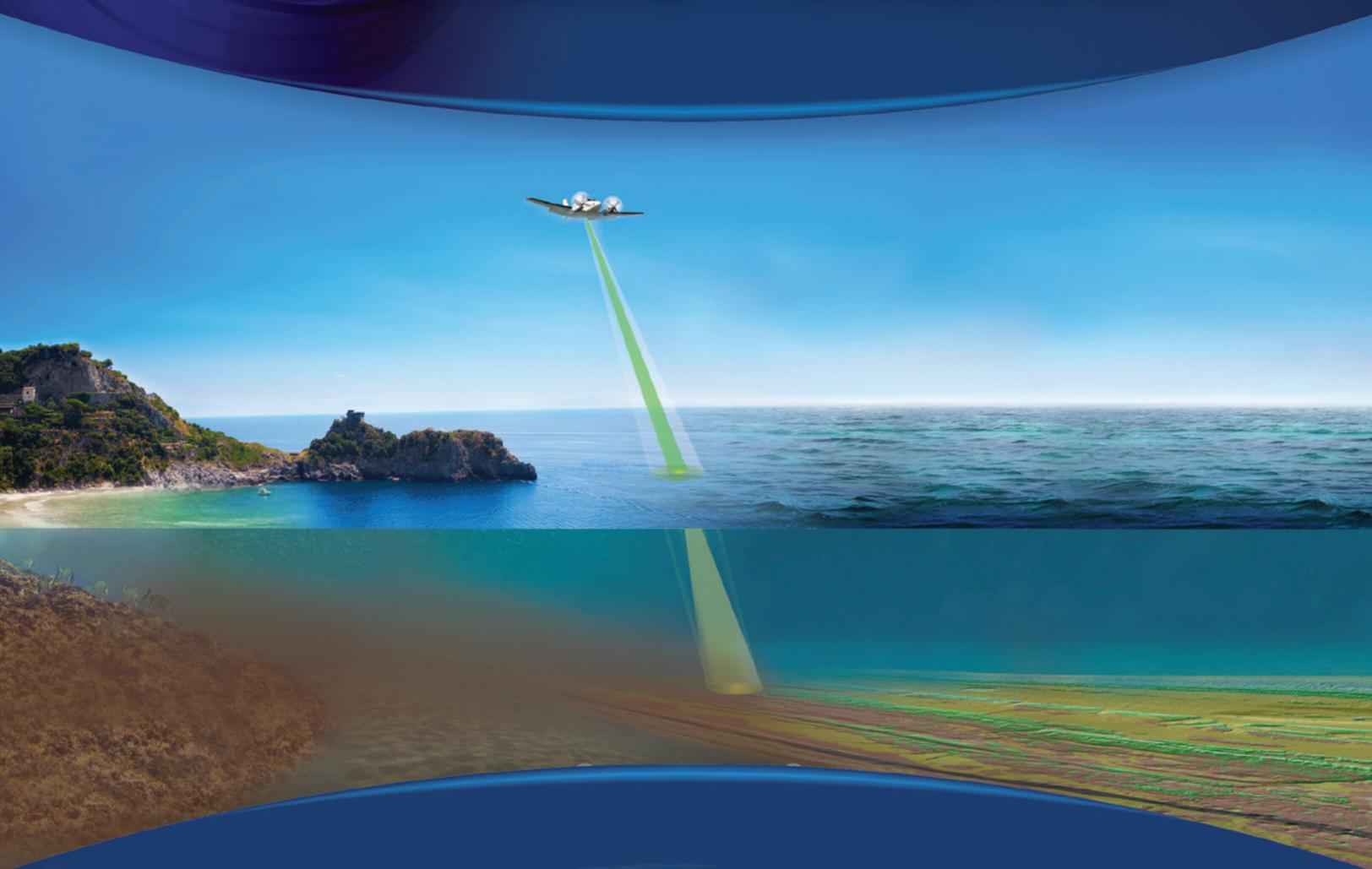




TELEDYNE OPTECH
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THE
SOLUTION
FOR AIRBORNE HYDROGRAPHY



Coastal Zone Mapping and Imaging Lidar

CZMIL Nova

Highly Accurate Bathymetry with Seamless Topography

The Optech Coastal Zone Mapping and Imaging Lidar (CZMIL Nova) is a breakthrough airborne multi-sensor system designed for the highly automated generation of 3D topography information for coastal zones, especially in turbid and muddy water conditions. Building on Optech's highly successful SHOALS program and over 25 years of industry-leading lidar expertise, CZMIL Nova is the only airborne bathymetric system tested against military specs such as shock, vibration and EMC, and validated by multiple government agencies to map coastal areas on a regular basis.

