Autonomous Crowdsourced Bathymetry (CSB)

Ongoing Private Sector Applications

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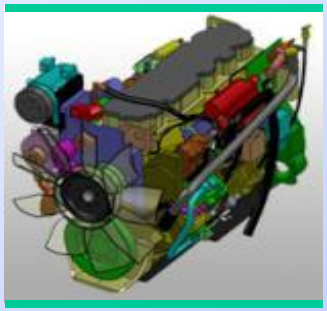
Who We Are

SURVICE Engineering (est. 1981) is a Maryland-based engineering consulting firm that supports the **US Department of Defense (DoD)**, as well as **homeland security**, **advanced technologies**, **environmental**, and **commercial** markets. In addition to working to make combat systems which are survivable (hence our company name), we are involved in a variety of research and development efforts to improve the state-of-the-art in a number of technical disciplines.

SURVICE currently employs 350 people in offices across the United States.

Test & Evaluation



Modeling & Simulation/ Software Engineering

Dimensional Metrology and Reverse Engineering

Studies & Analysis

Information Technologies & Management

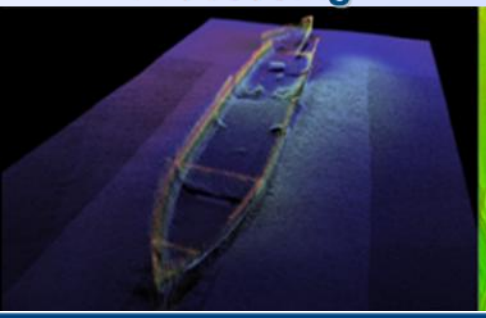
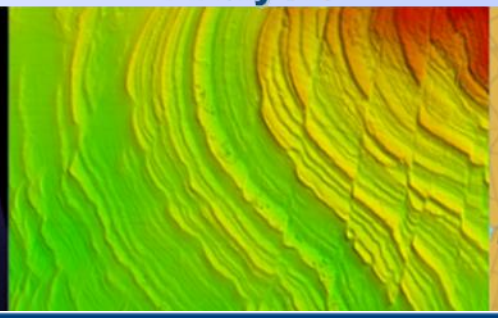
Who We Are

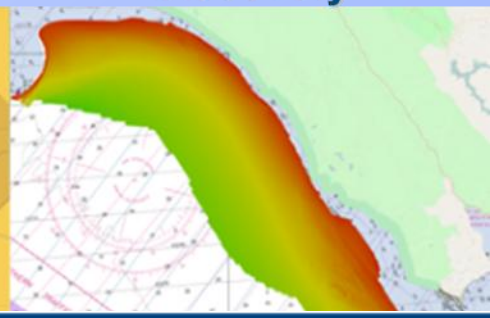
caris

- Over 30 Years in the Geospatial Information Systems (GIS) Software Development Business
- Successful installations in over 85 countries
- 170 employees in total between Canada, Netherlands, USA, Australia and the UK
- Industry leading team of Technical Support professionals with industry experience and academic backing
- 20+ Alliance Companies in other countries
- ISO 9001:2008 certified

QUALITY MANAGEMENT SYSTEM ISO 9001:2008 caris

Processing | Analysis | Production | Discovery

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ARGUS Overview

- Onboard ARGUS unit plugs into vessel's existing GPS and water depth sensors
- **Autonomously** records GPS position, water depth, water temperature, other environmental and weather data
- **Automatically** offloads using extended-range marine WiFi, cellular, satellite
- Collective processing provides bathymetry profiles
- **Continuous** bathymetry updates result from routine vessel activity

