

# The Role of Survey Launches in Coastal Hydrography of the Future

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*March 2007*

## Abstract

Survey launches and ships have been utilized as primary hydrographic platforms since the beginning of coastal hydrography. Traditional tools such as leadlines, single beam sonar, side scan sonar and multibeam sonars are well established as reliable means of data acquisition from a manned surface vessel, particularly a survey launch which has the distinct advantages of shallow draft and high maneuverability. In recent years, new technologies and platforms including airborne lidar, autonomous underwater vehicles and autonomous surface vessels have emerged. These innovations are being increasingly utilized in the hydrographic survey community with continuously improving results.

NOAA ship RAINIER's 2006 field season utilized and integrated data acquired by airborne lidar with data acquired by multibeam sonars mounted on 29 ft launches. The results of the experience highlighted the value of a manned survey platform as an essential part of the hydrographic survey model for tomorrow.

This paper examines the role of manned survey vessels within the range of hydrographic platforms and techniques expected to be ready for deployment in the near future. As NOAA prepares to build its next generation of hydrographic survey ships and launches, we apply RAINIER's experience to examine the evolving concept of operations in coastal hydrography and consider the changing vessel design requirements necessitated by the emergence of new survey systems and platforms. An integration of the traditional survey launch outfitted with the capabilities to support newer technologies is explored as a viable model for NOAA's fleet.

## Background

Throughout the evolution of technology in determining the character of the seafloor, manned survey launches have remained the reliable workhorse and recurring tool in coastal hydrography. More maneuverable and with less draft than a ship, launches have offered obvious benefit to even the earliest forms of positioning and sounding. As technology moved from leadline and sextants into the realm of sonar and GPS, these small boats continued to bring together cutting edge tools and onsite human expertise.

Today, survey launches around the world are outfitted with a vast array of technology and in most cases are still staffed with survey specialists or hydrographers. In addition to these launches, autonomous surface and underwater vehicles, manned and unmanned aircraft, synthetic aperture radar from satellites, and various other forms of technology have begun to contribute valuable survey data. As these tools enter the picture, it has become important to consider the role, if any, of the manned survey launch and its support platform in the future of coastal survey. RAINIER's forty-year experience with this progression of technology provides a valuable case study to examine the ideal future survey platform for NOAA's fleet.

RAINIER carries and operates six 29-foot survey launches which collectively operate throughout shallow water and coastal areas. Each launch is outfitted to specialize in different aspects of this survey mission, often combining traditional methods with current technology:

<b>Launch</b>	<b>Equipment</b>	<b>Survey Specialty</b>
<b>RA-1</b>	(1)Knudsen 320M Vertical Beam ES (2)Klein 3000 Towfish Side Scan Sonar (3)Leadline (4)Bottom Sampler	(1) Define the inshore limit of hydrography (2) Object detection and identification (3) Shoreline verification in water too shallow to acquire soundings
<b>RA-2</b>	(1)Knudsen 320M Vertical Beam (2)Leadline (3)Bottom Sampler	(1) Define the inshore limit of hydrography, recon work (2) Shoreline verification in water too shallow to acquire soundings
<b>RA-3</b>	(1)Reson SeaBat 8101 multibeam	Acquire mainscheme bathymetry in depths of 4-150 meters
<b>RA-4</b>	(1)Reson SeaBat 8125, (2)SeaBeam Elac 1180	(1) Very high resolution bathymetry in depth ranging from 4 to 60 meters (2) Obtain full-bottom coverage in depths ranging from 80 to 400 meters
<b>RA-5</b>	Reson SeaBat 8101 multibeam	Acquire mainscheme bathymetry in depths of 4-150 meters, and in areas prone to unexpected changes in bathymetry (rocks)
<b>RA-6</b>	(1)Klein 5500 Side Scan Sonar (2)SeaBeam Elac 1180	(1) Object detection and identification (2) Obtain full-bottom coverage in depths ranging from 80 to 400 meters

*Table 1. Survey launches with equipment specifications*



*Figure 1. Survey launch in the field (Hubbard Glacier, Yakutat, AK)*

Survey launches are, at a minimum, manned by a qualified launch Coxswain, qualified Hydrographer-In-Charge (HIC), and a HIC-in-training. Data are acquired by the launches and then processed aboard the ship after each day of survey operation. This data is then reviewed and used to plan for the next day of surveying, specifically addressing the need to maximize safe bottom coverage and to address any problems with acquisition.

