



With operations in Canada, the US and Europe and service personnel in Russia and Japan, Optech is a company with a truly global reach.



Optech's new facilities near Toronto, Canada, are purpose-built for the design, manufacture and testing of advanced sensor systems.

3D PIONEERS

A Visit to Optech

It has been my privilege to visit the folks at Optech on three occasions, twice for company visits and once for the company's user conference. My first visit was in 2002, when the company was located in a business park mostly composed of one-story nondescript buildings. Subsequently, they moved into a beautiful purpose-built headquarters that accurately reflects the success of the company. Along the way, 51 percent of the company was acquired by a \$2 billion tech powerhouse, and the future looks very bright.

We met with the company CEO, Don Carswell, at Intergeo last year and based on that meeting, were able to generate two articles, one for [The American Surveyor](#) and a similar one for our [LiDAR News Magazine](#). Because my last visit was in 2009, I decided it was time for another visit to Toronto to get an update on this innovative company.

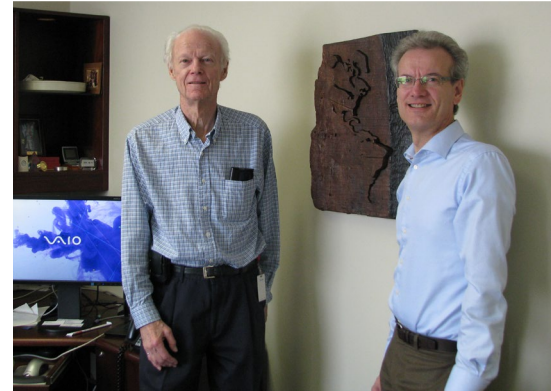
Because acquisitions are sometimes not good for the company being acquired, my first question to Don was about how the Teledyne acquisition has been playing out. I learned that 10,000-employee

Teledyne is a company of companies, a total of 39, all high-tech and niche, ranging from measurement to marine, LiDAR to digital imaging, to oil & gas and more. A wonderful synergy exists and at round table meetings, the companies are allowed to describe what they are doing so other companies can share similar experiences, thereby eliminating newly plowed ground. An internally non-profit R&D wing—Teledyne Scientific & Imaging—exists in North Carolina, and all the companies benefit from the research being performed. Don said 10 of the 39 are directly involved in geospatial, and stated that nothing but positive changes have been the result of the

BY MARC CHEVES, PS



Completed in 2013, Optech's purpose-built 80,000-sq. ft. hangar includes classrooms for on-site customer training.

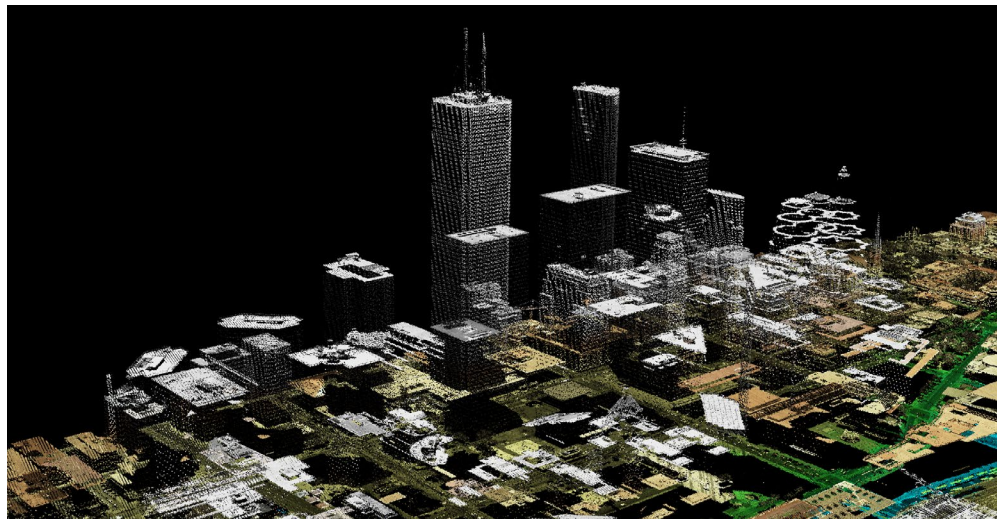


Founder Dr. Allan Carswell (left) focuses on special projects while strategy and operations are in the capable hands of CEO Don Carswell (right).

acquisition. According to Don, Optech itself will spend more on R&D this year than in the last three years combined.