These agencies rely on CZMIL Nova for the following reasons:

1. Proven in real-world projects to deliver in water conditions where other systems simply leave gaps
2. Best seamless topo/bathy capability in clear waters up to 80 m and unmatched results in turbid waters
3. Best operational productivity with all-in-one HydroFusion workflow and data fusion software

Enabling technologies include:

- Wide swath for large-scale mapping and efficient coverage
- Circular lidar scan pattern providing two 'looks' for optimal object detection
- High-power laser with short pulse width enabling accurate land and water depth measurements in various conditions
- Software technology based on rigorous science to derive bathymetry from water too turbid for other sensors
- Segmented lidar detector capable of simultaneous recording of high-density topo/bathy data from a single laser
- Fully integrated RGB and hyperspectral sensors for advanced data fusion products in HydroFusion workflow
- Wide aperture for deep-water optical mapping

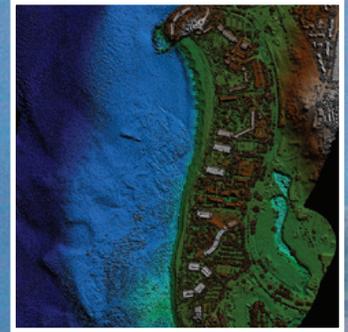
The high-performing lidar, hyperspectral and visual sensors are coupled with Optech CZMIL HydroFusion, the system's powerful yet simple-to-use software suite that handles mission planning and data processing for all three sensors in a single, unified interface. By combining CZMIL Nova's full-waveform lidar data and hyperspectral imagery into a wide range of physical and environmental data products, CZMIL HydroFusion accelerates product delivery and improves the quality of deliverables derived from fused lidar and imagery datasets.

Today, several CZMIL Nova systems are deployed in various countries, collecting seamless bathymetric and topographic data/imagery over large areas with high accuracy for their agencies.

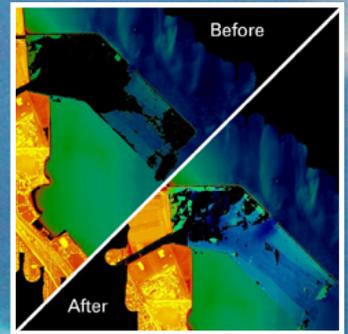
Applications

- Shoreline mapping and coastal management
- Harbor and navigation channel inspection
- Beach and coastal erosion monitoring
- Aquatic ecosystems management
- Rapid environmental assessment
- Underwater object detection
- Nautical charting
- Disaster response
- Water quality (IOPs) characterization
- Shallow water seafloor classification
- Water column characterization
- Benthic habitat classification
- Rapid hazard area mapping

CZMIL was designed by Optech for the U.S. Government under the auspices of the U.S. Army Corps of Engineers (USACE) and the Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX). It was built and tested by Optech with the assistance of the University of Southern Mississippi (USM).



