Multibeam Advisory Committee (MAC) 2020 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 the protocols & tools for system assessment*
  - *Document, report, & publish MBES system performance*
  - *Provide on-board & remote support to ships*
  - *Share best practices & knowledge*
- Technical Reports
  - SAT, QAT, ANT
  - Document each MAC engagement
  - Host Non-USARF Reports
- Technical Resources
  - Cookbooks, guidance, tools, etc.
- Help Desk

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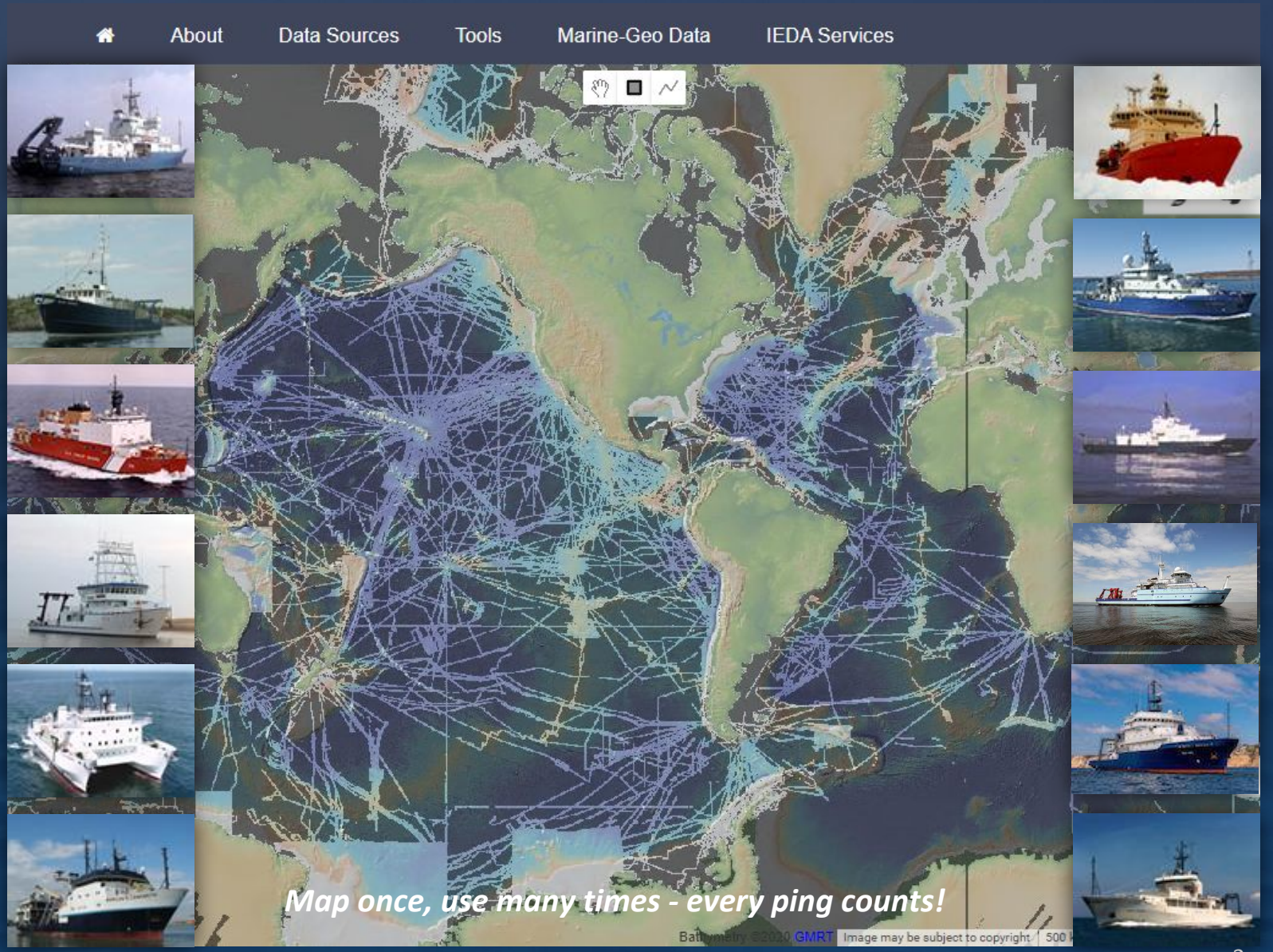
http://mac.unols.org

Mapping Systems in the U.S. Academic Fleet

- USARF vessels with MBES
  - 11 Research Vessels
  - 1 USCG Icebreaker
- 16 Kongsberg systems
  - EM710 / EM712
  - EM302
  - EM122 / EM124
- 2 Reson shallow systems
- RCRVs coming online soon



Kongsberg Systems in the U.S. Academic Fleet

Ship	System(s)	Gondola	Arrays	Life Cycle	MAC Visits
Atlantis	EM122	Y	2010 ?	Late-Life	QAT*
Healy	EM122	N	2010	Late-Life	QAT, ANT
Kilo Moana	EM122 / EM710	N	2012	Mid-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	EM122 / EM712	N	2016	Mid-Life	SAT, QAT
Thomas G. Thompson	EM302	N	2018	Early-Life	SAT

**Includes virtual visits*

MAC Activities since RVTEC 2019

Remote support for:

