DIFFERENTIAL LORAN-C FOR BUOY POSITION CHECKING

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PREFACE

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PREFACE

This is the final report of work performed under a contract, "Data Reduction Analysis--Differential LORAN-C for Buoy Position Checking", funded by the Telecommunications and Electronics Branch of the Canadian Coast Guard. The Scientific Authority for this contract was J.C. Rennie.

Part of the work contained herein was funded by a strategic research grant from the Natural Sciences and Engineering Research Council of Canada, entitled "Marine Geodesy".

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NOTE: Appendices V, VI, and VII are bound in a separate volume. A limited number of copies have been made, and are available upon request.

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EXECUTIVE SUMMARY

A first experiment to evaluate the usefulness of differential LORAN-C for buoy position checking was held along the Nova Scotia south shore between August and September 1982, by the Telecommunications and Electronics Branch of the Canadian Coast Guard. The criterion for buoy position checking is that buoy movements as small as 15 metres should be detectable. Time difference (TD) measurements were made simultaneously at a monitor site, and at 23 remote sites occupied repeatedly by either van or helicopter. The remote sites consist of 10 van sites, 8 helicopter landing sites, and 5 actual buoys over which the helicopter hovered. A total of 32,858 TD measurements were obtained. This report presents an analysis of this data.

All the raw TD measurements, and the (remote-monitor) TD differences were statistically analyzed and graphically plotted, and the results are contained in the appendices to this report. The repeatability of the differential TD measurements was determined by comparing the values for each visit to each site against the mean for all visits to that site. These TD repeatability results were converted to position determination repeatability results, using a simple conversion procedure developed in this report. Differential LORAN-C positioning repeatability (at the 95% confidence level) was found to be

1) approximately 12 metres for the van sites (averaging 2 hours of TD observations per visit)
2) approximately 14 metres for the helicopter landing sites (averaging 7 minutes of data per visit).

The helicopter buoy hovering results demonstrated that a better method of positioning the helicopter relative to the buoy must be found. The single pair of visits using a flypast technique showed promise and should be further pursued. Questions about LORAN signal and receiver stability, effective range of the technique, and data recording and processing procedures remain to be answered before the technique will be a practical operational tool. Twelve specific recommendations for future tests are presented.

CHAPTER 1

INTRODUCTION

Determining whether or not a floating aid to navigation (buoy) has been moved off its correct position (due to storm action, for example) is a difficult and expensive procedure.

The Telecommunications and Electronics Branch of the Canadian Coast Guard is investigating the feasibility of using LORAN-C in a differential mode, in order to find a more cost-effective solution to this problem.

The specification against which differential LORAN-C repeatability must be compared is that it must be capable of detecting buoy position shifts as small as 15 metres, at the 95% confidence level.

A first experiment to evaluuate the usefulness of differential LORAN-C for buoy position checking was held along the Nova Scotia south shore between August and October 1982 (Canadian Coast Guard, 1982). Ten sites were occupied up to five times each by a LORAN-C receiver mounted in a van, and thirteen sites were occupied up to five times each by the same receiver mounted in a helicopter. At eight of the helicopter sites the helicopter landed to make the measurements. The other five sites were actual floating buoys, over which the helicopter hovered while the measurements were made. In order to permit differential LORAN-C corrections to be made to these measurements, two monitor receivers were operated simultaneously with the van/helicopter receiver. The total numbers of LORAN-C time difference records obtained on the van, on the helicopter and at the monitor site respectively were 8193, 603 and 24062.

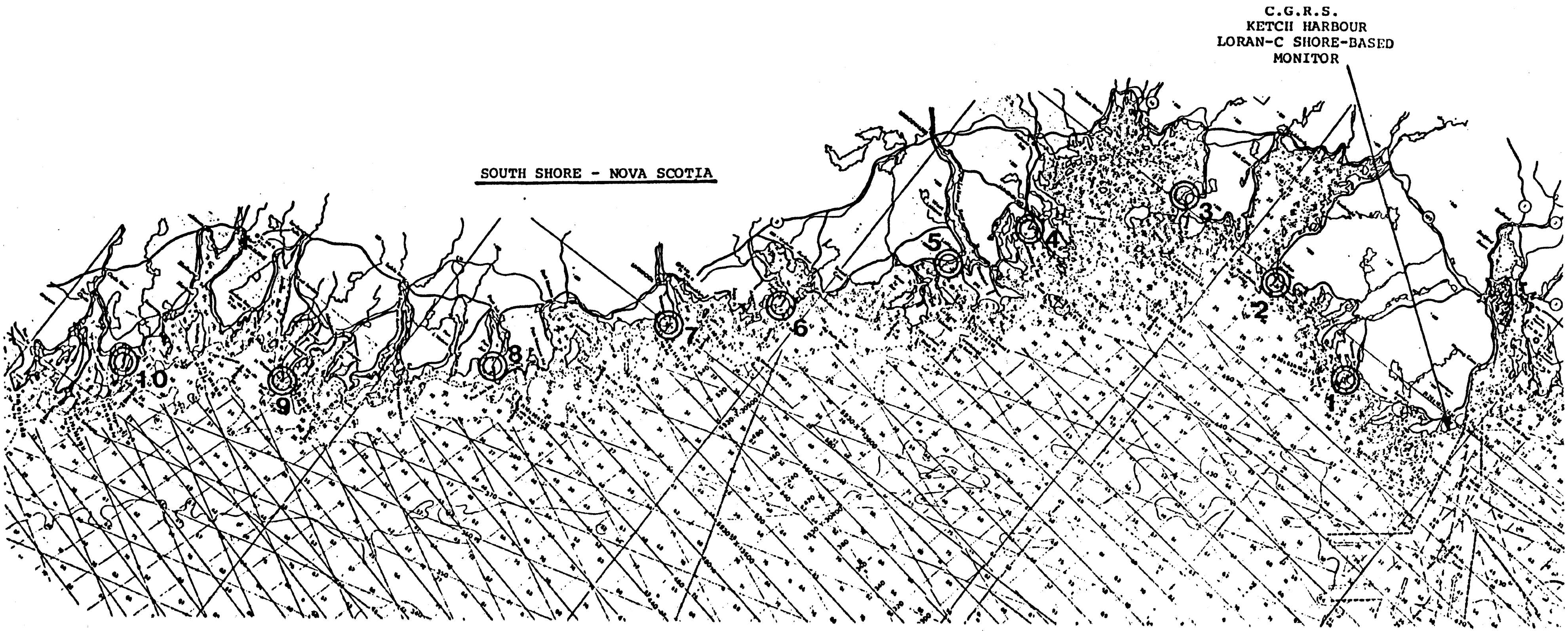
This report describes the reduction and processing of this data, and presents the results of this processing. The LORAN-C data is described in Chapter 2. The methods of analysis used are described in Chapter 3. Plots of the observed time differences (TD), and of the (remote-monitor) differences in TD were plotted as a function of time. The results are presented in Chapter 4, and Appendices V, VI, and VII (bound separately). The observed TDs and (remote-monitor) differences in TD were analyzed statistically. The results are presented in Chapter 5 and Appendix III. The TD and TD differences results were converted into corresponding position shifts. The conversion procedures are described in Appendix II. Position shift results are presented in Chapter 6. Conclusions and recommendations are presented in Chapter 7.

CHAPTER 2

DATA SUMMARY

Besides the monitor site at Ketch Harbour, LORAN-C time difference (TD) data has been recorded at 23 remote sites. Of these 23 remote sites, the first 10 were visited by a van containing LORAN-C receiving and recording equipment. Figure 2.1 is a map showing where the van sites were located on the south shore of Nova Scotia. The 13 helicopter site locations are depicted in Figure 2.2. Note that the helicopter sites are consistently more seaward than the van sites, corresponding more closely to actual buoy locations.

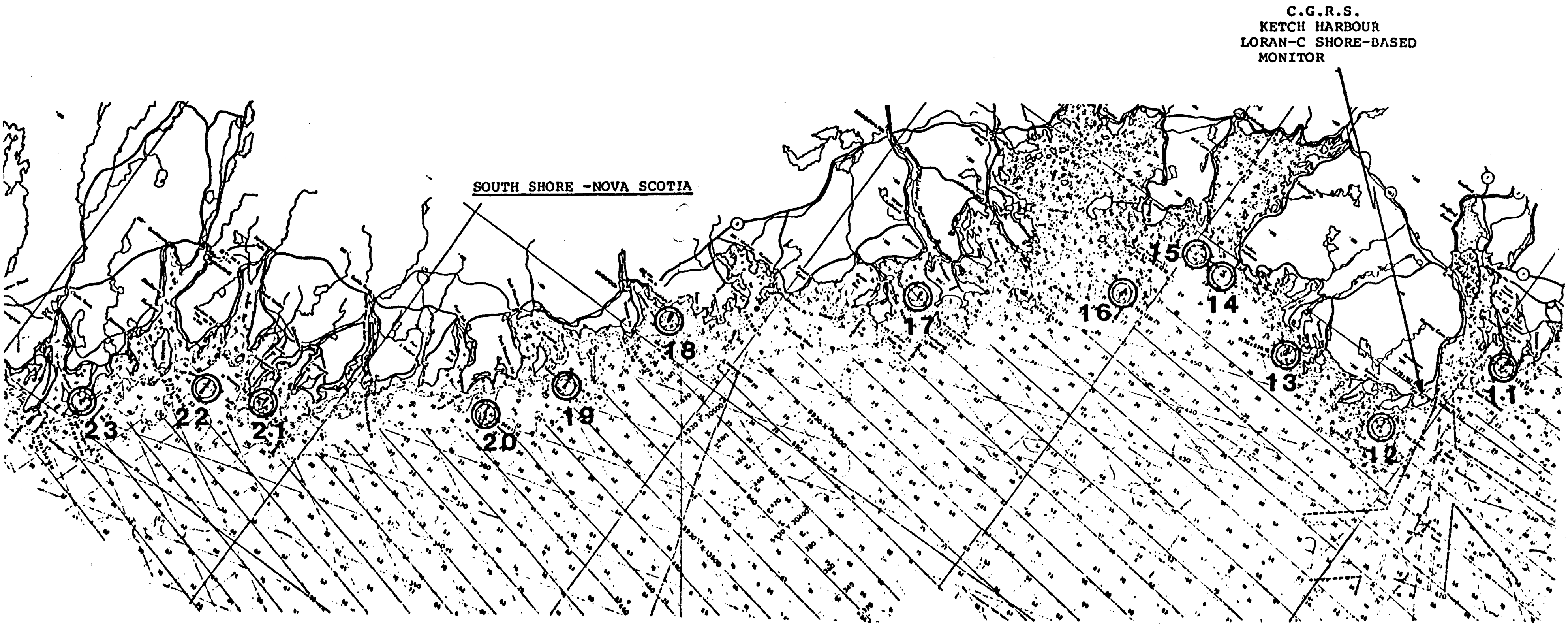
A total of 24,062 records were recorded at the Ketch Harbour monitor. Initially, these records were recorded every 150 samples, and looked as shown in the Table 2.1. A sample size of 150 means that a record was recorded approximately every 3 minutes and 6 seconds (about 465 records per day). Note that data was also recorded for two receivers, serial numbers 2220 and 1017. Time recorded is UT time, and the difference between an assumed constant value and the actual reading was noted. The standard deviation of the 150 sample average was also recorded (this is used in later computation; see Chapter 3). All of the data from day 218 up to day 251 were recorded to the nearest 10 nsec. From hour 17, day 251 until hour 23, day 253, the monitor data was recorded approximately every 1 minute 38 seconds (or sample size = 75). Starting on day 264, the resolution was increased to 1 nsec for both the readings and standard deviations, and the sample size was decreased to 30 from 75. This means that a record is recorded approximately every 44 seconds (about 1965 records per day). The cleaned data were reformatted into the so-called UNB format as shown in



VAN TEST SITES

1. LOWER PROSPECT (GOVT WHARF)
2. PEGGY's COVE
3. BLANDFORD (MAHONE BAY)
4. BATTERY POINT
5. DUBLIN SHORE (GOVT WHARF)
6. MEDWAY HEAD
7. WESTERN HEAD (LIVERPOOL)
8. PORT JOLI HARBOUR (GOVT WHARF)
9. WESTERN HEAD (LOCKEPORT)
10. INGOMAR CEMETERY

Figure 2.1 Van Site Locations



HELICOPTER TEST SITES

11. Devils Island Light (L)
12. Sambro Island Light (L)
13. Betty Island Light (L)
14. Peggys Point Buoy (H)
15. Horseshoe Ledge Buoy (H)
16. Pearl Island Light (L)
17. Mosher Island Light (L)
18. Coffin Island Light (L)
19. White Point Rock Buoy (H)
20. Little Hope Island Light (L)
21. Gull Rock Island Light (L)
22. Jig Rock Buoy (H)
23. Budget Rock Buoy (H)

(L) Helicopter landing. (H) Helicopter Hovering

Figure 2.2 Helicopter Site Locations

LORAN-C @ KETCH
SAMPLE SIZE 150
TIME 2:11:52 JULIAN DAY: 224/365 YEAR: 1982
TD-A 13822.92 TD-B 30157.23 TD-C 13822.92 TD-D 30157.23
RX#1 (FOR TD A,B) S/N: 2220 RX#2 (FOR TD C,D) S/N: 1017

TIME	NA	DA	SDA	NB	DB	SDB	NC	DC	SDC	ND	DD	SDD
~~2:15:12~~	~~151~~	~~-8~~	~~2~~	~~149~~	~~0~~	~~2~~	~~150~~	~~-3~~	~~2~~	~~149~~	~~11~~	~~2~~
2:18:18	150	-8	2	150	0	2	148	-2	2	150	10	2
2:21:24	150	-8	2	150	0	2	148	-2	2	150	11	2
2:24:30	150	-8	2	150	1	2	148	-3	2	150	12	2
2:27:36	150	-8	2	150	1	2	148	-2	2	150	12	2
2:30:43	150	-9	2	150	1	2	148	-2	2	150	12	2
2:33:49	150	-9	2	150	1	2	148	-2	2	150	11	2
2:36:55	150	-9	2	150	1	2	149	-3	2	150	12	2
~~2:40: 1~~	~~150~~	~~-9~~	~~2~~	~~150~~	~~1~~	~~2~~	~~148~~	~~-3~~	~~2~~	~~150~~	~~12~~	~~2~~
2:43: 7	150	-9	2	150	1	2	148	-3	2	150	11	2
2:46:14	150	-9	2	150	1	2	148	-3	2	150	11	3
2:49:20	150	-9	2	150	1	2	149	-3	2	150	11	3
2:52:26	150	-9	2	150	1	2	148	-3	2	150	11	2
2:55:32	150	-9	2	150	1	2	148	-4	2	150	12	3
2:58:39	150	-9	2	150	1	2	148	-3	2	150	12	2
3: 1:45	150	-9	2	150	1	2	148	-3	2	150	12	3

Table 2.1 Sample Monitor Data Records

1982	253	22: 7:11	13822.860	20	30157.320	20	13822.870	20	30157.330	20
1982	253	22: 8:51	13822.860	20	30157.310	20	13822.880	20	30157.330	20
1982	253	22:10:29	13822.860	20	30157.310	20	13822.870	20	30157.330	30
1982	253	22:12:44	13822.860	20	30157.300	20	13822.870	20	30157.330	20
1982	253	22:14:23	13822.860	10	30157.300	20	13822.870	20	30157.330	20
1982	253	22:16: 3	13822.860	20	30157.290	10	13822.880	20	30157.330	20
1982	253	22:17:41	13822.860	20	30157.290	20	13822.870	20	30157.320	20
1982	253	22:19:21	13822.860	10	30157.280	30	13822.870	20	30157.310	20
1982	253	22:20:59	13822.860	20	30157.270	20	13822.870	20	30157.310	20
1982	253	22:22:39	13822.860	20	30157.270	20	13822.890	20	30157.290	20
1982	253	22:24:17	13822.860	20	30157.260	10	13822.870	20	30157.300	20
1982	253	22:25:57	13822.870	20	30157.270	20	13822.880	20	30157.310	20
1982	253	22:27:35	13822.870	20	30157.270	20	13822.880	20	30157.310	20
1982	253	22:29:15	13822.880	20	30157.280	20	13822.880	20	30157.310	20
1982	253	22:30:53	13822.870	20	30157.280	20	13822.870	20	30157.320	20
1982	253	22:32:33	13822.880	20	30157.280	10	13822.880	20	30157.310	20
1982	253	22:34:12	13822.870	20	30157.290	10	13822.880	20	30157.310	20
1982	253	22:35:51	13822.880	20	30157.300	20	13822.890	20	30157.330	20
1982	253	22:37:29	13822.890	20	30157.290	20	13822.900	20	30157.310	20
1982	253	22:39: 9	13822.870	20	30157.290	20	13822.880	20	30157.310	20
1982	253	22:40:47	13822.870	20	30157.290	20	13822.880	20	30157.310	20
1982	253	22:42:27	13822.870	20	30157.300	20	13822.880	20	30157.310	20
1982	253	22:44: 5	13822.880	20	30157.290	20	13822.890	20	30157.310	20
1982	253	22:45:45	13822.890	20	30157.290	20	13822.900	20	30157.320	20
1982	253	22:47:24	13822.870	20	30157.300	20	13822.890	20	30157.320	20
1982	253	22:49: 3	13822.870	20	30157.300	20	13822.870	30	30157.300	20
1982	253	22:50:42	13822.870	20	30157.320	20	13822.890	20	30157.340	20
1982	253	22:52:21	13822.870	20	30157.320	20	13822.890	20	30157.330	20
1982	253	22:54: 0	13822.870	20	30157.320	20	13822.880	20	30157.330	20
1982	253	22:55:39	13822.860	20	30157.310	20	13822.880	20	30157.330	20
1982	264	1:27:40	13822.887	17	30157.244	17	13822.922	19	30157.287	18
1982	264	1:28:24	13822.898	18	30157.258	23	13822.925	16	30157.298	23
1982	264	1:29: 8	13822.888	21	30157.239	18	13822.916	15	30157.295	18
1982	264	1:29:52	13822.901	18	30157.252	12	13822.908	20	30157.294	23
1982	264	1:30:35	13822.895	23	30157.244	19	13822.913	19	30157.289	20
1982	264	1:31:19	13822.895	21	30157.256	21	13822.911	14	30157.280	17
1982	264	1:32: 3	13822.889	18	30157.255	11	13822.921	22	30157.303	20
1982	264	1:32:47	13822.893	28	30157.252	24	13822.914	18	30157.290	20
1982	264	1:33:31	13822.903	19	30157.256	18	13822.906	19	30157.290	22
1982	264	1:34:15	13822.901	13	30157.250	13	13822.917	13	30157.290	14

Table 2.2 UNB Format Monitor Data Records

Table 2.2. Each record contains the actual TD reading to the nearest nanosecond for both TDs for both receivers for each time. The year, day, hour, minute and second are recorded for every record. On day 273, at hour 21, minute 12, the sample size was again increased to 150, with the resolution remaining at 1 nanosecond. Table 2.3 summarizes the different

Time Span	Resolution (nsec)	Data Interval in seconds (sample size)
218.00 - 251.08	10	186 (150)
251.17 - 253.23	10	98 (75)
264.01 - 273.21	1	44 (30)
273.21 - 291.10	1	186 (150)
292.12 - 292.19	1	44 (30)

TABLE 2.3
Monitor Data Frequency and Resolution.

sample sizes and resolutions used to record the data at the monitor. The effect of these different frequencies and resolution show clearly on the sample plots in Chapter 4.

Figure 2.3 shows the periods for which monitor data was recorded. Notice the gaps in places which leaves some remote site visits without monitor data to form the differential observable.

Similarly, Figure 2.4 shows when data at the remote sites were observed. Table 2.4 gives an overall summary of the data observed at the remote sites. A sample size of 30 gave a data record at each van site every (approximately) 38 seconds. Only on the last visit to the van sites (days 264 to 268) were sample standard deviations recorded. This visit also increased the recording resolution from 10 nsec to 1 nsec.

Helicopter sites used a sample size of 20 to give one data record every (approximately) 27 seconds. The last three visits included sample standard deviations and a 1 nsec resolution. In addition, several

Figure 2.3 Calendar of Monitor Data

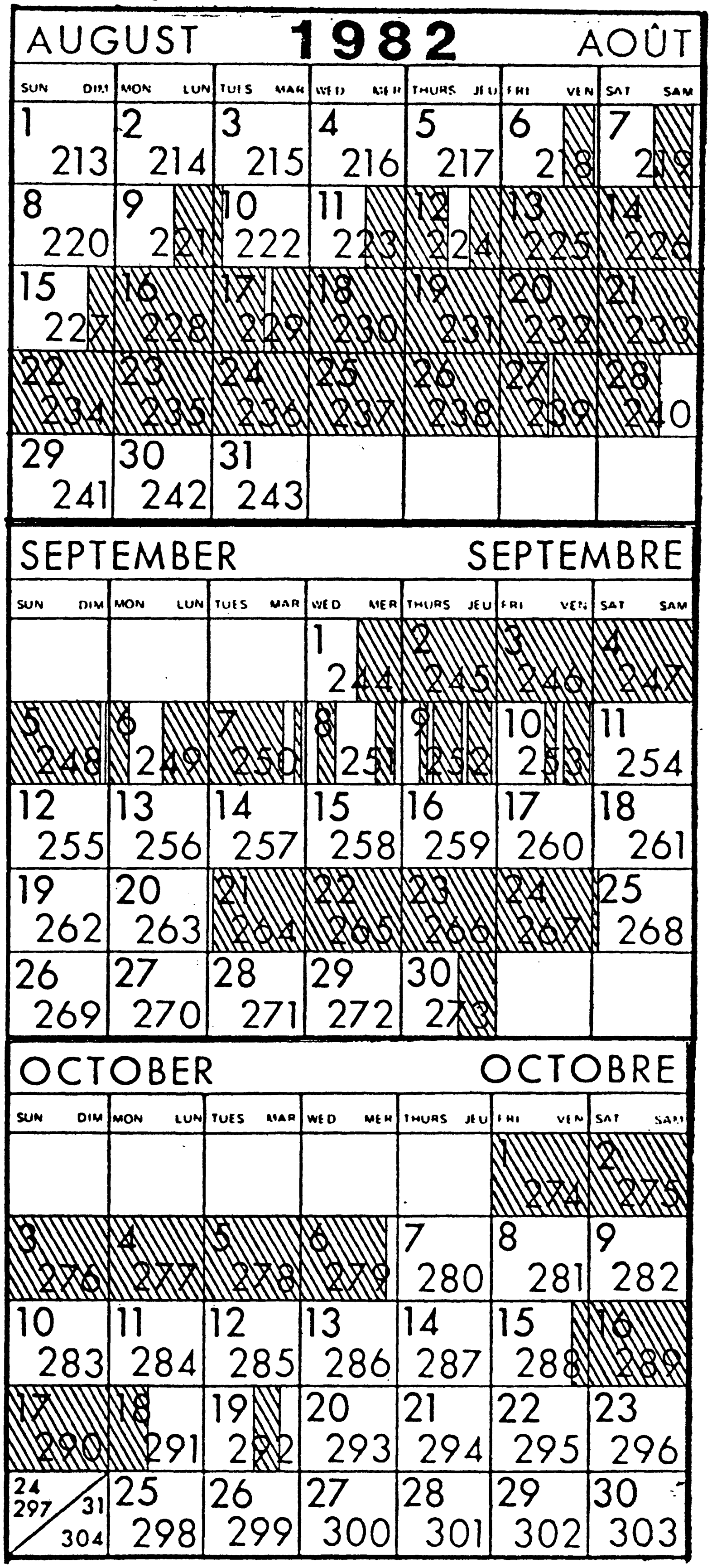


Figure 2.4 Calendar of Remote Site Data

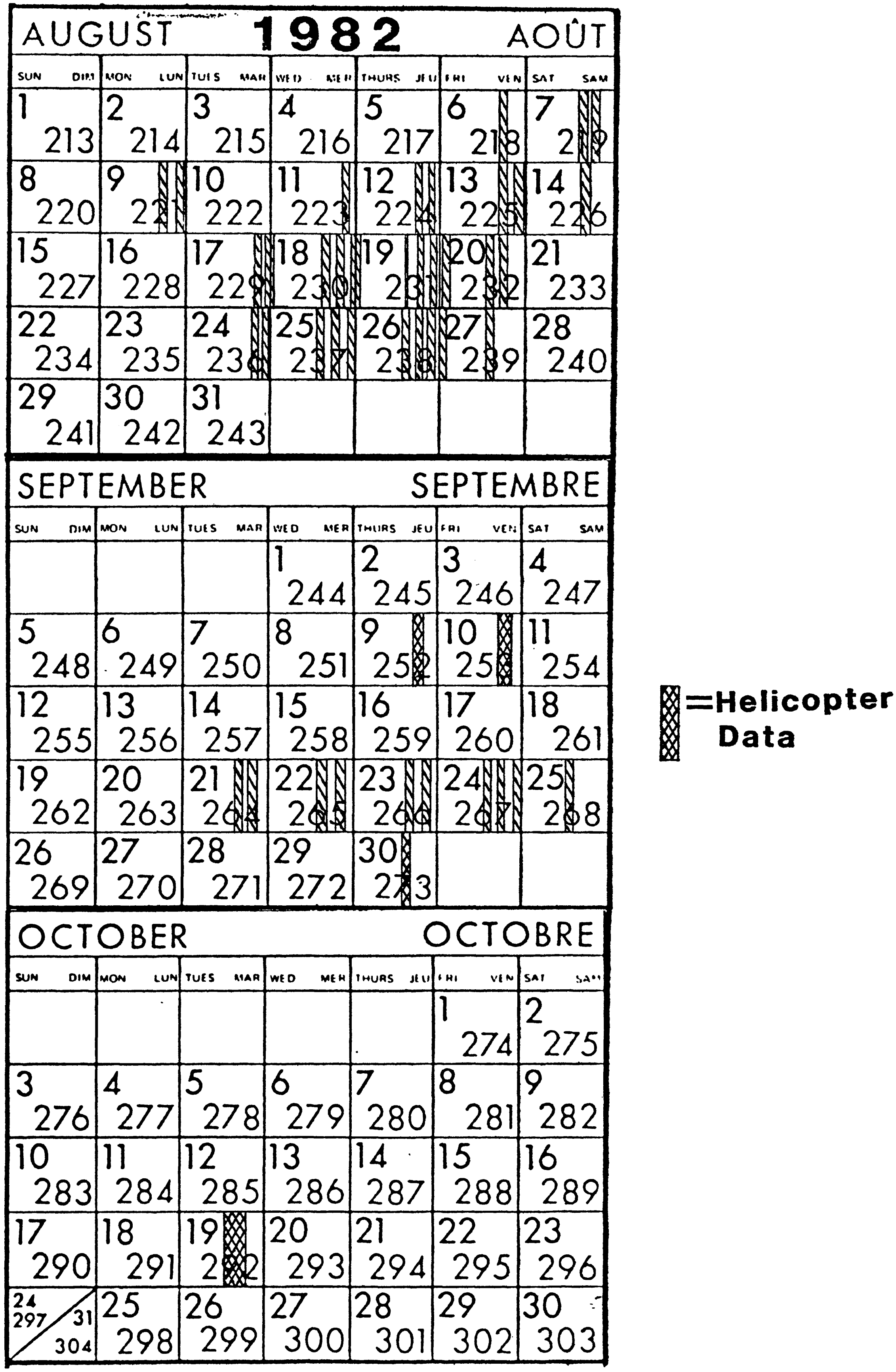


TABLE 2.4

Remote Site Data Summary

Site	Visit 1		Visit 2		Visit 3		Visit 4		Visit 5	
	From	To	From	To	From	To	From	To	From	To
1. Lower Prospect	218.1723	218.1929	229.1925	229.2131	236.1831	236.2037	264.1413	264.1649		
	219.1454	219.1701								
2. Peggy's Cove	219.1821	219.2028	229.2247	230.0053	236.2140	236.2346	264.1803	264.2014		
3. Blandford	221.1632	221.1840	230.1346	230.1553	237.1305	237.1519	265.1415	265.1626		
4. Battery Point	221.2059	221.2305	230.1847	230.2030	237.1710	237.1916	265.1905	265.2115		
5. Dublin Shore	223.1958	223.2204	230.2316	231.0136	237.2206	238.0012	266.1431	266.1641		
6. Medway Head	224.1619	224.1825	231.1402	231.1441	238.1322	238.1528	266.1923	266.2133		
			231.1713	231.1848						
7. Western Head (Liverpool)	224.2012	224.2218	231.2113	231.2319	238.1701	238.1907	267.1246	267.1456		
8. Port Joli Harbour	225.1624	225.1842	232.0044	232.0250	238.2029	238.2236	267.1631	267.1841		
9. Western Head (Lockeport)	225.2117	225.2323	232.1657	232.1903	238.2353	239.0160	267.2128	267.2338		
10. Ingomar Cemetary	226.1535	226.1741	232.1252	232.1458	239.1301	239.1507	268.1207	268.1423		
11. Devils Island Light	252.1754	252.1756	252.1915	252.1918	273.1411	273.1417	292.1230	292.1236	292.1840	292.1846
12. Sambro Island Light	252.1805	252.1807	252.1906	252.1909	273.1426	273.1432	292.1244	292.1250	292.1828	292.1833
13. Betty Island Light	252.1815	252.1817	252.1857	252.1859	273.1439	273.1446	292.1258	292.1304	292.1815	292.1821
14. Peggys Point Buoy	252.1825	252.1827	252.1849	252.1851	273.1453	273.1456	292.1311	292.1314		
15. Horshoe Ledge Buoy	252.1830	252.1832	252.1845	252.1847	273.1501	273.1504	292.1317	292.1320		
16. Pearl Island Light	252.1838	252.1840	253.1703	253.1707	273.1509	273.1516	292.1326	292.1332	292.1759	292.1806
17. Mosher Island Light	253.1719	253.1723	253.2040	253.2045	273.1527	273.1533	292.1343	292.1349	292.1743	292.1748
18. Coffin Island Light	253.1759	253.1803	253.2025	253.2029	273.1548	273.1552	292.1405	292.1409	292.1727	292.1732
19. White Point Rock Buoy	253.1839	253.1841	253.2015	253.2017			292.1511	292.1514	292.1652	292.1654
20. Little Hope Island Light	253.1848	253.1853	253.2004	253.2009			292.1520	292.1526	292.1641	292.1646
21. Gull Rock Island Light	253.1907	253.1912	253.1948	253.1954			292.1540	292.1546	292.1625	292.1631
22. Jig Rock Buoy	253.1920	253.1922	253.1940	253.1942			292.1553	292.1556	292.1615	292.1618
23. Budget Rock Buoy	253.1928	253.1930	253.1933	253.1936			292.1602	292.1605	292.1607	292.1610

Note: Times are given in DAY.HHMM where HH = hour, MM = minute.

"flyovers" (see Section 3.3) were made at Coffin Island during the third and fourth visits.

Plotting of the statistical summary data used distance from the monitor as the abscissa axis (see Chapter 5). Distances of the remote sites as scaled from a 1:633 600 map of the Maritimes are listed in Table 2.5.

Site	Distance (km)	Site	Distance (km)
1	15.2	11	11.4
2	29.8	12	6.3
3	46.3	13	19.0
4	61.5	14	30.4
5	69.7	15	35.5
6	90.6	16	42.5
7	102.0	17	67.8
8	128.0	18	100.1
9	156.5	19	114.7
10	178.4	20	124.8
		21	155.2
		22	162.8
		23	182.5

TABLE 2.5
Remote Site Distances from the Monitor.

2.1 Software for Data Handling

Recorded data at both Ketch Harbour monitor and remote sites (in particular that recorded at the "van" sites) contained many garbage characters and generally "unclean" data records. Program COPYCCG was written in FORTRAN (IBM FORTRAN 77 compiler) to clean the data as it was read from the raw data tape and copied to an intermediate disk file. This program has switches to select the following options:

(1) copy monitor data or van site data,

(2) copy new or old format data (old format records TDs only to the nearest 10 nsec).

FORTRAN program COPXCCG was written to copy "clean" keypunched helicopter data from card image files to intermediate disk files. Out of sequence time tags for records were corrected by a FORTRAN program SEQUENCE. Data records were copied to special TSIO [IBM, 1977] files for the plotting and statistical software using FORTRAN program MAKETSIO. A short FORTRAN program called DUMP was written to dump the intermediate data files to the printer. Figure 2.5 summarizes these programs and files. Note that there is a different intermediate and TSIO file for the monitor, each van site, and each helicopter site. Listings of these programs are given in Appendix IV.1.

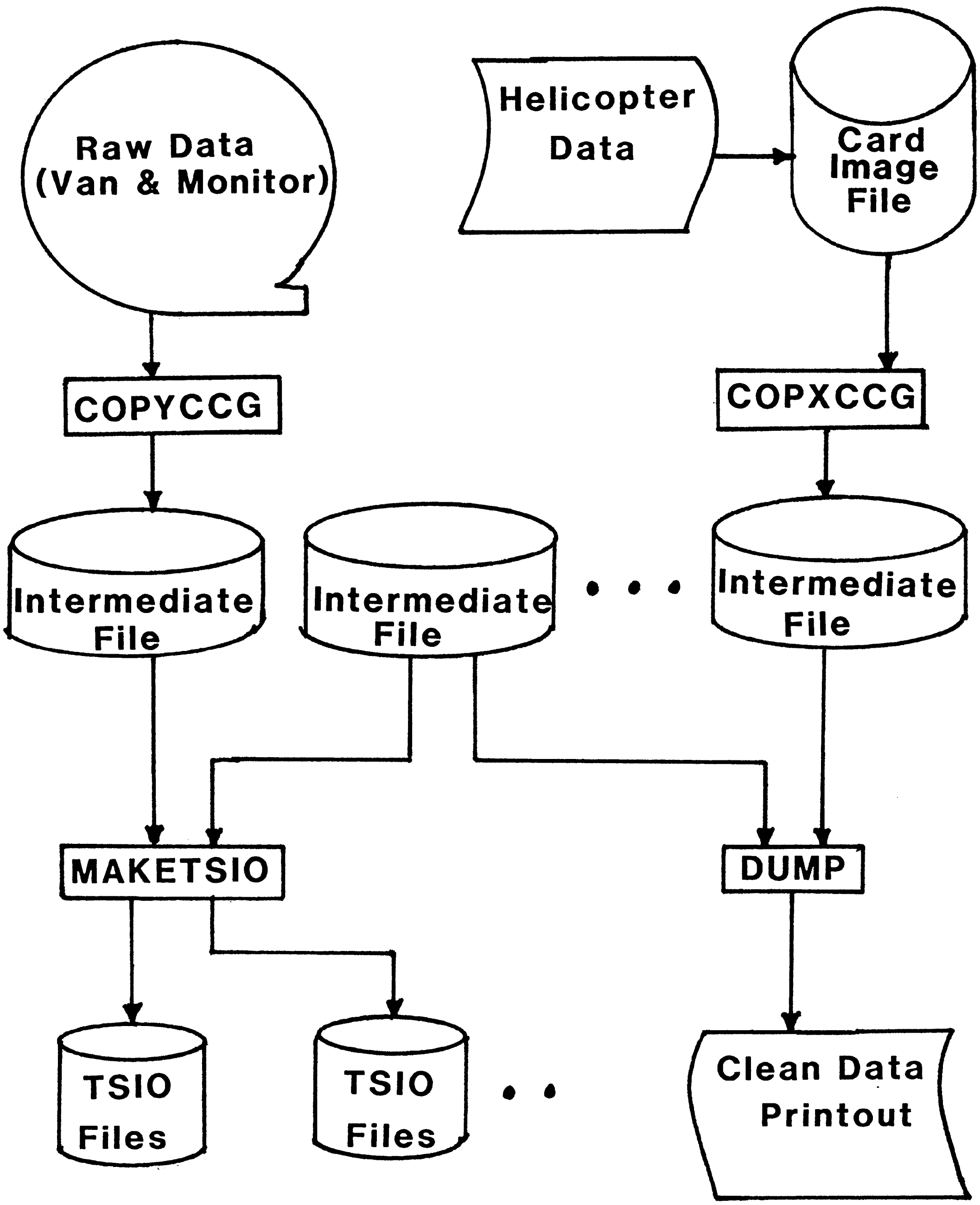


Figure 2.5 Data Handling Software

CHAPTER 3

METHOD OF ANALYSIS

Data at all 23 remote sites were both plotted and analysed statistically. Raw time difference (TD) data was plotted for all sites (including the Ketch Harbour monitor). Note that this raw data is already the mean of a number of samples as described in Chapter 2. In addition, the TD difference between remote sites and the monitor was plotted. Both the raw TDs and TD differences were statistically analysed to determine both their precision during a single visit, and their repeatability for visits at different times. A discussion of the plotting results is contained in Chapter 4. Chapter 5 discusses the statistical results. The actual mathematical models and methods used to obtain the results are discussed here.

3.1 Plotting

Each raw data point was plotted as read from the raw data tapes. Instead of a corrected TD, the difference ΔTD_i between TDs recorded at a remote site and those recorded at the monitor for the same time were plotted. This difference shows exactly the same signal structure as would a corrected TD as is shown by the following simple example:

$$\Delta TD_i = TD_i - TD_i^m \quad , \qquad (3.1)$$

where

ΔTD_i = difference between remote and monitor TD readings at time i,

TD_i = TD reading at the remote site at time i,

TD_i^m = TD reading at the monitor site at time i.

A corrected TD reading can be written as

$$TD_i^{corr} = TD_i - (TD_i^m - \overline{TD}^m) \quad , \qquad (3.2)$$

where

TD_i^{corr} = corrected TD reading at time i,

$\overline{TD}^m$ = average monitor TD established prior to the observing period.

Note that $TD_i^{corr} = \Delta TD_i + \overline{TD}^m$ is simply translated by the amount $\overline{TD}^m$.

One problem with this technique is that the remote data and monitor data were recorded at different times. This necessitated interpolating the monitor data between two times as shown in Figure 3.1. In the figure, monitor data is recorded every fifth time instant, and remote data is recorded every second time instant. To calculate the monitor data value using linear interpolation for time 2, the following equation is used:

$$TD_2^m = TD_1^m + \frac{(t_2 - t_1)}{(t_6 - t_1)} (TD_6^m - TD_1^m) \quad , \qquad (3.3)$$

where t_i = time at instant i. Generalizing this to times i, j and k gives

$$TD_i^m = TD_j^m + \frac{(t_i - t_j)}{(t_k - t_j)} (TD_k^m - TD_j^m) \quad , \qquad (3.4)$$

where

t_i = time of remote site observation,

t_j = time of first monitor site observation before time t_i,

t_k = time of the first monitor site observation after time t_i.

This is how the TD_i^m was obtained for use in (3.1) to compute the difference data to be plotted.

