U.S.Department of the Interior

Geological Survey

Raw gravity and navigation data from R/V Starella cruises S1-86, S2-86, and S3-86 in the Caribbean Sea.

Barry J. Irwin[1]

Open-File Report 90-43

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1. Woods Hole, MA 02543

1989

Raw gravity and navigation data from R/V Starella cruises S1-86, S2-86, and S3-86 in the Caribbean Sea.

by
Barry J. Irwin

During the last quarter of 1986, the U.S. Geological Survey (USGS) collected approximately 12,400 line kilometers of gravity data in the territorial waters of Jamaica, United Kingdom (Cayman Islands), Honduras, and Colombia.

The data set consists of ASCII records in 1- to 2-megabyte data files that are contained on 4 magnetic tapes: a total of 136.4 megabytes of data. The raw-data files consist of continuous 10.s records from 4 instruments: Trimble 4000A GPS satellite positioning system, LaCoste and Romberg Air-Sea Gravimeter (L&R) S-26, LaCoste and Romberg Air-Sea Gravimeter S-41 (cruises S2-86 and S3-86 only), and John Chance Starfix satellite positioning system. Records which contain X's indicate no data for that 10.s record interval.

Primary navigation for all cruises was the Starfix satellite system, which provided fixes with better than 10.m rms absolute accuracy in the WGS-84 datum. GPS provided backup and quality control for the Starfix system.

All gravity base station values were on the ISGN 1971 datum. Land gravity base station ties were run using a LaCoste and Romberg land gravimeter G-170. Preliminary crosscheck statistics were under 2.5 mgals rms for 164 line crossing differences.

Bathymetry data were collected using a Raytheon Precision Depth Recorder SP I, CESP II, PDD-200 C/PDS 5, and PTR-105. No digitized data are available for these cruises. Analog records are available for inspection at U.S. Geological Survey in Woods Hole, Mass.

Table 1 is a sample data listing, showing typical magnetic tape record outputs. The specific magnetic data record formats are included in tables 2, 3, and 4. Tables 5 and 6 contain calibration information and tables for the LaCoste and Romberg Air-Sea Gravimeter S-26. Table 7 contains calibration information for LaCoste and Romberg Air-Sea Gravimeter S-41. Tables 8, 9, 10, 11, and 12 are worksheets used to list gravity base station information for each cruise leg.

These data may be copied by contacting the USGS, Woods Hole, Massachusetts 02543, attention: Navigation/Gravity Project. For further information, call 508-548-8700 x272.

TABLE 1. Typical Data File Listing

```
------------------------------------------------------------------
Example 1
This example is for 2 consecutive 10 second records.
Record contains GPS, L&R S-26, L&R S-41, Starfix.

00 MON 321 17-NOV-86 18:20:58 16:05.0253N 079:11.6544W -0008 01.5 033578 +000.00
 008.34 096.1 -3.5069E-10 0043 3 13,11*
9990000 321     182100  064457  064481  00 0634 01 0007 02 0985 03 0007 04-0022
 05 0018 06-0177 07 0063 08 0000 09 0002
0920000 321     182100  000000  062178  00 0655 01-0003 02 1173 03 0007 04-0028
 05 0029 06-0317 07 0137 08 0010 09 0002
LO 18 21  0 626  16.083058 -79.194226 9
00 MON 321 17-NOV-86 18:21:11 16:05.0269N 079:11.6196W -0008 01.5 033574 +000.00
 009.25 092.5 +2.1801E-10 0001 3 13,11*
9990000 321     182110  064420  064447  00 0666 01 0010 02 0929 03 0008 04-0024
 05 0015 06-0194 07 0063 08 0002 09 0003
0920000 321     182110  000000  062146  00 0692 01-0002 02 1114 03 0008 04-0031
 05 0026 06-0347 07 0141 08 0012 09 0002
LO 18 21 10 625  16.083061 -79.193790 8
------------------------------------------------------------------
Example 2
This example is for 2 consecutive 10 second records.
Record contains GPS, L&R S-26,L&R S-41(no data), Starfix

00 TUE 301 28-OCT-86 16:49:58 17:54.6632N 076:05.0128W -0033 05.5 732838 -000.11
 010.37 001.0 -1.9876E-10 0033 4 13,06,11,09
1010000 301     165000  065811  065845  00-0049 01 0008 02 0030 03-0000 04-0003
 05-0017 06-0042 07 0022 08-0010 09-0000
XXXXX
LO 16 50  0  79  17.911151 -76.083658**
00 TUE 301 28-OCT-86 16:50:08 17:54.6948N 076:05.0137W -0029 05.5 732820 -000.01
 010.48 001.3 -3.6438E-11 0037 4 13,06,11,09
1010000 301     165010  065811  065845  00-0048 01 0007 02 0027 03 0000 04-0003
 05-0016 06-0038 07 0019 08-0010 09-0000
XXXXX
LO 16 50 11  84  17.911691 -76.083654**
------------------------------------------------------------------
Example 3
This example is for 2 consecutive 10 second records.
Record contains GPS (no data),L&R S-26, L&R S-41 (no data), Starfix

XXXXX
3519999 297     112840  064875  064919  00-0065 01 0003 02-0012 03-0002 04-0005
 05 0001 06-0014 07-0010 08-0014 09-0004
XXXXX
LO 11 28 40 569  17.522290 -73.538525**
XXXXX
3519999 297     112850  064877  064920  00-0065 01 0003 02-0014 03-0003 04-0005
 05 0001 06-0014 07-0010 08-0014 09-0004
XXXXX
LO 11 28 50  60  17.522252 -73.539012**

NOTE: X's in the record indicate NO DATA for that 10 second interval.
```