No crew interaction required

Completely autonomous recording and reporting of data

ARGUS provides an extremely efficient virtual, distributed survey vessel network

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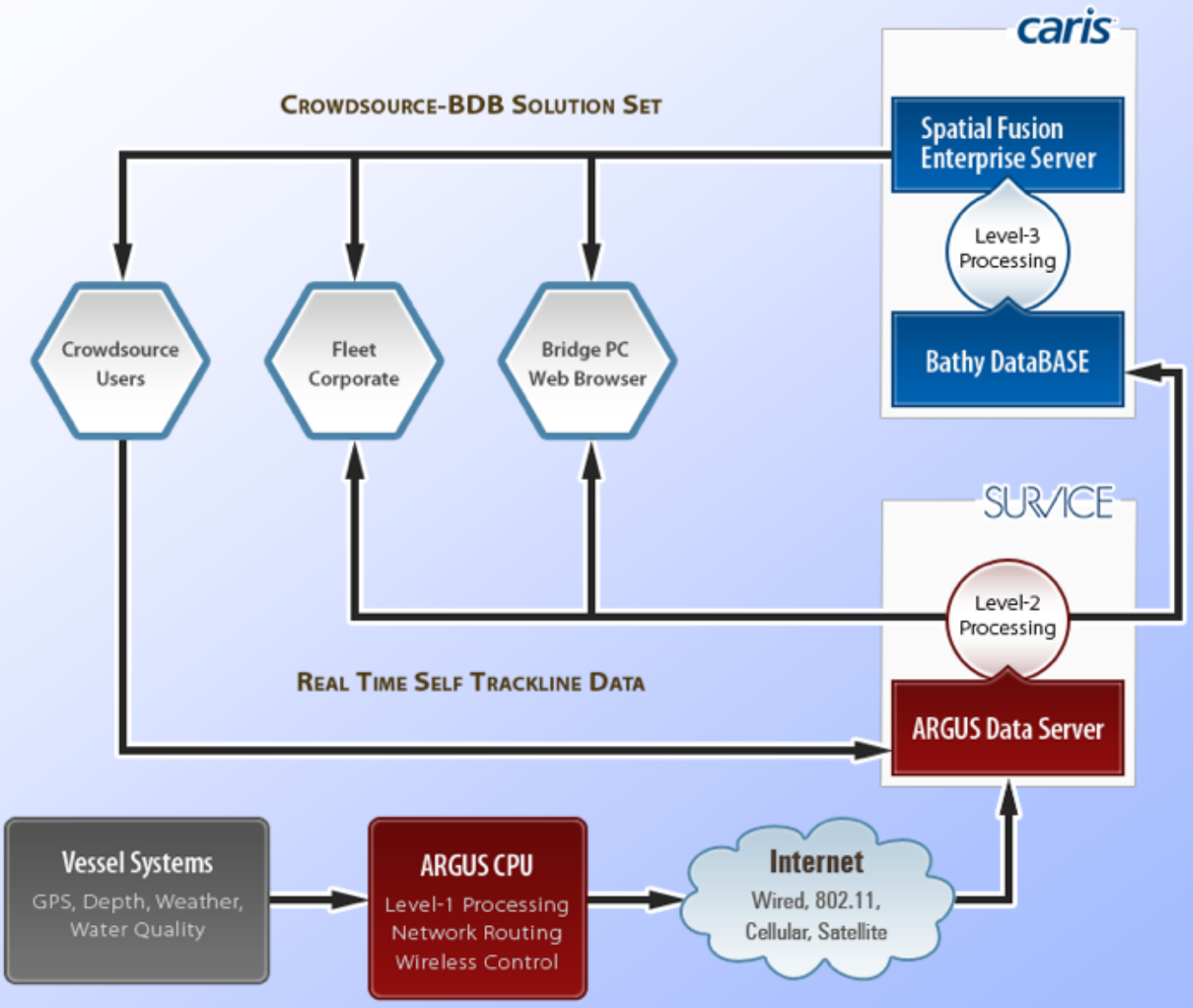
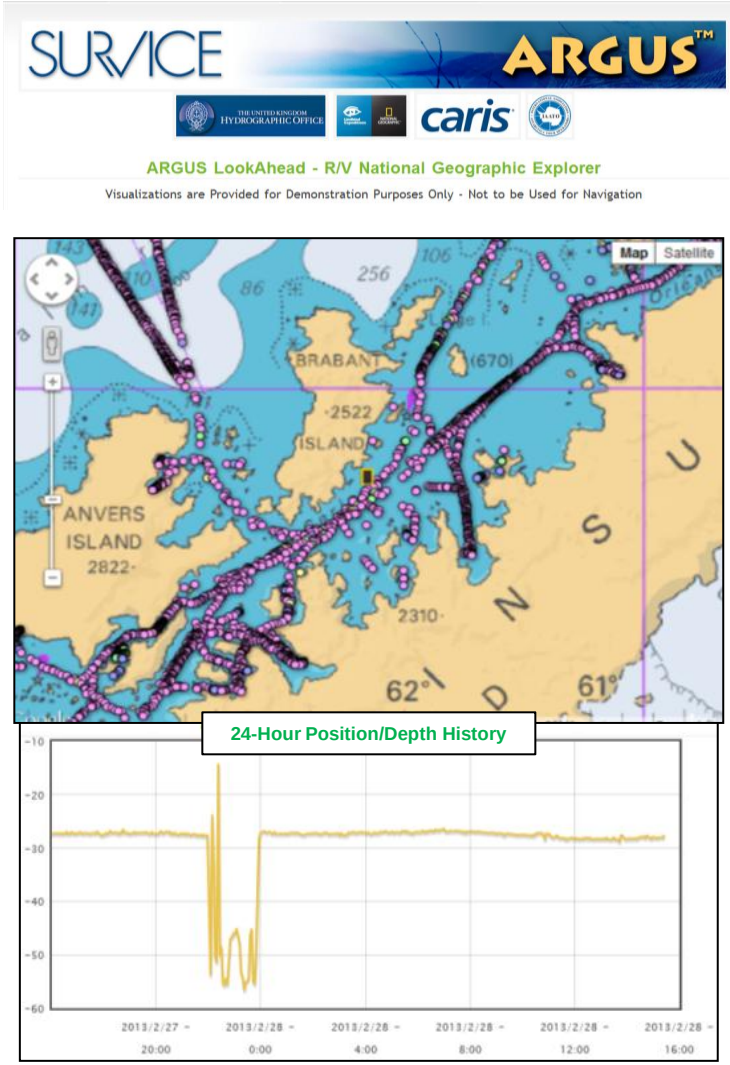
ARGUS-CSB Process