3.2 Statistics

The statistical summaries contained in Chapter 5 summarize the raw data for both monitor receivers, the remote site raw data and the remote site difference data. Besides the mean values for the different visits, and the number of observations made during each visit, data is listed under the

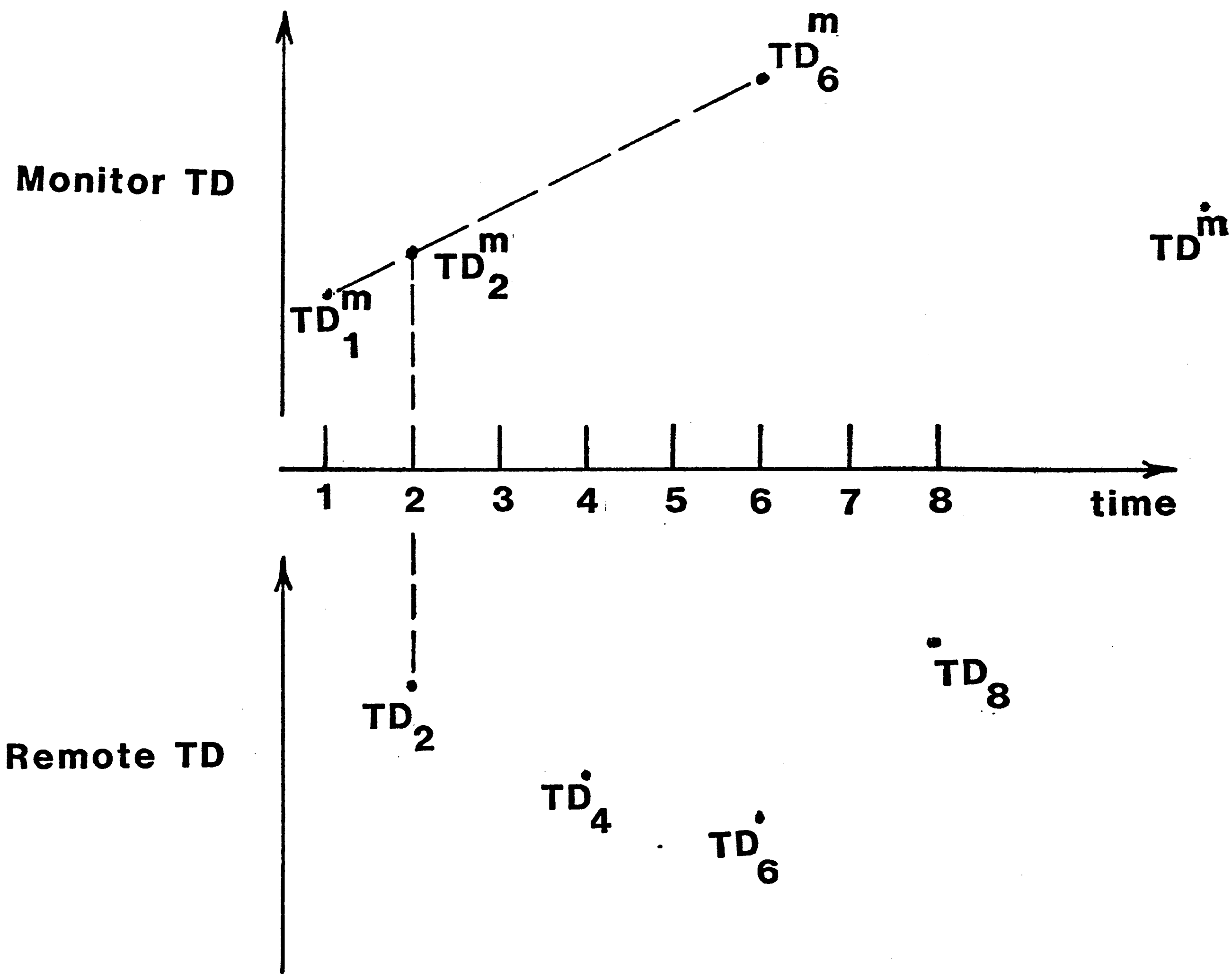


Figure 3.1 Monitor Data Linear Interpolation

headings SD1, SD2, DEL1, DEL2, and RHO.

SD1 is the actual standard deviation of the sample for the given time span and is computed as

$$SD1 = \left[\frac{1}{NUM-1} \sum_{i=1}^{NUM} (TD_i - \overline{TD})^2\right]^{1/2} \tag{3.5}$$

where

TD_i = raw TD value for time t_i (note that this could also be a monitor TD_i^m or a difference ΔTD_i value),

$\overline{TD}$ = mean TD value for the given time span,

NUM = number of data samples recorded in the given interval.

The mean value SD1 is computed as the standard deviation of all of the visits to the site (usually 4 or 5). This mean SD1 shows the spread of the mean values overall of the visits, and is the one single indicator which best shows the accuracy of determination of the mean TD. It is computed as

$$\overline{SD}1 = \frac{1}{NV-1} \sum_{i=1}^{NV} (\overline{TD}_i - \overline{TD}) \quad , \tag{3.6}$$

where

NV = number of visits,

$\overline{TD}$ = mean of all the visits to this site,

$\overline{TD}_i$ = mean for visit i to the site.

SD2 accounts for both the sample standard deviation given above, <u>plus</u> the indicated standard deviations recorded with the raw data. As indicated in Appendix I, this is the same as treating each individual observed TD before the sample average is taken as the observation. Equation (I.16) is used to compute SD2 as

$$SD2 = \left[(SD1)^2 + \frac{1}{NUM} \sum_{i=1}^{NUM} S_i^2\right]^{1/2}, \tag{3.7}$$

where S_i = standard deviation recorded with the raw data, or computed for the difference data as shown in equations (3.9) and (3.10) below.

The mean SD2 is computed treating the mean SD1 as the sample variance, and adding the individual visit SD2 variance computed according to (3.7), i.e.,

$$\overline{SD}2 = [(\overline{SD}1)^2 + \frac{1}{NV} \sum_{i=1}^{NV} (SD2)_i^2]^{1/2} \quad , \qquad (3.8)$$

for NV = number of visits to this site.

When computing SD2 for the <u>difference</u>, a simple error propagation applied to (3.1) gives the standard deviation of the difference $S_{\Delta TD_i}$ as

$$S_{\Delta TD_i} = [S^2_{TD_i} + S^2_{TD^m_i}]^{1/2} \quad , \qquad (3.9)$$

where

S_{TD_i} = recorded standard deviation of the remote TD at time i,

$S_{TD^m_i}$ = standard deviation of the monitor TD at time i.

Since TD^m_i is computed via (3.4), an error propagation must be done on (3.4) to obtain $S_{TD^m_i}$. This gives

$$S_{TD^m_i} = \{[1 - \frac{(t_i - t_j)}{(t_k - t_j)}]^2 \; S^2_{TD^m_j} + [\frac{(t_i - t_j)}{(t_k - t_j)}]^2 \; S^2_{TD^m_k}\}^{1/2} \qquad (3.10)$$

where

$S_{TD^m_j}$, $S_{TD^m_k}$ = recorded standard deviations of the monitor at times t_j and t_k respectively,

t_i, t_j, t_k = as explained in (3.4).

This $S_{TD^m_i}$ is then used in (3.9) to compute $S_{\Delta TD_i}$ for use in (3.7) when calculating SD2 for the difference data.

The columns labelled DEL1 and DEL2 list the difference of this visit's mean value from the overall mean value, and from the first visit's mean value, respectively. In equation form

$$DEL1_v = \bar{TD}_v - \bar{TD} \quad , \tag{3.11}$$

where

v = visit number,

$\bar{TD}$ = overall mean for all visits.

Note that $\bar{TD}$ is listed at the bottom of each section of the statistics summaries under mean value. The DEL2 values are computed as

$$DEL2_v = \bar{TD}_v - \bar{TD}_1 \quad , \tag{3.12}$$

i.e., the difference from the mean value of the first visit.

The column labelled RHO contained the <u>correlation</u> between the TDA and TDB channels for all the data types (monitor, remote, and difference). Each RHO is computed as

$$RHO = \frac{1}{NUM} \sum_{i=1}^{NUM} (TDA_i - \bar{TDA})(TDB_i - \bar{TDB}) \quad , \tag{3.13}$$

where

TDA_i, TDB_i = recorded TD for channels A and B respectively,

$\bar{TDA}$, $\bar{TDB}$ = mean values of channel A and B TDs for the given time span.

Using the computed RHO enables the computation of the <u>covariance matrix</u> for the computed TDA, TDB average values. This covariance matrix is given as

$$C_{TD} = \begin{bmatrix} (SD1)^2_{TDA} & SAB \\ SAB & (SD1)^2_{TDB} \end{bmatrix} \tag{3.14}$$

where

$SAB = RHO \times (SD1)_{TDA} \times (SD1)_{TDB}$ = covariance between A and B channels.

3.3 Helicopter Flypast Algorithms

Some observations at Coffin Island were made with the helicopter flying along two or more straight lines, the intersection of which gives the buoy position. This method eliminates any error due to time lag of the LORAN-C receiver whereby the reading at a time t_i corresponds to the position at time $t_i - \Delta t$.

Two algorithms were developed to derive the buoy position relative to the monitor station at LORAN-C coordinates. Both model the observation points in each flypast line as a straight line, and then find the intersection of the straight lines. Both methods can accept any number of points in a line, and any number of straight lines, the result being that of a least-squares fit. The first method considers each flypast line separately, finding a straight line which gives the least-squares fit to the observation points. The equations for the straight lines are then used to give the least-squares estimate of the intersection. The second method considers all the observations simultaneously, finding a least-squares estimate of the intersection and the slopes of each flypast line.

In order to account for the differential LORAN-C correction, two possibilities are available. One would be to perform the solution for the buoy position from the flypast data, without taking the differential corrections into account, and afterwards to apply some mean differntial correction based on the behavior of the signal at the monitor station during the entire flypast interval. This ignores, or at least smooths over, any time variation in the LORAN-C signal (which should have common effects at both monitor and helicopter) which may occur during the flypast procedure. Consequently here we have proceeded differently. Each TD observation made on the helicopter during the flypast was first differenced with an equivalent observation made at the monitor (obtained by interpolation as explained in Section 3.1), and these TD differences were then subjected to the algorithm described below.

3.3.1 Mathematical models

Method 1

Each flypast line is considered separately to produce a slope and an intercept. The mathematical model for the jth flypast line is

$$F_{ij} = a_j \, TDA_{ij} + b_j - TDB_{ij} = 0 \quad , \qquad (3.15)$$

where

a_j = slope of the jth flypast line (unknown),

b_j = intercept of the jth flypast line (unknown),

TDA_{ij}, TDB_{ij} = observations for point i, on flypast line j,

(i = 1,2,...m).

Using standard least-squares methods and notation [Vanicek and Krakiwsky, 1982]

First design matrix $\underset{(m,2)}{[A]} = \frac{\partial F}{\partial(a,\ b)} = \begin{bmatrix} TDA_{1j}, & 1 \\ TDA_{2j}, & 1 \\ \vdots & \\ TDA_{mj}, & 1 \end{bmatrix}$

Second design matrix $\underset{(m,2m)}{[B]} = \frac{\partial F}{\partial \ell} = \begin{bmatrix} a_j, & -1, & 0, & 0, & \dots & 0, & 0 \\ 0, & 0, & a_j, & -1, & \dots & 0, & 0 \\ & \vdots & & & & & \\ 0, & 0, & 0, & 0, & \dots & a_j, & -1 \end{bmatrix}$

Misclosure vector $\underset{(m,1)}{[w]}$ = $$\begin{bmatrix} a_j\ TDA_{1j} + b_j - TDB_{1j} \\ a_j\ TDA_{2j} + b_j - TDB_{2j} \\ \vdots \\ a_j\ TDA_{mj} + b_j - TDB_{mj} \end{bmatrix}$$

The resulting least-squares solutions

$$\begin{bmatrix} a \\ b \end{bmatrix} = \begin{bmatrix} a^o \\ b^o \end{bmatrix} - (A^T\ M^{-1}\ A)^{-1}(A^T\ M^{-1}\ w)$$

where $n = B\ C_l\ B^T$, for C_l = covariance matrix of the observations, and the covariance matrix $C_{(a,b)} = (A^T\ M^{-1}\ A)^{-1}$.

The straight lines are then combined to find the intersection point. The model is

$$G_j = a_j\ TDA + b_j - TDB = 0 \quad , j = 1,2,...p \qquad (3.16)$$

where a_j, b_j are the slope and intercept of the jth straight line (now treated as observations) and TDA, TDB are the required intersection points (in this step the unknowns).

First design matrix $\underset{(p,2)}{[A]} = \frac{\partial G}{\partial(TDA,TDB)}$ = $$\begin{bmatrix} a_1, & -1 \\ a_2, & -1 \\ & \vdots \\ a_p, & -1 \end{bmatrix}$$

Second design matrix $\underset{(p,2p)}{[B]} = \frac{\partial G}{\partial \ell}$ = $$\begin{bmatrix} TDA, & 1, & 0, & 0, & \dots & 0, & 0 \\ 0, & 0, & TDA, & 1, & \dots & 0, & 0 \\ & \vdots \\ 0, & 0, & 0, & 0, & \dots & TDA, & 1 \end{bmatrix}$$

Misclosure vector $\underset{(p,1)}{[w]}$ = $$\begin{bmatrix} a_1\ TDA^{(o)} + b_1 - TDB^{(o)} \\ a_2\ TDA^{(o)} + b_2 - TDB^{(o)} \\ \vdots \\ a_p\ TDA^{(o)} + b_p - TDB^{(o)} \end{bmatrix}$$

The covariance of the slopes a_j and intercepts b_j were derived in the first part of this method. Standard results then give

$$\begin{bmatrix} TDA \\ TDB \end{bmatrix} = \begin{bmatrix} TDA^{(o)} \\ TDB^{(o)} \end{bmatrix} - [A^T M^{-1} A]^{-1} [A^T M^{-1} w]$$

with the covariance matrix

$$C_{(TDA,TDB)} = (A^T M^{-1} A)^{-1}$$

Method 2

Each observation point is considered relative to the intersection point and the slope of its respective straight line. The model is:

$$a_j = \frac{TDB_i - TDB}{TDA_i - TDA} \tag{3.17}$$

where TDA,TDB = the required intersection point,

TDA_i, TDB_i = the ith observation point,

a_j = the slope of the jth straight line.

The model formulation becomes

$$F_i = (TDA_i - TDA)\, a_j - (TDB_i - TDB) = 0 \ , i = 1,2,\ldots m, \quad j = 1,2,\ldots p. \tag{3.18}$$

The first design matrix

$$\underset{(m,p+2)}{[A]} = \frac{\partial F}{\partial (TDA, TDB, a_j)} = \begin{bmatrix} -a_1, 1, (TDA_1 - TDA), 0, \ldots 0 \\ -a_1, 1, (TDA_2 - TDA), 0, \ldots 0 \\ \vdots \\ -a_2, 1, 0, (TDA_k - TDA), \ldots 0 \\ \vdots \\ -a_p, 1, 0, 0, \ldots (TDA_m - TDA) \end{bmatrix}$$

The second design matrix is

$$\underset{(m,2)}{[B]} = \frac{\partial F}{\partial \ell} = \begin{bmatrix} a_1, & -1 \\ a_1, & -1 \\ & \vdots \\ a_2, & -1 \\ & \vdots \\ a_p, & -1 \end{bmatrix}$$

The misclosure vector is

$$[w]_{(m,1)} = \begin{bmatrix} (TDA_1 - TDA)\, a_1 - (TDB_1 - TDB) \\ (TDA_2 - TDA)\, a_1 - (TDB_2 - TDB) \\ \vdots \\ (TDA_m - TDA)\, a_p - (TDB_m - TDB) \end{bmatrix}$$

where all the above design matrices and misclosure vectors are evaluated at some initial approximation of the values of the unknown parameters involved. Standard least-squares adjustment then gives

$$\begin{bmatrix} TDA \\ TDB \\ a_1 \\ \vdots \\ a_p \end{bmatrix} = \begin{bmatrix} TDA^{(o)} \\ TDB^{(o)} \\ a_1^{(o)} \\ \vdots \\ a_p^{(o)} \end{bmatrix} - [A^T M^{-1} A]^{-1} A^T M^{-1} w$$

3.3.2 Results of Coffin Island flypasts

The two flypasts at Coffin Island were each analysed using both methods described above. Taking the differential corrections from monitor receivers s/n 1017 and s/n 2220 into account, the results are shown in Table 3.1.

TABLE 3.1

Coffin Island Flypast Results

	Monitor 1017		Monitor 2220	
	Method 1	Method 2	Method 1	Method 2
Visit 1				
TDX	-244.928 ± 0.015	-244.938 ± 0.006	-244.938 ± 0.014	-244.943 ± 0.006
TDY	411.258 ± 0.018	411.258 ± 0.007	411.266 ± 0.017	411.265 ± 0.007
Slopes	0.861 ± 0.016	0.848 ± 0.017	0.859 ± 0.016	0.848 ± 0.016
	0.833 ± 0.007	0.832 ± 0.011	0.832 ± 0.007	0.832 ± 0.011
	-2.858 ± 0.116	-2.807 ± 0.175	-2.841 ± 0.117	-2.785 ± 0.170
	-3.241 ± 0.156	-2.848 ± 0.122	-3.279 ± 0.159	-2.877 ± 0.123
Visit 2				
TDX	-244.919 ± 0.009	-244.888 ± 0.006	-244.930 ± 0.010	-244.906 ± 0.006
TDY	411.159 ± 0.014	411.167 ± 0.007	411.184 ± 0.014	411.189 ± 0.007
Slopes	-3.144 ± 0.040	-2.723 ± 0.125	-3.067 ± 0.044	-2.739 ± 0.122
	0.825 ± 0.018	0.769 ± 0.041	0.831 ± 0.018	0.776 ± 0.040
	0.739 ± 0.010	0.768 ± 0.014	0.741 ± 0.009	0.772 ± 0.013
	-2.360 ± 0.137	-2.359 ± 0.121	-2.385 ± 0.141	-2.383 ± 0.120

CHAPTER 4

PLOTTING RESULTS

All 32,858 of the actual data records obtained from both monitor and remote sites have been plotted (24,062 monitor records and 8796 remote site records). In addition, the differenced data between each remote measurement and the corresponding monitor measurements have been plotted.

4.1 Monitor Data Plots

Figure 4.1 is a plot of the monitor data for day 229 (17 August 1982) for TDB. Two plots are superimposed: data received by the Internav LC404 receiver s.n. 2220, and data received by Internav LC404 receiver s.n. 1017. TDA is the difference in time of arrival of the LORAN-C signal from the master (Caribou, Maine) and Nantucket, Massachusetts (also called TDX). TDB is the difference in time of arrival of the LORAN-C signal from the master and Cape Race, Newfoundland (also called TDY). In addition, Figure 4.1 demonstrates a plot with the 10 nsec resolution and 186 second recording interval plots. Blank spaces in the plots show where data was not recorded. All of the monitor data in Appendix V was plotted on a 24 hour, day-by-day, basis (see Figure 2.3). Figure 4.2 shows the data recorded on day 252 for TDA at 10 nsec resolution and at an interval of 98 seconds. Figure 4.3 is a plot of the data for TDB day 266. It clearly shows the effect of increasing the resolution to 1 nsec, and reducing the recording interval to 44 seconds. The sample monitor data plot in Figure 4.4 (day 289, TDB) shows the effect of a 1 nsec resolution recorded every 186 seconds.

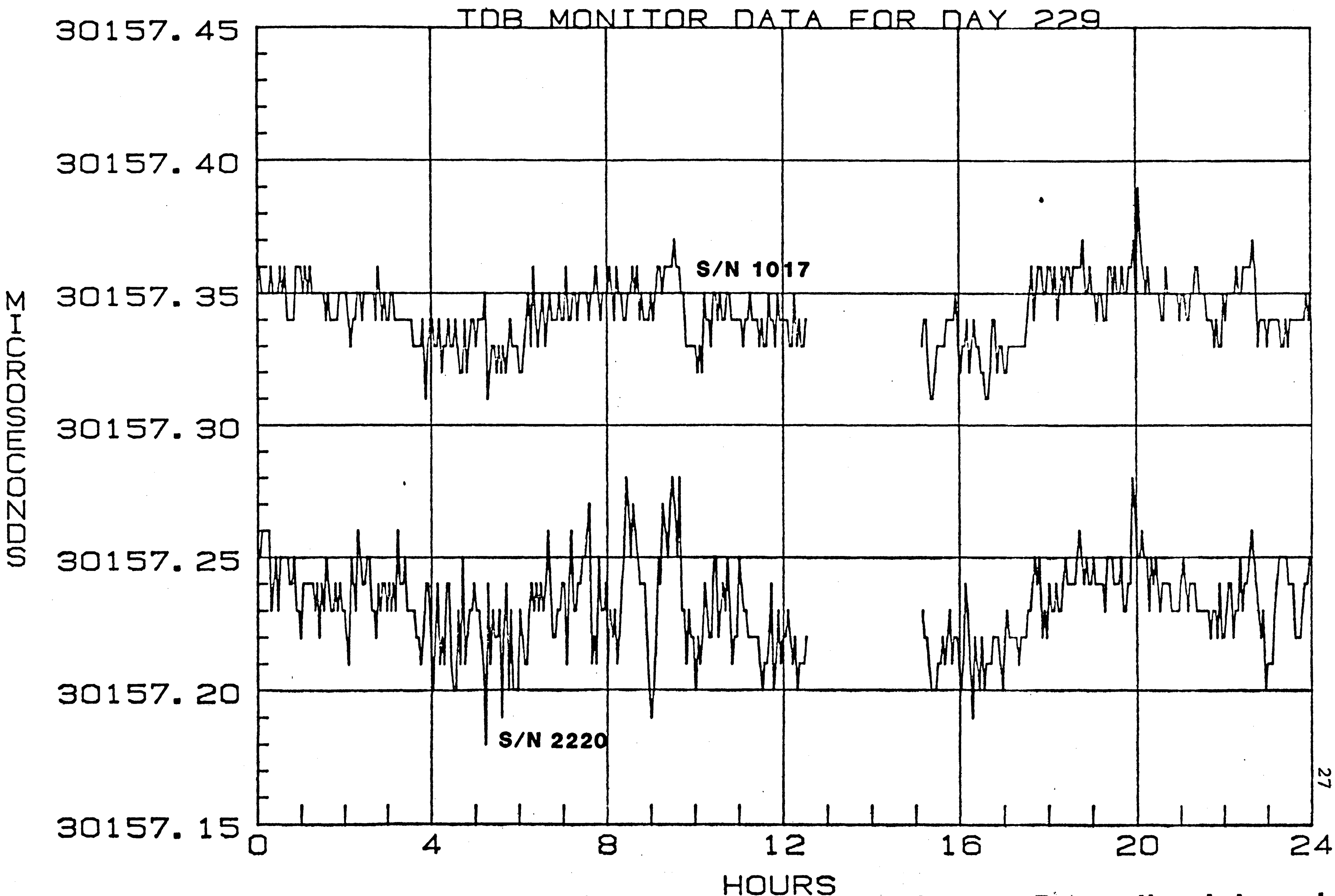


Figure 4.1 Monitor Data Plot at 10 nsec Resolution, 186 sec Recording Interval

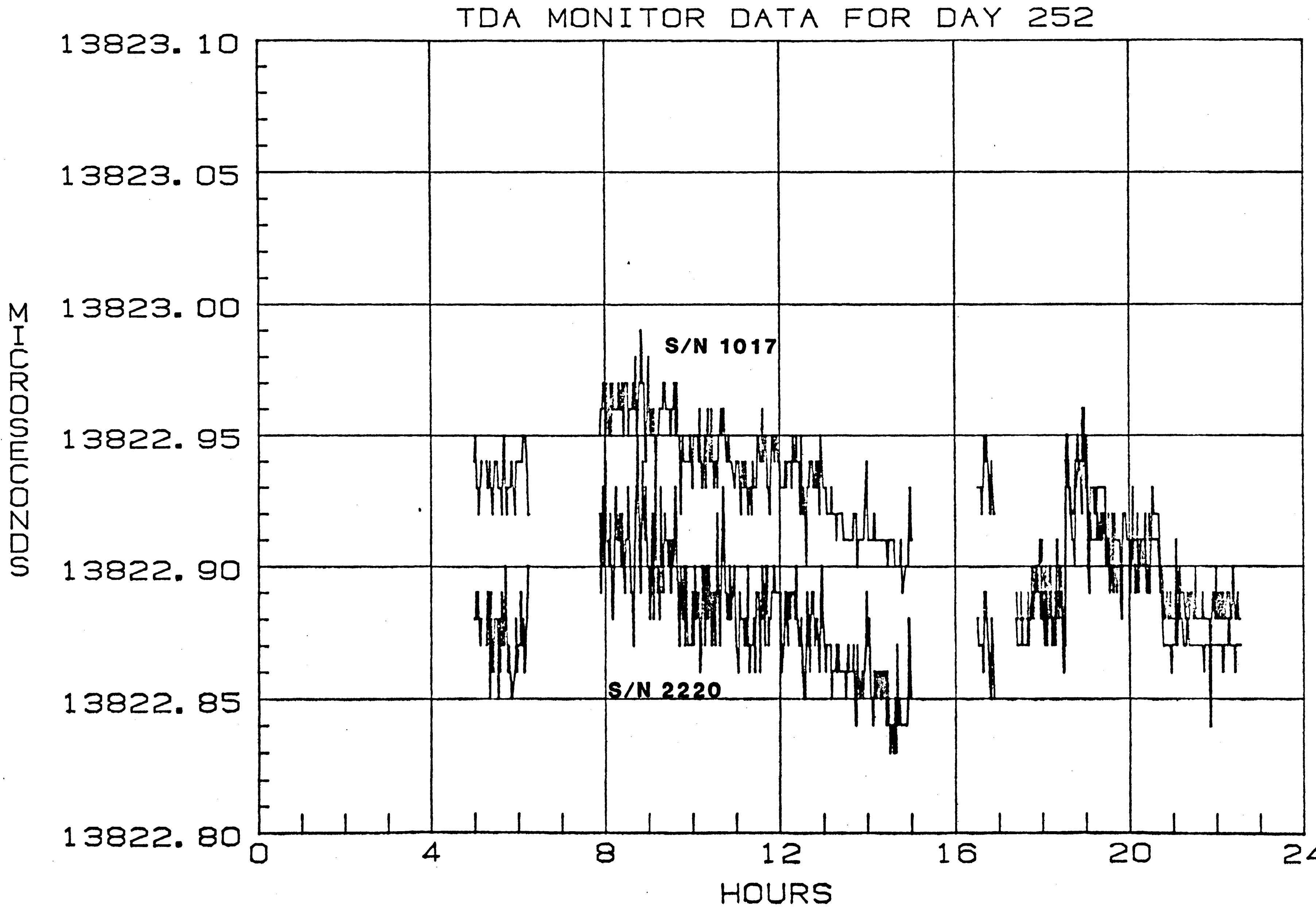


Figure 4.2 Monitor Data Plot at 10 nsec Resolution, 98 sec Recording Interval

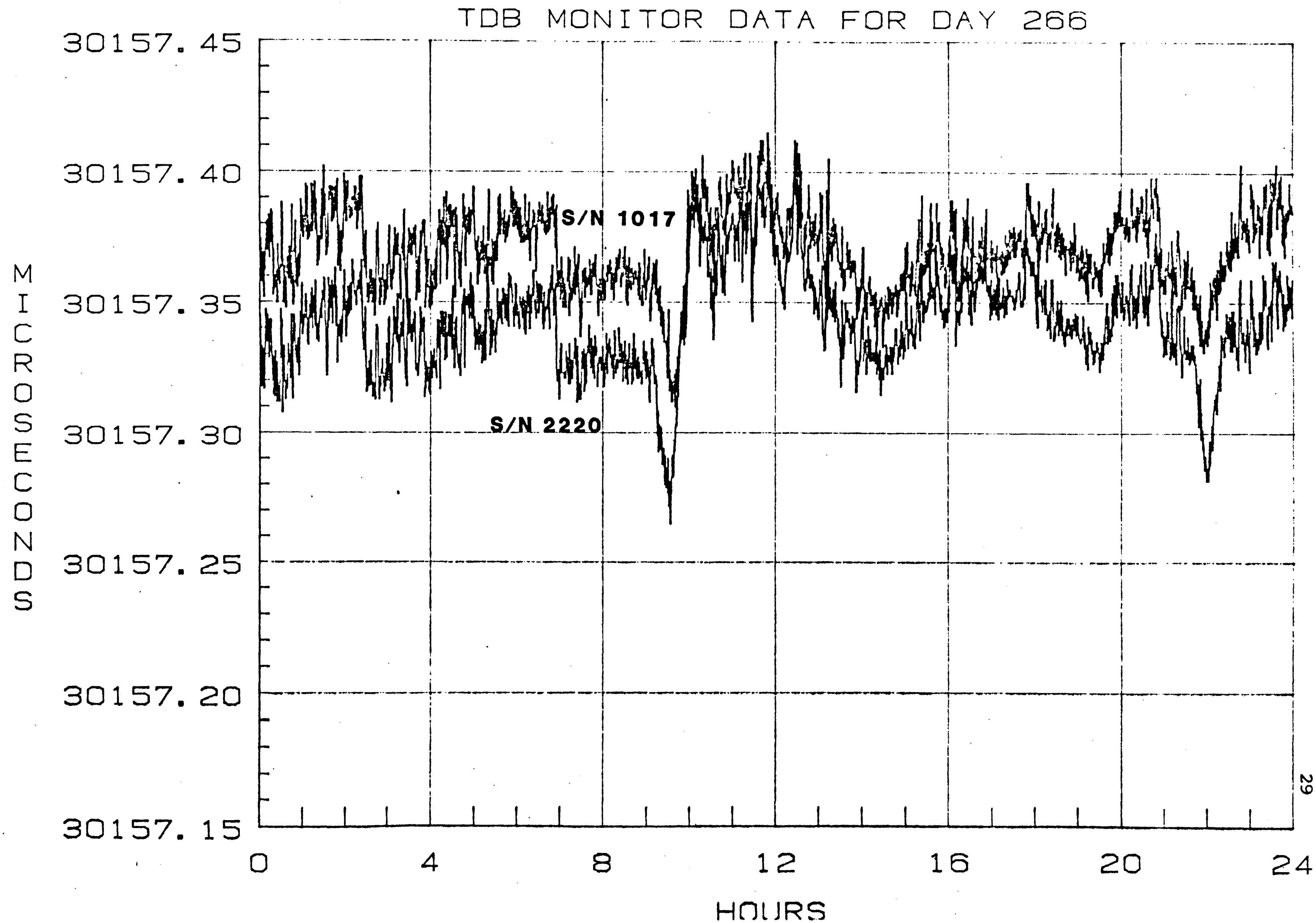


Figure 4.3 Monitor Data Plot at 1 nsec Resolution, 44 sec Recording Interval

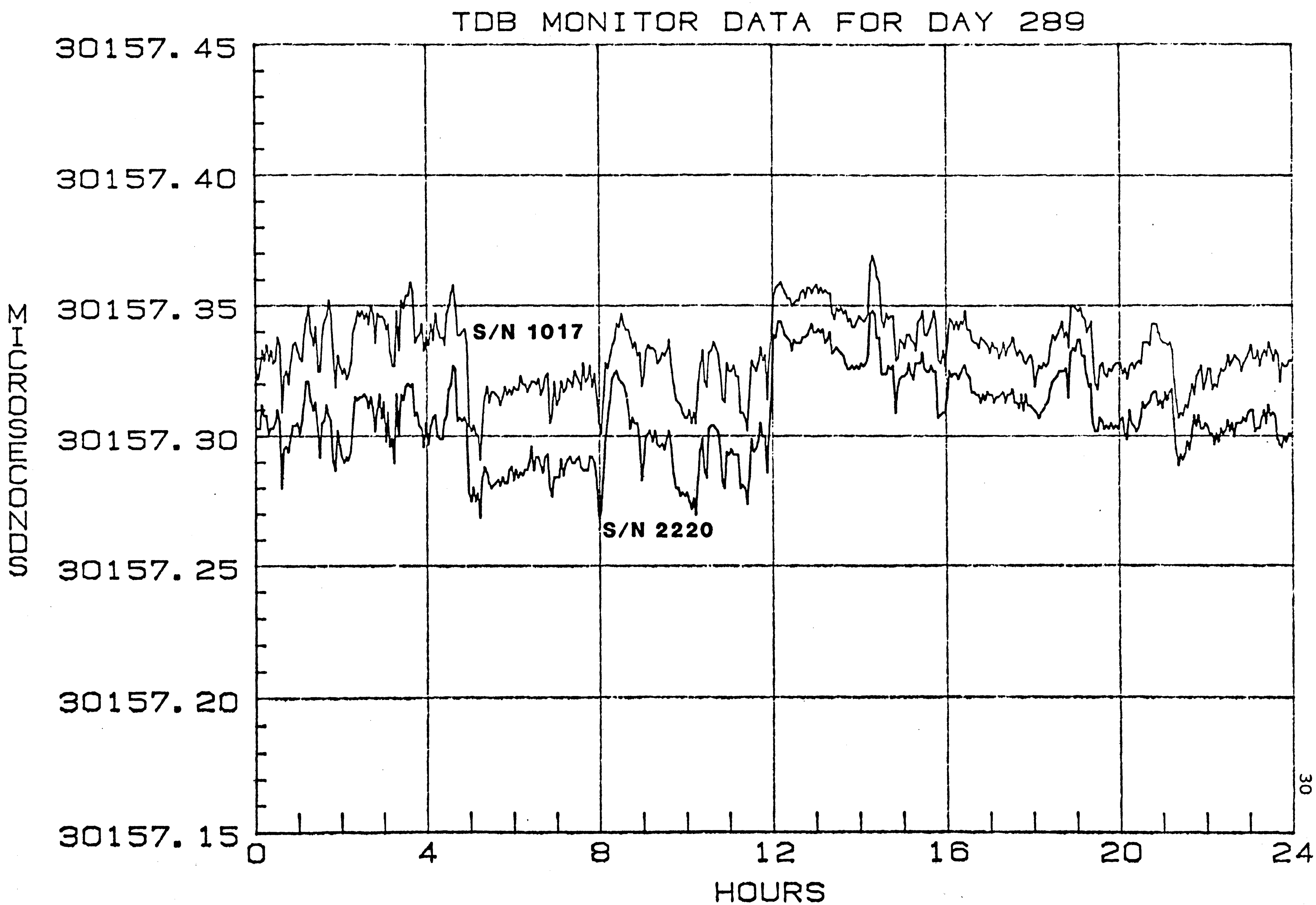


Figure 4.4 Monitor Data Plot at 1 nsec Resolution, 186 sec Recording Interval

4.2 Van Site Data Plots

Figure 4.5 shows the raw data plot for visit 1 to Ingomar Cemetary for TDA. All of the data for the 10 van sites has been plotted on a four hour time scale since only approximately 2 hours of data was recorded for each visit and to better show the signal structure. The 10 nsec resolution, and a recording interval of 38 seconds are depicted in Figure 4.5. Figure 7.1 shows a plot of van site data recorded at the 1 nsec resolution. Each visit to the site is plotted on a separate page.

A sample difference plot is shown in Figure 4.6. These differences are computed as explained in Chapter 3 (see equations (3.1) and (3.4)), and show how the corrected or differential data varies in time. It is this differential data which should vary more smoothly than the raw data recorded at the van site. The statistical analysis in Chapter 5 essentially verifies this. Two plots are shown: the difference between readings at the remote and at the monitor receiver s.n. 2220; and the difference between the readings at the remote and at the monitor receiver s.n. 1017. Appendix VI contains all of the data plots for all visits to all 10 van sites.

