Hydro INTERNATIONAL

AUVs

The first Autonomous Underwater Vehicles (AUVs) were developed in the 1970s at the Massachusetts Institute of Technology. AUVs are submersible platforms that are rapidly gaining a foothold in the offshore-survey industry. In military applications the vehicles are also known as Unmanned Undersea Vehicles (UUVs).

They are powered by batteries or fuel cells and can operate in water as shallow as several metres to depths of 6,000 metres. Developments in propulsion systems and power-source technology are providing these vehicles with extended endurance, both in time and distance. The offshore-survey industry uses AUVs for detailed mapping of the seafloor, allowing oil companies to install sub-sea completions and pipelines in the most cost-effective manner and with minimum disruption to the environment. A typical military mission for an AUV is to map an area for mine detection purposes. Scientists deploy AUVs to study the ocean and the ocean floor using INS, side-scan sonar, multi-beam echo sounders, magnetometers, thermistors, and other underwater sensors including AD(C)Ps and water-quality sensors.

Developments are underway to render AUVs capable of sub-sea intervention (interaction with sub-sea structures) and deep-sea mining (manganese nodules) as opposed to fly-by data collection. Most AUVs work in conjunction with surface vessels for support and navigation, although ultra-low-power, long-range variants are becoming capable of operating unattended for weeks or months at a time, periodically relaying data to shore by satellite before returning to be picked up.

AUVs are also playing an increasingly significant role in harbour survey. AUVs used for regular survey, optionally in combination with MCM for port security purposes, carry various sensors, from acoustic and optical-imaging devices to environmental and navigation systems.

AUVs are not yet commonly used in the dredging industry. Purchase costs have up until now been quite high, but low-cost, high-performance AUVs (LCAUV) such as the Hafmynd Gavia are currently available at a price considerably lower than conventional survey craft. And as such a vehicle can execute a survey in less time, using fewer personnel and less fuel, the purchase of an LCAUV is becoming an increasingly attractive idea.

This product survey gives an overview of currently available AUVs. However, we realise that the list is not complete, since every day new developments take place and the AUV market is one of the fastest growing within the survey industry. We welcome any input, suggestions and comments from manufacturers and users of these wonderful, independent underwater survey platforms. ■

Company	ATLAS MARIDAN ApS	ATLAS ELEKTRONIK GmbH
Name of Product	ATLAS MARIDAN SeaOtter MkI	ATLAS MARIDAN SeaOtter MkII
Vehicle Type	Autonomous Underwater Vehicle	Autonomous Underwater Vehicle
Total Number of AUVs built	5	under development
Commercial Options	Seabed Mapping, Hydrographic Surveys	Seabed Mapping, Hydrographic Surveys
Physical characteristics		
Weight of AUV (in air) (kg)	1500 kg	1100 kg
Maximum payload (kg)	300 kg	❑
Freight weight (kg)	❑	❑
Dimensions (LxWxH) (m)	4.5 x 1.2 x 0.6	3.45 x 0.98 x 0.48
Maximum depth rating (m)	600	600
Number of Thrusters: Directional / Lateral control	2/0	2 / 3
AUV hover capabilities	no	yes
Minimum Turning radius (m)	10m (adjustable)	< 10m
What type of Launch & Recovery system is used, how is the AUV recovered	Dedicated docking head which can be used from any crane/ davit in combination with a capstan (ATLAS LARS system)	Dedicated docking head which can be used from any crane/ davit in combination with a capstan (ATLAS LARS system)
Navigation and Payload		
Navigation sensors - standard	MARPOS Inertial Navigation System coupled with Doppler Log, DGPS, CTD and Pressure Sensors	MARPOS II Inertial Navigation System coupled with Doppler Log, DGPS, CTD and Pressure Sensor, full backup in hardware, software and algorithms
Navigation sensors - optional	USBL, LBL, Synthetic LBL	USBL, LBL, Synthetic LBL, SLAM
In case of an INS installed, what Navigation sensors are used to update position during a dive		
Payload Sensors - Standard	Klein 2000, Reson 8125 Multi-Beam Echosounder, Subbottom Profiler Geochirp	ATLAS Multi-Beam Multi-Aspect SAS Sonar
Payload Sensors - Optional	Customer selectable	Customer selectable
Battery and Endurance		
Total energy content of battery (kWh)	❑	❑
Nominal battery power (W)	❑	❑
Endurance at nominal power (hours)	7 (lead acid), 15 (NiMH)	24 @ 4kn
Average Speed / Maximum Speet (knots)	3/5	4/8
Telemetry and Control		
Is acoustic telemetry fitted / Baud rate (bits per sec)?	Acoustic Modem	Acoustic Modem
Is Radio telemetry fitted / Baud rate (bits per sec)?	Data Radio, WLAN	Data Radio, WLAN
What data is sent to the surface?	❑	❑
What control parameters are sent to the AUV?	❑	❑
In the event of a total system failure what is the emergency recovery procedure?	Dropweight Release, ARGOS Pinger, Strobe and VHF Beacon, Emergency Pinger	Airbag System, ARGOS Pinger, Strobe and VHF Beacon, Emergency Pinger
Apllications and Forecasts		
Current AUV Applications	Seabed Mapping, Hydrographic Surveys, Minehunting, Rapid Environmental Assessment	Minehunting, Rapid Environmental Assessment, Intelligence, Surveillance and Reconnaissance, Force Protection, Seabed Mapping, Hydrographic Surveys,
Forecast for the total number of commercial AUVs in operations worldwide, in 5 years time	❑	❑
Forecast for the major application area of AUVs, in 5 years time	❑	❑
Additional Notes & Comments	❑	❑