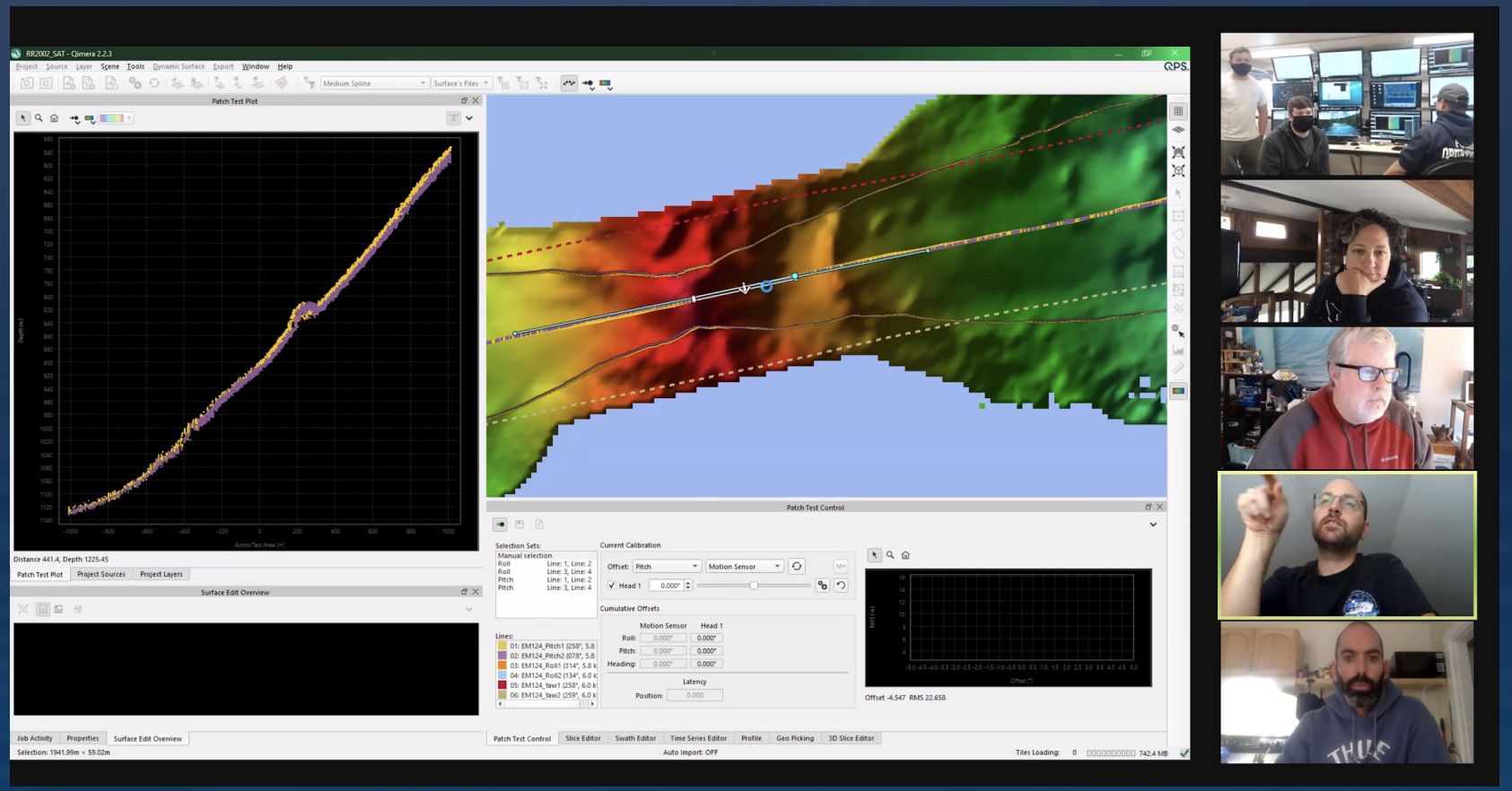
- Atlantis
- Kilo Moana (QAT)
- Armstrong (QAT)
- Revelle (SAT)
- Sikuliaq (QAT)
- Langseth

