Multibeam Advisory Committee (MAC) 2021 RVTEC Update

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The Multibeam Advisory Committee (MAC)

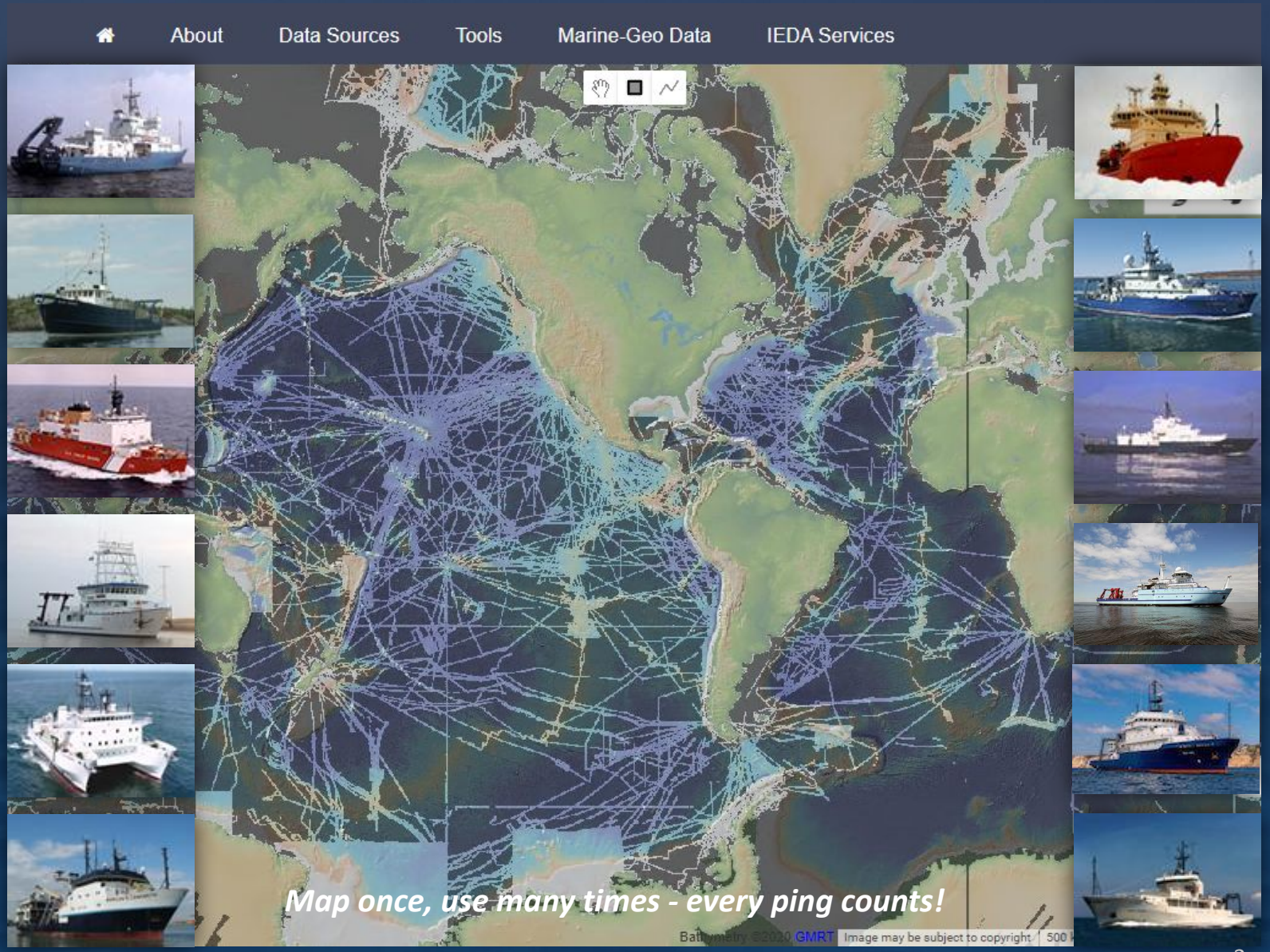
- Established 2011 with funding from NSF to ensure the consistent collection of high-quality multibeam data across the U.S. Academic Research Fleet (USARF)
  - ***Standardize*** *system performance testing*
  - ***Publish*** *performance and share best practices*
  - ***On-board & remote support*** *to ships*
- Technical Reports & Resources
  - SAT, QAT, ANT
  - Host Non-USARF Reports
  - Cookbooks, guidance, tools
- Help Desk: mac-help@unols.org
- New website!

Tech Reports

Report Title	Team
2021 Sikuliaq EM302/EM710 QAT	QAT
2021 Atlantis EM124 SAT	QAT
2021 Healy QAT	QAT
2021 Sally Ride EM124/EM712 QAT Report	QAT
2021 Kilo Moana EM122/EM719 QAT Report	QAT
2021 Revelle EM124/EM712 SAT	SAT
2021 Okeanos MKII SAT	SAT
2020 Healy EM122 QAT Report	QAT
2020 Kilo Moana EM122/EM710 QAT	QAT
2020 Sikuliaq EM302/EM710 Calibration Report	QAT

Mapping Systems in the U.S. Academic Fleet

- USARF vessels with MBES
  - 11 Research Vessels
  - 1 USCG Icebreaker
- 15 Kongsberg systems
  - EM710 / EM712
  - EM302
  - EM122 / EM124
- 2 Reson shallow systems
- RCRVs under construction



Kongsberg Systems in the U.S. Academic Fleet

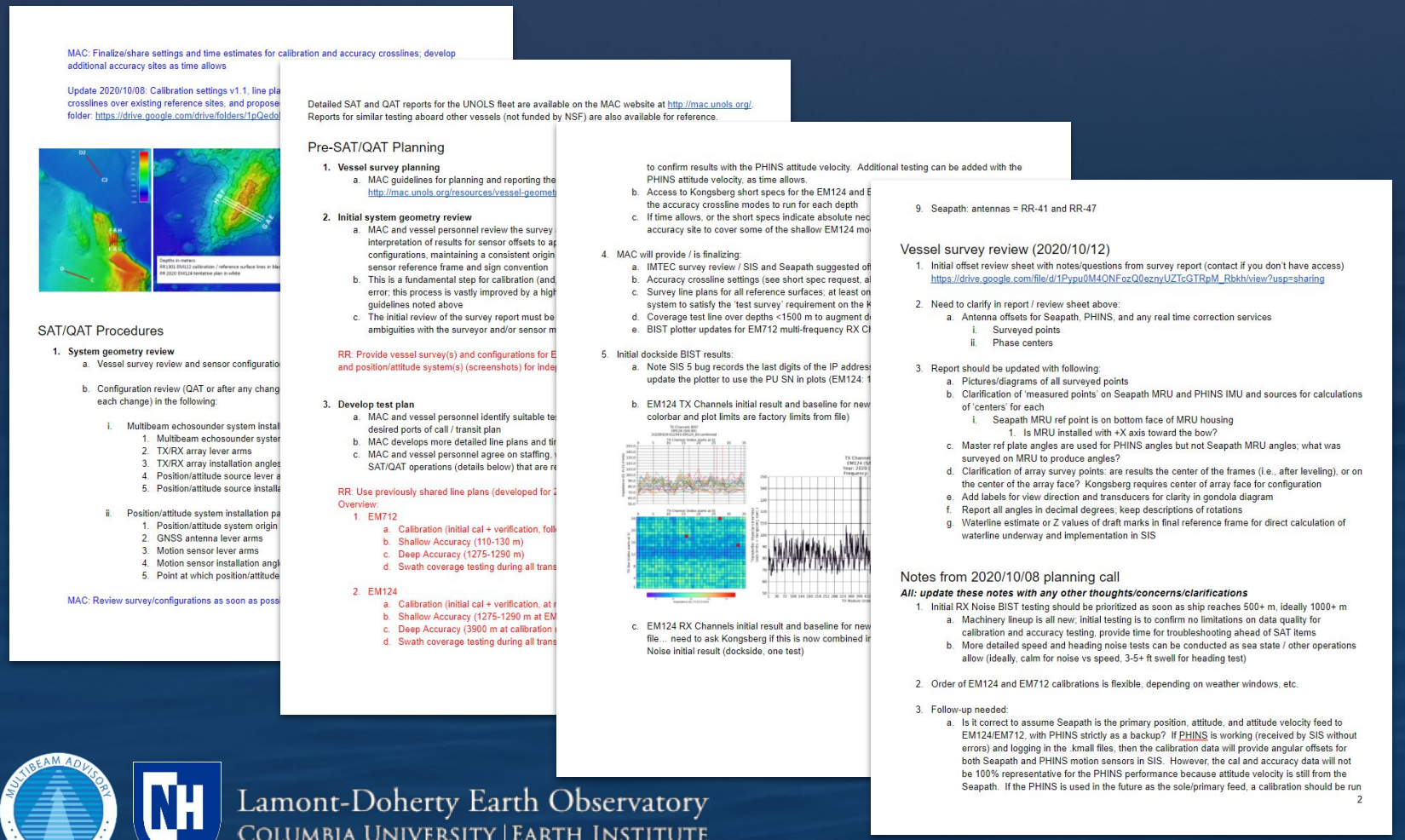
Ship	System(s)	Gondola	Arrays	Life Cycle	MAC Visits
Atlantis	**EM124**	Y	2021	Early-Life	QAT*, SAT*
Healy	EM122	N	2010	Late-Life	QAT, ANT
Kilo Moana	EM122 / EM710	N	2012	Late-Life	SAT, QAT*, ANT
Marcus G. Langseth	EM122	Y	2007 (TX) / 2010 (RX)	Late-Life	QAT*
Nathaniel B. Palmer	EM122	N	2015	Mid-Life	SAT, QAT, ANT
Neil Armstrong	EM122 / EM710	N	2016	Mid-Life	SAT, QAT
Roger Revelle	EM124 / EM712	Y	2020	Early-Life	SAT*, QAT
Sikuliaq	EM302 / EM710	N	2014	Mid-Life	SAT, QAT*
Sally Ride	**EM124** / EM712	N	2016	Mid-Life	SAT, QAT
Thomas G. Thompson	EM302	N	2018	Early-Life	SAT, QAT*