Responding to my question about why the look of the ILRIS terrestrial laser scanner has never changed, Don said rather than spending resources on the look of the instrument, the company has preferred instead on concentrating on making the workflow and software for the high-accuracy, long-range scanner better. He mentioned the success they are having with remote monitoring in mines, and a special workflow they have developed—Reconstructor—in partnership with the Italian company Gexcel. More about the ILRIS below.

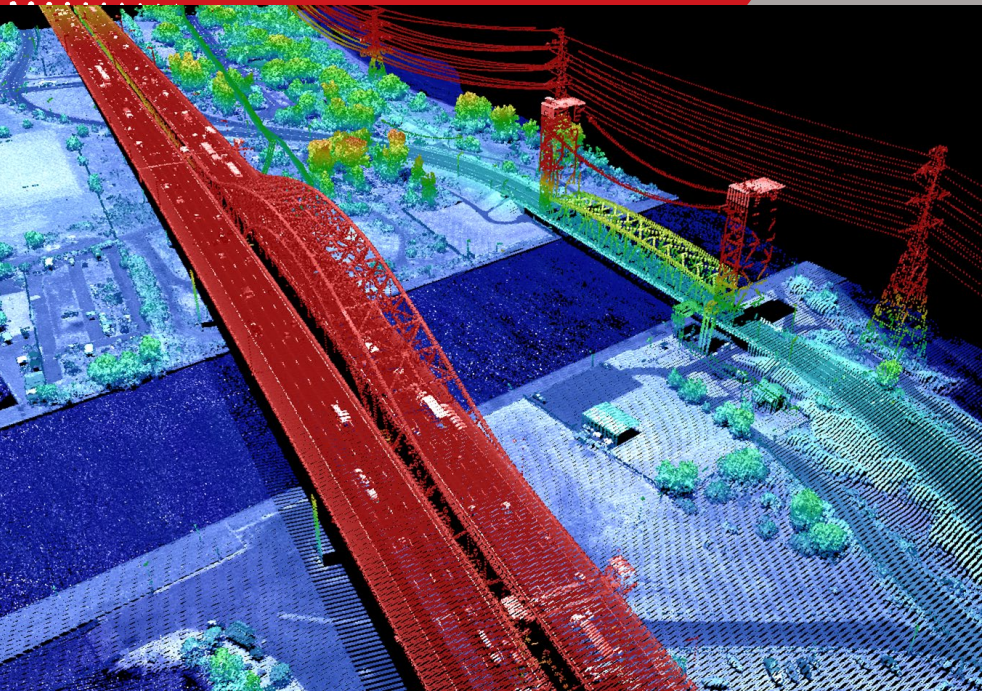
Responding to another question about problems I've heard about data within the mobile scanning industry, more specifically linking adjacent scans on linear projects, Don said the company has focused a lot of effort on improving its workflow and software. He said the accuracy of the Lynx data—at a relative $\pm 6\text{mm}$ —is not the problem, but that 2.5D is easier to solve for than



Point cloud data from an ALTM Pegasus, showing sensor utility for 3D urban modelling.