TABLE 2. Trimble 4000A Format

Field	Description
1-2	ID
3	
4-6	Day of week
7	
8-10	Julian day
11	
12-20	Date
21	
22-29	Time (UTC)
30	
31-41	Latitude
42	
43-54	Longitude
55	
56-60	Antenna height, meters(above ellipsoid)
61	
62-65	PDOP
66	
67-72	Receiver clock bias, ms
73	
74-80	Vertical velocity, knots
81	
82-87	Horizontal velocity, knots
88	
89-93	Heading, degrees
94	
95-105	Receiver frequency offset, cycles
106	
107-110	continuous cycles tracked
111	
112	Number satellites in solution
113	
114-118(124)	Satellites being tracked (2 to 4)

NOTE: X's in record indicate no data for that 10 second interval

TABLE 3. LaCoste and Romberg Air-Sea Gravimeter Format

Field	Description
1-7	ID thumbwheel switches
8	
9-15	Julian Day
16	
17-23	Time of day HHMMSS (GMT)
24	
25-31	Gravity counter readout
32	
33-39	Spring Tension counter readout
40	
41-47	AVB
48	
49-55	CC
56	
57-63	TC
64	
65-71	VCC
72	
73-79	AL
80	
81-87	Ax
88	
89-95	VE
96	
97-103	AVX
104	
105-111	AVL
112	
113-119	Ax-2

NOTE: X's in record indicate no data for that 10 second interval

TABLE 4. Starfix Format

Field	Description
1-2	ID
3	space
4-5	Hour
6	space
7-8	Minute
9	space
10-11	Second
12	space
13-15	Decimal second
16	space
17-26	Latitude
27	space
28-37	Longitude
38-39	Instrument status code

NOTE: X's in record indicate no data for that 10 second interval

LaCoste and Romberg Gravity Meters, Inc. (512) 346-0077
4807 Spicewood Springs Road, Bldg. 2, Austin, Texas 78759 TWX 9108741382

CALIBRATION INFORMATION FOR AIR SEA GRAVITY METER S-26

GRAVITY METER CALIBRATION FACTOR
SEE TABLE

I. ENCODER READOUTS

Analog Gravity 1 Count = .1 counter unit
Spring Tension 1 Count = .1 counter unit

II. ANALOG VOLTAGE READOUTS

ABBREVIATIONS:

Average Beam (AVB)	(Vertical Acceleration)^2 (VE)
total Cross Coupling (CC)	Second Order Imperfection Cross
Total Correction (TC)	Coupling (Ax-2)
Inherent Cross Coupling (VCC)	Cross Acceleration Squared (XA)^2
Long Imperfection Cross Coupling (AL)	Long Acceleration Squared (LA)^2
Cross Imperfection cross Coupling (Ax)	Milligal (mgl) Millivolt (mv)

