Alaska Peninsula Deployment of Laser Airborne Bathymetric System

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I. INTRODUCTION

Laser Airborne Depth Sounder (LADS) systems provide an accurate, rapid, safe and cost effective method of surveying coastal areas. The system has been used by governments and commercial organisations over the last decade to conduct surveys for nautical charting, coastal zone management, territorial sea baseline determination, offshore exploration and defence applications. In the field of nautical charting, commercial LADS surveys have been performed in Europe, the Middle East, Australasia and Scandinavia. This paper describes the conduct of LADS Mk II survey's for NOAA in Alaska during April – July 2003.

II. SYSTEM DETAILS - LADS MK II

The LADS Mk II system details have been previously described in Sinclair (2002). These details are repeated here for completeness, and because there have been some system enhancements in the intervening period.

The LADS Mk II system consists of an Airborne System for data collection and a Ground System for data processing. The Airborne System is fitted inside a Dash 8-200 series aircraft which has a transit speed of 250 knots at altitudes of up to 25,000 feet (7,620 metres) and an endurance of up to eight hours. Note that for aviation operations altitudes are reported in feet. The aircraft is certified by the Civil Aviation Safety Authority Australia, to Regular Passenger Transport standards and is fitted with the Traffic Alert and Collision Avoidance System. Survey operations are conducted from heights between 1,200 feet (366 metres) and 1,800 feet (549 metres) at ground speeds between 140 and 175 knots. The aircraft is fitted with a Nd: YAG laser on a stabilised platform. The laser operates at 900 Hertz to provide 5x5 metre laser spot spacing in the main line sounding mode of operation across a swath width of 240 metres. The electro-mechanical scanner also provides higher density modes of operation with laser spot spacings of 4x4, 3x3 and 2x2 metres with reduced swath widths. Green laser pulses are scanned beneath the aircraft in a rectilinear pattern. The pulses are reflected from the land, sea surface, within the water column and from the seabed (Fig. 1). The green returned laser energy from the land or sea surface and the sea floor is captured by the green receiver and then digitised and logged to Digital Linear Tape. An infra-red laser is directed vertically beneath the aircraft. The height of the aircraft is determined by the received infra-red laser pulses and this is supplemented by an AHRS inertial height reference and GPS height.

The LADS Mk II system can operate by day and night. Real-time positioning is provided by Wide-Area Differential GPS (WADGPS) and civilian GPS. During the survey in Alaska no WADGPS service was available. The Airborne System also contains GPS signal logging for use in determining post-processed DGPS and KGPS positions.

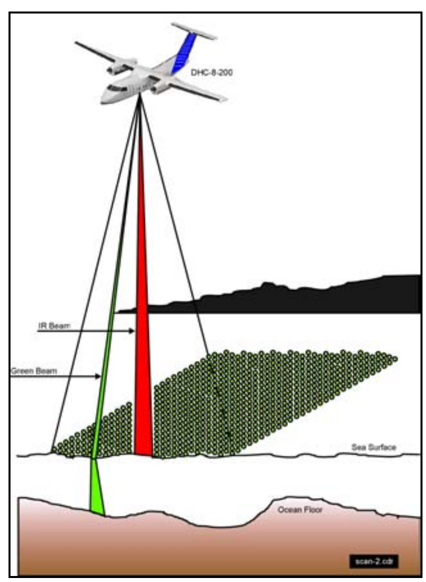

Fig. 1 - The laser scan

Data collected by the Airborne System is processed on the Ground System which consists of multiple terminals networked from a portable Compaq (DEC) Alpha workstation and ancillary equipment; digital linear tape (DLT) drive, digital audio tape (DAT) drive, A0 plotter and printers. Three Ground Systems are maintained by Tenix LADS Incorporated to support concurrent processing of different surveys in different locations. Each Ground System can be transported in the aircraft to the deployment site. The multiple terminals are connected to provide a user interface for the hydrographic surveyors.

The main functionality of the Ground System is based on proprietary software that facilitates all LADS survey management tasks from initial mission planning through to production of smooth sheets and deliverable digital data.

The primary functions are:

Mission planning. This includes the specification of the total survey area, spheroid and grid, survey sub-areas, line spacing, swath widths, survey lines to cover the sub-area, individual survey lines, crosslines, tidal areas and navigation check points.