Level 2 Results/Output

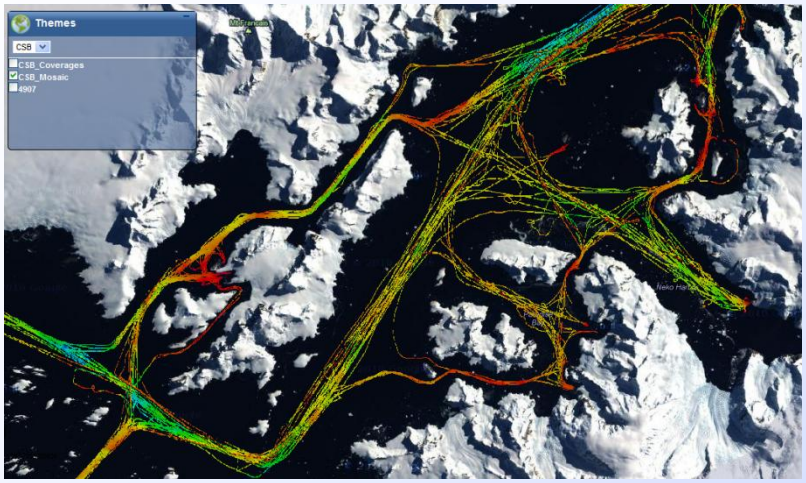


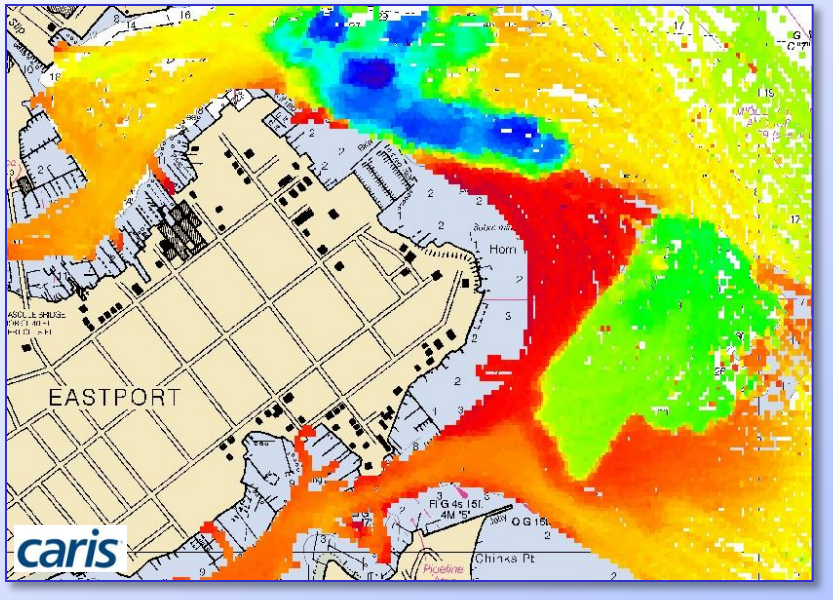
- Web-delivered vessel home page provides:
  - Real-time vessel position and depth histories
  - Vessel trackline history
  - Access to AO cooperative solution set
  - Latest position overlay on chart and data solution layers
- Interactive demo:

  ICW Trawler:

  http://argus.survice.com/vessel_tracking/images/view-Altair.html

Level 3 Results/Output



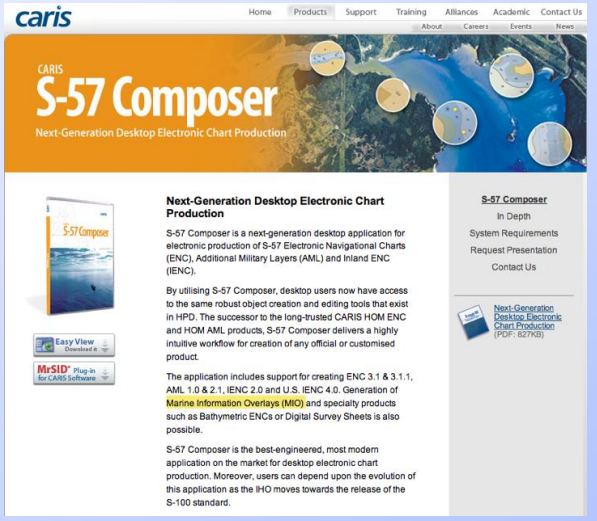


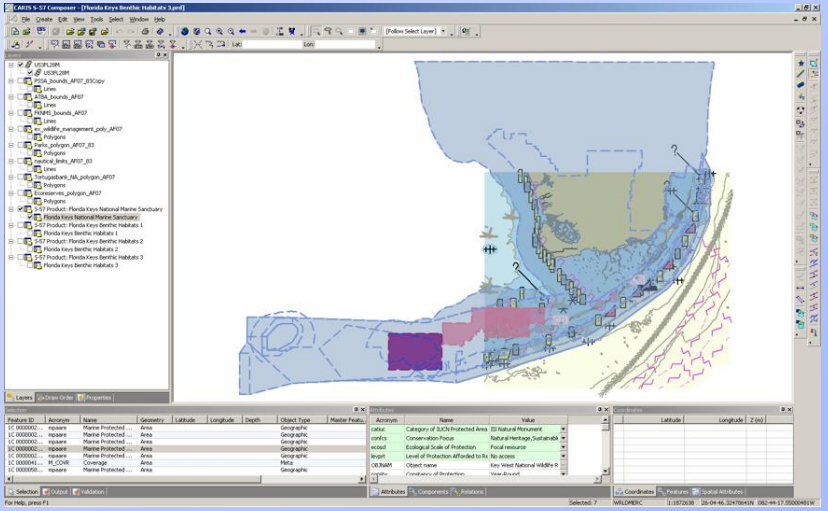
- CARIS BDB and SFE provide:
  - Powerful post-processing and visualization platforms
  - Web-served CSB solution sets
  - Incorporation of additional data layers from historical fieldsheets to the latest high density multibeam surveys
  - High resolution graphics
  - Industry standard bathymetric processing modules, with CSB-specific modules in development
- Interactive demo:

  http://crowd.caris.com/crowd

CARIS Marine Information Overlays (MIOs)

- Chart and navigation-related information that supplement the minimum information required by IMO ECDIS
  - Additional, non-mandatory, not covered by existing standards
- Supplemental information for “decision support”
  - Right information for task-at-hand
  - Voyage planning & route monitoring
  - Transfer data between users in a standard format
- Two basic types of MIOs
  - Static
    - Critical Habitats
    - Seafloor classification
    - Bathymetric
    - Geophysical data
    - Archeological
  - Dynamic
    - Tides
    - Current flow
    - Marine Mammals
    - Meteorological
    - Oceanographic