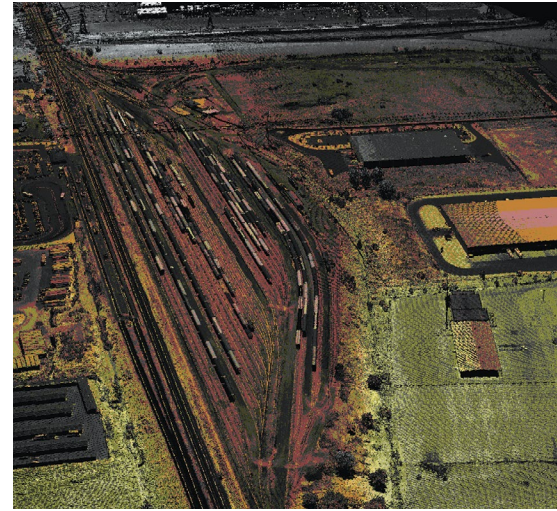
3D, for example properly placing the front and back of the same sign. He added that systematic error is the most difficult to control and that Optech has put a lot of effort into the least squares bundle block adjustment aspect of LMS. Don assured me that Optech has solved the scan alignment problem by more tightly coupling the GNSS and IMU data. More about this below.

While in Toronto, I also met with Michael Sitar, the business manager for airborne mapping systems, and we discussed the company history and many of Optech's industry firsts. For example, lasers were barely out of their infancy when Dr. Allan Carswell was studying them at York University in Toronto, Canada. Doug Houston, one of Dr. Carswell's graduate students and



LiDAR point cloud collected using high-precision ALTM ORION corridor mapping sensor.

Image courtesy of Merrick and Company.



later a project scientist at Optech itself, made the very first LiDAR measurements ever performed in Canada. Houston recently retired after more than 40 years with the company.

Likewise, Dr. Carswell worked with Sebastian Sizgoric, later President of Optech's American branch, to develop one of the world's first bathymetric LiDAR sensors in 1973. With this early model, Dr. Carswell demonstrated that water penetration down to 20 m deep was possible, and explored many elements of LiDAR bathymetry that are still used today. Optech bathymetric systems such as CZMIL now lead the industry in validated performance.

History of ALTM

Optech's leadership in airborne LiDAR applications began in 1982 when they developed both airborne ocean roughness measurement systems and airborne ice profiling systems for the Canadian Atmospheric Environment Service. This was well before GPS was available,



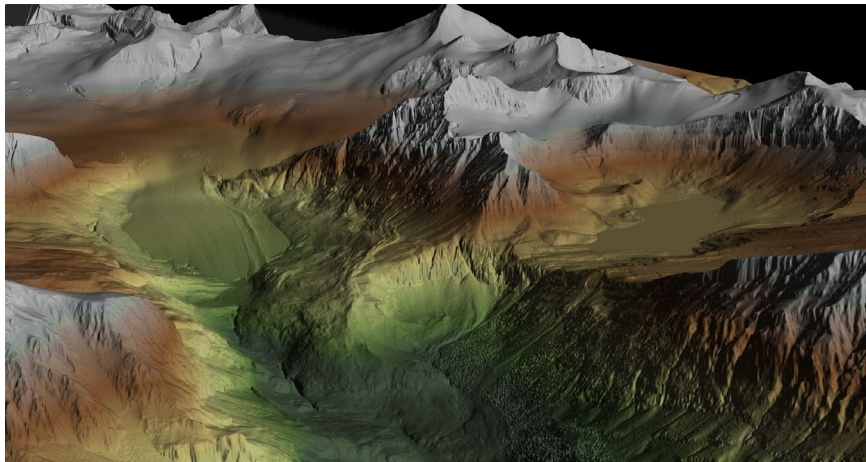
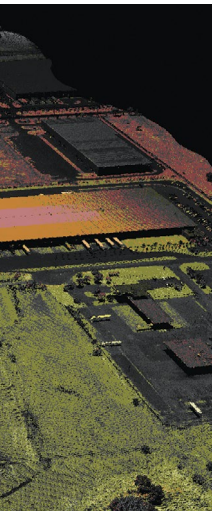
ALTM Orion and multi-sensor corridor mapping solution installed in client sensor pod and helicopter.