Sortie planning. A sortie plan is the specification of a series of survey objectives to be executed by the Airborne System. Survey lines and navigation check objectives are selected by the operator and written to floppy disk along with grid and spheroidal information.

Sortie processing. This function calculates sounding depths and positions from the raw sounding data logged by the Airborne System. Depths and positions are associated with various confidence metrics.

Data validation, checking, quality control and approval. The data is reviewed and edited by surveyors using a suite of tools which facilitate viewing and operating on data from a number of survey lines concurrently. In addition, the Ground System has specific data formats developed for integration with other survey software packages.

Data output. Approved data is output in digital formats and is then manipulated in third party CAD and GIS packages to meet specific customer requirements.

The Ground System also contains GPS signal logging equipment (base receiver) and allows KGPS positions and a KGPS height datum to be applied to the aircraft in order to calculate positions and depths. The KGPS solution is provided by the Ashtech PNAV package (at the time of purchase Ashtech was an independent company).

In addition, the networked Ground System stand alone workstations are used for visualisation and QC functions. The Ground System outputs data in digital formats suitable for several third party software packages. For NOAA the data visualisation process was carried out using the CARIS HIPS suite of tools. Data was imported into a HIPS project using the HIPS LADS import function through the HIPS import Wizard. The data was then visualised using the 3D and profile views within the Swath and Subset Editors. All data requiring further investigation was flagged using the HIPS status flags.

III. PERFORMANCE SPECIFICATIONS - LADS MK II

Table 1: LADS MkII Specifications

Maximum depth	70 metres	
Maximum topographic height	10 metres	(Currently being extended to 50 metres)
Sounding rate	900 soundings / second	(3.24 million soundings / hour)
Sounding patterns	5x5 metres	240 metres swath at 175 knots
	4x4 metres	192 metres swath at 140 knots
	3x3 metres	100 metres swath at 150 knots
	2x2 metres	50 metres swath at 140 knots
Aircraft operating heights	1,200 – 1,800 feet	366 - 549 metres
Aircraft endurance	8 hours	(+ 1 hour in reserve)
Aircraft range	2,000 nautical miles	

IV. SURVEY AREA – SHUMAGIN ISLANDS

The Task Order 1 survey area was in the vicinity of the Shumagin Islands, which are south of the Alaska Peninsula.

The initial requirement was to survey part of the Shumagin Islands area. Because of favourable weather conditions, efficient survey operations and the ability of the aircraft and survey team to conveniently mobilise it was possible to add further survey requirements, specifically additional areas in the Shumagin Islands and a second survey area in the vicinity of Cape Decision, South East Alaska, which was conducted under Task Order 2.