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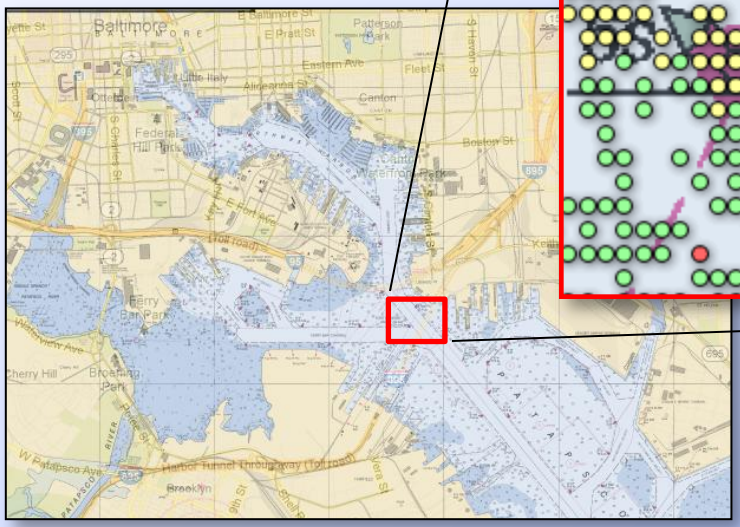
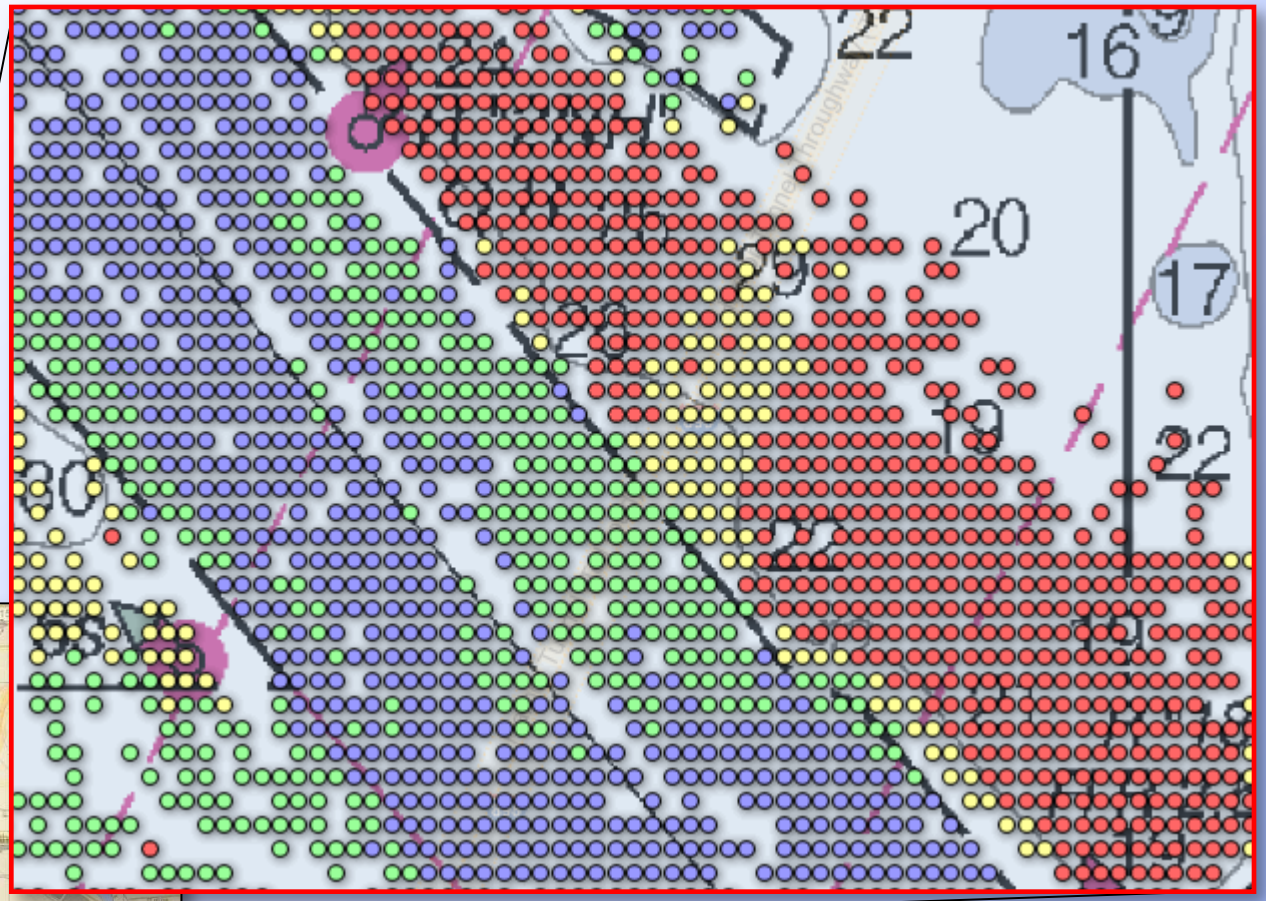
The Power of Crowd Source Bathymetry in Baltimore

Baltimore Pilot Study

- 3 vessels
- 10 months
- 14 million soundings
- 100,000 grid solutions
- 10 square kilometers





ARGUS™

Patented Crowd-Source Technology*

* US Patent 8,417,451 “Autonomous Cooperative Surveying”

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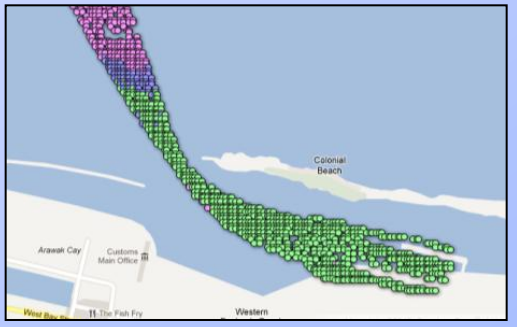
Ongoing Participation

