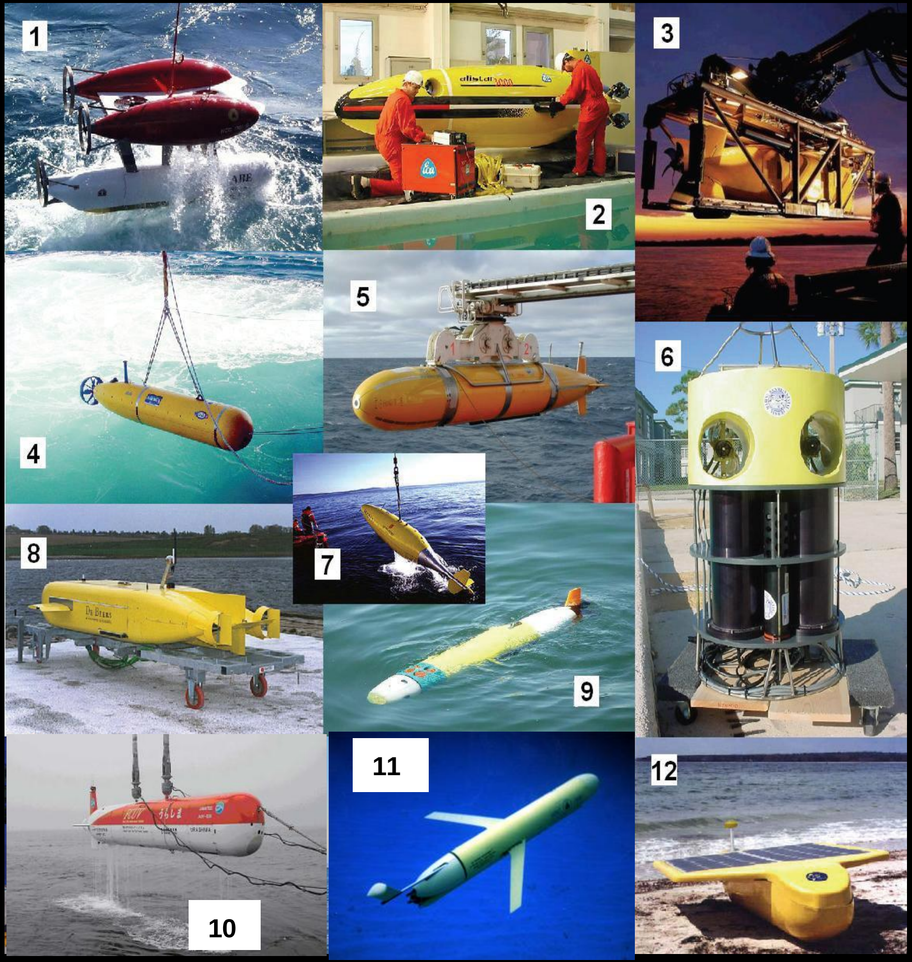
'AUVs', an Autonomous Underwater Vehicle Overview.

Douglas J. Wilson Ph.D.

Acoustic Oceanographer

Imagenex Technology Corp.



(1) Woods Hole Autonomous Benthic Explorer (ABE), (2) ECA, ALISTAR 3000, (3) Boeing, Oceaneering and Fugro, ECHO RANGER, (4) Bluefin Robotics, BLUEFIN 21, (5) Southampton Oceanography Center: AUTOSUB, (6) Florida Institute of Technology, TUVAAQ, (7) Kongsberg-Simrad: HUGIN 3000, (8) Atlas Maridan: M600, 9) Hydroid: REMUS 100, (10) JAMSTEC: Urishima, (11) Webb Research: Slocum Glider, (12) Autonomous Undersea Systems Institute: SAUV.

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.