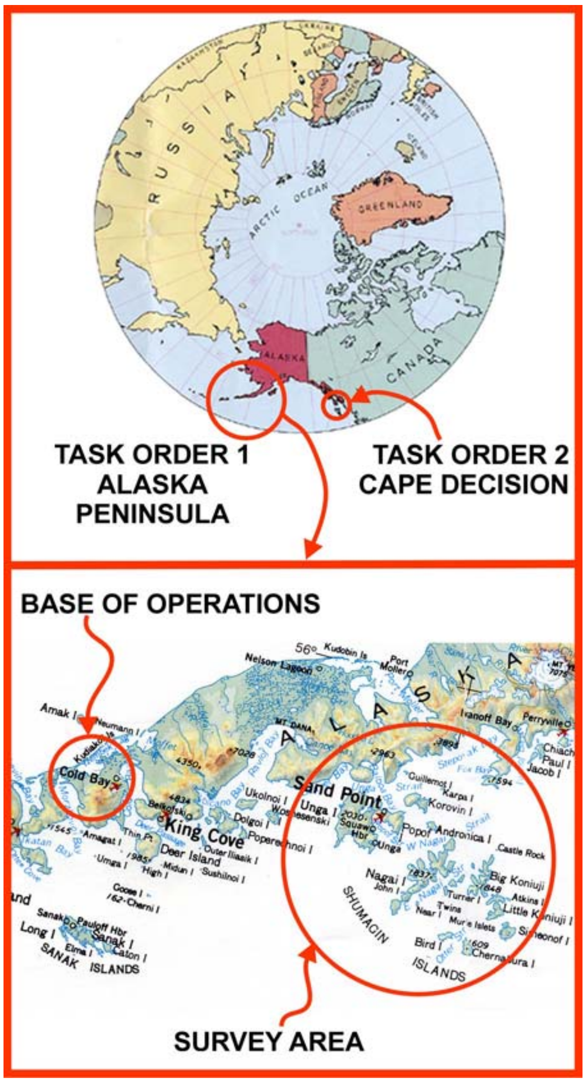

Fig. 2 – Location of Shumagin Islands survey area

V. SURVEY REQUIREMENT – NAUTICAL CHARTING

This LADS Mk II survey collected bathymetric data in remote, shallow, coastal areas to facilitate the primary requirement of updating nautical charts. Bathymetric data was collected to maximum depths of 20 – 30 metres depending on the water clarity. The existing nautical charts of the survey areas contained considerable areas with no soundings. The last survey of any scope in the area was completed in 1950 in Popof Straight, near Sand Point. The ability to update the charts using vessels and acoustic methods was affected by the treacherous coastline and remote nature of the survey area. The use of LADS MkII in this area allowed the coverage in the inshore areas to be achieved with maximum safety and efficiency.

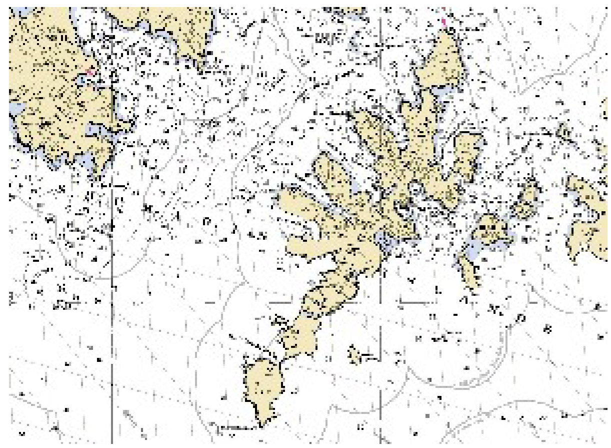

Fig. 3 – Section of existing NOAA chart covering part of the survey area in the Shumagin Islands

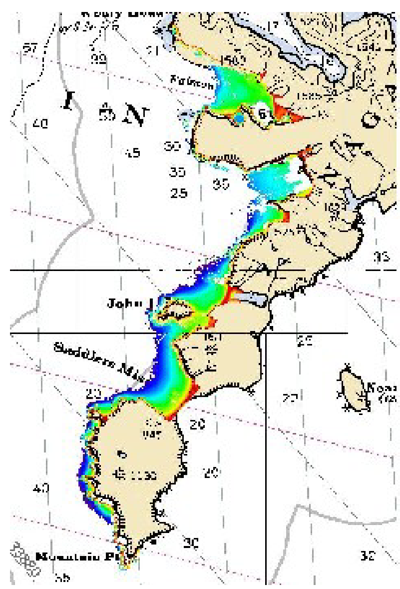

Fig. 4 – Depth coloured LADS data overlaid on NOAA chart on south-west coast of Nagai Island

In addition to the depth data, topographic elevations were also collected up to the 10 metre height contour to provide data for Tsunami inundation maps for NOAA's PMEL Tsunami Program.

VI. FIELD OPERATIONS – COLD BAY

The Shumagin Island survey area was executed from Cold Bay which is situated at the western end of the Alaska Peninsula. Although Cold Bay is remote and has limited commercial infrastructure, it has a suitable airfield, a manned weather station and is only 80 nautical miles from the survey area. It is this closeness to the survey area, which made it the most desirable operating site. The suitability was confirmed by a reconnaissance in March 2003 prior to the survey period.

Fig. 5: LADS Aircraft on the tarmac at Cold Bay Airport

Fig. 6: Township of Cold Bay

Tenix LADS Incorporated personnel were deployed to Cold Bay for a total of 15 weeks to conduct the survey. The staffing level altered during the period, but in general the field party numbered approximately 10 – 15 people. This group included surveyors, pilots, aircraft engineers, technical support and logistics personnel.

