Lamont-Doherty Earth Observatory of Columbia University

EW9801 DATA REDUCTION CRUISE SUMMARY

January 26, 1998 - February 12, 1998

Chief Scientist: Greg Moore (University of Hawaii)

Co-Chief Scientist: Julia Morgan (University of Hawaii)

Science Officer: Chris Leidhold, *cpl@ldeo.columbia.edu*
Lamont-Doherty of Columbia University

Science Party

Andreas Aichinger	Misumi Aoki	Stephan Bergbauer
Christian Berndt	Jackie Caplan-Auerbach	Denise Hills
Kazuhiko Kashiwase	Barrie Taylor	Zhiyong Zhao

Science Crew *LDEO*:

Chris Leidhold	Science Officer (*cpl@ldgo.columbia.edu*)
Matthew Cheslik	Pneumatics
John DiBernardo	Pneumatics Officer
Chuck Donaldson	Electronic Tech
Ropate Maiwiriwiri	Core Bosun
Mike Wittrick	Pneumatics
Gregory Vsevolozhsky	Data Reduction (*gregv@ldgo.columbia.edu*)

R/V Ewing Crew

Ian Young	Master
	Chief Engineer

Project Summary

A seismic reflection study of the south flank of Kilauea volcano, Hawaii, is conducted to constrain the kinematics and mechanics of landsliding along the slpes of young submarine volcanoes. The south flank of Kilauea is moving seaward at rates of 6-10 cm per year. Existing models for Kilauea assume that the south flank is sliding along a detachement surface near the top of the Cretateous oceanic crust upon which the volcano was built. Our study is desi gned to image this detachement surface and ancillary deformation structures within the mobile flank of Kilauea. Our data acquisition program employed R/V Ewing 's 8400 cu in array of 20 air guns as a source; reflections received by 160-channel streamer. In order to better understand landsliding process, Hydrosweep bathemetry data, over the older Nuuanu land-slide northeast of Oahu was, collected.

Navigation Processing

The following pages describe the GPS and shot processing pipeline used to create all the navigation based files: shot, hydrosweep centerbeam, magnetic, gravity, as well as the MCS navigation data.