**Includes virtual visits*

SAT / QAT Checklist

Standardized procedures in order of priority

Updated collaboratively throughout planning and at-sea operations



MAC: Finalize/share settings and time estimates for calibration and accuracy crosslines; develop additional accuracy sites as time allows

Update 2020/10/08: Calibration settings v1.1, line pla
crosslines over existing reference sites, and propose
folder: https://drive.google.com/drive/folders/1pQedo

SAT/QAT Procedures

1. System geometry review
   a. Vessel survey review and sensor configuratio
   b. Configuration review (QAT or after any chang each change) in the following:
      i. Multibeam echosounder system instal
         1. Multibeam echosounder syste
         2. TX/RX array lever arms
         3. TX/RX array installation angles
         4. Position/attitude source lever a
         5. Position/attitude source installa
      ii. Position/attitude system installation pa
         1. Position/attitude system origin
         2. GNSS antenna lever arms
         3. Motion sensor lever arms
         4. Motion sensor installation angl
         5. Point at which position/attitude

MAC: Review survey/configurations as soon as possi

Detailed SAT and QAT reports for the UNOLS fleet are available on the MAC website at http://mac.unols.org/. Reports for similar testing aboard other vessels (not funded by NSF) are also available for reference.

Pre-SAT/QAT Planning

1. Vessel survey planning
   a. MAC guidelines for planning and reporting the http://mac.unols.org/resources/vessel-geomet
2. Initial system geometry review
   a. MAC and vessel personnel review the survey interpretation of results for sensor offsets to ap configurations, maintaining a consistent origin sensor reference frame and sign convention
   b. This is a fundamental step for calibration (and error; this process is vastly improved by a high guidelines noted above
   c. The initial review of the survey report must be ambiguities with the surveyor and/or sensor m

RR: Provide vessel survey(s) and configurations for E and position/attitude system(s) (screenshots) for inde

3. Develop test plan
   a. MAC and vessel personnel identify suitable te desired ports of call / transit plan
   b. MAC develops more detailed line plans and ti
   c. MAC and vessel personnel agree on staffing, SAT/QAT operations (details below) that are re

RR: Use previously shared line plans (developed for 2
Overview:
1. EM712
   a. Calibration (initial cal + verification, foll
   b. Shallow Accuracy (110-130 m)
   c. Deep Accuracy (1275-1290 m)
   d. Swath coverage testing during all trans
2. EM124
   a. Calibration (initial cal + verification, at r
   b. Shallow Accuracy (1275-1290 m at EM
   c. Deep Accuracy (3900 m at calibration
   d. Swath coverage testing during all trans

to confirm results with the PHINS attitude velocity. Additional testing can be added with the PHINS attitude velocity, as time allows.
   b. Access to Kongsberg short specs for the EM124 and E the accuracy crossline modes to run for each depth
   c. If time allows, or the short specs indicate absolute nec accuracy site to cover some of the shallow EM124 mo

4. MAC will provide / is finalizing:
   a. IMTEC survey review / SIS and Seapath suggested of
   b. Accuracy crossline settings (see short spec request, a
   c. Survey line plans for all reference surfaces; at least on system to satisfy the 'test survey' requirement on the K
   d. Coverage test line over depths <1500 m to augment d
   e. BIST plotter updates for EM712 multi-frequency RX Cl

5. Initial dockside BIST results:
   a. Note SIS 5 bug records the last digits of the IP addres update the plotter to use the PU SN in plots (EM124: 1
   b. EM124 TX Channels initial result and baseline for new colorbar and plot limits are factory limits from file)

   c. EM124 RX Channels initial result and baseline for new file… need to ask Kongsberg if this is now combined ir Noise initial result (dockside, one test)

9. Seapath: antennas = RR-41 and RR-47

Vessel survey review (2020/10/12)

1. Initial offset review sheet with notes/questions from survey report (contact if you don't have access) https://drive.google.com/file/d/1Pypu0M4ONFozQ0eznyUZTcGTRpM_Rbkh/view?usp=sharing
2. Need to clarify in report / review sheet above:
   a. Antenna offsets for Seapath, PHINS, and any real time correction services
      i. Surveyed points
      ii. Phase centers
3. Report should be updated with following:
   a. Pictures/diagrams of all surveyed points
   b. Clarification of 'measured points' on Seapath MRU and PHINS IMU and sources for calculations of 'centers' for each
      i. Seapath MRU ref point is on bottom face of MRU housing
         1. Is MRU installed with +X axis toward the bow?
   c. Master ref plate angles are used for PHINS angles but not Seapath MRU angles; what was surveyed on MRU to produce angles?
   d. Clarification of array survey points: are results the center of the frames (i.e., after leveling), or on the center of the array face? Kongsberg requires center of array face for configuration
   e. Add labels for view direction and transducers for clarity in gondola diagram
   f. Report all angles in decimal degrees; keep descriptions of rotations
   g. Waterline estimate or Z values of draft marks in final reference frame for direct calculation of waterline underway and implementation in SIS

Notes from 2020/10/08 planning call

All: update these notes with any other thoughts/concerns/clarifications

1. Initial RX Noise BIST testing should be prioritized as soon as ship reaches 500+ m, ideally 1000+ m
   a. Machinery lineup is all new; initial testing is to confirm no limitations on data quality for calibration and accuracy testing, provide time for troubleshooting ahead of SAT items
   b. More detailed speed and heading noise tests can be conducted as sea state / other operations allow (ideally, calm for noise vs speed, 3-5+ ft swell for heading test)
2. Order of EM124 and EM712 calibrations is flexible, depending on weather windows, etc.
3. Follow-up needed:
   a. Is it correct to assume Seapath is the primary position, attitude, and attitude velocity feed to EM124/EM712, with PHINS strictly as a backup? If PHINS is working (received by SIS without errors) and logging in the .kmall files, then the calibration data will provide angular offsets for both Seapath and PHINS motion sensors in SIS. However, the cal and accuracy data will not be 100% representative for the PHINS performance because attitude velocity is still from the Seapath. If the PHINS is used in the future as the sole/primary feed, a calibration should be run

2

Multibeam Advisory Committee
Mapping System SAT/QAT Checklist

Roger Revelle EM124 / EM712 SAT
San Diego, October 2020

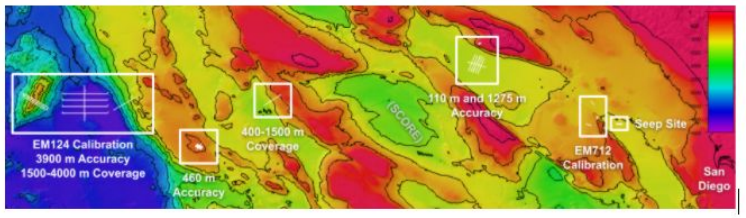
General

Shared documents for RR 2020 SAT planning

Revelle IMTEC survey docs

MAC geometry review

MAC assessment tools in development



Notes for next planning call (2020/10/14 ~5 PM ET)