Assessment Tools

US EEZ SOMP Symposium

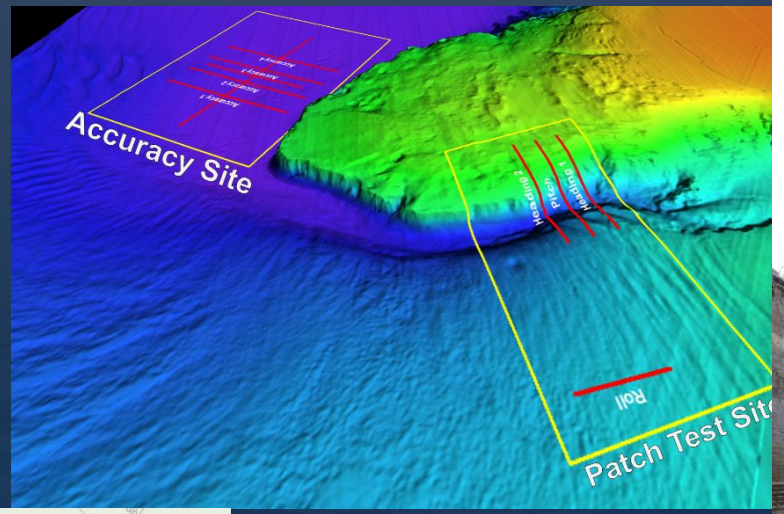
Non-MAC testing

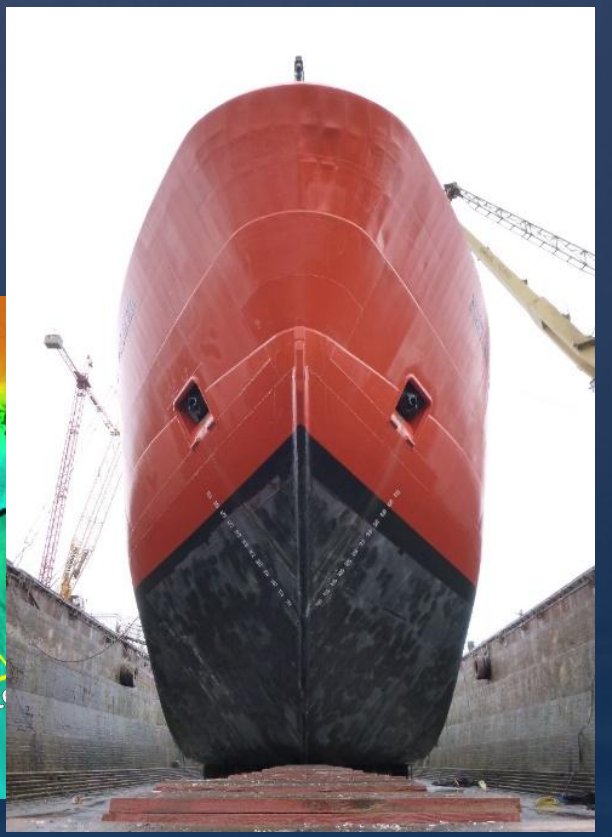
- NOAA Ship Okeanos
- E/V Nautilus

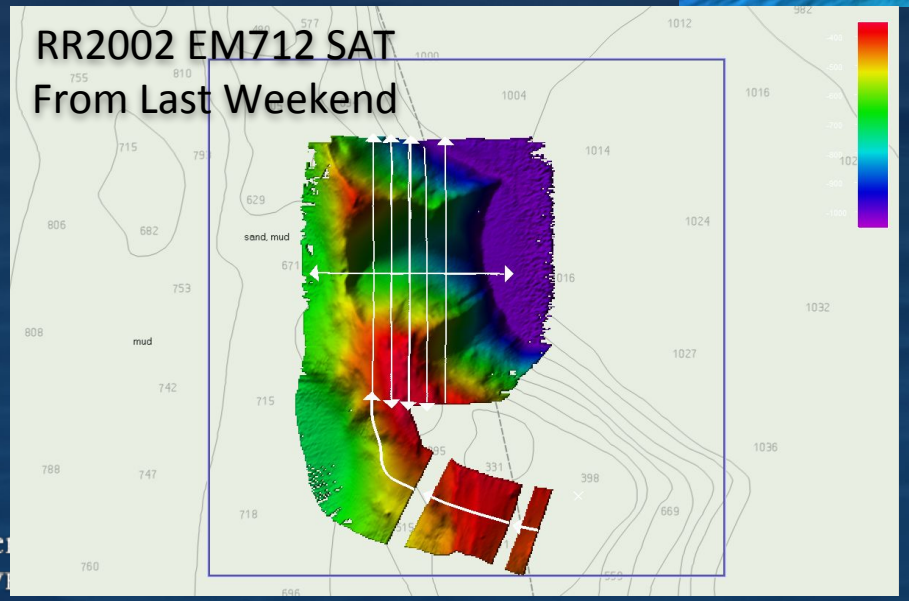


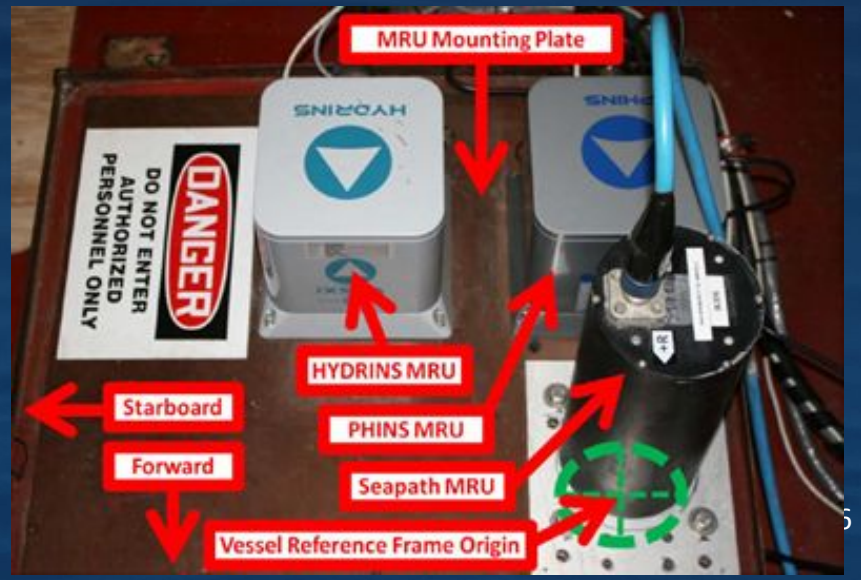
MAC System Performance Approach

1. Shipboard Acceptance Tests - SAT -(11)
   - Baseline performance
2. Acoustic Noise Tests - ANT - (9)
   - Characterize vessel noise
3. Quality Assurance Tests - QAT - (24)
   - Monitor existing installations
4. Tools
   - Acquisition and planning
   - Assessment









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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. Reporting

Multibeam Advisory Committee

Mapping System SAT/QAT Checklist

Roger Revelle EM124 / EM712 SAT
San Diego, October 2020

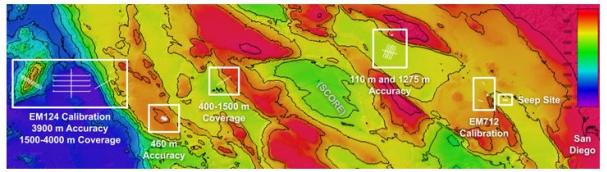
General

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 latest SIS 5 format?
9. Seapath: antennas = RR-41 and RR-47