While this platform has served reliably throughout the history of coastal hydrography, emerging technology has complemented these techniques and has proved extremely valuable in the field.

### Survey Methods in 2006

RAINIER's 2006 field season utilized traditional launch capabilities and also integrated airborne lidar data to complete survey operations in potentially hazardous coastal areas in Alaska. The technology available to RAINIER was combined to maximize safety of personnel and quality of survey data. The integration of lidar significantly reduced the amount of time that survey launches worked in very close proximity to the shore, and reduced the shoreline items that required examination. This kept RAINIER's launches, and thus the launch crews, away from many dangerous situations.

The role of the survey launch under these conditions was to operate a traditional multibeam survey in the main survey area and to overlap with the high quality lidar data along the shore. Additionally, launch teams were sent to disambiguate and investigate shoreline items that were potentially navigationally significant, or items that were not resolved by lidar due to its limitations. This combination produced some valuable results, one example of which is shown and explained below.

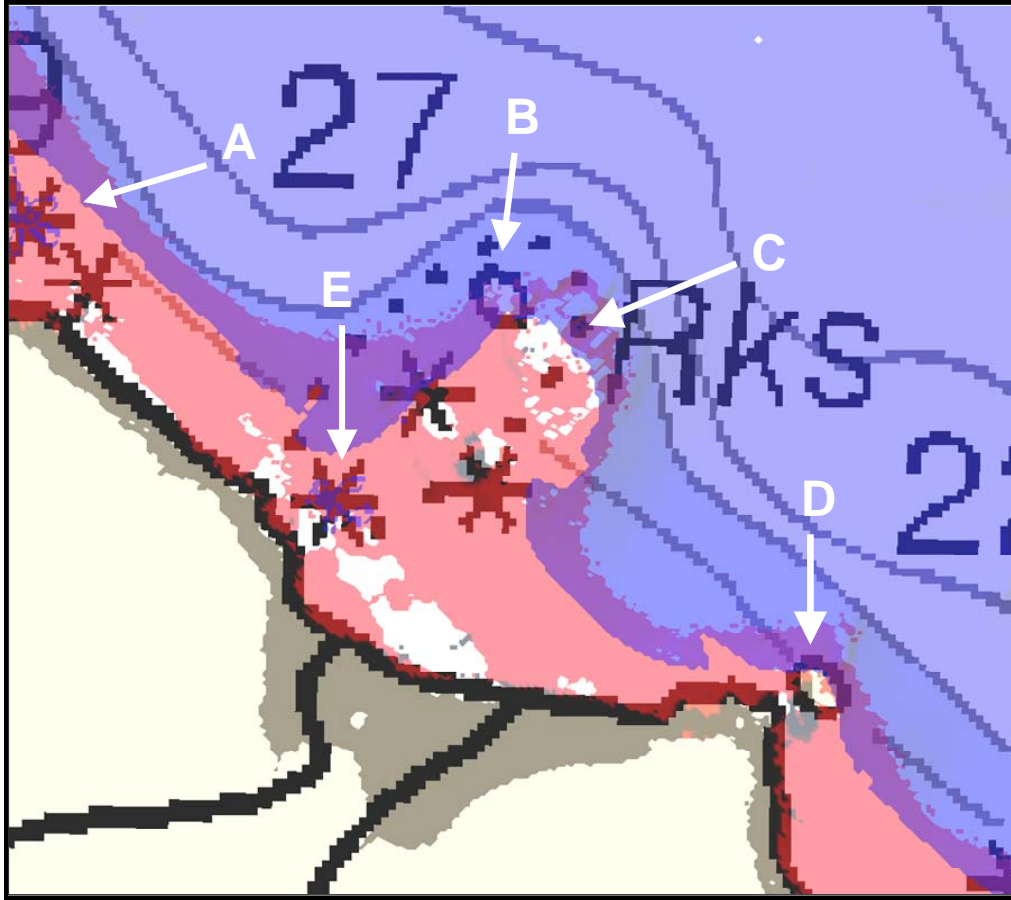


Figure 2. Junction shoreline data of lidar (red) and launch bathymetry (blue) showing gaps in both acquisition systems. These gaps were filled by launch crews onsite.