Over 100 million soundings

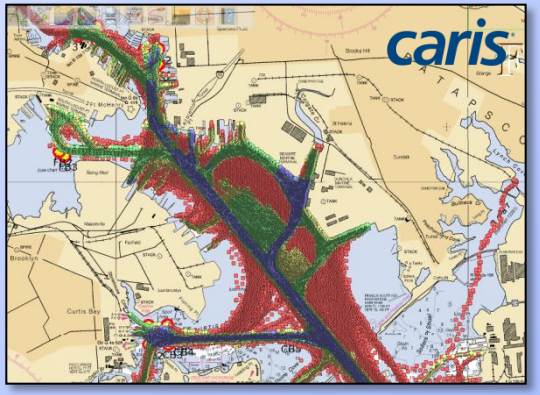
- **Sea Tow**
  Chesapeake Bay, Coastal NJ, Long Island
- **International Cruise Ships (IAATO)**
  National Geographic Explorer, Arctic, Antarctic
- **Carnival Pride -** Baltimore, Bahamas
- **McAllister Towing -** Baltimore, New York
- **Maryland Pilots -** Baltimore, Chesapeake
- **Reality Check Sailing Charters**
  Texas, Louisiana, GoM, Florida, ICW, Bahamas
- **Towson University -** Towson, MD
- **Washington College -** Chestertown, MD
- **Capital Yacht Charters -** Washington, DC
- **USCG Auxiliary -** Long Island, NY
- **UNH CCOM -** Portsmouth, NH
- **University of Southern Mississippi**
- **Florida DEP -** St. Augustine, FL
- **Intracoastal Waterway and Great Lakes trawlers**

Jersey Shore

New York Harbor



Nassau, Bahamas



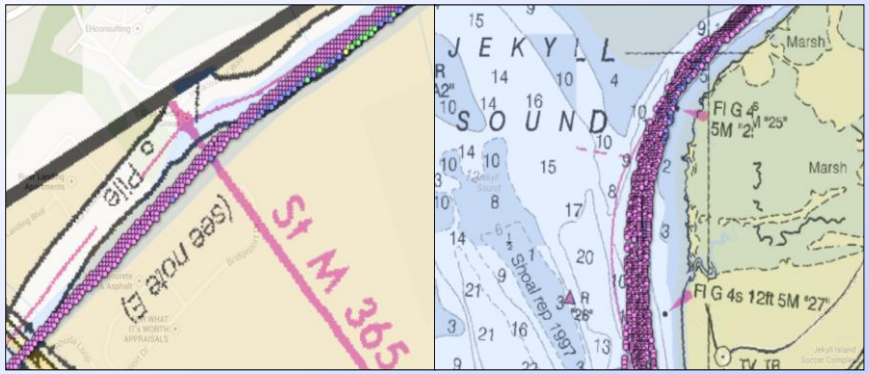
Baltimore

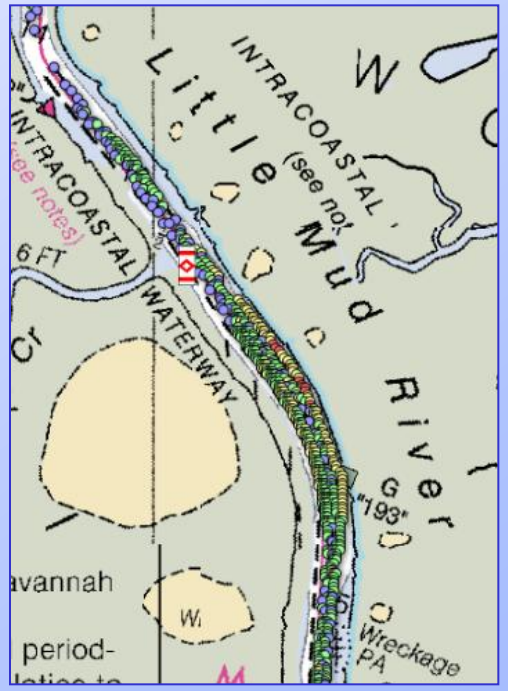
Port Canaveral, FL

Case Study: The Magenta Line Intracoastal Waterway

- ARGUS has processed over 20 million **crowdsourced physical measurements** on the ICW, **centered on the true magenta line**.

- The team of SURVICE, CARIS, Towson University, and USM is working to **apply academic expertise in hydrographic science and data mining** to process this data and generate the true magenta line.

