GAVIA
AUTONOMOUS UNDERWATER VEHICLE
PRODUCT DESCRIPTION

CinC (Commercial in Confidence)

GAVIA

January 2004

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is

USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

1 THE GAVIA CONCEPT

THE GAVIA AUV SYSTEM DEVELOPED BY HAFMYND – GAVIA LTD, IS THE FIRST COMMERCIALLY AVAILABLE FULLY MODULAR VEHICLE SYSTEM AND THE FIRST COMPACT AUV CAPABLE OF DEEP-WATER OPERATIONS. THE GAVIA BASE VEHICLE IS A MOBILE SENSOR PLATFORM THAT CAN BE CONFIGURED ON-DECK FOR A PARTICULAR TASK OR OPERATING CONDITIONS BY THE ADDITION OF ONE OR MORE SENSOR, NAVIGATION OR BATTERY MODULES, WHICH ARE INSERTED INTO THE VEHICLE AND LOCKED IN PLACE BY MEANS OF A UNIQUE TWIST-LOCK SYSTEM.

- Fully modular
- Plug-and-play module interface
- Intelligent artificial crew
- High cruising speed
- Long range
- Battery modules replaced in minutes
- 2000-meter depth rating available
- A selection of sensors
- DVL-aided INS option
- Global satellite link
- Remote operation and servicing
- Over-the-horizon deployment
- Buoy-free operation

1.1 HAFMYND AND GAVIA

Hafmynd ltd, www.hafmynd.is, was formed as a company in 1999 but traces its roots back to the Science Institute of the University of Iceland 25 years ago.

Gavia's product description was put on paper in 1996. The idea behind Gavia is to integrate into a small and free-swimming robot some of the most important instruments of a research vessel. In addition, the crew is mimicked to operate Gavia and its equipment much like the crew and scientists of a research vessel. First tests took place in late 1997 and first missions in 1998.

The development of Gavia is a joint effort of Hafmynd ltd and the following:

1. Faculty of Engineering of the University of Iceland
2. Fisheries Institute of the University of Iceland
3. Marine Research Institute of Iceland
4. Department of Biology of the University of Iceland

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is

USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

Several University students have done their master's theses in relation to Gavia's development.

Grants have been awarded by the Icelandic Research Council and other funds.

Hafmynd ltd is the sole owner of the Gavia design and IP rights. Hafmynd is owned by individuals who take great personal interest in the Gavia system and are willing to support future development and marketing. This is evident from the high degree of sophistication of the Gavia design, which is internationally regarded as the most advanced system in its class.

Hafmynd controls the development, production and marketing of the Gavia system, which enables the company to act rapidly to market trends and customer requirements. New sensors and devices can thus be integrated in the shortest possible time.

Hafmynd is part of the Mallard Holding Group. One of these companies, Össur, manufactures the mechanical parts of Gavia under ISO 9000. Most of the electronic assemblies of Gavia are OTS made by 3rd party under ISO 9000. Gavia is assembled by Hafmynd ltd according to Hafmynd's quality assurance program. The company TM Software backs-up the software development team of Hafmynd. See below.

Össur

Creates prosthetics and orthotics that enable people to live the kind of life they want to, a life without limitations. Aware of the challenges you face, we respond, always refining and improving on what exists today.

Innovation - our heritage and our future
Ossur's key inventors each designed the products they themselves dreamed of as prosthetic users. Understanding and listening to customers has always been central to our development of new products, and it always will be. From post-operative programs to long-term support and rehabilitation, Ossur's holistic approach underpins its philosophy and goals. Each day brings a fresh challenge. http://www.ossur.com/template1.asp?PageID=1

TM Software

TM Software, Inc. is one of Iceland's largest software companies. It focuses on the development, sale and service of its own software, which is sold under the trademarks of its subsidiaries that operate in separate specialised sectors. The group's leading brand names are WiseFish, Orka, Vigor Financials, Theriak and Libra.

For the past four years running, TM Software Inc. has received awards as one of Europe's 500 most progressive companies, and is the only Icelandic company to have done so.

TM Software's operations were split up between the independent subsidiaries at the end of 2001, so laying the foundations for the further growth of the subsidiaries.

The parent company, TM Software, sees its main role as being to support the subsidiaries in exploring new opportunities and to utilise the synergy potential offered by direct involvement in their operation. It is also the parent company's role to foster and develop new commercial openings in the fields of software and information technology. http://www.tolvumyndir.is/

1.2 HAFMYND'S INTERNATIONAL STRUCTURE

North America:	**Gavia AUV Corporation** has recently been incorporated on the West coast of the US. Gavia AUV Corporation handles marketing of the Gavia system in North America and Japan. Production of Gavia in the US by Gavia AUV Corporation is planned offering a **second source** for the Gavia system.
Japan:	**Gavia AUV Corporation**
UK:	**Hydro Products Ltd**., Aberdeen, Scotland
	GeoAcoustics Ltd
Far East:	**GeoAcoustics** Ltd, Singapore
Scandinavia:	**BoKrogh Ltd**

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

1.2.1 DEVELOPMENT COLLABORATION

GeoAcoustics Ltd. are developing an ISO standard bathymetry sonar module based on the **GeoSwath.**

1.3 EXHIBITION PLAN 2003 - 2004

Oceans 03	San Diego, USA, 22 - 26 September 2003
UUVS 03	Southampton, UK, 22 - 26 September 2003
US Maritime Security Expo	NY, USA, 6 - 9 November 2003
FCT Meeting	Washington, 12 - 13 November, 2003
IEEE Homeland Security	RI, USA, 9 - 10 December
Underwater Battlespace	London, UK, January 2004
Underwater Intervention	New Orleans, USA, Feb. 2004
Oceanology International	London, UK, 16 - 19 March 2004
Underwater Defence Technology	Nice, France, June 2004
Oceans 04	Kobe, Japan, September 2004

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is

USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

2 THE GAVIA ARCHITECTURE

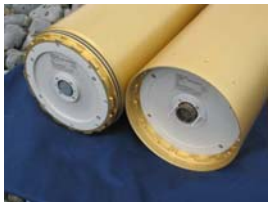


Figure 1 The Gavia modules are splash-proof, facilitating, for example, on-deck Battery Module swapping. The male and female parts of the Gavia modules are shown.

Gavia is made up of several individual cylindrical modules that are locked together using a twist-lock system forming a single rigid pressure hull. The splash-proof end plates of the modules are electrically connected using standard circular military connectors. These connectors transfer power, real-time control signals on a standard CAN bus and asynchronous data and CORBA remote procedure calls on a fast 100 Mbit/s Ethernet bus across the length of the vehicle. Each module is a stand-alone unit that can be operated outside of the vehicle for charging, data access etc. Access to the internal vehicle network is also provided by wireless LAN, global Iridium satellite link, and the optional acoustic through-water communication link.

Gavia's autonomous vehicle control software is organised in a unique distributed architecture modelled on the division of responsibilities among the hands of a manually controlled vessel. The composition of the Gavia Intelligent Artificial Crew varies with the modular configuration of the vehicle. Different crewmembers operate as separate independent processes communicating over the vehicle Ethernet bus using industry standard CORBA interfaces. Specialist crewmembers can be added to the crew to provide application specific data analysis capabilities for reactive vehicle control.

2.1 PLUG AND PLAY MODULARITY

The Gavia plug-and-play module interface presents the necessary mechanical, electrical and software interface to allow straightforward integration of new sensor modules by sensor developers or end-users. The Gavia Base Vehicle serves as a common platform for a variety of AUV applications with specific capabilities added in the form of optional Gavia modules. The range of Gavia AUV modules include a high-precision DVL-aided INS, a digital camera, rechargeable batteries, acoustic communication and positioning systems and side-scan sonars. A survey-grade swath bathymetry system module will be available soon, developed by GeoAcoustics.

The modularity makes Gavia an ideal platform and starting point for various AUV applications, including marine research, surveying, surveillance, sensor development and AUV methodology research.

2.2 BREAKING THE BOUNDARIES

Extensive hull profile development has brought Gavia the characteristics of low drag and low power consumption for maximum speed, range and endurance.

