effectively.

km.kongsberg.com/AUV

www.hydroid.com

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