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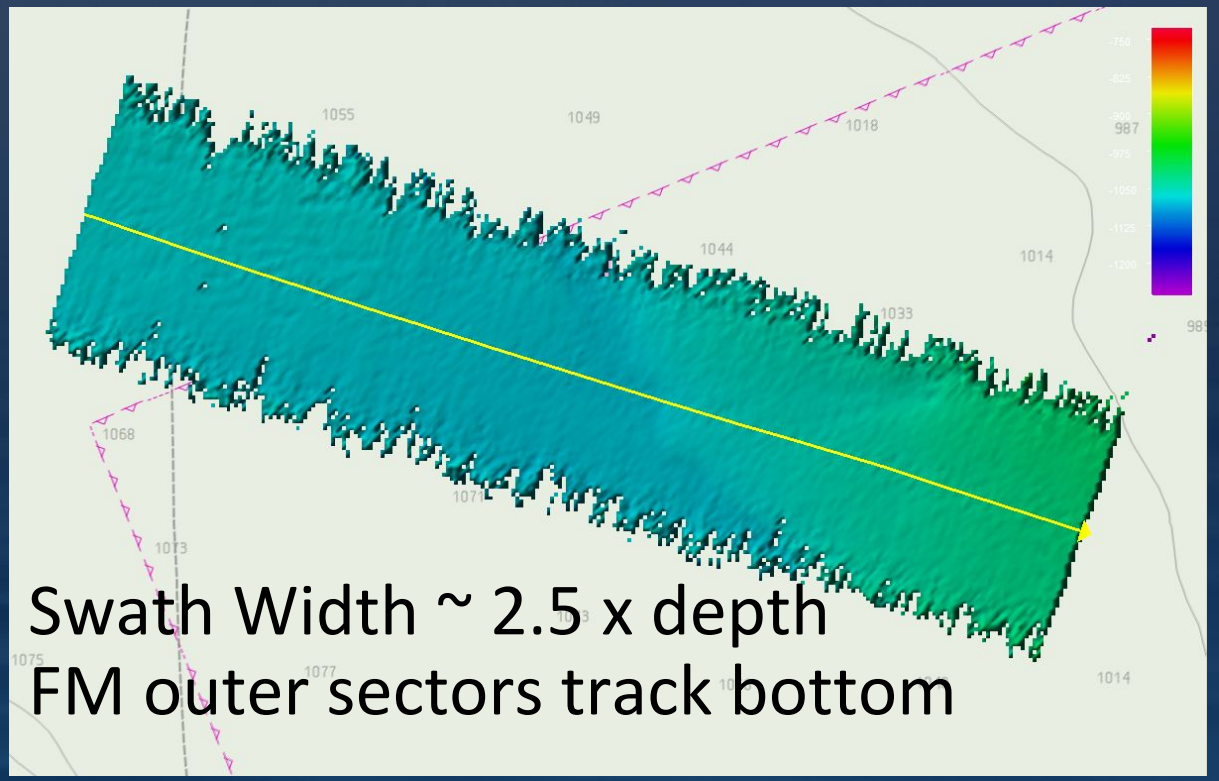
Why spend the time reviewing offsets and testing?

Rotated TX Array Orientation

Swath Width ~ 1 x depth
FM outer sectors cannot track bottom

Correct TX Array Orientation



Swath Width ~ 2.5 x depth
FM outer sectors track bottom

Recent Lessons Learned from a Fleet-wide Perspective

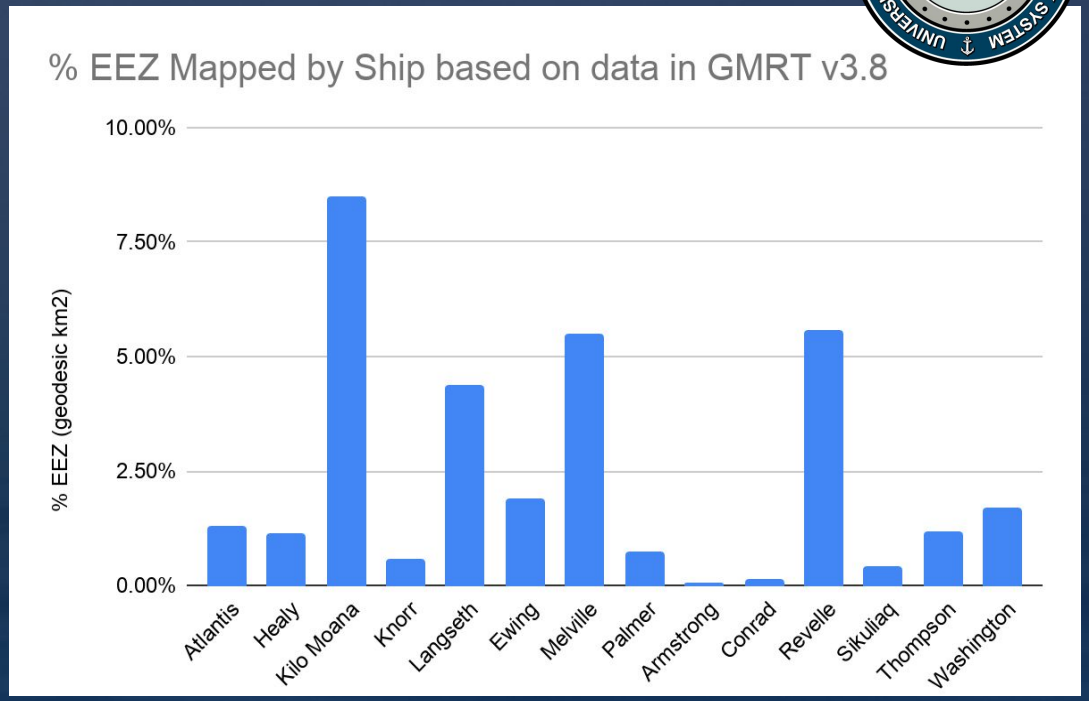
- High speed internet to the ship helps greatly with remote support
  - Zoom, Google Drive, Slack? (email is not ideal)
- Use of common tools across data life cycle helps system performance assessment
  - Catch problems early
  - Open access to performance reports is critical
  - Post-cruise quality assessment via R2R and GMRT e.g. GMRT extinction plots
- Mistakes and variability in survey reports continue to be a problem and can affect other sensors
  - MAC guidelines for survey reports