Four independent control surfaces provide active roll control for stabilized tilted operation. Actuator and thruster performance are unaffected by operating depth, eliminating the need for pressurized moving seals that are prone to wear and leakage.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

2.3 RELIABILITY BY DESIGN

The control planes are shielded by the propeller nozzle thereby greatly reducing the danger of snagging or accidental damage from hitting objects or accidental banging against a ship's hull.

The Gavia hull is made from corrosion-resistant aluminium alloy. For further protection the metal surface is hard anodised in a golden colour providing visual detection at sea. (Other colours are available for special applications). Double O-rings provide sealing at module joints and there is an additional O-ring seal on the end-panels of each module protecting the electronics, facilitating on-deck module replacement.

Reliability of operation has been assured through modular design and clearly defined responsibilities of the Intelligent Artificial Crew that is found aboard all Gavia vehicles, irrespective of configuration. Members of the crew execute instructions as separate processes on the networked PCs running the open source Linux operating system kernel, while time-critical functions are handled by the real-time micro-controller network.

2.4 EASE OF OPERATION

Data accumulated during a mission is stored on hard disk for straightforward browsing by means of Gavia's on-board web-server. Browsing and secure file transfer is available over fast wireless LAN connection, satellite or acoustic links. Remote mission planning and servicing is available through the same communication channels.

Several other features have been incorporated into the design of Gavia for ease of use and convenience to the operator. The greatest convenience factor though is the small size, which enables Gavia to be operated by one or two persons.

2.5 CONNECTIVITY

Communication with the vehicle TCP/IP connections are available over 11 Mbit/s Wireless Ethernet, global Iridium satellite link at 2.4 kbit/s and optionally an acoustic link at up to 2 kbit/s.

- High-speed Wireless LAN
- Iridium satellite link
- Acoustic link (optional)

2.6 A CHOICE OF OPERATIONAL CYCLES

Endurance and range depend on cruising speed, equipment duty-cycle and the type and number of battery modules installed.

A battery module is easily replaced on deck. It is possible to charge spare battery modules while the vehicle is away on a mission. Rapid battery module replacement enables the use of high survey speeds without paying downtime loss associated with charging. Gavia has built-in battery chargers, simplifying external support needs in the field.

2.7 TRANSPORT, LAUNCH AND RECOVERY

Gavia can be deployed and recovered by one or two persons e.g. from a small boat. It has been a design goal for Gavia to be operated in the field by relatively inexperienced technicians; the design optimises the operator friendliness and ease of transportation aspects of Gavia.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

Figure 2 The Gavia Base Vehicle is transported in two Pelican cases with the surface equipment contained in a third smaller case.

2.8 THE CAPTAIN AND HIS CREW

The Gavia autonomous vehicle control software is organized in a unique distributed architecture modelled on the division of responsibilities amongst the hands of a marine vessel. The Gavia Intelligent Artificial Crew (IAC) comprises a full crew responsible for the safe navigation of the vessel together with project personnel responsible for meeting the goals of the mission.

The Captain has the same responsibilities as on board any other vessel. He oversees the operation of the vessel and decides on actions in response to exceptional or critical circumstances.

There are a number of Pilots on board Gavia and specialist Pilots can be easily added for particular tasks. Each adds a particular skill: one knows how to track the seabed, another how to avoid obstacles and so forth.

The Engineer oversees the operation of the hardware, such as power system, motors etc. and reports to the captain in case there is a need for action.

The Navigator maintains a best estimate of the vehicle position at any given time, making use of all available instrumentation.

2.8.1 MISSION SPECIFIC CREWMEMBERS

A specialist Instrument Operator accompanies each instrument onboard the vessel, such as the Doppler Velocity Log, side-scan sonar, digital camera etc. The Instrument Operator works the instrument, logs data and monitors its health.

Data Analysts are hired as required for a particular mission. They process sensor data in real-time for use in reactive behaviours.

The Mission Commander is responsible for the aims of the mission as laid down in the mission plan.

2.9 GAVIA – THE IDEAL AUV PLATFORM

2.9.1 DESIGN YOUR OWN PAYLOAD MODULE

A Payload Module can be designed by the customer, based on a generic payload module available from Hafmynd – Gavia. The Payload Module supplies power, control signals and Ethernet communication to the local payload.

A custom module can also contain a single PC accommodating customer supplied crewmembers for particular operating system or processing needs.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

Crewmembers can also be designed by the customer for specialized tasks, and coded in any number of programming languages providing industry-standard C0RBA support.

2.10 OPERATION

With the vehicle captain handling reaction to exceptional circumstances, the user is free to concentrate on the goals of this mission.

2.11 MISSION PLANNING

Flexible mission planning is provided by Gavia's powerful AUV Scripting Language (ASL). Mission plans can be fixed geo-referenced paths as well as dynamic paths to be determined in real-time by an on-board data analyst. Throughout the mission, sensors may be switched on and off as required.

2.12 MISSION SIMULATION

Gavia has a built-in Simulation Mode that enables the testing of complete missions prior to deployment. Simulated missions are executed by the same crewmembers following the same mission plan as real missions.

2.13 REMOTE CONTROL

Gavia can be remotely controlled through any of her communication channels: The fast wireless LAN, the global Iridium satellite link, and the optional Acoustic link. Missions can be temporarily halted or aborted and new missions can be uploaded for execution.

2.14 REMOTE DATA ACCESS

Vehicle data can be remotely browsed on Gavia's on-board web-server during and after mission, and files downloaded using secure data transfer.

2.15 DATA PROCESSING

Data files are stored in open standard formats for maximum interoperability with third party data-analysis software and GIS systems.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

3 GAVIA AUV BASE VEHICLE

Figure 3 GAVIA base vehicle.

The Gavia® base vehicle comes with satellite-augmented GPS for surface positioning, wireless LAN for remote control, in-water mission upload and data download, and Iridium satellite link for over-the-horizon operation and global remote field servicing. All Gavia modules can be moved freely between vehicles by the operator on-deck by means of the unique Gavia QuickLock™ system. The modular system supports field-serviceability and reduces the number of systems required to maintain a given level of system availability.

The surface equipment required for operating Gavia includes a PC laptop computer running the graphical Gavia Operator Console for mission planning and remote control and a web browser to access the Gavia Data Pre-viewer on Gavia's on-board web server.

The Gavia AUV base vehicle is offered as a common platform serving a variety of AUV applications. Application specific capabilities are added to the base system in the form of optional Gavia modules. In time a Gavia AUV system can be expanded by adding further Gavia modules as requirements evolve and new modules become available.

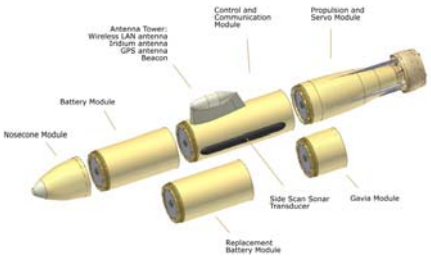
Gavia is available in the following depth ratings: 200, 500, 1000 and 2000 m.

The standard colour of Gavia is golden but other colours are available.

3.1 GAVIA BASE VEHICLE MODULES

The Gavia Base Vehicle consists of the following modules:

1. Nosecone Module
2. Battery Module
3. Control and Communication Module
4. Propulsion and actuator Module



See the next section for optional Gavia modules and equipment.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

4 GAVIA BASE VEHICLE MODULES

4.1 NOSECONE PAYLOAD MODULE

Figure 4 Nosecone module of Gavia.

The standard Nosecone Module comes with a view port for a digital stills or video camera. The Nosecone Module can be equipped with a digital camera with or without a local PC and hard disk for storage. The Nosecone and camera can be rotated in 45° steps for different viewing directions. The camera is offered separately (see High-performance Digital Camera).

A collision avoidance sonar is fitted in the Nosecone as standard. Customer-supplied instrumentation can also be fitted in the Nosecone if desired.

The module is splash proof, facilitating on-deck replacement.