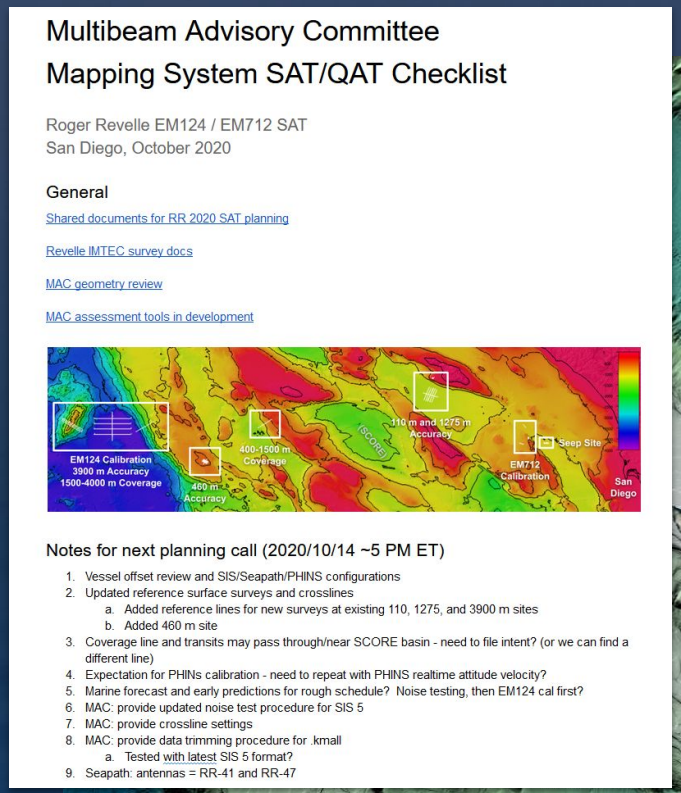
1. Vessel offset review and SIS/Seapath/PHINS configurations
2. Updated reference surface surveys and crosslines
   a. Added reference lines for new surveys at existing 110, 1275, and 3900 m sites
   b. Added 460 m site
3. Coverage line and transits may pass through/near SCORE basin - need to file intent? (or we can find a different line)
4. Expectation for PHINs calibration - need to repeat with PHINS realtime attitude velocity?
5. Marine forecast and early predictions for rough schedule? Noise testing, then EM124 cal first?
6. MAC: provide updated noise test procedure for SIS 5
7. MAC: provide crossline settings
8. MAC: provide data trimming procedure for .kmall
   a. Tested with the latest SIS 5 format?

1

System Performance Testing

SAT and QAT procedures include:

1. Geometry & Configuration
2. Calibration (patch test)
3. RX noise testing
4. Swath accuracy
5. Swath coverage (extinction)
6. Impedance testing
7. Water column evaluation
8. BS normalization
9. Reporting



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Vessel Offset Survey Reports

Data quality depends on correct configuration

Vessel and sensor offsets must be clearly documented

Survey reports directly impact data quality for decades

Vessel and sensor offset survey reports **must** include:

1. **Origin** of survey reference frame
2. **Axes** of survey reference frame
3. **Sign conventions** of survey results
4. **Images** of surveyed points and sensors
5. **Sigma** / standard deviation or uncertainty
6. **Second review** before submission

[Please give this to your surveyor!](http://mac.unols.org/resources/vessel-geometry-and-mbes-offset-recommendations)

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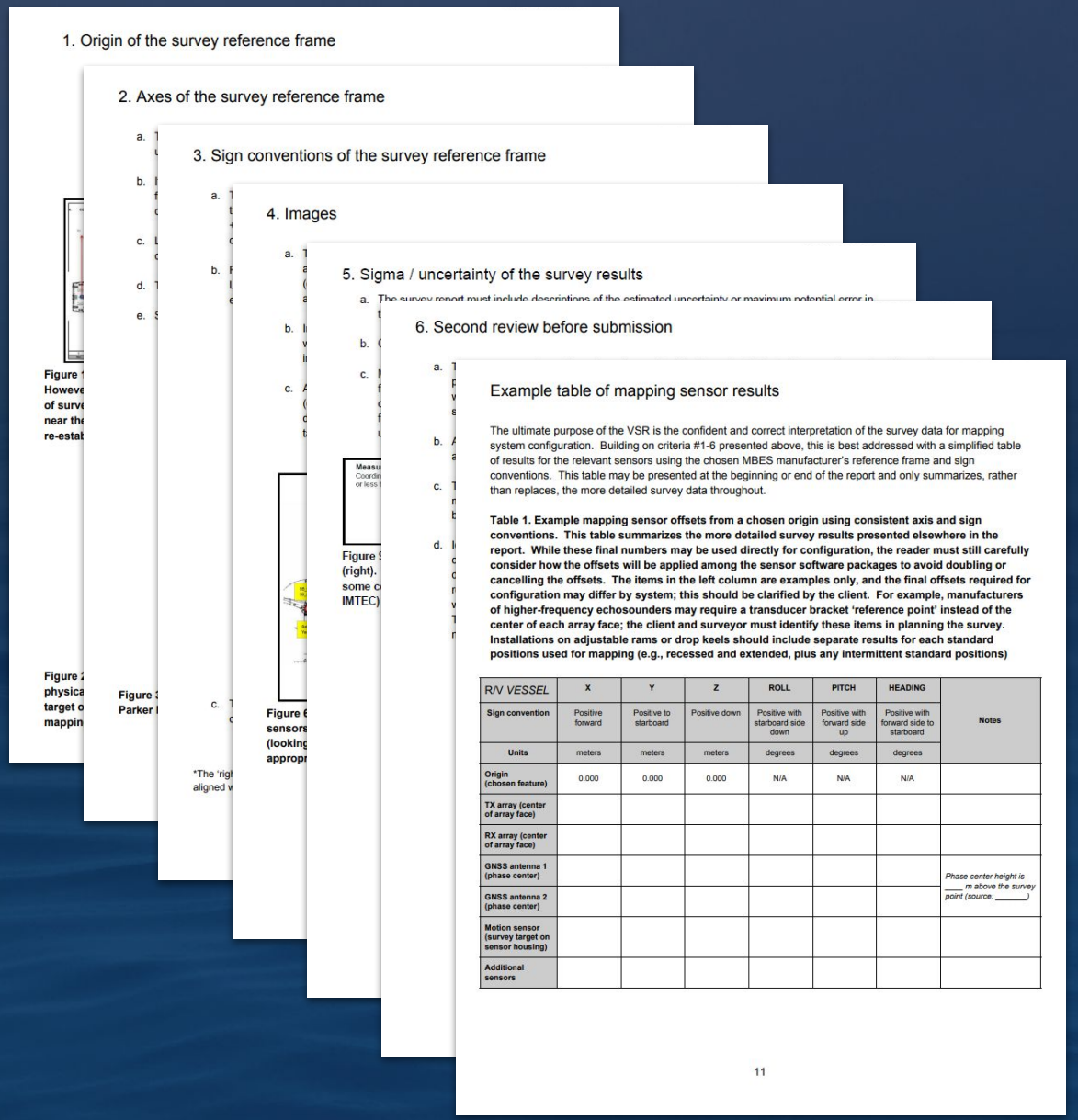

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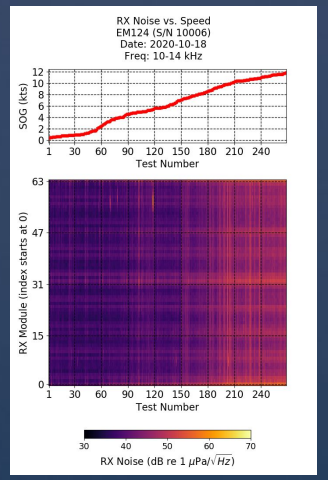
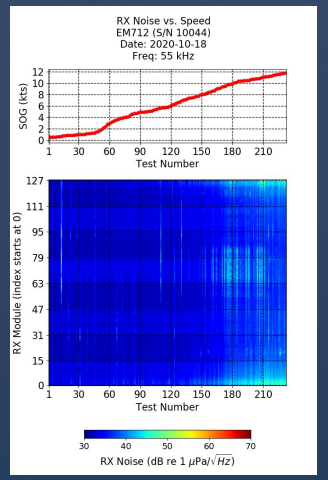
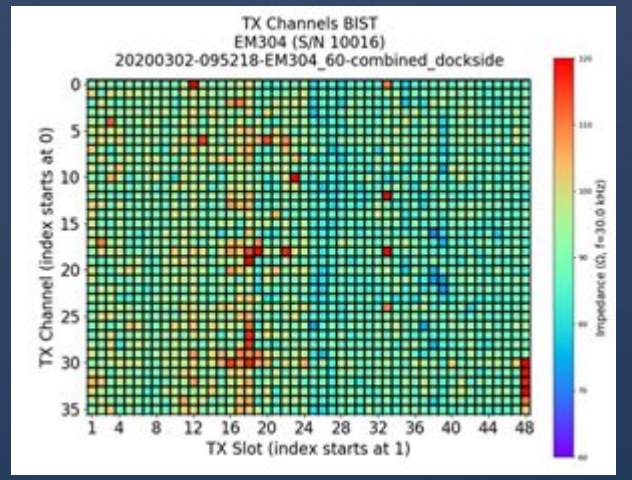
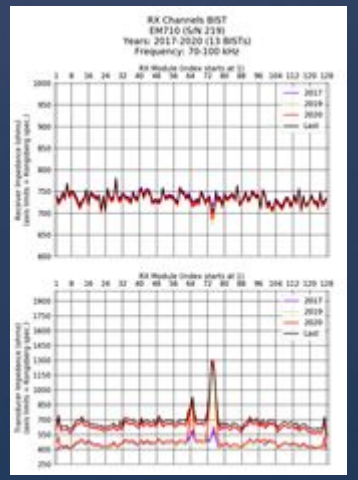
Assessment Tools