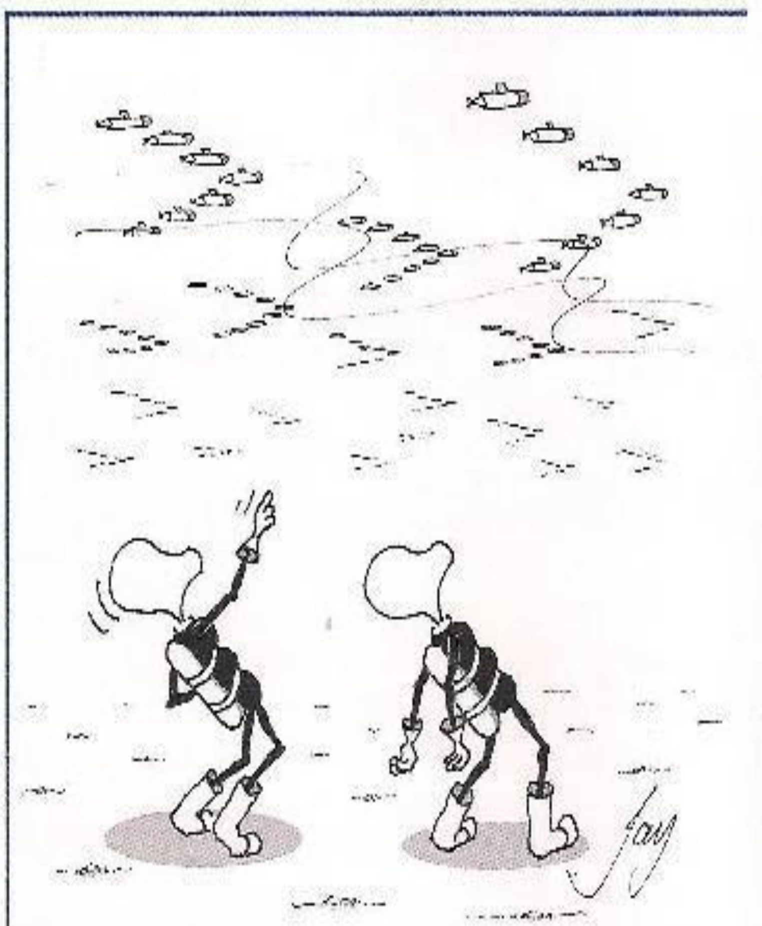
(1)Robo-Jelly, an example of small bio-mimetic research AUV (approximately 16 cm across) Virginia Tech.

(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

What Can an AUV DO for you ?



"What a sight! It's the summer migration to 'UUVS' at Southampton!"

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

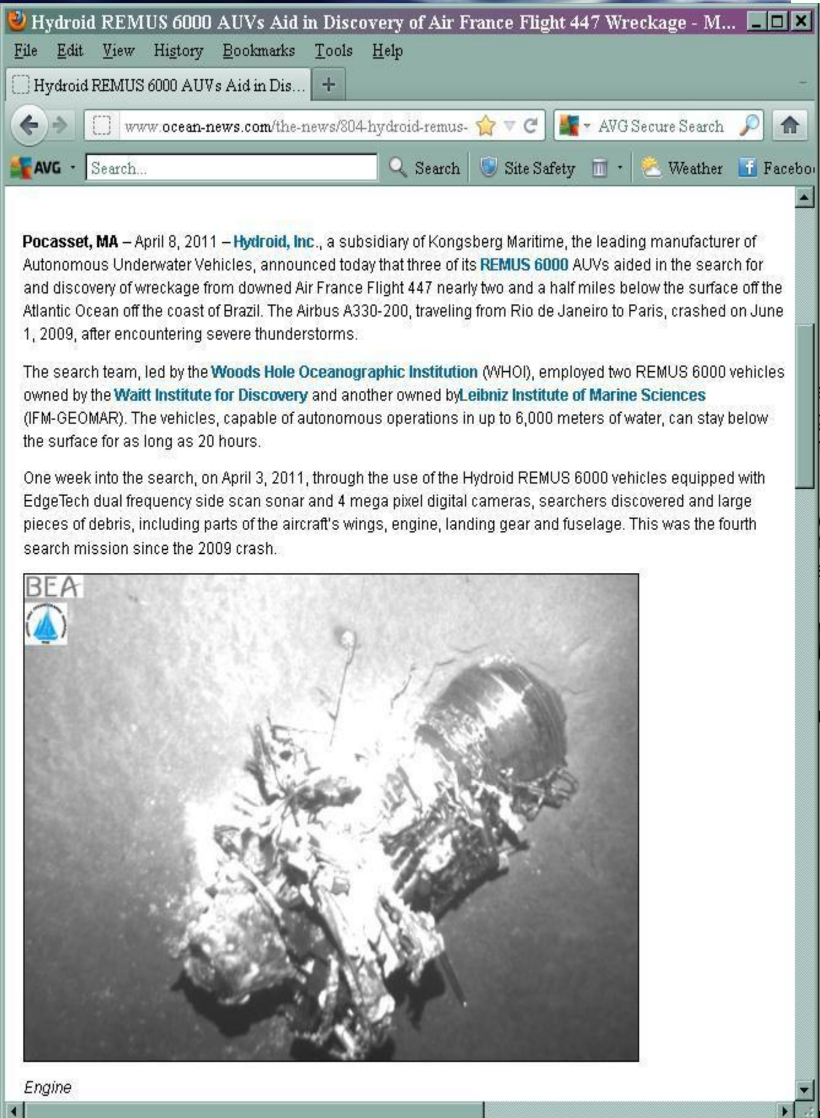
b) running in deeper areas where towfish are difficult or impractical, or

