Potential Fields Pool Equipment (PFPE) Focus Group

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Outline

- Review status and discuss future actions for:
  - Spares pool
  - Gyros
  - System Monitoring
  - Technical Support
  - Training
  - Data logging and quality control
    - Standardized data logging
  - Best Practices

Feedback from the gravimeter operators is crucial
PFPE – Present Status

• 6 gravimeters presently permanently installed in the fleet
• Thompson will be receive a permanent gravimeter in 2011
• 2 pool gravimeters for use on ships of opportunity
  – Contact PFPE for information and scheduling
• Tuesday morning - Talk about the background and goals of PFPE (“the big picture”)

PuPtH–HPresentHStatus

• eHgravimetersHpresentlyHpermanentlyHinstalledHinHtheHfleet
• ThompsonHwillHbeHreceiveHaHpermanentHgravimeterHinHaY’’
• aHpoolHgravimetersHforHuseHonHshipsHofHopportunity
  – Contact HPuPtHforHinformationHandHscheduling
• TuesdayHmorningHUHTalkHaboutHtheHbackgroundHandHgoalsHofHPuPtHP“theHbigHpicture””)
Spare Parts

• Status
  – Have been pooling spares for almost 18 months.
  – Last fall, we acquired all remaining BGM-3 spares from Lockheed Martin
  – All of the vessels have at least one complete set of spares.
  – Additional parts are stored at WHOI for shipment to vessels when required.

• Future Actions:
  – Obtain access to NGA’s pool of spares; in progress
  – Develop the ability to troubleshoot and repair failed boards
  – Develop and build replacement digital panel meters (DPMs)
Gyros

• Status:
  – In 2009, 9 gyros were sent back to US Dynamics (USD) for refurbishment.
  – 3 of those gyros failed within 3 months and were returned to USD
    • Sensors underwent a “severe impact”
      – USD claims the sensors were mishandled in shipping.
      – These sensors originally came from USD wired backwards
    • USD is repairing these gyros at no cost

• Future Actions:
  – There are additional gyros in the fleet that will need to be recalled for repair. First we need gyros to replace the recalled ones
  – NSF has provided funds for an additional 6 gyros to be refurbished. These gyros are presently at USD.
System Monitoring

• Status
  – Informing scientists that they are responsible for checking the gravimeter on an hourly basis during gravity surveys.
  – Earlier this year, we began a system of logging gravimeter test point values on a weekly basis.
    • Having this history available to technicians on the ship and on shore is valuable when a sensor fails
      – e.g., failures on the Langseth and Knorr this summer
    • The present method, a Google spreadsheet, is a “stop-gap” method.

• Future Actions:
  – Need to explore a more permanent option for getting values to shore
    • Open to suggestions on better ways to do this.
Technical Support

• Status
  – Kinsey and Herr provide support by email and phone at any time.
  – Email has been the most common method for passing information.
    • Email threads have gotten long and confusing at times.
    • Not archived

• Future Actions:
  – Better methods for sharing information
    • Community email thread?
    • Wiki that contains incident history for future reference
Training/Education

• Status
  – As necessary training occurring during sensor installs and service visits

• Future Actions
  – Formalize training during annual service visits
  – Have each operator designate a technician responsible for taking the lead on gravimeter issues
    • Provides a resource within the institution
    • Could serve as the at-sea tech on cruises where gravity is a crucial part of the science program
Gravity Ties

• Status
  – Ties are occurring on an as needed basis.
  – Some gravimeters go more than a year without a tie
  – Posting a comprehensive gravity station database is not possible
    • Both Randy and James can provide station information for specific ports
  – Are providing land meters on an as needed basis

• Future Actions
  – PFPE is working to obtain land meters for all ships.
  – Need to increase the frequency of gravity ties to make the data valuable to R2R
    • Attempting to provide a compilation of gravity ties for all UNOLS homeports
    • Looking at ways to coordinate with ships getting the gravity ties done
Data Logging

• **Status**
  – Institutions each have their own way of logging data
  – Scientists have expressed frustration at:
    • Having to merge data from multiple data files (i.e., gravimetry, GPS, bathymetry) to process gravity data
    • The varying data formats between the vessels
    • Having GPS or water depth sensor failures result in incomplete data sets
  – Pool gravimeters are being deployed on vessels that have minimal data logging capabilities

• **Future Work**
  – Develop a standard data logging program and format for all UNOLS gravimeters
    • Needs to be compatible with existing ship servers
    • Data needs to be compatible with R2R
Data Quality Control

• Status
  – Often gravimeter data is not looked at until weeks or months after it has been obtained
    • There have been incidents where data was flawed
  – Presently we have to reduce the gravity data manually to ensure quality data.
    • Happens rarely; usually only by an interested scientists

• Future Action:
  – Develop an automated program that loads the previous day’s data, reduces it and makes a plot for data quality control with comparisons to bathymetry or satellite gravimetry
    • Not a substitute for data post-processing!
To address data logging and quality control issues, PFPE has started developing a gravity logging program:

