Integrating industrial Multichannel Laser Scanners for small vessel operations

JALBTCX 2015

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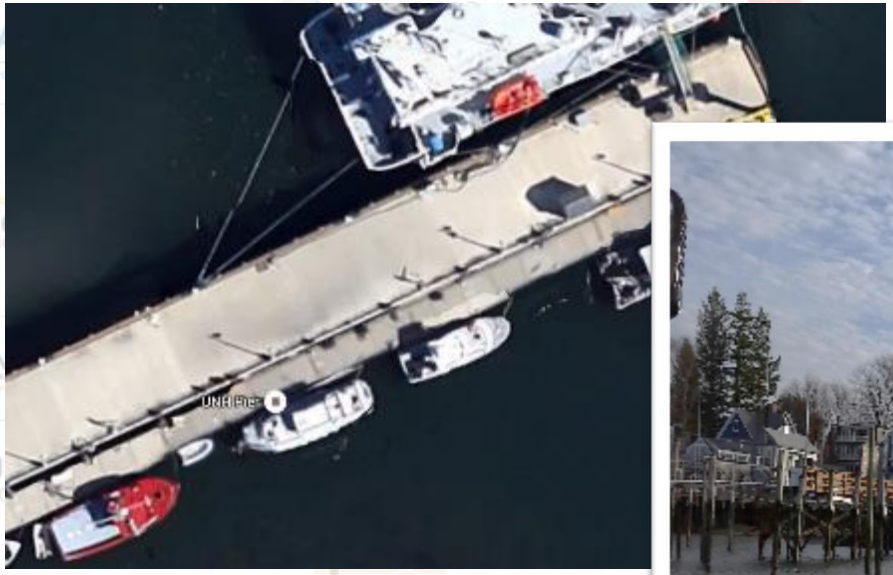
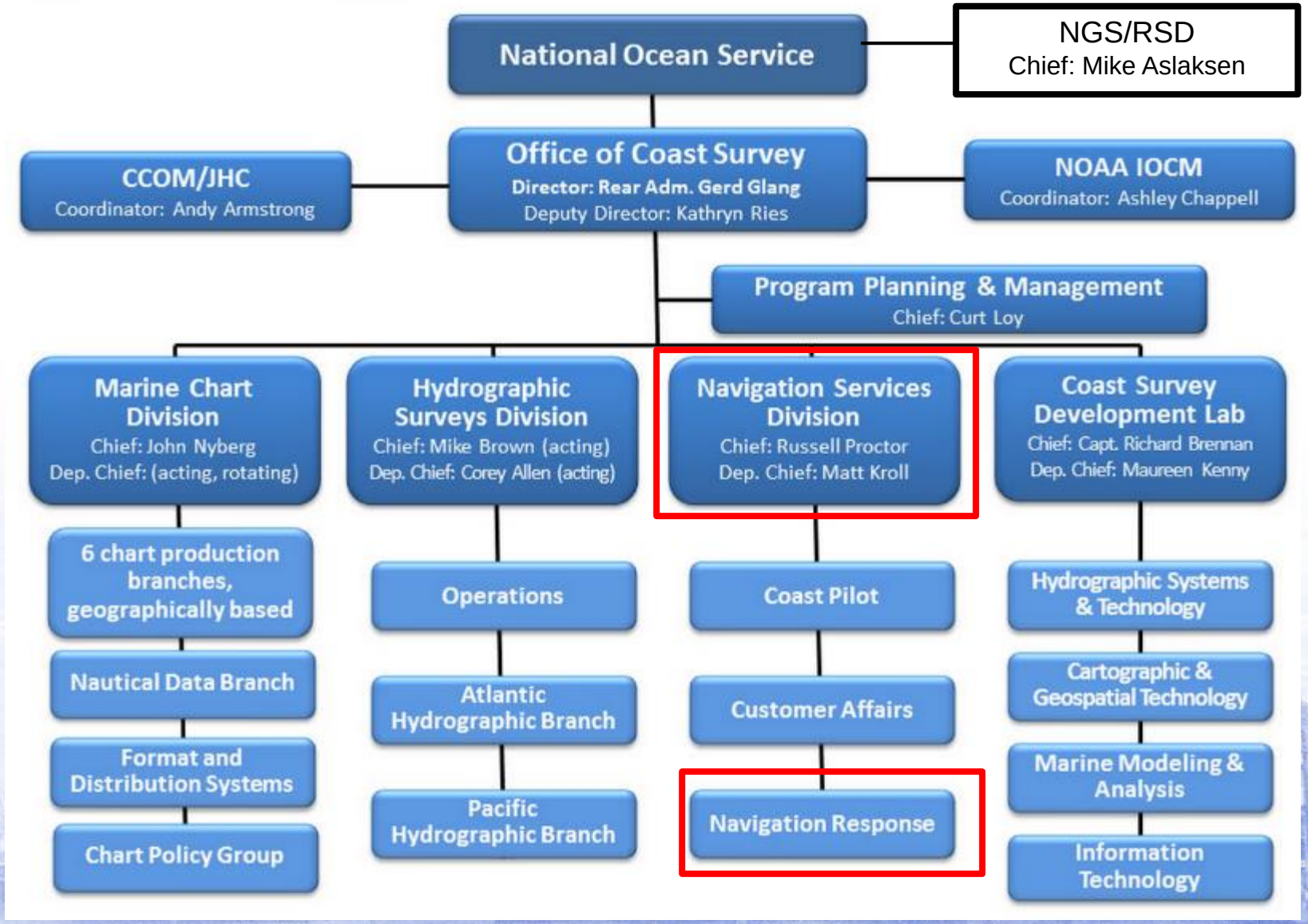
CCOM's Industrial Associates Program

(http://ccom.unh.edu/partners)



Mobile laser scanner for NRT

NOS/OCS/NSD/Navigation Response



Mobile laser scanner for NRT

Background

The navigational response teams (NRT) of OCS/NSD are in charge of mapping hydrographic surveys to support chart update for 175 major U.S. ports.