4.3 Helicopter Data Plots

A maximum of 8 minutes of data were recorded during one visit to any helicopter site. All visits to a single helicopter site were plotted on one page, with one page for TDA channel, and a second page for TDB. The axis labels on the bottom show the day, hour, and minute during which the different visits (see Table 2.4) were made. For example, in Figure 4.7, the first visit was made during day 253, hour 17 from minute 19 to minute 23 (approximately). This shows very clearly how the raw data changes from visit to visit. The helicopter difference plots (see Figure 4.8) show how

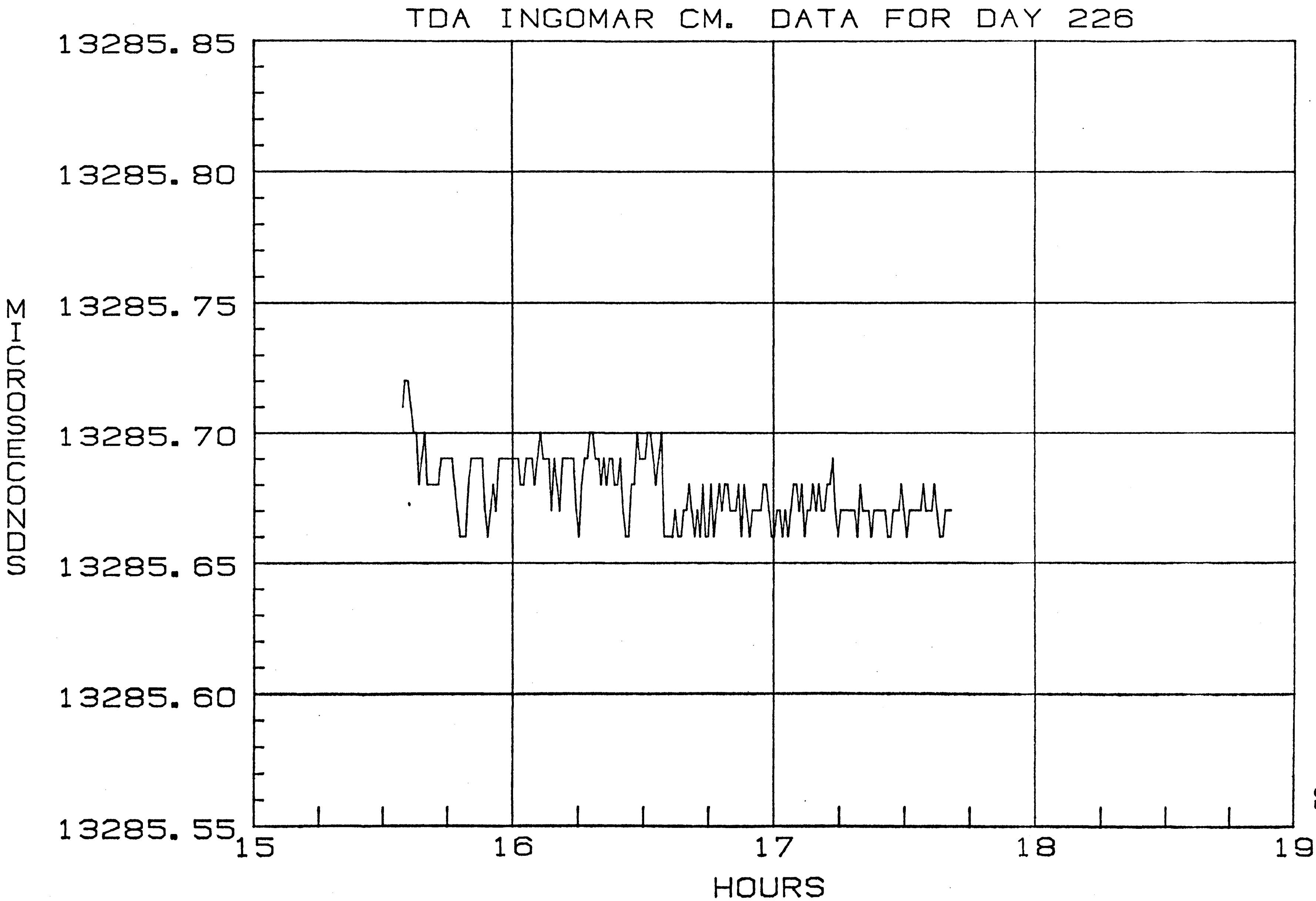


Figure 4.5 Sample Van Site (Ingomar Cemetary) Data Plot

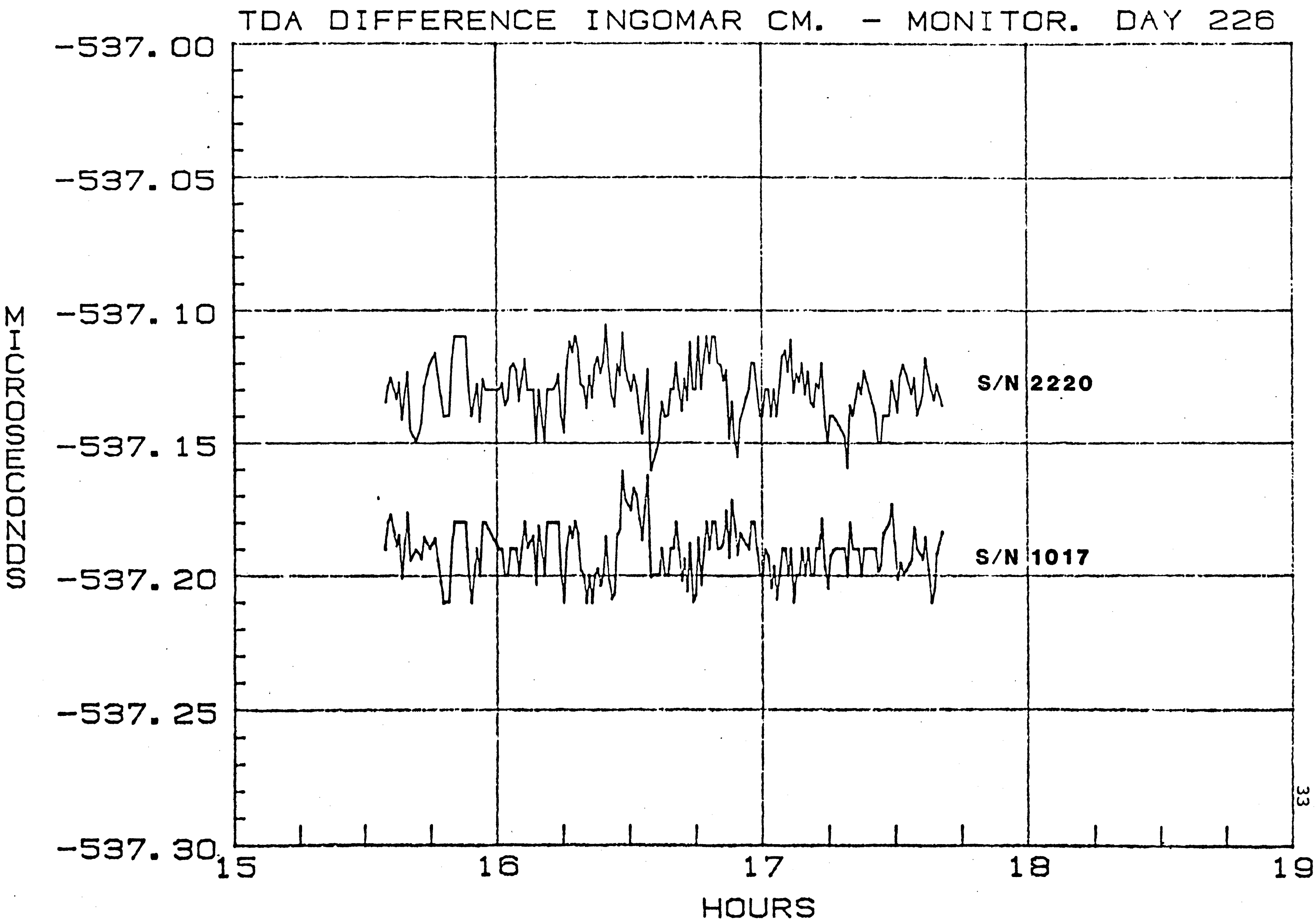


Figure 4.6 Sample Van Site (Ingomar Cemetary) Difference Data Plot

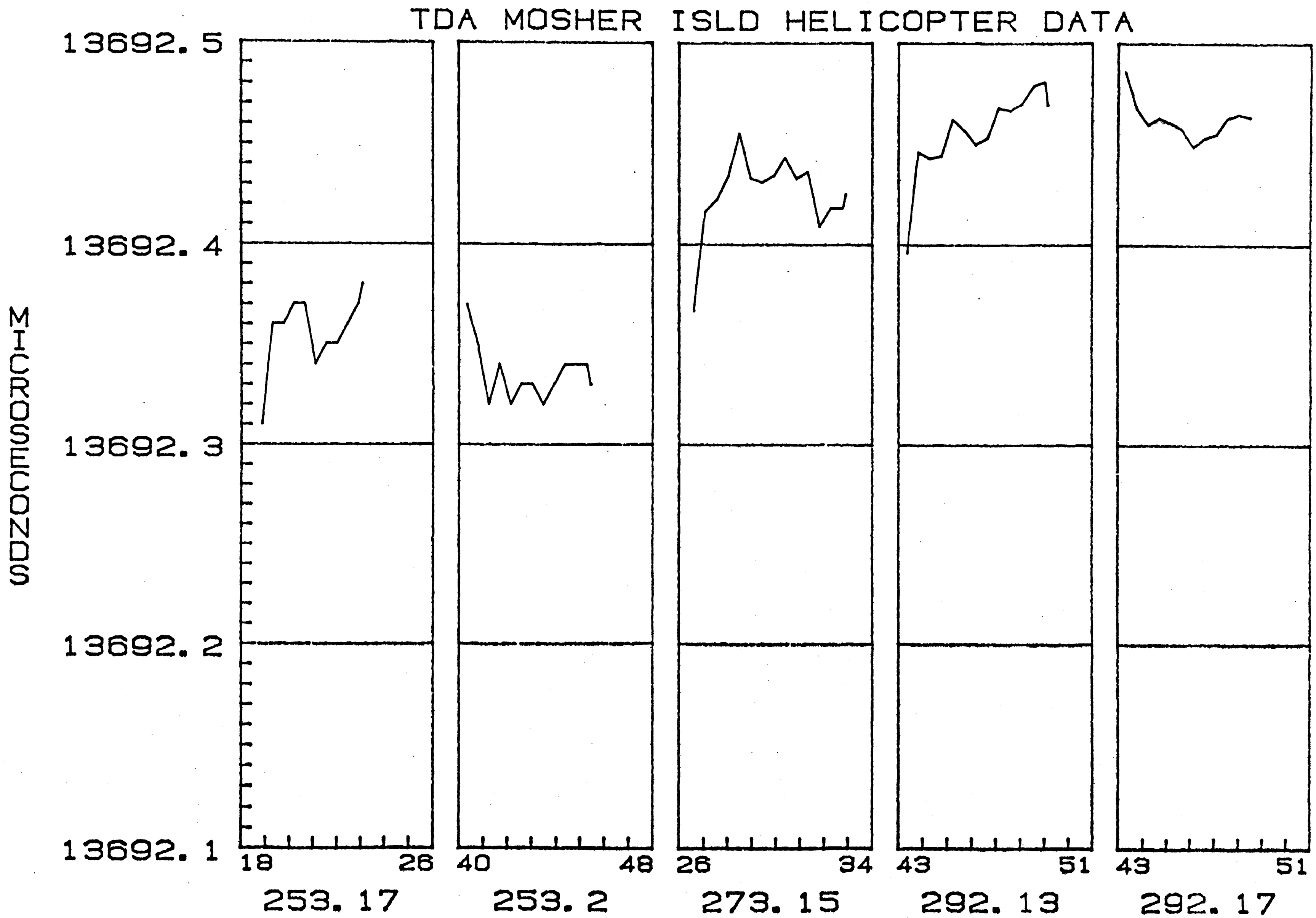


Figure 4.7 Sample Helicopter Data Plot

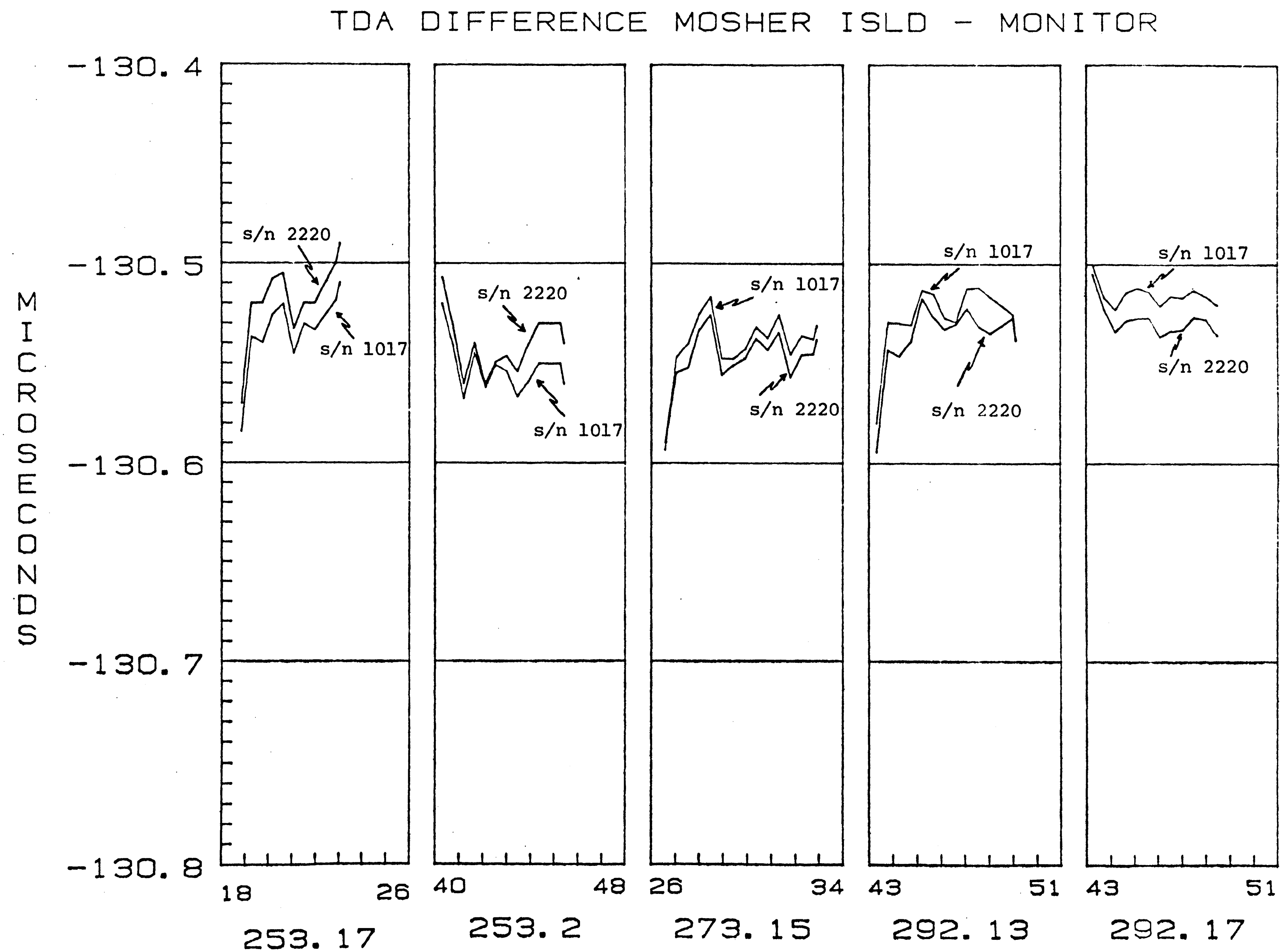


Figure 4.8 Sample Helicopter Difference Data Plot

the differential data varies from visit to visit. As for the van sites, two plots are shown: the difference between the remote data and monitor receiver 2220; and the difference between the remote data and monitor receiver 1017. By comparing Figures 4.7 and 4.8, one can clearly see that the differential data is much more consistent between visits than the monitor data. This is also verified by the statistical analysis in Chapter 7. Four plots (both raw and differential data for TDA and TDB) for each of the 13 helicopter sites (see Chapter 2) are given in Appendix VII. Any site title ending with 'B' means that it was a buoy site where the helicopter was hovering.

4.4 Software for Data Plotting

All of the plotting software has been written in APL (A Programming Language [Polivka and Pakin, 1975; IBM, 1978]). The IBM graphics software package called GRAPHPAK [IBM, 1981], which is also written in APL, was used to drive the HP7470 graphics plotter and produce the final plots. APL programs are called functions, with no distinction between a main program and a subroutine. All plotting functions are contained in the APL workspace 6691001 PLOTCCG.

Function GETLOR is used to retrieve the data to be plotted from disk into the APL workspace. After the data is in the workspace, it is plotted using function LPLOT (for monitor or van site data) or function HPLOT (for helicopter data). Function LAXIS (or HAXIS for helicopter data) then draws the axes, labels, and titles for the data plots. If difference data is to be plotted, the difference data is obtained using the DIFF or HDIFF functions. This difference data is then plotted using LPLOT or HPLOT. Tables 4.1 through 4.4 list operating instructions for the plotting package. Figure 4.9 is a simplified flowchart showing the main functions. Table 4.5

lists and briefly explains the primary global variables used by the plotting software. Function listings for the plotting software are contained in Appendix IV.2.

TABLE 4.1

Operating Instructions for Plotting Monitor Data.

1. ENTER APL
)LOAD 6691001 PLOTCCG   Sign onto APL

2. FILNAM←'CCGLORAN.KETCH'

3. DAT←10 GETLOR 224.0 225.0
   Get the monitor data for day 224. Data is assumed to exist on file TSIO.AAGGBILJ.CCGLORAN.KETCH. Note that beginning and ending times are given. If 224.16 224.22 are given as the time arguments, this means to get all data between 1600 and 2200 on day 224.

4. 'MA' LPLOT DAT (note: blue pen in left position; red pen in right)
   This plots the monitor data on the HP7470; a red line is drawn for the one receiver's data (serial no. 2220), a blue line is drawn for the other receiver (serial no. 1017).

5. 'MA' LAXIS DAT (note: change red pen to black)
   This plots the axes, and prints the labels and title. It assumes that 24 hours of data was plotted starting at hour 0 until hour 24. For tick marks not extended, type TM←0 0.

6. This will plot the TDA values. To plot the TDB data, supply 'MB' instead of 'MA' in steps 4 and 5 above.

TABLE 4.2

Operating Instructions for Plotting Van Site Data.

There are 10 posible van sites numbered 1 to 10 (see Figure 4.2).

1. RSITE←3 (site 3 = Blandford)

2. FILNAM←RFNAME[RSITE;]

3. DAT←6 GETLOR 221.0 222.0
   Get the data for day 221.

4. 'RA' LPLOT DAT (note: black pen in left position, green pen in right position)
   This plots the data within the plotting windows defined by arrays RWA and RWB (see Figure 4.2).

5. 'RA' LAXIS DAT
   This plots the axes, labels, and titles. Station names are stored in array RNAME (see Figure 4.2). It is assumed the plot will cover 4 hours.

6. TDB values are plotted by changing the 'RA' to 'RB' in steps 4 and 5 above.

TABLE 4.3

Operating Instructions for Plotting Van Site Difference Data.

1. RSITE←3

2. FILNAM←RFNAME[RSITE;]

3. DAT←6 GETLOR 221.0 222.0
   Get the data for day 221.

4. DIFDAT←DIFF DAT
   Form the difference data array DIFDAT. Monitor data values are automatically read from disk and interpolated.

5. 'DA' LPLOT DIFDAT (note: <u>red</u> pen in right position; <u>blue</u> pen in left position)
   This plots the difference data. A red line indicates the difference between the van site and monitor serial no. 2220; blue is the difference between van site and monitor serial no. 1017.

6. 'DA' LAXIS DIFDAT (note: replace <u>red</u> pen with <u>black</u>)
   This plots the axes, labels, and title. A data span of a maximum of four hours is assumed for the difference plot.

7. Using 'DB' instead of 'DA' in the arguments for steps 5 and 6 above will plot the TDB difference values.

TABLE 4.4

Operating Instructions for Plotting Helicopter Data.

Helicopter data sites are numbered 11 through 23 (e.g., 21 = Gull Rock Light) as shown in Figure 4.2.

1. RSITE←21

2. FILNAM←RFNAME[RSITE;]

3. DAT←6 GETLOR 252.0 292.0
   This gets all the data for this helicopter site.

4. 'HA' HPLOT DAT (note: black pen in left; green pen in right)

5. 'HA' HAXIS DAT
   This plots the axes, labels, and title. Note that all 5 visits to the site are plotted simultaneously.

6. Use 'HB' in place of 'HA' in steps 4 and 5 above to plot TDB data.

7. DIFDAT←HDIFF DAT
   This gets the difference data between the monitor and helicopter site for all visits.

8. 'HDA' HPLOT DIFDAT (note: blue pen in left, red pen in right)
   This plots the difference data.

9. 'HDA' HAXIS DIFDAT (note: change red pen to black)

10. Steps 8 and 9 above are repeated with 'HDB' instead of 'HDA' in the argument to plot TDB data differences.

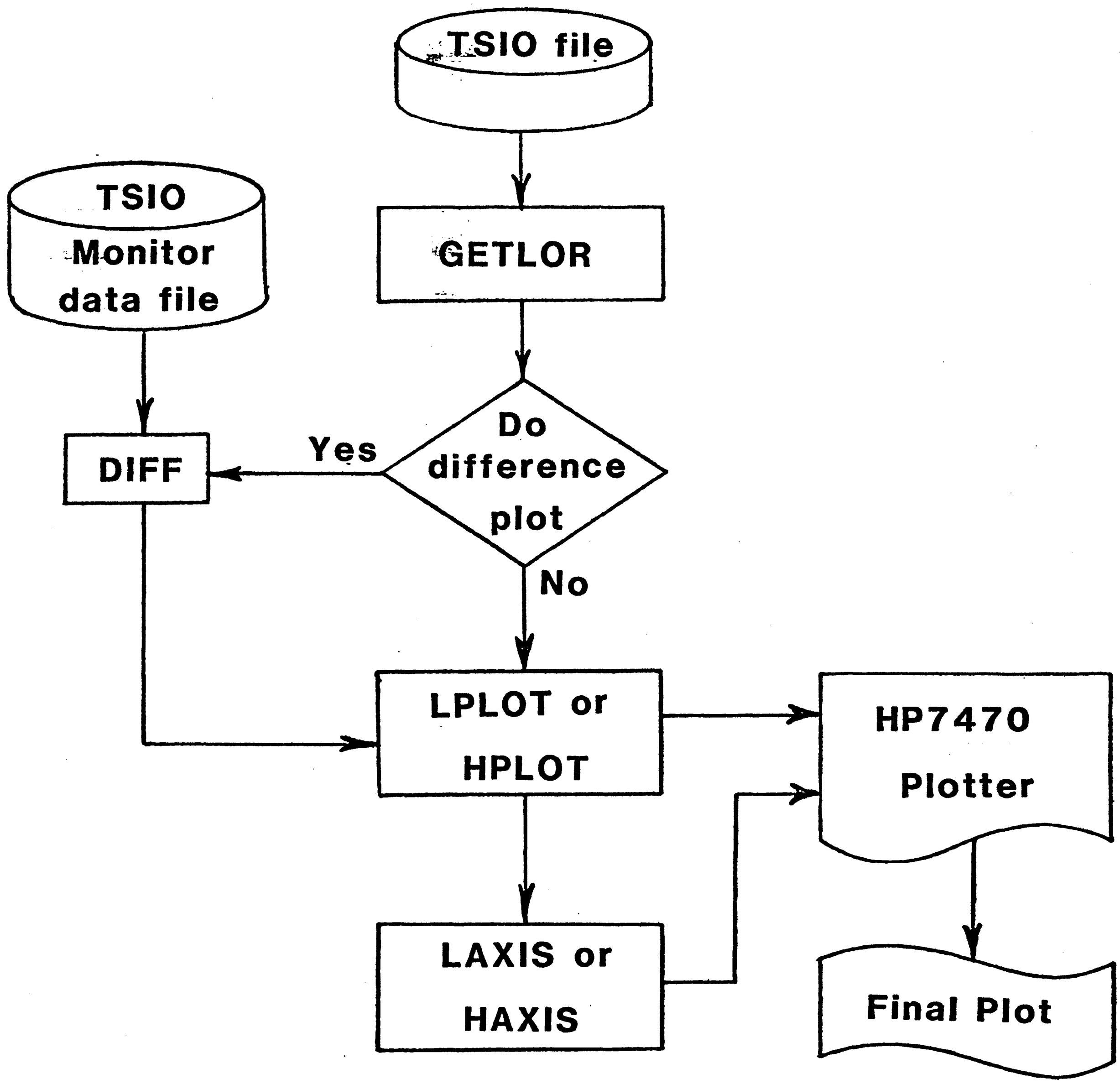


Figure 4.9 Data Plotting Function Flowchart

SITE	RFNAME (TSIO file name)	RNAME (site name)	RMAX (# records in file)	TDAW (TDA plot windows in usec)				TDBW (TDB plot windows in usec)			
1	CCGLORNC,LPROSPEC	L, PROSPECT	1022	0	13805.7	24	13806	0	30229.8	24	30230.1
2	CCGLORNC,PGYSCOVE	PEGGYS COVE	802	0	13820.65	24	13820.95	0	30321.4	24	30321.7
3	CCGLORNC,BLANDFRD	BLANDFORD	815	0	13826.3	24	13826.6	0	30418.6	24	30418.9
4	CCGLORNC,BATTRYPT	BATTERY PT,	599	0	13752.1	24	13752.4	0	30473.1	24	30473.4
5	CCGLORNC,DUBLINSH	DUBLIN SHR,	801	0	13704.3	24	13704.6	0	30489.65	24	30489.95
6	CCGLORNC,MEDWAYHD	MEDWAY HEAD	825	0	13616.25	24	13616.55	0	30541.75	24	30542.05
7	CCGLORNC,WHEADLIV	W,HEAD LIV,	800	0	13554.5	24	13554.8	0	30586.7	24	30587
8	CCGLORNC,PORTJOLI	PORT JOLI	812	0	13466.25	24	13466.55	0	30635.65	24	30635.95
9	CCGLORNC,WHEADLOK	W,HEAD LOK,	800	0	13353.25	24	13353.55	0	30711.1	24	30711.4
10	CCGLORNC,INGOMARC	INGOMAR CM,	802	0	13285.55	24	13285.85	0	30783.2	24	30783.5
11	CCGLORAN,DEVILSIS	DEVILS ISLD	57	0	13866.45	24	13866.95	0	30120.85	24	30121.35
12	CCGLORAN,SAMBROIS	SAMBRO ISLD	56	0	13801.85	24	13802.35	0	30153.95	24	30154.45
13	CCGLORAN,BETTYISL	BETTY ISLND	56	0	13799.45	24	13799.95	0	30247.15	24	30247.65
14	CCGLORAN,PEGGYPTB	PEGGY PT,B,	24	0	13812.65	24	13813.15	0	30324.65	24	30325.15
15	CCGLORAN,HORSHOLT	HORSHO L,B,	25	0	13810.05	24	13810.55	0	30344.15	24	30344.65
16	CCGLORAN,PEARLISL	PEARL ISLHD	60	0	13768.05	24	13768.55	0	30366.65	24	30367.15
17	CCGLORAN,MOSHERIS	MOSHER ISLD	64	0	13692.15	24	13692.65	0	30465.65	24	30466.15
18	CCGLORAN,COFFINIS	COFFIN ISLD	180	0	13577.85	24	13578.35	0	30568.85	24	30569.35
19	CCGLORAN,WHITEPTB	WHITE PT,B,	27	0	13519.35	24	13519.85	0	30589.65	24	30590.15
20	CCGLORAN,LITTLHOP	LITTLE HOPE	49	0	13455.25	24	13455.75	0	30601.05	24	30601.55
21	CCGLORAN,GULLROCK	GULL ROCK	54	0	13352.55	24	13353.05	0	30698.45	24	30698.95
22	CCGLORAN,JIGROCKB	JIG ROCK B,	26	0	13308.85	24	13309.35	0	30752.25	24	30752.75
23	CCGLORAN,BUDGETRK	BUDGT RK,B,	27	0	13262.85	24	13263.35	0	30770.25	24	30770.75

NOTE: SVP is 19 7 96 65

Table 4.5 Global Variables for Plotting Functions

CHAPTER 5

STATISTICAL ANALYSIS RESULTS

A complete statistical analysis of the observed data has been made. Table 5.1 is a sample table from the complete set contained in Appendix III. It contains the means and standard deviations for each visit to the site, as well as the correlation between TDA and TDB values. The five separate sections record the statistics for each monitor receiver, the remote site data, and the difference between remote and monitor data. The difference data is the differential or corrected observable which we are primarily interested in. All units are microseconds except for the standard deviation columns which are in nanoseconds. Chapter 3.2 contains a complete description of how the statistical summaries were calculated.

By calculating the root mean square (RMS) of all visits to the sites, Table 5.2 was generated. This Table summarizes the plots of the differences of the mean TDs from the overall mean for all visits which are plotted against distance in Figures 5.1 to 5.12. It shows the spread of the mean values over the different visits. As confirmed by the conversion to position shifts in Chapter 6, the differential data has a lower RMS than the raw data for most sites.

5.1 Differential TD repeatability as a function of distance

Figures 5.1 to 5.12 are plots of the DEL1 columns in the statistical summary tables, against the distance of the remote site from the monitor. Only the difference or differential data has been plotted. These plots clearly show the repeatability of the differential LORAN-C technique from visit to visit. In general, the van sites show slightly better results,

◊ 9. W.HEAD LOK. STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
225.2117-225.2323	40	13822.815(10)(23)	¯0.055	0.000	30157.235(23)(31)	¯0.025	0.000	¯0.498
232.1657-232.1903	40	13822.890(21)(44)	0.020	0.075	30157.221(14)(41)	¯0.039	¯0.014	0.449
238.2353-239.0160	40	13822.859(17)(44)	¯0.011	0.044	30157.269(16)(45)	0.008	0.034	0.528
267.2128-267.2338	176	13822.916(8)(19)	0.046	0.101	30157.317(18)(24)	0.056	0.081	0.318
MEAN VALUE		13822.870(43)(55)			30157.261(42)(56)			0.199

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
225.2117-225.2323	40	13822.873(10)(22)	¯0.032	0.000	30157.361(14)(24)	0.012	0.000	¯0.381
232.1657-232.1903	40	13822.913(13)(32)	0.008	0.040	30157.336(11)(30)	¯0.013	¯0.025	0.322
238.2353-239.0160	40	13822.910(11)(33)	0.005	0.037	30157.356(12)(32)	0.006	¯0.006	0.220
267.2128-267.2338	176	13822.923(8)(18)	0.019	0.050	30157.345(14)(22)	¯0.004	¯0.016	0.545
MEAN VALUE		13822.905(22)(35)			30157.350(11)(29)			0.177

VAN SITE W.HEAD LOK.

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
225.2117-225.2323	200	13353.358(12)(12)	¯0.043	0.000	30711.278(38)(38)	0.033	0.000	¯0.366
232.1657-232.1903	200	13353.433(15)(15)	0.032	0.074	30711.211(11)(11)	¯0.034	¯0.067	0.410
238.2353-239.0160	200	13353.391(8)(8)	¯0.010	0.032	30711.234(16)(16)	¯0.011	¯0.043	0.270
267.2128-267.2338	201	13353.422(7)(18)	0.021	0.063	30711.258(52)(56)	0.012	¯0.020	0.067
MEAN VALUE		13353.401(33)(36)			30711.245(29)(45)			0.095

DIFFERENCE W.HEAD LOK. - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
225.2117-225.2323	200	¯469.457(9)(19)	0.012	0.000	554.042(37)(41)	0.058	0.000	¯0.005
232.1657-232.1903	200	¯469.457(14)(34)	0.012	0.000	553.990(11)(33)	0.005	¯0.052	0.432
238.2353-239.0160	200	¯469.469(15)(36)	0.001	¯0.011	553.966(16)(37)	¯0.019	¯0.077	0.585
267.2128-267.2338	201	¯469.494(6)(22)	¯0.025	¯0.037	553.941(57)(62)	¯0.044	¯0.101	0.154
MEAN VALUE		¯469.457(17)(34)			554.042(43)(62)			0.292

DIFFERENCE W.HEAD LOK. - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
225.2117-225.2323	200	¯469.515(8)(18)	¯0.011	0.000	553.917(35)(39)	0.021	0.000	0.150
232.1657-232.1903	200	¯469.480(10)(26)	0.024	0.035	553.875(9)(24)	¯0.021	¯0.042	0.352
238.2353-239.0160	200	¯469.519(10)(27)	¯0.015	¯0.004	553.879(11)(27)	¯0.017	¯0.038	0.558
267.2128-267.2338	201	¯469.502(6)(22)	0.002	0.013	553.912(56)(61)	0.017	¯0.004	0.045
MEAN VALUE		¯469.504(18)(29)			553.896(22)(46)			0.276

Table 5.1 Sample Statistical Summary

RMS OF ALL VISITS IN NANOSECONDS

SITE	RAW DATA TDA	RAW DATA TDB	DIFF. 2220 TDA	DIFF. 2220 TDB	DIFF. 1017 TDA	DIFF. 1017 TDB
1	16	22	10	23	13	17
2	17	17	14	26	17	13
3	16	19	20	37	13	8
4	26	43	28	33	18	16
5	29	20	20	23	13	20
6	25	30	22	21	21	18
7	33	31	18	40	19	28
8	41	25	20	38	17	20
9	29	25	15	38	15	19
10	35	20	9	17	17	9
11	21	28	23	15	16	14
12	85	23	26	11	35	10
13	43	38	12	24	16	31
14	113	170	90	168	93	169
15	178	319	140	326	141	325
16	37	46	14	31	16	40
17	52	49	10	28	12	37
18	59	44	10	40	16	48
19	132	76	84	58	94	65
20	61	69	16	57	8	62
21	46	72	25	59	13	67
22	148	95	85	81	97	88
23	112	120	48	108	60	118