- Receives gravimeter, GPS, ship gyro, water depth sensor data over serial ports or the network.
- When one data stream goes offline, a secondary data stream is automatically used – ensures continuous data.
- Can be run in parallel with existing data logging systems.
- Logs all data in a single data stream. Data is logged and can also be broadcast on the network.
- Could also run a daily quality control data reduction and generate a GMT plot.
- Would include necessary functionality for gravity ties.
Data Logging - Status

• Status
  – Prototype developed and used on 2 science cruises this year
    • Melville Cruise to the Galapagos Spreading Center
    • Summer 2010 Louis S St Laurent expedition to the Arctic.
  – Positive feedback from science; especially the merged gravity, navigation, and water depth data format
Data Logging – Future Action

• Continue code development for the pool gravimeters.

• Next steps include:
  – Input from operators and scientists is crucial
    • Discussions with scientists at AGU
  – Review how institutions have done logging in the past. Where good work exists, merge it into the new code
  – Implement side-by-side with existing logging programs
    • Can be run on a netbook with serial or network data feeds
  – Add a preliminary real-time reduction and data display
  – Work with R2R and other researchers developing post-processing code to ensure compatibility
Best Practices

• Status
  – We have begun documenting gravimeter procedures for the pool gravimeters.
  – Contents include:
    • Daily and weekly maintenance
    • Procedures for gravity ties
    • Survey guidelines
    • Troubleshooting

• Future Action
  – Input from both technicians and scientists on contents
Discussion

- Spares Pool
- Technical Support
- System Monitoring
- Training
- Gravity Ties
- Data logging and quality control
  - Standardized logging and data format
- Best Practices

Contact Info:
  James Kinsey: jkinsey@whoi.edu
Importance of Marine Gravimetry

• Improves scientific understanding of a variety of earth science problems
  - mid-ocean ridge and plume-ridge structure, the margins, and the polar regions.
• Compared to satellites, marine gravimetry provides superior resolution, both in terms of minimum detectable spatial wavelength and the resolved gravity measurement
• Detailed studies of individual features continue to require shipboard gravity data
Existing Infrastructure

• Prior to 2007, only 3 gravimeters were permanently installed on UNOLS vessels
  – BGM-3 gravimeters on the Ewing/Langseth and the Melville
  – A LaCoste and Rohmberg on the Kilo Moana

• An agreement with NavO provided access to their gravimeters.

• NavO terminated their gravimeter program in 2007 forcing UNOLS to find an alternate source.
2007 Fugro Acquisition - Background

- In 2007, Fugro offered to sell used BGM-3 gravimeters and spare parts to the UNOLS community.
- WHOI, SIO, and UAF successfully submitted a proposal to acquire this equipment (NSF-OCE-0705964).
- This equipment was refurbished and delivered to UNOLS by Randy Herr.

Acquired equipment included:

- 7 working gravimeters
- 4 gyros
- 8 horizontal accelerometers
- Over 20 power supplies
- Over 20 boards

BGM-3 testing in Randy Herr’s “Lab”
### 2007 Fugro Acquisition - Results

<table>
<thead>
<tr>
<th>Gravimeter</th>
<th>Purchaser</th>
<th>In Service Date</th>
<th>Host Vessel (Operator)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S210⁺</td>
<td>NSF</td>
<td>2011</td>
<td>R/V Thompson (UWash)</td>
</tr>
<tr>
<td>S213</td>
<td>LDEO</td>
<td>1984</td>
<td>R/V Marcus Langseth (LDEO)</td>
</tr>
<tr>
<td>S218</td>
<td>NSF</td>
<td>2007</td>
<td>R/V Revelle (SIO)</td>
</tr>
<tr>
<td>S219</td>
<td>NSF</td>
<td>2007</td>
<td>R/V Knorr (WHOI)</td>
</tr>
<tr>
<td>S220⁺</td>
<td>NSF</td>
<td>2007</td>
<td>WHOI (WHOI)</td>
</tr>
<tr>
<td>S221</td>
<td>NSF</td>
<td>2007</td>
<td>USCGS Healy (UAF)</td>
</tr>
<tr>
<td>S222⁺</td>
<td>NSF</td>
<td>2007</td>
<td>USCGS Healy (UAF)</td>
</tr>
<tr>
<td>S223⁺</td>
<td>NSF</td>
<td>2007</td>
<td>CCGS Louis S. St. Laurent (WHOI)</td>
</tr>
<tr>
<td>S224</td>
<td>SIO</td>
<td></td>
<td>R/V Melville (SIO)</td>
</tr>
</tbody>
</table>

† Scheduled to be installed in Spring 2011  
‡ Pool gravimeter.  
* Scheduled to be transferred to the Arctic Regional Research Vessel (ARRV) in 2014.