In addition, the NRT are on call to respond to emergencies, speeding the resumption of shipping after storms, and protecting life and property from underwater dangers to navigation.

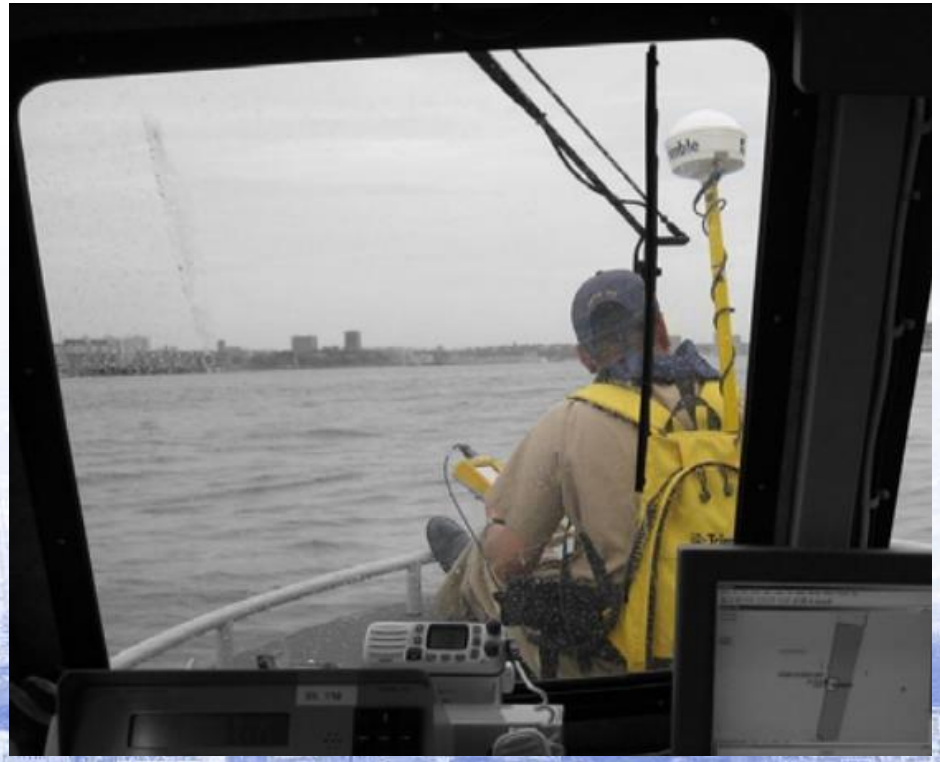
Features that pose danger to navigation include natural (e.g., shoals and boulders) man-made (e.g., piers, piles) features.

NOAA Office Coast Survey - Navigation Response Teams (NRT)

Motivation

For large-scale charting (1:5,000 and larger), it is important to be able to differentiate features such as docks to separate the submerged bottom-fixed structure to the surface construction.

The accuracy of the horizontal position and a tidally-referenced height of the bottom-fixed features is required at a decimeter level for multi-scale charting purposes.



Motivation

Currently, above water features are mapped using backpack mounted GPS equipment, handheld laser range finders, handheld compasses, and digital point-and-shoot cameras.

Such operations provide a reasonable first-order approximation to the location of the feature, however the result is a single measurement with a variable horizontal accuracy in the order of meters. In addition, the survey vessel is required to be stationary increasing survey time.

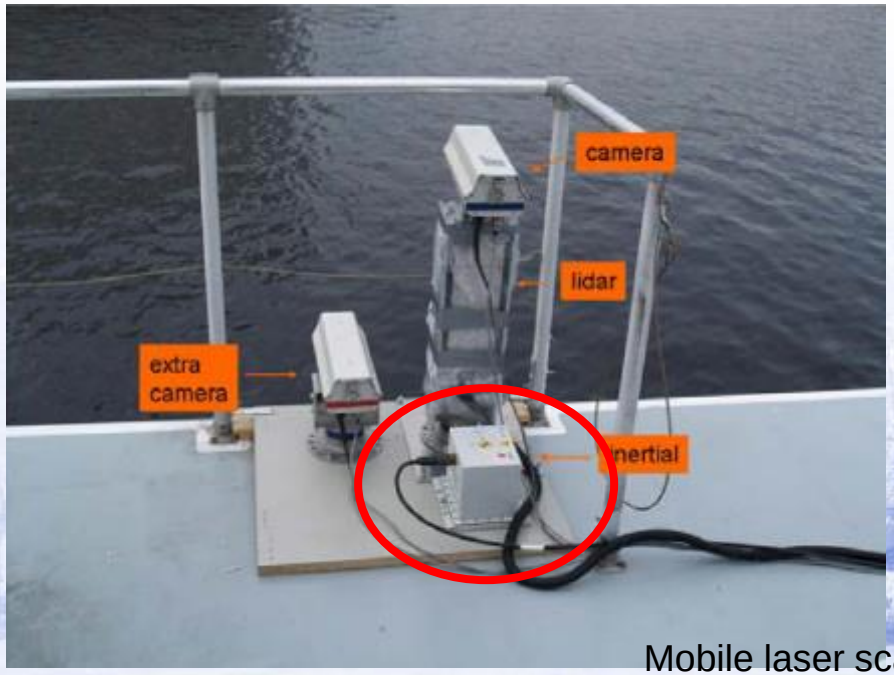
R/V Rainier, 2009
(Keku Stair, AK)

