An Integrated Software Package for Monitoring BGM-3 Gravimeters

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An NSF funded effort is currently underway at PFPE to develop a next generation gravity software that builds upon and expands the PFPE *gravlog* software, a gravity logging program reliably used on some of the UNOLS BGM-3 gravimeters over the past 2 years. This software aims to provide the UNOLS fleet with a user-friendly and semi-automated tool for monitoring the BGM-3 and performing essential instrument tests such as ship-to-shore gravity ties and in-port tests (zero damp and tilt test). The program would generate consolidated meta-data (e.g., bias) for use in post-processing and to provide to the Rolling Deck to Repository (R2R effort). This software will help provide a UNOLS-wide tool for doing these procedures and help establish "best practices". This program would replace the "test_log" program developed at LDEO in the 1990s and used by PFPE, Randy Herr, and others over the past 20 years.

Achieving the above stated primary goal requires implementing filters for reducing the gravity data and a graphical display for showing the reduced gravity measurements in real-time. Having implemented these capabilities, it is easy to extend this code to provide an almost real-time (delayed by half the length of the Gaussian Filter) display of the free-water anomaly and allow comparisons to ship's bathymetry. Such a program would allow both technicians and scientists to easily monitor the gravimeter status and data.

This effort **does not** seek to *(1)* replace gravimeter data loggers already used on ships; or *(2)* provide reduced data for scientific use; or (3) provide quality assurance of the exhaustive data.

Code Architecture

To achieve these goals, two programs have been developed: gravlog and gravG.

Gravlog

Gravlog is a C/C++ program that provides low level data management and filtering functions and executes most of the math. It runs as a daemon (i.e., in the background) on a computer directly connected to the gravimeter's data buffer via a serial connection. Filter parameters can be changed by the user in the GUI program described below and the changes made without rebuffering the data.

Gravlog was originally developed in May 2010 for use on PFPE pool gravimeters and has been used on four deployments to date. The most recent upgrades were completed in February 2012 and its functionality validated against the test_log software during the recent BGM-3 deployment on the R/V Kilo Moana. When ran with the same filter type and length, the reduced gravity computed by gravlog and test_log agreed to within 0.01mGal, the accuracy of test_log.

Additional work for doing real-time, underway reduction is on-going and includes:
- real time Eotvos and latitude corrections
- real time filtering of reduced gravity (using a Gaussian filter), ship speed, ship heading, and depth under keel.

GravG

GravG is a graphical user interface (GUI) client which displays real time data and gravimeter health status, supports common instrument tests (e.g., ship-to-shore ties and in-port tests), and allows the user to interface with gravlog.   The program is coded in Qt, can run in Linux, Windows, or Mac, and is connected to Gravlog via network UDP. This program does not necessarily have to be installed in the gravimeter room and can therefore be displayed on a computer elsewhere on the ship. Functionality includes:

- real time visual indications of gravimeter health and gravity data quality
- semi-automated dockside gravity tie interface
- semi-automated in-port tests (zero damp and tilt)
- quality assurance of test-generated metadata (bias, etc...)
- automatic report generation

Figure 1 shows a picture of the GUI during a gravity tie on the R/V Kilo Moana in March 2012. During the Kilo Moana install, gravlog/gravG were used to monitor gravimeter performance and perform the ship-to-shore gravity tie. The semi-automated gravity tie agreed with the traditional method to within 0.01 mGal.

The core of the code is complete and the following tasks are scheduled for this spring:
- Further validation of the core during the R/V Knorr port period at WHOI at the end of March / beginning of April.
- Automatic reload by the server side of the new bias computed after the gravity tie is performed.
- Automatic report generation
- Zero damp and tilt test interface
- General cleaning and organization of the GUI layout (e.g., user-selectable axis scales for the GUI).

Hardware Requirements

The hardware for gravlog requires a Linux-compatible computer. To date, we have run it on laptops running Ubuntu and on a rackmount server with a rackmount console (LCD screen, keyboard and trackpad) although a wall mounted monitor could also be used. The GUI can also be run on the same computer or on another computer elsewhere on the ship. The GUI can be run on a Windows, Linux, or Macintosh computer.
The system requires interfacing to the ship GPS, echosounder and gyroscope data feeds. Both serial and network UDP are supported.

Future Plans

Having completed this initial development, we plan to deploy the code on 2-3 UNOLS vessels this spring for testing and to solicit feedback from ship technicians prior to another round of code modifications this summer. We plan to present this effort at the 2012 UNOLS RVTEC meeting and then start implementing on all UNOLS gravimeters in 2013.