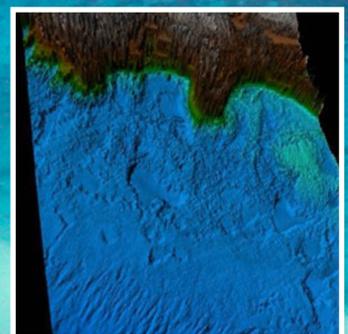
Seamless Topo/Bathy



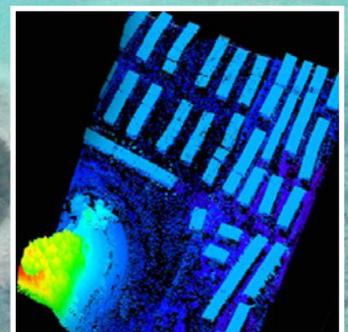
Turbid Water Performance



Efficient Airborne Coverage



Water & Bottom Characterization



Object Detection

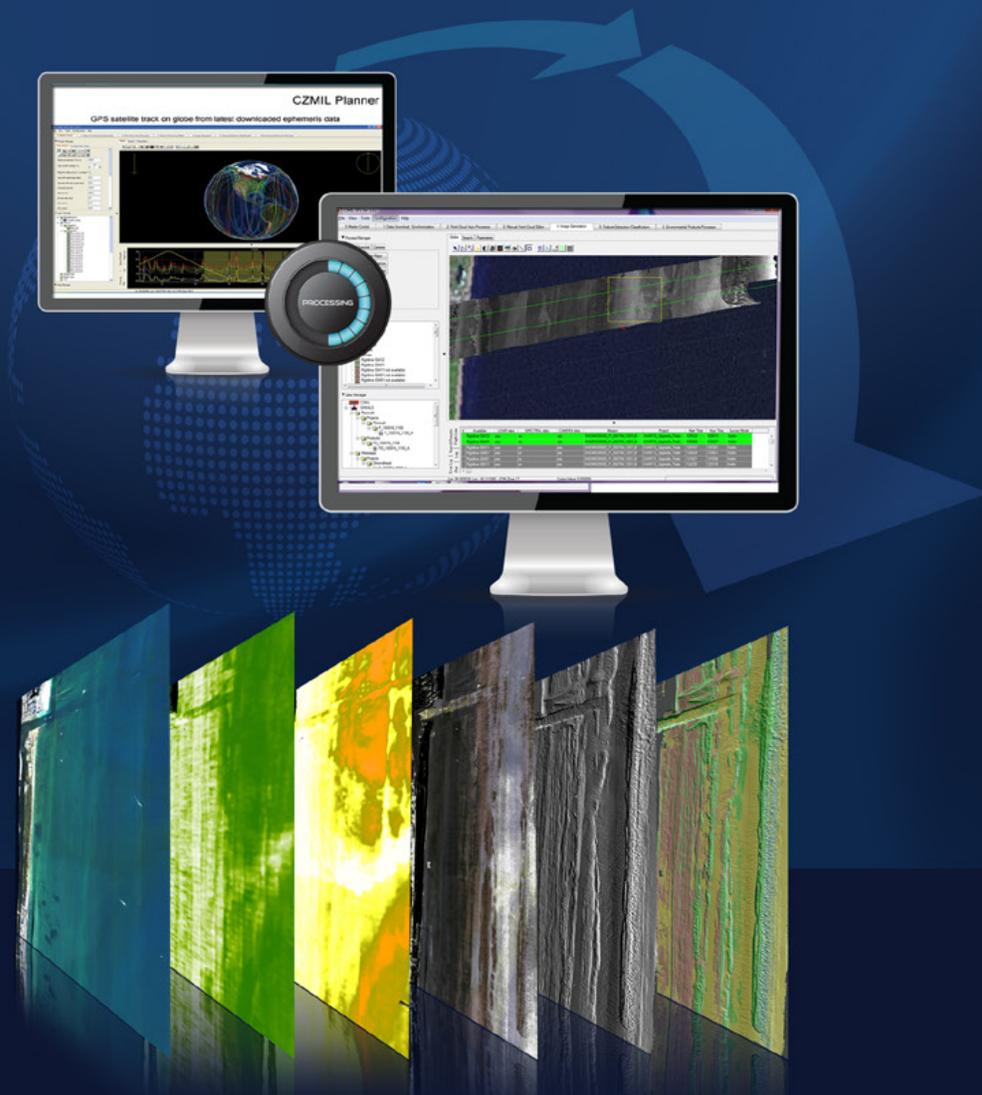
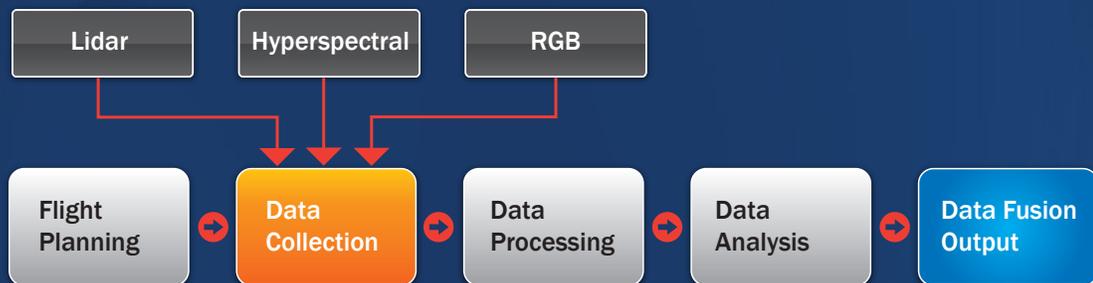
Complete Hydrographic Workflow Software

Optech CZMIL HydroFusion includes mission planning, data processing and the generation of the final bathy/topo products, all in one easy-to-use interface. It's a powerful end-to-end software suite designed specifically for Optech CZMIL Nova that accelerates data and product delivery, and improves the quality of information products derived

from fused lidar and imagery datasets. Even with unskilled operators, HydroFusion automatically produces high-resolution 3D data and environmental image products by combining the full lidar waveform with the hyperspectral and RGB images in a data fusion paradigm.