Previous work

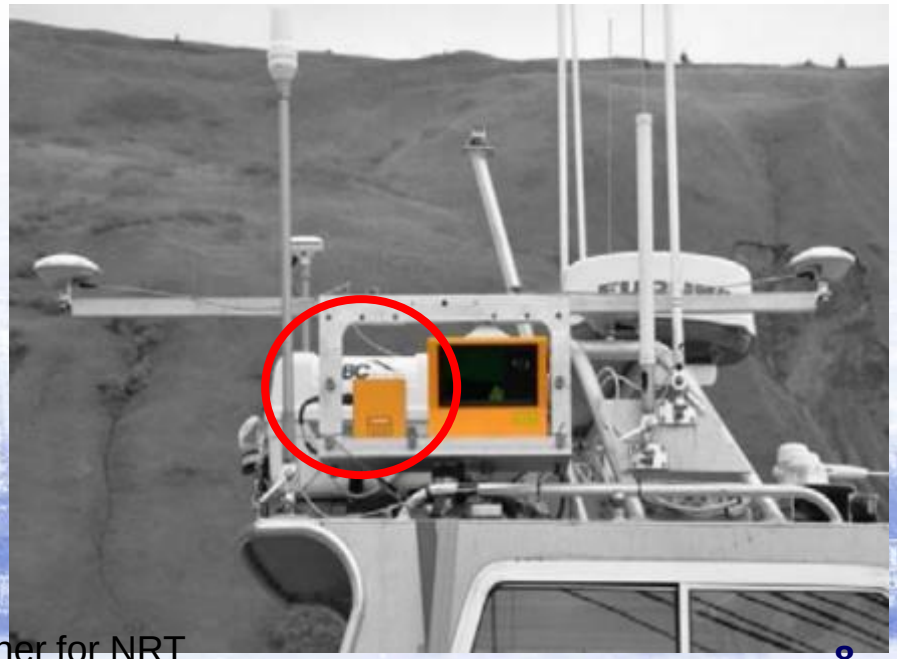
Previous work conducted by HSD has shown that survey-grade 3D laser scanner can be used to remotely map the danger-to-navigation features.

Over the past decade, NOAA has conducted two evaluation projects using long-range (maximum detection greater than 100 m) survey-grade laser scanners:

In 2007 using a Riegl LMS-Z420i laser scanner in Norfolk, VA (Brennan et al., 2007).



In 2011 using an Applanix LandMark scanner in Norfolk, VA and Kodiak, AK (Willey et al., 2011).



Industrial laser scanners

- Previous work has shown that survey-grade 3D laser scanner can be used effectively to remotely map the danger-to-navigation features.
- However, current systems exceed a hundred thousand dollars.
- Alternative proposed: Industrial safety 2D laser scanner; costs are substantially cheaper ($5K to $20K).
- Many of these are used for real time navigation and obstacle avoidance (e.g. autonomous platforms).

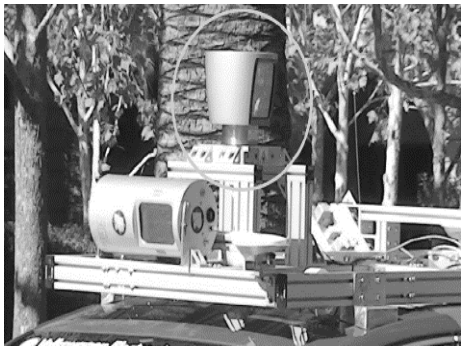
Industrial Laser Scanners for Autonomous Navigation (pictured: SICK and Velodyne LIDAR Sensors)

Cost

$$$

Survey commercial ($50K to $200K)

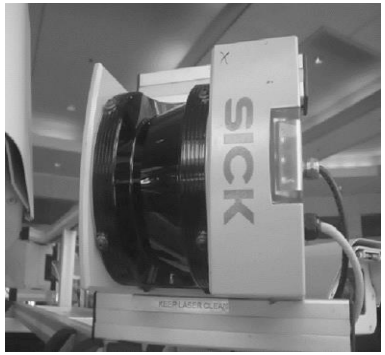
- Faro
- Optech
- Riegl
- Leica
- MDL/Renishaw
- Topcon
- Trimble
- Applanix



$$

Industrial commercial ($6K to $20K)

- Velodyne
- Sick
- Hokuyo
- Ibeo
- Neptec



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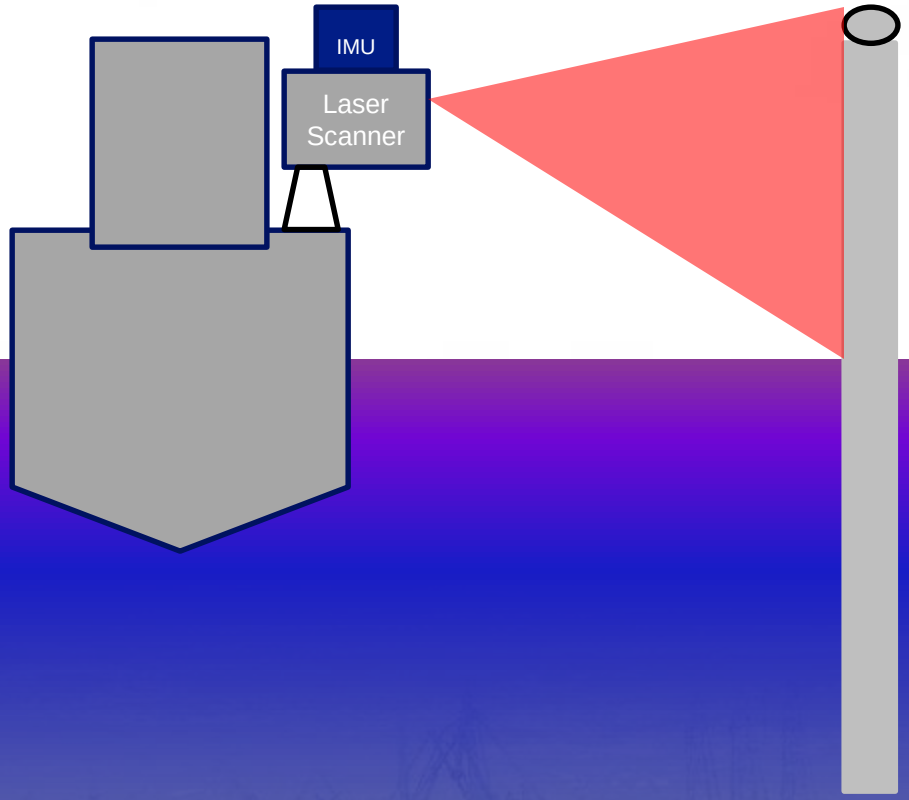
Non-standard (gaming) commercial ($1k)

- Microsoft

(http://ccom.unh.edu/user/tbutkiewicz)

Current Market for Mobile Laser Scanners



Objectives

Evaluate the performance of a economical industrial-safety 2D laser scanner for mapping dangers-to-navigation from a small survey vessel:

- Piers
- Piles
- Other unsubmerged features that pose danger to navigation

Additional benefits:

Mapping air gaps – Typical 2D laser scanners have a 180 field of view, which allow to map from straight down to above the vessel.