N/A Not Applicable
❑ No information received

C+C Technologies	C+C Technologies	C+C Technologies	Fugro
C-Surveyor-I	C-Surveyor-II	C-Surveyor-III	Echo Surveyor
Kongsburg Simrad: Hugin 3000 with C & C upgrades and software	Kongsburg Simrad: Hugin 3000 with extended hull, C & C upgrades and software	Kongsburg Simrad: Hugin 4500 with extended hull, C & C upgrades and software	Hugin 3000
3	❑	❑	2
Geophysical Survey, Pipeline Route Survey, Cable Route Survey & Environmental	Geophysical Survey, Pipeline Route Survey, Cable Route Survey & Environmental	Geophysical Survey, Pipeline Route Survey, Cable Route Survey & Environmental	❑
1400 Kg	N/A	N/A	1450
N/A	N/A	N/A	❑
N/A	N/A	N/A	13000
5.35m x 1m x 1m	6.53m x 1.05m x 1.05m	6.53m x 1.05m x 1.05m	5.35 x 1.0 x 1.0
3000m	3000m (to be upgraded to 4500m)	4500	3000
1 Propeller - directional tail fins	1 Propeller - directional tail fins	1 Propeller - directional tail fins	❑
N/A	N/A	N/A	No
15m	15m	15m	15m
AUV nosecone attahed to a length of rope is deployed once AUV is at surface. A harpoon is then used to recover rope. AUV is then pulled onto a custom made slegh which retracts into a servicing workshop.	AUV nosecone attahed to a length of rope is deployed once AUV is at surface. A harpoon is then used to recover rope. AUV is then pulled onto a custom made slegh which retracts into a servicing workshop.	AUV nosecone attahed to a length of rope is deployed once AUV is at surface. A harpoon is then used to recover rope. AUV is then pulled onto a custom made slegh which retracts into a servicing workshop.	Standard Hugin L&R system with hydraulic stinger and detachable nose cone
INS	INS	INS	Aided Inertial Navigation System, Simrad HiPAP 500 USBL, Inertial measurement unit (IMU) – iXSEA IMU 90, Depth pressure sensor - Parascientific Digiquartz, Doppler Velocity Log (DVL) – RDI Workhorse Navigator WHN-300, 307 kHZ
N/A	N/A	N/A	❑
DVL, Fiber optic Gyrocompass, USBL HiPaP system.	DVL, Fiber optic Gyrocompass, USBL HiPaP system.	DVL, Fiber optic Gyrocompass, USBL HiPaP system.	DGPS, USBL, IMU, DVL, Compass, Pressure sensor
Konsburg Simrad EM2000 Multi beam. Edgetech 120 / 410kHz Side Scan Sonar. Edgetech 2-8kHz Chirp Sub bottom profiler	Konsburg Simrad EM2000 Multi beam. Edgetech 120 / 410kHz Side Scan Sonar. Edgetech 1-6kHz Chirp Sub bottom profiler	Konsburg Simrad EM2000 Multi beam. Edgetech Dynamically focused ultra narrow beam Side Scan Sonar DW 106 220/ 410kHz. Edgetech 1-6kHz Chirp Sub bottom profiler	EM2000 mbes, Edgetech Fullspectrum sidescan sonar and subbottom profiler, CTD
Temperature & Salinity meter - Seabird SBE 19. Methane Sensor	Temperature & Salinity meter - Seabird SBE 19. Methane Sensor	Temperature & Salinity meter - Seabird SBE 19. Methane Sensor	Methane sniffer
45	45	60+	45
900 W	900 W	900 W	900
50+	75+	75+	60-70
4	4	4	3.5 / 6.0
Acoustic Data Link - Link Quest 12.75-21.25 kHz. Acoustic Command Link- Kongsberg Simrad 24-28kHz transduser.	Acoustic Data Link - Link Quest 12.75-21.25 kHz. Acoustic Command Link- Kongsberg Simrad 24-28kHz transduser.	Acoustic Data Link - Link Quest 12.75-21.25 kHz. Acoustic Command Link- Kongsberg Simrad 24-28kHz transduser.	LinkQuest 13.5 to 22.5kHz, 4250bps
Radio beacon- Novatech 102-212444 / 160,785MHz	Radio beacon- Novatech 102-212444 / 160,785MHz	Radio beacon- Novatech 102-212444 / 160,785MHz	Wood and Douglas UHF SX450
Selectable - Processed MBE, sidescan sonar and sub bottom profiler	Selectable - Processed MBE, sidescan sonar and sub bottom profiler	Selectable - Processed MBE, sidescan sonar and sub bottom profiler	Decimated data set of mbes, sss, sbp data
❑	❑	❑	Mission planning
AUV has drop weights, which depoly in event of emergency.	AUV has drop weights, which depoly in event of emergency.	AUV has drop weights, which depoly in event of emergency.	Surface for recovery: Drop weight, Inflatable air bladders, Ballast tank system, Radio Beacon, Acoustic Pinger, Releasable drop nose, Flash Lights on vehicle top and drop nose
❑	❑	❑	Seabed surveys for oil & gas field developments, principally deep water (>500m WD)
❑	❑	❑	❑
Military minesweeping, / beach surveying	❑	❑	Inspection and remote intervention in 10 years time
C & C Technologies has completed over 70,000km of commercial AUV surveys.	❑	❑	