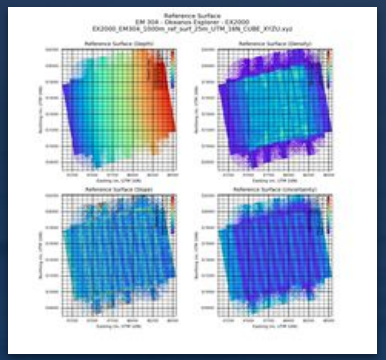
1. File Trimmer
2. BIST Plotter
3. Swath Coverage Plotter
4. Swath Accuracy Plotter

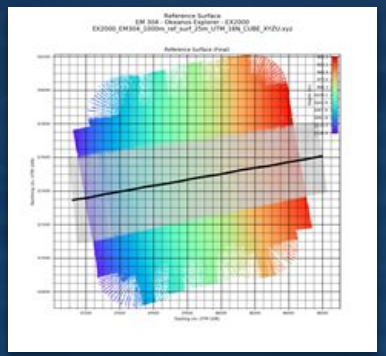












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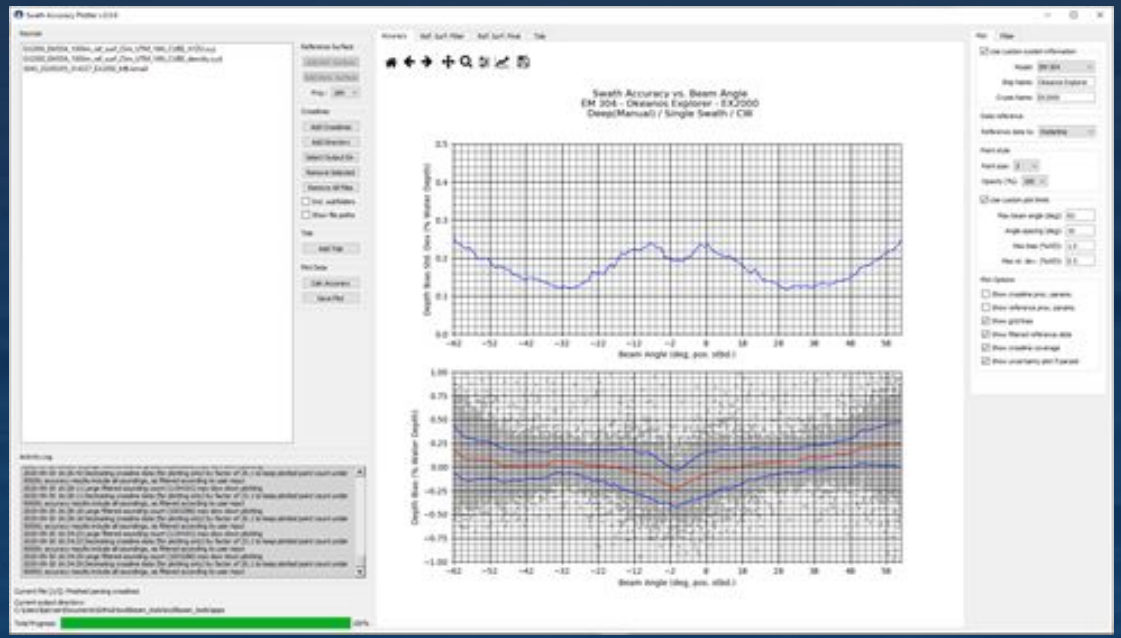

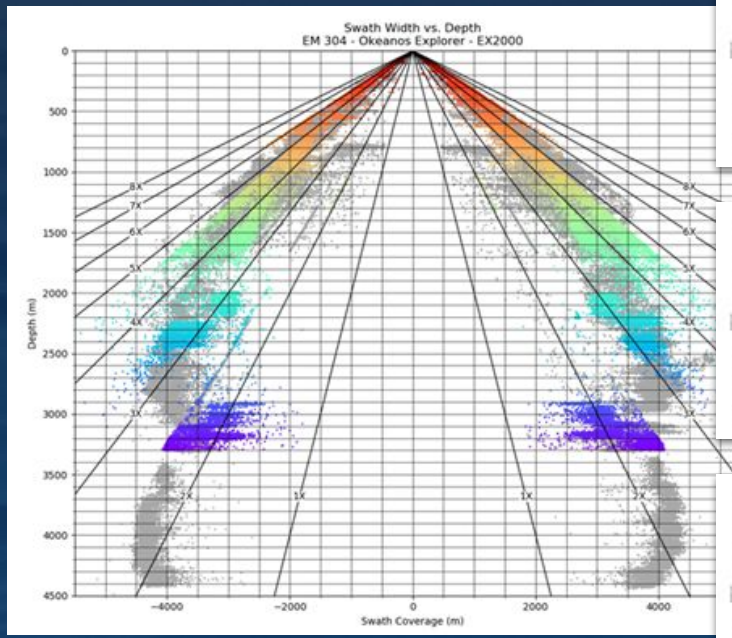

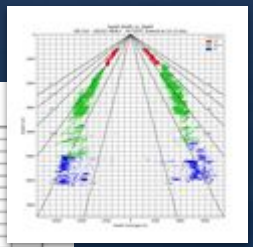

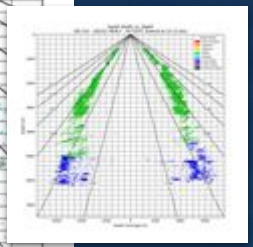

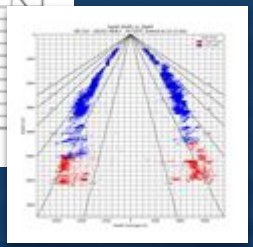

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MAC Activities since RVTEC 2020

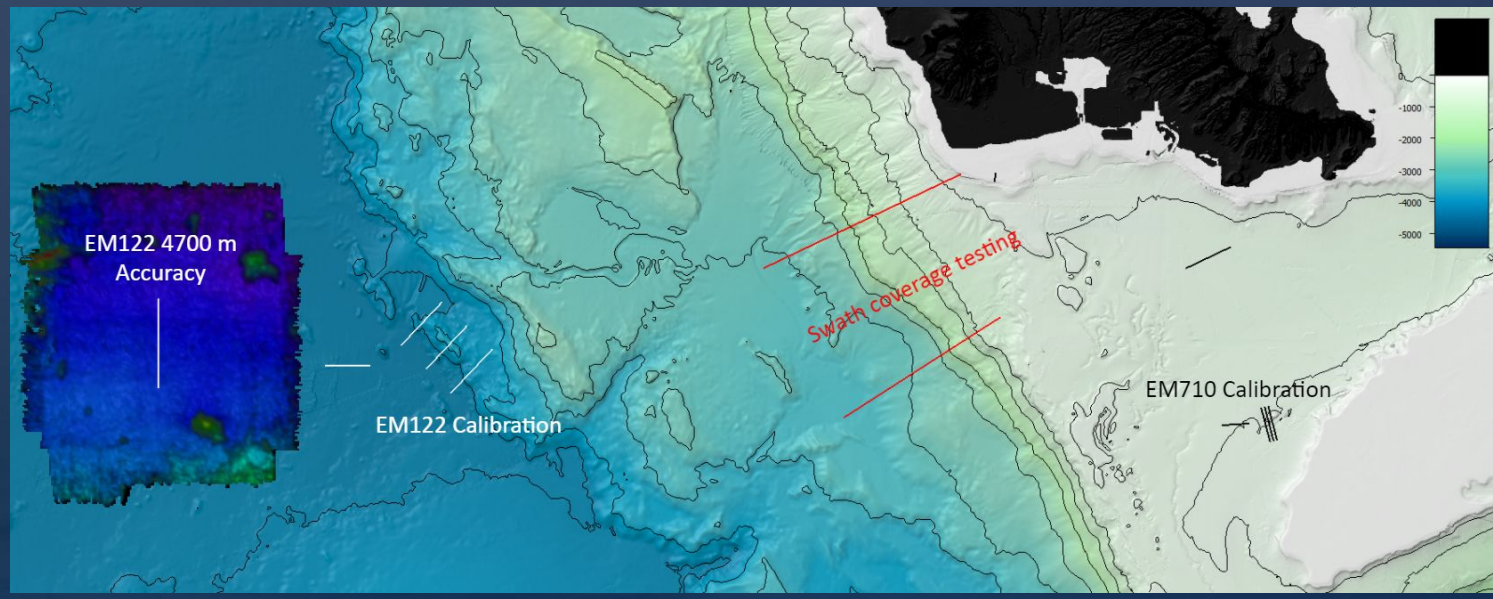
Remote* and on-board support:

- *Atlantis* (SAT*)
- *Healy* (QAT*)
- *Kilo Moana* (QAT*)
- *Sally Ride* (SAT)
- *Sikuliaq* (QAT*)
- *T. G. Thompson* (QAT*)