TECHNICAL SPECIFICATIONS OF NOSECONE PAYLOAD MODULE

Length	280 mm
Diameter	200 mm
Weight in air	2 kg
Volume	4 l
Buoyancy in fresh water	2 kg
Material	Hard anodized aluminium
	Acrylic plastic for camera view port

Free for custom payload or High Performance Digital Camera from Hafmynd.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

4.2 BATTERY MODULE

Figure 5 Gava Battery Module.

4.2.1 LiIon RECHARGEABLES

The Battery Module contains several independent “smart” LiIon battery packs and “smart” battery chargers. Each battery pack is monitored for 'health' and information on discharge current, charge current, number of charge cycles to date, battery voltage, internal battery temperature etc. The battery packs are protected against short-circuit and overcharge. The battery packs are controlled by an intelligent Switch, which provides optimum energy utilization under various operating conditions.

Total energy capacity of the Battery Module is 1 kWhour. The Battery Module can be charged in the vehicle or as a stand-alone unit. An external DC-source, such as the Gavia Mains Adapter, supplies power to the chargers. It is offered separately (see Surface Equipment). Alternatively a set of car batteries can be used for providing power to the battery chargers.

Battery modules can be swapped in minutes for rapid turnaround. More than one battery modules may be used in GAVIA at the same time to increase the range and duration.

4.2.2 LITHIUM PRIMARIES

Oprionally Lithium Primaries are available instead of the LiIon rechargeable for increased range and endurance. The Lithium primaries have a shelf life of 10 years.

Both Battery modules are splash proof, facilitating on-deck replacement.

Figure 6 Gavia Mains Adapter

TECHNICAL SPECIFICATIONS OF BATTERY MODULE

Full charge requires approximately 4 hours. The on-board chargers enter trickle charge on completion of the fast charge. Charger efficiency is around 80%.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

Length	380 mm (net length when installed in Gavia)
Diameter	200 mm
Weight	12 kg
Volume	12 l
Buoyancy in fresh water	0 kg
Battery chemistry	a) Rechargeable LiIon
	b) Lithium primaries
Energy capacity	a) 1000 Whour for LiIon rechargeables
	b) 2500 Whours for Lithium primaries
Discharge operating temperature	-20°C to 60°C
Charging temperature range:	0°C to 40°C
Storage temperature range:	-20°C to 60°C

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

4.3 CONTROL AND COMMUNICATION MODULE

Figure 7 Gavia Control and Communication Module.

The Control and Communication Module contains an antenna tower and an Iridium satellite modem, wireless high-speed LAN interface, GPS receiver, 3-axis fluxgate compass, inclinometers, and rate gyros. The module further contains a Pentium PC with 80 GB hard disk, control electronics, and autonomous vehicle control software installed on the PC. The Iridium and wireless LAN links provide separate TCP/IP network connections that are used interchangeably.

The module is splash proof, facilitating on-deck replacement.

TECHNICAL SPECIFICATIONS OF THE CONTROL AND COMMUNICATION MODULE	
Length	350 mm (net length when installed in Gavia)
Diameter	200 mm
Weight in air	11 kg
Volume	11 l
Buoyancy in fresh water	0
PROCESSING	
PC-computer	
Type	Industrial grade PC-104
Hard disk	80 GByte shockproof
Ethernet LAN	10/100 MB on the Gavia Bus
Wireless LAN	up to 11 Mb
Operating system	Linux
MICROCONTROLLER	A real time microcontroller handles time-critical functions and acts as back up to the PC in case of failure. The microcontroller can operate Gavia in emergency situations.
COMMUNICATION (see also optional acoustic modem module)	
Wireless LAN	up to 11 Mb
Satellite telephone	Iridium modem
Antenna	Patch antenna mounted in antenna tower
Coverage	Full global coverage in a single system
NAVIGATION (see also optional DVL - INS module)	
GPS receiver on surface	
Type	Lassen SK II, Trimble, Inc. Differential ready
Antenna	26 dB active micro-patch in antenna tower
Options	WASS GPS receiver available
Electronic compass (on surface and underwater)	
Type	TCM2 - +/-50°
Accuracy	±1 degree when level. The compass is calibrated in Gavia for hard and soft iron effects.
Depth sensor	Pressure sensor, Manufactured by Keller AG, Switzerland
Strobe and floodlight	High-intensity LED lamp for use with nosecone-mounted camera (optional strobe module available).

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

On/off	Magnetic switch activated from the outside of the hull
EMERGENCY AND SAFETY SYSTEM	
Acoustic beacon	Frequency 35 kHz, 2 Hz ping rate, range 300 m (1000 ft), includes surface tracker Emergency beacon High-intensity omni directional white LED mounted in antenna tower for visual location in the dark.
Operating status LED	Located in antenna tower for visual indication of operating status.
Leak detector	Intelligent leak detector reporting on the Gavia Control Bus.
Ground fault detector	Intelligent ground fault detector reporting on the Gavia Control Bus.
Safety overpressure valve	The safety overpressure valve opens if the pressure build-up inside Gavia exceeds a set limit.
Operating temp. range:	-0°C to +40°C (standard range)
Storage temp. range:	-20°C to +60°C (standard range)
SOFTWARE	
POWER CONSUMPTION	15 W operating

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

4.4 PROPULSION AND ACTUATOR MODULE

Figure 8 Gavia Propulsion and Actuator Module.

4.4.1 PROPULSION SYSTEM

This module contains a powerful three-phase brushless (electronically commutated) DC propulsion motor controlled by a high-grade OTS (off-the-shelf) digital motor controller with full control of speed in forward and reverse directions. The motor and controller provide very high efficiency and reliability. A three-bladed propeller has been designed for Gavia, which is matched to the torque of the motor and the hydrodynamic properties and the speed range of Gavia. An important feature of the propulsion system is that there are no pressurised rotating shaft seals. This eliminates leakage problems, simplifies maintenance and reduces friction losses and are unaffected by operating depth.

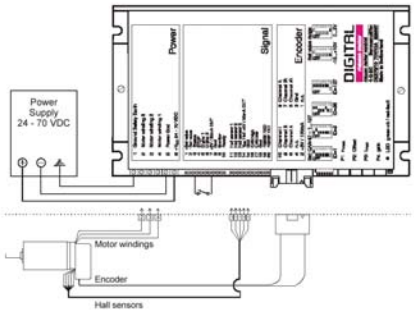


Figure 9 The brush-less propulsion motor and digital controller.

The propulsion system is controlled through the Gavia Control Bus.

4.4.2 ACTUATOR SYSTEM

Pitch, yaw and roll are controlled independently by four servomotors acting on four fins that are located aft of the propeller and protected by the propeller nozzle. The servomotors are three-phase high-grade brushless DC motors each controlled by advanced OTS digital controllers. The servomotors and controllers ensure high-efficiency and reliability. An important feature of the servomotor system is that there are no pressurised rotating shaft seals. This eliminates leakage problems, simplifies maintenance and reduces friction losses and are unaffected by operating depth. The independent control surfaces provide active roll control for stabilized tilted operation.

A unique feature of the propulsion and actuator system of Gavia is that it produces vectored thrust thus providing full control from standstill and good low speed control.

The servomotor system is controlled through the Gavia Control Bus.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

The module is splash proof, facilitating on-deck replacement.

TECHNICAL SPECIFICATIONS OF THE PROPULSION AND ACTUATOR MODULE	
Length	680 mm
Diameter	200 mm
Weight in air	14 kg
Volume	14 l
Buoyancy in fresh water	0
PROPULSION MOTOR	
Type	Brush-less (electronically commutated) DC motor.
Controller	High grade OTS motor controller communicating over the Gavia Control Bus.
SERVOMOTORS	
Type	Four (4) brush less (electronically commutated) DC motor with
Controller	High grade OTS motor controller communicating over the Gavia Control Bus.
Fins	Located aft of the propeller for vectored thrust. Protected by nozzle.
PROPELLER	
Type	3-bladed inside nozzle
Material	Sea grade brass
POWER CONSUMPTION	

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

4.5 OVERALL SPECIFICATIONS FOR GAVIA BASE VEHICLE

THE GAVIA BASE VEHICLE IS A LOW COST MINIMUM CONFIGURATION AUV PLATFORM. OPTIONAL GAVIA MODULES CAN BE ADDED TO THE BASE SYSTEM.