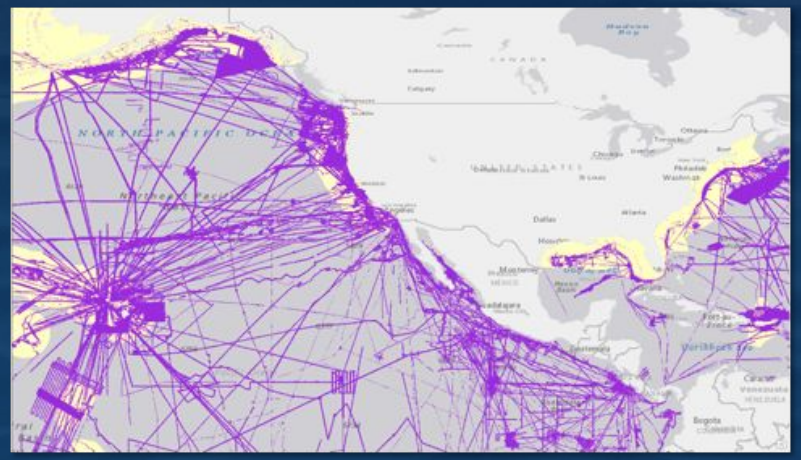
Benefits to US Research Community

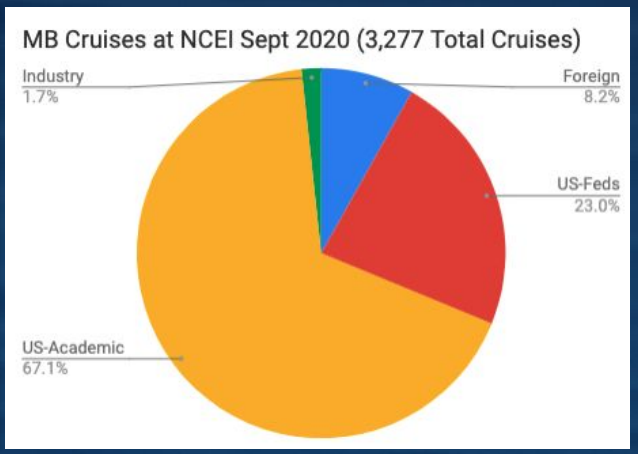
- Seabed mapping data is an essential ocean observation
  - Bathymetry, backscatter, water column data have broad applications in interdisciplinary research
- Very little of the ocean has been measured with direct observation
  - ~20% of the global ocean
  - ~50% of US EEZ
- Best practices and routine system checks promote data acquisition even when mapping is not a primary objective
  - US ARF vessels routinely acquire data during transits - providing new data that fills gaps in data coverage globally and within US EEZ
- Mapping data stewarded by complementary efforts of MAC, R2R and GMRT increase return on investment by ensuring that high quality data are acquired, archived and integrated into publicly available data syntheses

Contributions of the US ARF to National and Global Mapping

- US ARF is a significant contributor to:
  - NCEI/IHO MB archive > 60% by cruise
  - US EEZ mapping > 20%**
  - Global ocean mapping ~9%**
- Coordinated presentations at NOAA-led Standard Ocean Mapping Protocol (SOMP) Symposium
  - R2R, MAC, GMRT
- GMRT synthesis serves as base maps for many national and international web apps
- GMRT contributed directly to GEBCO/Seabed 2030







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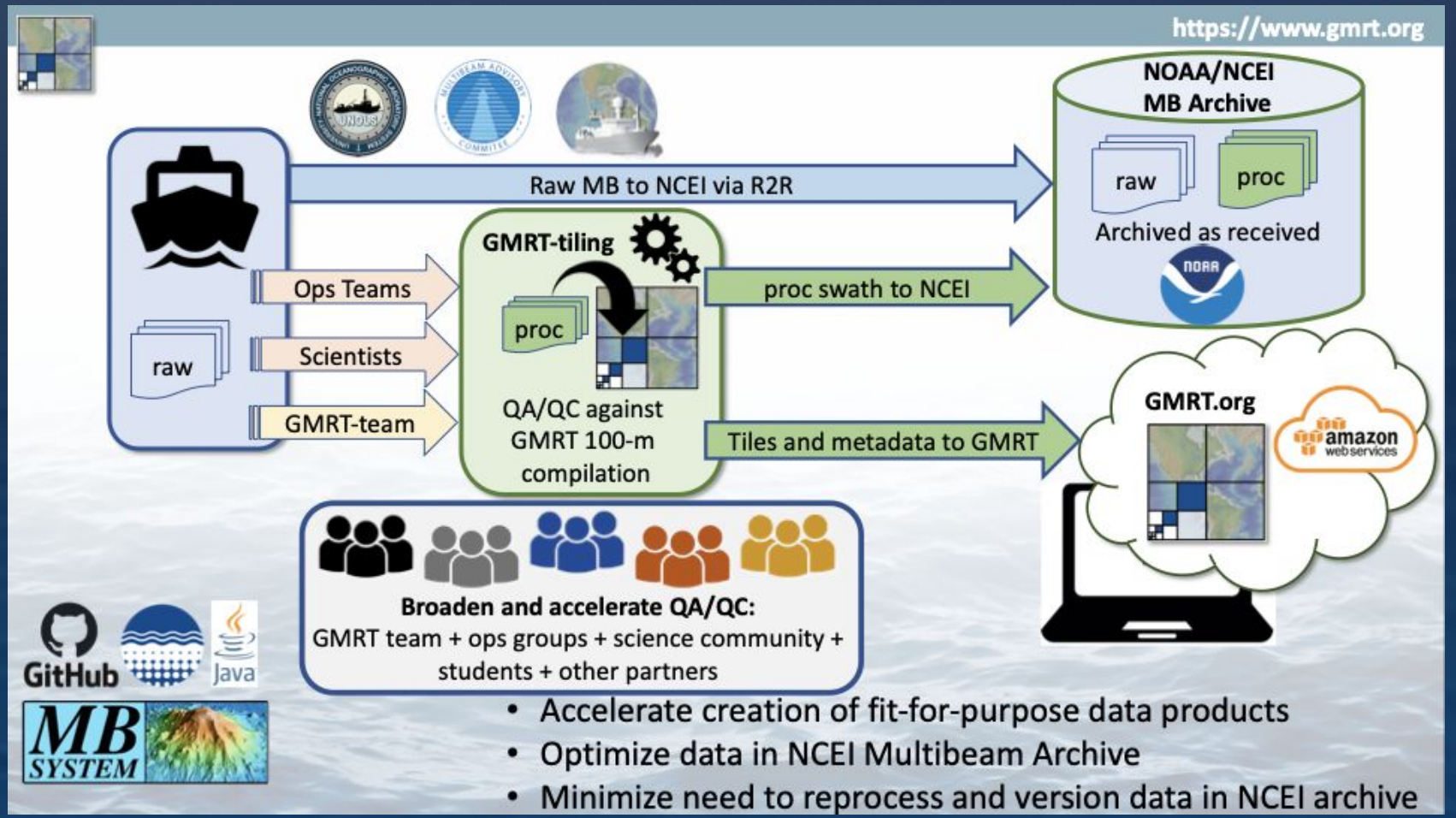
***based on GMRT v3.8*