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:



Hydroid REMUS 6000 AUVs Aid in Discovery of Air France Flight 447 Wreckage - M...

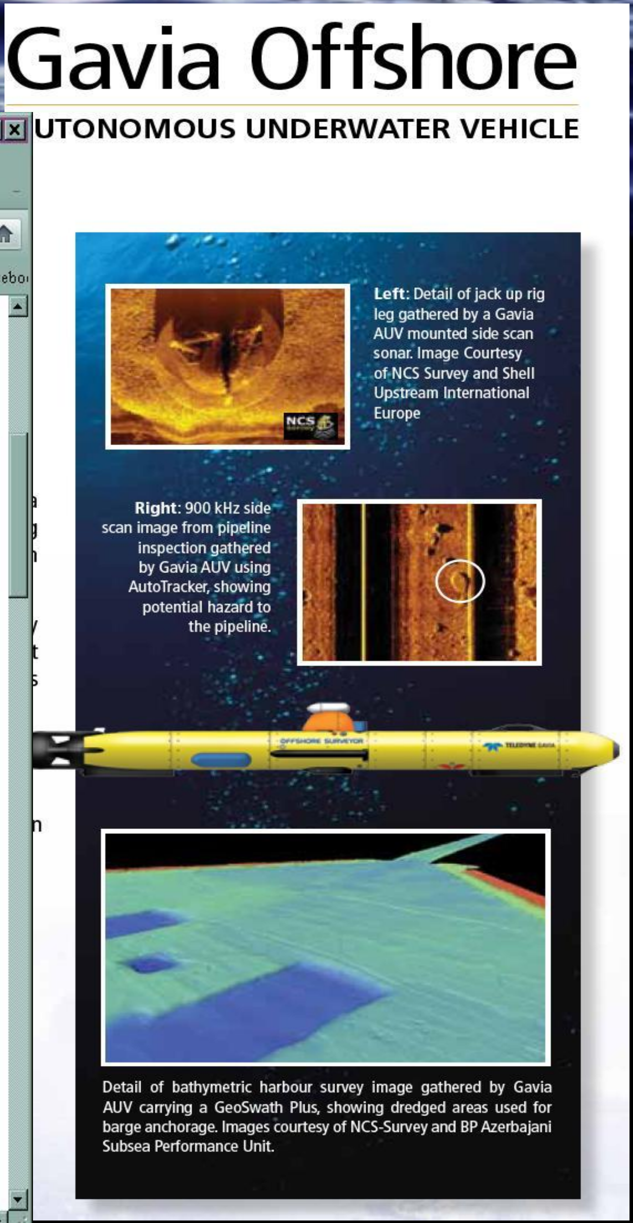
Pocasset, MA – April 8, 2011 – Hydroid, Inc., a subsidiary of Kongsberg Maritime, the leading manufacturer of Autonomous Underwater Vehicles, announced today that three of its REMUS 6000 AUVs aided in the search for and discovery of wreckage from downed Air France Flight 447 nearly two and a half miles below the surface off 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.