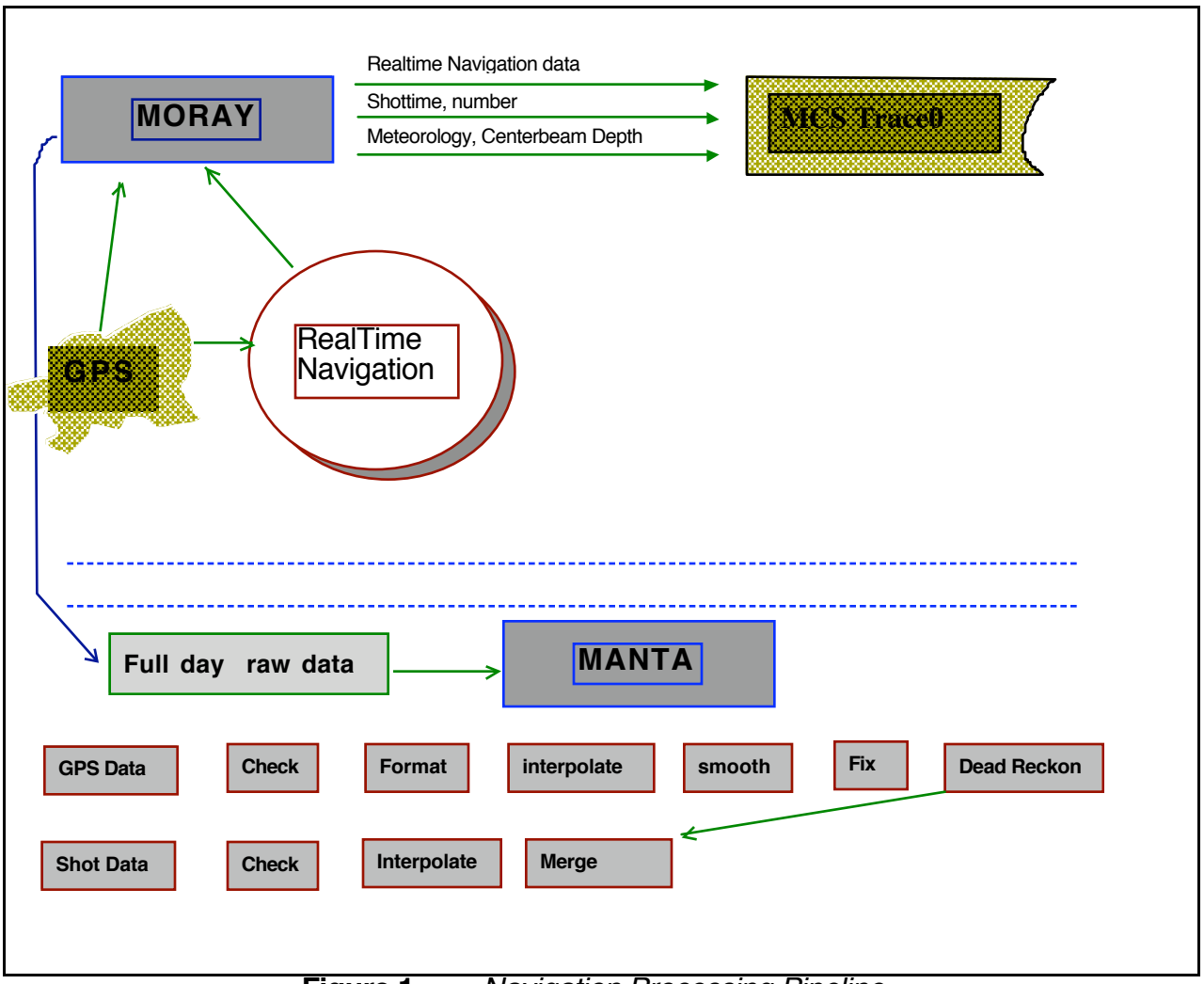

Figure 1. *Navigation Processing Pipeline*

Navigation Pipeline [refer to figure 1]

1. Logger
   Moray is the main logging system and is responsible for logging all the real-time data as well as controlling the intervals in which it is logged. This is also the system which controls the firing of the guns. In order to determine the time to fire, as well as the precise location the guns were fired, it relies on the *Real-time Navigation Process.*

2. Real-time Navigation Process
   This process uses the navigation from the selected GPS to provide a means of removing some of the randomness of the selective availability GPS by determining our current speed based on two points taken *filter_length* minutes apart. If available, the same information for the tailbuoy is reported. Simultaneously, the meteorological information and centerbeam data is collected. The output from this process (for both ship and tailbuoy) is:

   - The last lat/lon position (directly from the GPS) and the time (in seconds) of the last fix
   - ship speed in the east direction, ship speed in the west direction
   - Furuno speed and heading
   - Meteorological data

3. Using this data, ***MORAY*** determines the shot position based on the shot time and the time of the last GPS position fix. All this data is then passed on to the MCS system for Trace Zero data.

4. For non-real-time processing, raw gps data is transferred to Manta and processed. Navigation data is processed, then merged with all location specific information: hydrosweep center beam, shot-time, magnetic, and gravity. However, not all data is accumulated on every cruise.

5. GPS Processing

   - Check Data for mutant records and inconsistent times
   - Format the data into a standard format

     NMEA: Time Lat/Longps string

     Magnavox: Time PMVXG proprietary NMEA string

   - Interpolate the data where GPS coverage has been lost for any amount of time 3 minutes or less. In the case where differential coverage is in effect, throw away all values that are not differentially corrected before interpolation. Average the fixes into 30 second intervals:

     97+297:00:08:00.000 N 10 19.2790 W 104 25.4930

     97+297:00:08:30.000 N 10 19.4500 W 104 25.4380

   - Smooth the values with a 9 point running average algorithm. Output remains fixed at 30 second intervals
   - Fix the values to 1 minute intervals
   - Perform dead reckoning based on the furuno for any gaps in the data. At this point, if there are any gaps, they will be gaps greater than 3 minutes.

     97+295:03:49:00.000 N 8 59.9698 W 104 9.7289 gp2 56.0 0.1

     97+295:03:50:00.000 N 8 59.9459 W 104 9.7394 dr 1.8 0.3

   - Decimate the data to 20 minute fixes, then re-fix at 1 minute intervals using dead reckoning. This is done to smooth out the peaks due to selective availability. This is the final navigation.