GMRT: Tools for QA/QC of processed MBES data

GMRT v3.8 MBS

- 1,192 cruises, 36 vessels
- 34,764,597 square km
- 9.61% global ocean
- >20% US EEZ



Multibeam Assessment Resources

1. Survey report guidelines
2. SAT/QAT checklist
3. Open-source tools in development
   a. File Trimmer (.all only, .kmall*)
   b. Swath coverage plotter (.all, .kmall*)
   c. Swath accuracy plotter (.all, .kmall*)
   d. BIST plotter (SIS4, SIS5)
   e. Install / Runtime Param. Tracker*

http://mac.unols.org/resources/assessment-tools

Vessel Offset Survey Reports

Data quality depends on correct configuration

Vessel and sensor offsets must be clearly documented

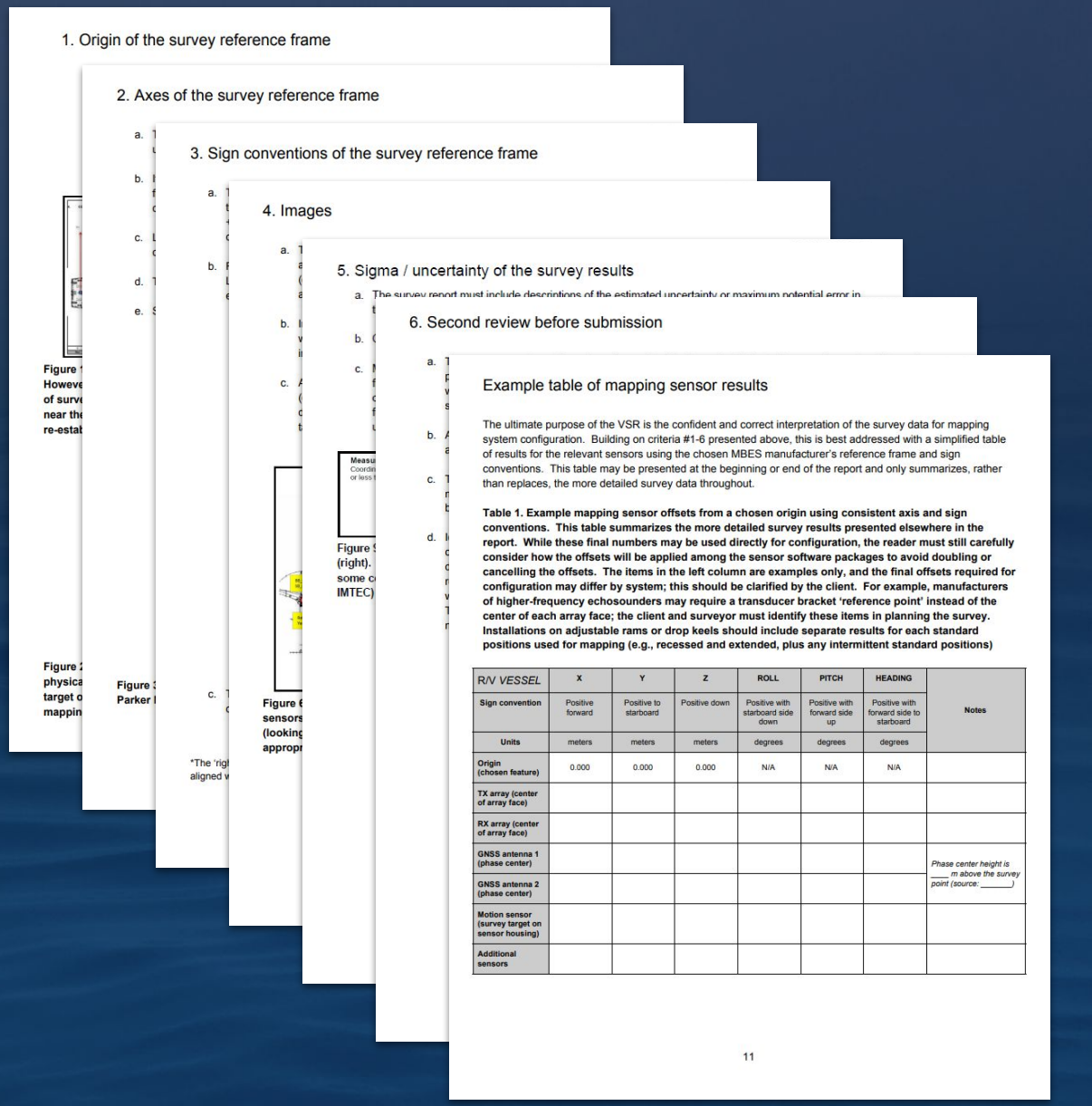
Survey reports directly impact data quality for decades