Image courtesy of Merrick & Company.

but the customer did not need exact mapping capabilities at that time, and it gave Optech early experience with the intricacies of airborne LiDAR. When Optech created the first prototype of the Optech ALTM airborne laser terrain mapper in 1993, the aerial LiDAR survey industry was born, and soon companies were popping up everywhere to get into the business.

Staff

From Michael I learned that Don originally joined the company in 1983 as a Programmer Analyst. In that job, Don made sure that Optech's software could handle the data produced by its cutting-edge hardware. This technical background and product knowledge enabled Don to move into managing projects such as ALTM and SHOALS-1000, and



High-altitude LiDAR glacier survey.

he took over as CEO when his father Allan became Chairman of the Board.

Optech continues its research to lead the LiDAR industry under the supervision of Chief Technology Officer Joe Liadsky. A 34-year veteran of the company, Joe originally joined as a Senior Engineer and was responsible for designing the electro-optical components that were crucial to the early Optech products such as ILRIS and ALTM. Nowadays, he leads Optech's large stable of scientists and engineers to make sure that the company keeps expanding its technological expertise.

Vice President of Business Development, Michel Stanier, is responsible for identifying and overseeing the execution of new business opportunities for Optech, and for managing Optech's product development. Mr. Stanier initially worked at Optech from 1992 to 1999 as a Project Scientist and Project Manager. After working at various technology companies, he rejoined Optech in 2011.

Facilities

In 2006 Optech moved into new headquarters in Vaughan, Canada, only

a few kilometers from York University. This facility contains extensive and well-equipped design and test laboratories so that staff can integrate, align, calibrate and test systems in-house. Although it started in Canada, Optech has since spread into several international offices over the years. In 2001 Optech opened its office in Kiln, Mississippi to serve as Optech's hub for bathymetry and work with the Joint Airborne LiDAR Bathymetry Technical Center of Expertise (JALBTCX). As a result, Kiln is the center of development and support for CZMIL Coastal Zone Mapping and Imaging LiDAR system. When Optech acquired the camera companies DiMAC in Belgium and GSI in New York it retained their offices, which are now centers of camera development, global marketing management (New York), and enhanced support for Europe and North America.

Optech has made it a point to be a global company, offering service and support wherever its customers may be. Based out of Canada, the USA, Belgium, Russia and Japan, Optech service technicians can visit customers to perform

maintenance and repairs on-site and minimize downtime.

Airborne Imaging Solutions

The acquisition of GSI and DiMAC expanded Optech's offerings in the airborne mapping space. No longer just a LiDAR company, Optech now offers a diverse product portfolio of both active and passive imaging sensors. With such a diverse product offering, Optech has further expanded its product portfolio

