'AUVs', an Autonomous Underwater Vehicle Overview.

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What is an AUV? (and why do we care?)

A is for Autonomous. The promise of robots making our lives easier by doing useful work for us is alive and well. AUVs are by definition free swimming, no wires attached. Autonomous can also mean making decisions.

U is for Underwater. Humans find underwater work difficult. Life support systems in submersibles add a significant amount of complexity and volume. Underwater can mean anything from swimming pools to the Mariana Trench. AUVs are being used anywhere.

V is for Vehicle. AUV's go! And they carry sensors with them. Control of where they go is usually part of the definition, otherwise they are called 'drifters'.
What can an AUV be?
Small, medium, large, and in many different shapes. Come in academic, commercial, and military classes.

(1) Robo-Jelly, an example of small biomimetic research AUV (approximately 16 cm across) Virginia Tech.

(2) The Hydroid REMUS family of vehicles. AUVs are also classified by depth rating, with the small REMUS 100 rated for 100 m depth, the large REMUS 6000 rated for 6000 m depth.

(3) Atlas-Marum's family of larger, defence industry-oriented AUV with multiple capabilities and options.

Fig. 1: ATLAS UUV Family
AUVs are rapidly advancing in capabilities, but are still expensive, so are typically employed where they are:
a) multiplying measurement capacity of ship-based cruises
b) running in deeper areas where towfish are difficult or impractical, or
c) where stealth is needed or hazardous conditions exist.

AUVs are mostly used to carry instrumentation, including:

- oceanographic measurements in the water column, CTDs and doppler velocimeters are often standard equipment.
- marine biological measurements (O2,PAR, CDOM), surveillance and monitoring,
- bottom mapping tasks, sidescan sonar and multibeam surveys, photo-mosaics, etc.
Some Examples:

Gavia Offshore
AUTONOMOUS UNDERWATER VEHICLE

POCASKET, MA – April 6, 2011 – Hydroid, Inc., a subsidiary of Kongsberg Maritime, the leading manufacturer of Autonomous Underwater Vehicles, announced today that three of its REMUS 6000 AUVs aided in the search for and discovery of wreckage from doomed Air France Flight 447 nearly two and a half miles below the surface of the Atlantic Ocean off the coast of Brazil. The Airbus A330-200, traveling from Rio de Janeiro to Paris, crashed on June 1, 2009, after encountering severe thunderstorms.

The search team, led by the Woods Hole Oceanographic Institution’s WHIPO, employed two REMUS 6000 vehicles owned by the Woods Hole Oceanographic Institution and another owned by the Institute of Marine Sciences (IMSC). The vehicles, capable of autonomous operations in up to 6,000 meters of water, can stay below the surface for as long as 20 hours.

One week into the search, on April 3, 2011, through the use of the Hydroid REMUS 6000 vehicles equipped with EdgeTech dual frequency side scan sonar and 3 mega pixel digital cameras, searchers discovered and large pieces of debris, including parts of the aircraft’s wings, engine, landing gear and fuselage. This was the fourth search mission since the 2009 crash.

Left: Detail of a bottom image captured by a Gavia AUV mounted side scan sonar. Image courtesy of WGS Survey and Shell Upstream International Europe.

Right: 900 kVz side scan image from pipeline inspection captured by Gavia AUV using AutoTraker, showing potential hazards to the pipeline.

The Mission

On April 7, 2011, a world-renowned underwater roboticist from Rutgers University conducted a second autonomous underwater robot mission on the wreck of a lost French vessel. The mission was part of the Scarlet Knight’s Trans-Atlantic Challenge, a research expedition to map the wreck of a 19th century Spanish ship that disappeared near the Massachusetts coastline.
What an AUV CAN'T do for you (yet!)

- They can't always find their way back home (1). They can't cook, clean or serve drinks either.
- They can't really know where they are all the time without significant help since GPS doesn't work underwater.
- They can't go fast (the fast ones are called 'torpedoes').
- They can't navigate as well as humans in complex situations.
- They can't climb back into the boat when they are done for the day. Recovery can be a challenge in rough weather.
Yet...

AUVs past, present, and future.

Here is a summary of SAAB's history with AUVs, starting with self-propelled 'torpedoes' from 1910. warfare, through torpedo shaped survey auvs and research into autonomous modes for commercial ROVs (HROVs) (2).
• AUVAC lists 60 companies and research groups developing or selling AUVs (3).

• There are contests for students to design, build and deploy AUVs every year e.g. ROBOSUB, and SAUC-E.

• Kongsberg announcing surveying projects which formally would have been done by ship, now done less expensively by Hugin.(4)

• AUGs (Autonomous Underwater Gliders) have crossed the Atlantic and recently ran under the Ross Ice shelf in the Antarctic (5), and are heading across the Pacific (6).
Future

- Hybrids (WHOI Nereus pictured), part AUV, part ROV, best of both?
- JAMSTEC has Fuel cell power, others sure to follow.
- Biomimetics such as robo-jelly, robo-octopus, have potentials for increased efficiency, capabilities.
- Navigation advances such as landscape recognition, high speed underwater modems and cheap fiber-optic gyros.
- Thermal powered, solar powered gliders and AUVs.
- Underwater docking stations.
- Advanced group behaviour.
- More advanced sensors, oil spill sniffers, mass spectrometers.

Video: MIT robofish set to snoop the deep seas
By Vlad Suvor posted September 2009 6:30 AM

WHOI Nereus HROV

Fuel cell from JAMSTEC's Urashima AUV

MIT's Kamal Yousef-Toumi and Valdivia Y-Alvorado
AUVs for Ocean Noise Assessment.

1. General considerations.

- Recording hydrophones are not a standard feature or even common option for most AUVs. They are a commercially available option on some gliders (AUGs).
- AUVs are expensive, but many universities already own one (or more).
- Integration of sensors into existing AUVs can be more challenging than expected.
- Propeller-driven AUVs have self-noise, along with active acoustic equipment (7). Gliders are quieter.
AUVs for Ocean Noise Assessment: What's out there now?

- Summary of work to 2007 from Meeting of Acoustic Society of America combined session on AUVs and ocean acoustics.
- WHOI developed towed array for REMUS 100.
- APL, University of Washington has recording hydrophones on their Sea Glider.
- APL and Scripps 'Liberdade XRay' glider platform.
- Heat Sound and Light Research towed array behind a Slocum glider. Portland State University NEAR lab also has a hydrophone equipped Slocum glider (8).
- The Wave Glider 'Autonomous Marine Vehicle' developed partly out of marine mammal acoustics research.
Summary.

• AUV's are 'autonomous', in a sense doing work independently while you are doing other things.
• Autonomous gliders like 'Slocum', Spray, and Sea-Glider have some unique capabilities in terms of quiet, long range operation.
• AUV's are becoming less expensive and more capable all the time. They are more complicated than moorings or ROVs, and they may not come back! Risk assessment should be considered.
• May require more sophisticated user knowledge, mission planning, but are quickly transitioning from research project, to research tool.
References.


(2) Jan Siesjo, Saab-SeaEye, 'Merging Technologies Creating the Double Eagle SAROV, a Hybrid ROV/AUV, Presented at UI 2009.


(5) Rutgers University Coastal Ocean Observation Lab, retrieved Jan 26 2012: http://rucool.marine.rutgers.edu/atlantic/index.html


(8) Portland State University NEAR lab http://nearlab.ece.pdx.edu/acoustics_mf.html