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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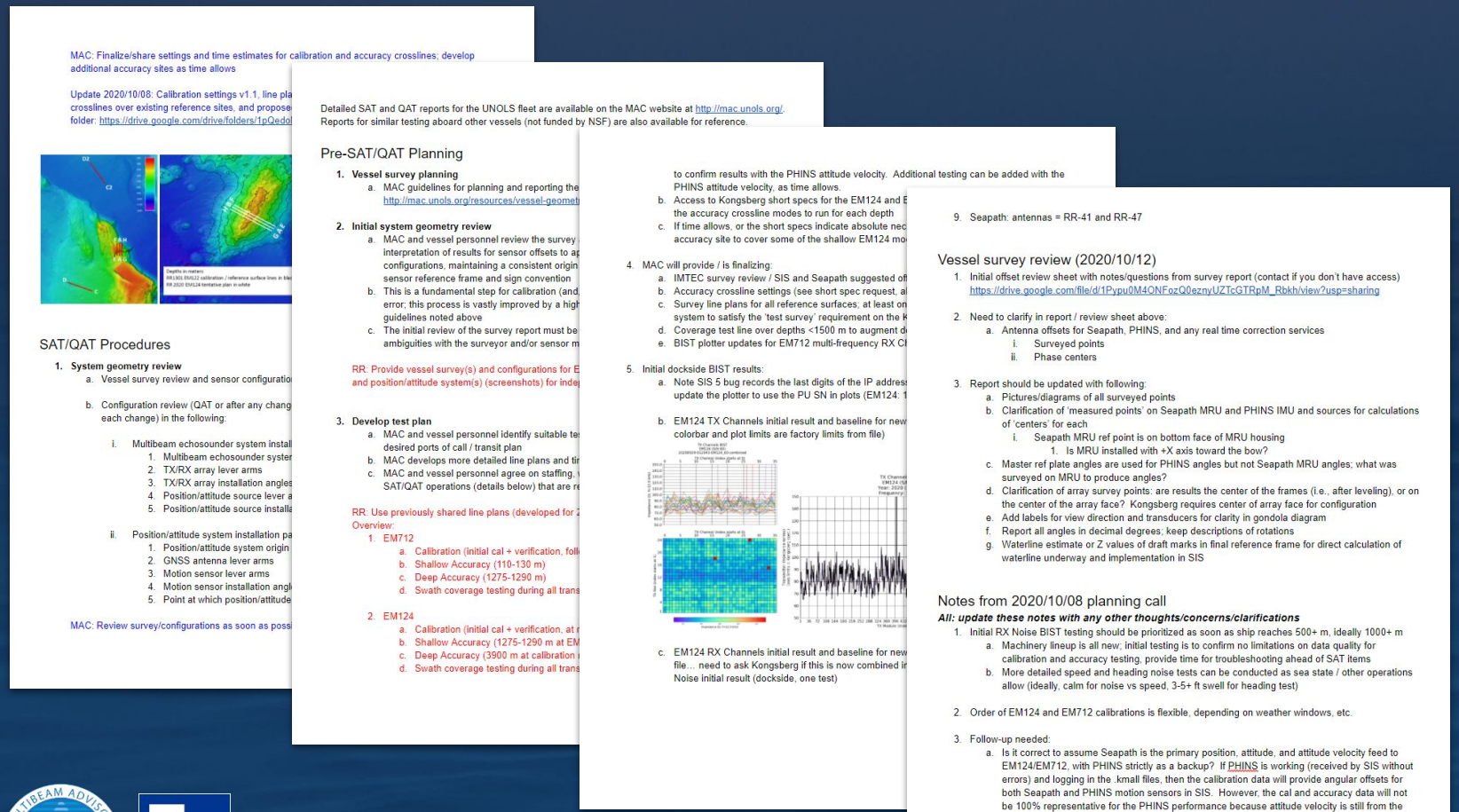
SAT / QAT Checklist

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 tir
   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
   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

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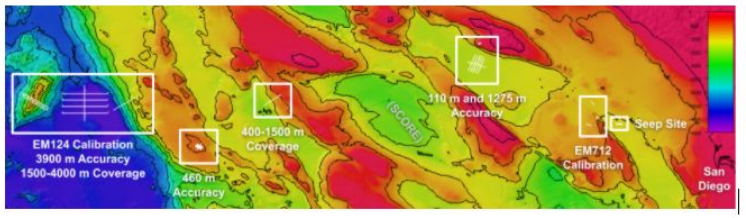

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1

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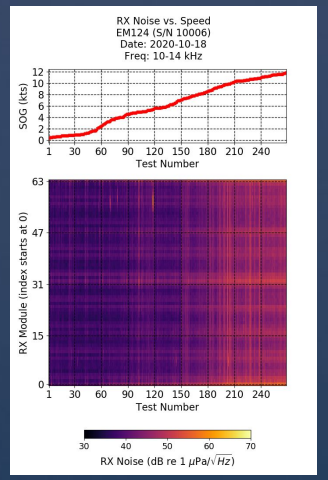
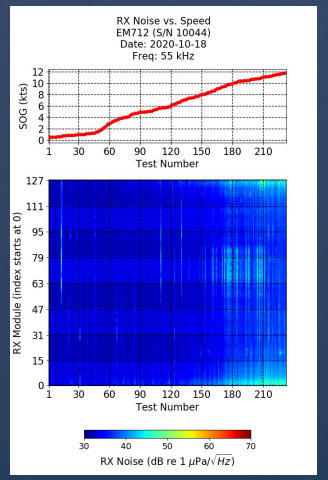
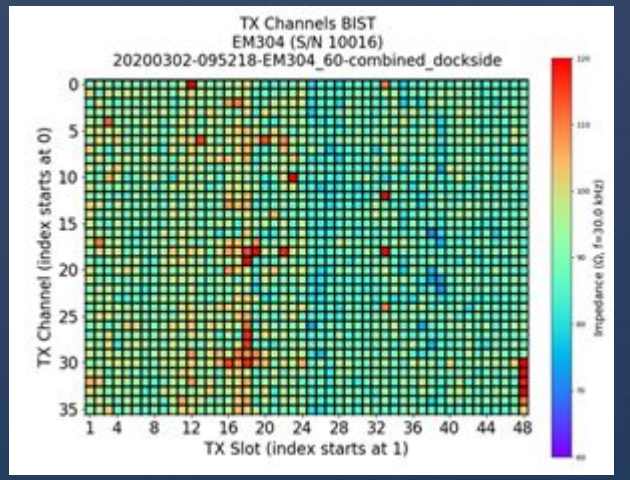
Assessment Tools