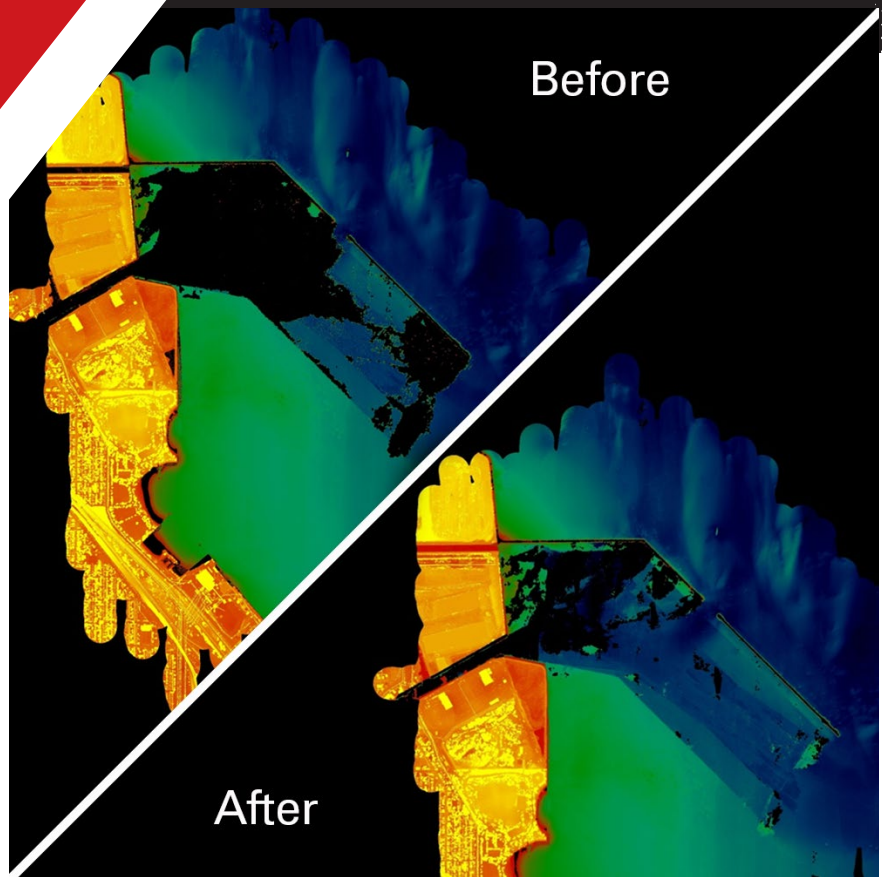


Don Carswell's early work as a Programmer Analyst gave him the experience to guide Optech through a sea of ever-changing technology.

to offer scalable, off-the-shelf sensor mounts (fixed and/or gyro-stabilized), and vibration isolation platforms that support any combination of LiDAR and cameras. With significant enhancements in sensor capabilities over the last few years, Optech has maximized the reliability of the systems while working closely with clients to optimize their configurations for best performance.

Sensor Technologies

Optech sensors were first to market with native roll compensation. This capability ensured that aircraft platform dynamics did not translate into the ground swath data. This provided nice straight flight lines about nadir, improving collection efficiency with reductions in required sidelap.



This before and after image of CZMIL bathymetry in turbid and muddy waters clearly shows the effectiveness of the new Turbid Water Module for HydroFusion. In this case an additional 12 m of depth and bottom detail was acquired.



The first commercial dual-laser lidar sensor, ALTM Pegasus provides incredible collection efficiency at altitudes up to 5000 m agl.

Optech released the industry's first Continuous Multipulse (CMP™) feature in 2006 to overcome the time-of-flight limitation associated with single-pulse designs and leverage the higher laser pulse power available to the user (sensors are instead signal-to-noise limited). Other manufacturers have since followed suit with variations on this collection-efficiency technology.

The key advantage of CMP has been its in-air implementation, enabling data coverage verification on the fly while in CMP mode, with no requirement for data post-processing to solve for pulse mode ambiguity.

Most recently, Optech has responded to commercial industry requests for increased vertical point density, without the headaches of voluminous full waveform data capture and storage. Optech has since announced the release of a new sensor recording capability that significantly increases available vertical point density beyond the traditional 4-return maximum. This new capability provides increased complex target resolution for forestry and powerline applications, without the processing burden of de-convolving waveforms. According to Sitar, positive feedback to this feature has been very strong.

Orion

The Optech Orion ALTM was the first UAV-specific LiDAR sensor design to be released to the commercial survey industry in 2008. A full-system solution available at under 1 cubic foot, the sensor platform was expanded to include removable SSD storage (in addition to its internal SSD), fully-integrated gyro-stabilization, and the capability to power, time-stamp, control and monitor up to six peripheral imaging sensors. Incorporating the latest in high-performance lasers and timing electronics, the company feels Orion has become an industry benchmark in data precision, accuracy and detectability for tight-tolerance applications, particularly in the powerline survey industry.