CHANNEL	READOUT	CALIBRATION	FRACTION OF CORRECTION IN CC
0	(AVB)	2mv/min = -1 mgl	
1	(CC)	10 mv = +1 mgl	
2	(TC)	10 mv = +1 mgl	
3	(VCC)	8 mv = +1 mgl	+1.15
4	(AL)	12 mv = -1 mgl	-.75
5	(Ax)	8 mv = -1 mgl	-1.25
6	$(VE)_2$	850 mv = $(100\ mgl)^2_2$	+.07
7	$(XA)^2_2$	300 mv = $(100\ mgl)^2_2$	
8	$(LA)^2$	2500 mv = $(100\ mgl)^2$	
9	(Ax-2)	10 mv = -1 mgl	-1.00

III. STRIP CHART READOUTS

Green Pen - Analog Gravity	1 div. = +1 mgl
Black Pen - Total Correction	1 div. = -1 mgl
Red Pen - Total Cross Coupling or	1 div. = +1 mgl
Av. Beam Position	1 div/min = -1 mgl
Orange Pen - Spring Tension of	1 div. = +1 mgl
Beam Position	80 div = 100 E.P.D.

STRIP CHART READOUTS (Soltec Recorder) (1 Volt Range)

Unfiltered Horizontal Acceleration	1 div. = 3000 mgl
Filtered Horizontal Acceleration	1 div. = 1 bubble div.

TABLE 5.

Milligal Values for LaCoste & Romberg, Inc. Air-Sea Gravity Meter S-26

COUNTER READING	MILLIGAL VALUE	INTERVAL FACTOR	COUNTER READING	MILLIGAL VALUE	INTERVAL FACTOR	COUNTER READING	MILLIGAL VALUE	INTERVAL FACTOR
000	000.00	1.03083						
100	103.08	1.03076	4100	4219.68	1.02827	8100	8332.18	1.02724
200	206.16	1.03067	4200	4322.50	1.02825	8200	8434.90	1.02719
300	309.23	1.03059	4300	4425.33	1.02824	8300	8537.62	1.02713
400	412.29	1.03046	4400	4528.16	1.02822	8400	8640.33	1.02709
500	515.33	1.03033	4500	4630.98	1.02820	8500	8743.04	1.02704
600	618.37	1.03022	4600	4733.80	1.02818	8600	8845.75	1.02699
700	721.39	1.03009	4700	4836.62	1.02819	8700	8948.45	1.02695
800	824.40	1.02994	4800	4939.44	1.02820	8800	9051.14	1.02691
900	927.39	1.02979	4900	5042.26	1.02822	8900	9153.83	1.02688
1000	1030.37	1.02961	5000	5145.08	1.02826	9000	9256.52	1.02685
1100	1133.33	1.02947	5100	5247.91	1.02830	9100	9359.21	1.02680
1200	1236.28	1.02935	5200	5350.74	1.02835	9200	9461.89	1.02677
1300	1339.21	1.02927	5300	5453.57	1.02840	9300	9564.57	1.02676
1400	1442.14	1.02920	5400	5556.41	1.02848	9400	9667.24	1.02675
1500	1545.06	1.02914	5500	5659.26	1.02850	9500	9769.92	1.02675
1600	1647.98	1.02908	5600	5762.11	1.02853	9600	9872.59	1.02673
1700	1750.89	1.02903	5700	5864.97	1.02853	9700	9975.27	1.02666
1800	1853.79	1.02899	5800	5967.82	1.02852	9800	10077.93	1.02658
1900	1956.69	1.02895	5900	6070.67	1.02849	9900	10180.59	1.02645
2000	2059.59	1.02891	6000	6173.52	1.02846	10000	10283.24	1.02635
2100	2162.48	1.02890	6100	6276.37	1.02842	10100	10385.87	1.02620
2200	2265.37	1.02886	6200	6379.21	1.02838	10200	10488.49	1.02602
2300	2368.26	1.02885	6300	6482.05	1.02833	10300	10591.09	1.02585
2400	2471.14	1.02883	6400	6584.89	1.02827	10400	10693.68	1.02565
2500	2574.03	1.02880	6500	6687.71	1.02822	10500	10796.24	1.02544
2600	2676.91	1.02879	6600	6790.54	1.02818	10600	10898.79	1.02520
2700	2779.79	1.02874	6700	6893.36	1.02813	10700	11001.31	1.02500
2800	2882.66	1.02869	6800	6996.17	1.02808	10800	11103.81	1.02481
2900	2985.53	1.02864	6900	7098.98	1.02801	10900	11206.29	1.02464
3000	3088.40	1.02860	7000	7201.78	1.02795	11000	11308.76	1.02448
3100	3191.26	1.02855	7100	7304.57	1.02790	11100	11411.20	1.02433
3200	3294.11	1.02851	7200	7407.37	1.02784	11200	11513.64	1.02417
3300	3396.96	1.02849	7300	7510.15	1.02778	11300	11616.06	1.02402
3400	3499.81	1.02845	7400	7612.93	1.02770	11400	11718.46	1.02389
3500	3602.66	1.02842	7500	7715.70	1.02765	11500	11820.85	1.02374
3600	3705.50	1.02839	7600	7818.46	1.02755	11600	11923.22	1.02361
3700	3808.34	1.02835	7700	7921.22	1.02748	11700	12025.59	1.02348
3800	3911.18	1.02834	7800	8023.97	1.02742	11800	12127.93	1.02334
3900	4014.01	1.02832	7900	8126.71	1.02735	11900	12230.27	1.02319
4000	4116.85	1.02830	8000	8229.45	1.02729	12000	12332.59	