6. Shot Data

   - Check the raw navblock file for mutant records and inconsistent times.
   - Interpolate between any missing shots using a simple interpolation algorithm, not correcting for latitude. Interpolated shots are marked with a "-" in the time header field.
   - Merge the shot times with the final navigation prepared in the *Step 5*. The distance traveled between the two fixes is determined, allowing us to calculate the point where the shot was fired based on the time:

     ```
     lat = final_nav[i].lat + (final_nav[i+1].lat - final_nav[i].lat) * (navblock_sec / (final_nav[i+1].tot_secs - final_nav[i].tot_secs));

     lon = final_nav[i].lon + (final_nav[i+1].lon - final_nav[i].lon) * (navblock_sec / (final_nav[i+1].tot_secs -
     final_nav[i].tot_secs));
     ```

Data Collected During Cruise

All times are specified in GMT.

Data Files

The data delivered to the research consists of the following subdirectories:

File/Directory Name	Description
processed	Processed data
raw_gps	Raw GPS files at 10 second fixes for days 98,026 - 98,043
hs	Processed and raw hydrosweep
xbt	XBT Raw data and the generated velocity profiles

The processed directory consists of the following files for each day of data:

n. - 1 minute navigation from the "x." file and "fu.s" file

```
yy+ddd:hh:mm:ss.mmm N 12 12.1234 E 123 12.1234   gp1 123.1 12.1
yr day  time                lat              lon              id    set   drift
```

id strings: "gp1" = GPS Trmble NT200D
"gp 2"=GPS Trimble NT200D
"gp3" = GPS Magnavox MX4200D Receiver #1
"dr" = Dead Reckoned position

vt.n - merged BGM-3 gravity with final nav.

```
yy+ddd:hh:mm:ss.mmm N 16  0.4273 W  73 20.3055  1980   -4.1
yr   day  time              lat             lon             theog  FAA

978416.9   27.6   9.9   13.2    -2.7   3.9     -2.8   3.8
 raw_grav eotvos drift   dc       raw_vel      smooth_vel
                         shift     N     E        N    E
```

mg.n - interpolated values merged with final nav. ; anomalies 1995 IGRF

```
yy+ddd:hh:mm:ss.mmm N 12 12.1234 E 123 12.1234     41200.8   -367.1
yr day  time              lat              lon              total      anomaly
                                                          intensity
```

hb.n - interpolated center beam merged with navigation

```
yy+ddd:hh:mm:ss:mmm N 12 12.1234 E 123.1234  2222.0
yr day  time              lat              lon          depth (meters)
```

ts.n - Shot time/Nav Block data remerged with final nav.

```
yy+ddd:hh:mm:ss.mmm 000913 N 53 17.4459 W 166 59.4171  MCS_LINE1
yr day   shot time        shot #   latitude        longitude        line name
```

ts.n.status - Shot status. Statistics of the shot file *(first, last, missing, errors)*

```
linename          Time of First Shot                  first      last
                                                      shot       shot
LINE ABC1:   yy+ddd:hh:mm:ss.mmm              065479 .. 070819
MISSING: 66791, 67749, 67907
```

m. - merged bathy, maggie, gravity with final nav.

```
yy+ddd:hh:mm:ss.mmm N 14  9.0555 W  67  2.3969   gp3 276.9  0.2
yr  day  time                  lat        lon          id     set   drift

5034.9   37401.8   17.2        -1.6    978349.0   13.1     9.1   13.2
depth    mag tot    mag         grv.    raw_grv   eotvos    tot   dc
           intensity  anomaly  faa                          drift  shift
```

Instruments

True Time Clock

Instrument Kinemetric/TrueTime Division Model GPS-DC GPS Synchronized Clock
Logging 1 minute intervals
Science Data None

The True Time clock is used to adjust the CPU clock of the logging computer. The logging computer captures the continuous time records from the clock and provides these as a service to the rest of the network via a UDP broadcast. This enables the computers on the network to adjust their CPU times to UTC time.

Day	Time	Comments
026	1800	Start Logging True time
043		End Processing True time

Sound Velocities

Instrument Sparton Expandable BathyThermograph (5) *XBT*
Processing Data is processed using the MB-System 4.3 to convert the depth/temperature readings to depth/sound velocity.
Science Data XBT and velocity profiles in *xbt* subdirectory

XBT	Location	
980101	21 51N	157 11W

Guns

Logging Varying intervals

Processing Gun Shot data is created initially with a fifteen minute filter for the navigation data to reduce the effects of the selective availability. This data is then combined with the one-minute navigation and corrected for course and speed to produce the final formatted data.