During each survey flight (sortie), the aircraft proceeded to the survey area. Main line soundings were collected at 4 x 4 metre laser spot spacing with a line spacing of 80 metres. This line spacing of 80 metres combined with a swath width of 192 metres means that 200% coverage of the seabed was achieved on the mainline soundings.

Sub-areas were designed with regard to the efficiency of conducting LIDAR survey operations. For example, the most efficient plan is to design sub-areas which are straight, long and narrow; this minimises the number of mainline survey lines which need to be flown and therefore the number of turns required between lines and maximises the time spent surveying on each line. Other factors that influenced the design of the sub-areas were the existence of high ground in the survey area and the likelihood of low cloud.

A total of 33 survey flights were flown during the period of April to July with 5638 nautical miles of survey lines being flown averaging in excess of 170 nautical line miles per flight.

In addition to the main lines of sounding, sorties included depth and position checks, refly lines and examinations. Benchmarks, cross-tie lines, dynamic position checks and NAVCAL checks are discussed later in the article. Refly lines are flown to improve coverage in some areas by filling gaps in previously collected data. Refly lines are generated prior to a sortie, and are based on validation of data collected on previous flights. Examinations are normally short survey lines with a high resolution laser spot spacing, (typically 3m x 3m or 2m x 2m). They are designed to enhance data resolution in very shallow areas, or over shoals with significant impact on safe navigation of vessels, in order to confirm the least depth in these areas.

A. *Efficient Surveying*

Survey lines were planned to obtain 200% coverage of the survey area. Adjacent lines were flown on different days under different survey conditions. This plan provides the ability to achieve a high data yield in complex areas where there is white water and turbidity. It also provides redundant data which aides in the interpretation of raw laser waveforms in difficult areas, and can help to interpret returns from schools of fish and whales.

Survey sorties were conducted to avoid periods of poor GPS coverage due to the low number of satellites. This routine enabled the highest quality position data to be utilised. Survey sorties were flown during periods when sea conditions inshore were slight or moderate, which reduced the impact of turbidity on the returned waveforms. Monitoring of the environmental conditions to avoid turbidity in this manner does incur penalties in terms of days or hours lost due to unsuitable weather which needs to be considered during survey planning.

The other weather factors that had the potential to incur refly penalties were low cloud and localised turbulence. Unlike sea conditions which were generalised over the survey area, low cloud and turbulence were difficult to predict from the Cold Bay operating site. Turbulence in particular was localised to specific high ground features and wind directions. Low cloud was managed by flying survey lines at approximately 1200 feet rather than the normal 1800 feet. LADS MkII has an electro-mechanical scanning system that is able to compensate for the lower operating height by adjusting the scan angles, which ensures the swath width for 4x4 metre laser spot spacing is maintained at 192 metres. Without this feature gaps could be present in the main line soundings when the aircraft operates at other heights. Turbulence can also generate gaps in main line soundings if the aircraft deviates from the planned survey line. The LADS MkII system includes an autopilot coupling to keep the aircraft on track and a stabilised platform that maintains the laser transceiver in a nominally level plane independent from aircraft perturbations. The adjustable scanning system, autopilot coupling and stabilised platform were important features in avoiding gaps in the Shumagin Island survey data.

B. Flexible Survey Operations – Forward Deployment to Sitka

The Shumagin Island survey progressed ahead of the anticipated schedule because of efficient survey operations combined with weather conditions that were more benign than expected. As a result of the better than expected progress NOAA tasked a second survey area in the vicinity of Cape Decision in the Alexander Archipelago.

Cape Decision is approximately 930 nautical miles from Cold Bay. To complete the Cape Decision survey forward deployments of equipment and personnel were required. A reconnaissance was carried out by logistics and survey staff, and Sitka was selected as the most appropriate forward deployment base. In order to execute both surveys concurrently and with maximum efficiency it was decided forward deployments to Sitka would take place during periods of poor weather in the Shumagin Island survey area. Three forward deployments were made from Cold Bay to Sitka, during periods when weather conditions were unsuitable for survey operations in Cold Bay, and suitable in Sitka due to the geographical separation. Seven flights were completed to the Cape Decision survey area from Sitka.