N.D.P. 6-6-72

TABLE 6.

JCIEN LACOSTE TWX 9108741382
(512) 458-4205 **LaCOSTE AND ROMBERG GRAVITY METERS, INC.** LAR AUS
6606 North Lamar • Austin, Texas 78752

June 1986

CALIBRATION INFORMATION FOR AIR SEA GRAVITY METER S-41

ıvity Meter Calibration Factor 1 Counter Unit = .9904 mgl.

, ENCODER READOUTS

Analog Gravity 1 Count = .1 counter unit = .09904 mgl.
Spring Tension 1 Count = .1 counter unit = .09904 mgl.

. ANALOG VOLTAGE READOUTS

Abbreviations:

Average Beam (AVB)	(Vertical Acceleration)^2 (VE)
Total Cross Coupling (CC)	Second Order Imperfection Cross Coupling (Ax-2)
Total Correction (TC)	Average Cross Acceleration (AVX)
Inherent Cross Coupling (VCC)	Average Long Acceleration (AVL)
Long Imperfection Cross Coupling (AL)	Milligal (mgl.) Millivolt (mv)
Cross Imperfection Cross Coupling (Ax)	

CHANNEL	READOUT	CALIBRATION	FRACTION OF CORRECTION IN C C
0	(AVB)	2mv/min = -1 mgl.	
1	(CC)	10 mv = +1 mgl.	
2	(TC)	10 mv = -1 mgl.	
3	(VCC)	9 mv = +1 mgl.	+1.05
4	(AL)	70 mv = +1 mgl.	+ .15
5	(Ax)	100 mv = -1 mgl.	- .10
6	(VE)	2000 mv (100 K mgl)^2	+ .01
7	(AVX)	10 mv = 100 K mgl	
8	(AVL)	10 mv = 100 K mgl	
9	(Ax-2)	30 mv = -1 mgl	- .30

II. STRIP CHART READOUTS

Green Pen - Analog Gravity	1 div. = +1 mgl.
Black Pen - Total Correction	1 div. = -1 mgl.
Red Pen - Total Cross Coupling or	1 div. = +1 mgl.
Av. Beam Position	1 div/min. = -1 mgl.
Orange Pen - Spring Tension of	1 div. = +1 mgl.
Beam Position	80 div. = 100 E.P.D.

V. STRIP CHART READOUTS (Soltec Recorder) (1 Volt Range)

Unfiltered Horizontal Acceleration	1 div. = 3000 mgl.
Filtered Horizontal Acceleration	1 div. = 1 bubble div.

TABLE 7.

