Multibeam Advisory Committee (MAC) **2021 UNOLS Update**

Paul Johnson¹, Vicki Ferrini^{2,1}, Kevin Jerram¹

¹ Center for Coastal & Ocean Mapping, University of New Hampshire ² Lamont-Doherty Earth Observatory, Columbia University

Supported under NSF Grants: 1933720, 1933776







The Multibeam Advisory Committee (MAC) SHIPBOARDA TO THE LEAD OF THE

- Established 2011 with funding from NSF to ensure the consistent collection of high-quality multibeam data across the U.S. Academic Research Fleet (USARF)
 - **On-board & remote support** for ships
 - **Standardize** system performance testing
 - **Publish** performance and share best practices
- Technical Reports & Resources
 - Sea Acceptance, Quality Assurance, Noise
 - Reports from USARF and other vessels
 - Cookbooks, guidance, tools
- Help Desk: mac-help@unols.org
 - Website: https://mac.unols.org





Mapping Systems in the U.S. Academic Fleet

- 12 USARF vessels w/ MBES
 - 11 Research Vessels
 - 1 USCG Icebreaker
- 15 Kongsberg systems
 - o EM710 / EM712
 - ∘ EM302
 - o EM122 / EM124
- 2 Reson shallow systems

₾ COLUMBIA CLIMATE SCHOOL

- 3 RCRVs on the way
 - o EM304 / EM2040







Kongsberg Systems in the U.S. Academic Fleet

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



SAT / QAT Checklist

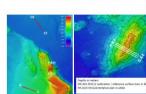
Standardized testing procedures in order of priority

Updated collaboratively throughout planning and at-sea operations

Especially useful for communication during remote support

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 configuration
- b. Configuration review (QAT or after any change each change) in the following
 - i. Multibeam echosounder system instal
 - Multibeam echosounder syste
 - 2. TX/RX array lever arms TX/RX array installation angle
 - Position/attitude source lever
 - 5. Position/attitude source install
 - ii. Position/attitude system installation pa 1. Position/attitude system origin
 - 2. GNSS antenna lever arms
 - Motion sensor lever arms
 - 4. Motion sensor installation and
 - 5. Point at which position/attitude

MAC: Review survey/configurations as soon as poss

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

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
- c. The initial review of the survey report must be ambiguities with the surveyor and/or sensor n

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

3. Develop test plan

- a. MAC and vessel personnel identify suitable t
- 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 r
- RR: Use previously shared line plans (developed for

- a. Calibration (initial cal + verification, fol
- 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 a
- b. Shallow Accuracy (1275-1290 m at EN c Deep Accuracy (3900 m at calibration
- d. Swath coverage testing during all trans

to confirm results with the PHINS attitude velocity. Additional and a second at the se PHINS attitude velocity, as time allows.

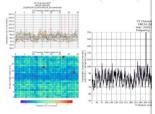
- b. Access to Kongsberg short specs for the EM124 and E the accuracy crossline modes to run for each depth
- c. If time allows, or the short specs indicate absolute ned accuracy site to cover some of the shallow EM124 mo

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 or
- system to satisfy the 'test survey' requirement on the l
- d. Coverage test line over depths <1500 m to augment d e. BIST plotter updates for EM712 multi-frequency RX CI

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:
- b FM124 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 nev file... need to ask Kongsberg if this is now combined i 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
 - Surveyed points
- 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
 - 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? Kongsherg requires center of array face for configuration
- e. Add labels for view direction and transducers for clarity in gondola diagram.
- 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.

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

Multibeam Advisory Committee Mapping System SAT/QAT Checklist

Roger Revelle EM124 / EM712 SAT San Diego, October 2020

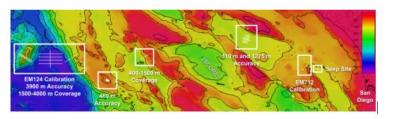
General

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
- Updated reference surface surveys and crosslines
 - a. Added reference lines for new surveys at existing 110, 1275, and 3900 m sites
- 3. Coverage line and transits may pass through/near SCORE basin need to file intent? (or we can find a
- 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?