HydroFusion Ver 1.2 includes significant improvements that focus on faster processing, enhanced accuracy, and versatility:

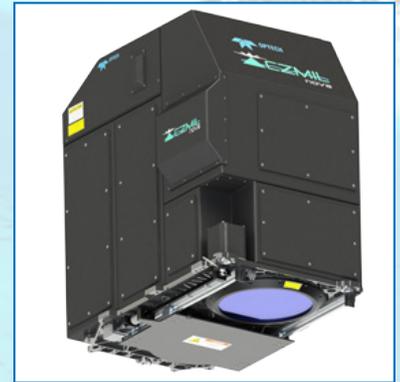
- Improved data coverage and point accuracy with surface detection tools for non-ideal water surface conditions
- Geo-calibrator tool handles the automatic geo-calibration and validation of lidar data
- Color balancing tool improves the color for camera image mosaics, delivering more accurate and useful imagery
- Automatic spatial filters eliminate most data outliers in processing, reducing time needed for point cloud editing
- For each shot, a range of valuable attributes is stored along with the XYZ data, and is easily accessed by a query
- An optimized tool downloads raw lidar data to the local workspace in <50% of the actual data collection time
- Mission plans can be imported from and exported to popular file formats such as ESRI SHP and Google KML



System Overview

Bathymetric Lidar System

CZMIL Nova's hybrid scanned-flash lidar system is a product of Optech's decades of experience in developing and deploying industry-leading bathymetric lidar sensors. Its enlarged receiver pupil and doubled spatial resolution enable wide swaths that let you cover large areas faster and improve the quality of information from fused lidar/imagery datasets. The high-powered short burst of CZMIL Nova's green laser differentiates water surfaces and bottoms even in shallow, turbid waters, and its refractive circular scanner captures targets from multiple directions, improving underwater object detection. Finally, its segmented detector collects 7 return waveforms for each laser shot with HydroFusion resolving up to 31 discrete points from each waveform, increasing the effective point density without the need for potentially less reliable multiple lasers.



Hyperspectral Camera

The CZMIL Nova hyperspectral imager is an ITRES CASI-1500H that enriches the data collected from the lidar sensor by capturing the spectrum between 365 and 1050 nm. The automated data fusion and advanced algorithms that are part of CZMIL HydroFusion automatically process the hyperspectral data to create surface and bottom reflectance charts, chlorophyll maps, and other environmental data products.

This optional imaging sensor is ideal for government agencies and scientific organizations that need more detailed information about the water quality being scanned.



RGB Camera

CZMIL Nova collects 16-MPix RGB images with an Optech CS-4800i digital aerial camera to create a crisp photomosaic of the survey area and fuel the creation of data fusion deliverables. For users with specialized requirements, the system is extensible to include Optech's line of cameras, including 80-MP cameras for high-resolution imagery and mid-wave/long-wave infrared models to collect thermal data about the water surface.



IMU & POS

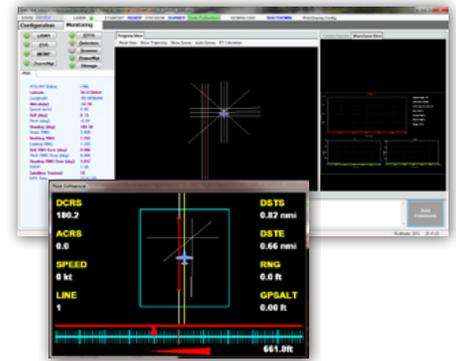
CZMIL Nova attains its world-leading accuracy with the help of a best-in-class inertial solution including a high-accuracy inertial measurement unit (IMU) and an embedded GNSS receiver. Tightly-coupled inertial processing capabilities allow the aircraft to perform steep-angle turns without losing the lock on the GNSS satellites, increasing collection efficiency and productivity.