Orion is available in three model configurations including Orion H, M and C-series. Each series is tuned to deliver maximum performance relative to the specific application space. For example, the Orion C-Series is a low-altitude corridor mapping sensor employing a

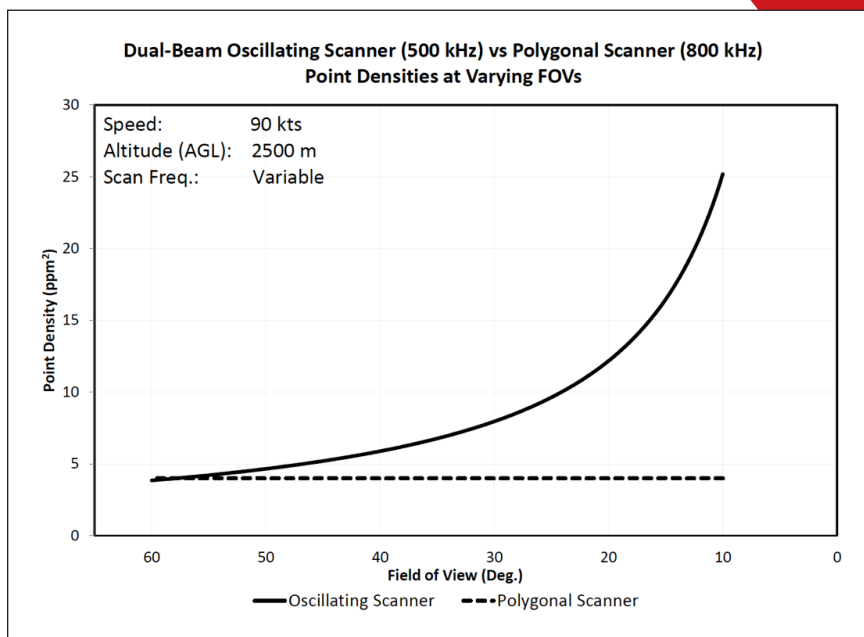


Figure 1: Dual-beam point density plot comparing oscillating scanner versus polygonal scanner at varying FOVs.

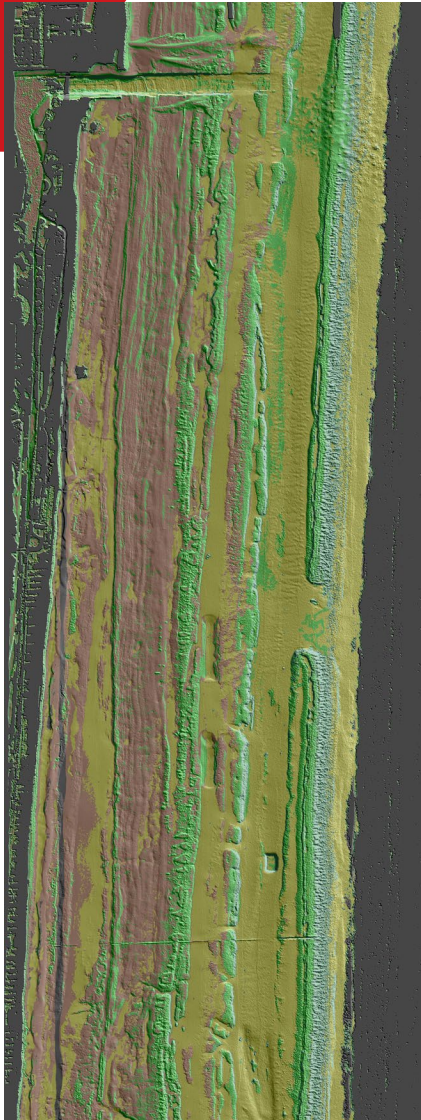
Class 1, 1.5 micron wavelength laser capable of exceptional data precision, small target detectability and high point density. The Orion H-series provides high collection efficiency for wide-area projects with available CMP and high-altitude performance at altitudes exceeding 4000m AGL.