The Cape Decision survey was able to be surveyed concurrently because of the range of the aircraft and the ability to mobilise the equipment and personnel to complete the survey in a timely fashion. This is an example of the inherent benefit of airborne LIDAR survey, a data collection tool that is able to quickly transit between survey areas. Because of the multiple Ground Processing systems, processing of data continued at the Cold Bay site whilst forward deployments to Sitka occurred.

VII. SURVEY DETAILS - POSITIONING

Data collection and processing were conducted on the Airborne and Ground Systems on the World Geodetic System 1984 (WGS 84) datum and Universal Transverse Mercator (Northern Hemisphere) projection (UTM N) in Zone 4, Central Meridian 159° West. All units are in metres. This data was processed and all soundings are relative to the North American Datum 1983 (NAD 83).

Throughout the survey the real-time position of the LADS Mk II system was derived from an Ashtech GG24 GPS receiver. The LADS MkII system also includes a receiver for reception of third party WADGPS corrections to augment the autonomous positioning. However, the provider of the service did not have coverage in the survey area.

KGPS (L1 + L2 carrier phase) positions were also obtained by simultaneous PNAV data logging throughout each sortie with two Ashtech Z12 dual frequency GPS receivers; the reference receiver at a coordinated local GPS base station and the roving receiver onboard the aircraft. The GPS base station was established by Tenix LADS surveyors on the roof of the processing building at Cold Bay.

Fig. 7 – Reference Station, Antenna atop Cold Bay lodge

Table 2: Static Calibration results

Positioning System	Easting NAD 83	Northing NAD 83			
Absolute Position of GPS Antenna	263 294.196	6 123 512.742			
Session 1	Mean Easting (95% confidence)	Mean Northing (95% confidence)	Δ East (m)	Δ North (m)	Absolute Accuracy (95% conf)
AS Raw GPS	263 294.144 +/- 3.004	6 123 511.436 +/- 3.349	0.052	1.306	5.806
PNAV KGPS	263 294.337 +/- 0.015	6 123 512.722 +/- 0.022	-0.141	0.020	0.169

Following each flight the PNAV data was imported into the Ground System where the integrity of the GPS solution was checked and the more accurate KGPS position applied to the soundings.

A. Positioning Checks

A number of quality checks were conducted on the positioning system during the survey.

- A twenty four hour GPS site certification was conducted of the local reference station to check for multipath in accordance with NOAA procedures.
- Prior to commencing sounding, a static position check was conducted with the LADS Mk II aircraft on the tarmac at Cold Bay airport.
- During each sortie the positioning systems were checked dynamically against each other.

Navigation checks were also conducted by overflying the local GPS reference station.

B. Static Position Check

On 20 April, static position checks of the LADS Mk II Airborne System positioning systems were undertaken using a three-point control network independently established at the Cold Bay Airport.

The following table shows the comparison of different static GPS solutions for the position of the aircraft GPS antenna.

The stated theoretical accuracy of each of the positioning systems has been compared against the absolute accuracy achieved during the static position check in the following table:

Table 3: Calculated GPS accuracy figures

Positioning System	Baseline Distance (km)	Theoretical GPS Accuracy (95% confidence) (m)	Absolute Accuracy (95% confidence) (m)
Raw GPS	-	13.0	5.8
KGPS	1	0.3	0.17

C. Dynamic Position Check – Dynamic Calibration

As part of the processing of each sortie a relative check was made between the two positioning systems – autonomous civilian GPS and KGPS. For each survey line the mean difference and standard deviation were calculated. The table below presents the mean difference and standard deviation between the positioning systems for each sortie.

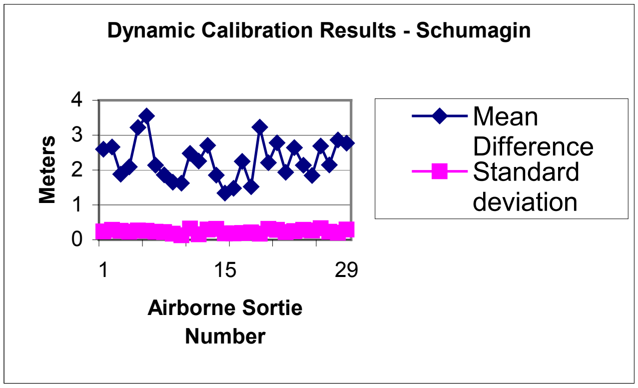

Fig. 8: Dynamic Calibration Results

These results show very good agreement between the real-time position and the post-processed KGPS position. Although this calibration is a relative check the results are indicative of correct GPS operation and therefore sounding positioning.

