Fugro Commence New Airborne Lidar Bathymetry Trials

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SUMMARY

Fugro has unveiled a new cycle of bathymetric lidar system development with the launch of trials of the all new Fugro LADS Mk 3 Airborne Lidar Bathymetry system. Developed from the operationally proven Fugro LADS Mk II and RAN LADS 2 technologies, set to work trials have commenced. The system has been made more environmentally friendly and is smaller and lighter and more efficient to operate whilst maintaining or improving upon the robust performance features of its predecessor systems. It is designed for operation in a wider range of aircraft and is suitable for small turbo props and rotary wing aircraft alike.

The Fugro LADS Mk 3 system continues to offer a high laser power, large aperture receiver and automatic gain controls enabling superior system performance. Maximum depth performance has been extended to 80 metres subject to environmental conditions. IHO Order 1a and 1b data are collected, and the faster laser rate provides wider and more efficient swath widths up to 430 metres. Leading edge improvements in shallow water performance, seabed reflectivity, target detection, operating altitudes and hyperspectral imagery have also been implemented.

The system enables the coastal zone to be surveyed faster and more cost effectively, by enabling high quality data to be collected across a wide range of environmental conditions without the requirement for a large aircraft. The system architecture has been designed to facilitate continuous development of the technology, with plans to further increase laser rates and swath widths.

This system is ideal for operations in a wide range of marine environments. The system also enables the Fugro LADS technology to be acquired by government agencies and hydrographic offices, as it can be operated from a wide range of aircraft and be used for nautical charting, environmental projects such as climate change and coastal zone management. The architecture of the system also protects customers against redundancy, as it is designed with a future upgrade path to incorporate emerging developments on which Fugro's team of specialist engineers and hydrographers are currently engaged.

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1. LADS TECHNOLOGY

1.1 History

1.1.1 RAN LADS 1

The original LADS technology was developed for the Royal Australian Navy (RAN) from the experimental program of laser development and research into the optical properties of the propagation of light through water conducted in the 1970s and early 1980s by the Defence Research Centre Salisbury (DRCS), South Australia. The experimental WRELADS system proved the concept and demonstrated the advantages of the technology in coastal waters, and in 1989 industry was invited to turn experimental concepts into an operational hydrographic survey tool. This culminated in the building of the original RAN LADS system by a consortium lead by BHP Engineering and Vision Systems, a predecessor of Fugro LADS Corporation. This system entered service in October 1992 and was operated from a Fokker F27 aircraft. The airborne system incorporated a flash tube laser operating at 168 Hz; data was logged on 9-track tapes and processed on a MIPS computers in an air-conditioned container on a semi-trailer. As technology developed, and in light of operational experience, the RAN LADS system was continually upgraded to meet emerging requirements. The system operated extensively around the Australian coastline including the Great Barrier Reef and was decommissioned in 2008, after operating continuously a period of 15.5 years.

1.1.2 LADS Mk II

In 1998 the LADS Mk II system was launched for the commercial survey market with the first commercial survey conducted for the Norwegian Hydrographic Service. This system incorporated a diode pumped laser operating at 990 Hz and was operated from a Dash 8 aircraft. The processing system was based on a Dec-Alpha computer and data was stored on DLT tapes. This system was also continuously upgraded throughout its life to take advantage of technological advances, operational experience and changing requirements. In December 2009 the system was transferred into the Fokker F27 aircraft. The LADS Mk II system operated for government and commercial customers around the world including Australia, New Zealand, the Middle East, Europe and Northern America and was decommissioned in March 2011, after operating continuously for a period of 14.5 years.

1.1.3 RAN LADS 2

On 10 November 2008 a new RAN LADS 2 system commenced operations for the RAN. The system specification was similar to the upgraded LADS Mk II system at that time with upgraded hardware and software, and also included some specific developments for the RAN. The system commenced operations in the Fokker F27, however 12 months later was

transferred to the Dash 8 aircraft in November 2009. The system continues to operate around the Australian coastline for the RAN.

1.2 Fugro LADS Technical Philosophy

1.2.1 Design Philosophy

The cornerstones of the original Fugro LADS technical philosophy are based on maximising the quality of the data collected, a focus on hydrographic survey for nautical charting and refreshing the technology through a continual upgrade process. These are discussed below.

1.2.2 Data Quality

The Fugro LADS systems have been designed with an emphasis on data quality. This is based on collecting signals with the highest quality signal to noise ratio. This has the most impact on the accuracy of the data, the ability to discriminate real targets from noise, and to maximise depth performance of the system under prevailing environmental conditions.

Firstly, the laser power of 7 mJ at the laser head and 5 mJ exiting the aircraft ensures the maximum power is transmitted commensurate with laser safety regulations and the divergence of the laser beam. The wide aperture receiver is designed to capture the maximum amount of returned light and the automatic gain control is designed to apply the appropriate gain to ensure the signal is captured clearly from the noise. We have conducted experiments using lower laser powers and witnessed the deterioration in the signal quality and coverage under these circumstances.