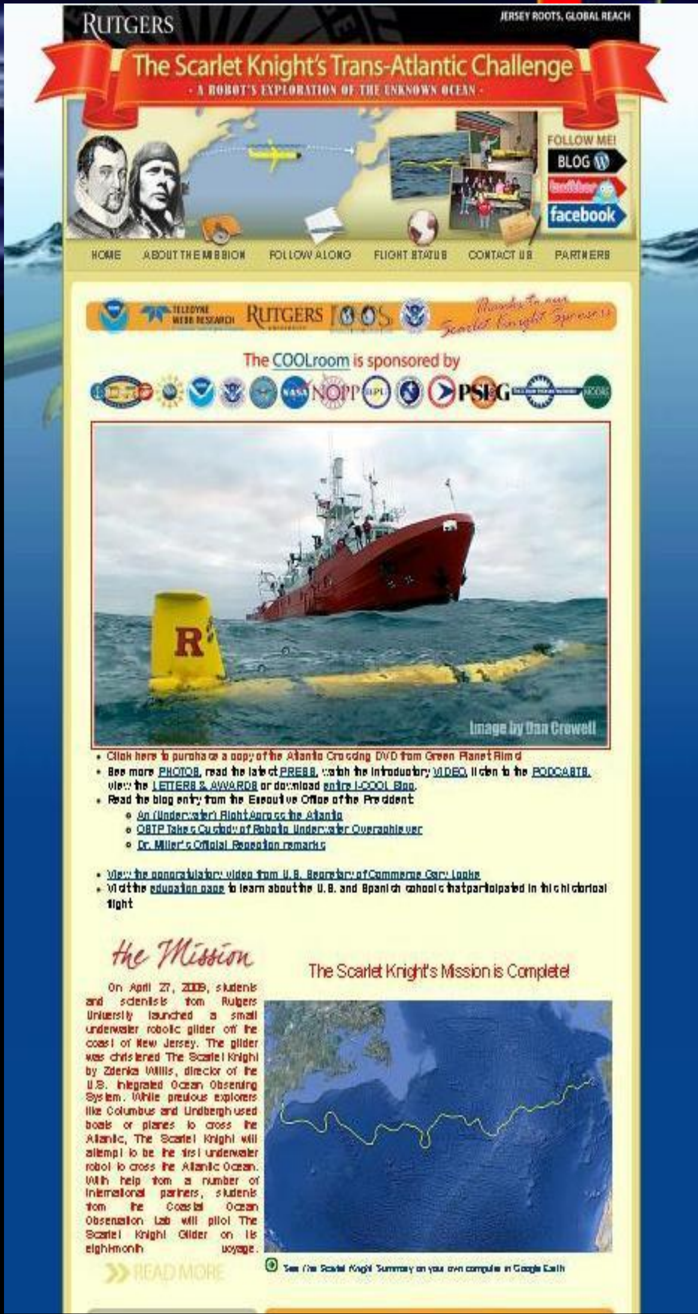
The search team, led by the Woods Hole Oceanographic Institution (WHOI), employed two REMUS 6000 vehicles owned by the Waitt Institute for Discovery and another owned by Leibniz Institute of Marine Sciences (IFM-GEOMAR). The vehicles, capable of autonomous operations in up to 6,000 meters of water, can 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 4 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.