D. NAVCAL Check

On some survey flights a navigation check was conducted over the GPS base station antenna at Cold Bay Lodge. The Lodge was overflown and then after the flight the recorded position was determined from the downward looking video record.

Initial corrections (both port/starboard and forward/aft) for the platform position in relation to the coordinated mark were manually extracted from the downward looking video tape by the hydrographic surveyor after each sortie. These initial corrections were entered into the Ground System which were combined with the platform pitch and roll, aircraft position, aircraft heading and time over the mark to compute the actual offsets in eastings and northings in metres. These results are shown in the table below.

Table 4: Position Check over Cold Bay Lodge

			∆ East (m)		∆ North (m)	
Nav Check Name	No. of Sorties flown	No. of Passes	Mean	Standard Deviation	Mean	Standard Deviation
Cold Bay Lodge	18	31	3.7	+/- 2.6	-1.5	+/-3.8

The precision of this check is limited by the difficulty in accurately determining the centre of the target and the video pixel size, however it provides a gross error check on position. The results are consistent with correct system operation.

A theoretical assessment of LADS MkII position accuracy is contained in Sinclair (2002).

VIII. SURVEY DETAILS - DEPTH SOUNDING

Survey lines were predominantly flown within each sub-area at a spacing of 80 metres, which provided 200% coverage as the system was operated at 4x4 metre laser spot spacing.

In addition to general mainline soundings (4m x 4m laser spot spacing) examinations at a higher resolution (3m x 3m and 2m x 2m) were conducted in the vicinity of the AWOIS (Automated Wreck and Obstruction Information System) items which were nominated by NOAA. Five items were investigated. The following table shows the results of the AWOIS investigations:

Table 5 – Results of 3 x 3 AWOIS Investigations

AWOIS	Description	AWOIS Position	LADS Position	Comment
52,982	Rock Awash	55°21'31" N 160°31'05" W	55°21'31.55" N 160°30'04.12" W	LADS position confirmed by follow up investigation.
52,983	Sewer Pipe	55°20'29" N 160°30'15" W		No definitive comment could be made based on the LADS data. Pipe dimensions (8" diameter) are substantially less than stated object detection capability of LADS MkII
53,984	Wreck 'Ray Mar Houston'	55°20'51" N 160°27'41" W	55°21'26.34" N 160°28'19.86" W	LADS position confirmed by follow up investigation.
53,985	Visible Mast	55°20'12" N 160°31'28" W		Lack of wreck or visible mast substantiated by follow up investigation (echo sounder) and discussion with local residents.
53,986	Wreck 'Conquest'	55°20'12" N 160°32'24" W	55°20'08.19" N 160°32'20.46" W	LADS position (130 m SE) yet to be confirmed by a follow up investigation.

The survey sub-area in Popof Strait was also conducted at the higher resolution of 3m x 3m sounding spacing. Higher density laser data was required in this area because it is a shallow channel frequently used for navigation. This approach of using a higher density sounding pattern in areas where obstructions or shoals are regarded as likely to pose hazards to navigations is consistent with other surveys conducted by Tenix LADS Incorporated that mandate the object detection (100% Bottom Search) requirements as described in the IHO Order 1 Specification.

The detection of small targets on the seabed requires high-density and high-quality data and a processing system capable of identifying these features. In clear, shallow water, 2x2 metre or 3x3 metre laser spot spacing is required to provide the highest probability of detecting small objects, hence a 3m x 3m spot spacing was used for the AWOIS investigations and in the Popof Straight area. The LADS Mk II Ground System has a special Bottom Object Detection (BOD) algorithm which detects raw laser waveforms from small objects close to the seabed.