Company	Fugro	Fugro	Fugro	Hafmynd Ehf
Name of Product	Echo Mapper	Echo Surveyor	Echo Mapper	Gavia AUV
Vehicle Type	Bluefin 21	Hugin 3000	Bluefin	Modular, man portable AUV
Total Number of AUVs built	1	2	2	10
Commercial Options	❑	❑	❑	❑
Physical characteristics				
Weight of AUV (in air) (kg)	500	1450	500	Dependent on configuration: 48-70kg
Maximum payload (kg)	❑	❑	❑	❑
Freight weight (kg)		13000	2.000	from 120kg
Dimensions (LxWxH) (m)	3.9 x 0.5 x 0.5	5.35 x 1.0 x 1.0	3.9 x 0.5 x 0.5	Dependent on configuration from 1.7m x 200mm diameter
Maximum depth rating (m)	3000	3000	3000	2000m
Number of Thrusters: Directional / Lateral control	❑	❑	1	4 independent control surfaces located in nozzle
AUV hover capabilities	No	No	No	no
Minimum Turning radius (m)	15m	15m	10m	6m
What type of Launch & Recovery system is used, how is the AUV recovered	standard ship's articulated crane	Standard Hugin L&R system with hydraulic stinger and detachable nose cone	Various, including articulated A-frame or standard vessel articulated crane with catch mechanism	Currently the vehicle is launched and recovered by hand from a small boat. A launch and recovery system utilising a crane is under development
Navigation and Payload				
Navigation sensors - standard	Sonardyne USBL, Inertial navigation unit – Litton LN 250 INS, Depth pressure sensor - Parascientific Digiquartz, DVL – RDI Workhorse Navigator WHN-300, 307 kHZ	Aided Inertial Navigation System, Simrad HiPAP 500 USBL, IMU – iXSEA IMU 90, Depth pressure sensor - Parascientific Digiquartz, DVL – RDI Workhorse Navigator WHN-300, 307 kHZ	Sonardyne USBL, Inertial navigation unit – Litton LN 250 INS, Depth pressure sensor - Parascientific Digiquartz, DVL – RDI Workhorse Navigator WHN-300, 307 kHZ	GPS, Magnetic Compass and Orientation Sensor
Navigation sensors - optional	❑	❑	❑	DVL aided INS, LBL, USBL
In case of an INS installed, what Navigation sensors are used to update position during a dive	DGPS, USBL, IMU, DVL, Compass, Pressure sensor	DGPS, USBL, IMU, DVL, Compass, Pressure sensor	DGPS, USBL, IMU, DVL, Pressure sensor	DVL, USBL can update the INS if installed
Payload Sensors - Standard	Reson Seabat 7125 mbes, Edgetech Fullspectrum sidescan sonar and subbottom profiler, CTD	EM2000 mbes, Edgetech Fullspectrum sidescan sonar and subbottom profiler, CTD	Reson Seabat 7125 mbes, Edgetech Fullspectrum sidescan sonar and subbottom profiler, sound velocimeter	None
Payload Sensors - Optional	❑	Methane sniffer	❑	CTD, Sound Velocity, Backscatter, SSS, Swath Bathymetry Sonar, Camera ans Strobe
Battery and Endurance				
Total energy content of battery (kWh)	11	45	11	1kW Lithioin ion rechargeable in Gavia battery module
Nominal battery power (W)	❑	900	320	Dependent of speed and configuration
Endurance at nominal power (hours)	20	60-70	20	Dependent of speed and configuration
Aver. Speed / Max. Speed (knots)	3.5 / 6.0	3.5 / 6.0	3.0/4.0	3/6
Telemetry and Control				
Is acoustic telemetry fitted / Baud rate (bits per sec)?	❑	LinkQuest 13.5 of 22.5 kHz, 4250bps	Benthos 16-20 kHz, 800bps	2 kbaud
Is Radio telemetry fitted / Baud rate (bits per sec)?	❑	Wood and Douglas UHF SX450	Freewave spreadspectrum 115 kBd	11mbit/s WLAN
What data is sent to the surface?	❑	Decimated data set of mbes, sss, sbp data	Vehicle status	Status and positional updates every 40s
What control parameters are sent to the AUV?	❑	Mission planning	Mission control	It is possible to send mission updates to the vehicle through 3 communication channels (Iridium, WLAN and acoustic modem)
In the event of a total system failure what is the emergency recovery procedure?	❑	Vehicle attempts to surface Radio Beacon, Acoustic Pinger, Releasable drop nose, Flash Lights on vehicle top and drop nose	Surface for recovery, independent acoustic command system, radio beacon, acoustic pinger, strobe light, satellite telephone	Vehicle attempts to surface and sends a text message with GPS position. If underwater a back-up acoustic pinger will activate
Apllications and Forecasts				
Current AUV Applications	Seabed surveys for oil & gas field developments, principally deep water (>500m WD)	Seabed surveys for oil & gas field developments, principally deep water (>500m WD)	Seabed surveys for oil & gas field developments, principally deep water (>500m WD)	Military, Scientific, Commercial
Forecast for the total number of commercial AUVs in operations worldwide, in 5 years time	❑	15	15	❑
Forecast for the major application area of AUVs, in 5 years time	❑	Inspection and remote intervention	Oil and gas development, construction, environmental monitoring	❑
Additional Notes & Comments	❑	❑	Echo mapper is completely transportable by scheduled aircraft	❑