In this section of a survey, items A and E were charted rocks that were not detected with lidar and were thus submitted to RAINIER for disproval. Survey launches investigated these items and disproved the charted rocks with a vertical beam echosounder using two highly maneuverable and shallow draft jet boats (RA-1 and RA-2).

Item B was also not detected with lidar and was submitted to RAINIER for investigation. This item was disproved with 100% multibeam using the very high-resolution shallow water bathymetry capabilities of the Reson 8125 multibeam (RA-4).

Finally, items C and D (as well as several other areas) appear as gaps in the data. These areas of sparse lidar coverage were also too shallow for sonar work. They were instead investigated by launch crews visually and by leadline for disambiguation and notation by the hydrographer onsite (see Figure 4). The expertise to judge items as navigationally significant, and to properly attribute them for navigational use is a key aspect of the overall project. Below is this same survey area shown notated by the hydrographer on the launch.

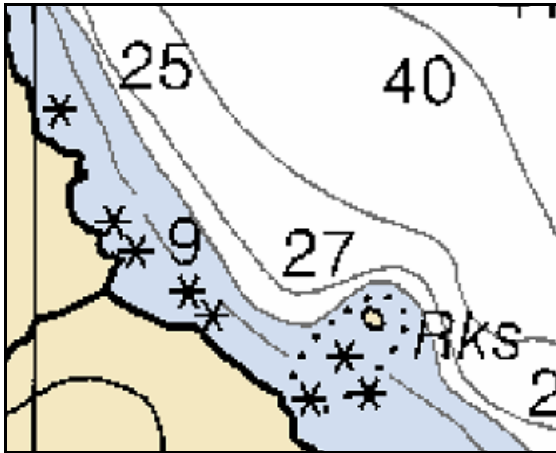


Figure 3. Chart of area shown in Figure 2 without lidar/bathymetry overlay.

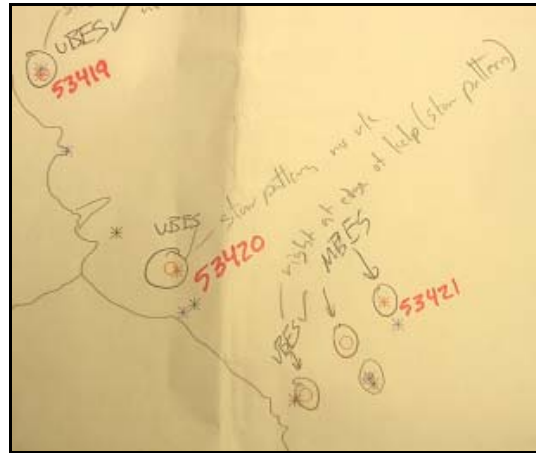


Figure 4. Same area notated by hydrographer onsite.

The notations from the field seen in *Figure 4* serve to ‘fill the blanks’ and identify navigational significance where automated data methods cannot reach a robust solution.

The value of the manned survey launch in this setting lies in the inherent disambiguation abilities of launch crews as well as the unique shallow-water capabilities of a highly maneuverable boat. Also, the instant flexibility of crews to fall back on traditional tools such as leadlines and paper sketches offers coverage in areas that no other method can reach. Eyes in the field clarified questionable data and assigned navigational importance, while high-resolution launch bathymetry junctioned with high-quality lidar data to produce confidence soundings.

It is clear that each piece of technology accomplishes some tasks very well while failing to accomplish others. It is helpful to analyze the available platforms to determine the weak and strong points of each, in order to build a solid integrated concept of operations. Below in *Figure 5* is a breakdown of common survey tasks along with other important considerations of survey work, and how launch and lidar operations generally perform within each.