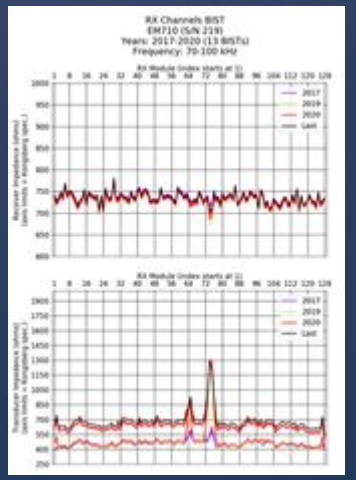
Live demonstration:

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









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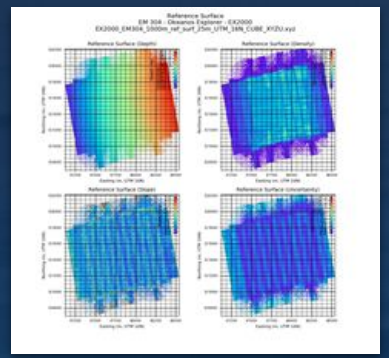

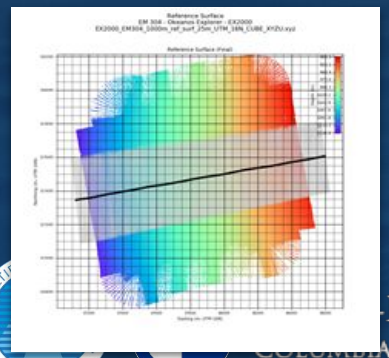

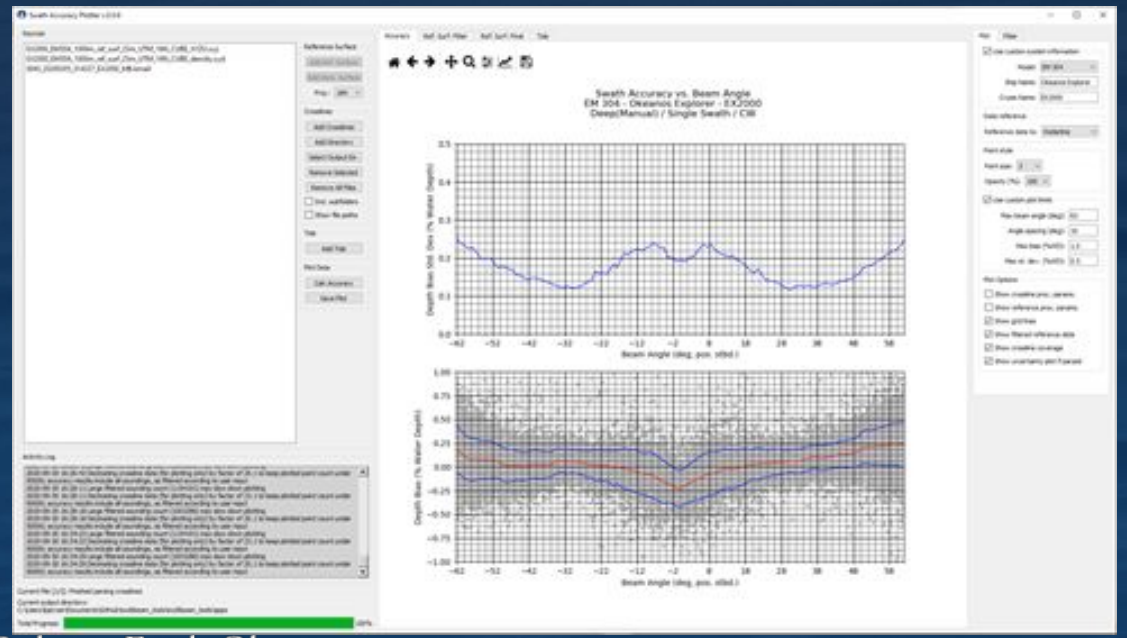

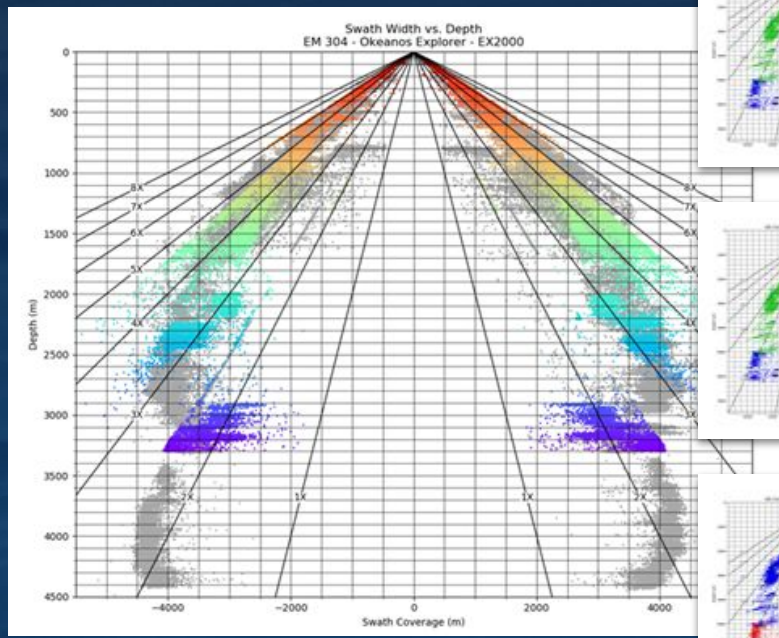

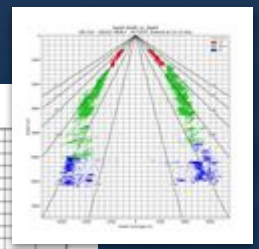

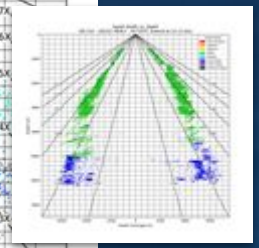

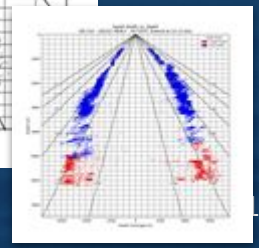

Thank you!

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