Interface software

Option 1: Hypack – this software is already available on the ships and has the capability to interface with other laser scanner systems (Riegl, Optech and MDL) using the HYSWEEP® HARDWARE setup. This will satisfy the need to interface directly with the auxiliary systems (GPS and INS).

Option 2: Software development kits used with 2D laser scanners (e.g., VeloView – developed under the Apache 2.0 license). This will require to develop an interface using the available protocols from all the sensors, including GPS and INS.

Deliverables

Currently, a laser range finder is used to estimate the location to a target (e.g., pile or pier) with a picture. The location is estimate based on the position of the vessel and a representative range and azimuth to the target.

Step 1: provide a XY location and point cloud image of the target.

Step 2: provide a point cloud of the target with potentially a vectorized model of the shape with respect to the water surface.

Hardware (System requirements)

- Environmental: outdoor (splash proof, humidity and temperature)
- Operational range: at least 50 m.
- Power: Eye-safe.
- Pulse Repetition Frequency (PRF): at least 10HZ @ 5 knt (~2.5 m/s)
- Angular Resolution:

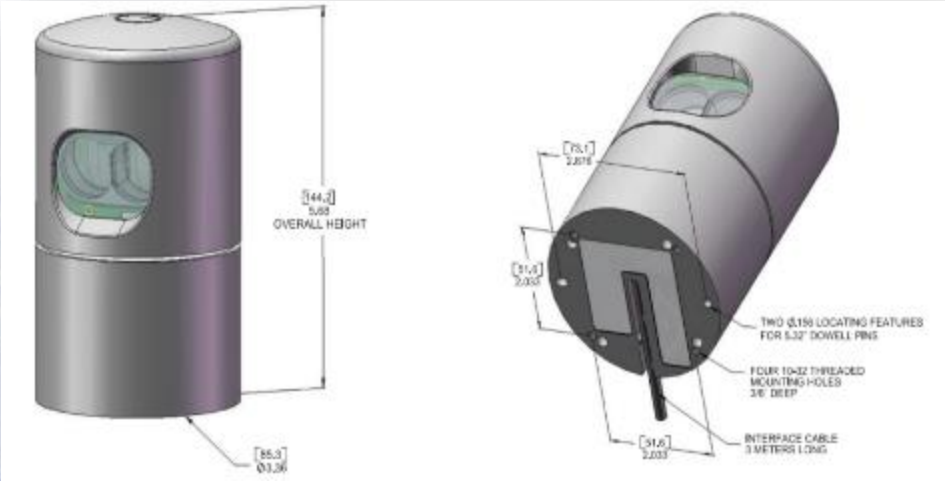
Angle	100 m	75 m	50 m	25 m
0.25˚	450 mm	338 mm	225 mm	113 mm
0.125˚	225 mm	169 mm	113 mm	56 mm

Velodyne HDL-32E Laser Scanner

System Specifications

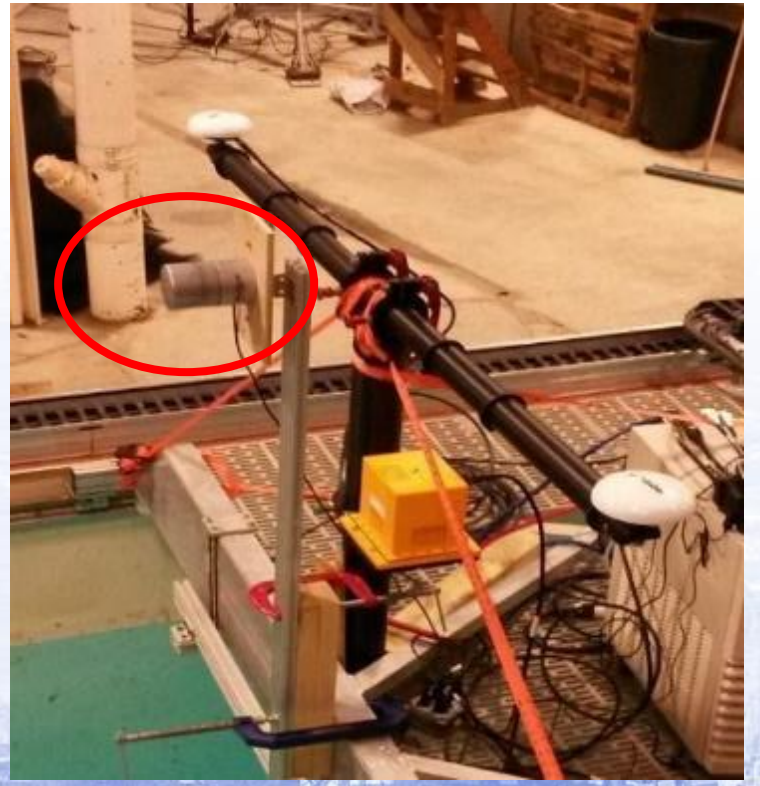
- PRF– 700,000 points per second
- Range - 100 m
- Azimuth resolution – 0.01° 0.0025° to 0.01°
- Vertical resolution: 1.33°
- Scan rate – 5 Hz to 20 Hz