1.2.3 Nautical Charting

From the commencement of operations in 1992, the focus of the hardware and software has been to collect data for nautical charting. The first requirement for this is to have appropriate data quality, as described above. The next requirement is the development of robust algorithms based on signal to noise ratio, to detect the seabed and importantly, to discriminate small objects from noise. Tools have been developed for the hydrographic surveyor to review and edit the data, using the same systematic approach to maintain data quality. Lastly, tools have been developed to produce hydrographic products and assign the data with S-57 attributes. The software architecture has been developed and refined to support the hydrographic processes and workflow, to ensure that the data is fit for nautical charting.

1.2.4 Continual System Upgrades

The Fugro LADS systems have been supported by a team of specialist hardware engineers including mechanical, electronics, electro-optical and optics and software engineers including real-time and post processing software. The systems have been continually upgraded in the light of operational experience, to solve problems, to provide new capability and to mitigate obsolescence or to take advantage of new technical developments. This has provided system longevity, and is the reason the RAN LADS 1 and Fugro LADS Mk II systems were able to operate and remain competitive each for a period of approximately 15 years.

Previous system improvements have included extending the depth capability from 50 to 70 metres, introducing faster laser developments, introduction of a topographic capability, digital imagery including georeferenced mosaicing, hyperspectral data collection and processing, seabed reflectivity and classification, collecting data relative to the ellipsoid, improvements in shallow water performance, improvements and more systematic target detection, extending operational heights for low cloud and high ground, improvements in GPS positioning, improved application of tide models including for NOAA, integration with third party software and continuous software enhancements. Having a technical team directly supporting surveyors conducting RAN and contract surveys has provided continuous feedback which has facilitated development of the systems to keep them current.

1.2.5 Coastal Zone Management and Habitat Mapping

Due to the continuous development process the Fugro LADS system has developed from it roots of nautical charting to coastal zone management and habitat mapping applications. Development of capabilities for digital imagery, hyperspectral data, seabed reflectivity and classification and topographic data have enabled the Fugro LADS system to used for coastal zone management, habitat mapping and tsunami inundation modelling applications.

2. FUGRO LADS MK 3

2.1 System design

2.1.1 Basic Requirements

The requirements behind the Fugro LADS Mk 3 system are to maintain the positive performance discriminators of the previous Fugro LADS systems without the requirement for a large dedicated aircraft. This is in recognition of the fact that the requirement for contract surveys covers both small and large projects. Depending on size and remoteness, some surveys are more suited to smaller aircraft and some to larger. The challenge was to build a system that has the capability of the previous systems, and without compromise, could be deployed in an aircraft of opportunity, commensurate with the size of the job. The system needs to be able to be operated from an aircraft flown by a single pilot with a single operator, although two pilot operations are also facilitated.

The requirements of the Fugro LADS Mk 3 system were to reduce the mass, dimensions and power consumption of the system whilst improving the laser rate, depth performance, horizontal and vertical accuracy and target detection capability of the system. As a minimum, the system must be able to achieve IHO Order 1a and 1b performance over all depths and target detection to a minimum of 20 metres, subject to water clarity and the selection of an appropriate laser spot spacing.

In refining these characteristics, Fugro LADS was able to work collaboratively with other Fugro companies experienced in hydrographic surveys. This gave Fugro the widest possible base of experience to ensure requirements could be encapsulated and improved upon in the new system design.

2.1.2 Major Components

The Fugro LADS Mk 3 system has been redesigned as two main units, an equipment cabinet and a sensor head unit, with ancillary units, an operator's laptop and a pilot's display. The equipment cabinet weight 97 kg and the sensor head 135 kg and current draw is 70 Amps at 28Vdc, with an additional 35 Amps for the air-conditioning unit.

An optional unit is the hyperspectral scanner. The scanning head will fit on the sensor head platform and the control box is situated behind the operator's seat. A separate air-conditioning unit is also provided if the aircraft air-conditioning is not adequate.

Image 1 – Fugro LADS Mk 3 depot set to work trials

2.1.3 Aircraft considerations

A Cessna 441 was selected as the trials platform for the new system because of the local availability of a suitable aircraft that is owned and operated by Fugro. The system is also considered suitable for other aircraft of similar size, such as the King Air 200 and possibly A90 and others. Twin engine turbo-prop aircraft are preferred, either pressurised or unpressurised, however this is not mandatory. Operations from helicopters are also envisaged.

The airborne system has been designed for robustness, reliability, ease of maintenance, ease of installation and modularity to facilitate operation in a wide range of aircraft and be maintainable world wide. The system is designed to be transported by air freight if required, and can be moved installed and commissioned in a suitably prepared aircraft in two days by two personnel. The use of field replaceable units enables replacement in the field without recalibration.