FOR EXTENDED SPECIFICATIONS, REFER TO THE OPTIONAL GAVIA MODULES.

TECHNICAL SPECIFICATIONS OF GAVIA BASE VEHICLE

Length	1.69 m (66")
Diameter	0.2 m (7.87")
Weight in air	39 kg (86 lbs)
Volume	39 l
Trim weight	1 kg based on seawater salinity of 30 ppt
Max operating depth	200, 500, 1000, 2000 m
Propulsion	DC brush-less motor to ducted three bladed propeller
Velocity range	0 to 3.5 m/s, fully variable forward and reverse
Control	4 independently controlled fins for yaw, pitch and roll, located aft of propeller generating vectored thrust for full control from standstill
On/off	Magnetic switch activated from the outside of the hull
Communications	Wireless LAN (11 Mb), Iridium satellite link and optionally bi-directional acoustic communications link
Navigation	GPS on surface. Dead reckoning underwater with electronic compass and propeller turns.

EMERGENCY AND SAFETY SYSTEM

Acoustic beacon	Frequency 40 kHz, 2 Hz ping rate, range 300 m (1000 ft), includes surface tracker
Emergency beacon	High-intensity omni directional white LED mounted in antenna tower for visual location in the dark.
Operating status LED	Located in antenna tower for visual indication of operating status.
Leak detector	Intelligent leak detector reporting on the Gavia Control Bus.
Ground fault detector	Intelligent ground fault detector reporting on the Gavia Control Bus.
Safety overpressure valve	The safety overpressure valve opens if the pressure build-up inside Gavia exceeds a set limit.

Sensors	1. Pressure sensor, Manufactured by Keller AG, Switzerland 2. Electronic compass
Software	Gavia Intelligent Artificial Crew
Temperature range	Operating: 0°C to +40°C Storage: -20°C to +60°C Extended range available.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

4.6 OPERATING ENVIRONMENT

Gavia is designed for operation in seawater but can as well be operated in fresh water. Gavia is designed to have slight reserve buoyancy in fresh water. When used in seawater her weight is increased to account for the increased density of seawater.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

5 OPTIONAL GAVIA MODULES AND EQUIPMENT

Several optional modules can be added to the Gavia Base Vehicle without affecting the performance and stability. The optional Gavia modules are described below. Modules can also be custom made for particular applications and equipment as desired.

All sensors are high-grade off-the-shelf products supplied to Hafmynd from instrument manufacturers. The modules are interconnected by hand using the built-in QuickLock system that snaps the modules together mechanically and electrically.

The Gavia Intelligent Artificial Crew reflects the modular mechanical design and facilitates the integration of new modules with or without new crewmembers. See the 'CAPTAIN AND HIS CREW' and 'HOW TO DESIGN A GAVIA PAYLOAD MODULE'. Thus it's a simple matter to add a module to suit a particular application.

The following modules and systems are currently available:

1. High-performance digital camera
2. DVL-aided INS module
3. Single frequency side-scan sonar
4. Dual frequency side-scan sonar
5. Scientific CTD
6. Sound velocity meter
7. Forward-looking obstacle avoidance sonar
8. Acoustic communication module
9. Payload module

The following will be available in 2004:

GeoSwath bathymetric module

These are described below.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

5.1 HIGH-PERFORMANCE DIGITAL CAMERA

The camera is mounted in the Nosecone Module. This is a high-performance low-light variable frame rate digital camera with 1280x1024 resolution and 12 bit colour depth together with a dedicated PC computer and hard disk for data storage. Video frame-rate capability and / or single shot. Floodlight or strobe is provided through a view port at the bottom of the CONTROL AND COMMUNICATION MODULE. Thus a separate strobe module is not required unless there are special requirements on lighting.

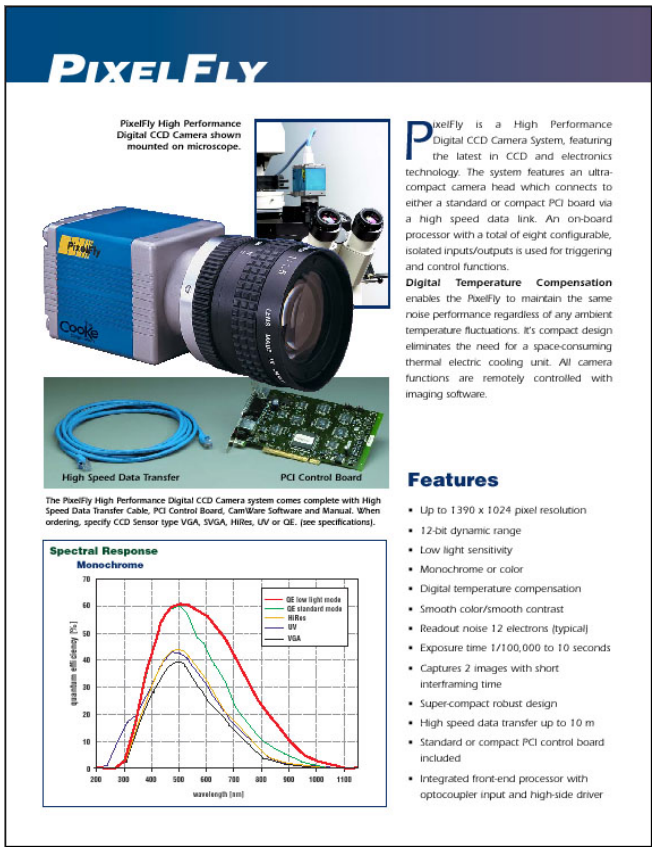


Figure 10 The PixelFly CCD camera.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

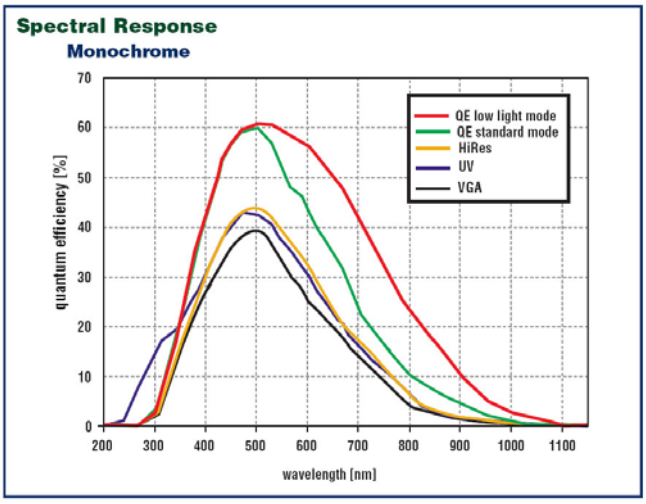


Figure 11 Spectral response of the PixelFly CCD camera.

TECHNICAL SPECIFICATIONS

For detailed technical specifications see the section on PixelFly High Performance Digital Camera.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

5.2 DVL-AIDED INS MODULES

Figure 12 Gavia DVL-aided INS Module.

Buoy-free navigation is accomplished by the STANDARD-PRECISION or the HIGH-PRECISION DVL-aided INS MODULES containing the Kearfott Guidance T-16 IMU and T-24 IMU respectively, and the new 600 kHz Phased Array DVL from RD Instruments. This provides very good navigation performance underwater with positional drift of less than 3 m/h for the High-precision type and less than 20 m/h for the Standard precision type, with DVL in bottom lock (within 90m of the bottom). When operating at an altitude above 90 meters the INS operate without DVL-aiding and navigation is purely inertial and much less accurate.

The new 600 kHz Phased Array DVL provides bottom tracking to an altitude of around 90 meters. It is also used to keep a constant altitude over the seabed in bottom track mode, for example, while photographing. In applications requiring close-range photography an altitude as low as 1 metre is normal assuming a relatively flat bottom.

The module is splash proof, facilitating on-deck replacement.

