Potential Fields Pool Equipment (PFPE) Focus Group

James Kinsey – jkinsey@whoi.edu

Randy Herr – Randyherr@aol.com

Dan Fornari – dfornari@whoi.edu

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")

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:
  - Include procedures in the Best Practices Manual
  - 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**!

Data Logging – Prototype Program

- 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 acclerometers

- Over 20 power supplies

- Over 20 boards

BGM-3 testing in Randy Herr's "Lab"

2007 Fugro Acquisition - Results

Gravimeter	Purchaser	In Service Date	Host Vessel (Operator)
S210[†]	NSF	2011	*R/V Thompson* (UWash)
S213	LDEO	1984	*R/V Marcus Langseth* (LDEO)
S218	NSF	2007	*R/V Revelle* (SIO)
S219	NSF	2007	*R/V Knorr* (WHOI)
S220[‡]	NSF	2007	WHOI (WHOI)
S221	NSF	2007	*USCGS Healy* (UAF)
S222[*]	NSF	2007	*USCGS Healy* (UAF)
S223[‡]	NSF	2007	*CCGS Louis S. St. Laurent* (WHOI)
S224	SIO		*R/V Melville* (SIO)

† 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

Left, 2008 Oceanus install for the Red Sea cruise. Right, 2010 install on the CCGS Louis S. St Laurent for Law of the Sea work in the Arctic.

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.
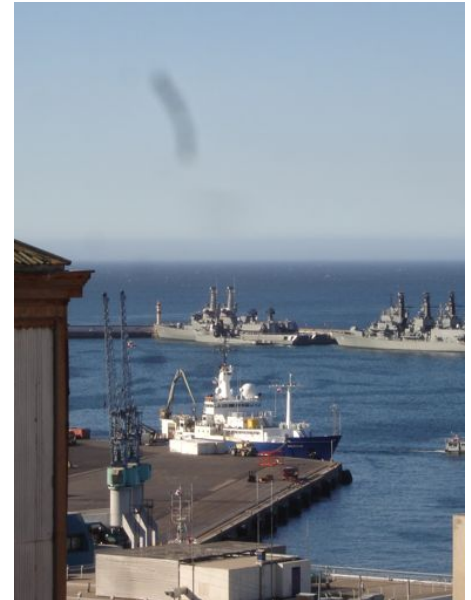
Recently Marine Gravity Cruises

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

Vessel (Gravimeter)	Site	PI
R/V Oceanus (S223)	Red Sea	Bower (WHOI)
R/V Atlantis (S223)	Guaymas Basin	Lizarralde & Soule (WHOI)
R/V Atlantis (S223)	Galapagos Spreading Center	Sinton (UHawaii) & Behn (WHOI)
R/V Melville (S224)	Northern Galapagos Region	Harpp (Colgate)
R/V Revelle (S218)	Chatham Rise	Collins (WHOI)
L.S. St. Laurent (S223)	Arctic	Childs & Hutchinson (USGS)
USCGS Healy (S221)	Arctic	Childs & Hutchinson (USGS)
USCGS Healy (S222)	Arctic	Childs & Hutchinson (USGS)
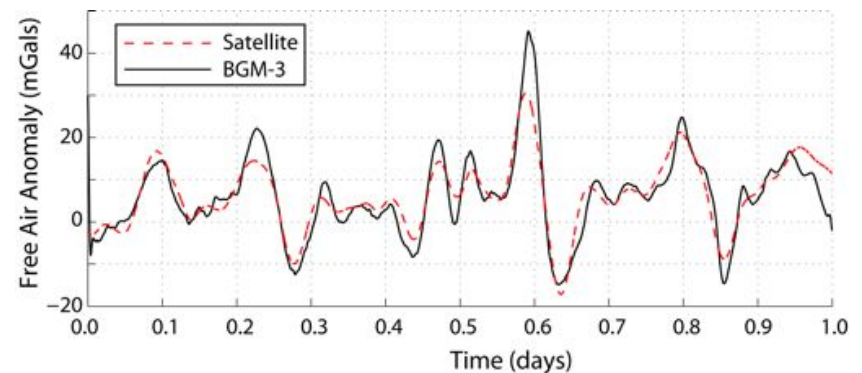
PFPE – Present Status

- 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**!