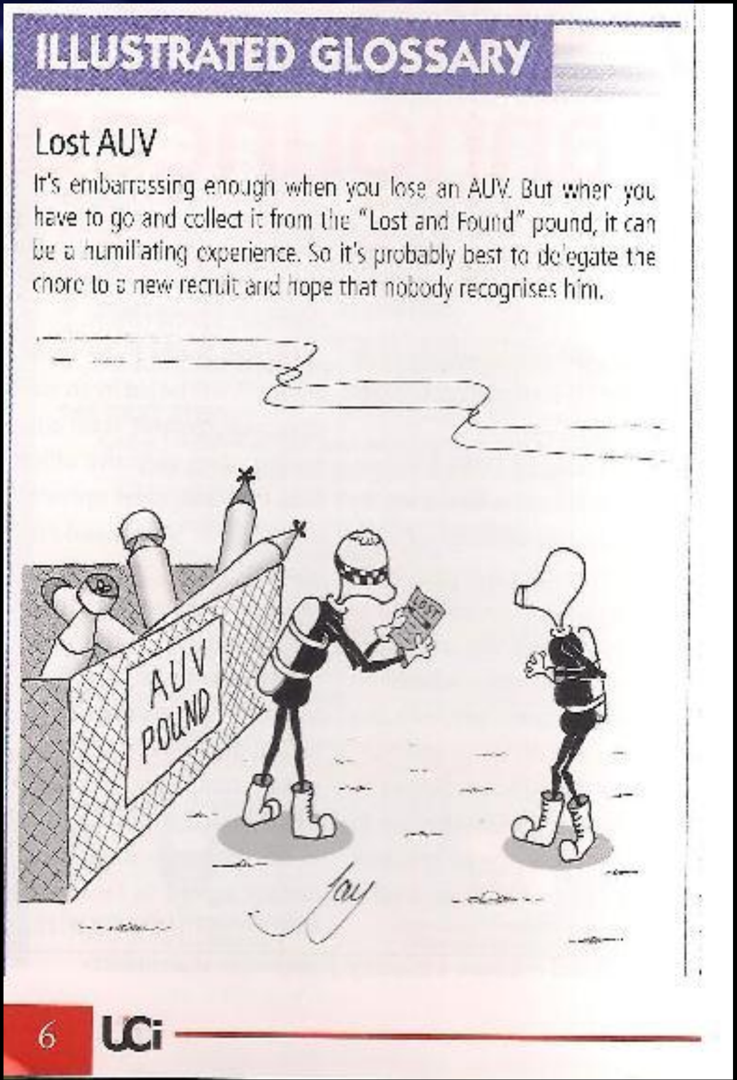
BEA

Engine





What an AUV CAN'T do for you (yet!)


ILLUSTRATED GLOSSARY

Lost AUV

It's embarrassing enough when you lose an AUV. But when you have to go and collect it from the "Lost and Found" pound, it can be a humiliating experience. So it's probably best to delegate the chore to a new recruit and hope that nobody recognises him.

6 UCi

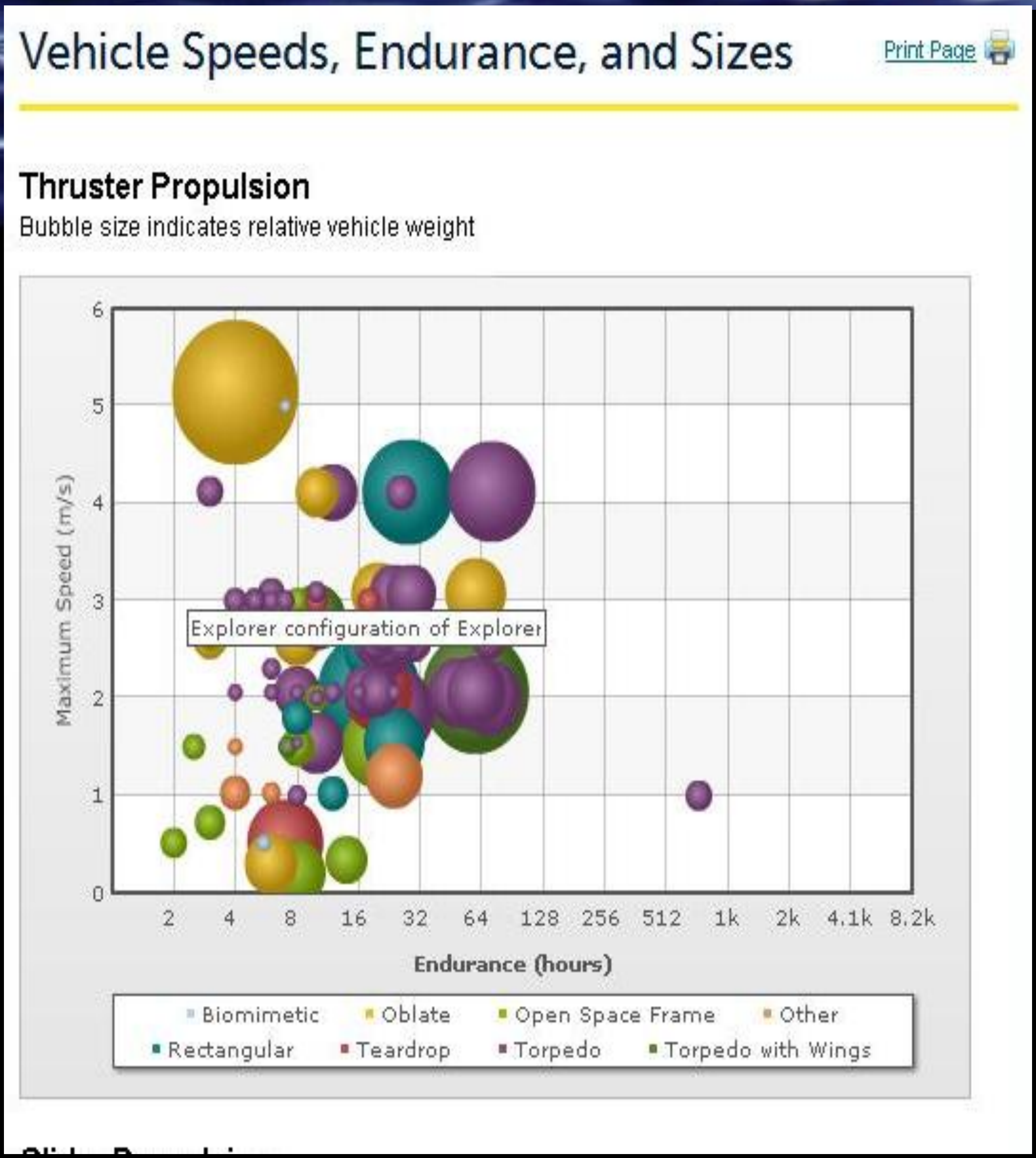
- They can't always find their way back home (1). They can't cook, clean or serve drinks either.
- They can't really know where they are all the time without significant help since GPS doesn't work underwater.
- They can't go fast (the fast ones are called 'torpedoes').
- They can't navigate as well 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).