Table 5.2 Time Difference RMS Values of all Visits

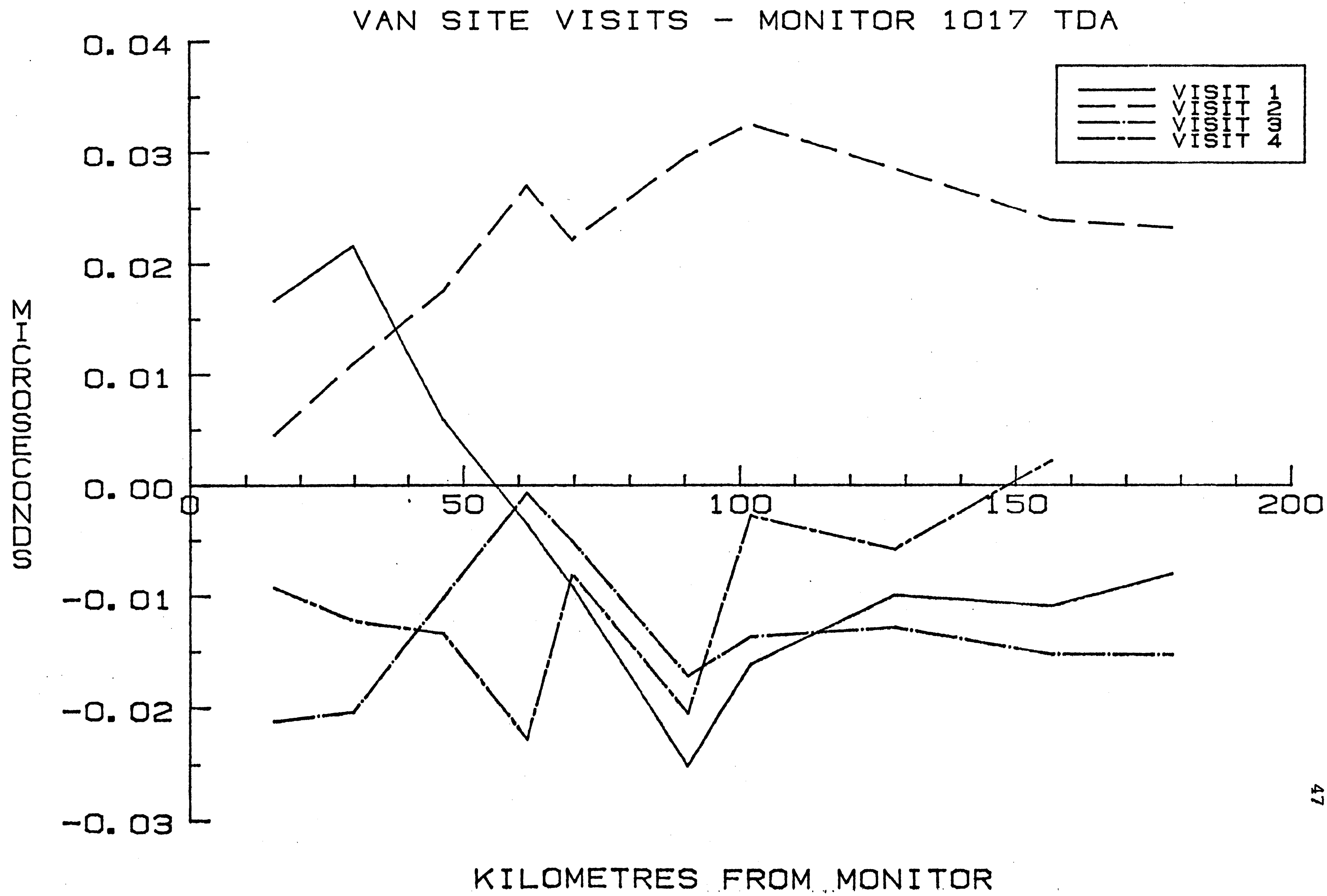


Figure 5.1 Van - Mon.1017 TDA vs Distance

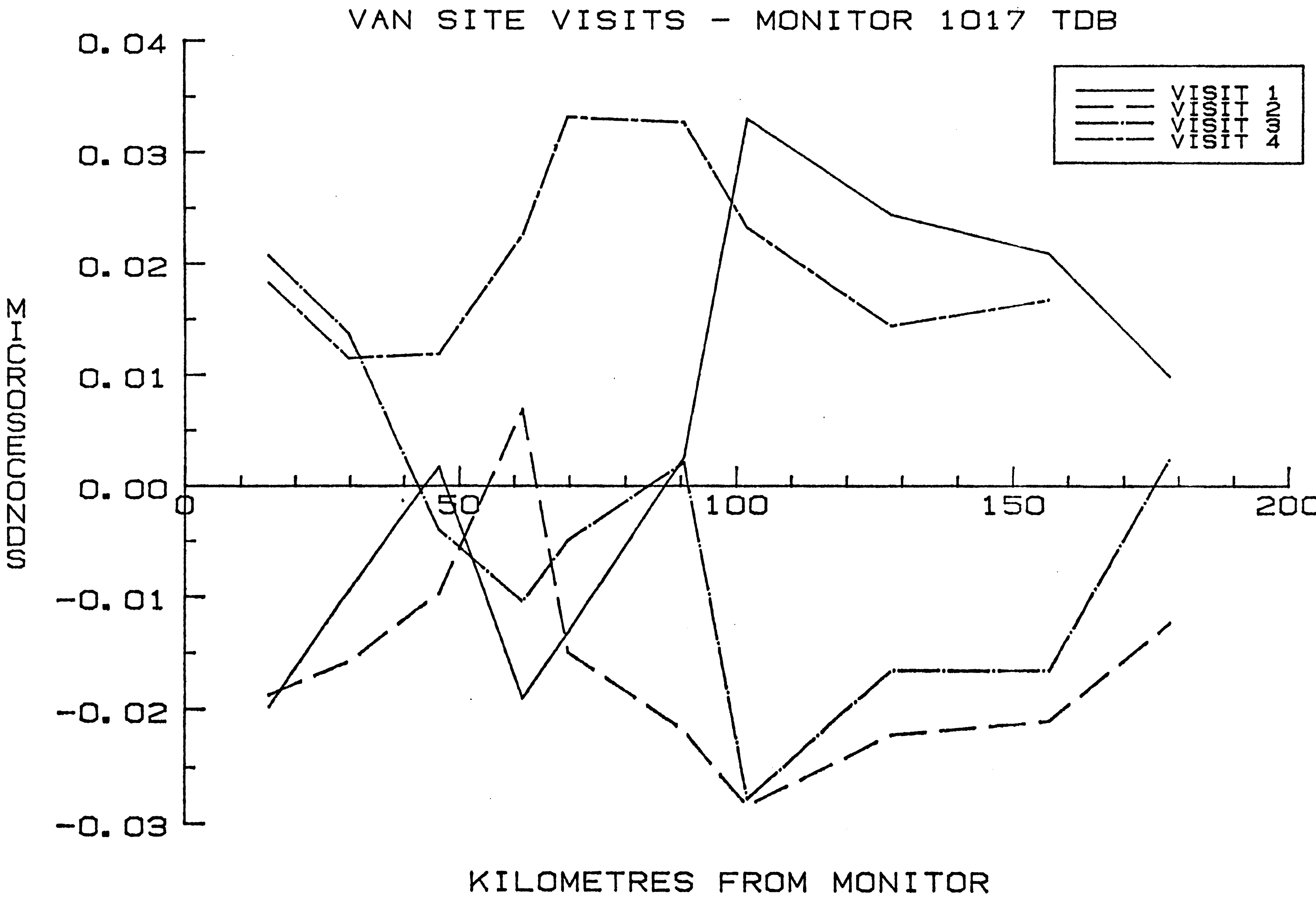


Figure 5.2 Van - Mon.1017 TDB vs Distance

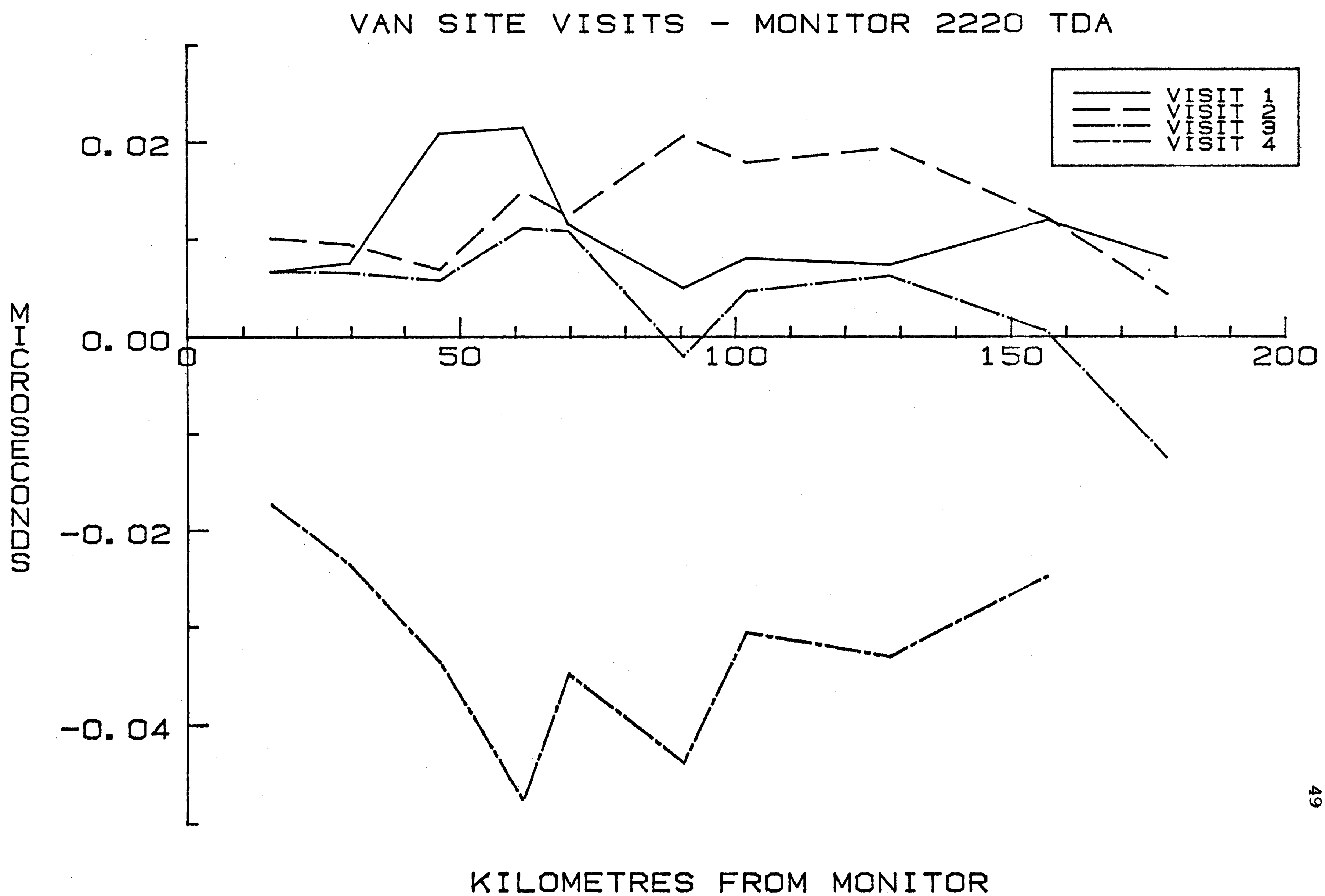


Figure 5.3 Van - Mon.2220 TDA vs Distance

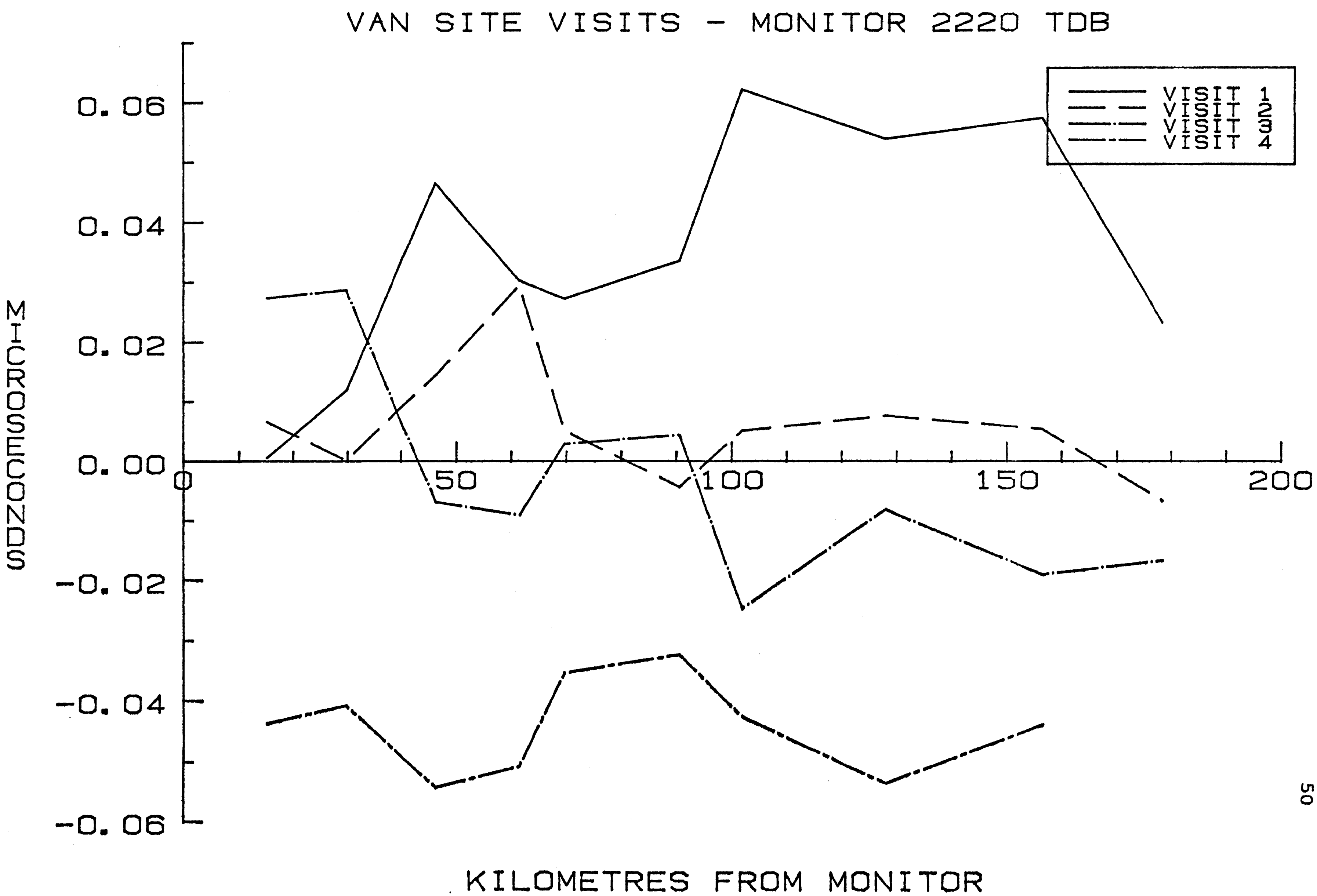


Figure 5.4 Van - Mon.2220 TDB vs Distance

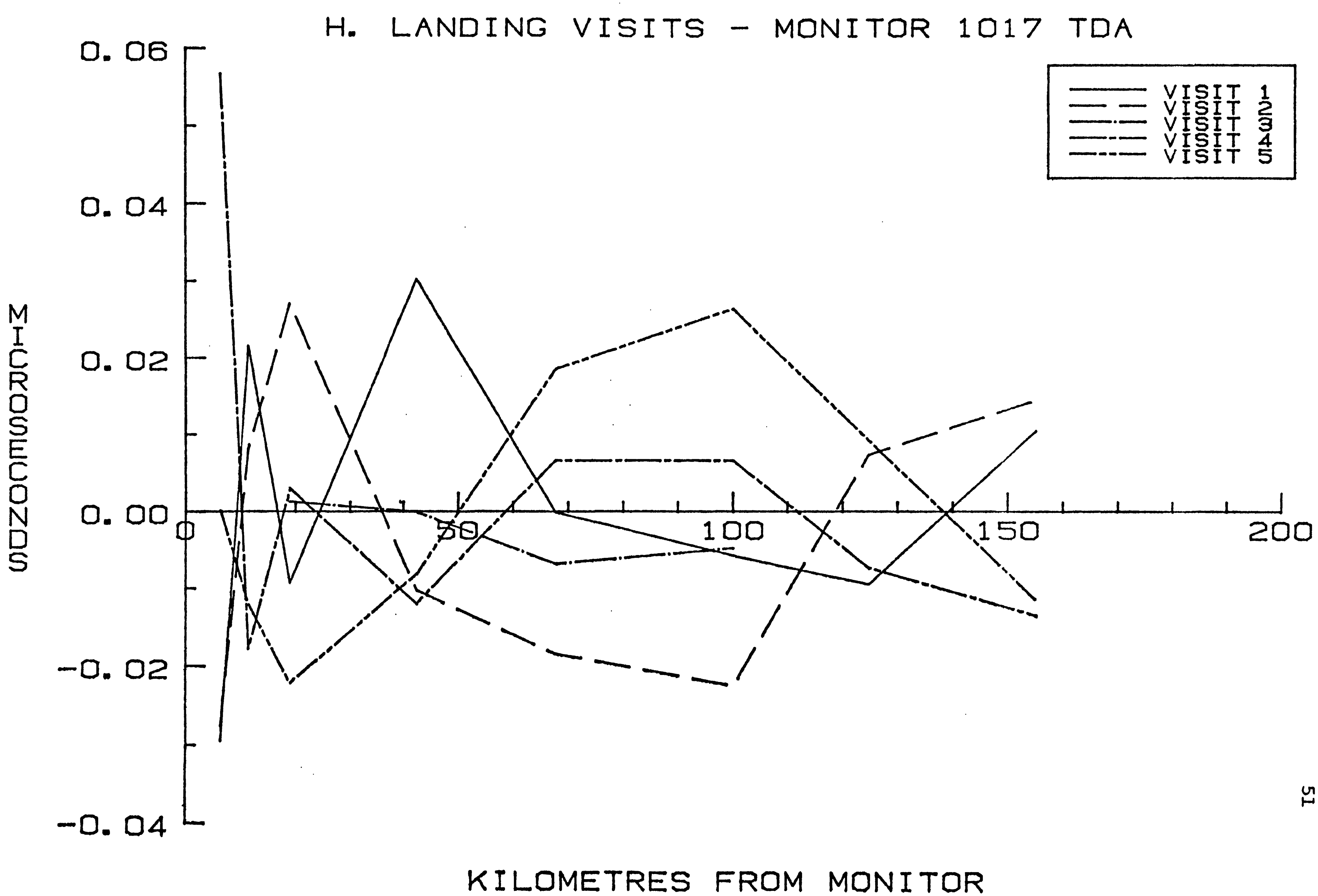


Figure 5.5 H.Landing - Mon.1017 TDA vs Distance

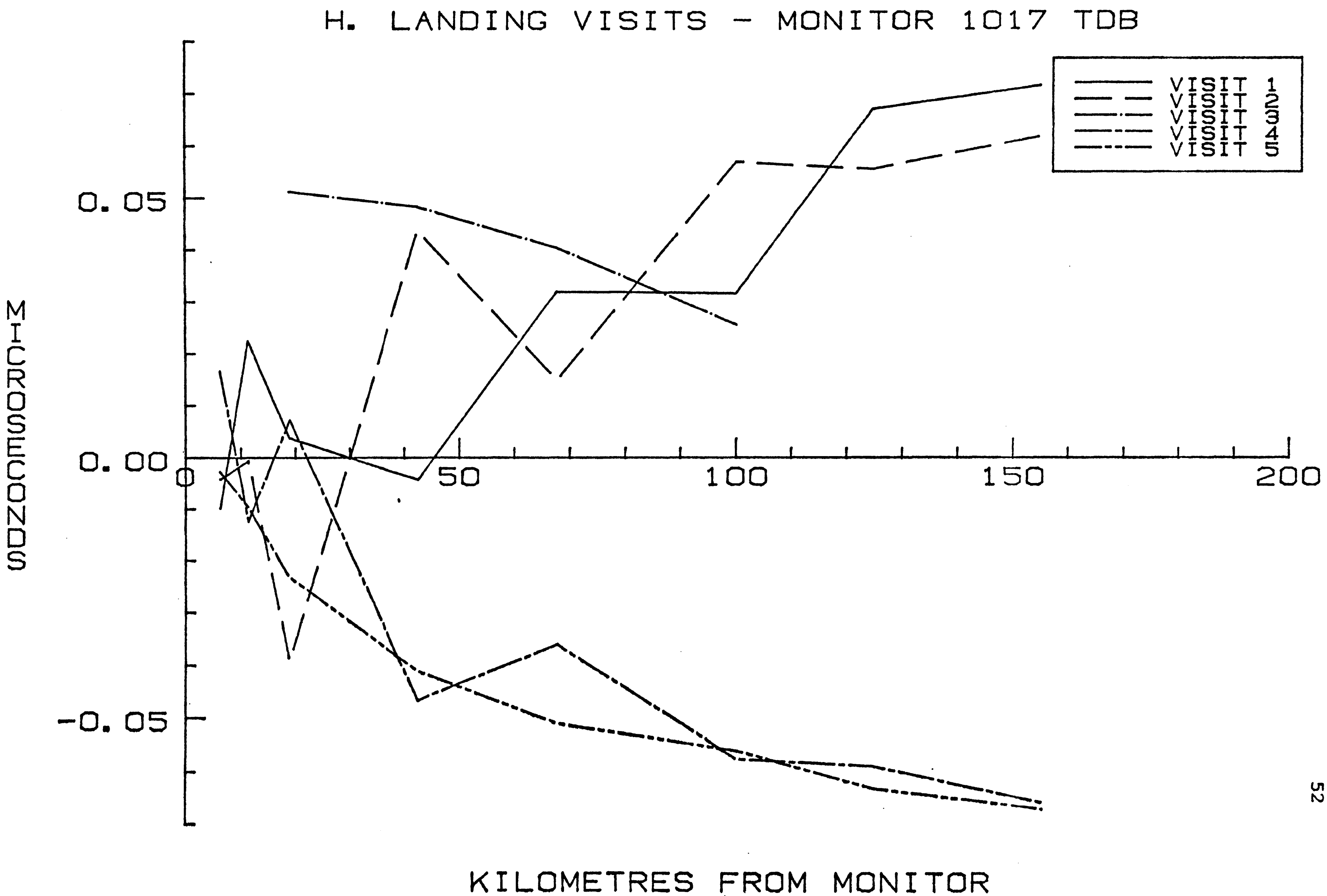


Figure 5.6 H.Landing - Mon.1017 TDB vs Distance

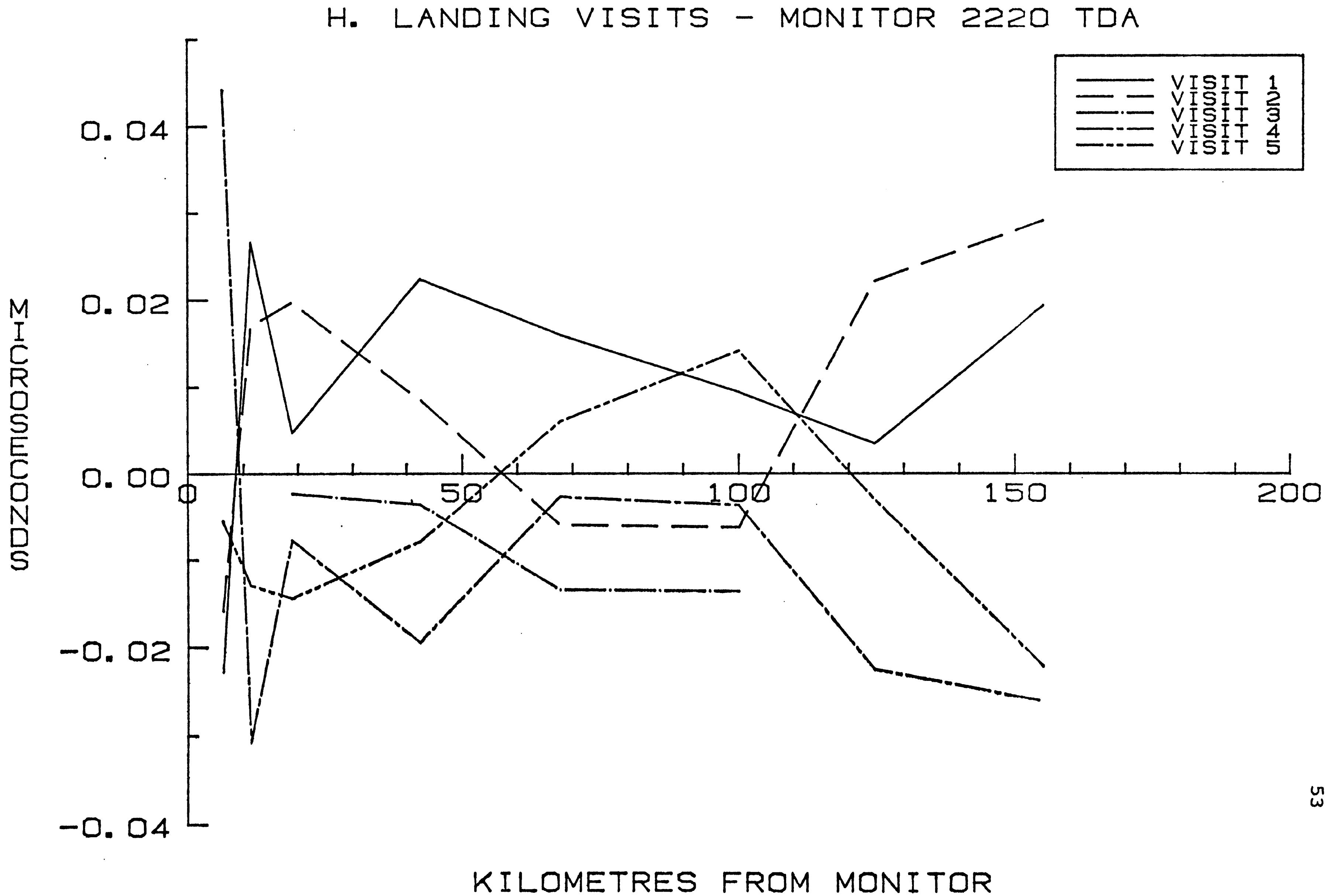


Figure 5.7 H.Landing - Mon.2220 TDA vs Distance

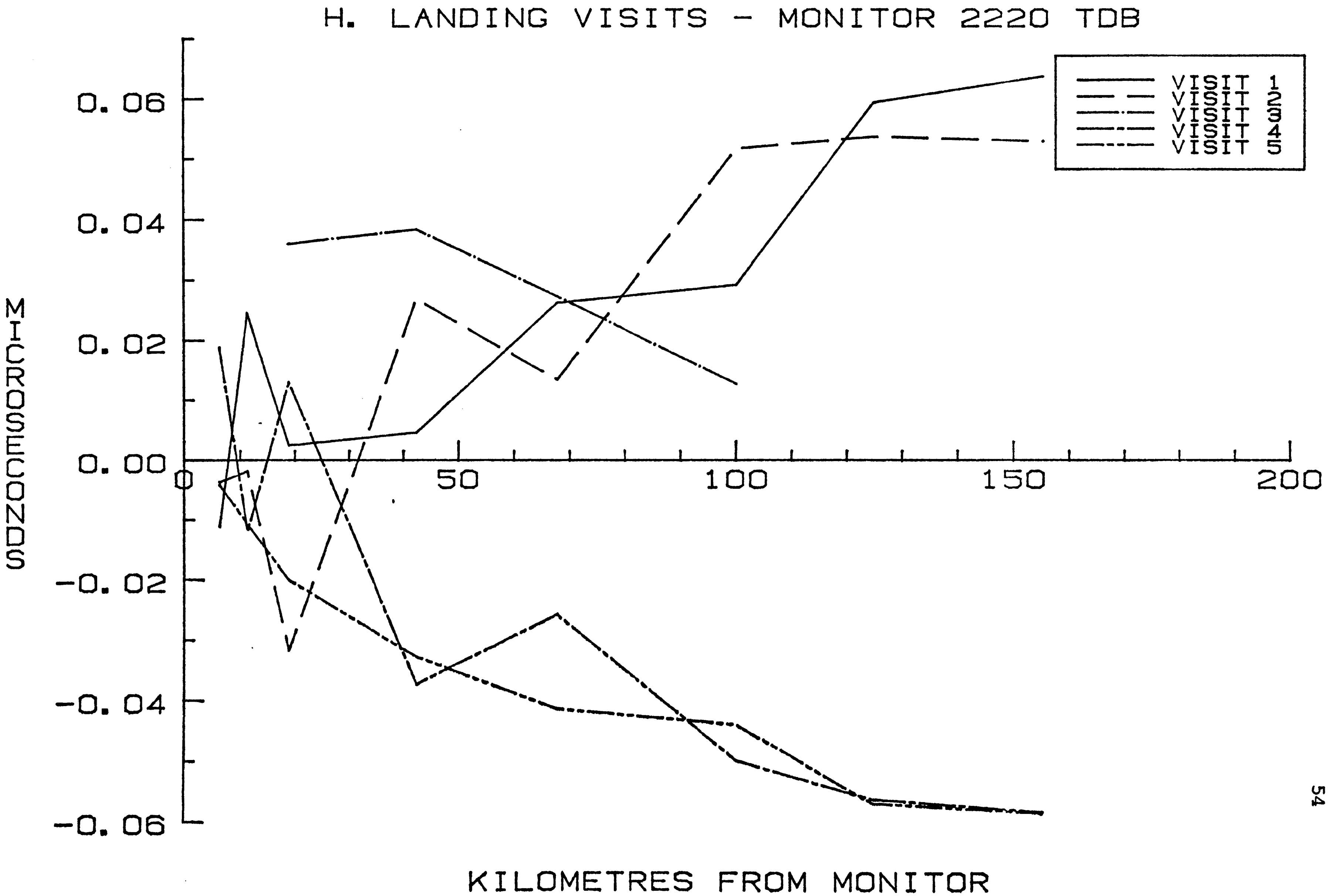


Figure 5.8 H.Landing Mon.2220 TDB vs Distance

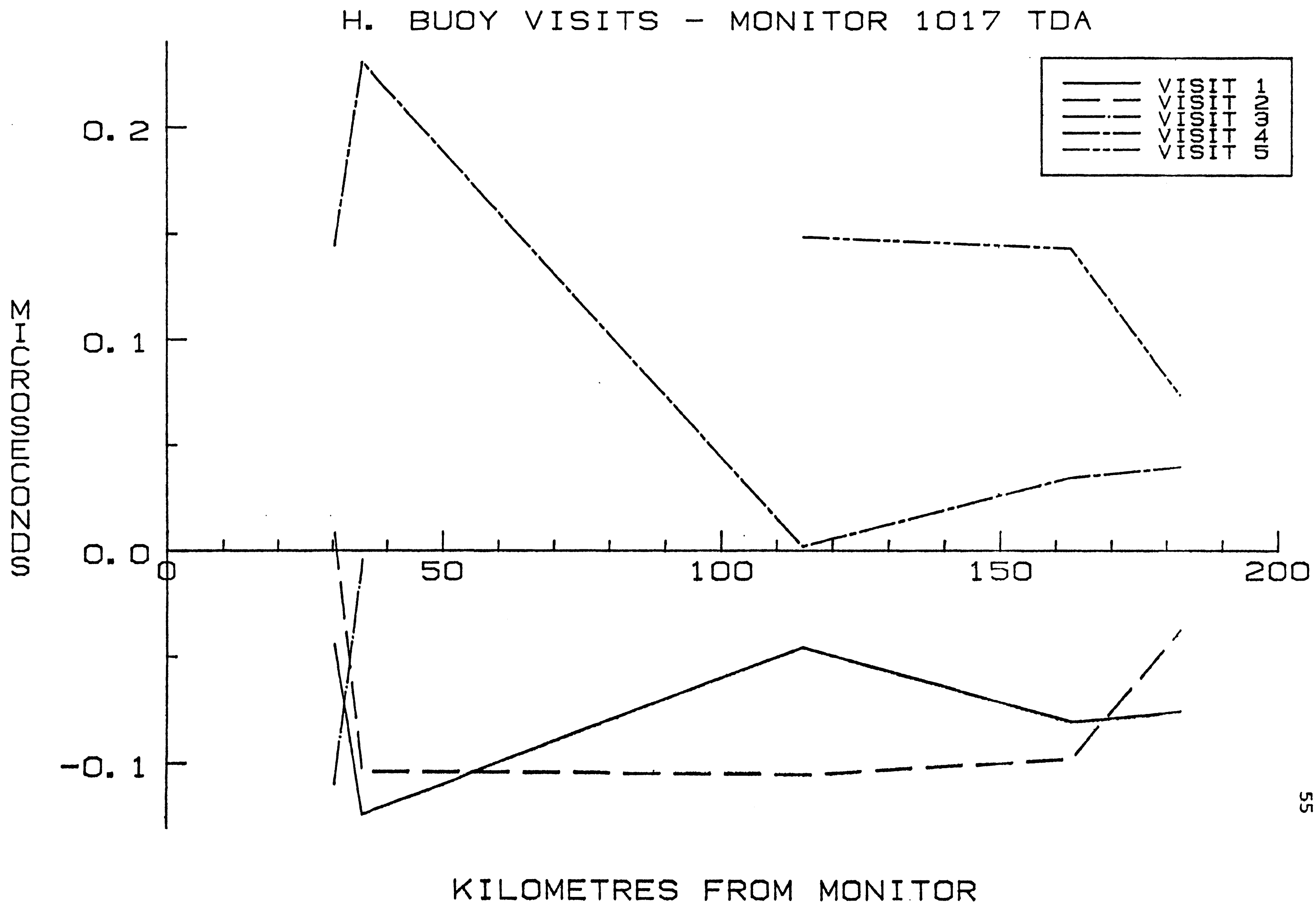


Figure 5.9 H.Buoy - Mon.1017 TDA vs Distance

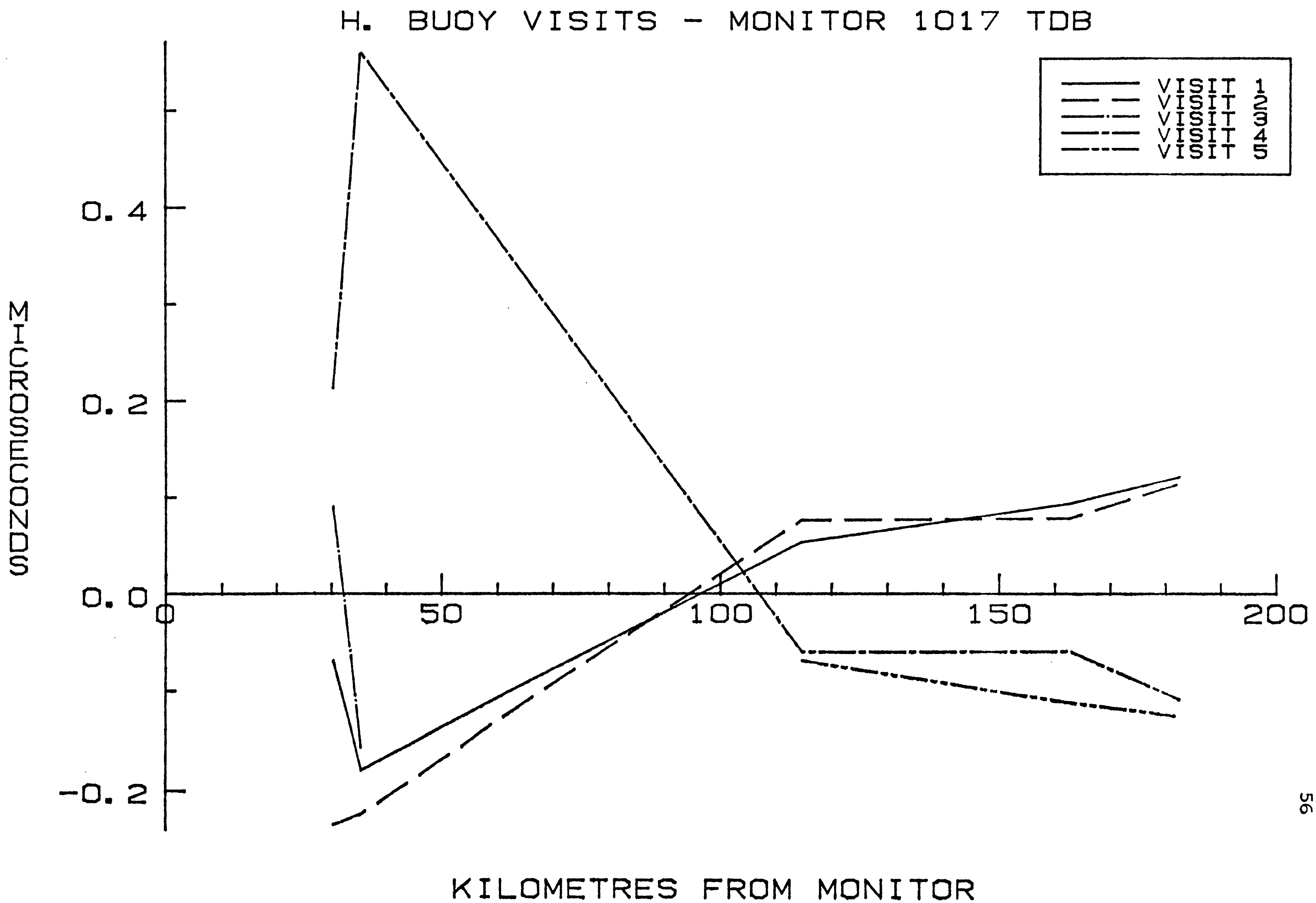


Figure 5.10 H.Buoy - Mon.1017 TDB vs Distance

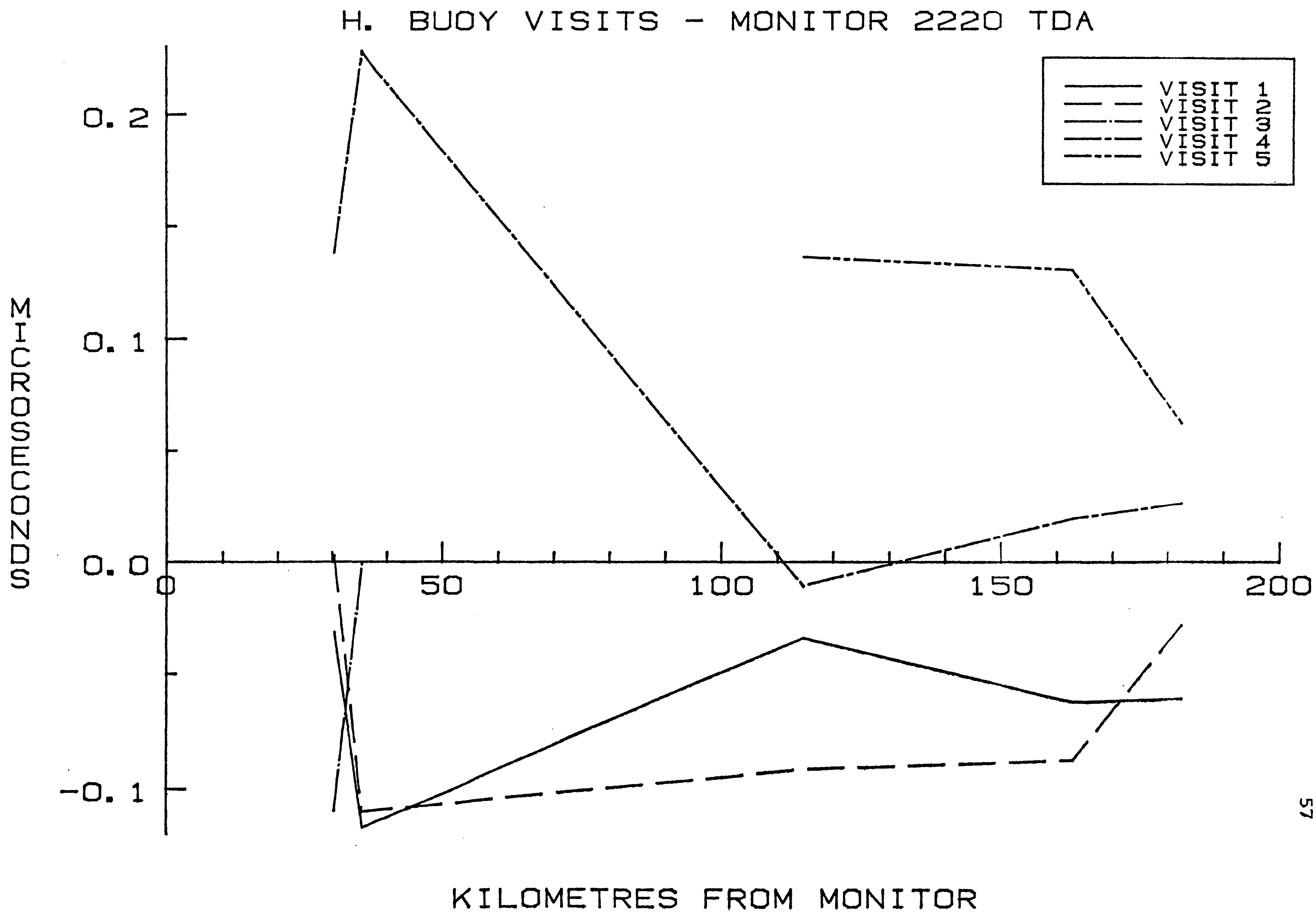


Figure 5.11 H.Buoy - Mon.2220 TDA vs Distance

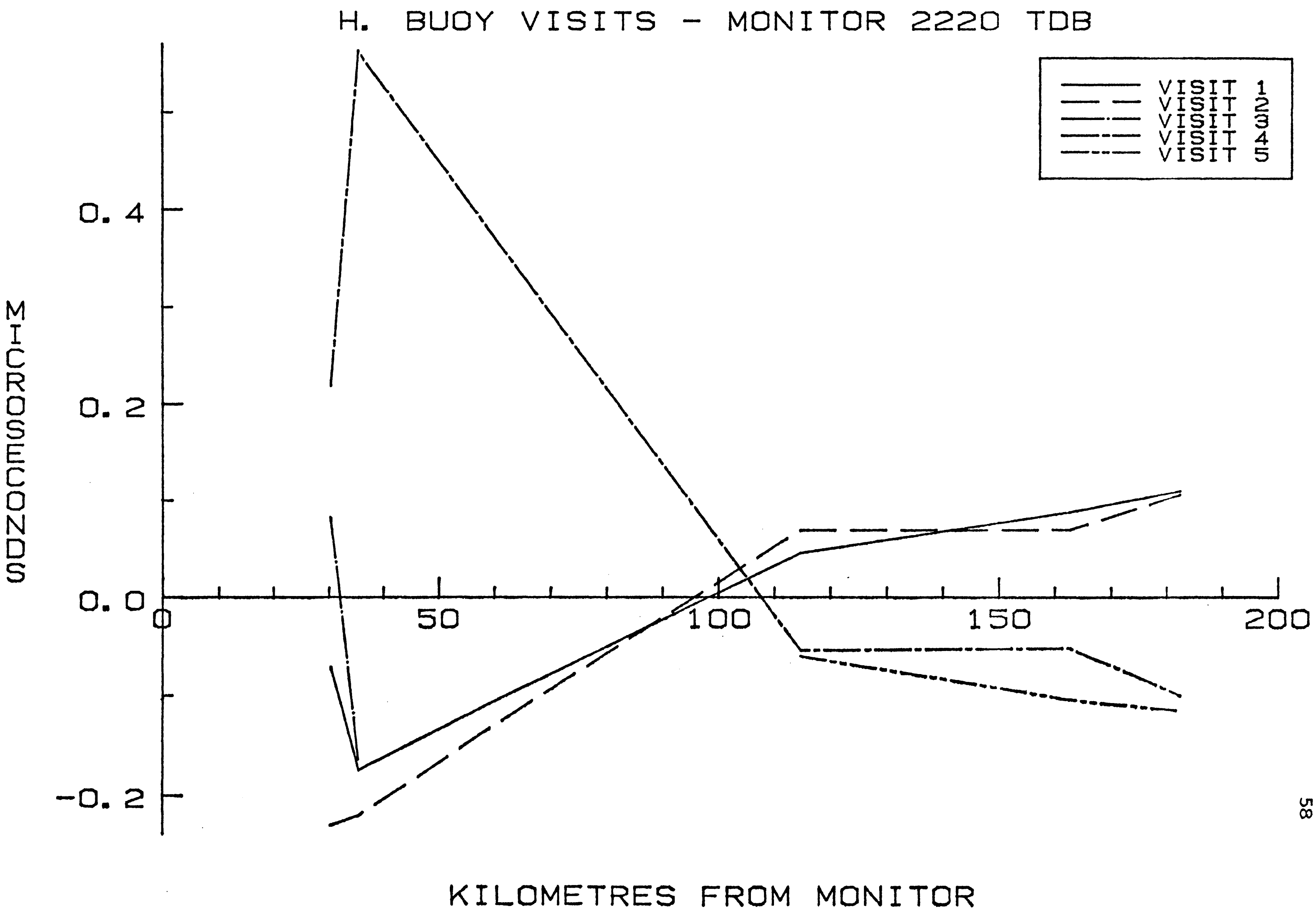


Figure 5.12 H.Buoy - Mon.2220 TDB vs Distance

probably due to the longer averaging time (two hours as opposed to eight minutes). The conversion of these TD repeatabilities to position repeatabilities is given in the next Chapter. Functions INITSUM, SUMAXIS, SUMPLOT and SUMU in Appendix IV.2 were used to draw these plots.

5.2 Software for Statistical Analysis

The statistical analysis software is written in APL, and contained in APL workspace 6691001 CCGSTAT. Function STAT is used to compute the statistics for a given remote site, either van or helicopter. Results for all sites are stored in global variables MRSTAT (monitor serial no. 2220) and MBSTAT (monitor serial no. 1017). The data is then printed using function SPRINT, which produces a one page statistical summary of the data observed at this site. The operator's instructions for the statistics calculations are given in Table 5.3. Figure 5.13 is a simple flowchart showing the main functions used. Appendix IV.3 contains listings of all the APL functions used for the statistical analysis.

Table 5.4 lists the global variables used. Arrays MRINDX and MBINDX are the index vectors to the 25-column arrays MRSTAT and MBSTAT, respectively. Each element of MRINDX and MBINDX contains the numbers of rows of MRSTAT and MBSTAT corresponding to each of the remote sites (1 through 23 inclusive). MRINDX also indexes the variables NUMR, NUMM and NUMD, which contain the number of observations obtained at the remote site, monitor, and differentially, for each time span. Note that m is any row (indexed by MRINDX and MBINDX) of the statistical summary array. The contents of MRSTAT are:

MRSTAT[m;1 2] = begin and end times of remote site data

TABLE 5.3

Operating Instructions for Statistical Calculations.

1. ENTER APL
)LOAD 6691001 CCGSTAT   Sign on APL

2. RSITE←3
   Assign the site number (see Figure 4.2).

3. RSITE STAT 0.01
   Compute the statistics for this site. All data for this site is automatically read from disk (along with the necessary monitor data), and statistical summaries are computed for each visit. The argument 0.01 is the time in days between successive records to be considered as indicating a different visit to the site.

4. UPDATE
   This updates the master arrays MRSTAT and MBSTAT. This must be done in sequence for sites 1, 2, 3, ..., 23.

5. SPRINT
   This prints the data for site RSITE. After all sites are defined, steps 3 and 4 do <u>not</u> need to be repeated to reprint the data.