Notes

[1] Continued options:
Sub-bottom profiler-Chirp system, forward looking obstacle avoidance sonar, hydrophone, dissolved oxygen sensor, salinity/conductivity sensor, PH sensor, Various Video systems, fiber tether package, live video surveillance, Battery system upgrade

N/A Not Applicable
❑ No information received

Hylands Underwater Vehicles	Kongsberg Maritime	Kongsberg Maritime	Kongsberg Maritime	Prizm Adv. Comm. Electr., Inc.
NanoSeeker	HUGIN 1000	HUGIN 3000	HUGIN 4500	Fetch 3.5 Class AUV
Micro AUV	AUV (comprising supervised or autonomous modes of operation)	AUV (comprising supervised or autonomous modes of operation)	AUV (comprising supervised or autonomous modes of operation)	Fully Autonomous Underwater Vehicle
1	10 including HUGIN 3000	10 including HUGIN 1000	10 including HUGIN 1000	7
❑	Offshore oil and gas surveying, military, research	Offshore oil and gas surveying, military, research	Offshore oil and gas surveying, military, research	Inertial Navigation System, Profiling Sonar System, etc. [1]
0,1	500-750 (battery and payload configuration dependent)	1400 kg	1900 kg	73 kg
0,02	150	250	350	Integrated
	As above	As above	As above	85kg
150mm x 32mm	L=4.5m, D=0,75m	L=5.3m, D=1,00m	L=6.0m, D=1,00m	2.3m - conical
10?	1000 and 3000m depth versions	3000m depth versions	4500m depth versions	200m
1	NA	NA	NA	One
None	NA	NA	NA	N/A
0.5?	12m	15m	18m	9m
By hand	Ramp based Launch & Recovery system for different stern heights. Automatic release of nose cone and catch of recovey line (between nose and vehicle) by graphnel or air recovey harpoon.			Manually or with use of provided launch and recovery cradle
6 axis IMU, compass, depth	INS, DVL, Pressure sensor, Altimeters (ahead and down), GPS	INS, DVL, Pressure sensor, Altimeters (ahead and down), GPS	INS, DVL, Pressure sensor, Altimeters (ahead and down), GPS	Mission planning via Fugawi Echart program, WAAS enabled GPS, RDI Workhorse Navigator Doppler Velocity Log, TCM2 Compass
GPS	USBL, NavUTP (transponder ranging), terrain navigation, SAS micro navigation	USBL, NavUTP (transponder ranging), terrain navigation, SAS micro navigation	USBL, NavUTP (transponder ranging), terrain navigation, SAS micro navigation	IXSEAA Phins (Inertial Navigational System)
See above	GPS, USBL, NavUTP (transponder ranging), terrain navigation, SAS micro navigation	GPS, USBL, NavUTP (transponder ranging), terrain navigation, SAS micro navigation	GPS, USBL, NavUTP (transponder ranging), terrain navigation, SAS micro navigation	WAAS enabled GPS