Science Data *ts.n*

Day	Time	Line	Shots
28:	12:31	KilSF1:	000001 .. 002165
28:	12:31	KilSF1:	000001 .. 002165
29:	00:00	KilSF1:	002166 .. 002741
29:	03:05	KilSF2:	000001 .. 001469
29:	10:52	KilSF3:	000003 .. 001535
29:	19:22	KilSF4:	000001 .. 000896
30:	00:00	KilSF4:	000897 .. 001248
30:	01:50	KilSF5:	000001 .. 001853
30:	19:15	KilSF6:	000002 .. 000888
31:	00:00	KilSF6:	000889 .. 002050
31:	06:24	KilSF7:	000001 .. 001510
31:	14:55	KilSF8:	000001 .. 001479
31:	22:54	KilSF9:	000001 .. 000182
32:	00:00	KilSF9:	000183 .. 001201
32:	05:34	KilSF10:	000003 .. 001545
32:	14:25	KilSF11:	000001 .. 001789
33:	00:00	KilSF11:	001790 .. 001716
33:	21:46	KilSF13:	000001 .. 000446
34:	00:00	KilSF13:	000447 .. 001534
34:	05:30	KilSF14:	000002 .. 000491
34:	08:06	KilSF15:	000002 .. 002194
34:	18:58	KilSF16:	000001 .. 000867
35:	00:00	KilSF16:	000868 .. 002017
35:	06:01	KilSF17:	000001 .. 000896
35:	10:24	KilSF18:	000002 .. 001581
35:	19:21	KilSF19:	000001 .. 000757
35:	23:15	KilSF20:	000001 .. 000152
36:	00:00	KilSF20:	000153 .. 002440
36:	11:37	KilSF21:	000001 .. 001824
36:	21:04	KilSF22:	000001 .. 000549
37:	00:00	KilSF22:	000550 .. 000761
37:	01:46	KilSF23:	000002 .. 001459
37:	08:47	KilSF24:	000002 .. 000743
37:	12:21	KilSF25:	000001 .. 000968
37:	17:20	KilSF26:	000002 .. 001289
38:	00:00	KilSF26:	001290 .. 002071
38:	04:03	KilSF27:	000001 .. 001168
38:	09:43	KilSF28:	000001 .. 001131
38:	15:13	KilSF29:	000003 .. 001571
38:	23:23	KilSF30:	000001 .. 000124

39:	00:00	KilSF30:	000125 .. 002512
39:	12:51	LANAI1:	000002 .. 002036
40:	00:00	LANAI1:	002037 .. 002047
40:	00:08	LANAI2:	000002 .. 000812
40:	04:02	LANAI2a	000001 .. 000319
40:	05:33	LANAI3:	000002 .. 002411
40:	16:48	OAHU1:	000001 .. 001462
41:	00:00	OAHU1:	001463 .. 002373
41:	04:21	OAHU2:	000002 .. 002461

Speed and Heading

Instrument Furuno CI-30 2-axis Doppler speed log, Sperry MK-27 gyro
Logging 3 second intervals
Processing The raw Furuno data is processed by taking the mean of all values within the even minute range and outputting the speed and heading on the even minute. All values taken during the 30 seconds before and after the even minute are used to calculate the median.

Science Data: None

Day	Time	Comments
346	1800	Start Logging of Furuno Data
017		End Processing of Furuno data

GPS SATELLITE FIXES:

Instruments gp1: GPS Trimble NT200D
gp2: GPS Trimble NT200D
gp3: Magnavox MX-4200 Global Positioning System

Logging 10 second intervals on all receivers

Checking

gp3: Minimum number of SATs: 3
Dilution of precision maximum: north = 4.0, east = 4.0
Speed maximum: 20.0

Reject fixes with high drifts in navigation

Processing **See Navigation Processing Pipeline**

Science Data *n.*

Day	Time	Comments
026	1800	Started Logging of GPS Data
043		End GPS Data Logs

BATHYMETRY:

Instrument Krupp Atlas Hydrosweep Center Beam

Logging Each Hydrosweep Ping is logged, and center beam data is extracted and logged separately.

Processing Raw data is checked to process only good centerbeam records that were acquired in *survey* mode.
This data is then processed to produce a median value for each even minute. The median is the median of all records 30 seconds before and after the even minute.

Final Data The median is merged with the one-minute navigation fixes to provide the final centerbeam data.

