

AUV SURVEYS: EXTENDING OUR REACH 24,000 KILOMETERS LATER

Thomas S. Chance, President
C & C Technologies, Inc.
Lafayette, Louisiana USA (www.cctechnol.com)
thomas.chance@cctechnol.com

Abstract

This paper describes the evolution of the first commercially successful surveying Autonomous Underwater Vehicle (AUV), which was developed by C & C Technologies, Inc., Lafayette, Louisiana in conjunction with Kongsberg Simrad, of Horten, Norway. Data examples are provided that reveal deepwater geology and items of archaeological significance that have never before been seen. The system capabilities are described in detail as well as the vehicle's sensor suite and proposed near term upgrades.

Introduction

C & C Technologies, Inc. is a privately owned international surveying and mapping company, established in 1992, which specializes in Autonomous Underwater Vehicle (AUV) survey services and decimeter-level worldwide satellite

telemetry, video, and altimeters.

In addition to integrating a variety of survey sensors, the engineers at C & C developed



Navy ORCA Vehicle

supporting software for the Navy. Data compression techniques were developed to transmit the large data sets collected by the variety of sensors mounted aboard the ORCA vehicles to monitor survey progress and sensor



C & C Technologies, Inc.

positioning. In 1993, C & C was awarded a five-year contract with the U.S. Naval Research Laboratory (NRL) to aid in their development of AUV technology. This research program included payload modifications to the Navy's two existing ORCA vehicles. Sensor integrations implemented during this program included multibeam bathymetry, subbottom profilers, obstacle-avoidance sonars, radio



ORCA Collecting & Transmitting Data

performance in real time. "Auto Survey Software" was also developed to allow the AUV to intelligently survey in the most efficient fashion.

The development of Auto Survey Software provides the Navy with truly autonomous survey capability. This five-year Navy AUV program was instrumental in C & C's growth to a staff now comprising 180 employees. It also propelled the company to the forefront of commercial worldwide AUV operations.

AUV Evolution

In the mid-1990's, due to the commercial engineering requirements of oil exploration companies, the demand for cost-effective high-resolution mapping in deep water was increasing. In order to meet this need, C & C scientists invested one full year evaluating the available vendors of AUV technology. Research included meeting with designers and manufacturers and witnessing AUV demonstrations in the US, Canada, and Norway.

It became obvious that the majority of the existing AUVs were academic in nature, had limited capabilities, and were equipped with inadequate electrical power sources to support required survey sensors. After careful consideration, it was determined that the Kongsberg Simrad Hugin AUV was the only vehicle with true commercial potential. The Hugin had a proven track record, it had operated at appreciable depths for extended periods of time, and was integrated with a Launch-and-Recovery System (LARS).

Recognizing the Hugin AUV's clear superiority, C & C entered into a formal contract with Kongsberg Simrad to develop a third-generation Hugin 3000. Over the next fifteen months, a host of C & C engineers and software developers lived in Norway and worked hand-in-hand with Kongsberg Simrad personnel to develop the new,

more capable, Hugin vehicle. As the engineers at Kongsberg Simrad concentrated on developing "the Hugin tractor", or the vehicle itself, C & C's scientists were busy integrating and updating the payload relying and building upon the technical experience gained during their U.S. Navy AUV research program.

In November 2000, C & C's survey AUV was completed and became fully operational in the Gulf of Mexico by January 2001. The vehicle has an operational depth rating of 3,000 meters and its dimensions are 5.3 meters in length with a maximum diameter of 1.0 meter. Its standard suite of sensors includes the following: a Kongsberg Simrad 200 kHz multibeam echo sounder, Edgetech dual frequency 120 & 410 kHz sidescan sonar, Edgetech 2-10 kHz subbottom profiler, and several CTD sensor options. A flexible payload arrangement allows the sensor suite to be reconfigured to meet specific scientific mission requirements.