This algorithm was used in the AWOIS investigation. Example waveforms depicting the BOD algorithm in operation are shown in the figure below.

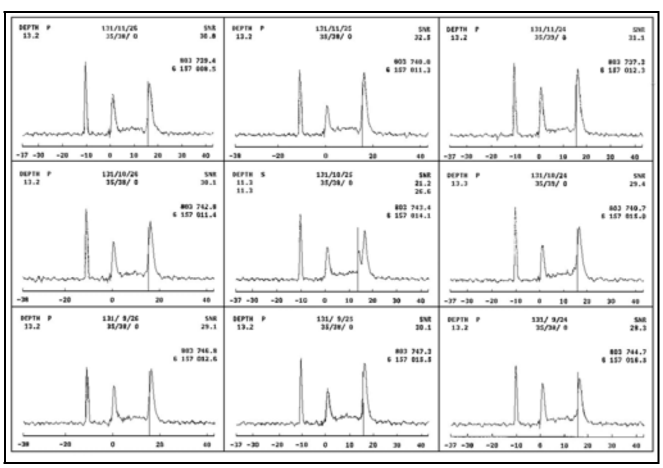

Fig. 9 - Display of Raw Laser Waveforms on LADS Mk II Ground System.

3x3 metre laser spot spacing

2 metre cube target visible on central sounding (11.3 metres).

IX. DEPTH CHECKS

A. Depth Comparisons

The Ground System includes quantitative functions that provide outputs to check the depth sounding functionality of the system through cross tie lines and benchmarks.

Benchmark areas are normally areas approximately 300 x 300 metres that are located on a single survey run, ideally in varying depths but with each benchmark containing little depth variation. The benchmark areas are regarded as control depths and on each sortie a benchmark run is completed over the control areas. To provide an independent benchmark check it is necessary to survey the benchmark areas with an independent system. However given the nature of the survey this was not possible so the benchmark areas provide a relative assessment of depth accuracy. A total of 5 areas were identified; depths ranged from 4 to 18 metres. Survey lines were regularly flown over the benchmarks and statistical comparison of the depths produced to assess the relative accuracy of the depth calculation. The results are summarised in the table below, where MDD represents the mean depth difference of the survey sorties compared to the benchmark 'sortie', and SD represents the standard deviation of the MDD.

Table 6 - Benchmark comparisons

Site Name	Nominal Depth (metres)	MDD (metres)	SD (metres)
Nth Sand Point	14.5m	-0.07	0.19
Sth Sand Point	5m	-0.01	0.12
North Korovin	4m	-0.01	0.09
Centre Korovin	12m	0.05	0.15
Centre Korovin	12m	0.05	0.15

The relative comparison offered by the benchmark analysis is indicative of correct system operation. The ability to sound cross-tie lines perpendicular to the main sounding pattern was restricted due to the presence of high ground close to the coast. Five cross-tie lines were sounded across the survey areas. The results of the cross-tie comparisons are shown in Table 6. Cross-tie comparisons are a more macro check than benchmarks as they effectively check depth calculations across a range of seabed topography and across tidal zone areas (the application of tidal reductions is discussed in the next section).

Table 7 – Cross-Tie comparisons

Location of cross-tie line	Depth Range (metres)	MDD (metres)	SD (metres)
Sth East Unga	7 - 25m	0.07	0.18
Popof Straight	2 - 18m	0.16	0.22
Popof Straight	15 - 18m	-0.14	0.16
Popof Straight	16 - 19m	-0.02	0.20
N of Popof	7-10m	-0.01	0.20

The comparisons indicate excellent repeatability over the entire survey area. The results are consistent with correct system operation.

A theoretical assessment of LADS MkII depth accuracy is contained in Sinclair (2002).

X. SURVEY DETAILS – APPLICATION OF TIDES.

Vertical control for the survey was based on the Mean Lower Low Water tidal datum (MLLW). MLLW is the average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch.

Only one tide station at Sand Point was used for the duration of the survey. This tide station is an electronic recording tide gauge that was established by NOAA on 10 September 1972. The Sand Point gauge recorded continuously for the entire survey. Data was recorded at 6-minute intervals.