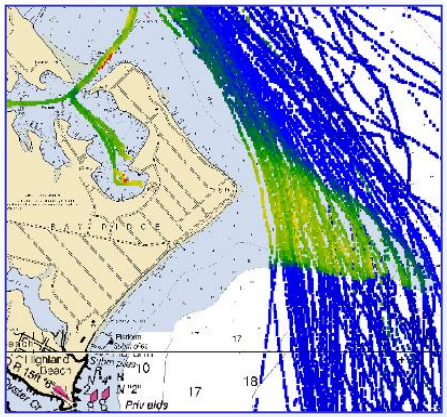


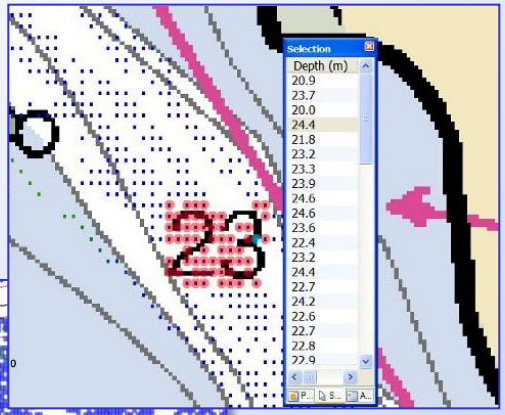


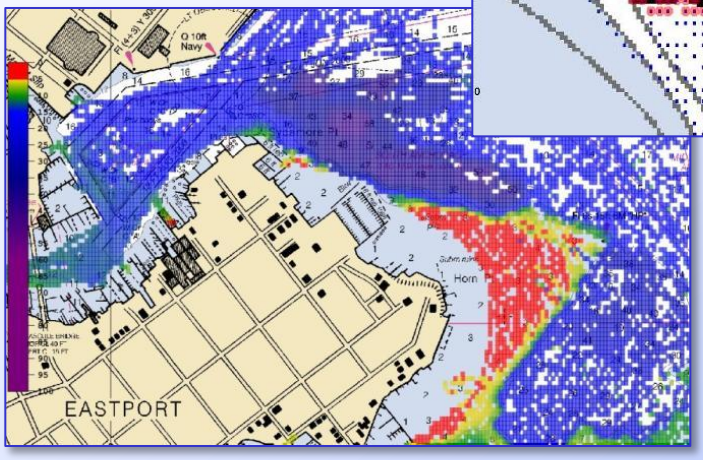
The True Magenta Line

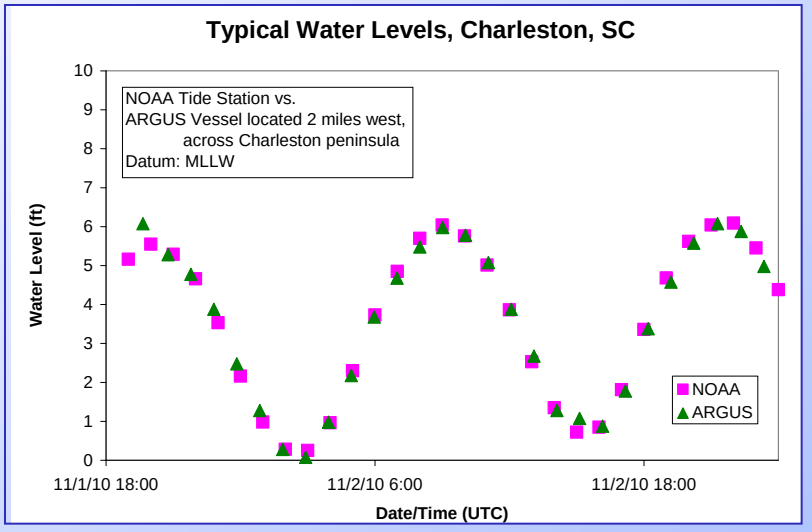
ARGUS solutions indicate the deepest point of the channel cross section, and thus the preferred route of travel.

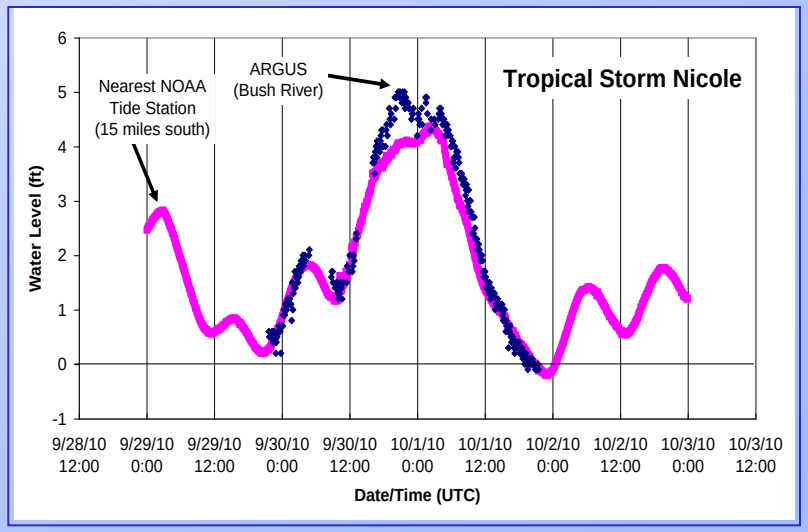
Process Validity











- Comparison to NOAA charts and tide gages indicates validity of the data and process
- Stationary vessel “float” data not only provides depth measurements, but also contributes to tide corrections
- Float data provides an enhancement to existing tide station networks

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How Good is it?