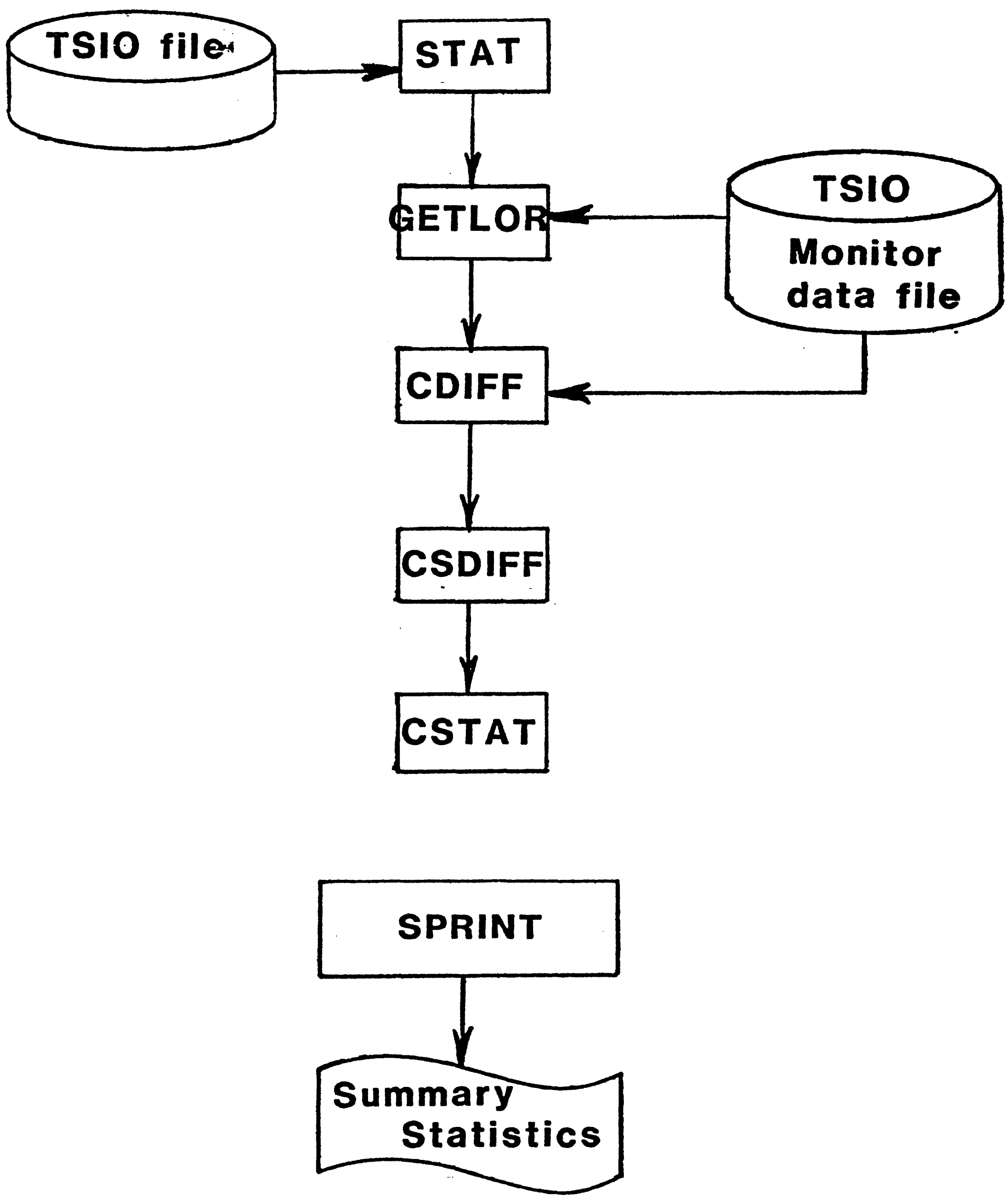


Figure 5.13 Statistical Function Flowchart

1	CCGLORNC,LPROSPEC	L. PROSPECT	1022
2	CCGLORNC,PGYSCOVE	PEGGYS COVE	802
3	CCGLORNC,BLANDFRD	BLANDFORD	815
4	CCGLORNC,BATTRYPT	BATTERY PT.	599
5	CCGLORNC,DUBLINSH	DUBLIN SHR.	801
6	CCGLORNC,MEDWAYHD	MEDWAY HEAD	825
7	CCGLORNC,WHEADLIV	W.HEAD LIV.	800
8	CCGLORNC,FORTJOLI	PORT JOLI	812
9	CCGLORNC,WHEADLOK	W.HEAD LOK.	800
10	CCGLORNC,INGOMARC	INGOMAR CM.	802
11	CCGLORAN,DEVILSIS	DEVILS ISLD	57
12	CCGLORAN,SAMBROIS	SAMBRO ISLD	56
13	CCGLORAN,BETTYISL	BETTY ISLND	56
14	CCGLORAN,PEGGYPTB	PEGGY PT.B.	24
15	CCGLORAN,HORSHOLT	HORSHO L.B.	25
16	CCGLORAN,PEARLISL	PEARL ISLND	60
17	CCGLORAN,MOSHERIS	MOSHER ISLD	64
18	CCGLORAN,COFFINLO	COFFIN ISLD	49
19	CCGLORAN,WHITEPTB	WHITE PT.B.	27
20	CCGLORAN,LITTLHOP	LITTLE HOPE	49
21	CCGLORAN,GULLROCK	GULL ROCK	54
22	CCGLORAN,JIGROCKB	JIG ROCK B.	26
23	CCGLORAN,BUDGETRK	BUDGT RK.B.	27

Table 5.4 Global Variables for Statistical Functions

in format DDD.HHMM.

MRSTAT[m;3 4] = begin and end times of monitor (and difference) data.

MRSTAT[m;5 6 7] = mean and standard deviations (see Section 5.1) for TDSs recorded at the monitor for the time span contained in columns 3 and 4.

MRSTAT[m; 8 9 10]] = mean and standard deviations for TDBs recorded at the monitor for the time span contained in columns 3 and 4.

MRSTAT[m; 11 12 13] = mean and standard deviations for remote site TDA data (van or helicopter) recorded for the time interval indicated by columns 1 and 2.

MRSTAT[m; 14 15 16] = mean and standard deviations for remote site TDB data recorded for the time interval indicated by columns 1 and 2.

MRSTAT[m; 17 18 19] = mean and standard deviations for the difference between remote and monitor site TDA values.

MRSTAT[m; 20 21 22] = mean and standard deviations for the difference between remote and monitor site TDB values.

MRSTAT[m; 23 24 25] = correlations between TDA and TDB data for the monitor data (23), raw data (24), and difference data (25).

CHAPTER 6

POSITION SHIFT RESULTS

For buoy position monitoring, we want to be able to detect buoy movements as small as 15 metres. The basic question that must be answered concerning differential LORAN-C is then whether or not it is capable of detecting a 15 metre change in position. In this experiemht a slightly different question was posed: given repeated visits to the same site (no change in coordinates), will the positions computed from the differential LORAN-C measurements be repeatable within 15 metres? The implicit assumption made here is that if the resolution and repeatability of differential LORAN-C is sufficient to warrant a positive answer to this question, then it will also be sufficient to detect whether an actual position shift has occurred.

So far in this report we have looked at results related to the repeatability of differential LORAN-C TD measurements. In this chapter we consider the corresponding positions, and their repeatability. The conversion from TD measurements to positions is discussed in Appendix II. In this chapter we apply the equations derived in Appendix II, following the procedure outlined in Section II.4 of that appendix. Our procedure then consists of the following five steps:

1) On a small scale chart (such as in Figure II.11), for each test site, measure the three angles a_{ipj}, a_{ipk}, and α_{ip}. In our case a_{ipj} is the angle subtended by the Caribou-Nantucket baseline at the test point, a_{ipk} is the angle subtended by the Caribou-Cape Race baseline at the test point, and α_{ip} is the azimuth from Caribou to the test point. The

results of these measurements are shown in Table 6.1.

2) Using equations (II.56), (II.57), (II.58), (II.59), (II.60), and (II.62), compute the elements of the $\underline{M}$ matrix, which linearly relates the shifts in the two TD patterns (expressed in microseconds) to shifts in latitude and longitude (expressed in metres). This need only be done once per test site.

3) From the results of several visits to each test site, the 'reference' TD values for that site were computed as described in Section 3.2: a) the means of all TD observations foreach visit were computed, then b) the 'site mean' was computed as the mean of all of these 'visit means'. This site mean was taken as the reference TD value for that site. Using equation 3.11, the differences between this site mean and each of the visit means was taken as a set of 'observed TD shifts'. This process was repeated for differential LORAN, using the receiver at the remote site combined with each of the two receivers at the monitor site. All these observed TD shifts are tabulated as DEL1 in Appendix IV.

4) Using these observed TD shifts, together with equations (II.45), (II.47), and (II.48), the distance and direction of the position shift corresponding to each (TDA,TDB) pair of observed TD shifts was computed. The distances of all such position shifts are tabulated in Table 6.2.

5) The test sites were divided into van sites (numbers 1-10 in Tables 6.1 and 6.2), helicopter landing sites (numbers

11, 12, 13, 16, 17, 18, 20, 21), and helicopter hovering sites (numbers 14, 15, 19, 22, 23). The position shift distances from Table 6.2, for each kind of site, were ranked in magnitude. Deciles of the ranked values were found. The results are shown in Table 6.3. These deciles were then plotted in Figures 6.1, 6.2, and 6.3, for each of the three kinds of site respectively.

During two visits to Coffin Island, flypast measurements of the reference site were made. The results are described in Section 3.3. From a comparison of these two flypast visits, one set of observed differential TD shifts can be formed, in the sense (visit2 - visit1), for each of the two monitor receivers. These lead to corresponding position shifts of 19 m (using monitor s/n 1017) and 16 m (for monitor s/n 2220). Although Coffin Island is a helicopter landing site, these flypasts represent an alternative to hovering. Therefore they have been shown on Figure 6.3.

TABLE 6.1

Lattice Geometry Measurements

Site		α_{ip}	a_{ipj}	a_{ipk}
MON	Ketch Harbour	129	71°	119°
VAN 1	Lower Prospect	130	72	117
2	Peggys Cove	133	76	117
3	Blandford	133	78	116
4	Battery Point	136	80	112
5	Dublin Shore	139	82	110
6	Medway Head	141	84	106
7	Western Head Liverpool	144	86	103
8	Port Joli	147	88	100
9	Western Head Lockeport	152	93	95
10	Ingomar	154	95	91
HEL 11	Devils Island Light	130	72	121
12	Sambro Island Light	132	73	117
13	Betty Island Light	130	72	117
14	Peggy's Point Buoy	133	76	117
15	Horeshoe Ledge Buoy	133	76	117
16	Pearl Island Light	135	78	114
17	Mosher Island Light	139	82	110
18	Coffin Island Light	144	86	103
19	White Point Rock Buoy	145	86	102
20	Little Hope Island Light	147	88	100
21	Gull Rock Island Light	152	93	95
22	Jig Rock Buoy	152	93	94
23	Budget Rock Buoy	154	95	91

REMOTE SITE MOVEMENT IN METRES

SITE	----DIFFERENCE SERIAL NO. 2220----					----DIFFERENCE SERIAL NO. 1017----					------------RAW DATA------------				
	VISIT1	VISIT2	VISIT3	VISIT4	VISIT5	VISIT1	VISIT2	VISIT3	VISIT4	VISIT5	VISIT1	VISIT2	VISIT3	VISIT4	VISIT5
1	1.7	2.9	5.2	9.2		5.3	3.4	6.3	3.9		5.9	3.8	9.6	3.4	
2	2.9	2.3	5.5	9.7		5.4	3.7	5.3	3.4		4.6	4.3	7.5	2.1	
3	10.2	3.2	1.7	13.3		1.5	4.4	2.6	3.6		7.1	6.2	4.0	2.2	
4	7.9	6.7	2.9	15.2		3.6	6.6	1.9	6.4		14.1	6.8	3.4	12.8	
5	5.9	3.1	2.6	10.8		3.4	5.5	1.6	6.2		10.7	6.4	2.6	8.8	
6	6.5	4.6	0.9	12.0		5.7	7.5	3.9	7.4		10.5	9.5	3.7	9.9	
7	12.2	4.1	4.8	11.0		7.0	8.7	6.4	4.5		11.5	7.6	4.6	12.1	
8	10.8	4.6	2.0	13.1		5.1	7.3	4.4	3.0		13.0	12.5	3.9	7.1	
9	12.2	2.8	3.9	10.6		4.7	6.3	4.8	3.5		10.7	9.3	3.2	5.2	
10	5.3	1.6	4.4			2.6	5.3	3.1			10.9	9.1	2.6		
11	8.5	4.3		8.4	4.0	7.1	2.1		5.2	3.7	7.7	5.7		7.3	8.7
12	6.3	4.1		12.0	1.6	7.8	7.1		14.9	0.5	30.4	19.7		22.9	25.3
13	1.3	7.2	6.3	2.9	5.3	2.4	9.4	9.1	1.5	7.3	21.8	8.6	13.0	10.4	3.8
14	15.5	40.8	29.1	54.4		17.2	41.4	29.5	54.7		27.2	42.4	26.9	61.6	
15	44.6	50.0	29.8	119.9		46.3	49.5	28.1	119.9		58.8	51.1	28.2	124.6	
16	5.5	5.5	6.9	8.6	6.4	7.2	8.0	8.7	9.2	7.9	5.1	18.3	12.4	10.5	8.6
17	6.4	2.7	5.6	4.8	7.6	5.9	4.8	7.4	6.7	9.9	13.4	16.4	12.4	13.5	16.5
18	6.2	10.0	3.7	9.7	8.8	6.1	11.7	5.0	11.1	11.9	13.9	18.3	4.2	18.5	15.2
19	11.2	23.5		10.9	31.5	13.9	26.5		11.6	34.5	22.6	37.3		17.2	42.9
20	11.8	11.9		12.4	11.3	13.2	11.2		11.9	12.5	19.1	17.5		16.9	19.8
21	13.9	12.8		13.4	13.1	14.9	13.2		14.0	14.1	16.6	17.1		17.4	16.5
22	21.6	22.4		11.3	33.6	24.7	25.0		13.8	36.5	34.3	34.8		24.3	44.6
23	25.6	22.7		21.4	26.9	29.1	24.8		23.9	29.9	35.8	30.6		30.3	35.9

Table 6.2

TABLE 6.3

Ranked Position Shifts

VAN SITES			H. LANDING SITES			H. BUOY SITES		
RAW	DIFF (1017)	DIFF (2220)	RAW	DIFF (1017)	DIFF (2220)	RAW	DIFF (1017)	DIFF (2220)
2.1	1.5	0.9	3.8	0.5	1.3	17.2	11.6	10.9
2.2	1.6	1.6	4.2	1.5	1.6	22.6	13.8	11.2
2.6	1.9	1.7	5.1	2.1	2.7	24.3	13.9	11.3
2.6	2.6	1.7	5.7	2.4	2.9	26.9	17.2	15.5
3.2	2.6	2.0	7.3	3.7	3.7	27.2	23.9	21.4
3.4	3.0	2.3	7.7	4.8	4.0	28.2	24.8	21.6
3.4	3.1	2.6	8.6	5.0	4.1	30.3	24.7	22.4
3.7	3.4	2.8	8.6	5.2	4.3	30.6	25.0	22.7
3.8	3.4	2.9	8.7	5.9	4.8	34.3	26.5	23.5
3.9	3.4	2.9	10.4	6.1	5.3	34.8	28.1	25.6
4.0	3.5	2.9	10.5	6.7	5.5	35.8	29.1	26.9
4.3	3.6	3.1	12.4	7.1	5.5	35.9	29.5	29.1
4.6	3.6	3.2	12.4	7.1	5.6	37.3	29.9	29.8
4.6	3.7	3.9	13.0	7.2	6.2	42.4	34.5	31.5
5.2	3.9	4.1	13.4	7.3	6.3	42.9	36.5	33.6
5.9	3.9	4.4	13.5	7.4	6.3	44.6	41.4	40.8
6.2	4.4	4.6	13.9	7.8	6.4	51.1	46.3	44.6
6.4	4.4	4.6	15.2	7.9	6.4	58.8	49.5	50.0
6.8	4.5	4.8	16.4	8.0	6.9	61.6	54.7	54.4
7.1	4.7	5.2	16.5	8.7	7.2	124.6	119.9	119.9
7.1	4.8	5.3	16.5	9.1	7.6			
7.5	5.1	5.5	16.6	9.2	8.4			
7.6	5.3	5.9	16.9	9.4	8.5			
8.8	5.3	6.5	17.1	9.9	8.6			
9.1	5.3	6.7	17.4	11.1	8.8			
9.3	5.4	7.9	17.5	11.2	9.7			
9.5	5.5	9.2	18.3	11.7	10.0			
9.6	5.7	9.7	18.3	11.9	11.3			
9.9	6.2	10.2	18.5	11.9	11.8			
10.5	6.3	10.6	19.1	12.5	11.9			
10.7	6.3	10.8	19.7	13.2	12.0			
10.7	6.4	10.8	19.8	13.2	12.4			
10.7	6.4	11.0	21.8	14.0	12.8			
11.5	6.6	12.0	22.9	14.1	13.1			
12.1	7.0	12.2	25.3	14.9	13.4			
12.5	7.3	12.2	30.4	14.9	13.9			
12.8	7.4	13.1						
13.0	7.5	13.3						
14.1	8.7	15.2						

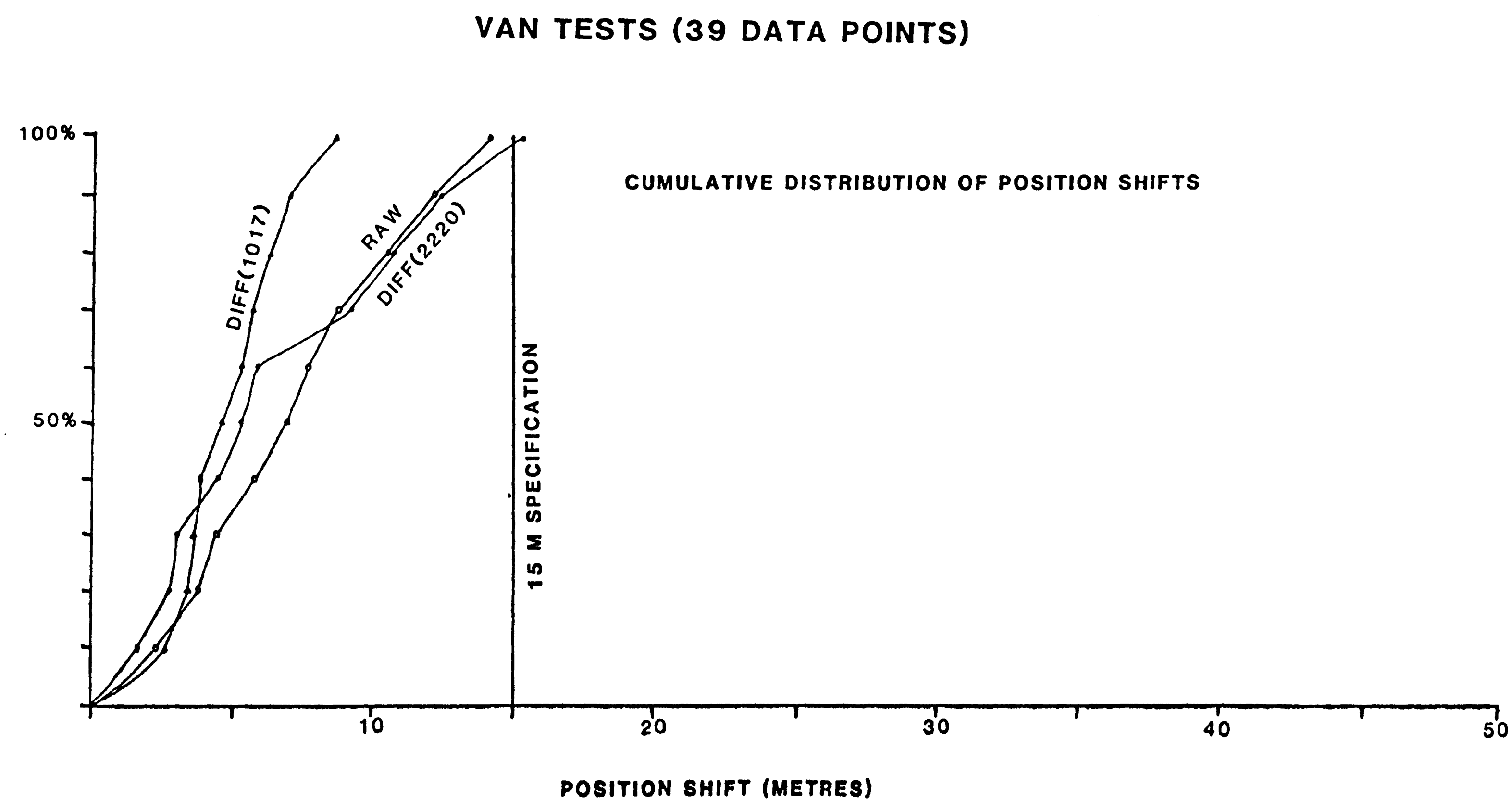
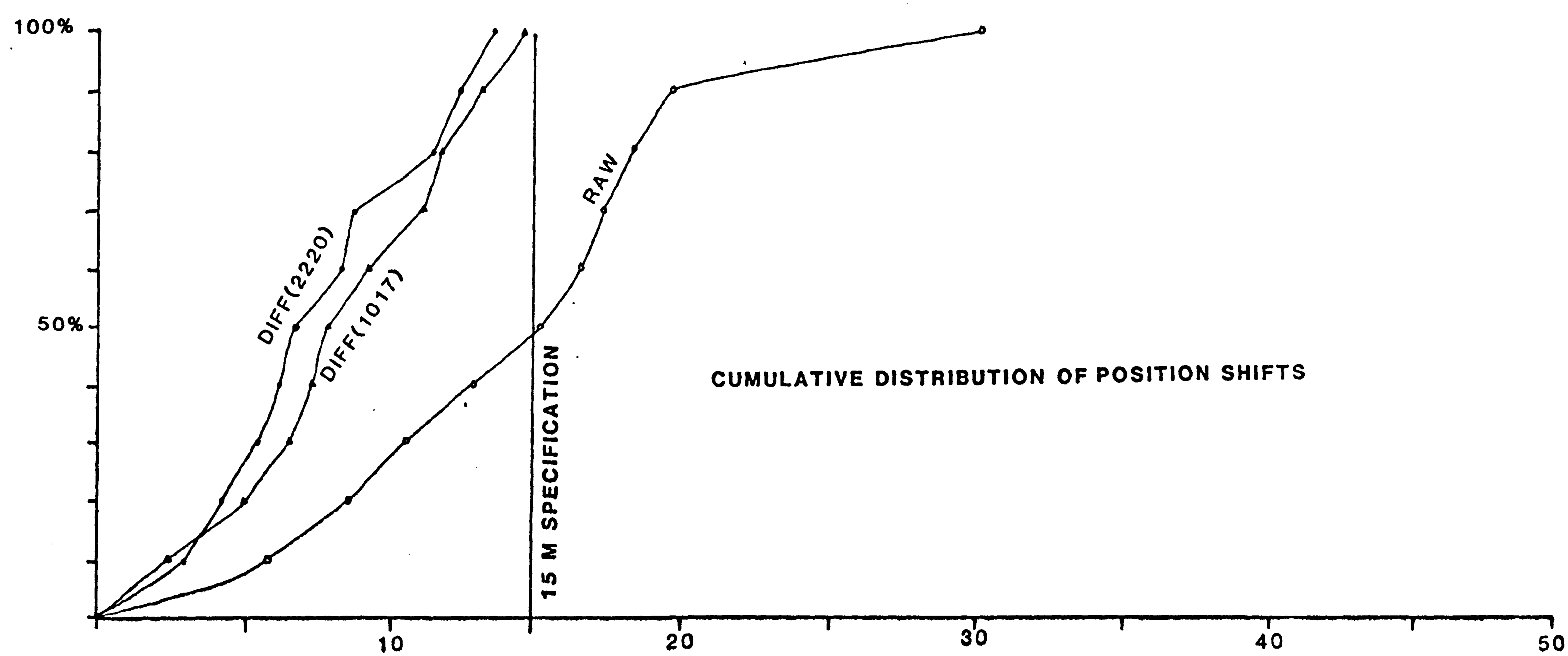

VAN TESTS (39 DATA POINTS)
CUMULATIVE DISTRIBUTION OF POSITION SHIFTS
100%
50%
DIFF(1017)
RAW
DIFF(2220)
15 M SPECIFICATION
10
20
30
40
50
POSITION SHIFT (METRES)

Figure 6.1

HELICOPTER LANDING TESTS (36 DATA POINTS)



POSITION SHIFT (METRES)

Figure 6.2

HELICOPTER HOVERING TESTS (20 DATA POINTS)

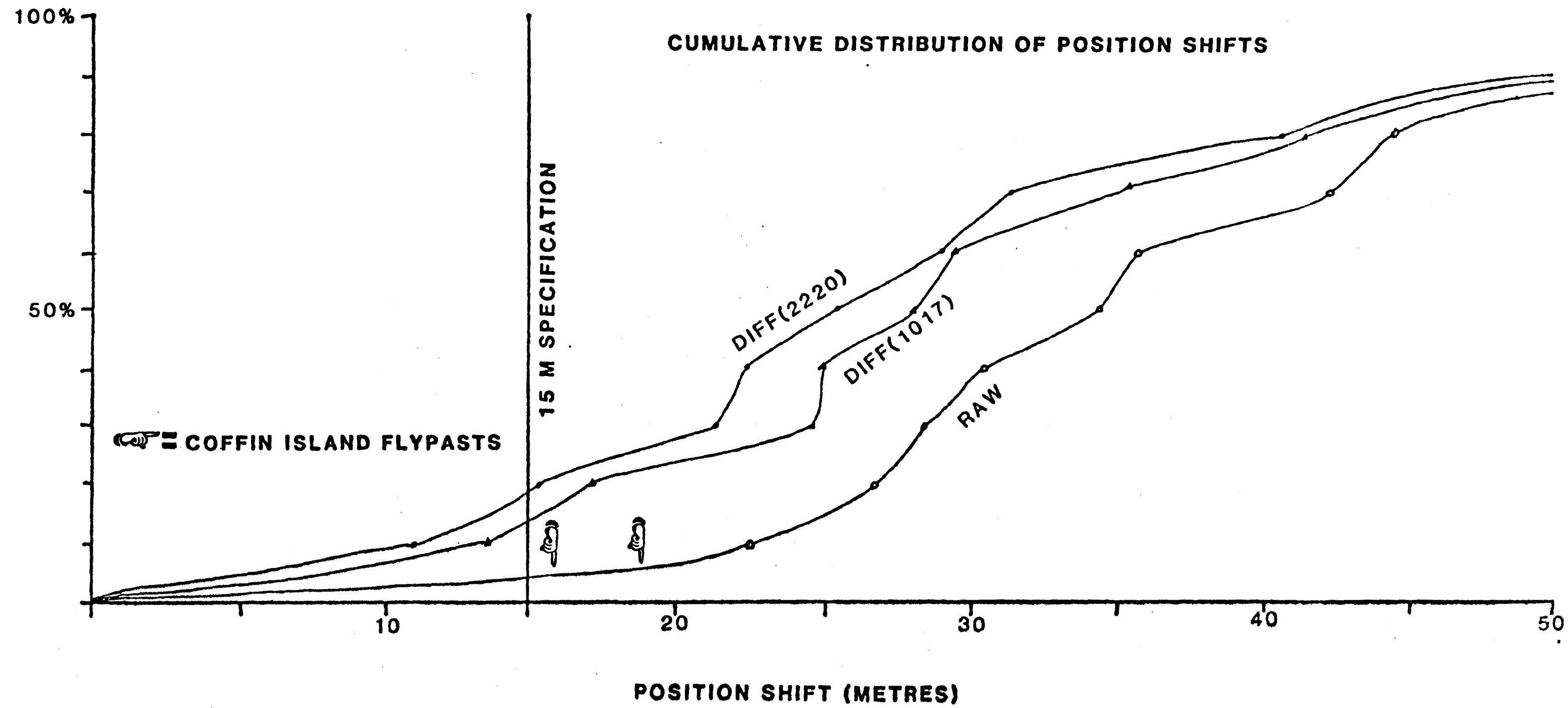


Figure 6.3

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

The main question posed of differential LORAN-C, if it is to be used for buoy position checking, is whether it is capable of detecting buoy movements as small as 15 metres, at the 95% confidence level.

Results of this initial experiment, as shown in Tables 6.2 and 6.3, and in Figures 6.1, 6.2 and 6.3, are generally favourable with respect to this criterion. Of the total of 150 van and helicopter landing differential comparisons in this experiment, 149 indicated repeatability to better than 15 metres. The exception was out by 15.2 metres. However this experiment was designed to test the repeatability of the technique at fixed sites, not the detection of motion of those sites.

> RECOMMENDATION 1: Future experiments should be held in which the van or helicopter is deliberately offset from its previous position by, say, 10 m and 20 m, along various azimuths.

However, this main question implies several more specific questions, not all of which can be answered from the results of this first experiment. We discuss each of these in turn, making recommendations where appropriate.

1) Is the LORAN-C radio signal stable enough (differentially) to meet the 15 metre repeatability criterion?

This is the most fundamental question. The results of this experiment indicate that in general it is. However it is not clear that this true at all times. One event which illustrates this occurred at about 2200 on day 267, when the van was making its fourth visit to Western Head Lockeport. Figure 7.1 shows the TDB difference between the van and monitors for this visit. A dip of about 0.20 microseconds, and later recovery of about 0.15 microseconds in the differential TD is evident. This is equivalent to a shift of 40 metres in the LOP, and a recovery of 30 metres. The same event is shown in Figures 7.2 and 7.3 for the raw van data and raw monitor data respectively. Two curious features are seen. The event seems to have occurred about 20 minutes earlier at the Ketch Harbour monitor than at the van at Western Head Lockeport. Secondly the magnitude of the event at the monitor is about half that at the van. This event is the most dramatic one captured cleanly during this experiment. However a similar event seems to have occurred, also on TDB at Western Head Lockeport, at the end of the van's first visit there at 2300 on day 225. In neither case was TDA affected, implying that they are somehow associated with the signal from Cape Race. A dip in TD of 0.20 microseconds, or 40 metres, is equivalent, for example, to an increase in the average refractivity over the line of 45 units, which would be very dramatic indeed, being just inside the 95% seasonal variation in refractivity for Halifax. Alternatively, such events may indicate some change in the transmission from Cape Race, although then the time and magnitude variations between the two sites are hard to explain. The clocks providing time tags at the two receivers are assumed to be much better synchronized than 20 minutes, for example.

> RECOMMENDATION 2: Such events should be correlated with weather and LORAN chain records to help identify their source.

> RECOMMENDATION 3: A long term (say one year) monitoring program at two or more widely separated sites (for example Halifax and Yarmouth) be established to identify the frequency and severity of such events, and any correlation they may have with weather and LORAN chain events.

2) Are LORAN-C receivers stable enough to effectively use the

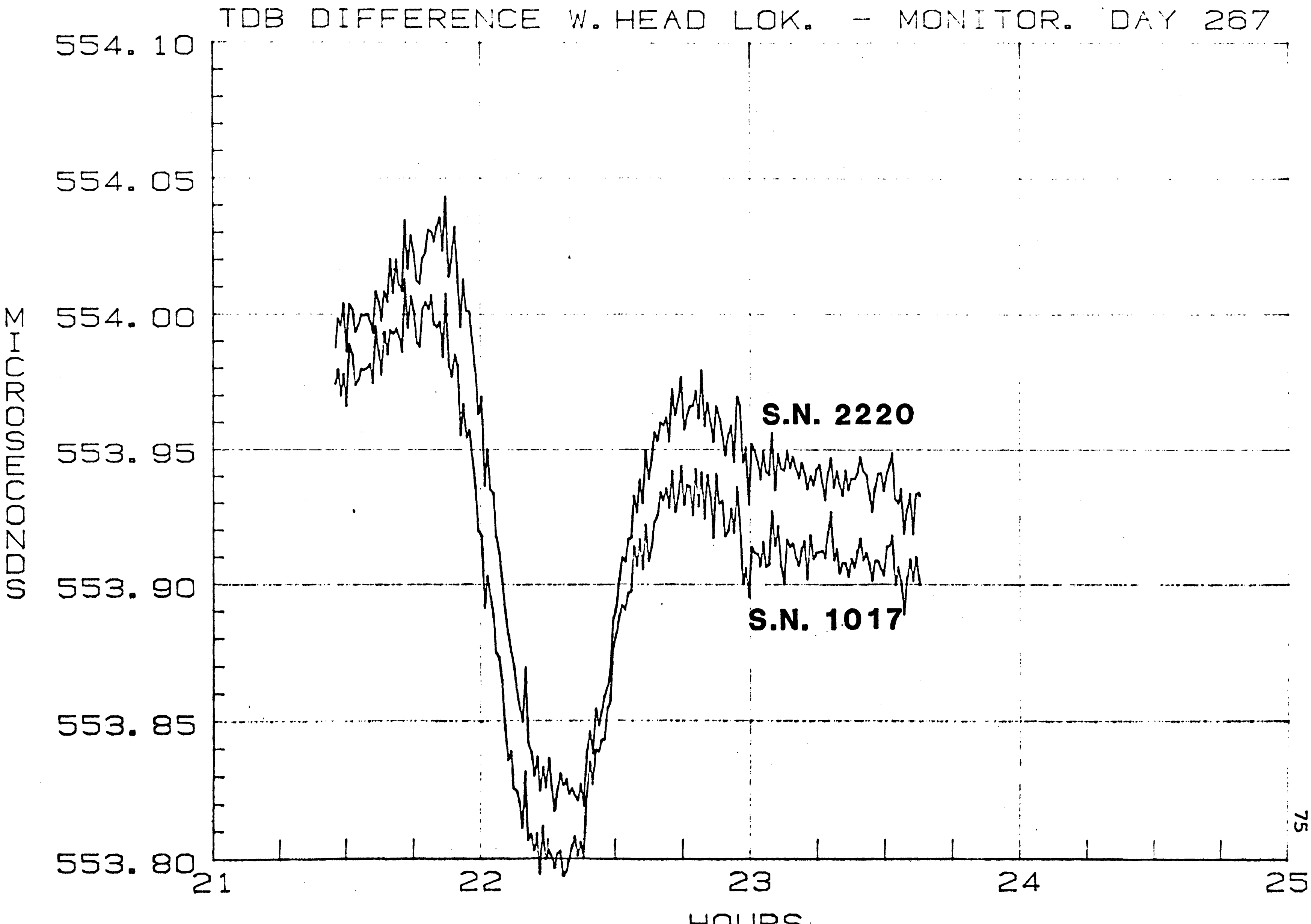


Figure 7.1 TDB Differential Dip

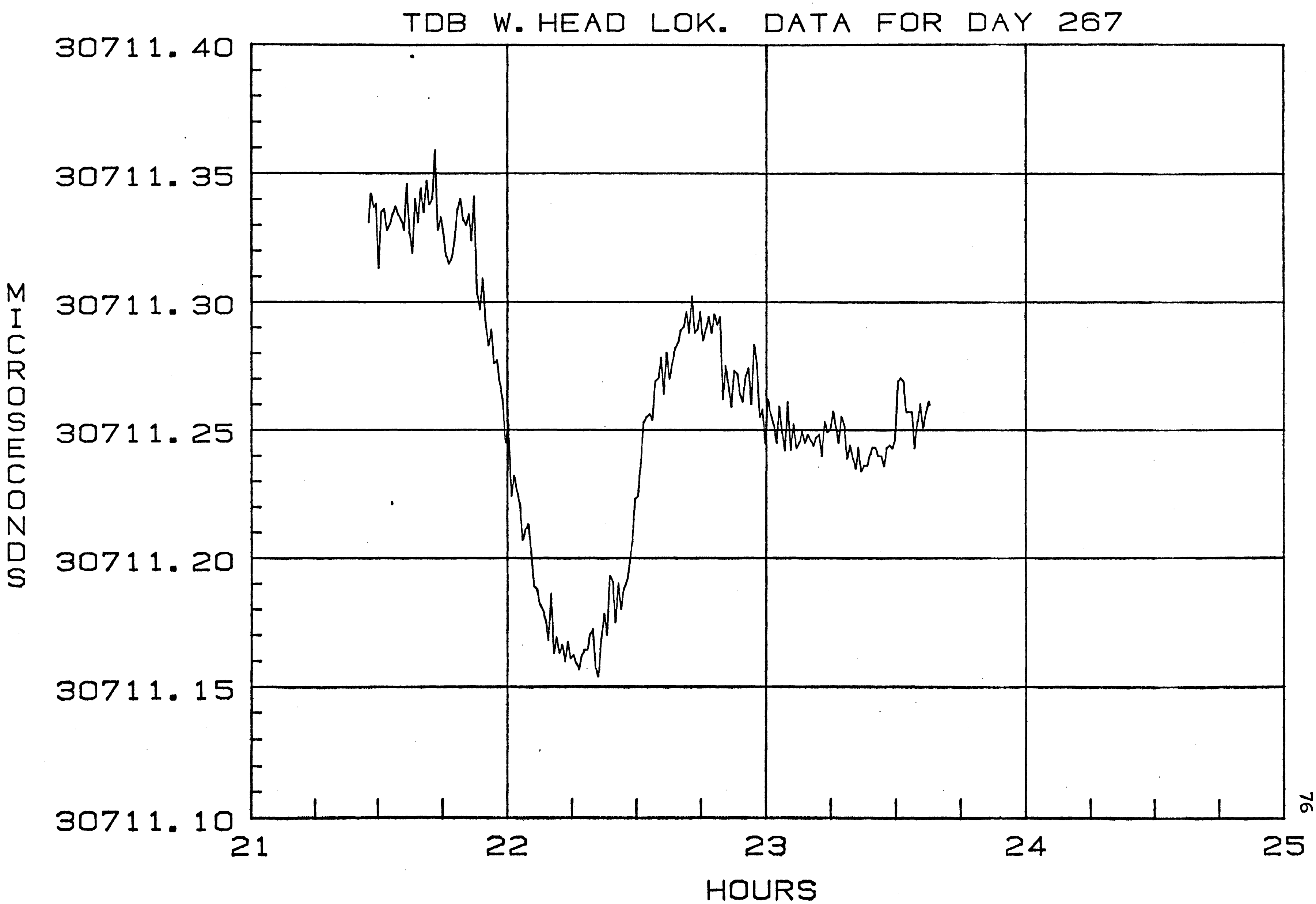


Figure 7.2 TDB Dip at Van

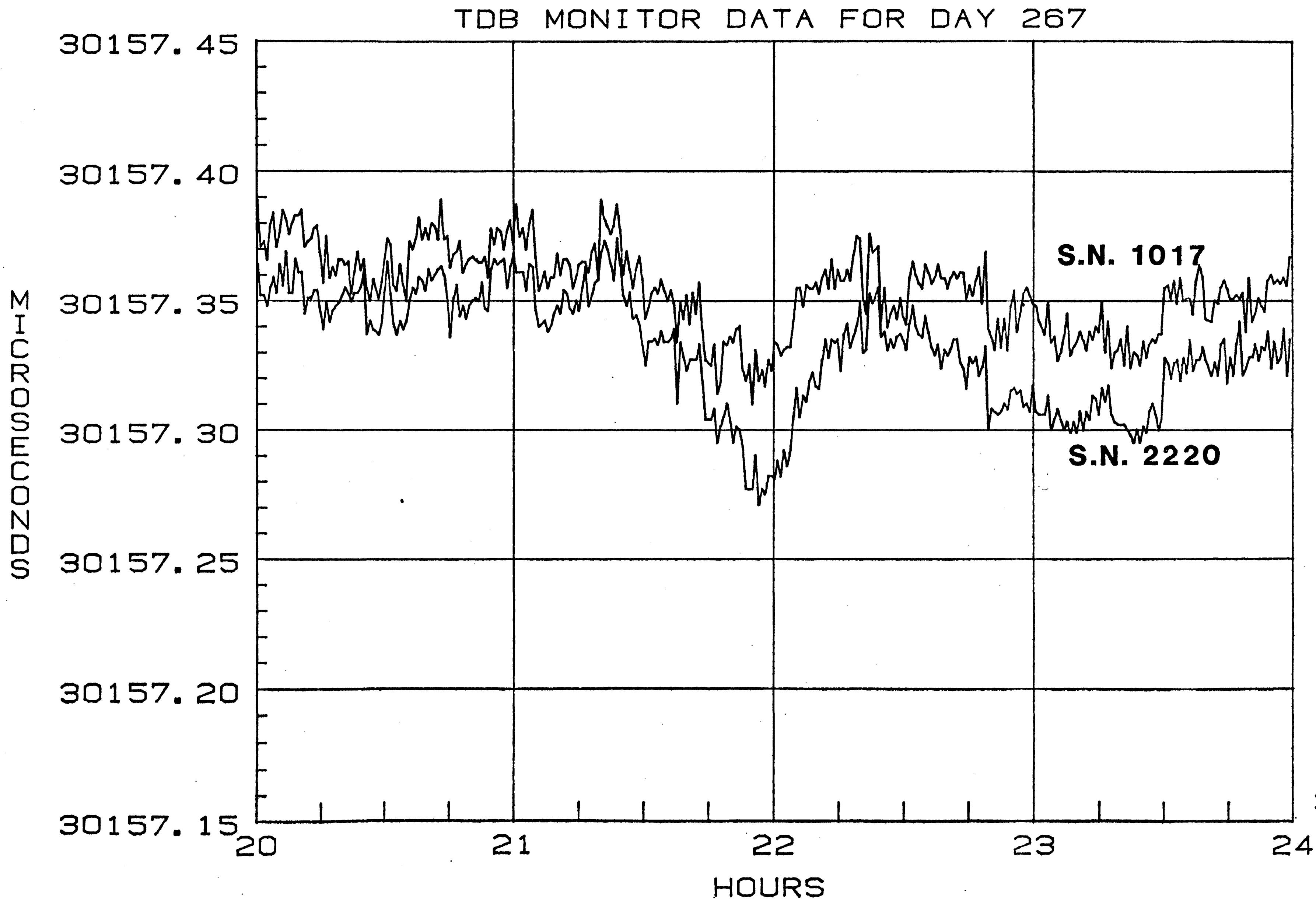


Figure 7.3 TDB Dip at Monitor

apparent stability of the differential LORAN-C signal?