IMAGENEX

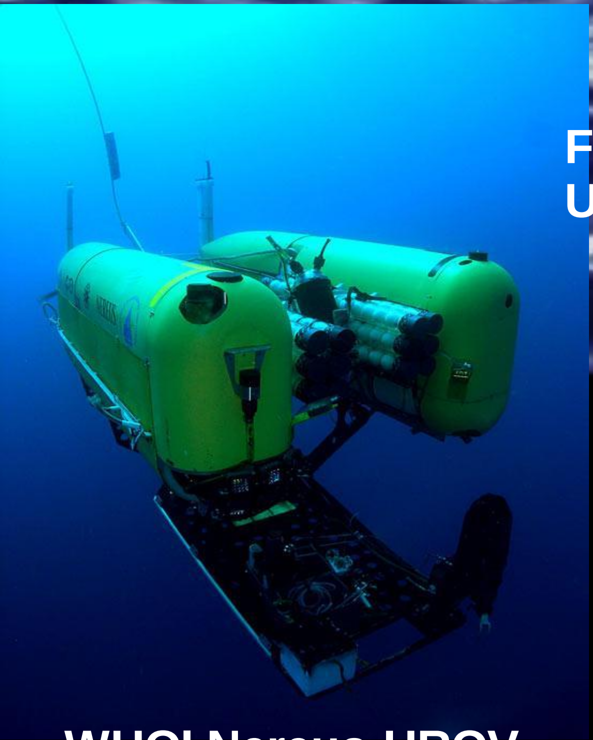
Present



Inforgraphic from http://AUVAC.org

- 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



WHOI Nereus HROV

Fuel cell from JAMSTEC's Urashima AUV

MIT's Kamal Yousef-Toumi and Valdivia Y- Alvorado

- 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, capabilites.
- 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.

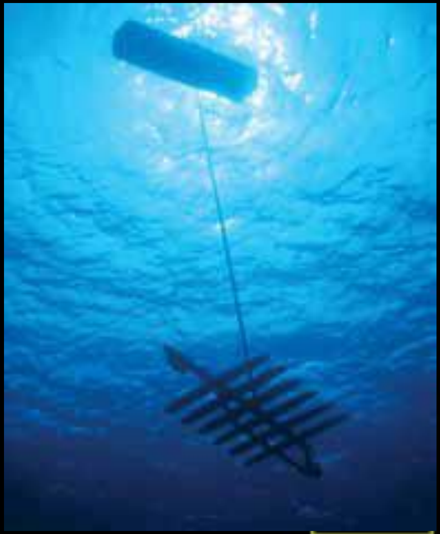
AUVs for Ocean Noise Assessment.

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 equiped Slocum glider (8).
- The Wave Glider 'Autonomous Marine Vehicle' developed partly out out 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.

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