Velodyne HDL-32E

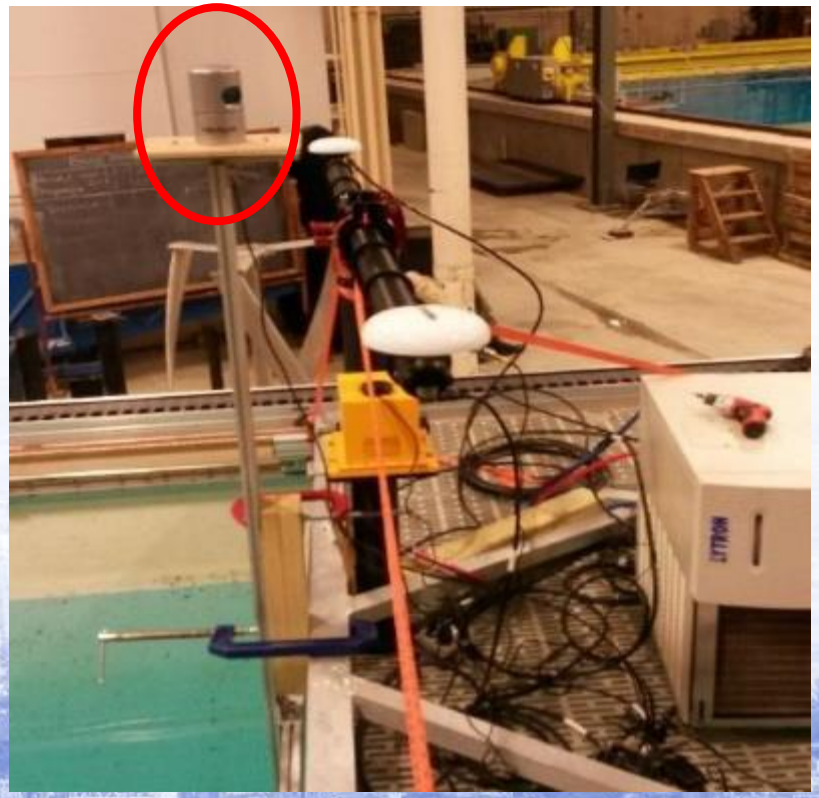


Laboratory settings – controlled environment (Chase Ocean Engineering Facilities, UNH) December 2014