5.2.1 RD INSTRUMENTS DOPPLER VELOCITY LOG

RD Instruments
Acoustic Doppler Solutions

Hafmynd has selected the RD Instruments Workhorse Navigator for the Gavia AUV. This DVL is the industry's first choice for precision navigation applications. RDI's Workhorse DVL has been designed to provide high rate precision velocity, direction and altitude updates for a wide variety of underwater tasks. RDI's Workhorse Navigator offers:

1. Phased array DVL with one circular transducer, potted with Epoxy for protection.
2. Patented BroadBand™ processing technology, providing users with both short and long term high precision velocity data.
3. Reliable and accurate high rate navigation and positioning data
4. Proven bottom detection algorithms, and single-ping bottom location, for robust and reliable bottom tracking over indeterminate terrain
5. Superior low altitude bottom tracking capability
6. Frequency is 600 kHz.
7. Bottom lock range is typically 90 m.
8. Approximately 7 pulses are emitted per second.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

TECHNICAL SPECIFICATIONS

For full technical specifications, please refer to the RD Instruments data sheet at the end of this document.

Acoustic Doppler Current Profiler (ADCP)

The DVL is available with a 600 kHz ADCP option with down-looking and up-looking transducers. The ADCP allows the vehicle to measure water velocity and direction above and below the vehicle and also provides echo intensity. Echo intensity or current velocity may be reported as a function of depth. The transducer also measures the velocity of the vehicle relative to the bottom as well as its altitude above the bottom. The velocity information, as well as the vehicle's heading, are used to compute the absolute magnitude and direction of the current. In addition, the velocity information relative to the seabed provides a very accurate dead-reckoning navigation input. The altitude measurement, when coupled with the vehicle's position and depth, provides the seabed bathymetry, and is also used as an input to the vehicle controller when operating in constant-altitude mode.

5.2.2 KEARFOTT GUIDANCE AND NAVIGATON CORPORATION

Figure 13 The Kearfott T24 high performance INS system.

For technical specifications of the Kearfott INS, please refer to the data sheet at the back of this document.

TECHNICAL SPECIFICATIONS OF THE DVL AND INS MODULE

Length and weight of T-16 INS	300 mm, 9,5 kg
Lenght and weight of T-24 INS	380 mm, 12,0 kg
Diameter	200 mm
Buoyancy in fresh water (kg):	0
Power of T-24 INS	<30 W
Power of T-16 INS	<25 W
DVL	
Frequency:	600 kHz
Range:	0.5 to 90 m
POWER CONSUMPTION	3 W

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

5.3 BATTERY MODULE

Figure 14 Gava Battery Module.

5.3.1 LiIon RECHARGEABLES

The Battery Module contains several independent “smart” LiIon battery packs and “smart” battery chargers. Each battery pack is monitored for 'health' and information on discharge current, charge current, number of charge cycles to date, battery voltage, internal battery temperature etc. The battery packs are protected against short-circuit and overcharge. The battery packs are controlled by an intelligent Switch, which provides optimum energy utilization under various operating conditions.

Total energy capacity of the Battery Module is 1 kWhour. The Battery Module can be charged in the vehicle or as a stand-alone unit. An external DC-source, such as the Gavia Mains Adapter, supplies power to the chargers. It is offered separately (see Surface Equipment). Alternatively a set of car batteries can be used for providing power to the battery chargers.

Battery modules can be swapped in minutes for rapid turnaround. More than one battery modules may be used in GAVIA at the same time to increase the range and duration.

5.3.2 LITHIUM PRIMARIES

Oprionally Lithium Primaries are available instead of the LiIon rechargeable for increased range and endurance. The Lithium primaries have a shelf life of 10 years.

Both Battery modules are splash proof, facilitating on-deck replacement.

Figure 15 Gavia Mains Adapter

TECHNICAL SPECIFICATIONS OF BATTERY MODULE

Full charge requires approximately 4 hours. The on-board chargers enter trickle charge on completion of the fast charge. Charger efficiency is around 80%.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

Length	380 mm (net length when installed in Gavia)
Diameter	200 mm
Weight	12 kg
Volume	12 l
Buoyancy in fresh water	0 kg
Battery chemistry	a) Rechargeable LiIon
	b) Lithium primaries
Energy capacity	a) 1000 Whour for LiIon rechargeables
	b) 2500 Whours for Lithium primaries
Discharge operating temperature	-20°C to 60°C
Charging temperature range:	0°C to 40°C
Storage temperature range:	-20°C to 60°C

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is

USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

5.4 SINGLE FREQUENCY SIDE-SCAN SONAR

The side scan sonar is made by Marine Sonic, Inc. www.marinesonic.com. Frequencies are available from 150 kHz to 2.4 kHz. The transducers are mounted at the optimum angle for the frequency. The sonar electronics are located inside the Control and Communication module and can be moved between vehicles by a trained technician. The transducer mounting holes are closed by blind-plugs if the transducers are removed. The plugs are included.

TECHNICAL SPECIFICATIONS

TOWFISH SPECIFICATIONS						
kHz	**DF***	**150**	**300**	**600**	**900**	**1200**
Length (m/in)	1.1/42	1.1/42	1.1/42	1.1/42	1.1/42	1.1/42
Diameter (cm/in)	15.6/6	10.2/4	10.2/4	10.2/4	10.2/4	10.2/4
Weight in air (kg/lbs)	29.5/65	16.8/37	15.9/35	15/33	15/33	15/33
Pulse Length (usec/cycles)		33/5	20/6	10/6	6.7/6	5/6
Typical Range Resolution - (cm/in)		58/23 @300M	29/11.4 @150M	9.7/3.8 @50M	7.8/3 @40M	3.9/1.5 @20M
Axial Resolution - aperture size (cm/in)		61/24	61/24	30.5/12	22.9/9	15.2/6
Typical Maximum Range (meters)		300-400	200+	75+	40+	25+

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is

USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

5.5 DUAL-FREQUENCY SIDE-SCAN SONAR

This is a 900/1800 kHz dual-frequency side-scan sonar made by Marine Sonic Technology Inc., USA. Two sets of transducers are mounted at the optimum angle for the frequency. The sonar electronics are located inside the Control and Communication Module and can be moved between vehicles by a trained technician. The transducer mounting holes are closed by blind-plugs if the transducers are removed. The plugs are included.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

5.6 SCIENTIFIC CTD

5.6.1 SeaBird SBE 49 FastCAT CTD

This is an integrated CTD sensor intended for use as a modular component in towed vehicles, ROVs, AUVs, or other autonomous platforms that can supply DC power and acquire serial data. FastCAT's pump-controlled / TC-ducted flow feature minimizes salinity spiking, and its 16 Hz sampling provides very high spatial resolution of oceanographic structures and gradients.

The SBE 49 FastCAT's temperature thermistor and conductivity cell are the same as used in SeaBird's premium 911 plus CTD system, while its pressure sensor is the superior, micro-machined, silicon strain gauge recently developed by Druck Inc. Sophisticated interface circuitry provides very high resolution and accuracy.

The SeaBird SBE 49 is an easy-to-use, light, and compact instrument made of titanium and other low-maintenance materials. It is well suited to a small vehicle like Gavia. There are straightforward commands for continuous (full rate or averaged) or single sample acquisition. EEPROM-stored calibration coefficients permit data output in ASCII engineering units (degrees C, Siemens/m, decibars, salinity [PSU], and sound velocity [m/s], or the user can select raw data output if desired.

FastCAT is powered from Gavia and is mounted piggyback on the vehicle. The RS-232C data is logged by Gavia's PC computer.

TECHNICAL SPECIFICATIONS

	Measuring range	Initial accuracy	Typical stability (per month)	Resolution
Conductivity	0 - 9 S/m	0.0003 S/m	0.0003 S/m	0.00005 S/m
Temperature	-5 - +35°C	0.002°C	0.0002°C	0.0001°C
Pressure	up to 2000 m	0.1% of f.s.	0.004% of f.s.	0.002% of f.s.