Navigation is accomplished through the integration of a Kongsberg Simrad HiPAP USBL (or a single bottom moored transponder), inertial navigation system, Doppler velocity log, and fiber optic gyro. Positional accuracy, as measured in 2,000 meters of water, is approximately 12.0 meters in real time and 3.5 meters after post processing. High & low speed acoustic links are provided for AUV command and control as well as real-time transfer of sensor and vehicle data. C & C's AUV also incorporates DGPS, a UHF radio for surface communication, and an integrated Inmarsat telephone, which provides a 'phone home' capability. A proprietary aluminum oxygen fuel cell provides mission duration of more than 48 hours at 4 knots with all sensors running.



C & C's AUV is delivered

Track Record

The superior data quality and cost effectiveness of C & C's AUV have not gone unnoticed by the commercial industry. Since January of 2000, C & C's AUV has completed worldwide mapping projects totaling more than 24,000 linear kilometers for the following clients: British Petroleum, Shell, Continental Shelf Associates, the Minerals Management Service, Samedan, Mariner, Total Fina Elf, Chevron, Kerr-McGee, Technip – CSOI, Burlington Resources, BHP Billiton, Ocean Energy, Global Industries, Conoco, El Paso Production, Williams Field Services, MedGaz, Canadian Natural Resources, Global Marine, the British Broadcast Company, Petrobras, and ExxonMobil.

This vehicle's comprehensive track record includes a multitude of surveys in the following locations: the Gulf of Mexico, Gibraltar, Spain, Angola, Nigeria, the Ivory Coast, Ghana, Algeria, and Brazil. Typical survey tasks include: cable route surveys, pipeline surveys, site surveys, drill casing searches, and geotechnical investigations. The vehicle has also performed several archeological investigations that include the discoveries of the U-166, a WWII German submarine sunk by a U.S. Navy

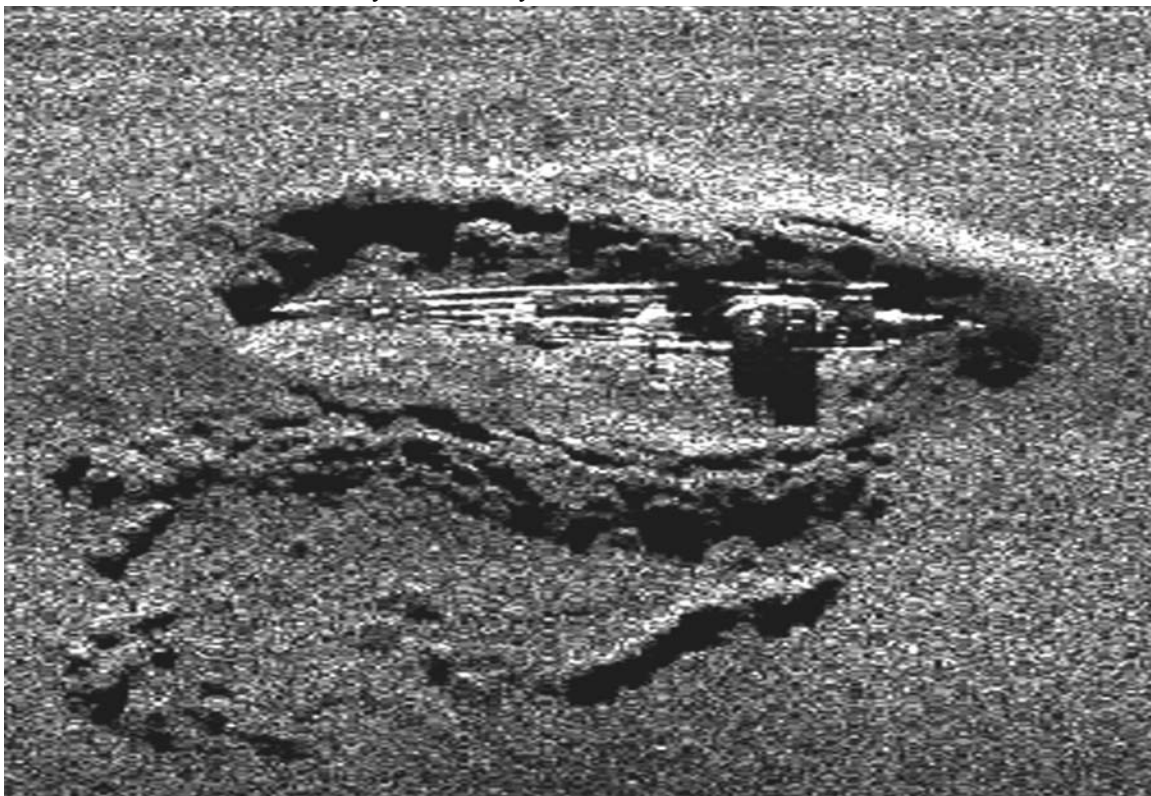
patrol boat in 5,000 feet of water in the Gulf of Mexico and the HMS ARK ROYAL, the British aircraft carrier lost in the Mediterranean Sea and responsible for sinking the German battleship, BISMARCK.