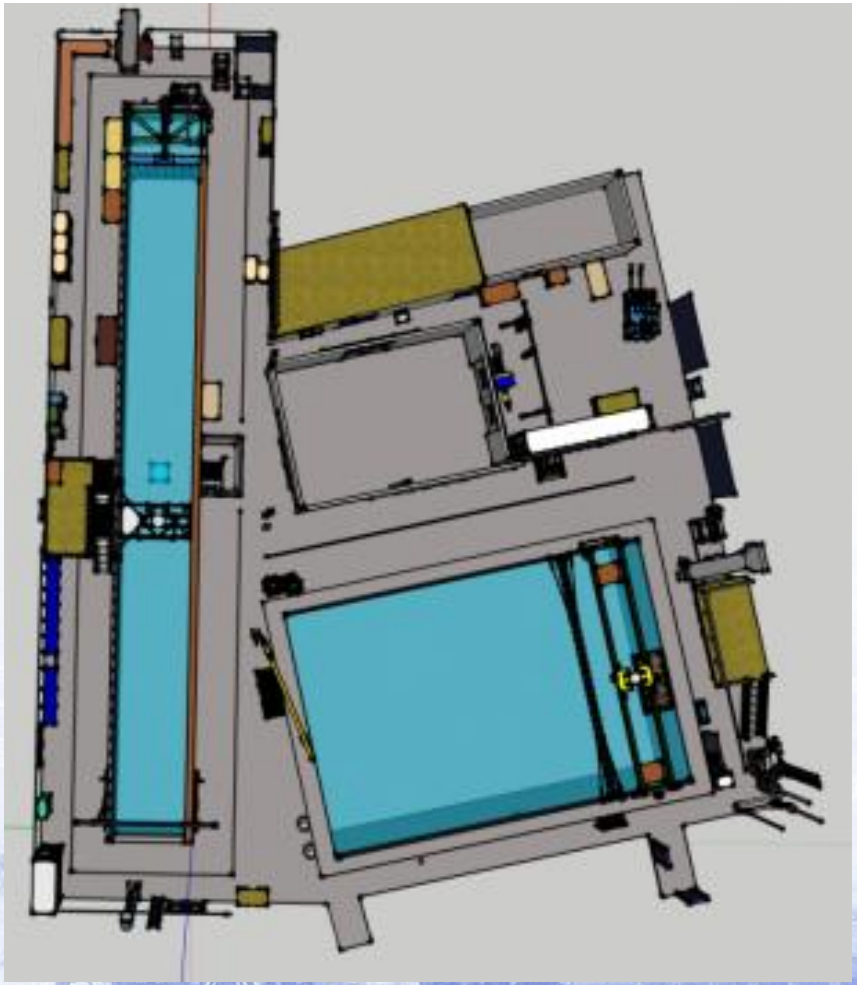
Vertical scanning configuration



Horizontal scanning configuration

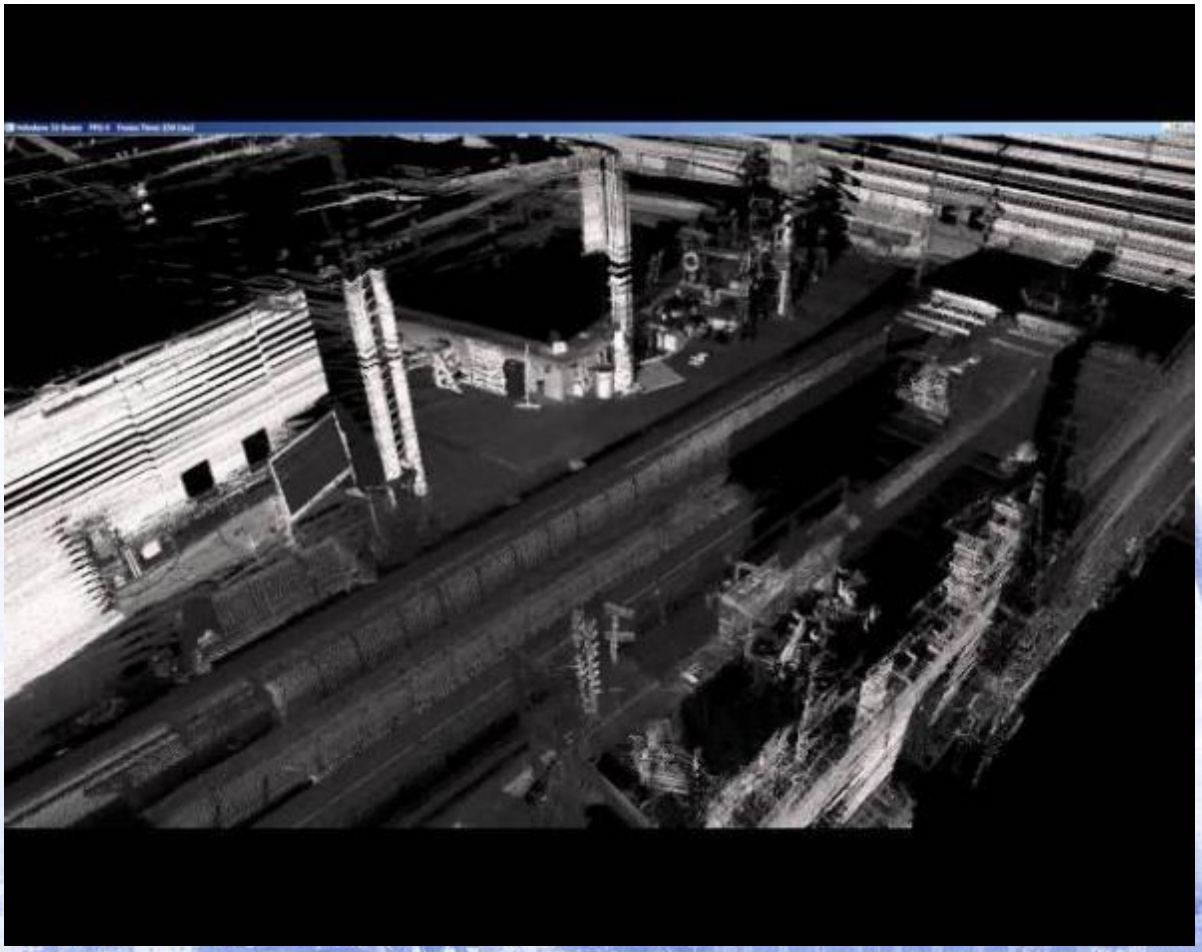


Shachak!