For detailed technical specifications please refer to www.seabird.com.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

5.7 SOUND VELOCITY METER

The Sound Velocity Meter is intended for correcting sonar data for variations in the speed of sound through water. The Sound Velocity Meter comes with the Gavia Sound Velocity Operator. Please contact Hafmynd for details.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

5.8 FORWARD-LOOKING OBSTACLE AVOIDANCE SONAR

The Forward-looking Sonar is located in the front of the Nosecone Module sending out a conical-shaped beam. The Gavia Collision Avoidance Pilot takes care of steering Gavia around the obstacle or stopping her. For details please contact Hafmynd.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

5.9 ACOUSTIC COMMUNICATION MODULE

Figure 16 Acoustic communication module

Figure 17 Topside unit for acoustic modem.

The Acoustic Communication Module contains an acoustic modem made by LinkQuest Inc., USA. Two types of modems are available, the UWM2000H and the UWM3000H http://www.link-quest.com. The modems have been tested under the most demanding conditions in very shallow water, achieving a range of 1 to 1.5 km at water depths of only 1 to 5 m. The modems offer full bi-directional data and mission transfer, using TCP/IP and also provide real time vehicle tracking to permit operators to remotely monitor mission progress and vehicle location while the AUV is submerged. LBL/USBL options are available. Please contact Hafmynd for details.

The module is splash proof, facilitating on-deck replacement.

TECHNICAL SPECIFICATIONS OF ACOUSTIC COMMUNICATION MODULE

Length	150 mm (net)
Diameter	200 mm
Weight in air	4.7 kg
Volume	4.7 l
Buoyancy in fresh water	0

5.9.1 UWM2000 ACOUSTIC MODEM SPECIFICATIONS

Working range:	1500 meters (narrow beam) 1000 meters (omni)
Maximum depth:	200 meters (surface unit) 1000 meters (bottom unit)

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

RS-232 data rate:	9600 bits/second
Payload data rate:	6600 bits/second
Acoustic link:	17.8k bits/second
Bit error rate:	less than 10^{-7}
Transmit mode power consumption:	4 Watts (narrow beam) or 8 Watts (omni)
Receive mode power consumption:	0.8 Watt
Sleep mode power consumption:	8 mW
Beam width of transducer:	210 degrees, omni-directional or 60 degrees, narrow beam
Operating Frequency:	26.775 to 44.625 kHz
RS-232 Configuration:	9600 baud, 1 start bit, 1 stop bit, no parity bit, and no flow control
RS-232 input data buffer:	900k bytes
Voltage:	9 to 24 volts
Operating temperature:	-2 to 45 °C
Storage temperature:	-5 to 75 °C
Overall length:	249.7 mm
Housing diameter:	87.2 to 126.2 mm
Weight out of water:	4.8 kg
Weight in water:	2.6 kg
Optional Higher Data Rate	19.2k bits/second

5.9.2 UWM3000 ACOUSTIC MODEM SPECIFICATIONS

Working range:	3000 meters
Maximum depth:	700, 3000, or 6000 meters
RS-232 data rate:	2500 bits/second
Payload data rate:	2000 bits/second
Acoustic link:	5000 bits/second
Bit error rate:	less than 10^{-7}
Transmit mode power consumption:	3 to 12 Watts
Receive mode power consumption:	1 Watt
Sleep mode power consumption:	10 mW

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

Beam width of transducer:	210 degrees, omni-directional
Operating Frequency:	7.5 to 12.5 kHz
RS-232 Configuration:	9600 baud, 1 start bit, 1 stop bit, no parity bit, and no flow control
RS-232 input data buffer:	900k bytes
Voltage:	18 to 28 volts
Operating temperature:	-2 to 45 °C
Storage temperature:	-5 to 75 °C
Overall length:	410 mm
Housing diameter:	140 mm
Weight out of water:	5.6 kg
Weight in water:	2.0 kg
Optional Higher Data Rate	5000 bits/second

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

5.10 PAYLOAD MODULE

Figure 18 Gava Payload Module.

The PAYLOAD MODULE is available for custom sensors and equipment. The Payload Module may contain, for example, a PC computer running a specialized algorithm for controlling Gavia in a certain way. For further information please consult Hafmynd.

Standard voltages used are +5 V and +12 V, generated by DC-DC converters, in addition to the raw battery voltage

The module is splash proof, facilitating on-deck replacement.

A software development kit (SDK) is available for the Payload module.

TECHNICAL SPECIFICATIONS OF PAYLOAD MODULE

Length	depending on requirements
Diameter	200 mm
Weight in air	depending on length and equipment
Volume	depending on length
Buoyancy in fresh water	depending on weight and length
Power	available for the payload

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

5.11 GeoSwath BATHYMETRIC SONAR MODULE - UNDER DEVELOPMENT

Figure 19 GeoSwath module (under development).

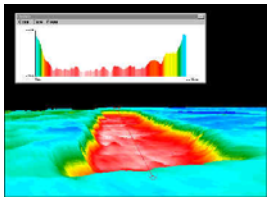


Figure 20 GeoSwath bathymetry

CinC (Commercial in Confidence)

GeoSwath is a PC based, swath bathymetry system supplied by GeoAcoustics Ltd., UK, which meets IHO standards for hydrographic survey. The GeoSwath swath bathymetry system offers swath coverage of up to 12 times water depth. http://www.geoacoustics.co.uk/Home.htm

GeoAcoustics will soon be offering a GeoSwath module for the Gavia AUV system, containing the new GeoSwath bathymetric sonar. Fitted on the Gavia AUV the GeoSwath can be used for deep and shallow water survey. This project exemplifies the flexibility of the Gavia modular system, with its standard mechanical, electrical, and software interfaces. Price, availability, and specifications of this module are to be announced.

The module is splash proof, facilitating on-deck replacement.

TECHNICAL SPECIFICATIONS OF GeoSwath MODULE

To be announced

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

6 SURFACE EQUIPMENT

The following surface equipment is offered:

6.1 STANDARD SURFACE EQUIPMENT

6.1.1 LAPTOP PC

Windows operating software (latest version). English keyboard and display. Latest version of the Gavia AUV GUI is installed, ready for use. The PC includes a wireless PCMCIA LAN card with high data rate.

6.1.2 HIGH-GAIN WIRELESS LAN ANTENNA

A directional wireless LAN antenna, antenna amplifier (subject to local regulations) and cables.

6.1.3 IRIDIUM SATELLITE TELEPHONE

Iridium satellite handset for data and voice communications, including two rechargeable LiIon battery packs, data cable and external roof-mount antenna.

6.1.4 GAVIA MAINS ADAPTER

The Gavia Mains Adapter is used for powering the on-board battery chargers while charging. Alternatively a set of car batteries can be used.

6.1.5 GAVIA OPERATOR SOFTWARE SUITE (GUI)

This is the latest version of the Gavia AUV GUI, installed on the laptop PC.

6.1.6 CARRYING FRAME

The carrying frame is made of anodised aluminium. Straps are included for fixing Gavia to the frame.

6.1.7 TRANSPORT CASES

Gavia is delivered in watertight Pelican cases. A smaller Pelican case is used for the laptop PC and Iridium handset.

6.1.8 TOOLS

A set of hand tools.

6.1.9 SPARE PARTS

A complete set of O-rings and O-ring lubrication.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

6.2 OPTIONAL SURFACE EQUIPMENT

6.2.1 ACOUSTIC SURFACE (top-side) MODEM TRANSPONDER

This is included with the Acoustic Communication Module installed in Gavia. Provides also real time vehicle tracking to permit operators to remotely monitor mission progress and vehicle location while the AUV is submerged.

Figure 21 Topside transponder for acoustic modem.

6.2.2 PRESSURE CALIBRATOR

This is a digital microprocessor controlled manometer. Fittings are included for screwing into the pressure sensor valve on the Control and Communication module of Gavia.

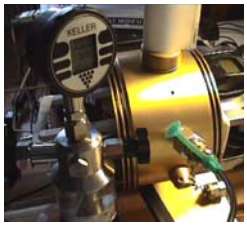


Figure 22 Pressure calibrator.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

7 GAVIA MAINTENANCE AND SUPPORT

Each Gavia module has its own intelligent processor, which allows it to be connected to a PC-computer, using ordinary Ethernet LAN (local area network), while being serviced or tested. Software for doing this is available from Hafmynd along with a mains adapter for powering the module during the tests.