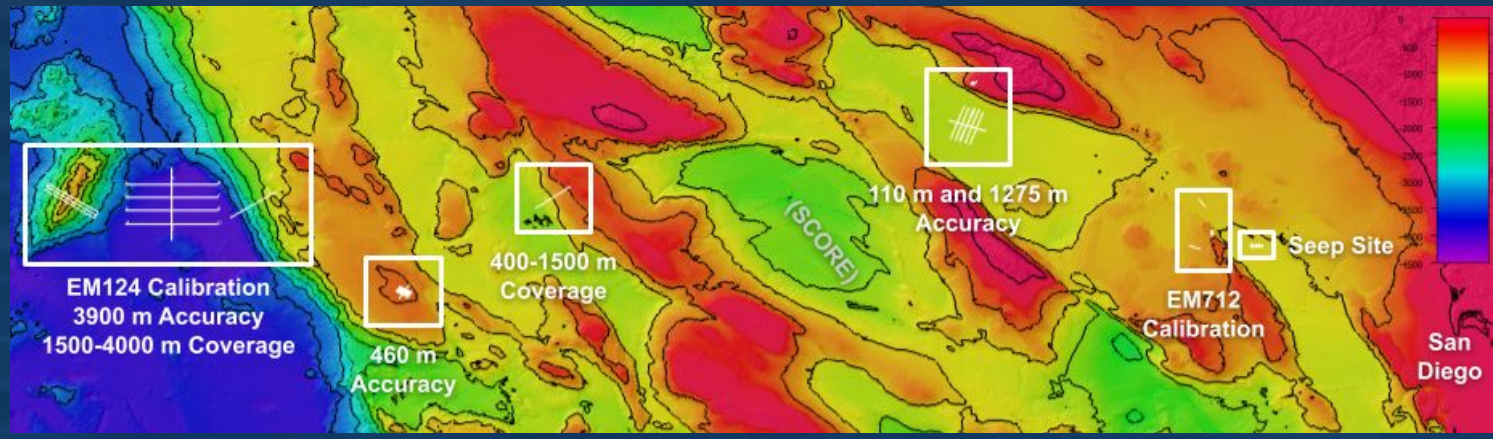
Assessment Tools (e.g., .kmall)

<u>Non-MAC</u> testing:

- *Saildrone, DRiX* (SAT)
- *Okeanos Explorer* (SAT)
- *Nautilus* (QAT)



THANK YOU to technicians and managers for making remote support possible



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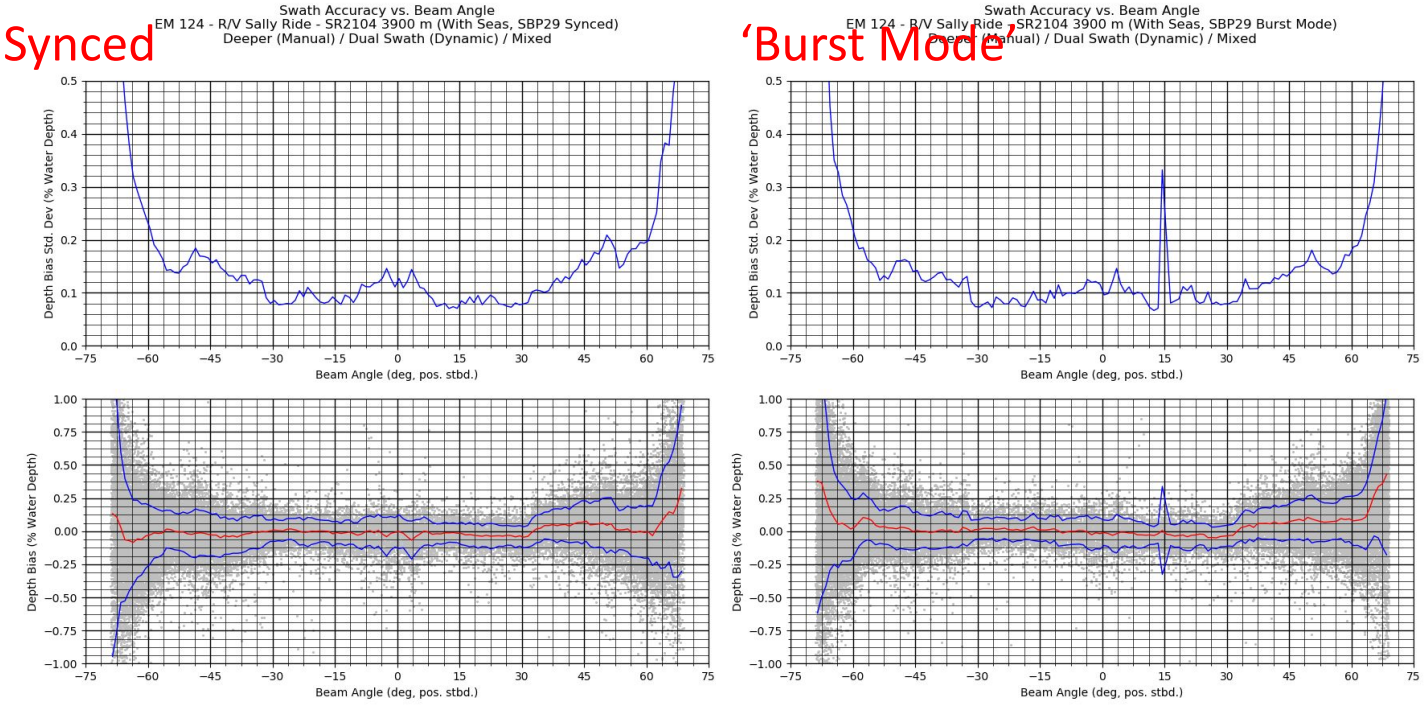
Lessons Learned 2020-21

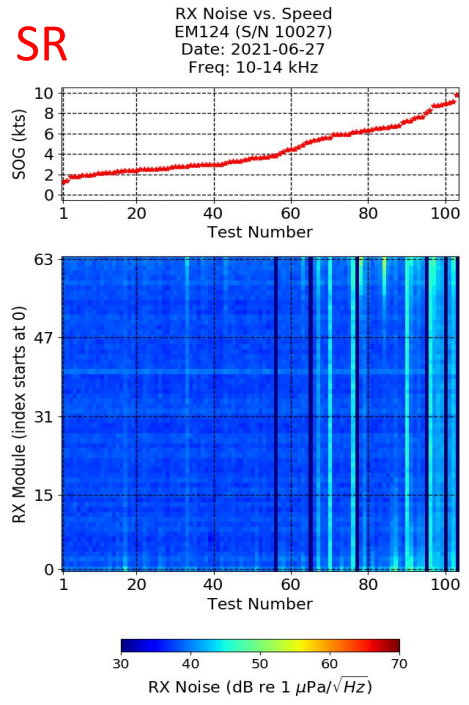
- Increasing utility of common sites and processing tools for assessments
  - Easier/faster planning with more confidence in site suitability
  - Catch problems early → ‘apples-to-apples’ comparisons
  - Open access to performance reports is critical (e.g., configuration appendices)
  - Post-cruise quality assessment via R2R and GMRT (e.g., GMRT extinction plots)

Synced

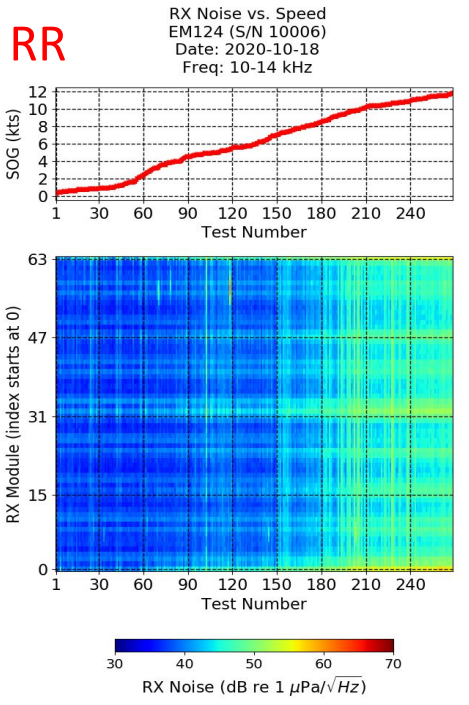


‘Burst Mode’

SR



RR



Lessons Learned 2020-21

- Translation from survey report to configuration remains a source of error
  - Correct values are often reported unclearly
  - Clear reports can be interpreted inconsistently
  - MAC guidelines / examples for survey reports
  - Available for early review and feedback

TX	0° - 1' - 59"	PORT	0° - 3' - 7"	BOW UP	0° - 6' - 40"	STBD UP
RX	0° - 5' - 24"	PORT	0° - 7' - 37"	BOW UP	0° - 9' - 7"	STBD UP

Transducer setup

	Forward, X / Roll	Starboard, Y / Pitch	Downward, Z / Heading
TX 1 Location offset (XYZ)	12.966	-0.489	6.197
TX 1 Angular offset (Roll/Pitch/Heading)	-0.111	0.519 ***	359.966
RX 1 Location offset (XYZ)	17.359	-1.429	6.195
RX 1 Angular offset (Roll/Pitch/Heading)	-0.152	0.127	359.910

