Lamont-Doherty Earth Observatory of Columbia University

EW-9804 Transit Data Summary

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Norfolk, Virginia - Halifax, Nova Scotia

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Notes:

- Post cruise gravity tie was not done correctly, so we are just using the previous gravity tie to continue the drift factors.

Navigation Processing

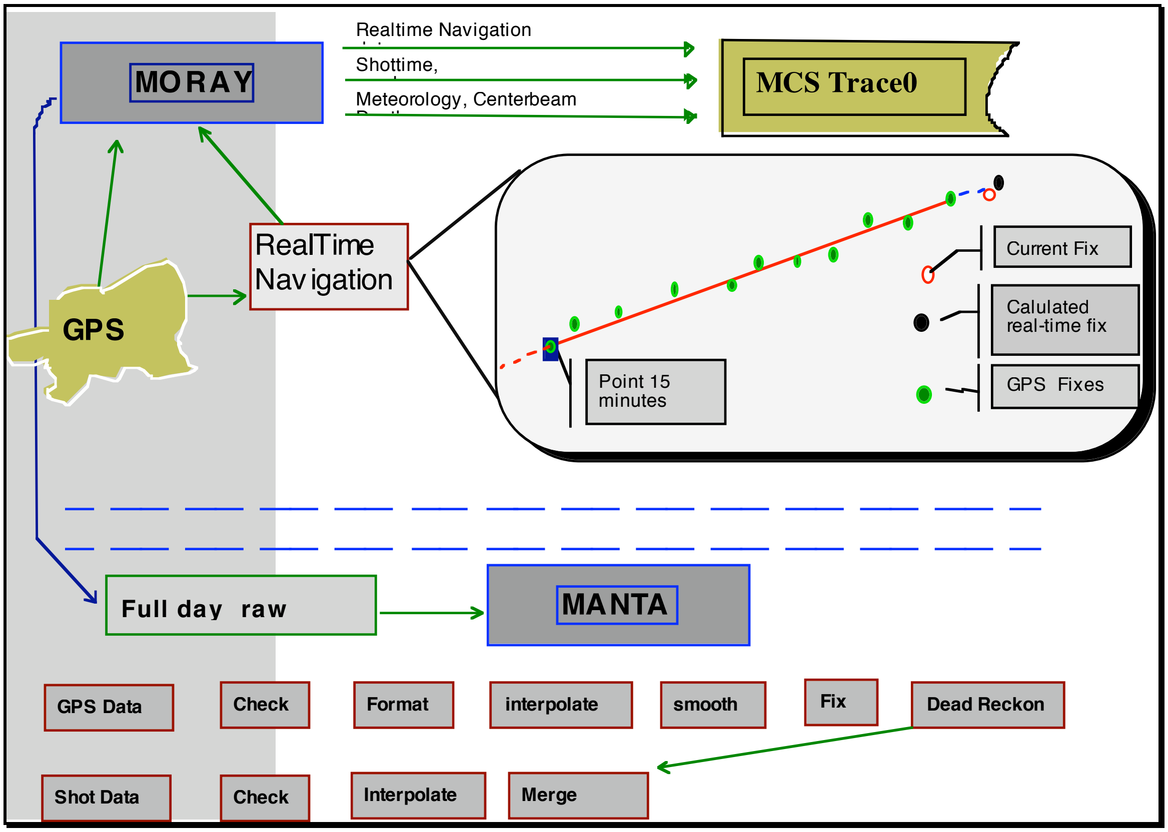

Figure 1. *Navigation Processing Pipeline*

1. **Logger** (Sparc 2, SunOS 4.1)
   Moray is the system responsible for logging all the real-time data from an array of serial ports. *Hydrosweep is the exception and is logged from a UDP broadcast from a SGI running IRIX.*
   Each data record logged by an instrument is time tagged with the CPU current time, which is synched every minute with one of the UTC receivers. The GPS records are also time-tagged, but the time of position comes from the times established by the receiver for the position.

   Moray also 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**
   One GPS is selected to be the receiver for the cruise, usually the TASMAN P(Y) Code GPS Receiver. The GPS data is logged to disk once every ten seconds.
   In order to shoot by distance, and also to predict where the shot occurred, we take two points (X seconds apart) from the specified GPS. From these two points, an average velocity is determined, and a "real-time" navigation position is output as the GPS fix. **See Figure 1.** The output of the real-time navigation is a file containing the following, used for real-time shot position and MCS data:

   - 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

From this velocity we determine the location of the shot when the shot-time does not fall precisely on a GPS fix; which is always. We also use this "RT Navigation" to determine our next "shot-by-distance". We determine our current velocity, the time it will take to travel x meters, and then set the shot-clock for that amount of time.

3. **GPS Post Processing**
Navigation data is post-processed in order to accurately determine our position due to selective availability, and in the case of the P(Y) Code receiver, eliminate some of the effects of the rolling of the ship.. This post-processed navigation is then applied to all position-specific data to provide consistent positions for all devices: *Magnetometer, Gravimeter, Hydrosweep Centerbeam*.

- Check data for mutant records and inconsistent times, and convert from GPS format to human-readable format.
- Interpolate data where GPS coverage is missing for any amount of time 3 minutes or *less*.
- When differential coverage is in effect, throw away fixes that are not differentially corrected.
- Smooth the values with a 9 point running average algorithm.
- 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. Output the set and drift for those points; also fixed at one minute intervals.

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 peaks due to selective availability. This is the final navigation.