Notes During the cruise, hydrosweep data was occasionally turned off while coring. The following chart shows all breaks greater than 5 minutes.

Science Data: *hb.n*

Day	Time	Comments
026	1800	Data logging/processing begins
042	1344 - 1658	Bad data quality
043		Data processing ends

SEA TEMPERATURE:

Instrument Omega DP10 Series
Logging 1 minute intervals
Checking none
Smoothing none
Science Data none

Day	Time	Comments
026	1800	Sea temperature logging began
043		Logging ends

WEATHER STATION:

Instrument R.M./. Young Precision Meteorological Instruments 26700 Series
Logging 1 minute interval
Final Data raw.
Notes Bird 2 is no longer used
Science Data none

Day	Time	Comments
026	1800	Logging Begins
043	2359	Ends

BGM-3 GRAVITY:

Instrument Bell Aerospace BGM-3 marine gravity meter
Logging 1 second intervals

Science Data *vt.n (Observed, Eotvos, Free Air Anomaly value at 00 seconds of each minute)*
m.n (merged bathy, maggie, gravity with final nav.)

Merge with navigation calculate Eotvos correction and Free Air Anomaly.
Checking Visual check of plot of data to determine satisfactory Eotvos corrections, reject spikes of data at turns.
Velocity smoothing 5 point running average throughout the cruise.
Processing

Since current BGM-3 output has double counts every few minutes the following scheme has been implemented until the hardware and interface code has been fixed:

1. Run a 1 minute Gaussian filter through the data. This will narrow the output spikes and make them stand out better. Output interval has been hard-wired to every 15 seconds.
2. Pass the output through filter1d (see gmtsystem) using -FG480 (an 8 minute Gaussian filter with robust option, i.e., ignore "outlier" points (i.e. the spikes).

Calculations

eotvos_corr = 7.5038 * vel_east * cos(lat) + .004154 * vel*vel
corrected_grv = raw_grv + eotvos_corr - drift - dc_shift
faa = corrected_grv - theoretical_grv

1980 theoretical gravity formula

$Y_0 = 978.0327 \times (1 + .0053024 \times \sin(\square) \times \sin(\square) - .0000058 \times \sin(2 \times \square) \times \sin(2 \times \square))$

DAY	TIME	COMMENTS
026	1800	gravity gyros fixed, started logging/processing
043		end of cruise, stopped logging/processing

EW-9801 Honolulu, Hawaii *OFFICIAL*

Pier/Ship	Latitude	Longitude	Reference	Latitude	Longitude
	21 18.062	N 157 51.96 W		N	W

Honolulu, Hawaii
Ship is docked at pier #1 reading was taken across from door #33 at 1150' mark.

Reference station is at pier #2 Honolulu harbor opposite door #41 of the Diamond head termina bldg. Site is midway between berth #2A and #2E along the west side of bldg. The site is 18" from edge of pier.

	Id	Date	Drift	Drift/Day	Total Drift
Pre Cruise	EW9709	1/24/98	1.56	0.03	0.00
Post Cruise	EW9801	2/13/98	1.70	0.08	1.70
Total Days		20.00			

Time	Entry	Value	
11:21	CDeck Level BELOW Pier	0.30	meters
11:21	Pier 1 L&R Value	2580.53	L&R
11:33	Reference L&R Value	2579.96	L&R
11:38	Pier 2 L&R Value	2580.53	L&R
Jan-04	Reference Gravity	978926.40	mGals
16:48	Gravity Meter Value (BGM Reading)	978944.10	mGals
	Potsdam Corrected	1	1 if corrected

*Gravity meter is **5.5** meters below CDeck*

Difference in meters between Gravity Meter and Pier: 5.80 meters

Height Cor = Pier Height * FAA Constant

5.80 × 0.31 = 1.80 mGals/min

Difference in mGals between Pier and Gravity Meter

Delta L&R = Pier (avg) - Reference * 1.06 L&R/mGal

(2580.53 − 2579.96) × 1.06 = 0.60 mGals

Pier Gravity = Reference + Delta mGals [+ Potsdam]

978926.40 + 0.60 + 13.60 = 978940.60 mgals

Gravity @meter = Pier Gravity+Height Correction

978940.60 + 1.80 = 978942.40 mGals

Current Mistie = BGM Reading - Calculated Gravity

978944.10 − 978942.40 = 1.70 mGals