Pegasus

The release of the Optech Pegasus ALTM dual-beam sensor in 2009 spawned a new generation of LiDAR sensors, focused on increasing collection efficiency and maximizing point density. Capable of 5000m AGL performance in dual-beam mode, Pegasus was the first commercially available LiDAR mapping sensor to incorporate multiple lasers, a common scanner and an embedded medium-format camera with optional full-waveform recording capability. Incorporating a fully programmable

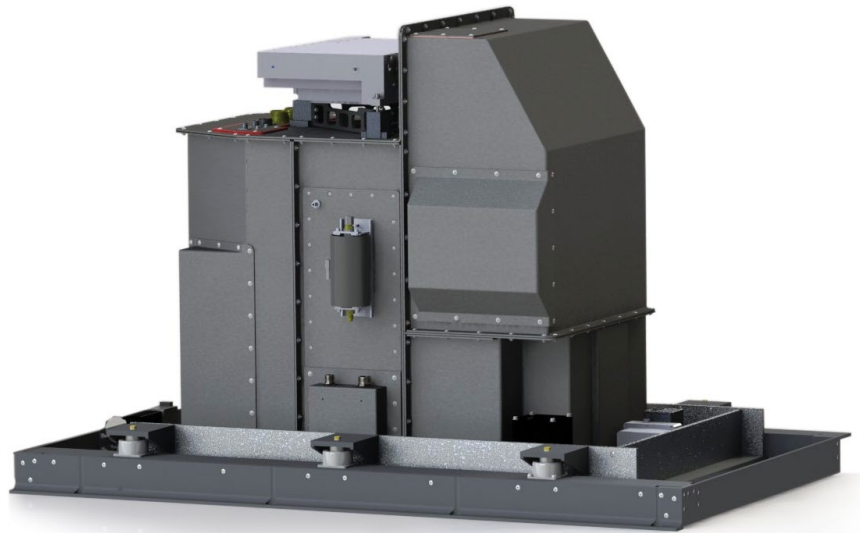
oscillating scanner with a user-selectable FOV, this dual-beam sensor has the inherent flexibility to maximize collection efficiency at large FOVs (>60°), or dramatically increase point density by constraining the entirety of its 500,000 point/second into smaller, user-definable FOVs (see **Figure 1**). Fully-automatic roll compensation enables straight data swaths and fewer flightlines.

The Pegasus sensor employs a paired-beam scan pattern, unlike alternative dual-beam sensor scan patterns that have a much larger time delay between the data streams over the same target, particularly at the scan ends. Beam pairing is critical to maximizing dual data stream co-registration. Co-registration is compromised when a significant time delay exists from when one data stream passes over the target relative to the second data stream due to inherent INS trajectory accuracy



Optech CZMIL and HydroFusion sea floor classification map obtained in Florida waters to around 35m depth. Other information that can be produced includes: surface and bottom reflectance, water column characterization, object detection, and seamless 3D land and bottom features.

variation. The Pegasus paired-beam pattern was developed to eliminate this extraneous data noise common with time delayed data streams, as well as significantly improving the overall laser point distribution predictability.



LiDAR Mapping Suite (LMS)

The company feels its latest LiDAR processing software, the Optech LMS LiDAR Mapping Suite, has set an industry standard in data processing efficiency and sensor calibration automation. Capable of processing both mobile and airborne LiDAR data via a single workflow, LMS has pushed LiDAR point cloud accuracy to the limit. Incorporating rigorous least-squares methods, robust processing algorithms and sensor optical models, LMS computes a dynamic error model and creates a geometrically correct point cloud. An integrated camera processing and boresight module is expected for 2014, making LMS the first software from a sensor manufacturer to incorporate both LiDAR and camera workflows into one common platform, enabling truly coincident datasets.

FMS Flight Management System

Optech released a new flight management system in 2012, Optech FMS, for all of its airborne sensors. This new software tightly integrates into one common interface a LiDAR sensor,

The powerful Optech CZMIL bathymetric LiDAR system has been validated and deployed by multiple governments. It has superior operational productivity and measurement capability in challenging water conditions. It also includes a unique all-in-one workflow, HydroFusion, for the generation of fused map product deliverables.

a gyro-stabilized mount, a waveform recorder and up to six independently triggered cameras. Designed to leverage a new real-time sensor protocol in the Pegasus and Orion sensor platforms, Optech FMS computes real-time point clouds in the air. This capability significantly increases collection confidence, even when in CMP mode, by computing true swath coverage on the fly. Gaps or variations from the flight plan can be identified and re-flown in the air as required, maximizing in-air collection confidence and confirming target detection. Optional real-time LAS files provide the unique opportunity for immediate data deliverables for rapid response applications.

