Overview of MAC Resources & Update on Sea Acceptance Tests of Multibeam Systems on New Vessels

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Kevin Jerram (UNH/CCOM-JHC)
What is the MAC?

- Multibeam Advisory Committee
- A community-based effort with the goal of ensuring that high-quality multibeam data are consistently collected across the U.S. Academic Research Fleet
- Motivated by 2010 workshop at NSF focused on issues with MB performance
- Funded in 2011; Renewed in 2015
What was the problem?

- Research vessels are used for many different types of oceanographic work
- Multibeam systems are just one of many complex sensors on each ship
- “Tribal Knowledge” does not scale
- Efficiencies gained through coordination

Modified From: http://evillusionist.files.wordpress.com/2012/05/call-center-cartoon-149.jpg
Why Is It Important?

< 15% Global Ocean is Mapped

Opportunistic data is very important - *Every Ping Counts*!
Complementary Fleet-Wide Multibeam Efforts

Data Acquisition

Data Documentation & Preservation

Data Reduction & Synthesis

GOAL: Well-documented high-quality publicly available data
Multibeam Advisory Committee (MAC)

**QAT** - Ensure multibeam sonar systems are operated in a consistent manner that maximizes data accuracy, precision, and scientific utility (Ferrini, Jerram, & Johnson)

**SAT** - Ensure all hull-mounted multibeam systems are installed, calibrated, and configured properly and consistently (Johnson, Jerram)

**ANT** - Perform acoustic noise tests to assess and potentially improve sensor efficiency (coverage) and data quality (Gates)
MAC Goals

• Engage Community of Stakeholders
  • Operating Institutions, Technicians, Scientists, Funding Agencies
  • Industry – hardware/software
  • Specialists
• Share information within and beyond UNOLS (e.g. NOAA, OET, SOI, etc)
• Facilitate communication
• Develop consistent protocols & best practices
• Complement other fleet-wide efforts
• Educate the next generation
### MBES Across the Fleet

<table>
<thead>
<tr>
<th></th>
<th>Kongsberg EM122</th>
<th>Kongsberg EM302</th>
<th>Kongsberg EM710/EM712</th>
<th>Reson 7125</th>
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<tr>
<td><strong>Atlantis</strong></td>
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<td><strong>Kilo Moana</strong></td>
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<td><strong>Ride</strong></td>
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<td><strong>Sikuliaq</strong></td>
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<td><strong>Thompson</strong></td>
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<td><strong>Sharp</strong></td>
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MAC Ship Visits

- At the request of Operators
- Most useful interaction – “boots on the deck”
- Different team(s) deployed, depending upon needs of ship
  - SAT/QAT/ANT share common tools and techniques
- Standard protocols for assessing systems across fleet
- Report generated for each visit
  - Initially only for the operator
  - After review, publicly available on MAC website
Ship Visits – SAT/QAT

- System Review
  - Sensor locations/offsets
- Patch Test
- Accuracy Assessment
- Swath Performance Test
- Noise Testing
- Water Column & Backscatter
- MAC activities complement manufacturer testing & assessment
- SAT = baseline; QAT = check-up
System Review

- Review & Document Sensor Offsets
  - MBES TX/RX, GPS, MRU

Review Reference Frames

Table 2: Hypack configuration of sensor offsets after system geometry review and calibration during MBES2021. These values reflect the offsets in Table 2 corrected from the initial reference frame, which is based on magnetic reference from waterline and transducer downlook as positive. Due to new waterline measurements made during MBES2021, the previous waterline was adjusted to match the new survey. The vertical measurements should be made relative to the waterline value in Table 2 and the Hypack's vertical reference. This table shows the offset values for each sensor and their respective positions in the survey area.

<table>
<thead>
<tr>
<th>Drop Kick</th>
<th>Sensors in Hypack Frame</th>
<th>Origin at IMU</th>
<th>Azimuthal</th>
<th>Attributed</th>
<th>Vertical</th>
<th>Pitch</th>
<th>Roll</th>
<th>Year</th>
</tr>
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<tbody>
<tr>
<td>Reversed inside hull</td>
<td>7155 TK</td>
<td>-1,567</td>
<td>-0.125</td>
<td>-1,300</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
<td></td>
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<tr>
<td>Flush with hull</td>
<td>7155 TK</td>
<td>-1,567</td>
<td>-0.125</td>
<td>-1,300</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Extended below hull</td>
<td>7155 TK</td>
<td>-1,567</td>
<td>-0.125</td>
<td>-1,300</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

POS-MV IMU
-0.00 | -0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

POS-AV IMU - Primary | -1,567 | -0.125 | -1,300 | 0.00 | 1.00 | 1.00 |

Waterline | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
Patch Test

• Residual angular offsets between motion sensor and sonar arrays (pitch, heading, and roll)
• Timing issues (latency)
• Recommended when:
  – system is new
  – ancillary systems are moved (e.g. MRU, GPS)
  – multibeam data is a primary cruise objective
• Can be conducted remotely
Remote Patch Test

- **Protocol**
  - MAC selects site & develops survey plan
  - Ship runs survey plan
  - Python script minimizes data file size
  - Data transmitted to shore
  - MAC evaluates & advises