AUV ready to launch

Performance

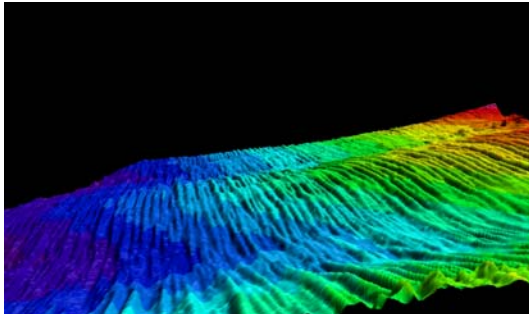
The benefits provided by C & C's AUV might be quantified by two methods: cost saving and improved data quality. When compared to the traditional survey alternative for water, the deep towed system, the cost savings realized by AUVs are quite evident. Savings result from a variety of unique traits that include a faster survey speed, better line turning capability, ability to survey curves and arcs, ability to follow



The U-166 rests in 5,000 of water in the Gulf of Mexico as Discovered by C & C's AUV

changing bathymetry, and faster line turns. The cost-saving consequences of these advantages are that an additional “chase vessel” is not required, data gaps become nonexistent, and the burden and expense associated with a tow cable and handling system are eliminated.

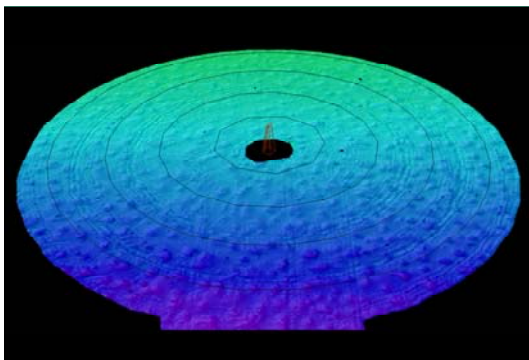
Data quality is improved for a variety of reasons. First, the vehicle is untethered, which decouples



AUV Bathymetry of Gulf of Mexico Furrows

it from a vessel and eliminates electrical noise associated with the ship’s onboard electronics. Also eliminated are the motions associated with the ship’s heaving, pitching, and the cable being deployed and retrieved. Another advantage is that the AUV maintains a fixed altitude off the bottom, providing optimum data on a consistent basis. The vehicle is normally programmed to maintain a height of 40 meters, which has been found to optimize data quality, but it may be commanded to map closer to the bottom if the project requirements deem it necessary.