After a survey flight, preliminary tide observations for Sand Point were downloaded from the CO-OPS website for the interim reduction of soundings to facilitate expedient validation of the survey data. These preliminary tide readings are the raw six minute tide observations that are delivered via satellite communication from the station to the website at hourly intervals.

Quality Controlled, verified tide observations for the Sand Point gauge were then later supplied by an independent organisation. All final soundings were reduced using the verified tides.

A. Tide Areas and Application

Tide areas that cover the extent of the survey were supplied by NOAA. Two total areas were required for the Shumagin Island area. Independent analysis prior to the commencement of the survey concluded that the zoning provided by NOAA was suitable to meet the accuracy specifications for soundings. The datum variance between tide areas should be below 0.070 metres and the majority of the differences in the 0.020 – 0.030 metre range.

Each of these tide areas use time and range correctors relative to the Sand Point Tide station. Soundings were reduced using the relevant time and range correctors.

Table 8 – Tide correctors

Tide Area	GS Identifier	Time Corrector	Range Corrector	Reference Station
SWA204A	TA1	0 minutes	x1.00	9459450
SWA193A	TA2	0 minutes	x1.02	9459450

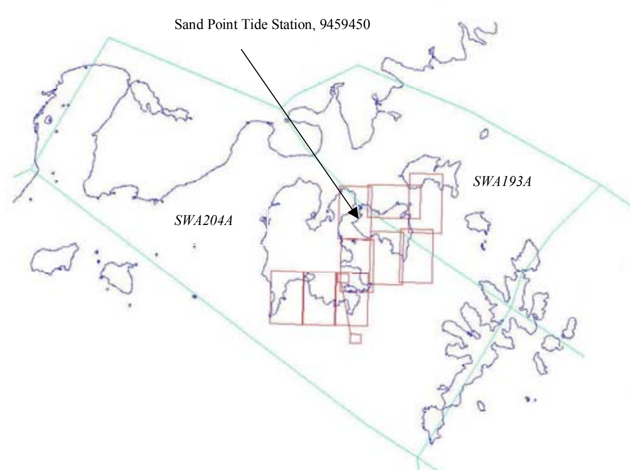

Fig. 10 – Tide Areas

XI. CONCLUSION

Providing data for the creation of modern, accurate nautical charts and tsunami inundation maps in a region such as the Shumagin Islands, Alaska, is a difficult and potentially dangerous job. The recent LADS MkII survey in the region demonstrates how airborne LIDAR can be used to collect the data safely and efficiently.

The survey was successful due to a combination of the LADS LIDAR technology being well suited to the survey requirement and the experience within the Tenix LADS Incorporated survey team. LIDAR survey in such a challenging environment requires a high level of expertise and flexibility within the survey team.

Data has been collected to maximum depths exceeding 20 metres in most areas. This LIDAR data will facilitate efficient and safe survey of the adjacent deeper areas by surface vessels next survey season.

REFERENCES

Sinclair M.J. 2002. LADS Survey – A Case Study on Australia's Northwest Shelf. *International Hydrographic Review* Vol 3 No 2:53-56

BIOGRAPHY

Mark Sinclair is the Survey Manager at Tenix LADS Corporation and is responsible for the design and execution of LADS Mk II survey projects around the world. He has been in charge of LADS Mk II laser surveys in Australia and New Zealand, Scandinavia (Norway and Finland) and the USA (Florida, Washington, Alaska and Midway Island). He has a broad marine background and joined LADS in January 1997 after serving 20 years in the Royal Australian Navy. Mark was the Project Director of this survey.

Darren Stephenson is the Survey Manager at Tenix LADS Incorporated and is responsible for the project management of the NOAA Lidar Anywhere contract. He has been the field party leader of LADS Mk II laser surveys in Australia and New Zealand, Scandinavia (Norway and Finland) and the USA (Florida, Washington, Alaska and Midway Island). He joined LADS in May 1998 after 7 years working as a hydrographic surveyor in the commercial offshore survey industry. Darren was the Project Manager for this survey.

Rhys Barker is responsible for Business Development activities for Tenix LADS Corporation. He has qualifications in both engineering (Electronic) and Business Administration and has been employed by Tenix LADS Corporation since 1995. Prior to his current position he has served in a variety of technical roles from system design to survey field support.