System Software

CZMIL NAV

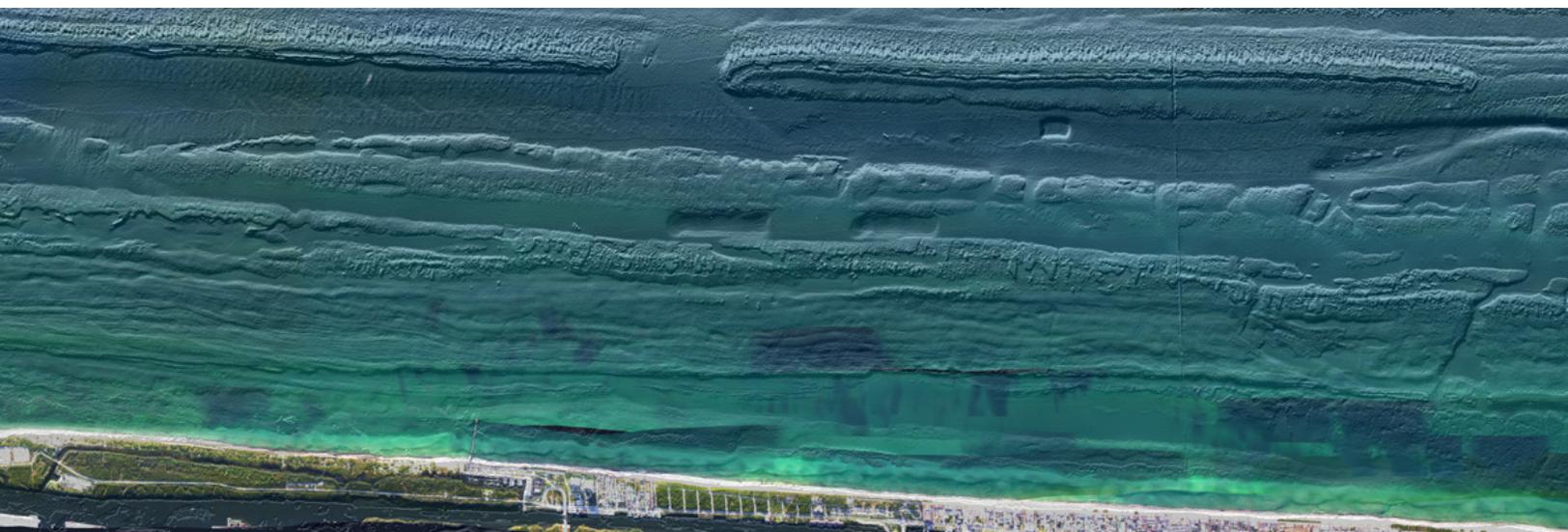
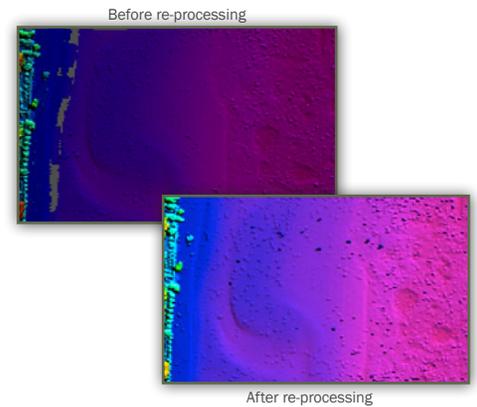
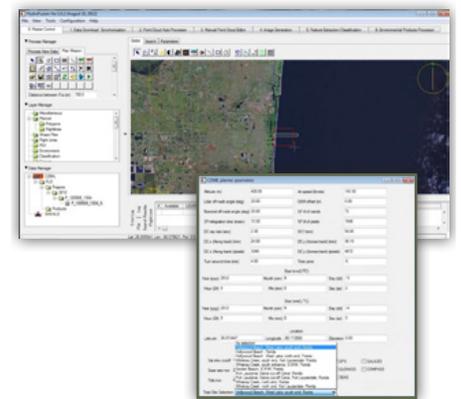
For improved ease of use, the operator controls and monitors CZMIL Nova and its three sensors using a laptop with a single program, the CZMIL NAV flight management system. To reduce operating costs, the program displays real-time swath coverage for in-air verification, meaning that you never get back to base only to find coverage gaps in your data that must be re-surveyed. In-air diagnostics and data displays let you verify that the data is meeting your accuracy requirements.



Optech CZMIL HydroFusion

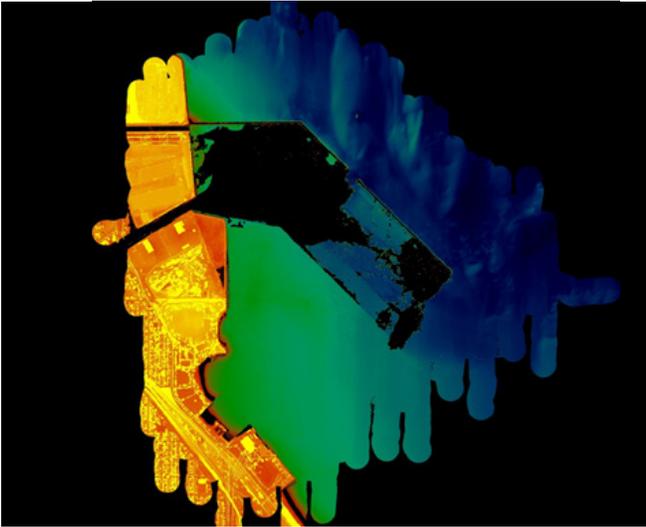
HydroFusion is a single program that provides mission planning, data collection quality control, and automated processes that lead to fused data results from CZMIL Nova's three sensors - lidar, hyperspectral, and camera - producing a variety of data products, from chlorophyll detection to benthic classification. With HydroFusion, the potentially complex processing of marine environment survey data is now a simple one-flow solution.