COLUMBIA CLIMATE LAMONT-DOHERTY EARTH OBSERVATORY System Performance Testing

SAT and QAT procedures include:

- 1. System offset / config. review
- 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**
- Reporting



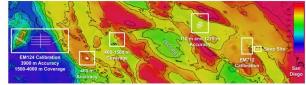
Multibeam Advisory Committee Mapping System SAT/QAT Checklist

Roger Revelle EM124 / EM712 SAT San Diego, October 2020

Shared documents for RR 2020 SAT planning

Revelle IMTEC survey docs

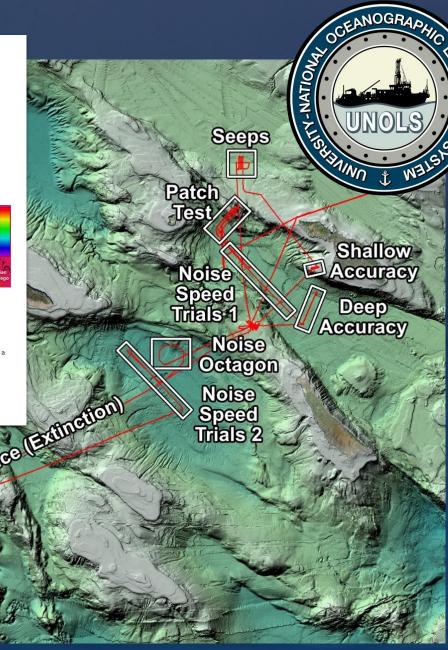
MAC assessment tools in development



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

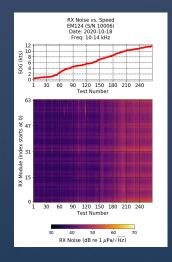
- Vessel offset review and SIS/Seapath/PHINS configurations
- 2. Updated reference surface surveys and crosslines
- Expectation for PHINs calibration need to repeat with PHINS realtime attitude velocity?
- Marine forecast and early predictions for rough schedule? Noise testing, then EM124 cal first?
- 6 MAC: provide updated noise test procedure for SIS 5
- 8. MAC: provide data trimming procedure for .kmall
 - Tested with latest SIS 5 format?

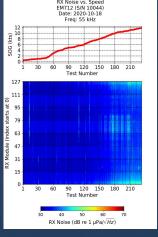


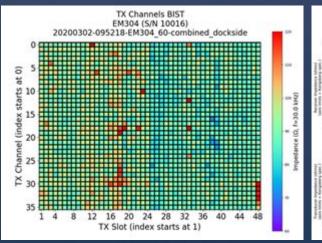


Assessment Tools

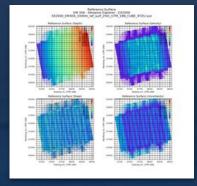
- 1. File Trimmer
- 2. BIST Plotter
- 3. Swath Coverage Plotter
- 4. Swath Accuracy Plotter

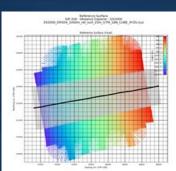




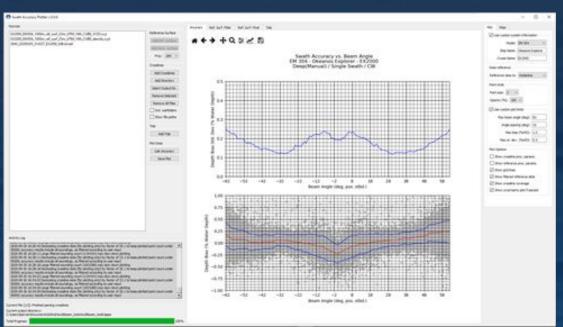


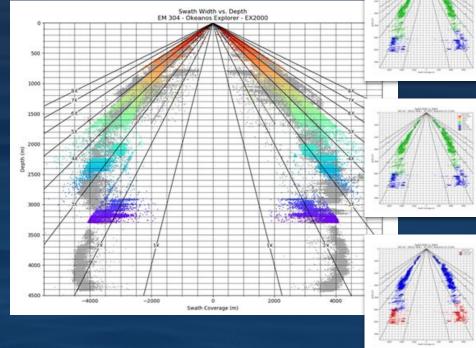
















MAC Activities since 2020

Remote* and on-board support:

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

Assessment Tools (e.g., .kmall)

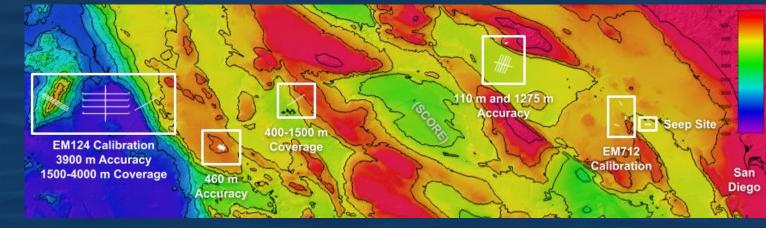
Non-MAC testing:

- *Saildrone* (EM304 / EM2040)
- DRiX (EM2040)
- Okeanos Explorer (EM304 MKII)
- Nautilus (EM302)