****

GRAVITY METER CALIBRATION WORKSHEET

****

SHIP R/V STARELLA DATE 22 Oct 86

LOCATION Bulkhead C DAY NO. 295
Roosevelt Roads Naval Station

COUNTRY Ceiba, Puerto Rico

OBSERVERS Irwin / Gann

FINAL AVERAGE

REFERENCE STATION #DOD-0272-1 978,662.02 (BASE STATION)

REFERENCE g (PIER) B = 978,660.1 from land tie

HEIGHT CORRECTION (1/1 m) + .34 pier to sea level
(x .3086m)

REFERENCE g (sea level) Bo = 978,660.44

		meter # S-26	meter # _____
average DIGITAL g (hour average)	GUN =	6,838.56	
BIAS	(Bo - GUN) =	971,821.88	

METER CHECK READINGS

METER NUMBER		S-26	S-___	S-___
METER PRESSURE		n/a		
MEASURING SCREW	SpTEN	n/a		
AUTO READER	~~Spten~~ Grav	6646.7		
DIGITAL Gun (ibm)	GunAVG	6838.56 (from table)		

SAMPLE TIME for average 1415 Z to _____ Z

*NOTE: EPSON PRINTER PAGE OR XEROX ATTACHED?
(IF NO EPSON PRINTER PAGE ATTACHED, THEN ATTACH A 6200A INTERFACE TAPE AND ENTER SPRING TENSION AS "DIGITAL Gun" ABOVE.

SAMPLE 6200A TAPE --->
as printed:
10 (09 to 00) L&R MONITORS
SPTEN
GRAVITY
TIME
DAY
LINE NUMBER /c:bcrfor4/

TABLE 8.

****

GRAVITY METER CALIBRATION WORKSHEET

****

SHIP R/V STARELLA DATE 25 Oct 86

LOCATION RO-RO Terminal, Berth 1 DAY NO. 298

COUNTRY Kingston, Jamaica

OBSERVERS Dodd / Gann

FINAL AVERAGE

REFERENCE STATION #DOD-1029-1 978,583.3 (BASE STATION)

REFERENCE g (PIER) B = 978,581.36 from land tie

HEIGHT CORRECTION (1.1 m) + .34 pier to sea level
(x .3086m)

REFERENCE g (sea level) Bo = 978,581.70

		meter # S-26	meter # _____
average DIGITAL g (hour average)	GUN =	6,759.79	
BIAS	(Bo - GUN) =	971,821.91	

METER CHECK READINGS

METER NUMBER		S-26	S-___	S-___
METER PRESSURE		n/a		
MEASURING SCREW	SpTEN	n/a		
AUTO READER	Grav ~~SpTen~~	6570.1		
DIGITAL Gun (ibm)	GunAVG	6759.79 (from table)		

SAMPLE TIME for average 1839Z to Z

*NOTE: EPSON PRINTER PAGE OR XEROX ATTACHED?

(IF NO EPSON PRINTER PAGE ATTACHED, THEN ATTACH A 6200A INTERFACE TAPE AND ENTER SPRING TENSION AS "DIGITAL Gun" ABOVE.

SAMPLE 6200A TAPE --->

as printed:

10 (09 to 00) L&R MONITORS
SPTEN
GRAVITY
TIME
DAY
LINE NUMBER

/c:bcrfor4/

TABLE 9.

****

GRAVITY METER CALIBRATION WORKSHEET

****

SHIP R/V STARELLA DATE 23 Nov 86

LOCATION RO-RO Terminal, Berth 2 DAY NO. 327

COUNTRY Kingston, Jamaica

OBSERVERS Gann

FINAL AVERAGE

REFERENCE STATION #DOD-1029-1 978,583.3 (BASE STATION)

REFERENCE g (PIER) B = 978,581.09 from land tie

HEIGHT CORRECTION (1.1 m) + .34 pier to sea level
(x .3086m)

REFERENCE g (sea level) Bo = 978,581.43

		meter # S-26	meter # S-41
average DIGITAL g (hour average)	GUN =	6,758.86	6,281.02
BIAS	(Bo - GUN) =	971,822.6	972,300.4

METER CHECK READINGS

METER NUMBER		S-26	S-41	S-
METER PRESSURE		n/a	n/a	
MEASURING SCREW	SpTEN	n/a	n/a	
AUTO READER	Gray ~~SpTen~~	6569.2	6341.9	
DIGITAL Gun (ibm)	GunAVG	6758.86	6281.02	

SAMPLE TIME for average (table) 2157 Z to (factor) Z

*NOTE: EPSON PRINTER PAGE OR XEROX ATTACHED?