- Flight planning with flightlines, automatic study area parameters, collection attributes, and a globe-based GUI for ease of locating, processing and managing data across missions
- Automatic classification of land and water shots is standard for Optech HydroFusion, and with the new re-processing feature data gaps near the shoreline can be eliminated.
 - In environments where automatic shoreline delineation is challenging, misclassified shots can be re-labeled and reprocessed on-the-fly.
 - Highly valuable in the QA/QC process and is tightly integrated in the processing workflow.
- Multi-sensor data fusion and automated classification algorithms to collect bathymetry in challenging conditions and produce detailed bottom classification maps
- Integrated 3D volume visualizer for advanced submerged object detection and water volume characteristic analysis, including leak detection
- Area-based visualization, lidar point cloud editing, and ortho-image mosaic tools

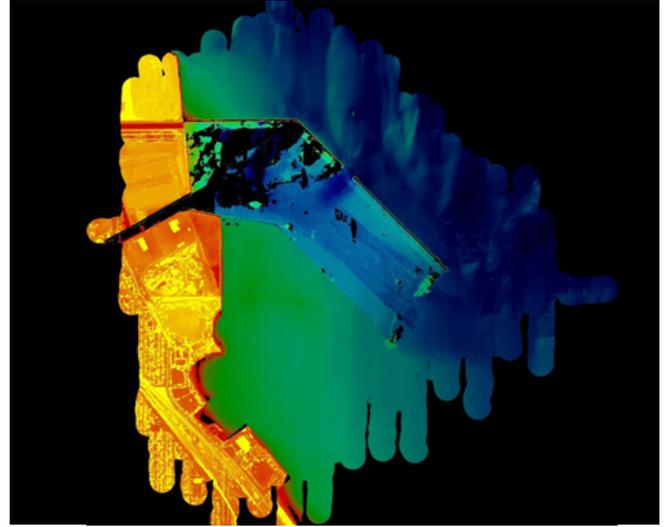


Turbid Water Penetration

With Optech CZMIL Nova, you can forge ahead into water never before accessible by air. Until now, most of the globe's coastal zones have been closed to airborne lidar because they contain turbid, muddy water ($K_d > 0.3 \text{ m}^{-1}$) that reduces the depth range of typical lidar bathymeters to almost zero. CZMIL Nova opens up these areas by using a short-duration high-power laser pulse, large receiver pupil, and advanced proprietary algorithms to penetrate highly turbid waters.



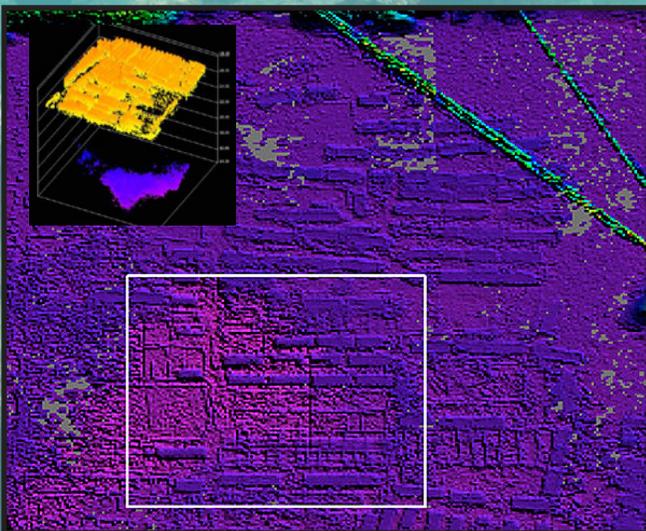
Undetected bottom with standard approach