GravGui

RGS FGS GPS DNV DEP HDG LINK

Data and gravimeter status lights

Gravity tie interface

Lock/Unlock

Gaussian

Samples

181

Set

Used samples

181

Port mode

Sea mode

Filter settings

Calibration tools

■ Depth ■ Gravity

1,000

800

600

Depth [m]

400

200

0

18:05:39   18:05:59   18:06:19   18:06:39   18:06:59

980,614

980,614

980,614

980,614

Gravity [mgal]

980,614

980,614

980,614

980,614

■ Heading ■ Speed

1,000

800

600

Heading [deg]

400

200

0

16:22:19   16:25:39   16:28:59   16:32:19   16:35:39   16:38:59

1,000

800

600

Speed [knots]

400

200

0

Gravity tie   In-port test

Real time plots

Raw counts
25060.00
Filt counts
25059.61
Raw gravity
980615.83
Reduced gravity
980613.84
Latitude

Longitude

Depth

Heading

DNV status
NO_DNV_ERROR
Sensor
S219
Scale factor
5.073231097
Bias
853480.6601

Raw sensor data

GravGui

Ship:
Personnel:
Port/Pier/Berth:
Gravity station number:
Station name:
mGal at pier: 980624.2
Start recording   COMPLETE!
Plot

25,059.7
25,059.6
25,059.6
25,059.6
25,059.6
25,059.6
25,059.6
25,059.6

0 500 1,000 1,500 2,000 2,500 3,000 3,500 4,000

Water height to pier 1: -14.58
Water height to pier 2: -14.58
Water height to pier 3: -14.58
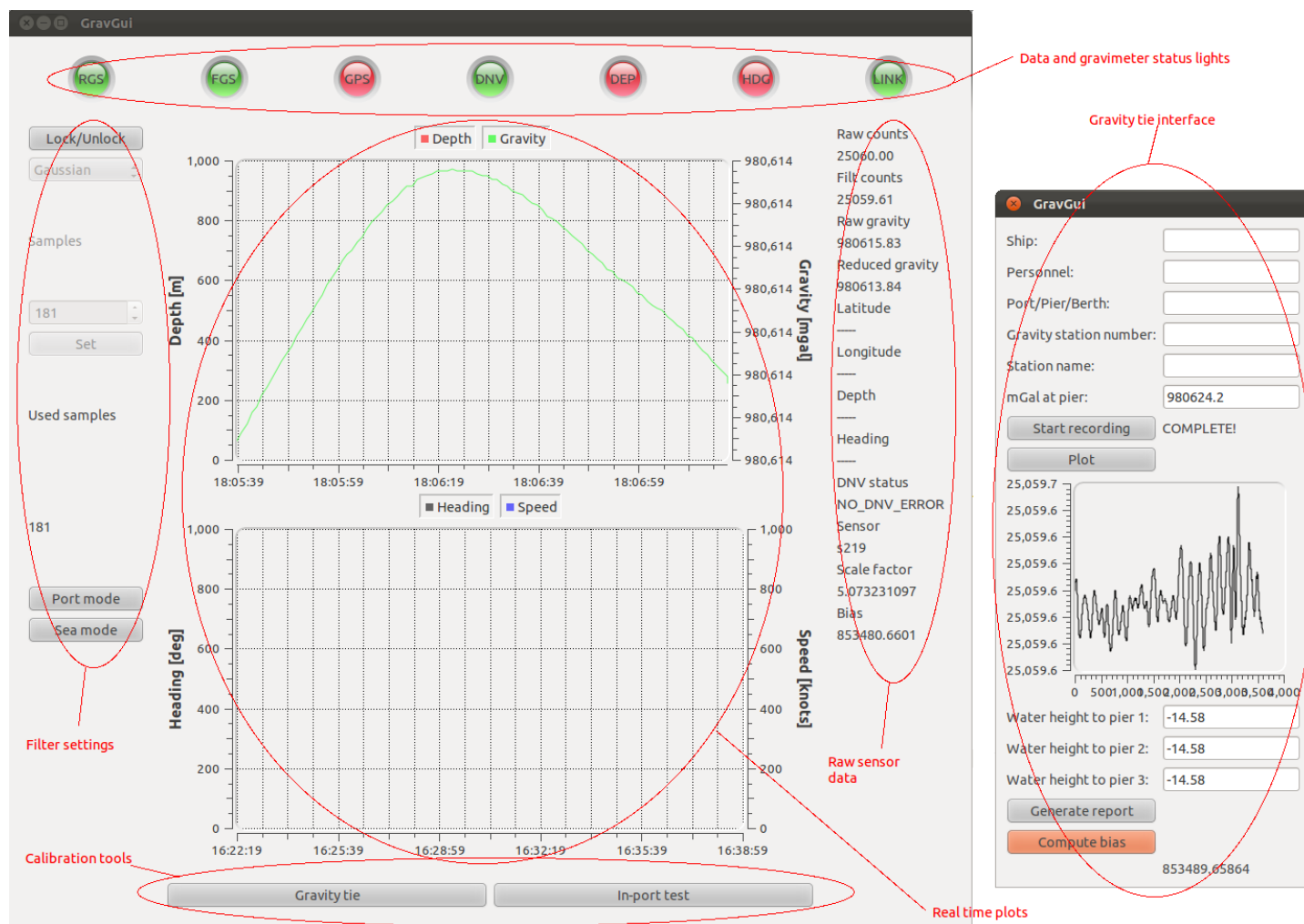Generate report
Compute bias
853489.65864

Figure 1: GravG status during a gravity tie on R/V Kilo Moana in March 2012. Key components of the GUI are identified.