Don’t forget to show the lab work in VeloView

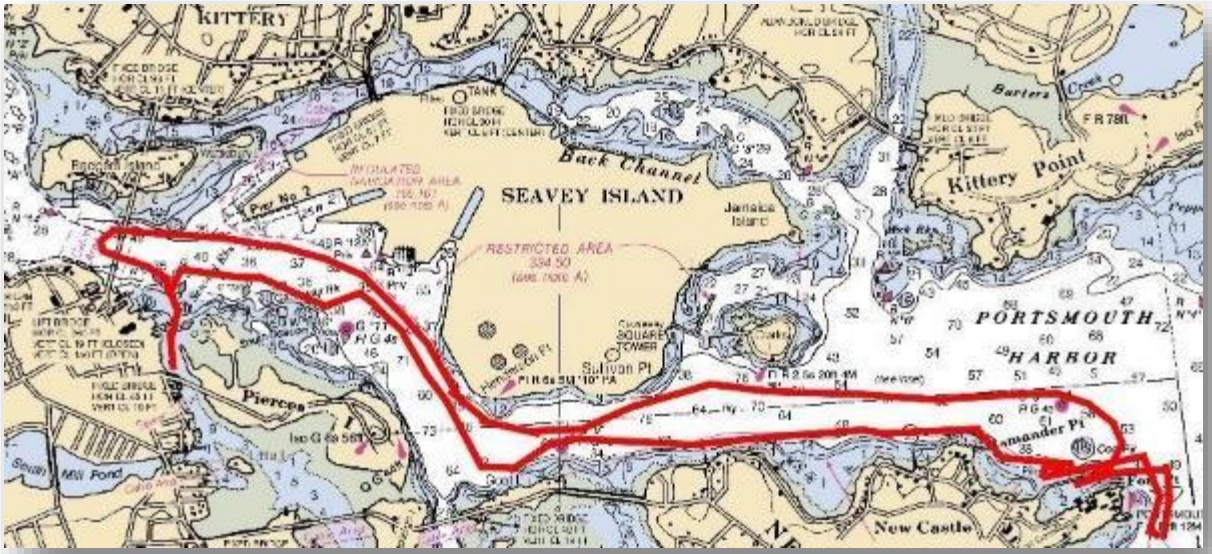


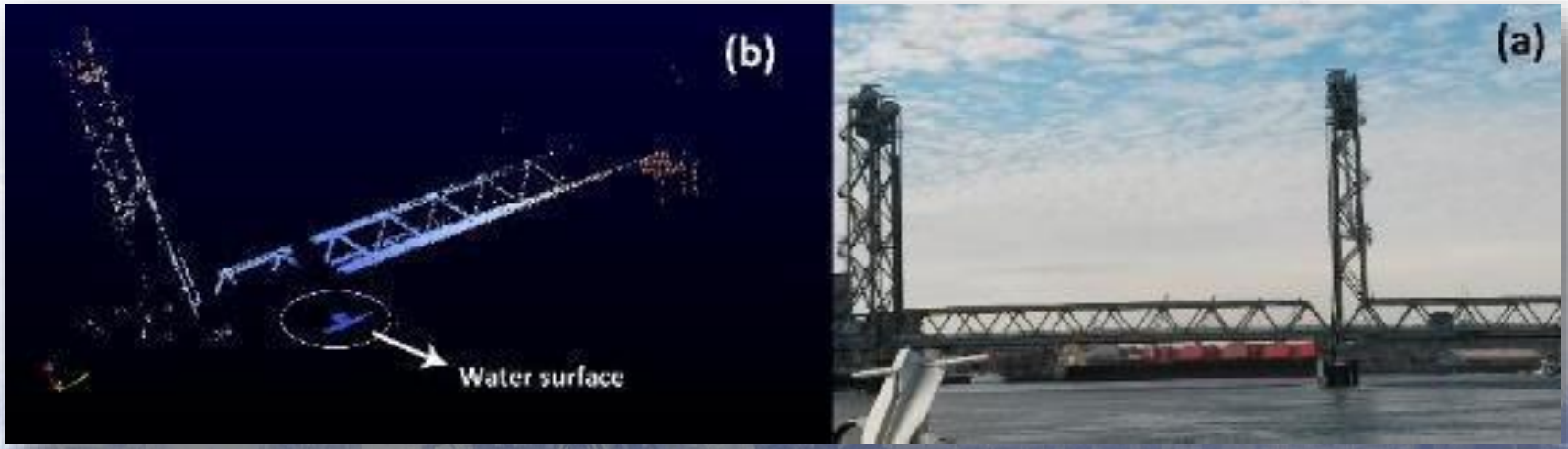
SLAM (Simultaneous Localization And Mapping)