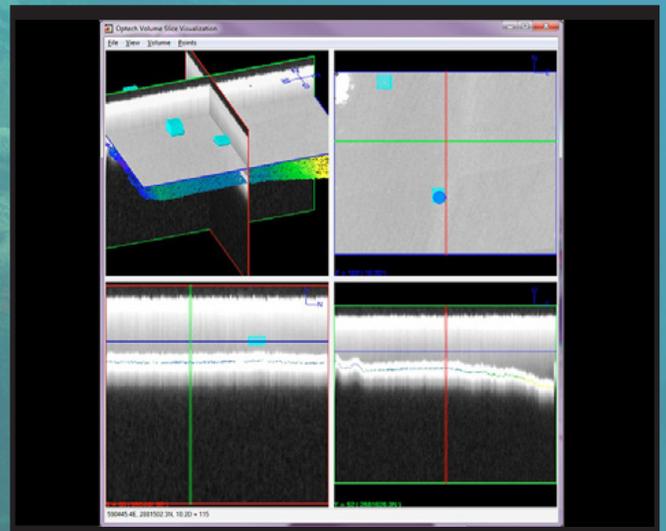
Bottom detected after enhanced HydroFusion Turbid Water Module process

Object Detection

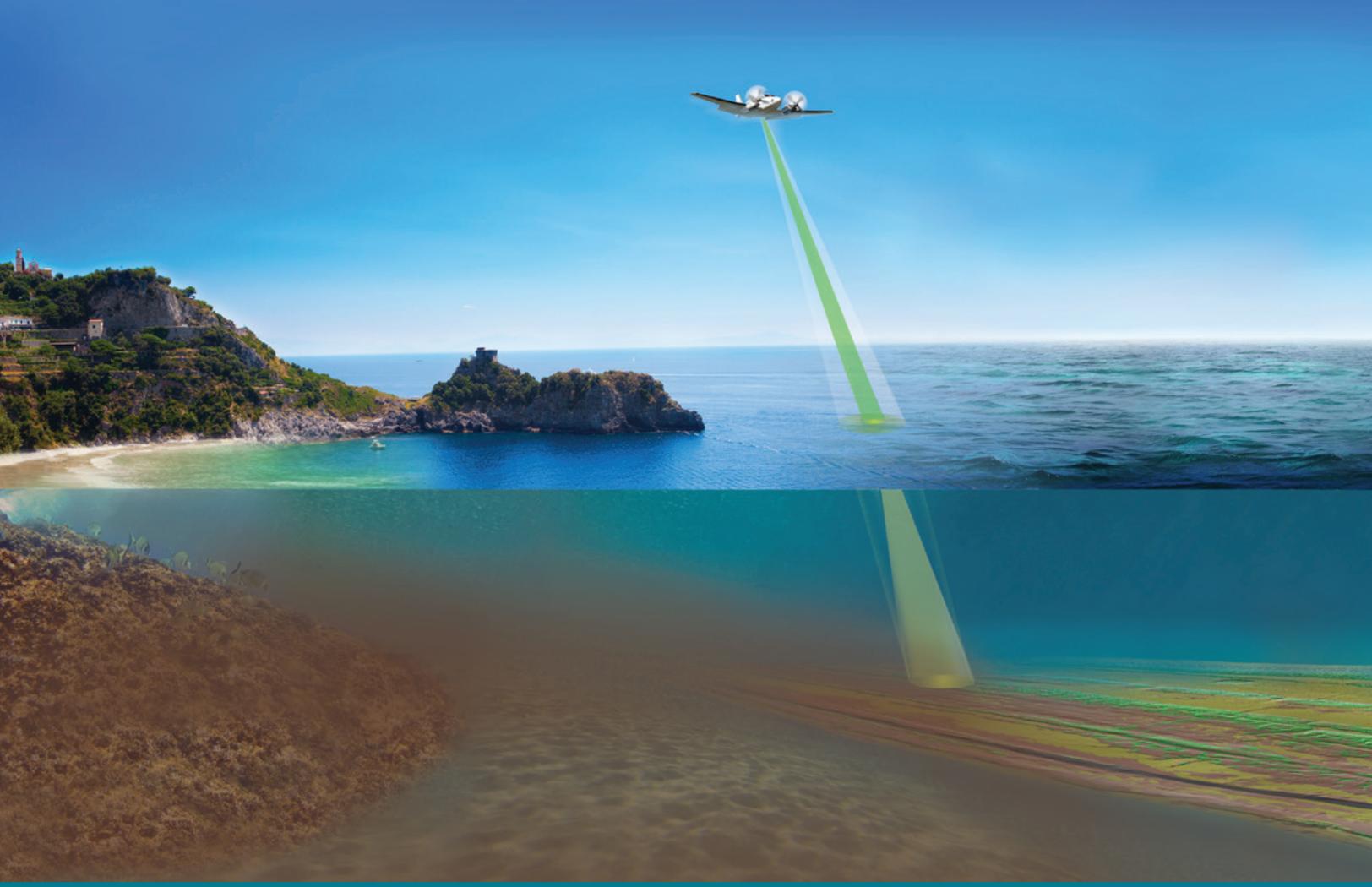
CZMIL Nova is the tool of choice for locating underwater objects and hazards safely and quickly. With a circular scan pattern that provides two looks at every object, a short pulse duration that increases vertical precision, and a 7-segment receiver that increases the spatial resolution of the lidar data, CZMIL Nova detects objects as small as 1 meter cube in water up to 25 meters deep. After the survey, HydroFusion makes it easy to find and identify the target objects with its wide array of 3D visualization tools.