(IF NO EPSON PRINTER PAGE ATTACHED, THEN ATTACH A 6200A INTERFACE TAPE AND ENTER SPRING TENSION AS "DIGITAL Gun" ABOVE.

SAMPLE 6200A TAPE --->

as printed:

10 (09 to 00) L&R MONITORS
SPTEN
GRAVITY
TIME
DAY
LINE NUMBER

/c:bcrfor4/

TABLE 10.

****

GRAVITY METER CALIBRATION WORKSHEET

****

SHIP R/V STARELLA DATE 21 Dec 86

LOCATION RO-RO Terminal, Berth 4 DAY NO. 355

COUNTRY Kingston, Jamaica

OBSERVERS Gann

FINAL AVERAGE

REFERENCE STATION # DOD-1029-1 978,583.3 (BASE STATION)

REFERENCE g (PIER) B = 978,580.67 from land tie

HEIGHT CORRECTION (0.5 m) + .15 pier to sea level
(x .3086m)

REFERENCE g (sea level) Bo = 978,580.82

		meter # S-26	meter # S-41
average DIGITAL g (hour average)	GUN =	6,758.97	6,279.3
BIAS	(Bo - GUN) =	971,821.85	972,301.5

METER CHECK READINGS

METER NUMBER		S-26	S-41	S-___
METER PRESSURE		n/a	n/a	
MEASURING SCREW	SpTEN	n/a	n/a	
AUTO READER	~~SpTen~~ Gray	6569.3	6340.7	
DIGITAL Gun (ibm)	GunAVG	6758.97	6279.3	
		(table)	(factor)	
SAMPLE TIME for average		1400 Z to	Z	

*NOTE: EPSON PRINTER PAGE OR XEROX ATTACHED?
(IF NO EPSON PRINTER PAGE ATTACHED, THEN ATTACH A 6200A INTERFACE TAPE AND ENTER SPRING TENSION AS "DIGITAL Gun" ABOVE.

SAMPLE 6200A TAPE --->

as printed:

10 (09 to 00) L&R MONITORS
SPTEN
GRAVITY
TIME
DAY
LINE NUMBER /c:bcrfor4/

TABLE 11.

****

GRAVITY METER CALIBRATION WORKSHEET

****

SHIP R/V STARELLA DATE 30 Dec 86

LOCATION RO-RO Terminal, Berth 4 DAY NO. 355

COUNTRY Kingston, Jamaica

OBSERVERS Strahle

FINAL AVERAGE

REFERENCE STATION #DOD 1029-1 978,583.3 (BASE STATION)

REFERENCE g (PIER) B = 978,580.67 from land tie

HEIGHT CORRECTION (2.2 m) + .68 pier to sea level
(x .3086m)

REFERENCE g (sea level) Bo = 978,581.35

		meter #S-26	meter # S-41
average DIGITAL g (hour average)	GUN =	6,760.8 *	(table problems)
BIAS	(Bo - GUN) =	971,820.55	n/a

METER CHECK READINGS * from digital print out

METER NUMBER		S- 26	S-41	S-
METER PRESSURE		n/a	n/a	
MEASURING SCREW	SpTEN	n/a	n/a	
AUTO READER	~~SpTEN~~ Gray	6570.8 cr		
DIGITAL Gun (~~ibm~~)	GunAVG	6760.5 mgal (from table)		
SAMPLE TIME for average		1645 Z to		Z

*NOTE: EPSON PRINTER PAGE OR XEROX ATTACHED?

(IF NO EPSON PRINTER PAGE ATTACHED, THEN ATTACH A 6200A INTERFACE TAPE AND ENTER SPRING TENSION AS "DIGITAL Gun" ABOVE.

SAMPLE 6200A TAPE --->

as printed:

10 (09 to 00) L&R MONITORS
SPTEN
GRAVITY
TIME
DAY
LINE NUMBER /c:bcrfor4/

TABLE 12.