http://youtu.be/BsJcpA8VN68



Portsmouth, New Hampshire - December 2014

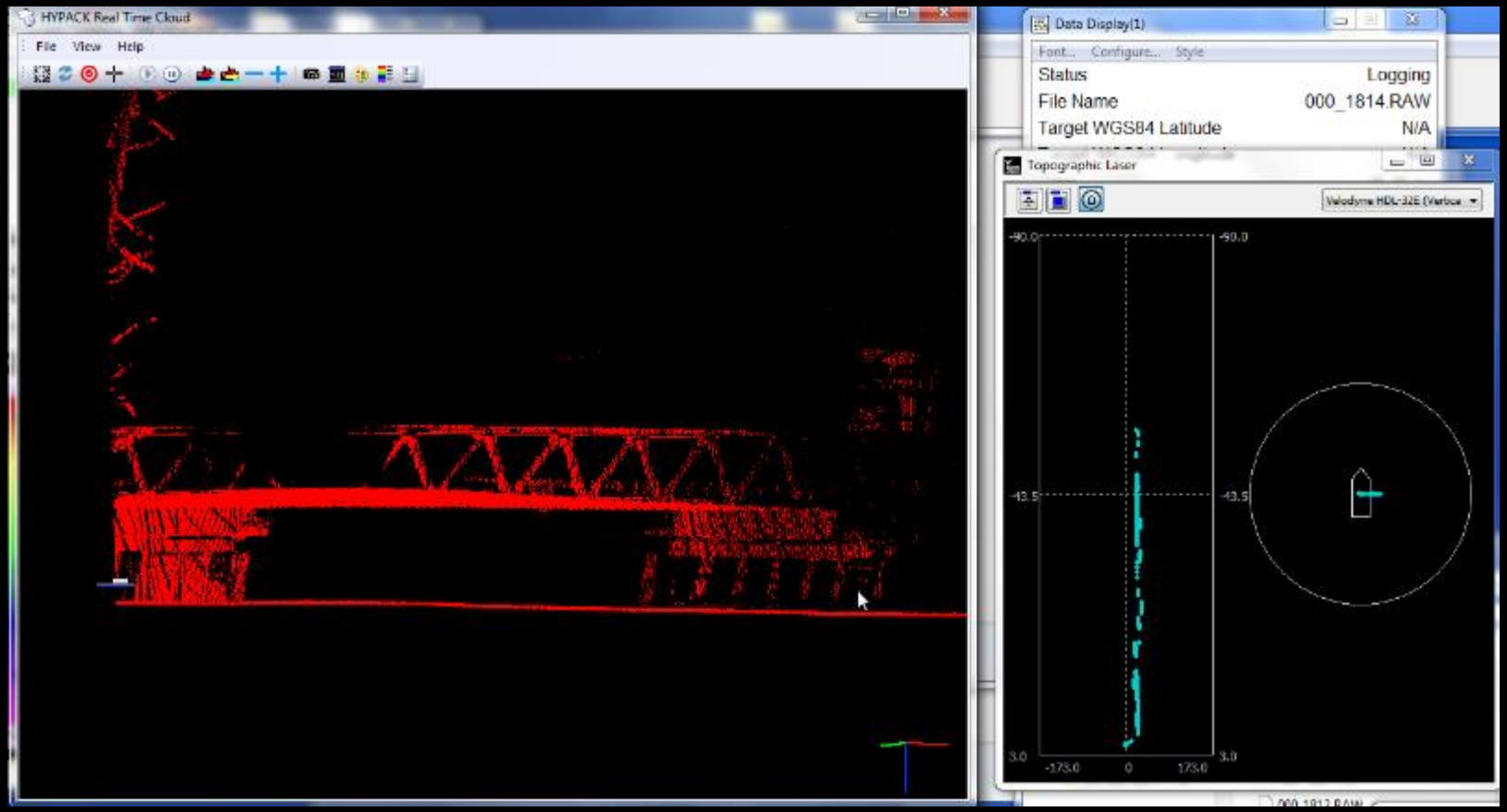




Mobile laser scanner for NRT

UNH/CCOM
Research Vessel Coastal Surveyor

Single Channel Implementation



Single Channel Implementation

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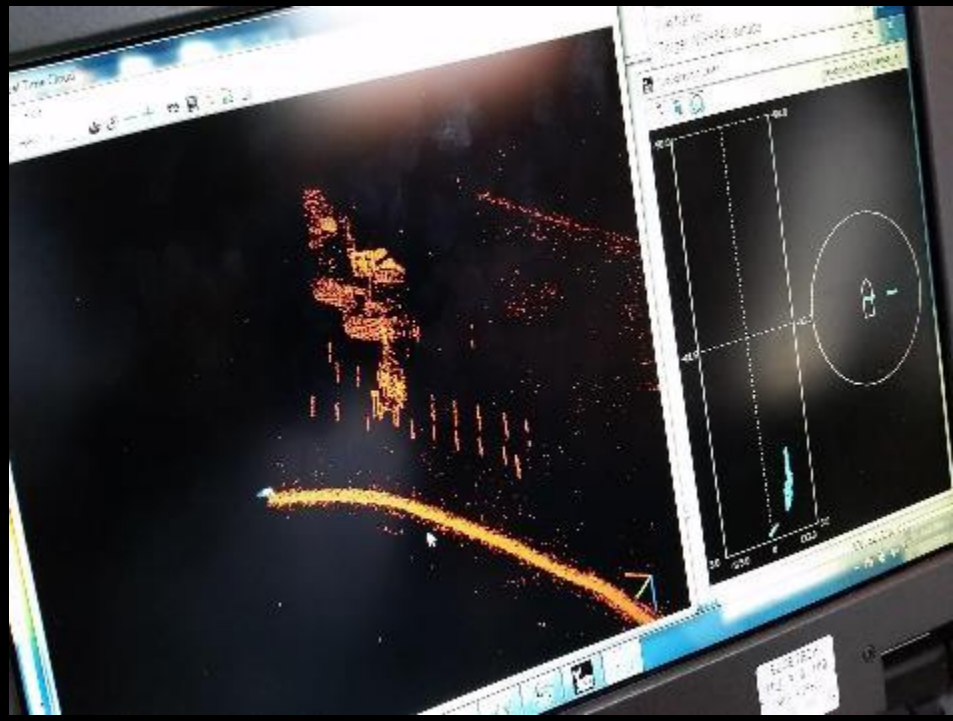


Conclusions

The results present a proof-of-concept that industrial-grade laser scanners can provide an economic alternative to survey-grade laser scanners.

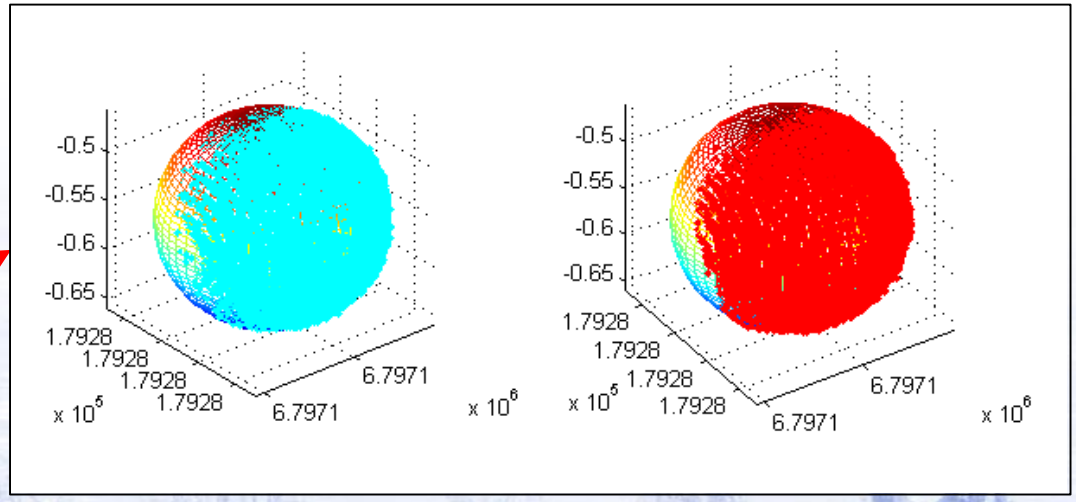
Future work will focus on decoding the system's integration and calibration process and final product delivery to the end-user. Two potential deliverables are:

- An S-57 attributed feature file of the horizontal location of the target with a tidally-referenced height detailing the Final Feature File. This method is currently compatible with the existing charting pipeline.
- Output a modeled feature with a defined geometrical shape that can be imported into CAD or GIS software.

Coming soon…

Boresight calibration – collaboration with CIDCO (Nicholas Seube)

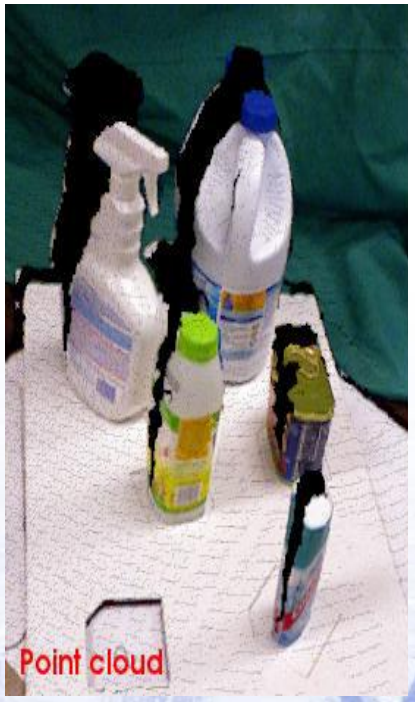
(Images from Picard et al., 2012)



The Leica HDS6200 and the IxSea Octan4 are mounted on a IXMotion TRI30 motion simulator, scanning a sphere of precision

Coming soon…

Intensity and operational evaluation
(NOAA collaborators: LTJG Eric Younkin and Jon Sellars)



(Image from Tombari, 2013)

Acknowledgments

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Also, the authors would like to thank David Oroshnik from Velodyne for evaluating the systems and participation in the experiments.

Thank you for listening!

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