The results of this experiment indicate this may not be the case. It appears that adjustment of the notch filters may adversely affect repeatability (whereas not adjusting them may adversely affect signal strength). For example the receivers were notched on day 252. Table 6.2 indicates that the subsequent (fourth) visit to the van sites was the worst (in terms of repeatability) for s/n 2220.

> RECOMMENDATION 4: The necessity and effectiveness of notching should be investigated by setting up two receivers at the same site, one correctly notched, and the other with no notches, and comparing their TD differences over an appropriate period of time.

> RECOMMENDATION 5: Problems introduced by spatial variations in the radio noise environment (which may require re-notching from place to place) be investigated by a set of experiments between two sites identified as having different interfering frequencies, using various combinations of notching between the two sites.

> RECOMMENDATION 6: Consideration should be given to a differential LORAN procedure in which the necessity for receiver stability from visit to visit be eliminated through calibration on each visit. For example, once the differential TD readings between the monitor and a set of fixed points (say, lighthouses) become well known, these fixed points could be used as differential LORAN calibration points. Any combination of receivers, notched or not, could be used. The helicopter would land at several of these calibration points on each tour through the buoys to be checked, in order to establish the difference between the "true" differential TD readings and those obtained by the particular pair of receivers in use during that day. This correction would then be applied to the differential readings observed at the buoys being checked.

3) Can the helicopter be positioned relative to the buoy sufficiently accurately on each visit to meet the 15 metre criterion?

This, rather than LORAN stability, may be the ultimate limitation of this buoy checking technique. Hovering over the buoy (at least as performed during this experiment) is obviously not good enough (see Figure 6.3). The flypast technique shows promise, but was tested in a very limited way in this experiment. Questions remain concerning how best to process flypast data. The two processing methods described in Section 3.3 gave very different TDX results for visit 2 (see Table 3.1). This is due to the different assumptions regarding helicopter behavior implied by the two algorithms. The first method assumes that the buoy will somehow lie at the centroid of the intersection of all the independent flypast trajectories. The second method assumes that every flypast will travel directly over the buoy.

> RECOMMENDATION 7: Further experiments should be designed to gain more practical experience with the flypast technique, both in terms of pilot procedure, and processing procedure.

> RECOMMENDATION 8: Consideration should be given to overcoming the relative buoy/helicopter positioning problem by making continuous radar range and bearing measurements from the helicopter to the buoy. These measurements should be integrated with the LORAN measurements. Together with appropriate flypast procedures this should permit tying each LORAN measurement to the buoy.

4) Does the differential technique improve LORAN-C repeatability?

Unquestionably, as demonstrated by comparing Figures 4.7 (raw data) and 4.8 (differentially corrected data), and by Figures 6.1 and 6.2. In Figure 6.1 the differential results using monitor s/n 2220 were degraded for reasons described under question 2 above.

5) How far from the monitor is the differential correction effective?

The van site results (Figures 5.1 to 5.4) do not show any strong distance dependence out to 150 km. The helicopter landing site results (Figures 5.5 to 5.8) indicate a distance dependence of differential TDB but not TDA. This may be due to some kind of coastal "edge" effect, since the Cape Race signal "grazes" the Nova Scotia coastline.

RECOMMENDATION 9: Further experiments should be designed to establish the effective range of the differential correction in different possible areas of application, in order to identify features (such as coastline grazing) which may limit the effective range.

6) What are the best resolution and averaging interval to use at the remote and monitor sites?

The resolution should be one nanosecond rather than ten, as demonstrated by comparing Figures 4.2 and 4.3. For this report, the data interval used was that available from the raw data. No attempt was made to investiagte the effect of smoothing the differential correction by averaging over longer periods in the processing.

RECOMMENDATION 10: The data from the present experiment should be subjected to a spectral analysis in order to ascertain the characteristic periods of LORAN-C signal variations. The results of this analysis would lead to an informed choice of recording and processing intervals.

RECOMMENDATION 11: An experiment should be performed in which the monitor data interval is equal to the remote receiver data interval, and in which the timing of the two data recordings are carefully synchronized. Data from such an experiment could be subjected to a more complete spectral analysis, and could be reprocessed at several averaging intervals in order to test the results of the spectral analysis.

7) Given some differential LORAN-C measurements, what is an efficient and practical way of deciding whether the buoy has moved?

Some first steps towards this end have been developed in Appendix II, in which a simple conversion from TD shifts to position shifts has been shown to be practical.

RECOMMENDATION 12: Consideration be given to testing various alternative implementations of the techniques in Appendix II under realistic operational conditions, and using various helicopter flying strategies, as discussed above.

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APPENDIX I

PARTITIONED SAMPLE STATISTICS

I.1 Notation and Transformations

Given a set of observation X_i, i=1,2,...,N, the sample statistics are N, $\bar{X}$ (the sample mean), and S^2 (the sample variance), given by

N = the number of observations

$$\bar{X} = \frac{1}{N} \sum_{i=1}^{N} X_i \qquad \text{(I.1)}$$

$$S^2 = \frac{1}{N-1} \sum_{i=1}^{N} (X_i - \bar{X})^2 = \frac{1}{N-1}\left(\sum_{i=1}^{N} X_i^2 - N\bar{X}^2 \right)$$

An alternative parameter set are the three sums

$$P = \sum_{i=1}^{N} 1$$

$$Q = \sum_{i=1}^{N} X_i \qquad \text{(I.2)}$$

$$R = \sum_{i=1}^{N} X_i^2$$

The transformation from (N, $\bar{X}$, S^2) to (P, Q, R) is

$$P = N$$

$$Q = N\,\bar{X} \qquad \text{(I.3)}$$

$$R = N\,\bar{X}^2 + (N-1)\,S^2$$

The transformation from (P, Q,R) to N, $\bar{X}$, S^2) is

$$N = P$$

$$\bar{X} = Q/P \tag{I.4}$$

$$S^2 = \frac{1}{P-1} (R - \frac{Q^2}{P})$$

I.2 Partitioned Samples

Let the set $\{X_i\}$ of N observations be partitioned into m subsets, each containing n_k observations. That is

$$\{X_i, i=1,2,\ldots,N\} = \{(x_{jk}, j=1,2,\ldots,n_k), k=1,2,\ldots,m\} \quad .$$

Then (I.1) becomes

$$N = \sum_{k=1}^{m} n_k$$

$$\bar{X} = \frac{1}{N} \sum_{k=1}^{m} \sum_{j=1}^{n_k} x_{jk} \tag{I.5}$$

$$S^2 = \frac{1}{N-1} \sum_{k=1}^{m} \sum_{j=1}^{n_k} (x_{jk} - \bar{X}^2)$$

and (I.2) becomes

$$P = \sum_{k=1}^{m} n_k$$

$$Q = \sum_{k=1}^{m} \sum_{j=1}^{n_k} x_{jk} \tag{I.6}$$

$$R = \sum_{k=1}^{m} \sum_{j=1}^{n_k} x_{jk}^2$$

For each subset we may have <u>subset</u> sample statistics given by

n_k

$$\bar{x}_k = \frac{1}{n_k} \sum_{j=1}^{n_k} x_{jk} \qquad (I.7)$$

$$s_k^2 = \frac{1}{n_k - 1} \sum_{j=1}^{n_k} (x_{jk} - \bar{x}_k)^2$$

and <u>subset</u> sums given by

$$P_k = n_k$$

$$Q_k = \sum_{j=1}^{n_k} x_{jk} \qquad (I.8)$$

$$R_k = \sum_{j=1}^{n_k} x_{jk}^{\;2}$$

Note that the subset sums are related to the total sums by

$$P = \sum_{k=1}^{m} P_k$$

$$Q = \sum_{k=1}^{m} Q_k \qquad (I.9)$$

$$R = \sum_{k=1}^{m} R_k$$

The transformation from $(n_k, \bar{x}_k, s_k^2)$ to (P_k, Q_k, R_k) is

$$P_k = n_k$$

$$Q_k = n_k \bar{x}_k \qquad (I.10)$$

$$R_k = n_k \bar{x}_k^2 + (n_k - 1) s_k^2$$

and from (P_k, Q_k, R_k) to $(n_k, \bar{x}_k, s_k^2)$ is

$$n_k = P_k$$
$$\bar{x}_k = Q_k/P_k \qquad (I.11)$$
$$s_k^2 = \frac{1}{P_k-1}\left(R_k - \frac{Q_k^2}{P_k}\right)$$

Consequently, the transformation from $\{n_k, \bar{x}_k, s_k^2\}$ to $(N, \bar{X}, S^2)$ can be obtained by using (I.10) then (I.9) and (I.4) to give

$$N = \sum_{k=1}^{m} n_k$$
$$\bar{X} = \frac{1}{N}\sum_{k=1}^{m} n_k \bar{x}_k \qquad (I.12)$$
$$S^2 = \frac{1}{N-1}\left[\sum_{k=1}^{m} (n_k - 1) s_k^2 + \sum_{k=1}^{m} n_k (\bar{x}_k - \bar{X})^2\right]$$

where we have used the identity

$$\sum_{k=1}^{m} n_k(\bar{x}_k - \bar{X})^2 = \sum_{k=1}^{m} n_k \bar{x}_k^2 - N\bar{X}^2 \qquad (I.13)$$

I.3 Practical Computations

We assume for simplicity that all the subsets are of equal size (all $n_k = n$), and that $n, m \gg 1$. Then (I.12) becomes

$$N = n\, m$$
$$\bar{X} = \frac{1}{m}\sum_{k=1}^{m} \bar{x}_k$$
$$S^2 = \frac{n-1}{nm-1}\sum_{k=1}^{m} s_k^2 + \frac{n}{nm-1}\sum_{k=1}^{m} (\bar{x}_k - \bar{X})^2 \qquad (I.14)$$
$$\simeq \frac{1}{m}\sum_{k=1}^{m} s_k^2 + \frac{1}{m}\sum_{k=1}^{m} (\bar{x}_k - \bar{X})^2$$

Now, if we treat each $\bar{x}_k$ as a simple observation (ignoring n_k and s_k) we find, by setting $X_i = \bar{x}_k$ in (I.1) that

$$N_* = m$$

$$\bar{X}_* = \frac{1}{m} \sum_{k=1}^{m} \bar{x}_k$$

$$S_*^2 = \frac{1}{m-1} \sum_{k=1}^{m} (\bar{x}_k - \bar{X}_*)^2 \qquad \text{(I.15)}$$

$$\simeq \frac{1}{m} \sum_{k=1}^{m} (\bar{x}_k - \bar{X}_*)^2$$

Finally, to convert from this approach (in which the $\bar{x}_k$ are observations) to the previous approach (in which the x_{jk} are observations) we use

$$N = n\, N_*$$

$$\bar{X} = \bar{X}_* \qquad \text{(I.16)}$$

$$S^2 = S_*^2 + \frac{1}{m} \sum_{k=1}^{m} s_k^2$$

The mean does not change, but the variance when all x_{jk} are considered observations is larger than the variance when only the subset means $\bar{x}_k$ are considered as observations.

The statistical summaries in this report list both S_* from (I.15) as "SD1", and S from (I.16) as "SD2".

APPENDIX II

LOP to Position Conversions

II.1 Introduction

In this appendix we consider two related problems, illustrated in Figures II.1 and II.2.

(1) Given the shifts in two LORAN-C line of position measurements (ΔTDX and ΔTDY), what is the resultant shift in position (P1 to P2)?

(2) Given the standard deviations on two LORAN-C line of position measurements (σ_x and σ_y), what is the size and orientation of the corresponding position error ellipse?

II.2 Conversion of LOP Change into Position Change

There are many ways of approaching this problem. The "brute force" analytical approach would be to compute the coordinates of P1 from TDX-1 and TDY-1, and then to independently compute the coordinates of P2 from TDX-2 and TDY-2, and finally to compute the distance and azimuth from P1 to P2. There are two disadvantages to this approach. First, we are essentially looking at the small difference (P1-P2) between two large numbers (P1 and P2), which will be very sensitive to errors in computing P1 and P2. Commercial LORAN-C coordinate converters, for example, may have enough roundoff error and sufficiently loose criteria for convergence of the solution to obscure the small differences (P1-P2). Secondly, this approach does require a computational facility capable of both coordinate conversion and distance/azimuth calculation.

At the other extreme is the "brute force" graphical approach, where P1 and P2 are plotted on a chart latticed with LORAN-C, and the position shift

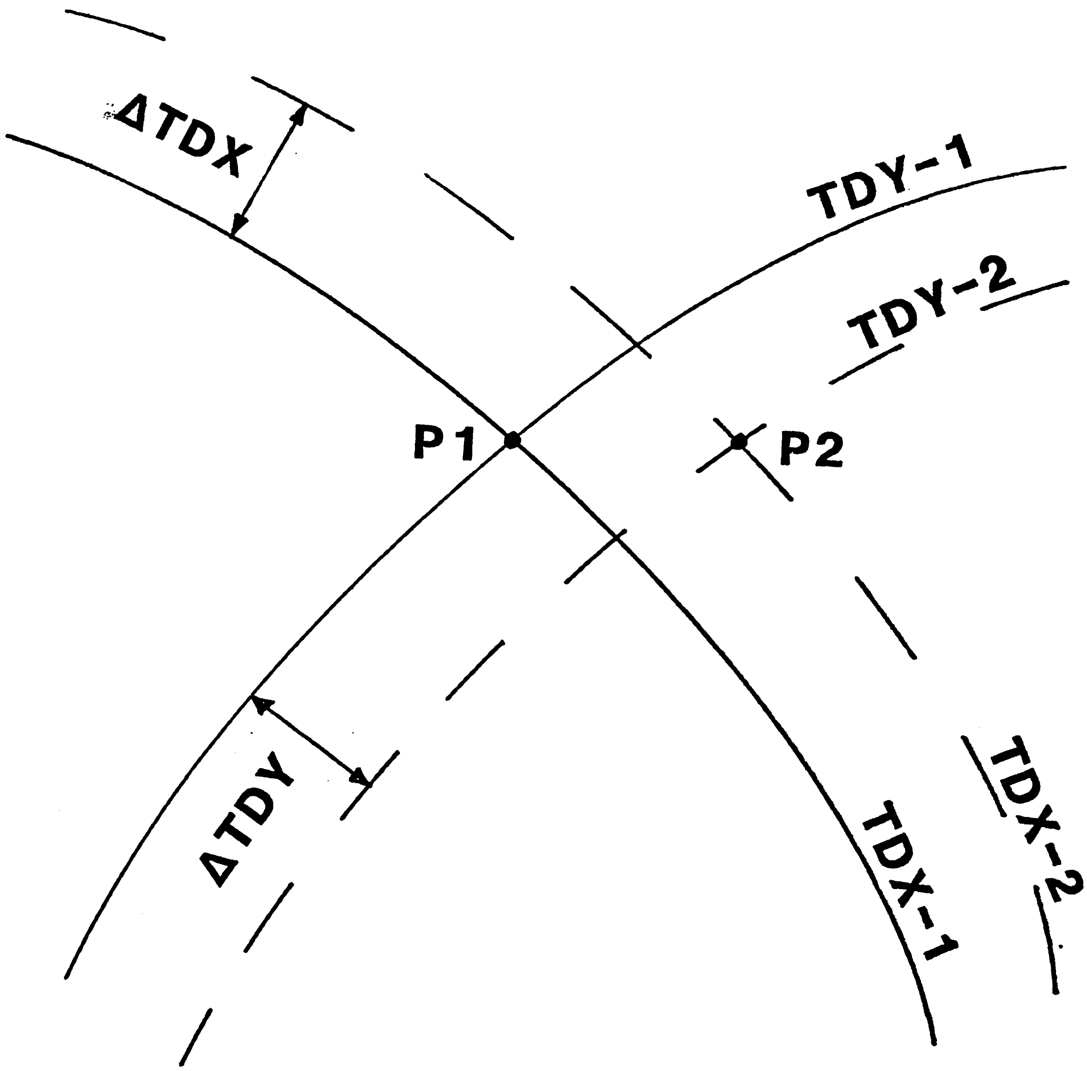


Figure II.1

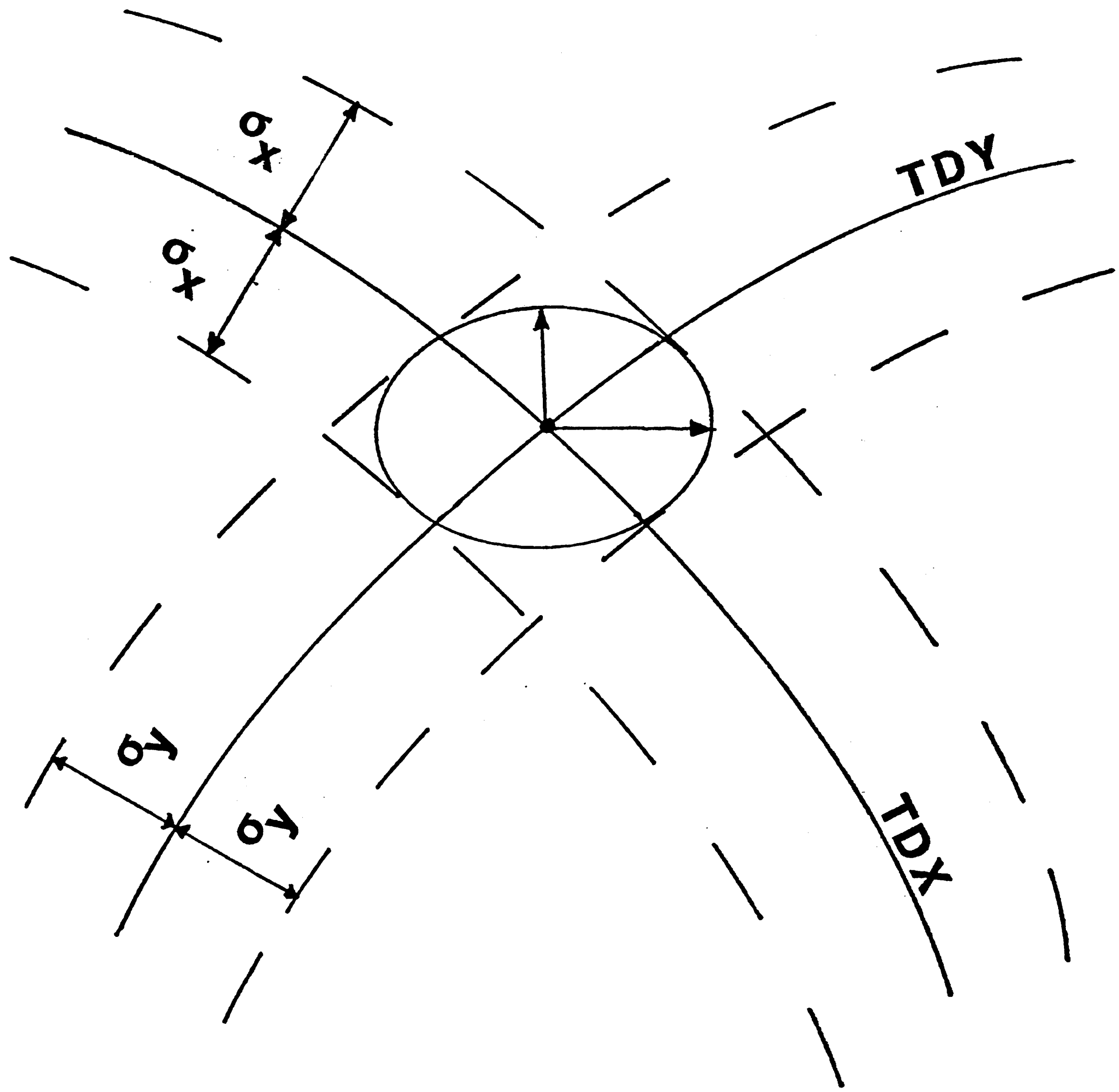


Figure II.2

scaled from the two plotted positions. This requires latticed charts of large enough scale to show small position shifts. For example, if we wished to have a 15 metre shift shown as a 1 cm shift on the chart, we would need a chart scale of 1:1500. Typically CHS LORAN-C latticed chart scales are ten to one hundred times smaller than that. Therefore special localized chartlets for each area, or even each buoy location, would have to be specially constructed.

What is needed here is a method of converting ΔTDX and ΔTDY directly into the position shift (P1-P2), without having to compute P1 and P2 separately first. This method should take advantage of the fact that for small changes in LOP and position, the lattice geometry does not change, and a linear approximation can be used. Thus we can replace Figure II.1 with Figure II.3. There are then two stages to such a method:

(1) Determine values for some parameters which describe the (constant) lattice geometry in the vicinity of the point (buoy) of interest. This need be done only once.

(2) Convert changes in LOPs to changes in position, using a simple relationship which includes the parameter values above.

Each stage of such a simplified method can be approached either analytically or geometrically. We review these two approaches in the following three sections.

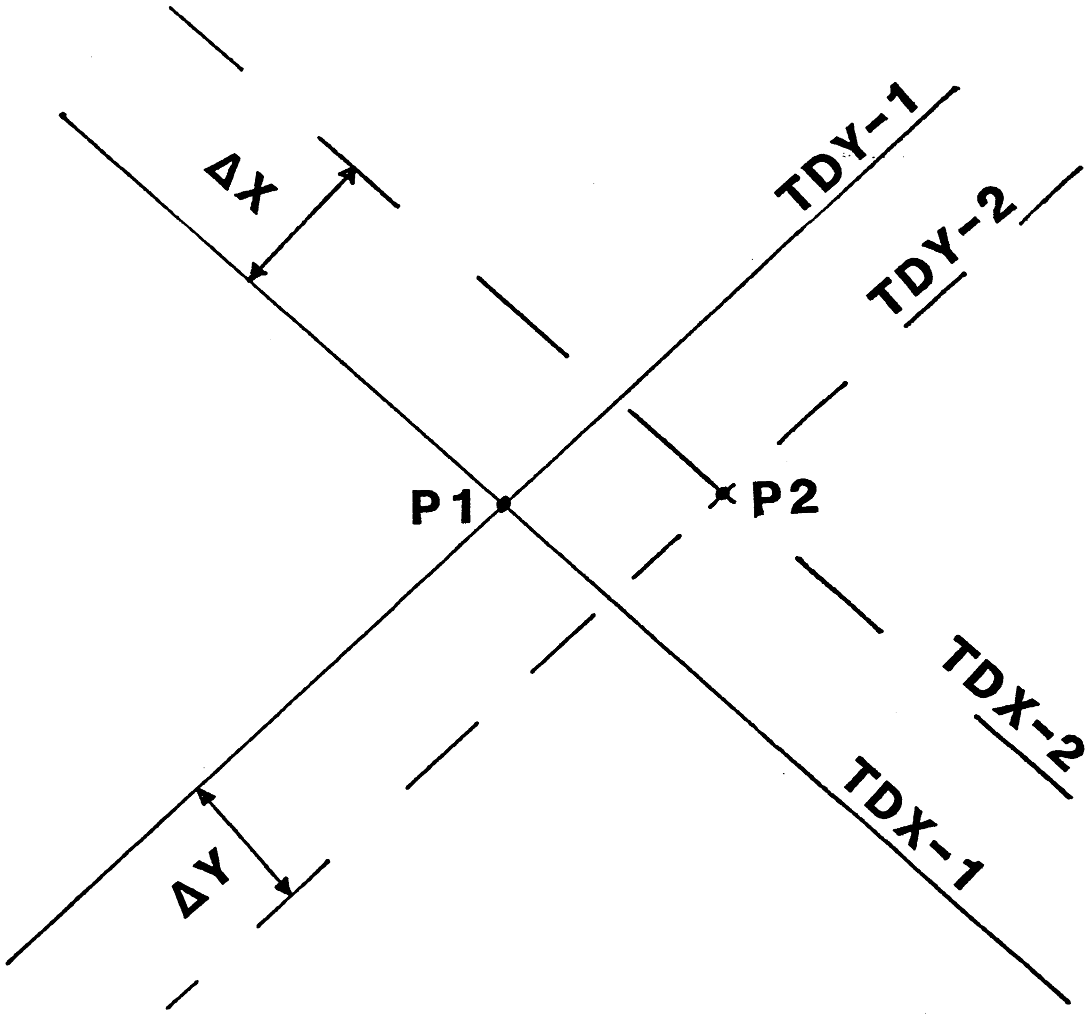


Figure II.3

II.2.1 Analytic approach

We apply the algorithms of the parametric least-squares adjustment to obtain the linear relationship (in vector form)

$$\underline{\delta} = \underline{M}\ \underline{\Delta} \quad , \tag{II.1}$$

where $\underline{\delta} = [(\phi_{P2} - \phi_{P1}), (\lambda_{P2} - \lambda_{P1})]^T$ is the vector shift from P1 to P2 (in metres)

$\underline{\Delta} = [\Delta TDX, \Delta TDY]^T$ is the vector of LOP changes

$\underline{M}$ = a 2 × 2 transformation matrix from $\underline{\Delta}$ to $\underline{\delta}$.

Then stage one of the method consists of determining $\underline{M}$, which is assumed to have constant elements, and need only be done once. Stage two merely applies the above equation for each set of $\underline{\Delta}$.

Let us develop an expression for $\underline{M}$. Given a vector of observations $\underline{\ell}$, a vector of unknown parameters $\underline{x}$, and an observation equation relating them

$$\underline{f}(\underline{x}) = \underline{\ell} \tag{II.2}$$

we use Taylor Series linearization about $\underline{x} = \underline{x}^o$ to obtain

$$\underline{f}(\underline{x}^o) + \left.\frac{\partial \underline{f}}{\partial \underline{x}}\right|_{\underline{x}^o} (\underline{x} - \underline{x}^o) = \underline{\ell} \quad . \tag{II.3}$$

or

$$\underline{f} + \underline{A}\ (\underline{x} - \underline{x}^o) = \underline{\ell} \tag{II.4}$$

where $\underline{A} = \left.\frac{\partial \underline{f}}{\partial \underline{x}}\right|_{\underline{x}^o}$ is the design matrix (see Section II.2.2 for details).

Now if we are given two sets of observations $\underline{\ell}_1$ and $\underline{\ell}_2$, with corresponding parameter values $\underline{x}_1$ and $\underline{x}_2$, we have

$$\underline{f} + \underline{A}\ (\underline{x}_1 - \underline{x}^o) = \underline{\ell}_1 \tag{II.5}$$

$$\underline{f} + \underline{A}\ (\underline{x}_2 - \underline{x}^o) = \underline{\ell}_2 \tag{II.6}$$

and the differential model becomes (subtracting (II.6) from (II.5))

$$\underline{A}\ (\underline{x}_2 - \underline{x}_1) = (\underline{\ell}_2 - \underline{\ell}_1) \qquad \text{(II.7)}$$

or

$$\underline{A}\ \underline{\delta} = \underline{\Delta} \quad . \qquad \text{(II.8)}$$

Premultiplying both sides by $(\underline{A}^T\underline{C}^{-1}\underline{A})^{-1}\ \underline{A}^T\underline{C}^{-1}$, (where $\underline{C}$ is the covariance matrix of $\underline{\Delta}$) we obtain

$$\underline{\delta} = (\underline{A}^T\underline{C}^{-1}\underline{A})^{-1}\ \underline{A}^T\underline{C}^{-1}\underline{\Delta} \quad , \qquad \text{(II.9)}$$

the linear parametric least squares solution. Hence, comparing (II.1) and (II.9) we see

$$\underline{M} = (\underline{A}^T\underline{C}^{-1}\underline{A})^{-1}\ \underline{A}^T\underline{C}^{-1} \quad . \qquad \text{(II.10)}$$

If we can ignore correlations between and differences in the weighting for the components of $\underline{\Delta}$ (i.e., measurements of ΔTDX and ΔTDY are equally accurate and uncorrelated) then we can set $\underline{C} = \underline{I}$ and

$$\underline{M} = (\underline{A}^T\underline{A})^{-1}\ \underline{A}^T \quad . \qquad \text{(II.11)}$$

$\underline{M}$ need only be computed once. Then for each set of LOP changes $\underline{\Delta}$ we use (II.1) to obtain the resulting position shift $\underline{\delta}$. The distance and azimuth of the shift can be obtained from $\underline{\delta}$ by using the standard rectangular to polar conversion.

II.2.2 Expression for the design matrix A

In order to obtain expressions for the elements of $\underline{A}$ we set $\underline{f}(\underline{x})$ in (II.2) to the hyperbolic expressions

$$\underline{f}(\underline{x}) = \begin{bmatrix} S_{ip} - S_{jp} \\ S_{ip} - S_{kp} \end{bmatrix} \qquad \text{(II.12)}$$

where

S_{ip} = distance from master (i) to receiver (p)

S_{jp} = distance from X slave (j) to receiver (p)

S_{kp} = distance from Y slave (k) to receiver (p).

Then

$$\underline{A} = \frac{\partial \underline{f}}{\partial \underline{x}} = \begin{bmatrix} \frac{\partial S_{ip}}{\partial \phi_p} - \frac{\partial S_{jp}}{\partial \phi_p} \, , & \frac{\partial S_{ip}}{\partial \phi_p} - \frac{\partial S_{kp}}{\partial \phi_p} \\ \frac{\partial S_{ip}}{\partial \lambda_p} - \frac{\partial S_{jp}}{\partial \lambda_p} \, , & \frac{\partial S_{ip}}{\partial \lambda_p} - \frac{\partial S_{kp}}{\partial \lambda_p} \end{bmatrix} \tag{II.13}$$

where (ϕ_p, λ_p) are approximate receiver coordinates $(\underline{x}^o)$. In order to compute these partial differential terms, we can assume either a spherical or a plane model. We consider a plane model in the next section. Here we consider the spherical model of Figure II.4:

$$S_{ip} = R \, \sigma_{ip} \tag{II.14}$$

$$\frac{\partial S_{ip}}{\partial \phi_p} = R \, \frac{\partial \phi_{ip}}{\partial \phi_p} \tag{II.15}$$

$$\frac{\partial S_{ip}}{\partial \lambda_p} = R \, \frac{\partial \sigma_{ip}}{\partial \lambda_p} \tag{II.16}$$

From the law of cosines for sides

$$\sigma_{ip} = \cos^{-1}[\sin\phi_i \, \sin\phi_p + \cos\phi_i \, \cos\phi_p \, \cos(\lambda_i - \lambda_p)] \tag{II.17}$$

$$\frac{\partial \sigma_{ip}}{\partial \phi_p} = \frac{- \sin\phi_i \, \cos\phi_p + \cos\phi_i \, \sin\phi_p \, \cos(\lambda_i - \lambda_p)}{\sin\sigma_{ip}} \tag{II.18}$$

$$\frac{\partial \sigma_{ip}}{\partial \lambda_p} = \frac{- \cos\phi_i \, \cos\phi_p \, \sin(\lambda_i - \lambda_p)}{\sin\sigma_{ip}} \tag{II.19}$$

In (II.13) the units assumed are $\underline{\delta}$ in radians and $\underline{\Delta}$ in metres. To convert the units of $\underline{\delta}$ to metres we must multiply the elements of $\underline{A}$ by $1/R$. To

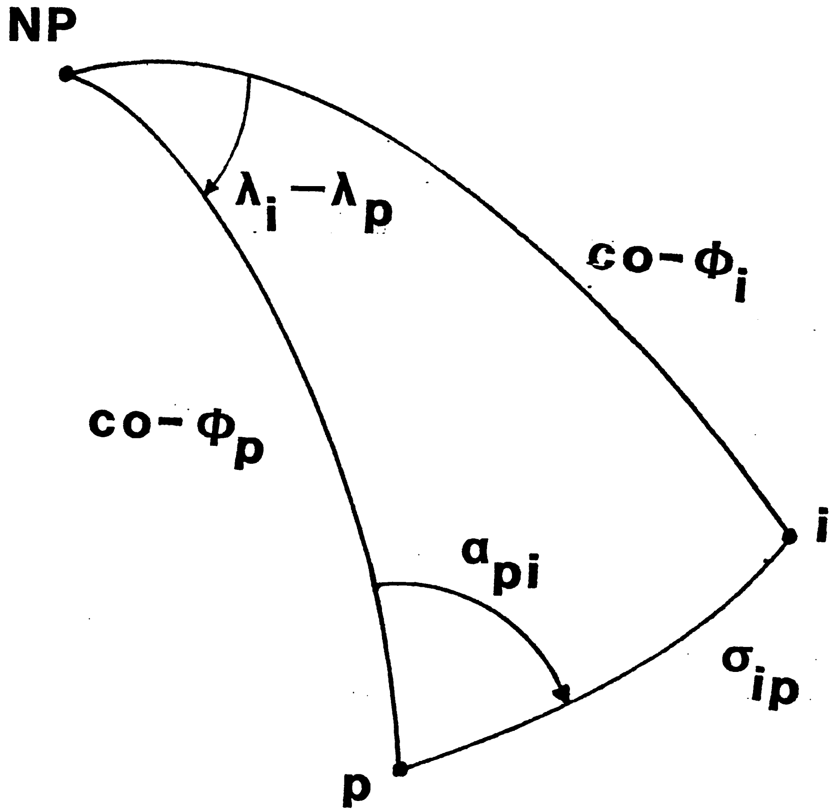


Figure II.4

convert the units of $\underline{\Delta}$ to microseconds, we must multiply the elements of $\underline{A}$ by $c \times 10^{-6}$, where c is the velocity of light in metres/second ($c \times 10^{-6} \simeq$ 300 metres/microsecond).

II.2.3 Lattice geometry

One set of four parameters sufficient to describe the lattice geometry in the vicinity of a point of interest P are

H_x = the conversion (at P) of ΔTDX in microseconds to a shift on the ground, ΔX in metres;

H_y = the conversion (at P) of ΔTDY in microseconds to a shift on the ground, ΔY in metres;

α_x = the azimuth of TDX lines of position at P.

α_y = the azimuth of TDY lines of position at P.

These need only be determined once for each point of interest P. Two ways of obtaining values for the conversion factors H and azimuths α are as follows.

(1) Using a small scale regional chart showing the LORAN-C master and slave transmitters, and the point of interest P, measure the angle a_{ipj} subtended at P by the LORAN-C master-slave baseline (see Figure II.5). The conversion factor H involves the conversion from microseconds to metres, given by $c \times 10^{-6}$ (300 metres/microsecond), and the lane expansion factor G.

To determine an expression for the lane expansion, we use the "hyperbolic theorem" which states that the direction of an hyperbolic line of position bisects the angle subtended by the reference station baseline. We first prove this theorem, and then apply it to obtain an expression for G in Figure II.5. We start with the observation equation

$$S_{ipj} = S_{ip} - S_{jp} \quad , \tag{II.20}$$

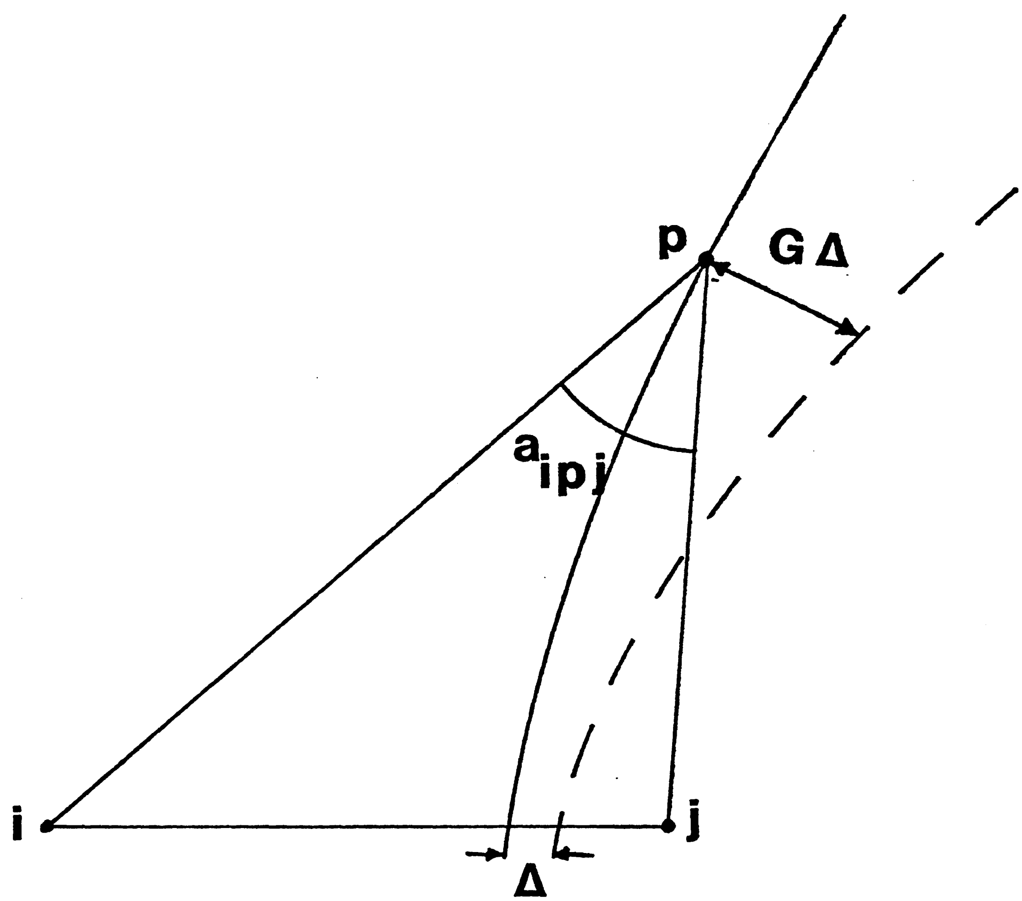


Figure II.5

and take its total differential

$$dS_{ipj} = dS_{ip} - dS_{jp} \quad . \tag{II.21}$$

Keeping the hyperbolic line of position constant, we obtain

$$0 = dS_{ip} - dS_{jp} \quad . \tag{II.22}$$

From the geometry of Figure II.6, we see the two triangles are congruent so that

$$\alpha_i = \alpha_j = \frac{a_{ipj}}{2} \quad . \tag{II.23}$$

The theorem is proven.