Example table of mapping sensor results

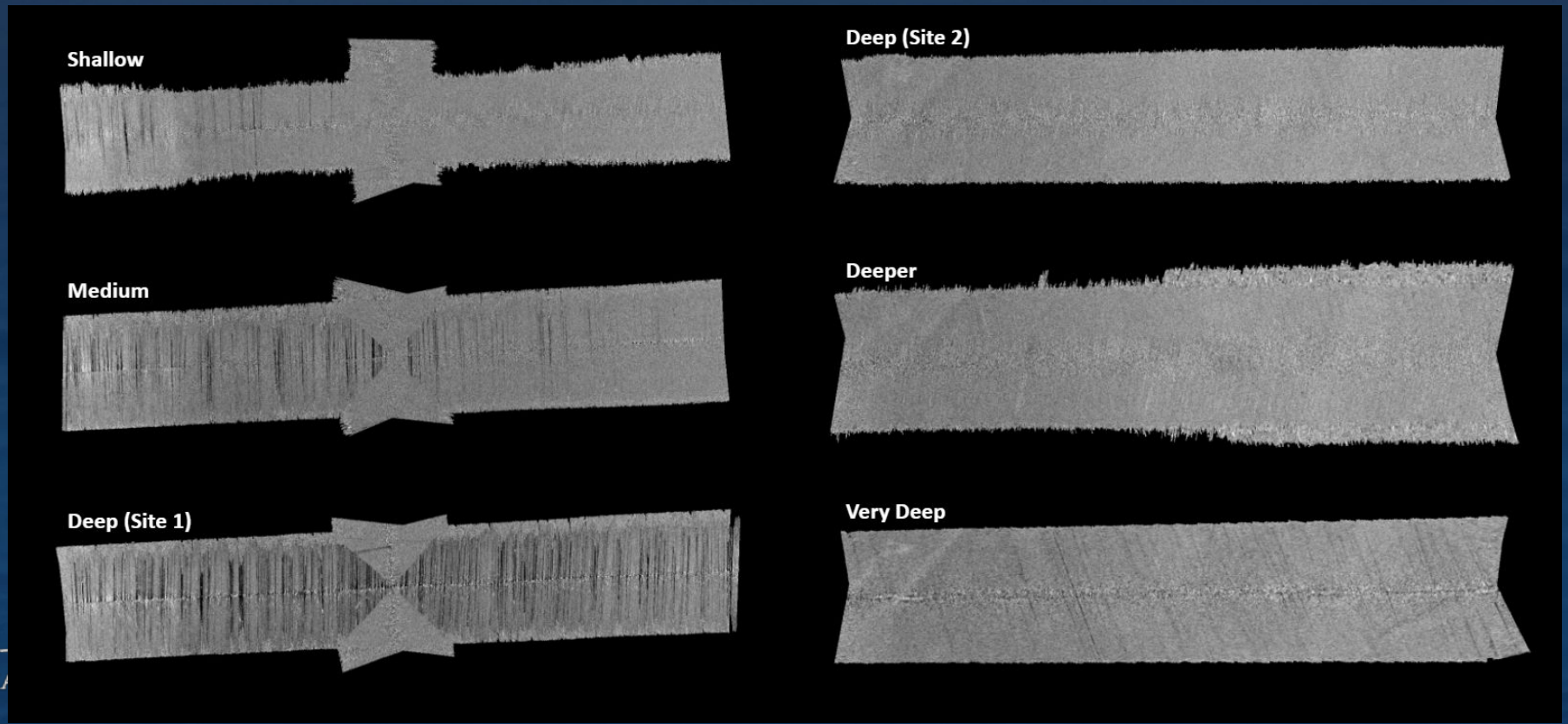
The ultimate purpose of the VSR is the confident and correct interpretation of the survey data for mapping system configuration. Building on criteria #1-6 presented above, this is best addressed with a simplified table of results for the relevant sensors using the chosen MBES manufacturer's reference frame and sign conventions. This table may be presented at the beginning or end of the report and only summarizes, rather than replaces, the more detailed survey data throughout.

Table 1. Example mapping sensor offsets from a chosen origin using consistent axis and sign conventions. This table summarizes the more detailed survey results presented elsewhere in the report. While these final numbers may be used directly for configuration, the reader must still carefully consider how the offsets will be applied among the sensor software packages to avoid doubling or cancelling the offsets. The items in the left column are examples only, and the final offsets required for configuration may differ by system; this should be clarified by the client. For example, manufacturers of higher-frequency echosounders may require a transducer bracket 'reference point' instead of the center of each array face; the client and surveyor must identify these items in planning the survey. Installations on adjustable rams or drop keels should include separate results for each standard positions used for mapping (e.g., recessed and extended, plus any intermittent standard positions)

R/V VESSEL	X	Y	Z	ROLL	PITCH	HEADING	Notes
Sign convention	Positive forward	Positive to starboard	Positive down	Positive with starboard side down	Positive with forward side up	Positive with forward side to starboard	
Units	meters	meters	meters	degrees	degrees	degrees	
Origin (chosen feature)	0.000	0.000	0.000	N/A	N/A	N/A	
TX array (center of array face)							
RX array (center of array face)							
GNSS antenna 1 (phase center)							*Phase center height is ____ m above the survey point (source: _____)*
GNSS antenna 2 (phase center)							
Motion sensor (survey target on sensor housing)							
Additional sensors							

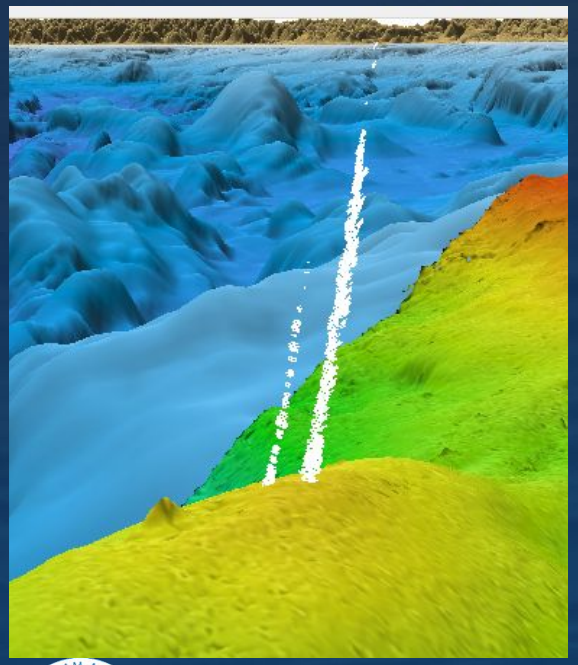
Lessons Learned 2020-21

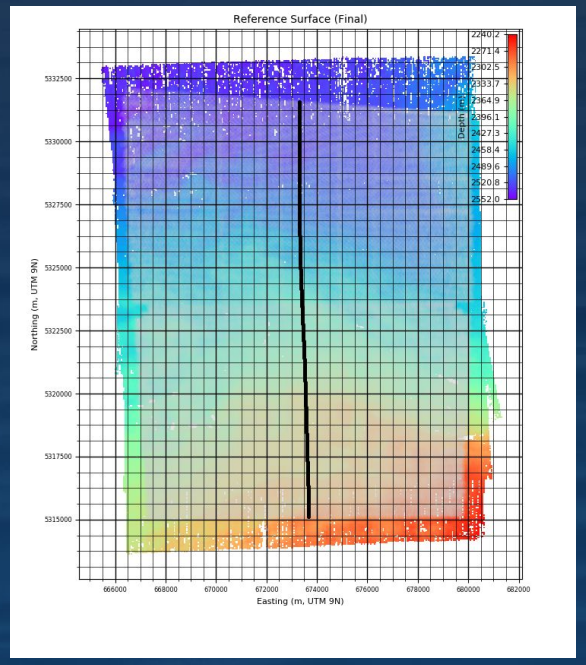
- Growing interest in backscatter (habitat mapping, seafloor characterization)
  - Can be valuable tool for monitoring changes in array response
  - Post-processing does not fix biases between TX sectors (‘stripes’) and TX modes
  - BS normalization should be a standard SAT item (or QAT if not done earlier)