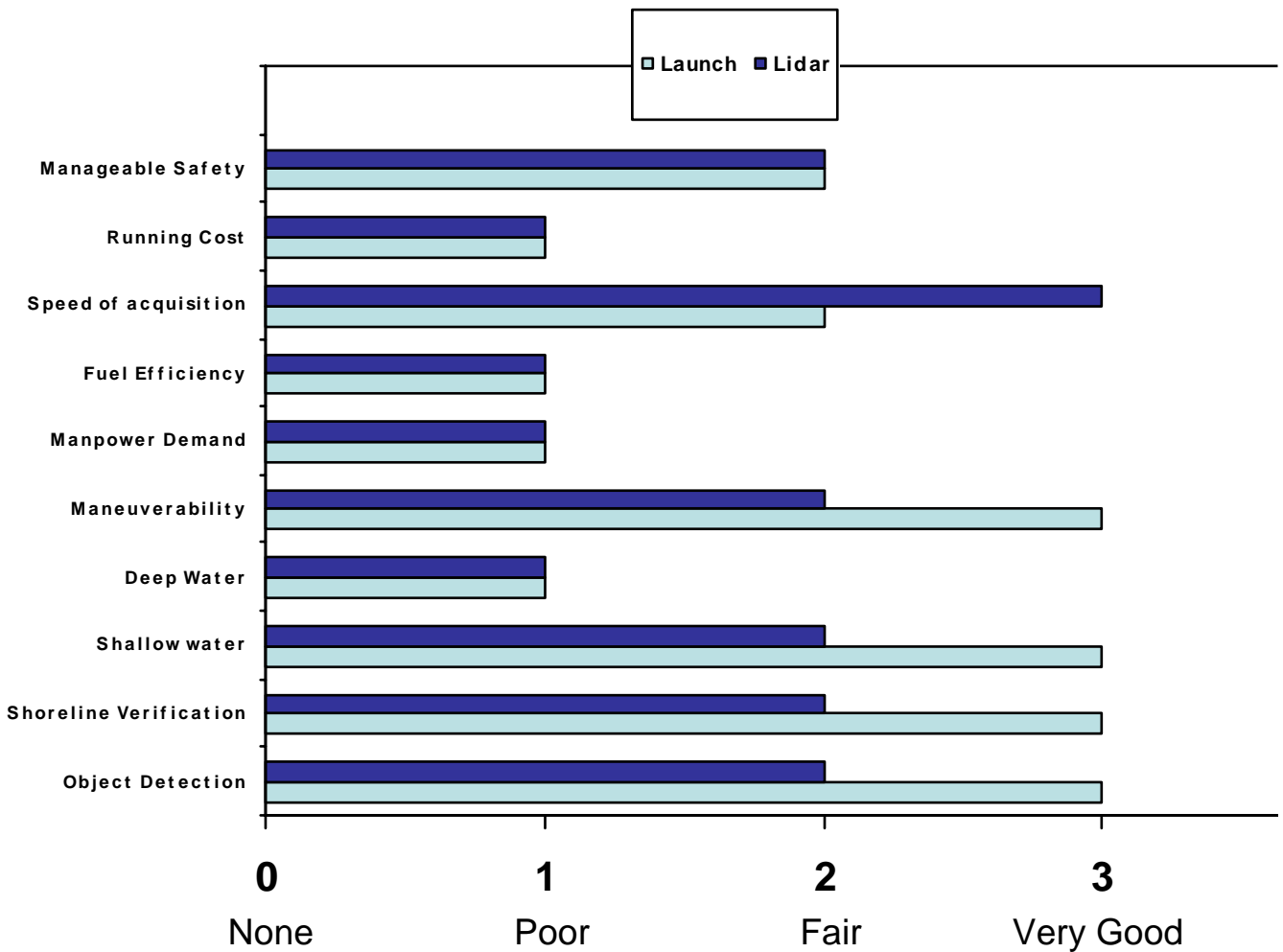


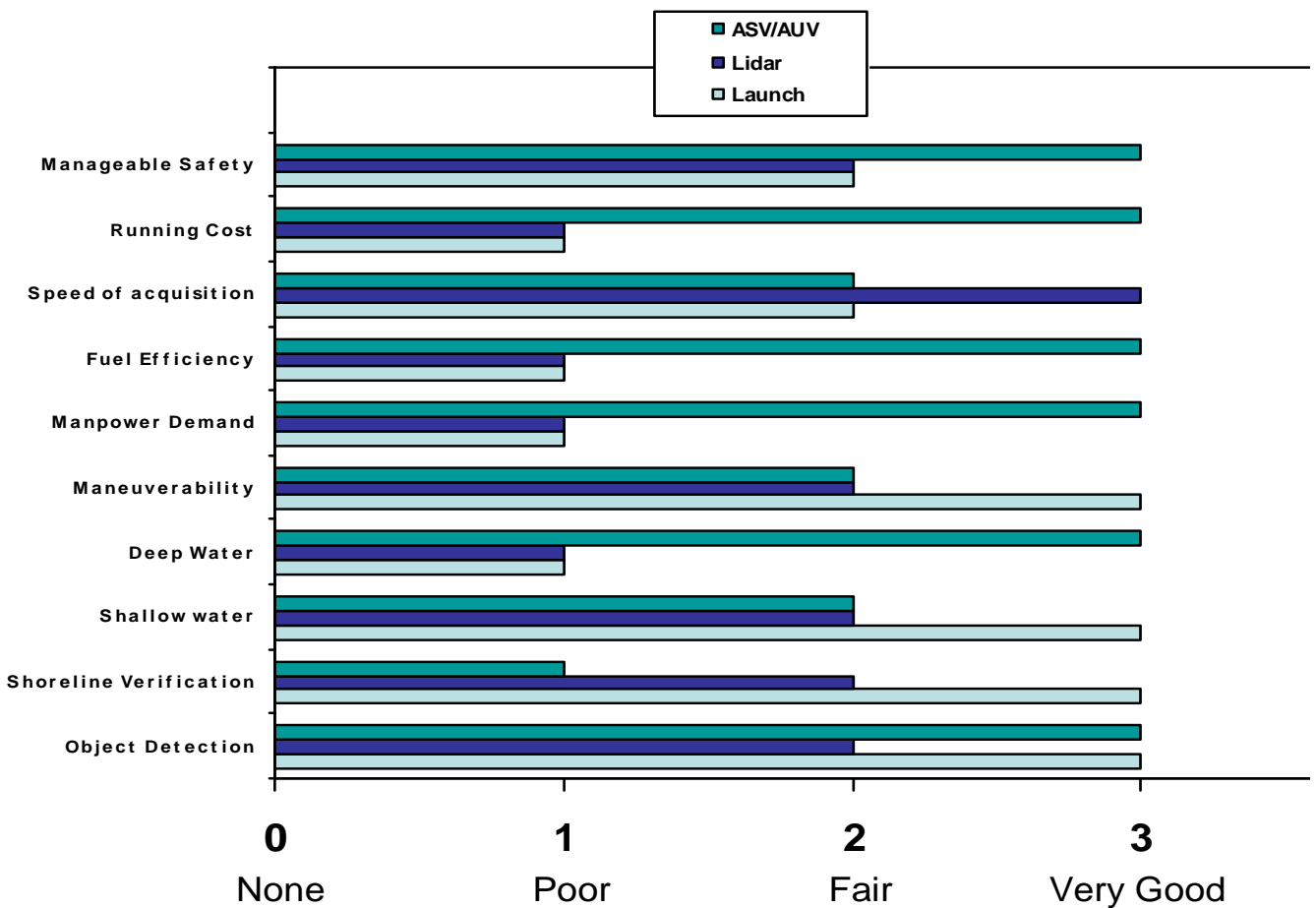
Figure 5. Abilities of lidar and launch survey systems by category

As seen in Figure 5, the limitations of a launch survey lies in the human factor, operational cost, and deep sea capability. Launch crews can only work a certain number of hours before an operation becomes unsafe or the launch runs out of fuel. Daylight is generally needed, and putting people on the water at any time comes with its own risks. Along with all of these things is of course cost. The cost of running a 6-7 ton launch with 3 crewmembers for an 8 hour day combines with the cost of the engineering support personnel, electronics technicians, and even cooks to support the operation. However, no other method is as effective in object detection, shoreline verification, and shallow water survey as is a launch and its crew. It is important to weigh these limitations and utilize this tool where it is at peak benefit.

Lidar operations suffer the same logistical limitations as a launch within these categories, but excel in speed of coastal bathymetric data acquisition. The biggest technological restriction of lidar is water clarity [1]. However, the ability of lidar to identify hazards before a launch is brought into an area greatly increases the planning confidence and safety of operations, as well as defining an inshore limit for launch work [2]. It is important to consider that many of the lidar values above will vary, depending on whether or not a plane is manned by a crew or is

autonomous. The values listed are assumed to be a manned operation. While a crew will maximize survey flexibility, it will cause categories such as cost and safety of personnel to suffer.

This combination of systems leaves obvious gaps in several areas of survey operations, leaving significant room for growth of integration of autonomous vehicles to complement the technological reach of a survey. When all three are combined, the operational gaps are filled and the benefits are maximized (See *Figure 6*).



*Figure 6. Abilities of each survey system by category*

Although RAINIER did not operate autonomous vehicles in the 2006 field season, tests by NOAA’s Coast Survey aboard the BAY HYDROGRAPHER in Chesapeake Bay as well as numerous organizations outside of NOAA indicate that unmanned vehicles minimize the risk to human life and require a different manning paradigm that may be extensible from current launch operations.