None	CTD, SSS, SAS (KM HISAS), MBE (EM 3000/3002)	CTD, SSS, SBP, MBE	CTD, SSS (dynamically focused), SBP(focused), MBE	Side scan sonar, conductivity, temperature, depth (STD) sensor, altimeter
Acoustic modem, CTD (planned)	SSS, Fishery research Echosounder (EK 60), turbidity sensor, laser optical plancton counter (LOPC), methane sniffer	SAS, Fishery research Echosounder (EK 60), turbidity sensor, methane sniffer	SAS, Fishery research Echosounder (EK 60), turbidity sensor, methane sniffer	Profiling Systems, forward looking obstacle avoidance sonar, hydrophone, dissolved oxygen sensor, PH sensor, Various video systems, fiber tether package, live video surveillance
1.5Wh	Pressure tolerant Lithium Polymere Battery Technology. 3x6kWh - total 18kWh.	Semi fuel cell: 45kWh.	Semi fuel cell: 60kWh.	Up to 5kWh
1.5W	Speed and payload dependent.	Speed and payload dependent.	Speed and payload dependent.	Up to 5kWh
0,5	Vehicle only: approx. 25@4kn With payload: approx. 16-20@4kn	With payload (SSS;SBP;MBE): 60@4kn	With payload (SSS;SBP;MBE): 70@4kn	24 nominal; 10+ @ 5kn
Unknown	4/6	4	4	Max 10
Unknown	Acoustic command link: 50bps, acoustic data link: 4-8kbs, emergency link: 10bps			Not required
Bluetooth	RF link: 9.6kbs, Satellite link: 2.6-9.6kbs	RF link: 9.6kbs, Satellite link: 2.6-9.6kbs	RF link: 9.6kbs, Satellite link: 2.6-9.6kbs	Tes
Unknown	Vehicle system status data (control system, navigation sensors, payload sensors, battery, etc.), payload sensor data (sub-sampled SSS,SAS/MBE data)			N/A, all data transmitted at surface
Unknown	Vehicle control parameters, mission plan modifications, etc	Vehicle control parameters, mission plan modifications, etc	Vehicle control parameters, mission plan modifications, etc	All control parameters sent remotely to AUV via mission planner, full remote control (fly via radio)
Vehicle attempts to surface	Fail safe drop weights, fail safe drop nose and air recovey bag. The HUGIN emergency system is mechanically, battery, hardware and software wise separated from the other vehicle systems.			Vehicle will float a preprogrammed emergency response enables when the vehicle senses it can not navigate
Environmental monitoring, sampling, distributed applications	Offshore oil and gas surveying, military, research	Offshore oil and gas surveying, military, research	Offshore oil and gas surveying, military, research	Hydrographic survey, marine sciences survey, mine countermeasures
100	100-200	100-200	100-200	100+
Environmental monitoring	Naval, research and offshore	Naval, research and offshore	Naval, research and offshore	Hydrographic survey, marine sciences survey, mine countermeasures
NanoSeeker is in development, prototype being built	❑	❑	❑	❑