From Figure II.5 we see that the lane expansion factor G is the ratio between the shift Δ in LOP on the baseline ij and the shift $G\,\Delta$ in LOP at point P. On the baseline

$$S_{ip} + S_{jp} = \text{baseline length} = \text{constant.} \tag{II.24}$$

Taking the total differential

$$dS_{ip} + dS_{jp} = 0 \quad , \tag{II.25}$$

and from (II.21) and (II.25)

$$dS_{ipj} = 2dS_{ip} = 2\Delta \quad . \tag{II.26}$$

At point P, from Figure II.7,

$$dS_{ip} = G\,\Delta \sin \alpha_i \quad , \tag{II.27}$$

$$- dS_{jp} = G\,\Delta \sin \alpha_j \quad , \tag{II.28}$$

and from (II.21) and the hyperbolic theorem (II.23)

$$dS_{ipj} = 2\,G\,\Delta \sin \left(\frac{a_{ipj}}{2}\right) \quad , \tag{II.29}$$

and from (II.26)

$$G = \operatorname{cosec} \left(\frac{a_{ipj}}{2}\right) \quad . \tag{II.30}$$

Hence the conversion from ΔTD in microseconds to a shift on the ground in metres is, from (II.26) and (II.30),

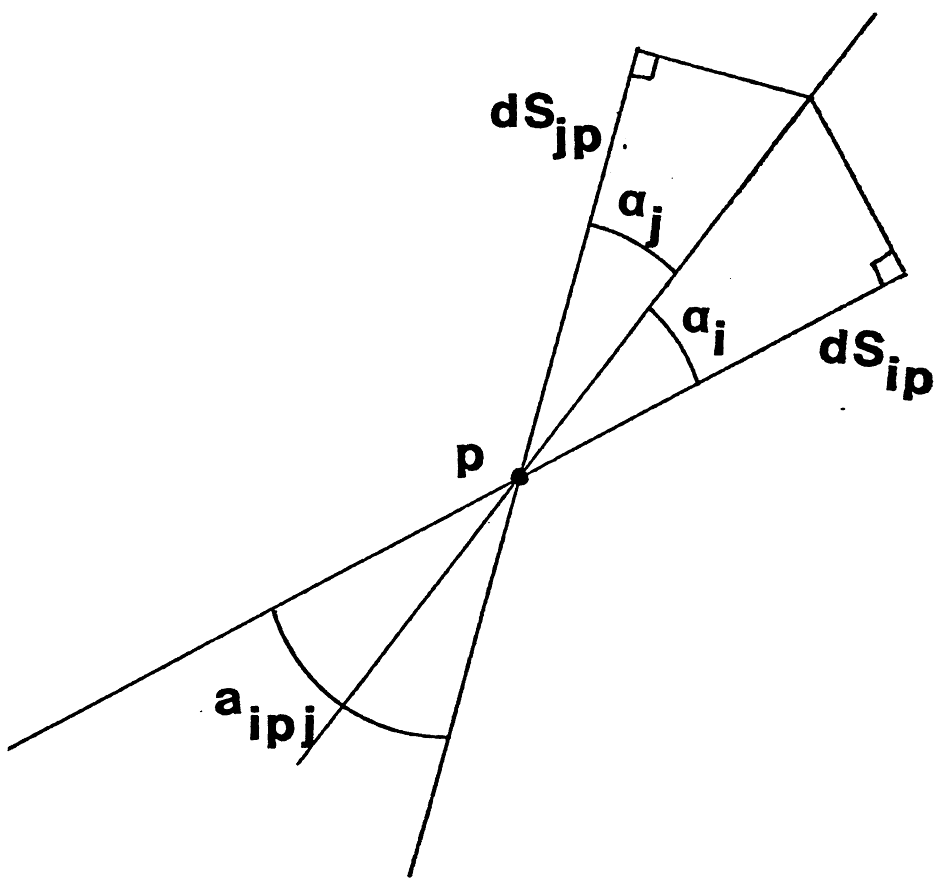


Figure II.6

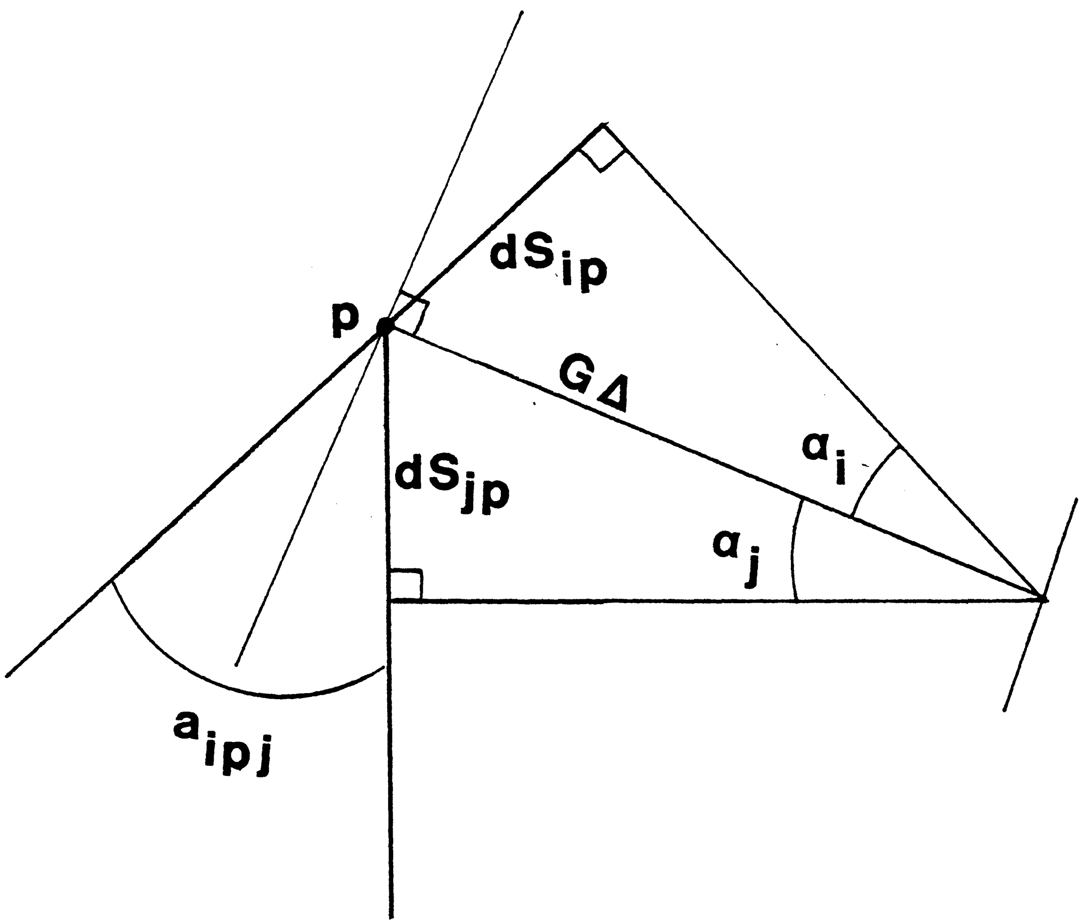


Figure II.7

$$H = \frac{(c \times 10^{-6})\ G\ \Delta}{dS_{ipj}} = 150\ \text{cosec}(\frac{a_{ipj}}{2}) \qquad (II.31)$$

Given the azimuth α_{ip} of the line joining the LORAN master (i) to the receiver (p), the azimuth of the TD line of position at P is given by

$$\alpha = \alpha_{ip} - \frac{a_{ipj}}{2} \qquad (II.32)$$

when $\alpha < \alpha_{ij}$, and by

$$\alpha = \alpha_{ip} + \frac{a_{ipj}}{2} - 180^{\circ} \qquad (II.33)$$

when $\alpha > \alpha_{ij}$. Note that θ, the angle of intersection between TDX and TDY lines of position at P is given by

$$\theta = \alpha_x - \alpha_y \quad . \qquad (II.34)$$

(2) Using a <u>large scale LORAN-C latticed local chart</u> showing the point of interest P, we can determine H by scaling off the distance in metres between two lines of position near P, and noting the difference between the corresponding TD values. Then

$$H = \frac{\text{scaled distance (in metres)}}{\Delta TD \text{ (in microseconds)}} \qquad (II.35)$$

The azimuths of the TD lines of position, can be directly measured from the large scale chart.

For each set of measurement changes (ΔTDX, ΔTDY) we can compute the equivalent shifts in metres (see Figure II.8)

$$\Delta x = H_x\ \Delta TDX \qquad (II.36)$$

$$\Delta y = H_y\ \Delta TDY \qquad (II.37)$$

We can then obtain the distance and direction of the resulting position shift from P1 to P2 either directly, or by first obtaining a plane approximation to the design matrix $\underline{A}$. Using the direct approach, the

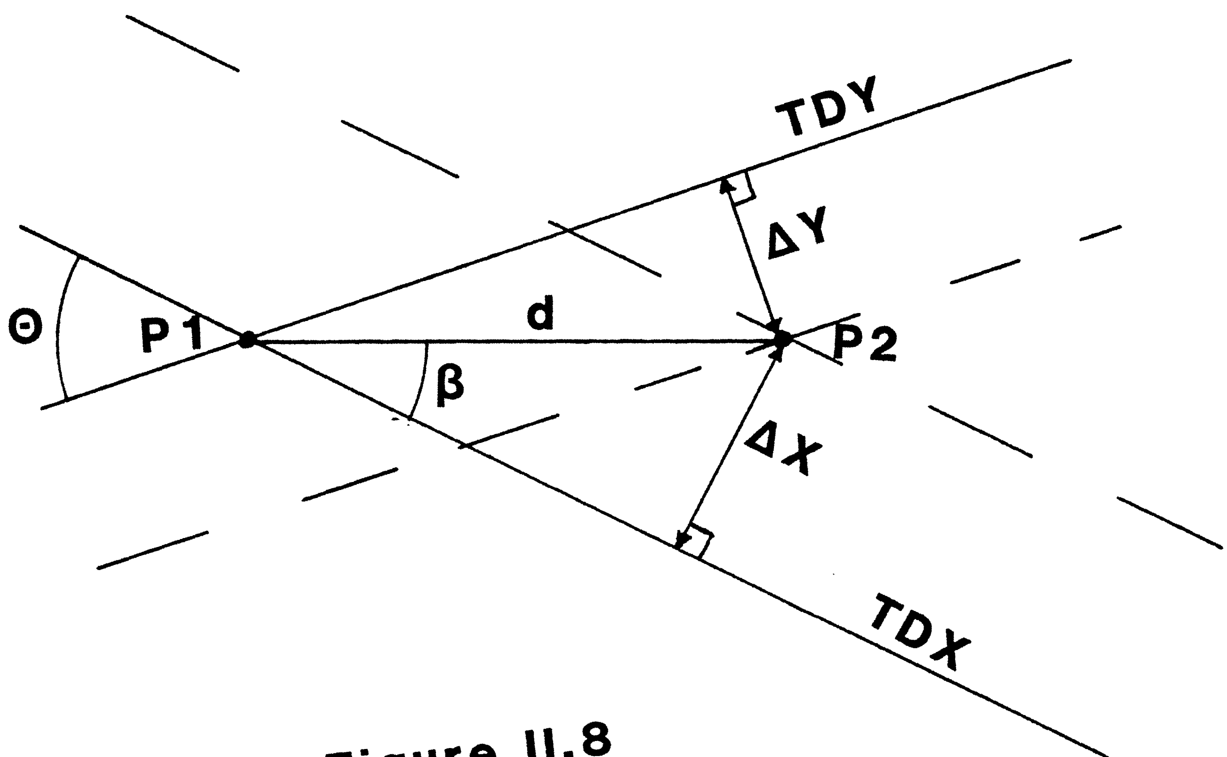


Figure II.8

distance and direction are obtained from the law of cosines to give

$$d = \csc\theta[\Delta x^2 + \Delta y^2 + 2\Delta x\, \Delta y \cos\theta]^{1/2} \qquad \text{(II.38)}$$

$$\beta = \sin^{-1}[\Delta x/d] \qquad \text{(II.39)}$$

Given the azimuth α_x of the TDX lines of position, then the azimuth of the position shift is of the form $\alpha_d = \alpha_x \pm \beta$ or $\alpha_d = \alpha_x \pm \beta + 180^\circ$, depending in which quadrant the position shift lies.

Using the indirect approach we seek a relationship of the form of (II.8). From Figure II.9 we see

$$\Delta x = d \sin(\alpha_x - \alpha_d) = (d \cos\alpha_d) \sin\alpha_x - (d \sin\alpha_d) \cos\alpha_x \qquad \text{(II.40)}$$

$$\Delta y = d \sin(\alpha_d - \alpha_y) = -(d \cos\alpha_d) \sin\alpha_y + (d \sin\alpha_d) \cos\alpha_y \qquad \text{(II.41)}$$

and that $d \cos\alpha_d = \Delta\phi$, $d \sin\alpha_d = \Delta\lambda$. Using (II.36) and (II.37) we have

$$\Delta TDX = \frac{\sin\alpha_x}{H_x}\Delta\phi - \frac{\cos\alpha_x}{H_x}\Delta\lambda \qquad \text{(II.42)}$$

$$\Delta TDY = -\frac{\sin\alpha_y}{H_y}\Delta\phi + \frac{\cos\alpha_y}{H_y}\Delta\lambda \qquad \text{(II.43)}$$

or in matrix form we have (II.8), $\underline{\Delta} = \underline{A}\,\underline{\delta}$, where

$$\underline{A} = \begin{bmatrix} \frac{\sin\alpha_x}{H_x} & -\frac{\cos\alpha_x}{H_x} \\ -\frac{\sin\alpha_y}{H_y} & \frac{\cos\alpha_y}{H_y} \end{bmatrix} \qquad \text{(II.44)}$$

To obtain the inverse relationship, as in (II.1), in this case we have $\underline{M} = \underline{A}^{-1}$, or

$$\underline{\delta} = \underline{A}^{-1}\,\underline{\Delta} \qquad \text{(II.45)}$$

where

$$\underline{A}^{-1} = \frac{1}{\sin\theta}\begin{bmatrix} H_x \cos\alpha_y & H_y \cos\alpha_x \\ H_x \sin\alpha_y & H_y \sin\alpha_x \end{bmatrix} \qquad \text{(II.46)}$$

and θ is given by (II.34). Finally we can obtain d and α_d from

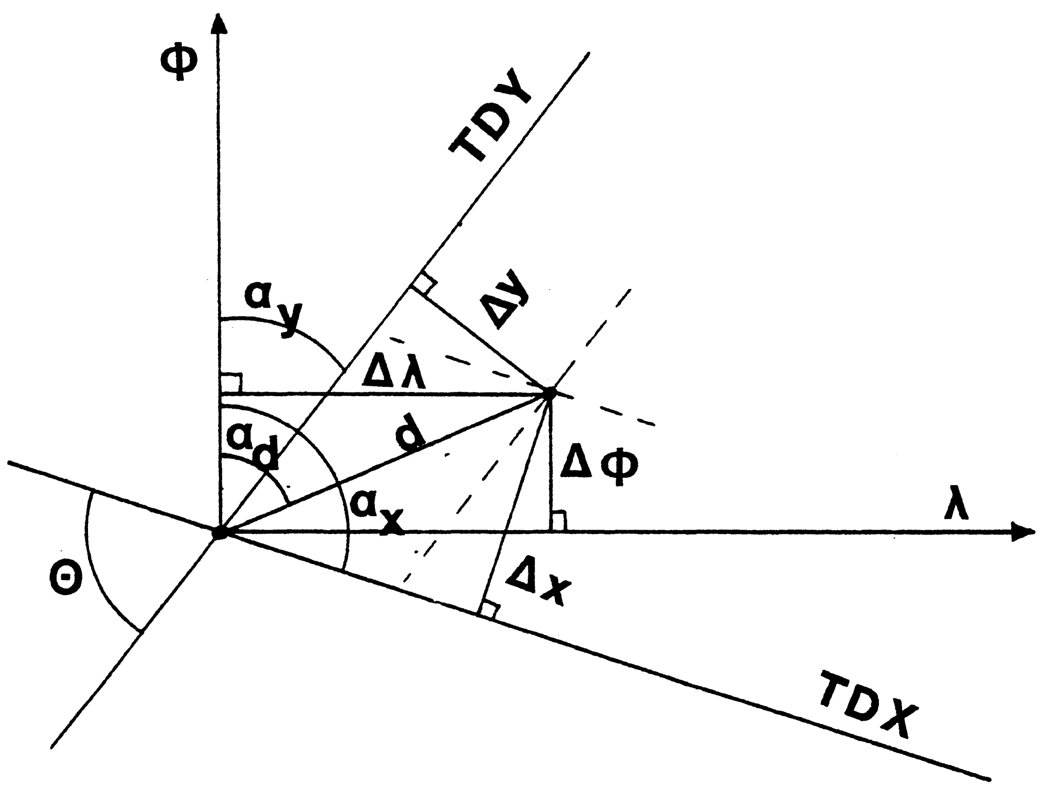


Figure II.9

$$d = \sqrt{\Delta\phi^2 + \Delta\lambda^2} \tag{II.47}$$

$$\alpha_d = \tan^{-1}(\Delta\lambda / \Delta\phi) \quad . \tag{II.48}$$

II.3 Conversion of LOP Standard Deviations to Position Error Ellipse

As in the discussion above, this problem can be approached either analytically or geometrically. In either case we are given the observation standard deviations

σ_{TDX} = TDX standard deviation

σ_{TDY} = TDY standard deviation

and want to obtain

σ_1 = semimajor axis of position error ellipse

σ_2 = semiminor axis of position error ellipse

α_1 = azimuth of σ_1.

In the analytic method we use the observation covariance matrix (in microsecond^2)

$$\underline{C_\ell} = \begin{bmatrix} \sigma^2_{TDX} & \sigma_{TDX-TDY} \\ \sigma_{TDX-TDY} & \sigma^2_{TDY} \end{bmatrix} \tag{II.49}$$

Note that it may or may not be easy or possible to determine the covariance $\sigma_{TDX-TDY}$ between TDX and TDY errors. To compute the position covariance matrix $\underline{C_\delta}$ we use

$$\underline{C_\delta} = (\underline{A}^T \underline{C_\ell}^{-1} \underline{A})^{-1} \tag{II.50}$$

where $\underline{A}$ is the design matrix, computed as in Section II.2.2, or as in

Section II.2.3. To obtain σ_1, σ_2, α_γ we evaluate the eigenvalues of

$$\underline{C_\delta} = \begin{bmatrix} c_{11} & c_{12} \\ c_{12} & c_{22} \end{bmatrix} \qquad \text{(II.51)}$$

using the relation

$$|\underline{C_\delta} - \sigma_i^2 \underline{I}| = 0 \quad , \quad i=1,2 \qquad \text{(II.52)}$$

to obtain

$$\sigma_1 = \{\frac{1}{2}(c_{11} + c_{22}) + \frac{1}{2}(c_{11} - c_{22})[1 + (\frac{2\, c_{12}}{c_{11} - c_{22}})^2]^{1/2}\}^{1/2} \qquad \text{(II.53)}$$

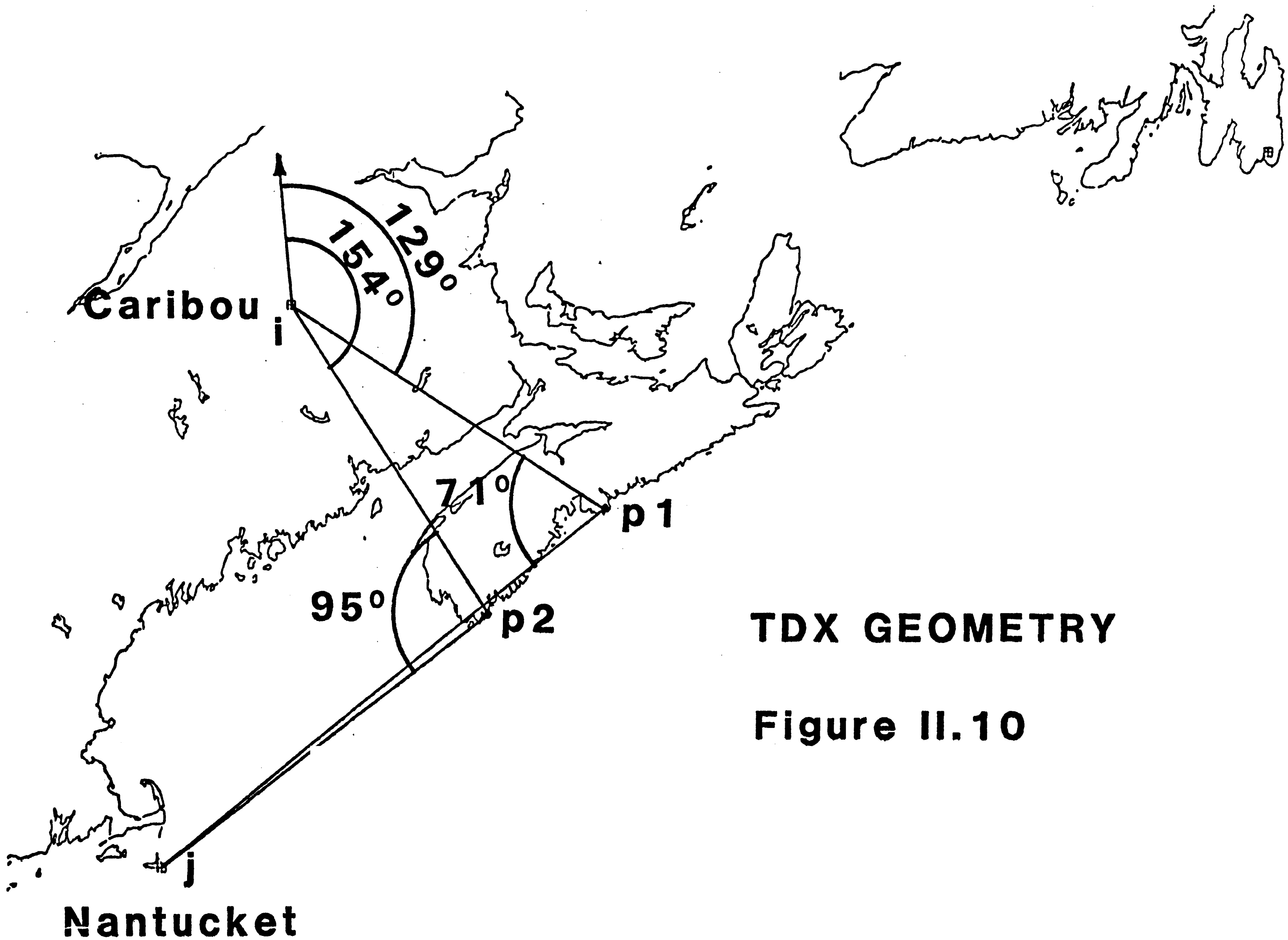
$$\sigma_2 = \{\frac{1}{2}(c_{11} + c_{22}) - \frac{1}{2}(c_{11} - c_{22})[1 + (\frac{2\, c_{12}}{c_{11} - c_{22}})^2]^{1/2}\}^{1/2} \qquad \text{(II.54)}$$

$$\alpha_1 = \tan^{-1}\{(\frac{c_{11} - c_{22}}{2\, c_{12}})(1 + [1 + (\frac{2\, c_{12}}{c_{11} - c_{22}})^2]^{1/2})\} \qquad \text{(II.55)}$$

II.4 Sample Calculations

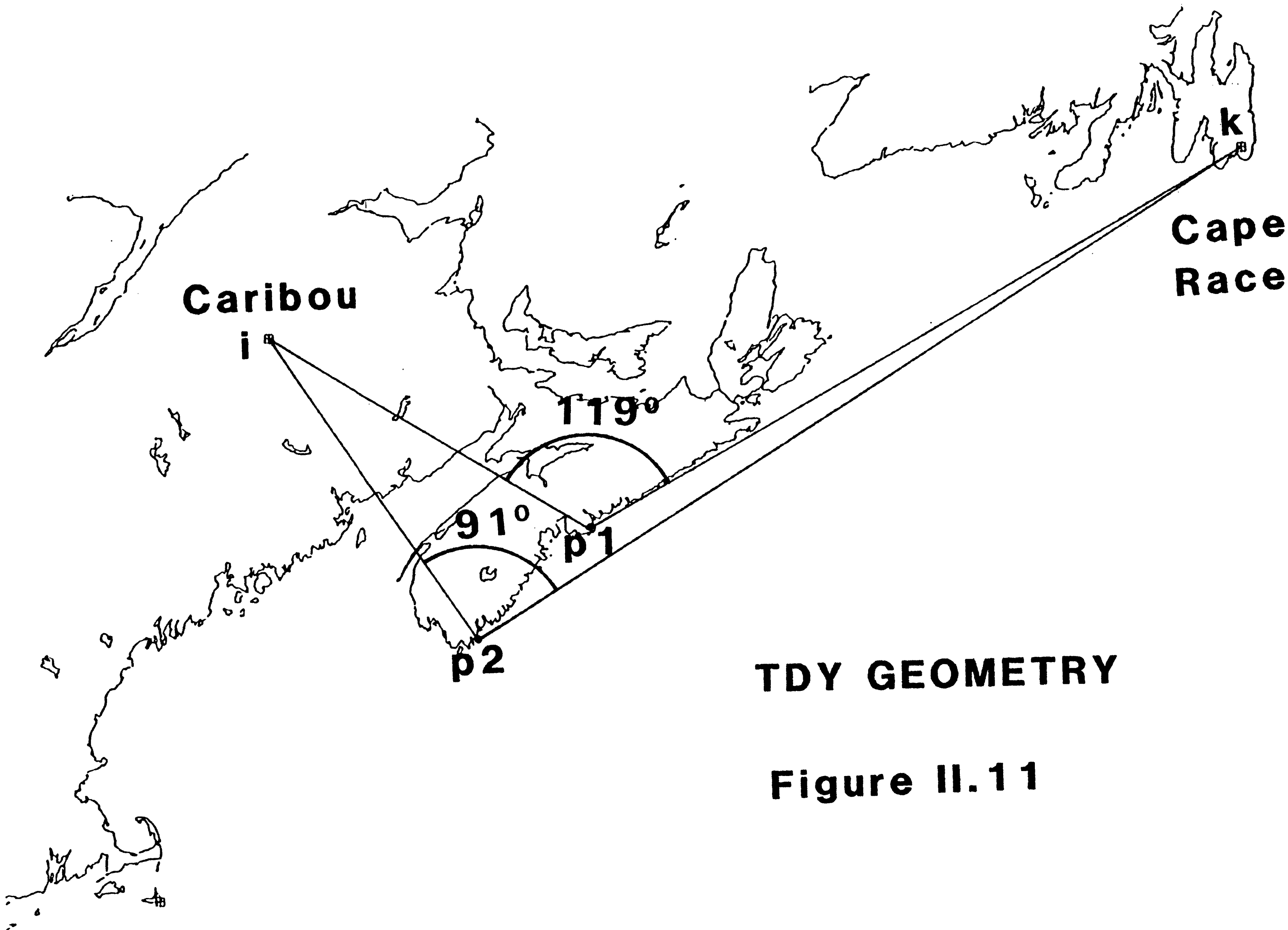
Let us consider two points within the coverage of the Canadian Maritimes LORAN-C Chain (GRI 5930), located along the South Shore of Nova Scotia at Ketch Harbour (P1) and Ingomar (P2). We determine the lattice geometry using two methods: a small scale chart and a larger scale chart.

Using the small scale regional chart shown in Figures II.10 and II.11, we measure three angles associated with each point:



TDX GEOMETRY

Figure II.10



TDY GEOMETRY

Figure II.11

	P1	P2
a_{ipj}	71^o	95^o
a_{ipk}	119^o	91^o
α_{ip}	129^o	154^o

TABLE II.1

Given these angles we can use (II.31), (II.32), (II.33), (II.34), and (II.44) to compute

$$H_x = 150 \operatorname{cosec}\left(\frac{a_{ipj}}{2}\right) \tag{II.56}$$

$$H_y = 150 \operatorname{cosec}\left(\frac{a_{ipk}}{2}\right) \tag{II.57}$$

$$\alpha_x = \alpha_{ip} - \frac{a_{ipj}}{2} \tag{II.58}$$

$$\alpha_y = \alpha_{ip} + \frac{a_{ipk}}{2} - 180^o \tag{II.59}$$

$$\theta = \alpha_x - \alpha_y \tag{II.60}$$

$$\underline{A} = \begin{bmatrix} \dfrac{\sin \alpha_x}{H_x} & -\dfrac{\cos \alpha_x}{H_x} \\ -\dfrac{\sin \alpha_y}{H_y} & \dfrac{\cos \alpha_y}{H_y} \end{bmatrix} \tag{II.61}$$

$$\underline{M} = \underline{A}^{-1} = \frac{1}{\sin \theta} \begin{bmatrix} H_x \cos \alpha_y & H_y \cos \alpha_x \\ H_x \sin \alpha_y & H_y \sin \alpha_x \end{bmatrix} \tag{II.62}$$

The results for P1 and P2 from Table II.1 are shown in Table II.2. Using the larger scale CHS chart 4012 (1:300 000) H and α values were scaled directly off the chart. The results are shown in Table II.3. We see that

TABLE II.2

	P1	P2
H_x	258 m/μs	203 m/μs
H_y	174 m/μs	210 m/μs
α_x	93.5°	106.5°
α_y	8.5°	19.5°
θ	85°	87°
$\underline{A}$	$\begin{bmatrix} 3.8687 \times 10^{-3} & 0.2366 \times 10^{-3} \\ -0.8495 \times 10^{-3} & 5.6840 \times 10^{-3} \end{bmatrix}$	$\begin{bmatrix} 4.7232 \times 10^{-3} & 1.3991 \times 10^{-3} \\ 1.5896 \times 10^{-3} & 4.4888 \times 10^{-3} \end{bmatrix}$
$\underline{A}^{-1}$	$\begin{bmatrix} 256.14 & -15.81 \\ 38.28 & 174.34 \end{bmatrix}$	$\begin{bmatrix} 191.62 & -59.73 \\ 67.86 & 201.63 \end{bmatrix}$

TABLE II.3

	P1	P2
H_x	264 m/μs	209 m/μs
H_y	177 m/μs	214 m/μs
α_x	93.5°	105°
α_y	10°	17.5°
θ	84°	86°
$\underline{A}$	$\begin{bmatrix} 3.7808 \times 10^{-3} & 0.2312 \times 10^{-3} \\ -0.9811 \times 10^{-3} & 5.5639 \times 10^{-3} \end{bmatrix}$	$\begin{bmatrix} 4.6217 \times 10^{-3} & 1.2384 \times 10^{-3} \\ -1.4052 \times 10^{-3} & 4.4566 \times 10^{-3} \end{bmatrix}$
$\underline{A}^{-1}$	$\begin{bmatrix} 261.42 & -10.87 \\ 46.10 & 177.64 \end{bmatrix}$	$\begin{bmatrix} 199.81 & -55.52 \\ 63.00 & 207.21 \end{bmatrix}$

the two sets of H values agree to within a few percent, and the two sets of azimuths to within a few degrees. This agreement indicates the values obtained from the small scale chart are sufficiently accurate for the purposes of this differential study.

Let us apply the lattice geometry values in Tables II.2 and II.3 to convert TD shifts into position shifts. For simplicity we consider the case when TDX and TDY both increase by 0.01 μs at both P1 and P2. We compute the corresponding position shifts two ways. Using the direct method, from (II.36), (II.37), (II.38), (II.39) and

$$\alpha_d = \alpha_x - \beta \qquad \text{(II.63)}$$

we have the results shown in Table II.4. Using the $\underline{A}^{-1}$ matrix and (II.45), (II.47), and (II.48) we have the results shown in Table II.5. Comparing Table II.4 and II.5 we see that

(a) TD shifts of 0.01 μs result in position shifts of about three metres at these locations.

(b) The magnitude of the position shifts at P1 and P2 agree to about 10%, for the same TD shifts.

(c) The direction of the position shifts at P1 and P2 agree to about 20°, for the same TD shifts.

(d) Scaling the basic lattice geometry data from either large or small scale charts yields results which agree to within about 3% in distance and 2° in direction.

(e) Using either the direct or $\underline{A}$-matrix methods of computing the position shifts yields results which agree to within about 1% in distance and 1° in direction.

	P1		P2	
	Table (II.2)	Table (II.3)	Table (II.2)	Table (II.3)
Δx	2.58 m	2.64 m	2.03 m	2.09 m
Δy	1.74 m	1.77 m	2.10 m	2.14 m
d	3.25 m	3.35 m	3.00 m	3.10 m
β	53^o	52^o	43^o	42^o
α_d	41^o	42^o	64^o	63^o

TABLE II.4

	P1		P2	
	Table (II.2)	Table (II.3)	Table (II.2)	Table (II.3)
$\Delta\phi$	2.40	2.51	1.32	1.44
$\Delta\lambda$	2.13	2.24	2.69	2.70
d	3.21	3.36	3.00	3.06
α_d	41^o	42^o	64^o	62^o

TABLE II.5

APPENDIX III

STATISTICAL SUMMARIES

One page summaries of the statistics for each of the 23 test sites used in this experiment are contained in this appendix. The format and method of computation are described in Chapter 5.