IHO STANDARDS FOR HYDROGRAPHIC SURVEYS (S-44)
5th Edition February 2008

TABLE 1
Minimum Standards for Hydrographic Surveys
(To be read in conjunction with the full text set out in this document.)

Reference	Order	Special	1a	1b	2
Chapter 1	**Description of areas.**	Areas where under-keel clearance is critical	Areas shallower than 100 metres where under-keel clearance is less critical but *features* of concern to surface shipping may exist.	Areas shallower than 100 metres where under-keel clearance is not considered to be an issue for the type of surface shipping expected to transit the area.	Areas generally deeper than 100 metres where a general description of the sea floor is considered adequate.
Chapter 2	**Maximum allowable THU 95% *Confidence level***	2 metres	5 metres + 5% of depth	5 metres + 5% of depth	20 metres + 10% of depth
Para 3.2 and note 1	**Maximum allowable TVU 95% *Confidence level***	a = 0.25 metre b = 0.0075	a = 0.5 metre b = 0.013	a = 0.5 metre b = 0.013	a = 1.0 metre b = 0.023
Glossary and note 2	***Full Sea floor Search***	Required	Required	Not required	Not required
Para 2.1 Para 3.4 Para 3.5 and note 3	***Feature Detection***	Cubic *features* > 1 metre	Cubic *features* > 2 metres, in depths up to 40 metres; 10% of depth beyond 40 metres	Not Applicable	Not Applicable
Para 3.6 and note 4	**Recommended maximum Line Spacing**	Not defined as *full sea floor search* is required	Not defined as *full sea floor search* is required	3 x average depth or 25 metres, whichever is greater For bathymetric lidar a spot spacing of 5 x 5 metres	4 x average depth
Chapter 2 and note 5	**Positioning of fixed aids to navigation and topography significant to navigation. (95% *Confidence level*)**	2 metres	2 metres	2 metres	5 metres
Chapter 2 and note 5	**Positioning of the Coastline and topography less significant to navigation (95% *Confidence level*)**	10 metres	20 metres	20 metres	20 metres
Chapter 2 and note 5	**Mean position of floating aids to navigation (95% *Confidence level*)**	10 metres	10 metres	10 metres	20 metres

Crowdsourced Bathymetry
One Solution for Addressing Nautical Chart Data Deficiencies
US Hydro 2013

Maxim van Norden, the University of Southern Mississippi
Paul Cooper, CARIS USA
John Hersey, the SURVICE Engineering Company

THU

Typically a GPS receiver using standalone positioning has a positioning uncertainty of **±10 m** at 95% confidence.

TVU

A large number of observations in the same locale will provide both a reliable gridded sounding and a reasonable value (**<3 ft**) for the associated TVU.

Depth (m)	Sounder Timing (m)	Draft (m)	Snd Speed ± 50 m/s (m)	Balt. Tide (m)	TVU (m)	IHO Order 1B (m)
5	0.06	0.3	0.17	0.2	0.40	0.50
10	0.08	0.3	0.33	0.2	0.50	0.52
15	0.11	0.3	0.50	0.2	0.63	0.54
20	0.13	0.3	0.67	0.2	0.77	0.56

Studies led by the University of Southern Mississippi and Towson University suggest that CSB can be used to meet current standards such as International Hydrographic Organization (IHO) S-44 Order 2, have immediate reconnaissance value, and can provide a vast improvement in positioning accuracy and reliability compared to the pre-GPS-positioned hydrographic data on Official charts.

•Van Norden, M., P. Cooper, and J. Hersey. "Crowdsourced Bathymetry: One Solution for Addressing Nautical Chart Data Deficiencies." *US Hydro 2013*.
•Sedaghat, L., J. Hersey, and M. McGuire. "Detecting Spatio-Temporal Outliers in Crowdsourced Bathymetry Data." *GEOCrowd 2013*.

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Active Partnerships

The project has been endorsed and continued development encouraged by:

- **Ian Moncrieff, UKHO CEO, CARIS 2012**
- **Mustafa İpteş, IHO Co-Director, US Hydro 2013**

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