4. **Shot Data Post Processing**

- Check the raw navblock file for mutant records and inconsistent times.
- Interpolate any missing shots using a simple interpolation algorithm which does not correct for changes in latitude. Interpolated shots are marked with a **-** in the cpu time field.
- Merge the shot times with the final navigation prepared in **Step 2.** The shot-point is calculated using the final 1 minute navigation fixes and the difference in time from the closest fix:

```
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) * (navbock_sec / (final_nav[i+1].tot_secs - final_nav[i].tot_secs));
```

Data Collected During this Cruise

Data Type	File Header	Description	Days Collected

Sea Temp	ct	Sea Temperature	137 - 140
Furuno	fu		137 - 140
Tasman GPS	gp1	Ycode GPS	137 - 140
Trimble GPS	gp02	Standard GPS	137 - 140
Magnavox GPS	gp3	Standard GPS	137 - 140
Hydrosweep Centerbeam	hb	Centerbeam depth	137 - 140
Hydrosweep Swath	hs	Full Hydrosweep	137 - 140
TrueTime	tr1	CPU vs UTC Time	137 - 140
Bell Gravity	vc	Bell Gravimeter data	137 - 140
Weather Station	wx	Variety of weather instrumentation	137 - 140

Processed File Formats - *Science Data*

n. - final navigation at even minute intervals

```
98+074:00:03:00.000 N 13  6.2214 W  59 37.9399   gp1   0.0   0.0
yr  +day   time              Latitude        Longitude        gps   set  drift
```

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)
```

m. - merged bathymetry, magnetics, gravity with final navigation.

```
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
```

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
```

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
137	0000	Start Logging True time
140	2359	End Logging True time

Speed and Heading

Instrument Furuno CI-30 2-axis Doppler speed log, Sperry MK-27 gyro
Logging 3 second intervals
Processing Mean value of all good values within the same minute.
Science Data: None

Day	Time	Comments
137	0000	Start Logging of Furuno Data
140	2359	End Logging of Furuno data

Sea Temperature

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

Day	Time	Comments
137	0000	Start Logging Sea Temperature
140	2359	End Logging Sea Temperature

Weather Station

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

Day	Time	Comments
137	0000	Start Logging Weather Data
140	2359	End Logging Weather Data

GPS Fixes

Instruments gp1: TASMAN P(Y) GPS Receiver
gp2: GPS Trimble NT200D
gp3: Magnavox MX-4200 Global Positioning System
Logging 10 second fixes
Checking

- 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, based on comparison with Furuno smooth speed and heading.

Processing ***See Navigation Processing***
Science Data gp**x**.n

Notes Final Navigation is based on TASMAN, gp1 See File GPS_ERRORS for times when the Pcode dropped to S/A mode.

Day	Time	Comments
137	0000	Started Logging of GPS Data
140	2359	End Logging/Processing of GPS Data

Bathymetry

Instrument Krupp Atlas Hydrosweep Center Beam
Logging Each ping is logged, and center beam data is extracted and logged separately.
Processing Use only good centerbeam records that were acquired in *survey* mode. Produce a median value for each even minute
Final Data Merge the median with the one-minute navigation fixes.
Notes The following chart shows all discontinuities greater than 5 minutes.
Science Data *hb.n*

Day	Time	Comments
137	0000	Start logging Hydrosweep data
140	2359	End Processing Hydrosweep Data

Gravity

Instrument Bell Gravity Meter (BGM-3)
Logging 1 second intervals, raw gravity counts
Processing Check gravity, run through 1 minute Gaussian filter and output mGals at 6 second intervals to display output spikes. Run through a second 6 minute gaussian filter. Using the smoothed data, get the median value of every minute and output as the final gravity.
Final Data Merge this with the navigation and remove the EOTVOS errors. Also remove spikes due to hard course changes.
Science Data *ts.n*
Gravity Ties It is usual practice to have a gravity tie to a gravity reference base station during the port stay. A portable gravity metter (Lacoste Model G #70) is used to make a pierside reading, a reading at the reference station, and then another pierside reading. The pierside gravity value, adjusted in value according to the height of the BGM gravity meter is compared to the BGM gravity meter reading. By comparing these readings with the reference station we can determine the drift of the gravity meter from one por t to the next. We determine the drift and divide that drift by the number of days on the cruise and come up with an average drift/day. This amount is added to the gravity readings over the course of each day. Normally the drift/day is less than 0.1 mgals.

Pre Cruise Gravity Tie

EW-9802 Bridgetown, Barbados, West Indies

Pier/Ship	Latitude	Longitude

Bollard 23, same pier as reference pier

Reference	Latitude	Longitude
	13 06.4N	59 37.9W

Bollard 34. 3rd Bollard from north end of breakwater at the deep water harbor.

	Id	Date	Mistie	Drift/Day	DC Shift
Pre Cruise	EW9801	2/13/98	1.70	0.01	1.56
Post Cruise	EW9802	3/12/98	1.87	0.01	1.70
Total Days		27.00	0.17		

Time	Entry	Value	
16:58	CDeck Level BELOW Pier	0.33	meters
16:58	Pier 1 L&R Value	1969.80	L&R
17:09	Reference L&R Value	1970.40	L&R
17:16	Pier 2 L&R Value	1969.83	L&R
	Reference Gravity	978294.44	mGals
	Gravity Meter Value (BGM Reading)	978297.50	mGals
	Potsdam Corrected	0	1 if corrected

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

Difference in meters between Gravity Meter and Pier 5.83 meters

Height Cor = Pier Height * FAA Constant

5.83	0.31			1.81	mGals/min

Difference in mGals between Pier and Gravity Meter

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

1969.82	1970.40	1.06		-0.62	mGals

Pier Gravity = Reference + Delta mGals [+ Potsdam]

978294.44	-0.62	0.00		978293.82	mgals

Gravity @meter = Pier Gravity+Height Correction

978293.82	1.81			978295.63	mGals

Current Mistie = BGM Reading - Calculated Gravity

978297.50	978295.63			1.87	mGals