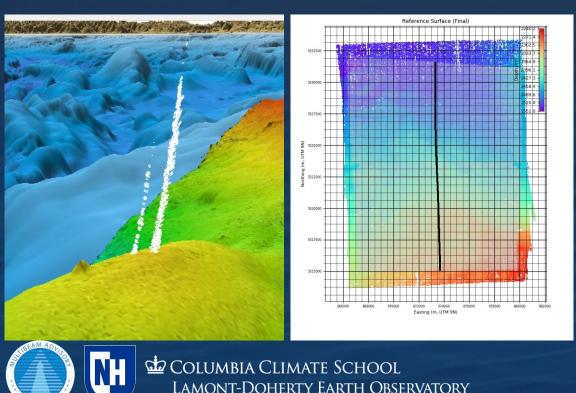


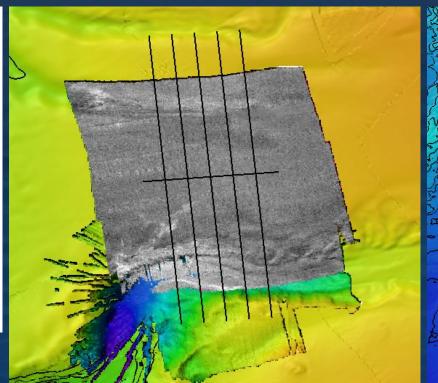
THANK YOU to technicians and managers for making remote support possible

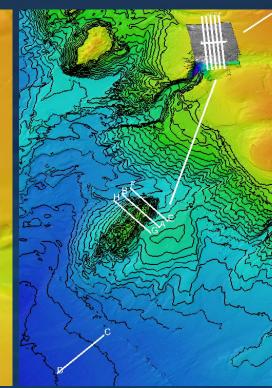


Lessons Learned 2020-21

- Standard test sites and methods = efficient use of ship time and personnel
- Transit mapping fills the gaps *and* helps to catch problems early
- Performance testing plans are flexible, with limits
- Scientist / user feedback is extremely valuable





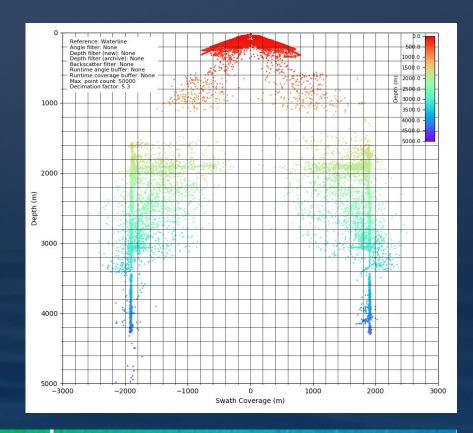






Next Steps: Transit Data

- Increasing and improving transit mapping data
- Map The Gaps
 - US EEZ, GMRT, Seabed 2030, UN Ocean Decade
 - Swath coverage, backscatter normalization, etc.
- Improving resources/tools for transits
 - Sound Speed Manager
 - Route planning for gaps
 - Reoccupying test sites en route



TX tilt = 0.00°, Pen. Filter Weak

TX t

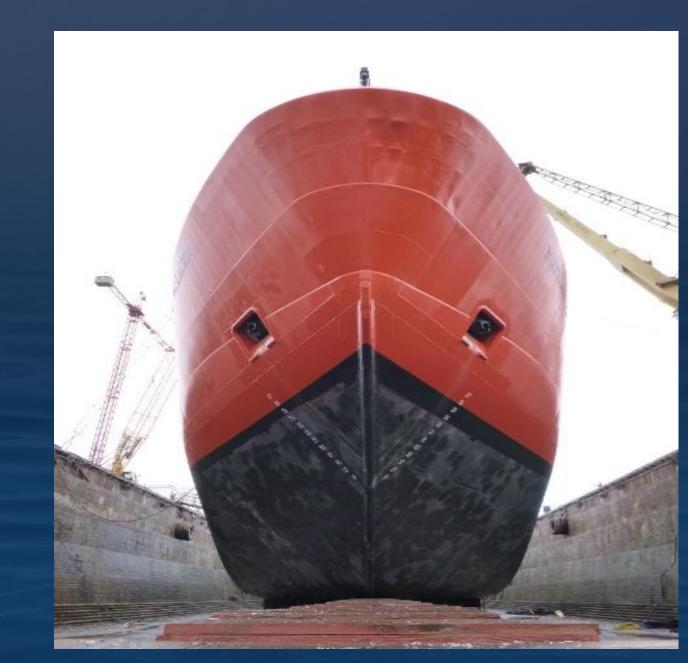
TX tilt = -3.00°, Pen. Filter Off





What's Next?

- RCRVs planning in progress
- Healy EM122 replacement
- Late-life cycle systems
 - EOL performance testing
 - o Ship purposes / regions?
- Best practice documentation
 - Ocean Best Practices
- What Went Wrong Wednesday



Thank you!

http://mac.unols.org

mac-help@unols.org