Submerged fish cages and ocean bottom



3D VOXEL analysis tools for object analysis



Depth Accuracy

The CZMIL line of bathymetric sensors are the most validated airborne system for depth accuracy in a variety of real-world water conditions. Several CZMIL systems are being used by government agencies throughout the world, and this unique ability to derive accurate information in more than just clear water environments makes the system and its integrated CZMIL HydroFusion workflow indispensable. The breakthroughs in receiver sensitivity, pulse width, pulse power, laser efficiency and shallow-water optimization algorithms incorporated into the CZMIL Nova have introduced and opened up new targets for airborne lidar bathymetry. The segmented lidar detector improves point density by capturing seven segmented returns, one deep channel, and one IR channel, resulting in nine return signals for each pulse fired, and HydroFusion's shallow-water algorithms let you discriminate the sea surface from the bottom even in turbid and muddy water.

Seamless Productivity

The CZMIL HydroFusion workflow is a key factor in the superior level of productivity consistently demonstrated by CZMIL systems in the capture, processing and generation of fused data products. Seamless coverage is optimized with CZMIL Nova's high pulse power and large receiver aperture, which reduces dropout rates even at altitudes up to 1,000 meters. The system is capable of seamlessly collecting simultaneous topographic and bathymetric data, in addition to being integrated with software that automatically adjusts data processing parameters for land and water. CZMIL Nova is optimized for weight and power consumption, able to be mounted in aircraft as small as a Piper Navajo. It also has a ruggedized design that is optimized for airworthiness and military standards. Combined with the advanced features of the CZMIL Nova sensor system, the end-to-end management of collection quality and processing using CZMIL HydroFusion extracts data from each of the three individual sensors, producing a dozen or more data fusion deliverables. You can survey right up to the shoreline without leaving a data gap at the water's edge. Truly accurate and seamless!

CZMIL Nova Specifications

	Parameters	Specifications
General Specifications	Operating altitude	400 m (nominal), up to 1,000m
	Aircraft speed	140 kts (nominal)
	Hyperspectral sensor	CASI-1500H
	Digital cameras	T4800i
	Positioning & GPS/GNSS	Applanix POS AV™
	Positioning system	OmniSTAR capable (subscription required)
Lidar Hydrographic Mode	Shallow channels measurement rate	70 kHz
	Shallow channels maximum depth	$2/K_g$ (bottom reflectivity > 15%)
	Deep channel measurement rate	10 kHz
	Deep channel maximum depth	$4.2/K_g$ (bottom reflectivity > 15%)
	Depth measurement accuracy	$\sqrt{(0.3^2 + (0.013d)^2)}$ m, 2σ , 0 – 30 m
	Horizontal accuracy	$(3.5 + 0.05d)$ m, 2σ
	Scan angle	20° circular
	Swath width	70% of operating altitude
	Laser classification	Class 4 laser product: IEC 60825-1 Ed. 3.0 2014
Lidar Topographic Mode	Measurement rate	80 kHz
	Horizontal accuracy	± 1 m, 2σ
	Vertical accuracy	± 15 cm, 2σ
Physical	Power requirements	85 A for Lidar/camera @ 28 VDC and 95A @28VDC with CASI
	Operating temperature	0°C to 40°C
	Storage temperature	-10°C to +60°C
	Humidity	0-95% non-condensing
	Sensor head	89 W x 60 D x 90 H cm; 175 kg
	Control & operations rack	59 W x 56.5 D x 106 H cm; 112 kg
	Data processing software	CZMIL HydroFusion (Windows-based)



About Teledyne Optech

Teledyne Optech is the world leader in high-accuracy lidar 3D survey systems, integrated cameras, and productivity-enhancing workflows. With operations and staff worldwide, Teledyne Optech offers both standalone and fully integrated lidar and camera solutions in airborne mapping, airborne lidar bathymetry, mobile mapping, terrestrial laser scanning, mine cavity monitoring, and industrial process control, as well as space-proven sensors.

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