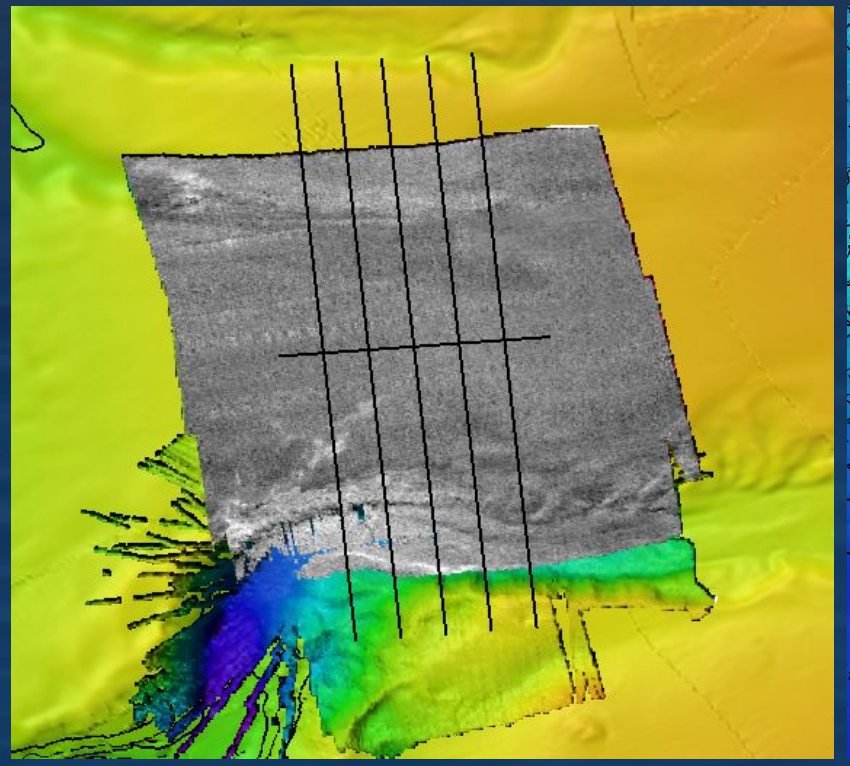


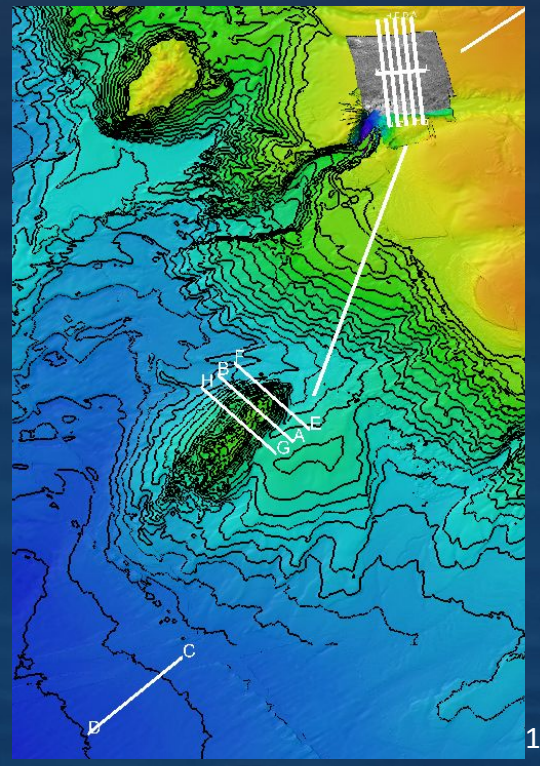
Lessons Learned 2020-21

- Performance testing plans are flexible, with limits
  - Standard SAT/QAT prioritized by impact on (and opportunity for) later testing
  - Advance planning means efficient use of ship time, proven sites, and personnel
  - Standard MB ‘patch test’ approach is effective, efficient, non-proprietary
  - MAC approach readily *dovetailed* (but not *replaced*) with other activities
    - Likewise, other systems have their dedicated test sites and time slots



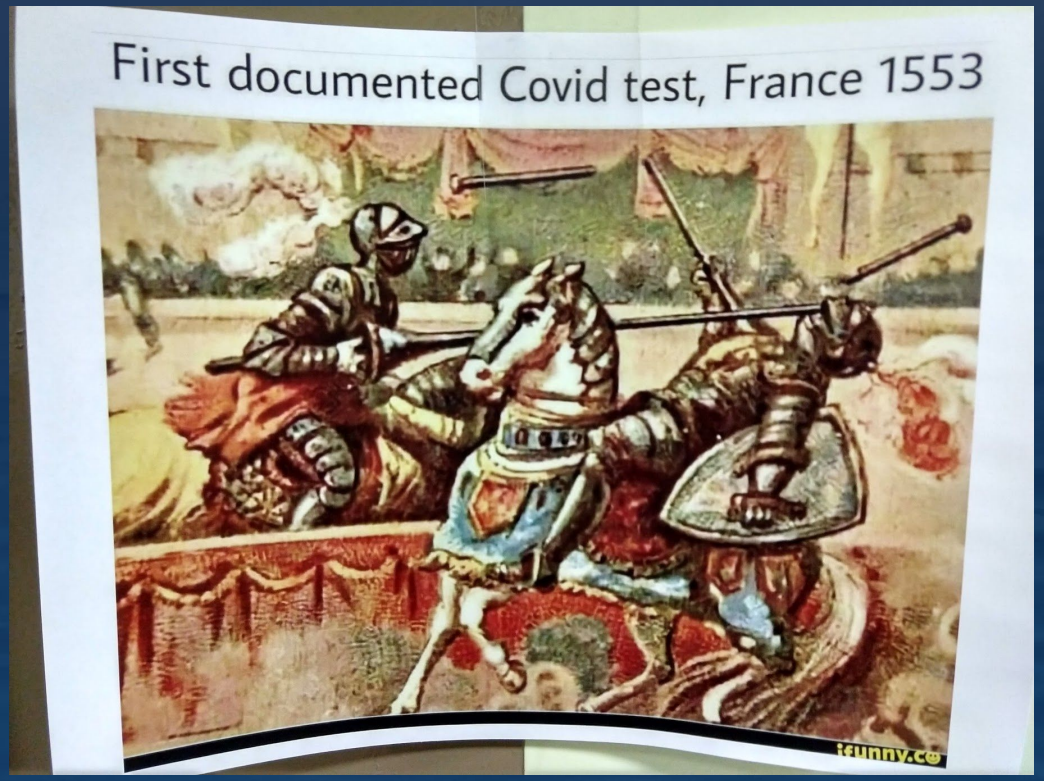






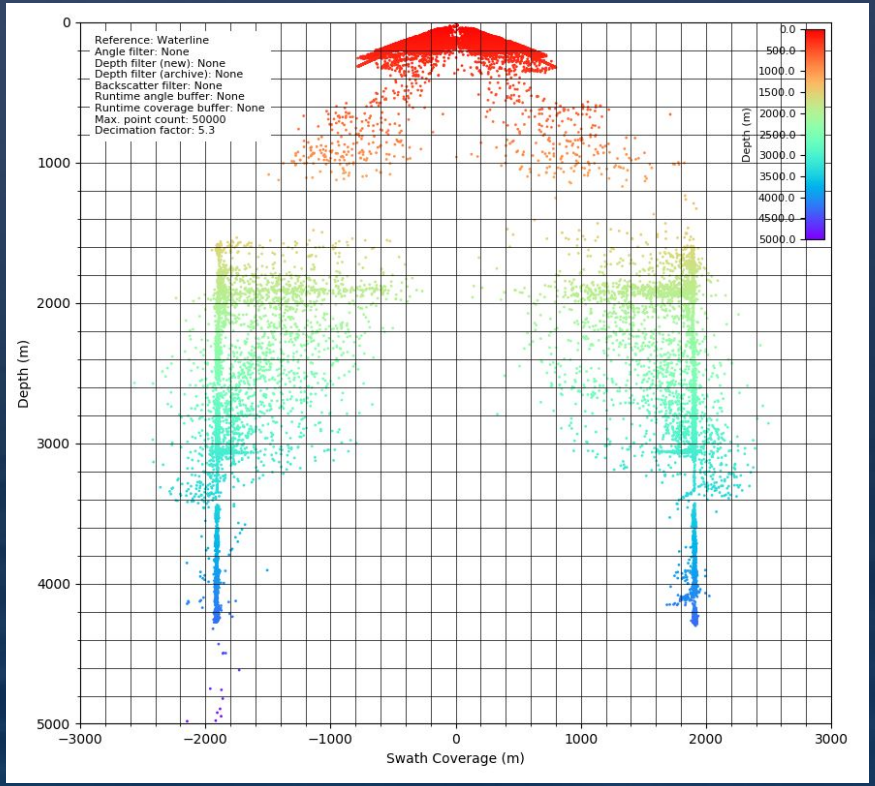
Lessons Learned 2020-21

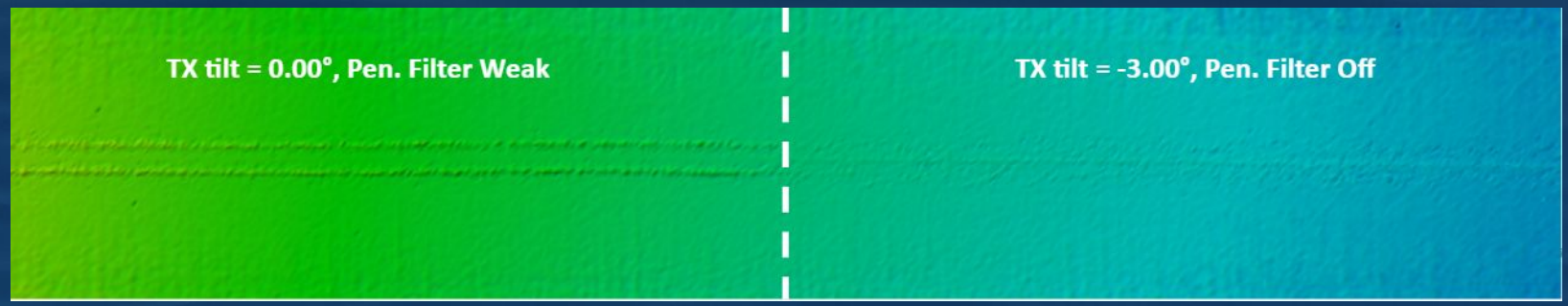
- High-speed ship-to-shore connections are invaluable for remote support
  - Google Drive, Zoom, WhatsApp, Slack (email gets cumbersome quickly)
- There's no substitute for being on board (with proper protocols in place)