In the field outside of NOAA, autonomous vehicles have proven promising for offshore work. Existing systems compare in data quality and quantity to full-size survey ships but at a fraction of the cost [3]. However, they are still limited in decision-making, obstacle avoidance, and speed [4, 5]. These vehicles excel in relatively deep, open water, but may run into problems as

their proximity to the coastal waves and features decrease. Development of autonomous vehicles has produced systems with a wide range of sizes, displacements, and levels of pure autonomy. Displacing anywhere from 36 to 8600 kg (or more) and capable of depths reaching near 6 km [4], the technological reach of these vehicles is expanding quickly. In order for a survey platform to function with one or several autonomous vehicles, the vehicles must be portable enough to deploy from a variety of small boats or ships and with enough autonomy to function with limited crew assistance. An effective integration of this technology to work alongside lidar and launch operations serves to equalize the parts within a survey and maximize the overall survey capability.

## Looking Ahead

Coastal survey is complex and involves many challenges. RAINIER's experience suggests that the scenario utilizing and integrating available technology while keeping people in the field assures greatest success.

To imagine a day of surveying in the near future, one might imagine a small unmanned lidar craft being launched from the bow or stern of a ship while an AUV is deployed over the side. A ship's launch transports and deploys an ASV to a square section of open water and continues on to survey in another heavily-featured inlet for the day. ASV operators ashore monitor and occasionally recall the ASV to a "safe haven" for maintenance. All of the incoming data are fed to the ship in real-time, while lidar/AUV/ASV positions and boundary/overlap data are provided to the launch crews in the area. Hydrographers-in-training, perhaps sitting in a 24/7 processing center, review incoming data and recommend any necessary changes to the survey plan to a senior hydrographer ashore, who communicates in real-time with the ship. Launch crews investigate the coast and identify features which are navigationally significant to the mariner. At the end of the day, maintenance and fueling is performed onsite while the autonomous vehicles continue to work through the night. By the next morning, full coverage areas have been approved and features found reported to the hydrographic agency for broadcast as a chart update via AIS. At the end of the survey project, the entire platform of vehicles and personnel is brought aboard and continues to its next assignment.

In order to accomplish this, the launch of the future will be equipped to:

- Carry, launch, and monitor various types of autonomous vehicles
- Junction in real-time with lidar and autonomous vehicle data
- Send this real-time data to a central processing facility or ship
- Provide accurate 100% bathymetric coverage of the coast
- Adapt on the fly to changing survey needs
- Offer onsite hydrographer expertise to assure a dependable product

The risks and cost associated with a manned launch are inherent but are acceptable when properly managed.

This future platform allows issues in the field to be immediately addressed to minimize downtime while maximizing technical capabilities. It allows personnel onsite to repair a boat,

retrieve a damaged vehicle, or to investigate and attribute items that are important to the mariner. The end product is a survey done with high efficiency in both cost and time, and with greater reliability and precision than present day surveys.

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## References

1. Guenther, G.C., Cunningham A.G., LaRocque, P.E. and Reid, D.J. 2000. Meeting the accuracy challenge in airborne lidar bathymetry, Proc. 20th EARSeL Symposium: Workshop on Lidar Remote Sensing of Land and Sea, June 16-17, Dresden, Germany, European Association of Remote Sensing Laboratories
2. West, G.R., Graham, T., Smith, K. and Spittal, J. 1999. Improving the efficiency, safety and economy of the New Zealand National Charting Programme through the integrated use of Lidar in a multi-sensor surveys, Proc. 1999 U.S. Hydrographic Conference, April 26-29, Mobile, AL.
3. Brian Bourgeois, Mike Harris, Pete Alleman, Jami Cheramie and Joyn Gravley. Autonomous Bathymetric Surveying, *Proceedings of the 10<sup>th</sup> Intl. Symposium on Unmanned Untethered Submersible Technology*, Durham, NH, September 1997.
4. Von Alt, C.. Autonomous Underwater Vehicles, *Prepared for the Autonomous Underwater Lagrangian and Sensors Workshop*, Woods Hole Oceanographic Institution, March 2003.
5. Lundquist, E. Autonomous Operations: What Does it Mean? Marine News, March 2007 No. 2 Vol. 16