The following can be tested:

1. Gavia electrical bus and Bus-connectors.
2. The Nosecone Module, including the optional digital camera, mounted in the Nosecone Module. The camera is controlled by a PC-computer inside the Nosecone Module.
3. The Battery Module.
4. The Control and Communication Module, including the
   a) GPS receiver (GPS test-antenna must be fed to open air ie external to building)
   b) Iridium satellite link (Iridium test-antenna must be fed to open air ie external to building)
   c) Wireless LAN link
   d) Side scan sonar, using "rub-test" of the transducers and/or dummy loads instead of the transducers.
5. Acoustic Communication Module.
6. Optional modules.

Some of these tests can also be performed on the Gavia vehicle itself, i.e. with the modules combined into a fully assembled vehicle.

The pressure sensor on Gavia should be calibrated once a year. This is done using the Pressure Calibrator, which is screwed into the pressure port on the Control and Communication Module of Gavia as shown in the photo below. Instructions are provided in the User's Manual. If the owner of Gavia intends to do this himself, he must purchase the pressure calibrator.

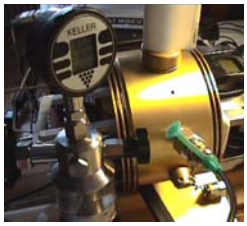


Figure 23 Pressure calibrator screwed into the pressure port of Gavia.

7.1 DESIGNED FOR LOW MAINTENANCE

Gavia is designed for harsh environments and rugged handling as is evident from looking at the vehicle. The propeller and control fins are shielded by the propeller nozzle thereby greatly reducing the danger of snagging or accidental damage from hitting objects or accidental banging against a ship's hull.

Data downloading and mission uploading are performed by a wireless link not requiring any cables or connectors nor does the vehicle have to be brought on board a boat or vessel for these tasks.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

Gavia's hull is made from corrosion-resistant aluminium alloy. For further protection the metal surface is hard anodised in a golden colour providing visual detection at sea. (Other colours are available for special applications). Double O-rings provide sealing at module joints and there is an additional O-ring seal on the end-panels of each module protecting the electronics, facilitating on-deck module replacement.

Reliability of operation has been assured through modular design and clearly defined responsibilities of the Intelligent Artificial Crew that is found aboard all Gavia vehicles, irrespective of configuration. Members of the crew execute instructions as separate processes on the networked PCs running the open source Linux operating system kernel, while time-critical functions are handled by the real-time micro-controller network.

The Battery Module contains several "Smart" LiIon battery packs that have an SMBus interface (System Management Bus). Each battery pack is monitored for 'health' and information on discharge current, charge current, number of charge cycles to date, battery voltage, internal battery temperature etc. The control software of Gavia "tells" the operator when it's time to replace the battery packs. The manufacturer of the LiIon battery packs recommends that they be replaced after approximately 200 full charge cycles.

O-rings should be routinely replaced once per year and should be performed by a qualified Gavia technician according to the Gavia Maintenance Manual.

7.2 SPARES

Gavia is made up of several individual cylindrical modules that are locked together using a twist-lock system forming a single rigid pressure hull. The Module twist-lock system accommodates mechanical and electrical interfaces between the modules, providing for mechanical attachment, pressure hull sealing and electrical connection.

An MCM vehicle may consist of the following modules:

1. Nosecone Camera Module with view port
2. Battery Module(s), mission duration dependent
3. Control and Communication Module, incorporating side-scan sonar.
4. Acoustic Modem Module with LBL/USBL capability.
5. Propulsion and actuator module with control planes protected by propeller nozzle.

The electrical interface within the twist-lock system provides three functions:-

1. Electrical power, for feeding power to the modules from the Battery Module(s).
2. Control signals, bi-directionally between Modules.
3. Ethernet LAN (local area network) for high-speed data transfer between the modules.

This modular concept simplifies maintenance (see also the top of this document). Firstly, any module may be replaced by a new generation module without concerns about Module internal components.

For example, should a module need replacement within say 5 years, it will be replaced with a currently available module, this may differ from the original internally but will perform in the same manner as original Module in every way. This is achievable by careful design and well-defined electrical and mechanical interfaces. An example - an acoustic modem with the latest performance capabilities may be

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

installed in a Gavia vehicle whenever it is deemed necessary and without presenting interface difficulties to the user.

All Gavia modules and parts carry a 2-year ex-works warranty against parts defects and workmanship.

Hafmynd guarantee includes the availability of replacement modules and spares for at least 5 years following signing of contract with the customer. Hafmynd also guarantees a fixed price for modules and spares for a 5 year period at not to exceed 5% higher than the current 2003/4 list price.

Other details of this guarantee are under finalisation by Hafmynd.

The propeller and fins are well protected inside the nozzle and therefore not prone to damage. Therefore they are not listed in the recommended spare parts list.

7.2.1 SPARES RECOMMENDED / REQUIRED TO BE HELD COSTSPER YEAR

Sensor module-specific spares are not included in the following listing as there may be special spares for some sensor modules and transducer assemblies.

We recommend the following spares as a min for routine service, one set per vehicle per year. These are available from Hafmynd ltd or via approved Representative agencies.

Item	Quantity	Comments
1. Ballast weights	2	Fitted inside Gavia at the end-panels of each module.
2. On/off magnet	1	For vehicle activation
3. Blanking plugs	2	One for each of the two underwater connectors on the Control and Communication Module (one connector is used while charging the batteries and the other is used for powering and communicating with an optional piggy-back-mounted sensor, such as a sound velocity probe or CTD)
4. O-ring kit	1	A complete kit of O-rings for Gavia
5. O-ring lubrication	1	A tube of O-ring lubrication.

The current list price of these min recommended spares is GBP 195.

Other spares such as propeller and fins are not considered required since these are well protected inside the propeller nozzle. The Propeller nozzle itself and the Propulsion and Actuator Module is available from Hafmynd ltd as a spare unit if customer requires a full module replacement.

Remote location Spares Kit:

Available for distant an/or long duration / critical operations. Factory will advise according to operational requirements to be confirmed by customer.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

7.3 USER DOCUMENTS FOR GAVIA

A user's guide and maintenance manual is supplied with Gavia. The manuals include system description, operation, procedures for checking Gavia, mission planning, the use of the Gavia GUI (graphics user interface), safety and troubleshooting.

7.4 CONTRACTOR SUPPORT

Hafmynd guarantee provides that replacement (spare) modules will be available for at least 5 years after signing of contract and that the price will be fixed, subject to a max 5% increase over current list prices, for the same period of time.

7.5 LIFE EXPECTANCY

Based on experience with Gavia and oceanographic instrumentation (for over 20 years) it is possible to keep Gavia in service for at least 10 years. This however depends on the quality of operations maintenance and service routines during the life cycle. Some external parts may have to be replaced earlier because of damage caused by operational hazard and fair wear and tear.

The most fragile part of Gavia had been the control rudders, which in the earlier version of Gavia, protruded out of the hull. Some were damaged or lost in operations and although being quickly replaced or repaired, the design required change. In the current new version of Gavia this problem no longer exists since the rudders have been moved and installed within the propeller nozzle, protected by the nozzle. The nozzle also protects the propeller and prevents it from contact with seabed objects, which might otherwise cause damage.

The plastic antenna housing has proved to be efficient and very reliable and our customers or our test team have never had to replace it on our test vehicles. However, damage to the antenna tower by, say a boat propeller can't be ruled out. The cabling from the Module hull to the plastic antenna housing is sealed so that leakage into the vehicle cannot occur.

Gavia has in numerous cases hit the seafloor, rocks and even crashed into a fibreglass boat. This has never caused any but minor damage apart from the earlier design rudder assy's, now redesigned as mentioned above.