2.1.4 System performance

The system has been designed with a maximum depth performance of 80 metres. Such performance will only be realised where water conditions are very clear. However, it has been witnessed during LADS Mk II operations around the world where the depth of the seabed has descended beyond the logging window of just over 70 metres. An example of this is the approaches to the main channel into Midway Island, where raw depths uncorrected for tide of 73 metres were measured as the waveforms moved out of the depth logging window. It seems unsatisfactory to be able to measure a depth under these circumstances but not record it, so the logging window has been extended to 80 metres. This may be useful in areas like parts of the Pacific Ocean, Coral Sea, Red Sea and Antarctica should ALB operations be conducted in that region.

The performance of the system has been enhanced by improving the physical and optical design of the transmit and receive sides of the system. This has been achieved through a number of improvements including the optical coatings on mirrors, lenses and windows to improve the reflectivity and transmission. This has enabled a higher laser power to be achieved with a lower current draw, which has enabled the laser to be run faster without compromising performance. The system has been launched initially with a 1.5 KHz laser with room for expansion. It is intended to further upgrade the laser rate in the next 12 months.

The benefit of the higher laser rate is higher density data and wider swath widths for improved efficiency. Experiments have been conducted from an altitude of 3000 feet, and excellent system performance has still been achieved. Higher altitude operations enable wider swath widths, and swath widths up to 600 metres have been achieved, albeit at a lower sounding density. However with the laser speed enhancement plan, this will facilitate higher density data over wider swath widths for improved sounding efficiency.

Improvements in shallow water performance have been realised through a minor adjustment to the rectilinear scan by tilting the scan forward of nadir by up to 5 degrees. This reduces surface saturation at nadir, which can occur in sheltered waters with glassy seas, whilst maintaining the performance benefits of a near nadir scan. This will also improve the system's very shallow water performance, by avoiding large returns at nadir. Other than this minor pitch compensation, the system is no longer mechanically compensated for roll. However the scanner is roll and off track compensated by up to 7 degrees through the programmable scanner, which will improve efficiency by reducing gaps due to off-track and aircraft roll.

The system is interfaced with an Applanix POS AV 610 inertial system. The system is also capable of being interfaced with the aircraft's autopilot; however this is not an essential requirement, as the autopilots of some older aircraft are not capable of being easily interfaced.

2.1.5 Improvement Plan

The system design has been considered to facilitate ongoing system upgrades in function and performance. These include improvements in laser speed, swath width, seabed reflectance,

very shallow water operations, operations on the ellipsoid, operations in swell, data processing times including area-based tile processing and inclusion of statistical analysis tools. This continual upgrade philosophy is the same as the previous Fugro LADS systems, which avoid obsolescence and increases longevity.

2.1.6 Software and processing

The software on the airborne system and ground data processing system are run through a user interface on a laptop. These laptops can be interchangeable. This reduces weight in the aircraft and the logistics in the field.

The aircraft laptop controls the laser system, digital camera and hyperspectral system. The processing laptop conducts all the data processing. A flat top screen can be plugged in to facilitate simultaneous review of data and imagery. The system can be networked to other processing laptops to provide multiple users access to the data. In addition, it also facilitates networking to low end windows laptops used for email etc, by hosting the session on the high end laptop and running a user remotely on the windows based machine. This enables scalability.

2.2 Conclusion

The LADS systems have been designed and built with an emphasis on quality and performance. With the ability to upgrade systems as technology advances or customer requirements change, Fugro has demonstrated that LADS systems are able to operate and remain competitive over an extended period of time. It is these engineering philosophies that Fugro has held onto and used when designing the new Fugro LADS Mk 3 system, that will avoid obsolescence, provide enhancements based on customer requirements and increase longevity of the Fugro LADS Mk 3 system and any future systems designed by the Fugro team.

BIOGRAPHICAL NOTES

Mark Sinclair is the Managing Director Fugro LADS Corporation (Adelaide, South Australia) and President Fugro LADS Incorporated (Ocean Springs, Mississippi). He is a mariner, hydrographic surveyor, completed IHO Category A course and certified to Level 1 (SSSI). He previously served as a Commander and seaman officer in the RAN Hydrographic Service.

Hugh Parker is the Sales and Marketing Manager of Fugro LADS Corporation (Adelaide, South Australia). He is a qualified Category A hydrographic surveyor and has been involved in bathymetric lidar surveying since 2001 and has successfully managed many bathymetric lidar surveys in various locations in Australia as well as the Middle East and Europe.

Mark Penley is the technical manager for Fugro LADS Corporation. He has over twenty years of industry experience and has been with Fugro LADS Corporation for the last fifteen years. Mark holds a BEng in Electronic Engineering, with specific experience in electro-optic design, analogue and digital control systems, and system engineering integration.

Paul Seaton is the Business Development Manager for Fugro Airborne LiDAR Bathymetry in the Middle East, Africa and Europe working with both Fugro Pelagos and Fugro LADS Corporation. He has over 20 years experience in senior management and business development roles in a range of government and private industry positions covering the Middle East and Asia/Pacific.

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