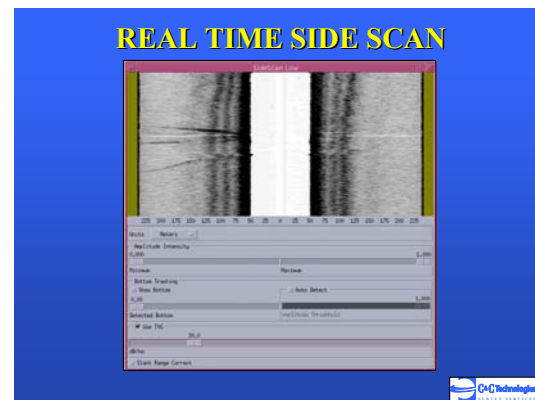
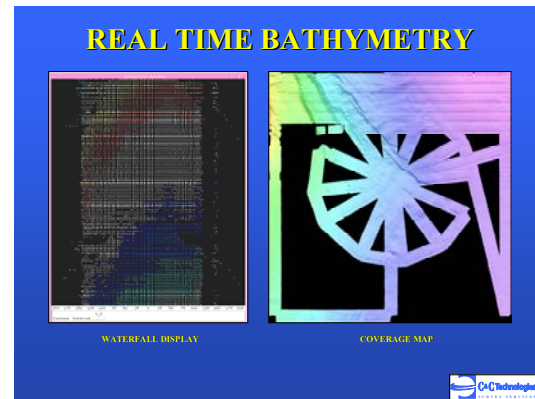
An additional feature of C & C’s AUV is that it allows the scientist or engineer to actually “go where no one has gone before”. Prior to its



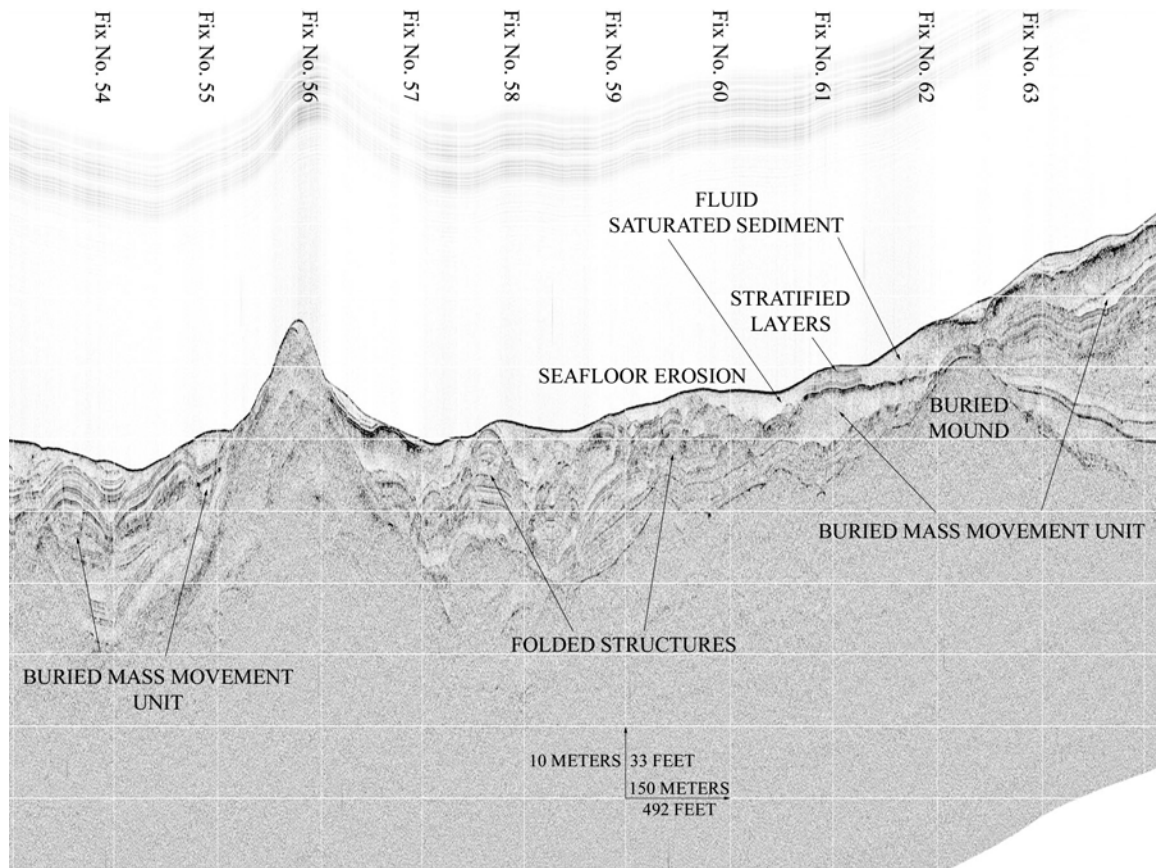
Concentric circles mapped around an oil platform