7.6 TRAINING SEMINAR

The Gavia AUV is designed to be easily operated using equipment such as a laptop PC and the Gavia Software User Interface (GUI). Although training by Hafmynd's personnel is not necessary, it may be advantageous. Therefore Hafmynd provides training courses for Gavia operators. These courses are available at Hafmynd's facilities or can be held at the customer's location. Please contact Hafmynd – Gavia for information.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

8 SeeTrack DATA ANALYSIS SOFTWARE

SeeTrack rapid mission visualization and CAD/CAC (computer aided detection / computer aided classification) analysis software is offered with the Gavia system in co-operation with SeeByte Ltd., Edinburgh http://www.seebyte.co.uk

This includes both on-board CAD/CAC (detection) and topside mission analysis software for rapid mission visualization and mine classification.

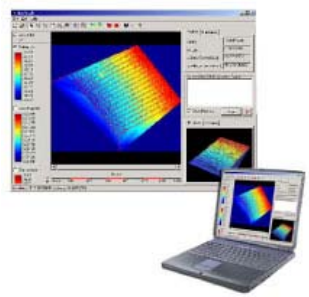


Figure 24 SeeTrack rapid mission visualisation and CAD/CAC analysis software.

The on-board CAD/CAC runs in real-time on the Gavia vehicle analysing side-scan sonar imagery on the fly for possible contacts. Details of contact position and relevant side-scan sonar snippets can be transmitted to the operator for classification mid-mission.

SeeTrack is a modular system, comprising a core system and several optional modules each providing a particular functionality. Two example systems are given below:

8.1 BASIC SYSTEM

The basic system bundle comprises:

- SeeTrack Core MCM System for rapid mission visualization
- Sonar Mosaicing option
- Mission Planning option

8.2 ADVANCED SYSTEM FOR MINE COUNTER MEASURES (MCM)

The Advanced System bundle consists of the Basic System bundle together with the following additional options:

- CAD/CAC on Sonar option
- CAD/CAC on Video option
- Navigation and Advanced Navigation processing option
- Sensor Fusion option

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

9 APPLICATIONS AND DATA EXAMPLES

Gavia's unique design allows her to be used in the most varied applications, ranging from general oceanography to mine counter measures. The modular design, which allows rapid battery replacement, supports high-speed search missions where time is critical. The 2000-meter depth rating is valuable for deep-water oceanography but at the same time makes Gavia's hull withstand the rough environment of the surf zone.

	Nosecone Module	Battery Module	Control and communication Module	Propulsion and steering Module	ADCP/DVL Module	DVL aided INS Module Standard Precision	DVL aided INS Module High Precision	Single frequency side scan sonar option	Dual frequency side scan sonar option	Interferometric side scan sonar Module (GeoSwath)	Camera option	CTD	Sound velocity probe	Scientific sensors as required	Navigation sonar option
Gavia base vehicle	√	√	√	√											
Gavia MCM vehicle	√	√	√	√			√		√		√		√		√
Gavia survey vehcle (IHO standard)	√	√	√	√			√			√			√		
Gavia research vehicle	√	√	√	√	√			√			√	√		√	
Gavia pipeline inspection vehicle	√	√	√	√			√			√	√		√		√

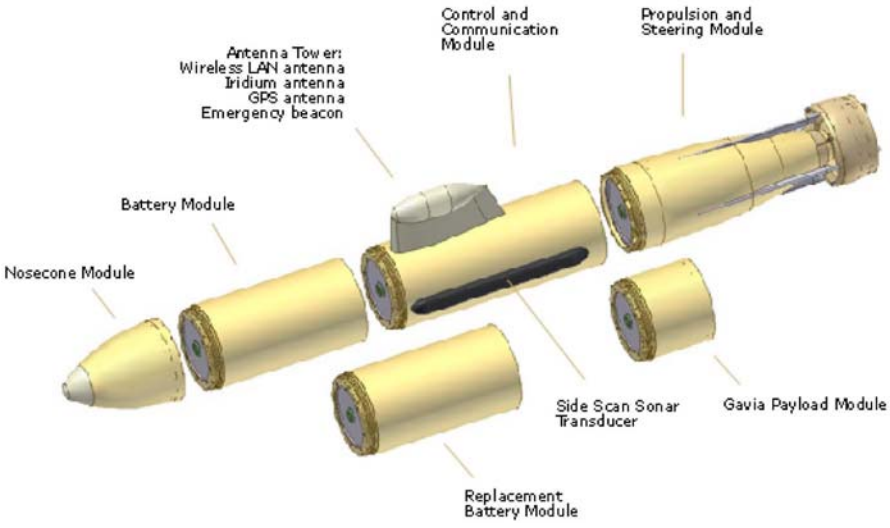


Figure 25

The chart vividly illustrates the Gavia AUV's unmatched versatility and gives possible mission configurations. The Gavia can be configured in virtually any manner to suit the mission at hand.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

9.1 DATA EXAMPLES

Figure 26 A crab, Hyas araneus, posing for Gavia at close range (detail from photo shot with 4 M-pixel nosecone-mounted digital camera and strobe).

Figure 27 Cucumaria frondosa lurching on the bottom.

Figure 28 Debris on the seabed photographed by Gavia (shot with a 4 M-pixel digital camera and strobe).

Figure 29 A digital video camera can be mounted in the nosecone of Gavia or at the front of the antenna tower, giving a better view when Gavia is surfaced. (This photo is shot with a Sony digital video camera).

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

Figure 30 A digital video camera mounted in the nosecone of Gavia. (Shot with Sony digital video camera and ambient illumination).

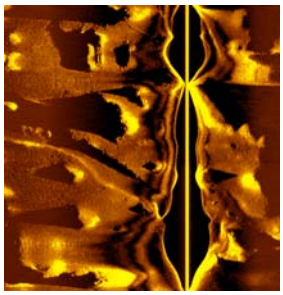


Figure 31 Dramatic feature on the seabed as seen with the Marine Sonic 600 kHz side scan sonar, range 30 m.

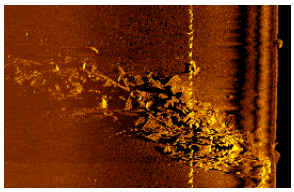


Figure 32 This side scan sonar image shows the wreck of a ship that exploded on the surface a few years ago.

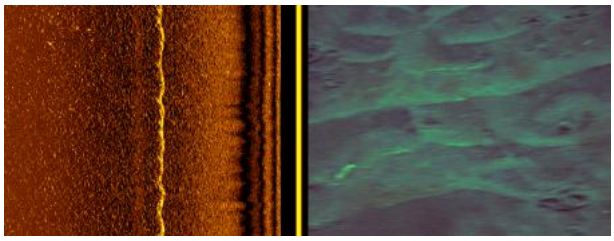


Figure 33 The Seabed of fjord Thistilfjordur in Iceland, which has a high population of scallops. Picture taken during a mission by the Marine Research Institute of Iceland in 2002. Compare texture seen on the side-scan sonar image to the picture, which was shot simultaneously.

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com

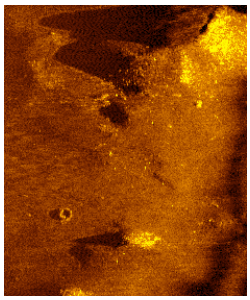


Figure 34 Detail of a side scan sonar image showing a car tire lying on the seabed. (Marine Sonic 600 kHz side scan sonar).

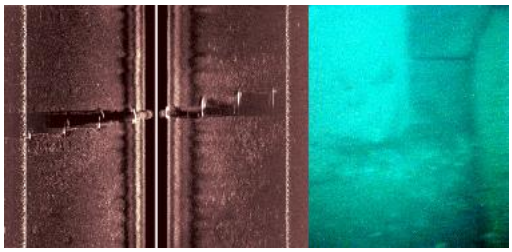


Figure 35 Photo shot by Gavia in 2002 using digital camera and ambient illumination at a depth of 40 m, showing part of a sewage pipe . The same sewage pipe is seen on the 600 kHz side scan sonar, set at a range of 30 m (on each side).

EUROPE: HAFMYND - GAVIA LTD
Fiskislod 73, 101 Reykjavik, ICELAND
tel: +354 511 2990, fax: +354 511 2999, e-mail: info@gavia.is
USA: GAVIA AUV CORPORATION
880 Calle Plano, Unit K, Camarillo, CA 93012
tel: (805) 484 6639 fax: (805) 484 9012, e-mail: info@gavia-auv.com