Healy (left), Revelle (center), and Knorr (right) Installations. Image Credit: R. Herr
Pool Gravimeters

• In addition to providing permanent gravimeters to 5 vessels, there are 2 pool gravimeters.
• Since 2007, these pool gravimeters have been used in the Red Sea, Guaymas Basin, Galapagos Spreading Center, and the Arctic.
• Maintained at WHOI

Pool Gravimeters

- Information on the pool gravimeters is located on the MISO website (Google ‘PFPE WHOI’)
PFPE – Motivation

• The acquisition of these gravimeters resolved the problem of *providing* gravimeters to the UNOLS fleet.
• It did not provide for the *long-term financial and technical support of this instrumentation*.
• In 2009, Fornari and Kinsey discussed with LDEO, SIO, UAF, and WHOI the possibility of forming a gravimeter pool to share equipment and technical expertise.
• All of the operating institutions supported this initiative.
• In June 2009, the Potential Fields Pool Equipment facility was formed.
• An NSF award (NSF-OCE-0943618) for $239k was awarded in Summer 2009 to provide equipment for PFPE
PFPE – Goals

- PFPE provides the UNOLS community with:
  - A supply of spares for maintaining the at-sea BGM-3s
    - Repairs or refurbishes sensors as necessary
  - Technical Support including on-shore support for the at-sea gravimeters
  - Two pool gravimeters for use of ships of opportunity or as complete emergency spares for the at-sea systems.

- PFPE does NOT post-process or archive marine gravity data
  - Such efforts are better suited toward other researchers or community initiatives.
PFPE – Resources

• A SeaSPY towed marine magnetometer available for community use
• An extensive set of gravimeter spares
  – Includes over $55k in spares bought from Lockheed-Martin in 2009

SeaSPY Towed Magnetometer
PFPE – Technical Support

• 24/7 on-shore technical support from Kinsey and Herr

• On-site visits for maintenance, cruise preparation, and emergency repair. Recent examples include:
  – February 2010 service visit to the Melville in Valparaiso, Chile and subsequent equipment shipments.
  – April 2010 emergency shipment and installation on the Marcus Langseth in Portland, OR.

Left, emergency gravimeter shipment to the Langseth; Right, Melville in Valparaiso, Chile in February 2010.
Recently Marine Gravity Cruises

- Over the past 3 years, a number of cruises have used the equipment and technical support provided by the Fugro acquisition and PFPE.

<table>
<thead>
<tr>
<th>Vessel (Gravimeter)</th>
<th>Site</th>
<th>PI</th>
</tr>
</thead>
<tbody>
<tr>
<td>R/V Oceanus (S223)</td>
<td>Red Sea</td>
<td>Bower (WHOI)</td>
</tr>
<tr>
<td>R/V Atlantis (S223)</td>
<td>Guaymas Basin</td>
<td>Lizarralde &amp; Soule (WHOI)</td>
</tr>
<tr>
<td>R/V Atlantis (S223)</td>
<td>Galapagos Spreading Center</td>
<td>Sinton (UHawaii) &amp; Behn (WHOI)</td>
</tr>
<tr>
<td>R/V Melville (S224)</td>
<td>Northern Galapagos Region</td>
<td>Harpp (Colgate)</td>
</tr>
<tr>
<td>R/V Revelle (S218)</td>
<td>Chatham Rise</td>
<td>Collins (WHOI)</td>
</tr>
<tr>
<td>L.S. St. Laurent (S223)</td>
<td>Arctic</td>
<td>Childs &amp; Hutchinson (USGS)</td>
</tr>
<tr>
<td>USCGS Healy (S221)</td>
<td>Arctic</td>
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![Graph showing Free Air Anomaly (mGal) over time (days)]
PFPE – Present Status

• Working with the gyroscope manufacturer to fix refurbished gyros that failed soon after install
  – Likely cause was improper wiring at time of refurbishment
  – PFPE will be recalling some gyros early next year so they can be serviced by USD.

• Monitoring the LDEO gravimeter at WHOI and plan to return the unit to the Langseth in 2011.

• Scheduled install on the Tommy Thompson in April 2011.
  – PFPE will provide towed magnetometer and gravimeter technical support for the Tomaniga-Tivey cruise in Fall 2011.
PFPE – Future Work

• Continue existing support services
• Work with the ship technicians to ensure gravimeters are calibrated and serviced as necessary
• In collaboration with the technicians and scientists:
  – Establish and document best practices
  – Work toward standardizing data formats and establishing at sea data quality control
• Coordinate these efforts with technicians, R2R, and researchers interested in developing tools for processing marine gravity
Data Quality Control

• Presently we have to reduce the gravity data manually to ensure quality data.

• Could easily expand this logging program to include a replay mode that:
  – loads in a data file
  – does a simple reduction
  – makes a GMT plot comparing the data to bathymetry and/or satellite data

• Easy to set this up as a cronjob for daily automated execution.

• Not a substitute for data post-processing!