development, collecting survey data in areas of difficult bathymetry was an impossible task, particularly in deep water. For example, towed systems are incapable handling the difficulties

associated with areas such as the Gulf of Mexico’s Sigsbee Escarpment without crashing the towfish or snagging the tow cable. C & C’s AUV has handled the Sigsbee with ease many times over.



C & C’s AUV can be programmed to follow virtually any route. Project requirements are now limited only by the scientists’ imagination, rather than by the archaic capabilities of a deep towed system. “Designer surveys”, an option unavailable to the world of traditional deep tow systems, are now being implemented on a regular basis. In short, C & C’s survey AUV provides improved data, faster, and less expensively than traditional deep towed systems.



AUV sub bottom data collected in the Gulf of Mexico

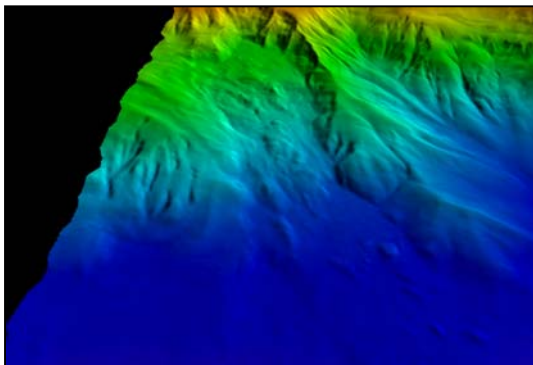
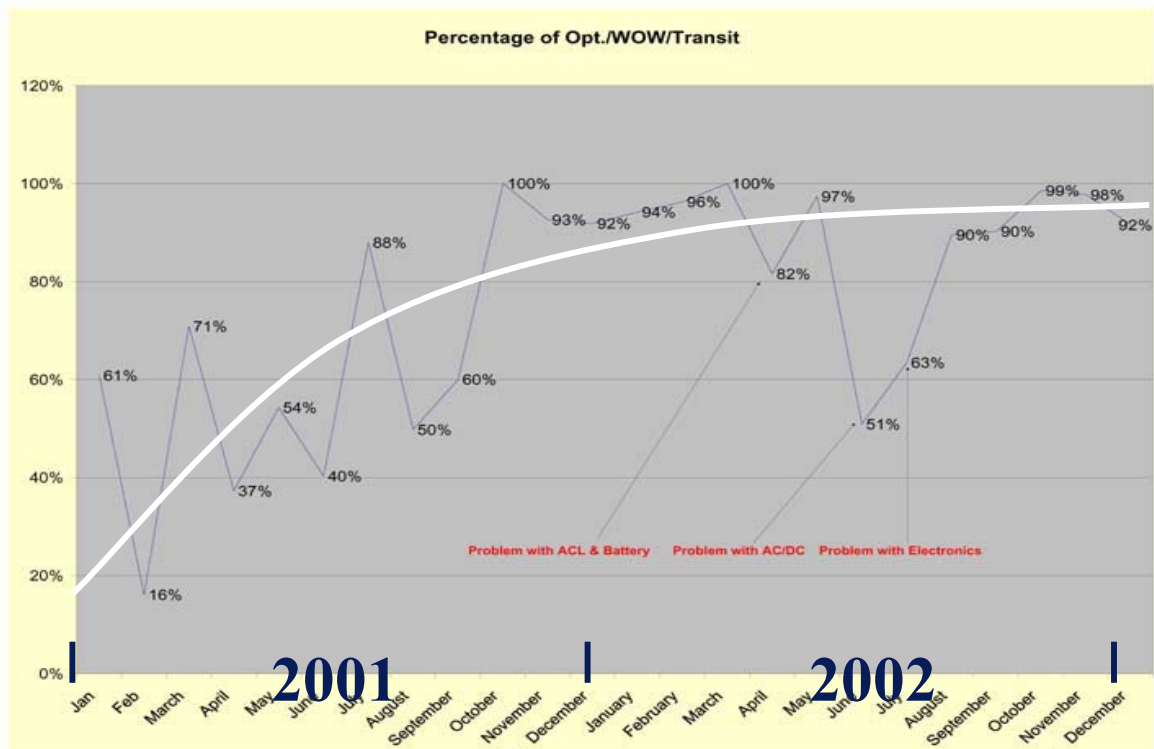
The introduction of real time data monitoring adds an entirely new dimension to AUV mapping. This capability is another consequence of the extensive AUV research and development provided by C & C to the U.S. Navy. Data compression techniques, implemented aboard the AUV, are used to collect, sub sample, compress, and transmit data as they are being collected. In addition to sensor data from its payload of side scan sonar, subbottom profiler, and multibeam bathymetry (binned at a five-meter grid size), command and control functions such as AUV speed, altitude, depth, orientation, battery levels, and other system parameters are presented in real time onboard the mother ship.