Next Steps: Transit Data

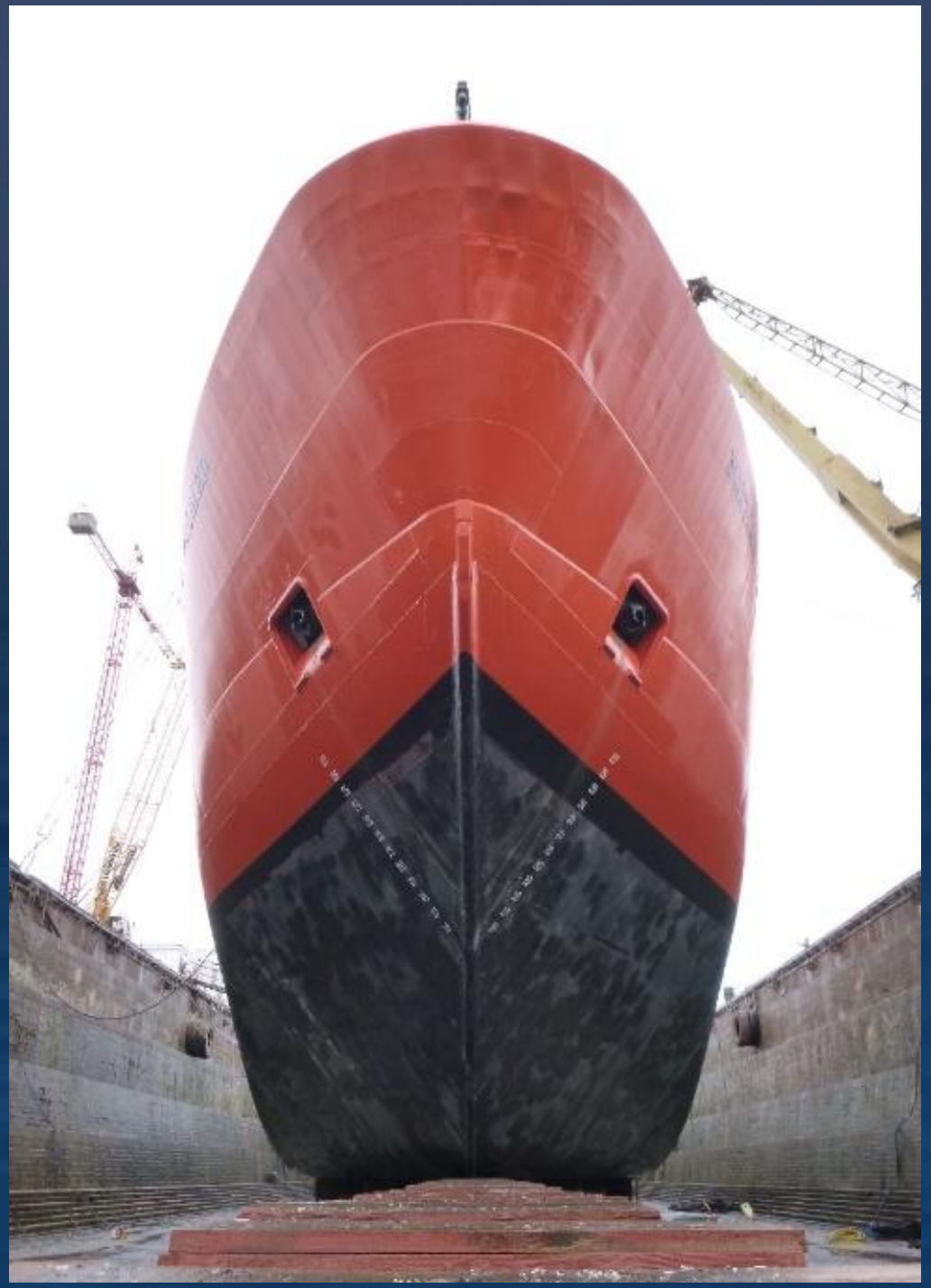
- Increasing and improving transit mapping data
- ***Map The Gaps***
  - US EEZ, GMRT, Seabed 2030, UN Ocean Decade
  - Opportunistic testing
    - Swath coverage, backscatter normalization, etc.
- What are your top challenges/roadblocks?
  - Email mac-help@unols.org or chat with us here
- What resources/tools would help?
  - Sound Speed Manager
  - Route planning for gaps
  - Test sites en route
  - Other?





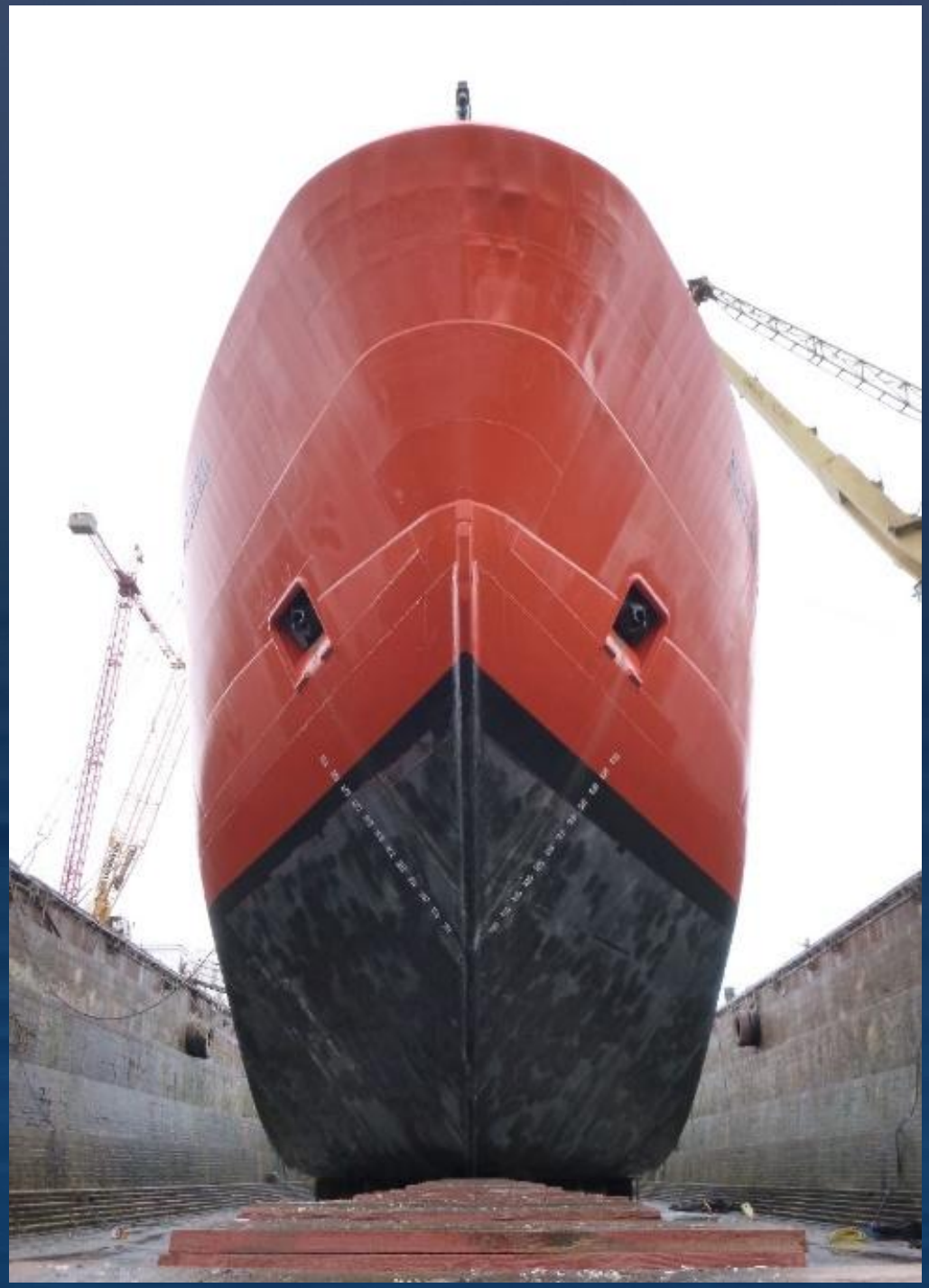
What's Next?

- RCRVs planning in progress
- *Healy* EM122 replacement
- Late-life cycle systems
  - EOL performance testing
  - Ship purposes / regions?
- Who is planning what (and when)?
  - Adding navigation/attitude systems?
  - Most recent patch test?
  - Any new noise issues?
  - Available to help plan SAT/QATs



What's Next?

- In talking with Tech Training Committee…
  - Multibeam 'quick guides' (Top 10?)
  - Wiki / community resource (GitHub?)
  - **What Went Wrong Wednesday** (Jan-Feb)



Thank you!

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