Full-waveform and discrete sensors

Optech has spent decades in the research and design of native full-waveform sensors. A necessity in the bathymetric application space, full waveform analysis has many benefits, including shallow-water depth extraction, true-ground detection, target cross-section normalization and improved vertical point density. While Optech's commercial airborne sensors have traditionally used discrete measurements for superior shot-to-shot precision, all sensors are full-waveform capable, with optional external waveform recorders. Such requirements for waveform analysis are often found in the forestry industry, where vertical density is preferred.

With subsequent improvements in time-of-flight electronics and powerful, narrow pulse-width lasers, Optech's discrete sensors have eliminated the need for time-consuming waveform analysis and XYZ point extraction to increase vertical point density. With recording limits for discrete returns removed and minimum target separation distances reduced, Optech's latest discrete sensors will be capable of providing vertical densities comparable to waveform extraction methods, but without the enormous waveform storage and processing bandwidth required to execute large projects. This translates into larger data volumes without the processing burden.

Bathymetry

Optech has continued pioneering airborne bathymetric systems ever since its early days. Circa 1985, Optech's LARSEN 500 created the

first LiDAR-based hydrographic chart, and around the first Gulf War Optech created the ALARMS underwater mine detection LiDAR for the US Defense Advanced Research Projects Agency (DARPA). Given the interest in bathymetric mapping and underwater object detection, Optech decided to create LiDAR systems adept at both tasks, such as the HAWKEYE system for the Swedish Navy and Hydrographic Department and the world-famous SHOALS system, which led to today's CZMIL Coastal Zone Imaging and Mapping LiDAR, known for the ability to map details even in turbid and muddy water conditions, and depths up to 80m in clear waters. Both CZMIL and its end-to-end workflow software HydroFusion have won numerous awards for technology innovation, and is the only airborne bathymetric system field verified and in use by multiple government agencies for critical projects.

Ground-based systems

After creating a 3D LiDAR mapper intended for use on an extraterrestrial rover in 1993, Optech decided to convert the design for terrestrial use as well, resulting in release of the ILRIS. The ILRIS has enjoyed several updates to its capabilities over the years since: In addition to raw range improvements, the ILRIS now boasts compatibility with inertial navigation systems for mobile surveying, software updates that enable users to process their data right in the field, and third-party software that provides automated operation for remote monitoring solutions.

Taking matters to the road, Optech produced the Lynx Mobile Mapper™,

which rapidly surveys corridors from the top of a moving vehicle. As always, Optech has worked with customers to adapt the system, initially designed for automobiles, for a range of different platforms including rail cars and boats. Optech also expanded its market appeal by redesigning the Lynx into two models, the traditional survey-grade Lynx SG1 for customers that need the utmost absolute accuracy, and the mapping-grade MG1 for users who need a lower price point while still being able to upgrade later to the SG1. Lynx users also benefit from the LMS software automation and enhanced workflow efficiency.

Conclusion

With the acquisition, what was once a Canadian company is now an American company, but much of its technical roots remain in Vaughan. While there, I sat in on a teleconference with Max Elbaz who heads up the CZMIL development in the Kiln office, and global marketing and US defense initiatives from the Rochester, NY office where he operates from. Optech truly is a global company and I found it telling that they refer to people who have purchased their equipment as clients rather than customers. During my previous visits I learned that technicians can be anywhere in the world in 24 hours. Retaining a family atmosphere, attracting a well-educated workforce, and benefitting from Teledyne's vast knowledge base, it's obvious that the best is yet to come from Optech. ■

Marc Cheves is editor of the *The American Surveyor*.