Real time data samples from the AUV's survey sensors provide not only a check of data quality, they are used by engineers and geoscientists to evaluate existing geomorphology. Should it be determined that an area being studied does not conform to engineering specifications, or that further developmental work is desired, the AUV can immediately be commanded to survey additional or other areas.

Commercial Challenge

Even following years of AUV developmental and operational experience with the Navy, transitioning into commercial AUV surveying proved to be an expensive and exhausting challenge for C & C. The subsequent chart reflects the survey performance of C & C's AUV during its first two years of operations. The white line is the trend drawn through the actual operational data, which is represented by the jagged blue line. As characterized, the AUV initially achieved a survey rate of less than 20 percent, even though it was received from Kongsberg Simrad after completing sea trials in Norway.

C & C's first year of commercial AUV operations, year 2001, proved to exhibit extremely uneven monthly performance rates varying from 20 to 100 percent. In year 2003, the AUV performance curve began to level off between 90 and 100 percent. Also reflected in this chart are two dips in year 2002, which are the result of AUV upgrades and reflect digressions in the learning curve.



AUV bathymetry data

Upgrades

Since its initial delivery to C & C, several AUV upgrades have been implemented. These include an Iridium "phone home" feature that facilitates worldwide automated communication between the vehicle, mother-ship, and C & C's home office, a single-transponder synthetic LBL, a GPS aiding of the Inertial Navigation System (INS), and the integration of terrain mapping navigation software.

Planned upgrades, which will enhance the AUV's covert performance, include multi-transponder LBL, Synthetic Aperture Sonar (SAS), and possibly a saltwater battery that will support the vehicle's electrical power requirements for weeks at a time. Also being implemented are further performance improvements to the AUV's Inertial Navigation System (INS) and its sensor payload.

Conclusion

Having amassed more than 24,000 linear kilometers of mapping to date, C & C's AUV has proven itself as a reliable mapping resource for commercial and government organizations. The many clients who have benefited from the capabilities of C & C's AUV, exemplify its reputation. Surveys that were impossible to execute with traditional deep towed technology are now routine and being completed in a fraction of the time. In short, C & C's AUV has brought the ocean's scientific community one giant step up the evolutionary ladder.