- **2014**
  - Marcus G. Langseth

- **2016**
  - Marcus G. Langseth
  - Atlantis

[Map and survey plan images]
Accuracy Assessment

- After system assessment
- Small survey with cross-line
- Analysis
  - Exclude grid nodes with:
    - Few pings
    - Slopes > 5°
  - Compute depth bias
  - Compute depth standard deviation
- Reference Surface grids are publicly available
Swath Performance Test

- Quantify swath width at a range of depths
- System health
- Important for survey planning
Basic Noise Testing

- Built-In Self Test (BIST)
- Platform noise environment
  - Active and passive RX noise measurements
  - Variety of speeds
  - Variety of headings relative to the prevailing swell
- Impedance measurements
  - Baseline & monitoring early warning signs for transducer degradation
- Routine BISTs encouraged
Acoustic Noise Team (ANT)

- Detailed assessment of ship acoustic characteristics
- Identify sources of noise
  - Ship noise
  - Cavitation
  - Bubble sweep-down
  - Machinery
  - Acoustic interference
- Recommend strategies to minimize noise

Images from Tim Gates
MAC SAT Visits

- **R/V Sikuliaq** – EM302 & EM710 [2014]
- **R/V Sally Ride** - EM122 & EM712 [2016]
August 2014

Plan:
- EM302 & EM710 SAT
  - System Review
  - Patch Test
  - Accuracy Assessment
  - Swath Performance Test
  - Preliminary Noise
  - Backscatter & Water Column Review

Reality:
- Challenging sea state and ocean conditions at times
- Successful calibration and testing
R/V Sikuliaq - 2016

- Antenna relocation and resurvey in San Diego
- EM710 / EM302 calibration during coring trials
**R/V Neil Armstrong**

- **February 2016**
- **Plan:**
  - EM122 & EM710 SAT
    - System Review
    - Patch Test
    - Accuracy Assessment
    - Swath Performance Test
    - Preliminary Noise
- **Reality:**
  - Challenging sea state and ocean conditions
  - Successful calibration and testing
R/V Sally Ride - SAT

• July 2016
• Plan:
  • EM122 & EM712 SAT
    • System Review
    • Patch Test
    • Accuracy Assessment
    • Swath Performance Test
    • Preliminary Noise
• Reality:
  • Challenging sea state at times
  • Successful calibration and testing
EM122 Swath Analysis Comparison

Neil Armstrong

Tested to > 5km depth

Sally Ride

Tested to < 3km depth

Both achieved > 5X water depth in water < 2 km
Open Access Resources & Reports

- Technical Reports
- Technical Resources
- Help Desk

The Early Days of the MAC

http://mac.unols.org
Technical Reports

- UNOLS ship visits
  - ANT, QAT, & SAT Reports
  - Reports from pre-MAC visits
- NOAA ship visits
- Other ship visits
  - R/V Falkor & EV Nautilus
- Not supported under NSF Grant
- Allows for development of new tools & techniques to be contributed back to MAC
- Broadens our understanding of MBES
MAC Technical Resources

- Software Tools
  - SVP Editor (new version in 2016)
  - Extinction Tool (VM - 2016)
  - Accuracy Assessment (VM - 2016)
  - Mapping Tools (VM - 2016)
  - BIST Plotting (VM - 2016)
  - BIST Database (2016)
- Cookbooks
  - Using SIS, Caris, etc…
  - More Coming…
- Documentation
  - GEBCO, NOAA, etc…
Cookbooks

• Coming Soon...
  – Patch Test (Caris & Qimera)
  – Site Selection
  – Updated SIS

Water Column Optimization

- To ascertain the depth to find water column targets, it is inconvenient if the reference frame in the image changes from ping to ping. Fixing the image scale may be of particular importance for operations where the water column display imagery is used to help coordinate other operations such as CTD or ROV.

- Fixing the image scale can be done through the “Show/Hide” interface which is accessed via the top left button in the water column imagery display. The “Depth Start Range Mode” and “Depth Stop Range Mode” should be set to fixed with reasonable scale values entered (e.g., image should stretch vertically from X meters to Y meters). The same is done for the “Across Start Range Mode” and “Across Stop Range Mode.” The number of grid lines are then set for both the X and Y Axes. This particular procedure is non-intuitive and some experimentation will be required to get a particular combination of Start/Stop range and number of grid lines to give reasonable (and usable) scales on the image. A more intuitive procedure would be to set the grid interval, however, this is not currently possible in SIS.

Caris Vessel Creation

- thin Caris HIPS and SIP, start the Vessel Editor by selecting: Edit > Vessel Editor
  Or Edit > Vessel Configuration

- The sonar is now pinging. Verify that all supporting sensors are reporting.
  - Position
  - Surface sound speed
  - Orientation

- The sonar may not necessarily be able to track the bottom yet. We will take care of that later in this procedure.

Lamont-Doherty Earth Observatory
Columbia University | Earth Institute
QAT – Shore-based Activities

• Develop Best Practice Documentation
• Remote Patch Tests
• Help Desk
• Troubleshooting
• Assist Scientists
  – survey planning
  – data processing

mac-help@unols.org
QAT – Coordinate with Fleet-wide MB Data Quality Efforts

• Code share & review
  – Extinction plots integrated into GMRT workflow & reports

• Assessment of R2R MB QA
  – Compare with GMRT reports
Next Steps...

• Ongoing MAC Technical Team activities
• Poster at 2016 AGU
• BIST Database [under development]
• Encyclopedia of lessons learned
  – Problems
  – Diagnostics
• UNOLS-wide coordination related to potential acoustic interference