◊ 1. L. PROSPECT STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
218.1723-218.1929	40	13822.931(7)(25)	0.028	0.000	30157.240(15)(28)	¯0.027	0.000	0.168
219.1454-219.1701	40	13822.916(10)(23)	0.013	¯0.015	30157.249(12)(23)	¯0.018	0.009	0.272
229.1925-229.2131	40	13822.886(8)(33)	¯0.016	¯0.044	30157.241(11)(34)	¯0.026	0.001	0.166
236.1831-236.2037	40	13822.866(11)(31)	¯0.036	¯0.064	30157.278(11)(29)	0.011	0.037	0.517
264.1413-264.1649	209	13822.912(8)(17)	0.010	¯0.019	30157.327(13)(19)	0.060	0.086	0.258
MEAN VALUE		13822.902(26)(37)			30157.267(37)(46)			0.276

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
218.1723-218.1929	40	13822.933(5)(22)	0.013	0.000	30157.337(12)(24)	¯0.017	0.000	0.242
219.1454-219.1701	40	13822.924(8)(21)	0.003	¯0.010	30157.356(10)(22)	0.002	0.019	0.503
229.1925-229.2131	40	13822.910(9)(26)	¯0.011	¯0.024	30157.353(9)(23)	0.000	0.016	0.384
236.1831-236.2037	40	13822.912(10)(25)	¯0.008	¯0.021	30157.371(10)(25)	0.017	0.034	0.213
264.1413-264.1649	209	13822.922(9)(17)	0.002	¯0.011	30157.352(10)(19)	¯0.002	0.015	0.303
MEAN VALUE		13822.920(10)(24)			30157.354(12)(26)			0.329

VAN SITE L. PROSPECT

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
218.1723-218.1929	200	13805.870(10)(10)	0.022	0.000	30229.939(11)(11)	¯0.017	0.000	¯0.023
219.1454-219.1701	200	13805.868(11)(11)	0.020	¯0.002	30229.939(13)(13)	¯0.018	0.000	0.433
229.1925-229.2131	200	13805.842(9)(9)	¯0.006	¯0.028	30229.937(11)(11)	¯0.019	¯0.002	0.256
236.1831-236.2037	200	13805.819(10)(10)	¯0.029	¯0.051	30229.994(13)(13)	0.038	0.055	0.412
264.1413-264.1649	223	13805.840(7)(16)	¯0.008	¯0.030	30229.973(21)(28)	0.017	0.034	0.407
MEAN VALUE		13805.848(22)(24)			30229.956(26)(31)			0.297

DIFFERENCE L. PROSPECT - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
218.1723-218.1929	200	¯17.060(12)(23)	¯0.006	0.000	72.698(21)(29)	0.009	0.000	¯0.087
219.1454-219.1701	200	¯17.047(7)(19)	0.007	0.013	72.690(11)(20)	0.001	¯0.009	0.053
229.1925-229.2131	200	¯17.044(10)(28)	0.010	0.016	72.696(12)(29)	0.007	¯0.003	0.283
236.1831-236.2037	200	¯17.047(10)(26)	0.007	0.013	72.717(13)(25)	0.027	0.018	0.421
264.1413-264.1649	223	¯17.071(6)(19)	¯0.017	¯0.011	72.645(12)(25)	¯0.044	¯0.053	0.325
MEAN VALUE		¯17.060(11)(26)			72.698(26)(37)			0.199

DIFFERENCE L. PROSPECT - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
218.1723-218.1929	200	¯17.063(12)(21)	0.009	0.000	72.602(20)(26)	¯0.001	0.000	0.032
219.1454-219.1701	200	¯17.055(8)(18)	0.017	0.008	72.583(10)(19)	¯0.020	¯0.019	0.296
229.1925-229.2131	200	¯17.068(9)(21)	0.005	¯0.005	72.584(10)(20)	¯0.019	¯0.018	0.292
236.1831-236.2037	200	¯17.093(10)(22)	¯0.021	¯0.030	72.624(12)(23)	0.021	0.021	0.268
264.1413-264.1649	223	¯17.081(6)(20)	¯0.009	¯0.018	72.621(16)(28)	0.018	0.019	0.392
MEAN VALUE		¯17.072(15)(26)			72.603(19)(30)			0.256

◊ 2. PEGGYS COVE STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
219.1821-219.2028	40	13822.908(5)(21)	0.010	0.000	30157.240(13)(24)	¯0.022	0.000	0.102
229.2247-230.0053	41	13822.896(11)(28)	¯0.002	¯0.012	30157.239(15)(29)	¯0.023	¯0.001	0.611
236.2140-236.2346	41	13822.863(14)(39)	¯0.035	¯0.045	30157.255(15)(38)	¯0.007	0.015	0.050
264.1803-264.2014	177	13822.924(11)(19)	0.026	0.016	30157.313(10)(17)	0.052	0.073	0.347
MEAN VALUE		13822.898(26)(38)			30157.262(35)(45)			0.277

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
219.1821-219.2028	40	13822.915(6)(21)	¯0.004	0.000	30157.349(12)(23)	0.000	0.000	¯0.081
229.2247-230.0053	41	13822.915(9)(24)	¯0.003	0.000	30157.342(7)(23)	¯0.007	¯0.007	0.412
236.2140-236.2346	41	13822.911(11)(30)	¯0.008	¯0.004	30157.357(7)(28)	0.008	0.009	0.529
264.1803-264.2014	177	13822.934(12)(19)	0.015	0.018	30157.349(10)(19)	¯0.001	0.000	0.349
MEAN VALUE		13822.919(10)(26)			30157.349(6)(24)			0.302

VAN SITE PEGGYS COVE

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
219.1821-219.2028	201	13820.793(7)(7)	0.018	0.000	30321.551(15)(15)	¯0.010	0.000	0.161
229.2247-230.0053	200	13820.783(11)(11)	0.008	¯0.010	30321.538(14)(14)	¯0.023	¯0.013	0.337
236.2140-236.2346	200	13820.748(11)(11)	¯0.028	¯0.046	30321.583(18)(18)	0.022	0.032	¯0.031
264.1803-264.2014	202	13820.778(12)(19)	0.002	¯0.016	30321.572(15)(22)	0.011	0.021	0.170
MEAN VALUE		13820.775(20)(24)			30321.561(20)(27)			0.159

DIFFERENCE PEGGYS COVE - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
219.1821-219.2028	201	¯2.115(6)(18)	0.008	0.000	164.311(8)(18)	0.012	0.000	0.134
229.2247-230.0053	200	¯2.113(9)(23)	0.009	0.002	164.299(12)(24)	0.000	¯0.012	0.304
236.2140-236.2346	200	¯2.116(9)(32)	0.007	¯0.001	164.328(18)(33)	0.029	0.017	0.316
264.1803-264.2014	202	¯2.146(7)(21)	¯0.024	¯0.031	164.258(9)(23)	¯0.041	¯0.053	¯0.006
MEAN VALUE		¯2.115(16)(29)			164.311(30)(39)			0.187

DIFFERENCE PEGGYS COVE - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
219.1821-219.2028	201	¯2.122(7)(18)	0.022	0.000	164.202(8)(18)	¯0.010	0.000	0.129
229.2247-230.0053	200	¯2.132(8)(20)	0.011	¯0.011	164.196(13)(22)	¯0.016	¯0.006	0.432
236.2140-236.2346	200	¯2.164(8)(25)	¯0.020	¯0.042	164.225(19)(29)	0.014	0.023	0.131
264.1803-264.2014	202	¯2.156(6)(21)	¯0.012	¯0.034	164.223(11)(24)	0.012	0.021	0.046
MEAN VALUE		¯2.143(20)(29)			164.212(15)(28)			0.184

◊ 3. BLANDFORD STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
221.1632-221.1840	40	13822.843(45)(50)	¯0.037	0.000	30157.177(12)(27)	¯0.078	0.000	0.182
230.1346-230.1553	40	13822.899(19)(28)	0.019	0.056	30157.240(19)(27)	¯0.014	0.063	0.890
237.1305-237.1519	43	13822.863(18)(25)	¯0.017	0.020	30157.280(9)(18)	0.026	0.103	¯0.269
265.1415-265.1626	175	13822.914(12)(20)	0.034	0.071	30157.321(10)(18)	0.066	0.144	0.544
MEAN VALUE		13822.880(32)(46)			30157.255(61)(65)			0.337

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
221.1632-221.1840	40	13822.885(33)(39)	¯0.022	0.000	30157.313(10)(26)	¯0.033	0.000	0.505
230.1346-230.1553	40	13822.915(14)(24)	0.008	0.030	30157.355(16)(26)	0.010	0.043	0.825
237.1305-237.1519	43	13822.906(19)(25)	¯0.001	0.021	30157.368(16)(24)	0.023	0.056	¯0.485
265.1415-265.1626	175	13822.921(12)(19)	0.014	0.035	30157.346(10)(19)	0.000	0.033	0.582
MEAN VALUE		13822.907(16)(32)			30157.346(24)(34)			0.357

VAN SITE BLANDFORD

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
221.1632-221.1840	203	13826.389(42)(42)	¯0.016	0.000	30418.663(18)(18)	¯0.031	0.000	0.532
230.1346-230.1553	200	13826.430(19)(19)	0.026	0.041	30418.695(26)(26)	0.000	0.031	0.807
237.1305-237.1519	212	13826.393(18)(18)	¯0.011	0.005	30418.713(19)(19)	0.019	0.050	¯0.265
265.1415-265.1626	201	13826.405(12)(19)	0.001	0.016	30418.706(11)(20)	0.012	0.043	0.548
MEAN VALUE		13826.404(19)(32)			30418.694(22)(31)			0.406

DIFFERENCE BLANDFORD - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
221.1632-221.1840	203	3.545(10)(20)	0.021	0.000	261.486(16)(26)	0.047	0.000	¯0.174
230.1346-230.1553	200	3.531(11)(21)	0.007	¯0.014	261.454(16)(22)	0.015	¯0.032	0.589
237.1305-237.1519	212	3.530(9)(16)	0.006	¯0.015	261.433(15)(20)	¯0.007	¯0.053	0.435
265.1415-265.1626	201	3.491(6)(20)	¯0.034	¯0.054	261.385(7)(22)	¯0.054	¯0.101	0.130
MEAN VALUE		3.545(23)(30)			261.486(42)(48)			0.245

DIFFERENCE BLANDFORD - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
221.1632-221.1840	203	3.503(15)(23)	0.006	0.000	261.351(14)(24)	0.002	0.000	0.324
230.1346-230.1553	200	3.515(10)(19)	0.018	0.012	261.339(14)(22)	¯0.010	¯0.011	0.554
237.1305-237.1519	212	3.487(10)(16)	¯0.010	¯0.016	261.345(10)(18)	¯0.004	¯0.006	0.325
265.1415-265.1626	201	3.484(6)(20)	¯0.013	¯0.019	261.361(7)(23)	0.012	0.010	0.185
MEAN VALUE		3.497(14)(24)			261.349(9)(24)			0.347

◊ 4. BATTERY PT. STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
221.2059-221.2305	40	13822.819(13)(24)	¯0.059	0.000	30157.179(11)(23)	¯0.086	0.000	0.377
230.1847-230.2030	33	13822.892(16)(39)	0.013	0.073	30157.239(20)(38)	¯0.025	0.060	0.726
237.1710-237.1916	40	13822.857(19)(37)	¯0.021	0.038	30157.261(9)(33)	¯0.003	0.083	0.688
265.1905-265.2115	176	13822.945(13)(20)	0.067	0.126	30157.379(30)(34)	0.114	0.200	0.221
MEAN VALUE		13822.878(54)(62)			30157.264(84)(90)			0.503

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
221.2059-221.2305	40	13822.877(12)(23)	¯0.034	0.000	30157.319(7)(20)	¯0.036	0.000	0.298
230.1847-230.2030	33	13822.912(15)(33)	0.001	0.035	30157.353(19)(33)	¯0.003	0.034	0.698
237.1710-237.1916	40	13822.901(18)(29)	¯0.010	0.024	30157.354(10)(24)	¯0.002	0.035	0.688
265.1905-265.2115	176	13822.953(12)(20)	0.042	0.076	30157.396(23)(29)	0.041	0.077	0.295
MEAN VALUE		13822.911(32)(41)			30157.355(32)(41)			0.495

VAN SITE BATTERY PT.

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
221.2059-221.2305	200	13752.229(14)(14)	¯0.038	0.000	30473.191(13)(13)	¯0.055	0.000	0.037
230.1847-230.2030	200	13752.295(16)(16)	0.028	0.066	30473.251(16)(16)	0.004	0.060	0.220
237.1710-237.1916	200	13752.257(20)(20)	¯0.010	0.027	30473.234(7)(7)	¯0.012	0.043	0.167
265.1905-265.2115	200	13752.286(12)(19)	0.019	0.057	30473.310(32)(36)	0.063	0.119	0.065
MEAN VALUE		13752.267(30)(35)			30473.246(49)(53)			0.122

DIFFERENCE BATTERY PT. - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
221.2059-221.2305	200	¯70.590(7)(18)	0.022	0.000	316.012(18)(24)	0.030	0.000	¯0.240
230.1847-230.2030	200	¯70.597(12)(31)	0.015	¯0.007	316.011(17)(31)	0.029	¯0.001	0.220
237.1710-237.1916	200	¯70.600(10)(28)	0.011	¯0.010	315.973(10)(27)	¯0.009	¯0.039	0.033
265.1905-265.2115	200	¯70.659(6)(20)	¯0.048	¯0.069	315.931(10)(23)	¯0.051	¯0.081	0.390
MEAN VALUE		¯70.590(32)(40)			316.012(39)(47)			0.101

DIFFERENCE BATTERY PT. - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
221.2059-221.2305	200	¯70.647(6)(17)	¯0.003	0.000	315.872(14)(21)	¯0.019	0.000	¯0.077
230.1847-230.2030	200	¯70.617(9)(26)	0.027	0.031	315.898(16)(27)	0.007	0.026	0.139
237.1710-237.1916	200	¯70.645(8)(20)	¯0.001	0.003	315.881(10)(20)	¯0.010	0.009	0.040
265.1905-265.2115	200	¯70.667(6)(20)	¯0.023	¯0.019	315.914(14)(26)	0.023	0.042	0.029
MEAN VALUE		¯70.644(21)(29)			315.891(19)(30)			0.033

◊ 5. DUBLIN SHR. STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
223.1958-223.2204	41	13822.827(13)(24)	¯0.055	0.000	30157.234(21)(29)	¯0.044	0.000	¯0.451
230.2316-231.0136	44	13822.897(21)(39)	0.016	0.070	30157.263(12)(36)	¯0.015	0.029	0.140
237.2206-238.0012	40	13822.861(17)(36)	¯0.020	0.034	30157.268(16)(34)	¯0.010	0.034	0.393
266.1431-266.1641	176	13822.941(11)(19)	0.060	0.114	30157.347(12)(19)	0.069	0.113	0.557
MEAN VALUE		13822.881(49)(58)			30157.278(48)(57)			0.160

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
223.1958-223.2204	41	13822.880(13)(24)	¯0.034	0.000	30157.361(19)(28)	¯0.003	0.000	¯0.415
230.2316-231.0136	44	13822.920(23)(34)	0.006	0.040	30157.369(11)(28)	0.005	0.008	0.514
237.2206-238.0012	40	13822.909(14)(27)	¯0.004	0.029	30157.362(13)(26)	¯0.002	0.001	0.204
266.1431-266.1641	176	13822.947(11)(19)	0.033	0.067	30157.365(11)(20)	0.001	0.004	0.505
MEAN VALUE		13822.914(28)(38)			30157.364(3)(26)			0.202

VAN SITE DUBLIN SHR.

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
223.1958-223.2204	200	13704.454(13)(13)	¯0.043	0.000	30489.831(23)(23)	¯0.017	0.000	¯0.558
230.2316-231.0136	201	13704.524(24)(24)	0.028	0.071	30489.838(15)(15)	¯0.010	0.007	0.429
237.2206-238.0012	200	13704.487(14)(14)	¯0.009	0.034	30489.841(15)(15)	¯0.007	0.009	¯0.045
266.1431-266.1641	201	13704.522(10)(18)	0.025	0.068	30489.881(14)(21)	0.034	0.050	0.513
MEAN VALUE		13704.497(33)(38)			30489.848(23)(30)			0.084

DIFFERENCE DUBLIN SHR. - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
223.1958-223.2204	200	¯118.373(7)(18)	0.012	0.000	332.597(12)(20)	0.027	0.000	0.315
230.2316-231.0136	201	¯118.372(15)(31)	0.012	0.001	332.575(15)(31)	0.005	¯0.022	0.371
237.2206-238.0012	200	¯118.374(10)(28)	0.011	¯0.001	332.573(19)(31)	0.003	¯0.024	0.324
266.1431-266.1641	201	¯118.419(5)(20)	¯0.035	¯0.046	332.534(7)(21)	¯0.035	¯0.063	0.137
MEAN VALUE		¯118.373(23)(34)			332.597(26)(37)			0.287

DIFFERENCE DUBLIN SHR. - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
223.1958-223.2204	200	¯118.426(7)(18)	¯0.009	0.000	332.470(16)(23)	¯0.013	0.000	0.220
230.2316-231.0136	201	¯118.395(11)(24)	0.022	0.031	332.468(11)(23)	¯0.015	¯0.002	0.098
237.2206-238.0012	200	¯118.422(9)(21)	¯0.005	0.004	332.478(13)(23)	¯0.005	0.008	0.124
266.1431-266.1641	201	¯118.425(5)(20)	¯0.008	0.001	332.516(9)(23)	0.033	0.047	0.025
MEAN VALUE		¯118.417(15)(26)			332.483(23)(32)			0.117

◊ 6. MEDWAY HEAD STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
224.1619-224.1835	44	13822.824(12)(32)	¯0.051	0.000	30157.222(9)(31)	¯0.038	0.000	0.379
231.1402-231.1441	13	13822.885(10)(32)	0.010	0.062	30157.235(13)(31)	¯0.026	0.012	0.488
231.1713-231.1848	30	13822.884(9)(32)	0.009	0.060	30157.225(21)(35)	¯0.035	0.003	¯0.204
238.1322-238.1528	40	13822.868(14)(31)	¯0.007	0.044	30157.274(18)(33)	0.014	0.051	0.750
266.1923-266.2133	175	13822.915(8)(17)	0.039	0.091	30157.345(12)(19)	0.085	0.123	0.063
MEAN VALUE		13822.875(33)(44)			30157.260(52)(60)			0.295

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
224.1619-224.1835	44	13822.885(10)(26)	¯0.021	0.000	30157.347(10)(26)	¯0.007	0.000	0.256
231.1402-231.1441	13	13822.902(6)(25)	¯0.004	0.017	30157.342(11)(24)	¯0.012	¯0.006	¯0.055
231.1713-231.1848	30	13822.906(6)(23)	0.000	0.021	30157.336(22)(30)	¯0.017	¯0.011	¯0.091
238.1322-238.1528	40	13822.914(12)(25)	0.008	0.029	30157.370(15)(26)	0.016	0.023	0.515
266.1923-266.2133	175	13822.922(8)(17)	0.016	0.037	30157.374(12)(20)	0.020	0.027	0.075
MEAN VALUE		13822.906(14)(27)			30157.354(17)(31)			0.140

VAN SITE MEDWAY HEAD

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
224.1619-224.1835	216	13616.339(11)(11)	¯0.046	0.000	30541.893(9)(9)	¯0.004	0.000	0.210
231.1402-231.1441	59	13616.415(8)(8)	0.030	0.076	30541.870(9)(9)	¯0.027	¯0.023	0.208
231.1713-231.1848	150	13616.415(6)(6)	0.030	0.076	30541.858(20)(20)	¯0.039	¯0.035	¯0.175
238.1322-238.1528	200	13616.376(14)(14)	¯0.009	0.037	30541.915(25)(25)	0.018	0.022	0.374
266.1923-266.2133	201	13616.381(7)(17)	¯0.004	0.042	30541.950(17)(27)	0.053	0.057	0.448
MEAN VALUE		13616.385(32)(34)			30541.897(37)(41)			0.213

DIFFERENCE MEDWAY HEAD - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
224.1619-224.1835	216	¯206.485(10)(26)	0.005	0.000	384.671(9)(25)	0.034	0.000	0.314
231.1402-231.1441	59	¯206.470(10)(27)	0.020	0.015	384.636(11)(26)	¯0.001	¯0.035	0.376
231.1713-231.1848	150	¯206.470(10)(26)	0.021	0.016	384.633(12)(26)	¯0.004	¯0.038	0.202
238.1322-238.1528	200	¯206.492(10)(25)	¯0.002	¯0.007	384.641(17)(29)	0.004	¯0.029	0.165
266.1923-266.2133	201	¯206.534(7)(21)	¯0.044	¯0.049	384.605(14)(27)	¯0.032	¯0.066	¯0.405
MEAN VALUE		¯206.485(26)(36)			384.671(24)(36)			0.131

DIFFERENCE MEDWAY HEAD - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
224.1619-224.1835	216	¯206.546(8)(21)	¯0.025	0.000	384.546(9)(22)	0.003	0.000	0.153
231.1402-231.1441	59	¯206.487(8)(21)	0.033	0.059	384.528(10)(20)	¯0.016	¯0.018	¯0.164
231.1713-231.1848	150	¯206.491(7)(20)	0.030	0.055	384.522(11)(20)	¯0.022	¯0.025	0.058
238.1322-238.1528	200	¯206.538(8)(20)	¯0.017	0.008	384.546(15)(23)	0.002	0.000	0.211
266.1923-266.2133	201	¯206.541(6)(21)	¯0.021	0.005	384.576(16)(29)	0.033	0.030	¯0.331
MEAN VALUE		¯206.521(29)(35)			384.544(21)(31)			¯0.015

◊ 7. W.HEAD LIV. STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
224.2012-224.2218	40	13822.822(20)(33)	¯0.055	0.000	30157.230(16)(31)	¯0.031	0.000	0.399
231.2113-231.2319	40	13822.866(18)(43)	¯0.011	0.044	30157.216(18)(41)	¯0.045	¯0.015	0.174
238.1701-238.1907	40	13822.866(16)(31)	¯0.011	0.044	30157.264(14)(30)	0.003	0.033	0.029
267.1246-267.1456	176	13822.954(12)(19)	0.077	0.132	30157.334(11)(19)	0.073	0.104	0.366
MEAN VALUE		13822.877(55)(64)			30157.261(53)(61)			0.242

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
224.2012-224.2218	40	13822.883(22)(31)	¯0.031	0.000	30157.349(14)(27)	¯0.002	0.000	0.415
231.2113-231.2319	40	13822.888(11)(31)	¯0.026	0.005	30157.339(11)(29)	¯0.011	¯0.009	0.132
238.1701-238.1907	40	13822.921(15)(25)	0.007	0.038	30157.356(14)(25)	0.006	0.008	¯0.083
267.1246-267.1456	176	13822.963(11)(19)	0.049	0.080	30157.357(9)(19)	0.007	0.009	0.238
MEAN VALUE		13822.914(37)(46)			30157.350(8)(26)			0.175

VAN SITE W.HEAD LIV.

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
224.2012-224.2218	200	13554.586(22)(22)	¯0.047	0.000	30586.912(14)(14)	0.031	0.000	¯0.231
231.2113-231.2319	200	13554.640(12)(12)	0.007	0.053	30586.841(11)(11)	¯0.039	¯0.071	0.201
238.1701-238.1907	200	13554.627(16)(16)	¯0.006	0.040	30586.859(11)(11)	¯0.022	¯0.054	0.111
267.1246-267.1456	201	13554.679(10)(19)	0.046	0.093	30586.911(16)(25)	0.030	¯0.001	0.253
MEAN VALUE		13554.633(38)(42)			30586.881(36)(40)			0.084

DIFFERENCE W.HEAD LIV. - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
224.2012-224.2218	200	¯268.236(9)(22)	0.008	0.000	429.682(16)(27)	0.062	0.000	0.073
231.2113-231.2319	200	¯268.226(14)(34)	0.018	0.010	429.624(23)(38)	0.005	¯0.057	0.445
238.1701-238.1907	200	¯268.240(9)(24)	0.005	¯0.003	429.595(11)(24)	¯0.025	¯0.087	0.258
267.1246-267.1456	201	¯268.275(6)(20)	¯0.031	¯0.039	429.576(9)(24)	¯0.043	¯0.105	0.273
MEAN VALUE		¯268.236(21)(33)			429.682(46)(54)			0.263

DIFFERENCE W.HEAD LIV. - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
224.2012-224.2218	200	¯268.297(8)(19)	¯0.016	0.000	429.563(14)(24)	0.033	0.000	0.063
231.2113-231.2319	200	¯268.248(8)(25)	0.033	0.049	429.502(16)(27)	¯0.029	¯0.062	0.179
238.1701-238.1907	200	¯268.294(7)(18)	¯0.014	0.003	429.502(11)(20)	¯0.028	¯0.061	0.218
267.1246-267.1456	201	¯268.283(6)(21)	¯0.003	0.013	429.553(12)(26)	0.023	¯0.010	0.337
MEAN VALUE		¯268.281(23)(31)			429.530(33)(41)			0.199

◊ 8. PORT JOLI STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
225.1624-225.1842	44	13822.813(14)(27)	¯0.065	0.000	30157.247(23)(34)	¯0.030	0.000	¯0.228
232.0044-232.0250	41	13822.906(19)(42)	0.028	0.093	30157.230(13)(38)	¯0.047	¯0.017	0.656
238.2029-238.2236	40	13822.854(11)(34)	¯0.024	0.041	30157.281(12)(34)	0.005	0.035	0.271
267.1631-267.1841	175	13822.938(13)(20)	0.060	0.125	30157.348(20)(25)	0.072	0.102	0.019
MEAN VALUE		13822.878(55)(64)			30157.276(52)(62)			0.179

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
225.1624-225.1842	44	13822.864(16)(26)	¯0.048	0.000	30157.356(18)(28)	0.000	0.000	¯0.423
232.0044-232.0250	41	13822.931(13)(34)	0.019	0.067	30157.339(8)(30)	¯0.017	¯0.017	0.486
238.2029-238.2236	40	13822.907(7)(23)	¯0.005	0.043	30157.370(9)(23)	0.014	0.014	0.083
267.1631-267.1841	175	13822.945(12)(20)	0.033	0.081	30157.360(21)(26)	0.004	0.004	¯0.096
MEAN VALUE		13822.912(35)(44)			30157.356(13)(30)			0.012

VAN SITE PORT JOLI

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
225.1624-225.1842	213	13466.374(12)(12)	¯0.057	0.000	30635.801(31)(31)	0.024	0.000	¯0.381
232.0044-232.0250	200	13466.479(15)(15)	0.048	0.105	30635.738(10)(10)	¯0.039	¯0.064	0.453
238.2029-238.2236	200	13466.414(7)(7)	¯0.018	0.040	30635.774(9)(9)	¯0.003	¯0.027	¯0.048
267.1631-267.1841	200	13466.459(13)(21)	0.027	0.085	30635.796(21)(29)	0.018	¯0.006	0.036
MEAN VALUE		13466.432(47)(49)			30635.777(29)(36)			0.015

DIFFERENCE PORT JOLI - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
225.1624-225.1842	213	¯356.439(9)(21)	0.007	0.000	478.555(15)(25)	0.054	0.000	0.328
232.0044-232.0250	200	¯356.427(14)(34)	0.019	0.012	478.509(13)(32)	0.008	¯0.046	0.452
238.2029-238.2236	200	¯356.440(9)(28)	0.006	¯0.001	478.493(10)(28)	¯0.008	¯0.062	0.271
267.1631-267.1841	200	¯356.479(6)(22)	¯0.033	¯0.040	478.447(11)(25)	¯0.054	¯0.108	0.229
MEAN VALUE		¯356.439(23)(35)			478.555(44)(52)			0.320

DIFFERENCE PORT JOLI - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
225.1624-225.1842	213	¯356.490(10)(20)	¯0.010	0.000	478.445(17)(24)	0.024	0.000	0.469
232.0044-232.0250	200	¯356.451(11)(28)	0.029	0.039	478.399(9)(26)	¯0.022	¯0.047	0.343
238.2029-238.2236	200	¯356.493(7)(19)	¯0.013	¯0.003	478.404(9)(20)	¯0.017	¯0.041	0.229
267.1631-267.1841	200	¯356.486(6)(22)	¯0.006	0.004	478.435(11)(26)	0.014	¯0.010	0.368
MEAN VALUE		¯356.480(19)(30)			478.421(23)(33)			0.352

◊ 9. W.HEAD LOK. STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
225.2117-225.2323	40	13822.815(10)(23)	¯0.055	0.000	30157.235(23)(31)	¯0.025	0.000	¯0.498
232.1657-232.1903	40	13822.890(21)(44)	0.020	0.075	30157.221(14)(41)	¯0.039	¯0.014	0.449
238.2353-239.0160	40	13822.859(17)(44)	¯0.011	0.044	30157.269(16)(45)	0.008	0.034	0.528
267.2128-267.2338	176	13822.916(8)(19)	0.046	0.101	30157.317(18)(24)	0.056	0.081	0.318
MEAN VALUE		13822.870(43)(55)			30157.261(42)(56)			0.199

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
225.2117-225.2323	40	13822.873(10)(22)	¯0.032	0.000	30157.361(14)(24)	0.012	0.000	¯0.381
232.1657-232.1903	40	13822.913(13)(32)	0.008	0.040	30157.336(11)(30)	¯0.013	¯0.025	0.322
238.2353-239.0160	40	13822.910(11)(33)	0.005	0.037	30157.356(12)(32)	0.006	¯0.006	0.220
267.2128-267.2338	176	13822.923(8)(18)	0.019	0.050	30157.345(14)(22)	¯0.004	¯0.016	0.545
MEAN VALUE		13822.905(22)(35)			30157.350(11)(29)			0.177

VAN SITE W.HEAD LOK.

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
225.2117-225.2323	200	13353.358(12)(12)	¯0.043	0.000	30711.278(38)(38)	0.033	0.000	¯0.366
232.1657-232.1903	200	13353.433(15)(15)	0.032	0.074	30711.211(11)(11)	¯0.034	¯0.067	0.410
238.2353-239.0160	200	13353.391(8)(8)	¯0.010	0.032	30711.234(16)(16)	¯0.011	¯0.043	0.270
267.2128-267.2338	201	13353.422(7)(18)	0.021	0.063	30711.258(52)(56)	0.012	¯0.020	0.067
MEAN VALUE		13353.401(33)(36)			30711.245(29)(45)			0.095

DIFFERENCE W.HEAD LOK. - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
225.2117-225.2323	200	¯469.457(9)(19)	0.012	0.000	554.042(37)(41)	0.058	0.000	¯0.005
232.1657-232.1903	200	¯469.457(14)(34)	0.012	0.000	553.990(11)(33)	0.005	¯0.052	0.432
238.2353-239.0160	200	¯469.469(15)(36)	0.001	¯0.011	553.966(16)(37)	¯0.019	¯0.077	0.585
267.2128-267.2338	201	¯469.494(6)(22)	¯0.025	¯0.037	553.941(57)(62)	¯0.044	¯0.101	0.154
MEAN VALUE		¯469.457(17)(34)			554.042(43)(62)			0.292

DIFFERENCE W.HEAD LOK. - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
225.2117-225.2323	200	¯469.515(8)(18)	¯0.011	0.000	553.917(35)(39)	0.021	0.000	0.150
232.1657-232.1903	200	¯469.480(10)(26)	0.024	0.035	553.875(9)(24)	¯0.021	¯0.042	0.352
238.2353-239.0160	200	¯469.519(10)(27)	¯0.015	¯0.004	553.879(11)(27)	¯0.017	¯0.038	0.558
267.2128-267.2338	201	¯469.502(6)(22)	0.002	0.013	553.912(56)(61)	0.017	¯0.004	0.045
MEAN VALUE		¯469.504(18)(29)			553.896(22)(46)			0.276

◊ 10. INGOMAR CM. STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
226.1535-226.1741	40	13822.808(14)(40)	¯0.049	0.000	30157.237(14)(40)	¯0.004	0.000	0.334
232.1252-232.1458	40	13822.894(16)(41)	0.038	0.087	30157.221(17)(41)	¯0.021	¯0.016	0.728
239.1301-239.1507	41	13822.868(12)(30)	0.011	0.060	30157.267(19)(32)	0.025	0.029	0.025
MEAN VALUE		13822.857(44)(58)			30157.242(23)(44)			0.362

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
226.1535-226.1741	40	13822.869(10)(29)	¯0.033	0.000	30157.359(10)(29)	0.009	0.000	0.281
232.1252-232.1458	40	13822.920(12)(32)	0.019	0.051	30157.335(14)(31)	¯0.015	¯0.024	0.707
239.1301-239.1507	41	13822.915(11)(23)	0.014	0.047	30157.356(18)(27)	0.006	¯0.003	0.056
MEAN VALUE		13822.901(28)(40)			30157.350(13)(32)			0.348

VAN SITE INGOMAR CM.

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
226.1535-226.1741	200	13285.677(13)(13)	¯0.052	0.000	30783.358(12)(12)	0.013	0.000	0.287
232.1252-232.1458	200	13285.760(11)(11)	0.031	0.083	30783.312(15)(15)	¯0.033	¯0.046	0.504
239.1301-239.1507	200	13285.717(11)(11)	¯0.013	0.040	30783.348(22)(22)	0.002	¯0.011	0.119
268.1207-268.1423	203	13285.764(9)(16)	0.035	0.087	30783.363(39)(43)	0.017	0.004	¯0.405
MEAN VALUE		13285.730(41)(43)			30783.345(23)(35)			0.126

DIFFERENCE INGOMAR CM. - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
226.1535-226.1741	200	¯537.130(11)(32)	0.008	0.000	626.121(11)(32)	0.023	0.000	0.260
232.1252-232.1458	200	¯537.134(13)(33)	0.004	¯0.004	626.091(14)(33)	¯0.007	¯0.030	0.555
239.1301-239.1507	200	¯537.151(10)(25)	¯0.012	¯0.020	626.081(10)(23)	¯0.017	¯0.040	¯0.018
MEAN VALUE		¯537.130(11)(32)			626.121(21)(37)			0.266

DIFFERENCE INGOMAR CM. - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
226.1535-226.1741	200	¯537.191(10)(24)	¯0.008	0.000	626.000(10)(24)	0.010	0.000	0.335
232.1252-232.1458	200	¯537.160(9)(26)	0.023	0.031	625.978(10)(25)	¯0.012	¯0.022	0.202
239.1301-239.1507	200	¯537.198(9)(19)	¯0.015	¯0.007	625.992(10)(20)	0.002	¯0.007	¯0.014
MEAN VALUE		¯537.183(21)(31)			625.990(11)(26)			0.174

◊ 11. DEVILS ISLD STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
252.1754-252.1756	1	13822.890(0)(10)	¯0.062	0.000	30157.320(0)(20)	0.007	0.000	0.000
252.1915-252.1918	1	13822.920(0)(10)	¯0.032	0.030	30157.300(0)(10)	¯0.013	¯0.020	0.000
292.1231-292.1236	8	13823.020(8)(19)	0.068	0.130	30157.314(5)(17)	0.001	¯0.006	0.366
292.1840-292.1846	8	13822.979(12)(18)	0.027	0.089	30157.318(12)(18)	0.005	¯0.002	0.829
MEAN VALUE		13822.952(59)(60)			30157.313(9)(19)			0.598

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
252.1754-252.1756	1	13822.900(0)(20)	¯0.055	0.000	30157.350(0)(20)	0.014	0.000	0.000
252.1915-252.1918	1	13822.930(0)(20)	¯0.025	0.030	30157.320(0)(10)	¯0.016	¯0.030	0.000
292.1231-292.1236	8	13823.011(7)(19)	0.056	0.111	30157.336(3)(17)	0.000	¯0.014	¯0.119
292.1840-292.1846	8	13822.980(10)(18)	0.025	0.080	30157.338(8)(20)	0.002	¯0.012	0.715
MEAN VALUE		13822.955(50)(54)			30157.336(12)(21)			0.298

HELICOPTER SITE DEVILS ISLD

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
252.1754-252.1756	6	13866.750(6)(6)	¯0.027	0.000	30121.085(5)(5)	0.026	0.000	0.000
252.1915-252.1918	7	13866.763(8)(8)	¯0.014	0.013	30121.036(11)(11)	¯0.024	¯0.049	¯0.024
273.1411-273.1417	16	13866.767(21)(27)	¯0.010	0.017	30121.101(22)(29)	0.041	0.016	0.896
292.1230-292.1236	15	13866.806(43)(49)	0.030	0.056	30121.031(24)(30)	¯0.029	¯0.054	0.853
292.1840-292.1846	14	13866.797(15)(29)	0.020	0.047	30121.045(19)(29)	¯0.014	¯0.040	¯0.160
MEAN VALUE		13866.777(24)(37)			30121.059(31)(39)			0.313

DIFFERENCE DEVILS ISLD - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
252.1754-252.1756	6	43.857(4)(10)	0.027	0.000	¯36.238(6)(16)	0.025	0.000	¯0.153
252.1915-252.1918	7	43.847(10)(13)	0.017	¯0.010	¯36.264(11)(15)	¯0.002	¯0.026	¯0.178
292.1231-292.1236	12	43.800(9)(26)	¯0.031	¯0.057	¯36.274(11)(23)	¯0.012	¯0.036	0.544
292.1840-292.1846	14	43.818(17)(32)	¯0.013	¯0.040	¯36.273(16)(30)	¯0.011	¯0.035	¯0.265
MEAN VALUE		43.857(27)(34)			¯36.238(17)(27)			¯0.013

DIFFERENCE DEVILS ISLD - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
252.1754-252.1756	6	43.849(7)(18)	0.022	0.000	¯36.261(5)(17)	0.022	0.000	0.410
252.1915-252.1918	7	43.836(11)(19)	0.008	¯0.013	¯36.284(11)(17)	¯0.001	¯0.023	¯0.148
292.1231-292.1236	12	43.810(8)(25)	¯0.018	¯0.039	¯36.296(9)(22)	¯0.012	¯0.035	0.217
292.1840-292.1846	14	43.816(15)(32)	¯0.012	¯0.034	¯36.293(16)(32)	¯0.010	¯0.032	¯0.394
MEAN VALUE		43.828(18)(30)			¯36.284(16)(28)			0.022

◊ 12. SAMBRO ISLD STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
252.1805-252.1807	2	13822.880(14)(21)	¯0.073	0.000	30157.295(7)(17)	¯0.012	0.000	¯0.500
252.1906-252.1909	2	13822.915(7)(21)	¯0.038	0.035	30157.300(0)(10)	¯0.007	0.005	1.000
292.1244-292.1250	8	13823.026(4)(15)	0.073	0.146	30157.315(5)(15)	0.009	0.020	0.480
292.1828-292.1833	8	13822.990(15)(23)	0.037	0.110	30157.317(13)(23)	0.010	0.022	0.836
MEAN VALUE		13822.953(67)(70)			30157.307(11)(20)			0.454

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
252.1805-252.1807	2	13822.890(14)(24)	¯0.068	0.000	30157.315(7)(21)	¯0.013	0.000	0.500
252.1906-252.1909	2	13822.930(0)(16)	¯0.028	0.040	30157.320(0)(16)	¯0.008	0.005	1.000
292.1244-292.1250	8	13823.017(6)(19)	0.059	0.127	30157.338(5)(19)	0.010	0.023	0.681
292.1828-292.1833	8	13822.994(17)(30)	0.036	0.104	30157.340(12)(28)	0.011	0.025	0.833
MEAN VALUE		13822.958(58)(62)			30157.328(12)(25)			0.754

HELICOPTER SITE SAMBRO ISLD

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
252.1805-252.1807	6	13802.002(25)(25)	¯0.117	0.000	30154.253(16)(16)	¯0.030	0.000	0.521
252.1906-252.1909	7	13802.043(8)(8)	¯0.075	0.041	30154.264(5)(5)	¯0.019	0.011	¯0.303
273.1426-273.1432	16	13802.204(21)(26)	0.086	0.203	30154.315(5)(18)	0.032	0.062	0.336
292.1244-292.1250	14	13802.216(15)(25)	0.098	0.214	30154.303(20)(28)	0.020	0.050	¯0.046
292.1828-292.1833	14	13802.127(18)(25)	0.009	0.125	30154.279(93)(158)	¯0.004	0.025	0.736
MEAN VALUE		13802.118(95)(98)			30154.283(26)(77)			0.249

DIFFERENCE SAMBRO ISLD - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
252.1805-252.1807	6	¯20.877(25)(28)	¯0.023	0.000	¯3.042(18)(23)	¯0.011	0.000	0.361
252.1906-252.1909	7	¯20.870(6)(18)	¯0.016	0.007	¯3.035(6)(11)	¯0.004	0.007	¯0.023
292.1244-292.1250	14	¯20.810(16)(28)	0.044	0.067	¯3.012(21)(31)	0.019	0.030	0.029
292.1828-292.1833	14	¯20.860(22)(32)	¯0.005	0.017	¯3.035(98)(161)	¯0.004	0.007	0.845
MEAN VALUE		¯20.877(30)(41)			¯3.042(13)(84)			0.303

DIFFERENCE SAMBRO ISLD - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
252.1805-252.1807	6	¯20.887(25)(30)	¯0.029	0.000	¯3.061(16)(23)	¯0.010	0.000	0.496
252.1906-252.1909	7	¯20.885(5)(15)	¯0.028	0.002	¯3.056(5)(15)	¯0.004	0.006	¯0.249
292.1244-292.1250	14	¯20.801(15)(29)	0.057	0.086	¯3.035(22)(33)	0.017	0.026	¯0.004
292.1828-292.1833	14	¯20.858(27)(39)	0.000	0.030	¯3.054(99)(163)	¯0.003	0.007	0.751
MEAN VALUE		¯20.858(40)(50)			¯3.052(12)(85)			0.248

◊ 13. BETTY ISLND STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD_1)(SD_2)	DEL_1	DEL_2	MEAN TDB (SD_1)(SD_2)	DEL_1	DEL_2	RHO
252.1815-252.1817	2	13822.875(7)(17)	¯0.086	0.000	30157.290(0)(16)	¯0.015	0.000	1.000
252.1857-252.1859	1	13822.960(0)(20)	¯0.001	0.085	30157.300(0)(10)	¯0.005	0.010	0.000
273.1443-273.1446	5	13822.968(5)(15)	0.007	0.093	30157.317(4)(14)	0.012	0.027	0.775
292.1258-292.1304	8	13823.010(6)(19)	0.050	0.135	30157.293(4)(16)	¯0.012	0.003	0.743
292.1815-292.1821	8	13822.991(2)(13)	0.030	0.116	30157.324(2)(15)	0.019	0.034	¯0.406
MEAN VALUE		13822.961(52)(55)			30157.305(15)(21)			0.528

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD_1)(SD_2)	DEL_1	DEL_2	MEAN TDB (SD_1)(SD_2)	DEL_1	DEL_2	RHO
252.1815-252.1817	2	13822.885(7)(21)	¯0.073	0.000	30157.305(7)(17)	¯0.016	0.000	0.500
252.1857-252.1859	1	13822.950(0)(20)	¯0.008	0.065	30157.320(0)(20)	¯0.001	0.015	0.000
273.1443-273.1446	5	13822.962(8)(17)	0.004	0.077	30157.319(7)(15)	¯0.002	0.014	0.726
292.1258-292.1304	8	13822.997(4)(16)	0.039	0.112	30157.315(5)(18)	¯0.005	0.010	0.536
292.1815-292.1821	8	13822.996(3)(17)	0.038	0.111	30157.344(4)(17)	0.023	0.039	0.654
MEAN VALUE		13822.958(46)(49)			30157.321(14)(23)			0.604

HELICOPTER SITE BETTY ISLND

TIME SPAN	NUM	MEAN TDA (SD_1)(SD_2)	DEL_1	DEL_2	MEAN TDB (SD_1)(SD_2)	DEL_1	DEL_2	RHO
252.1815-252.1817	6	13799.722(12)(12)	¯0.083	0.000	30247.310(28)(28)	¯0.017	0.000	0.776
252.1857-252.1859	7	13799.820(12)(12)	0.015	0.098	30247.281(20)(20)	¯0.045	¯0.029	0.697
273.1439-273.1446	15	13799.818(14)(21)	0.013	0.096	30247.397(60)(86)	0.070	0.087	0.631
292.1258-292.1304	14	13799.846(10)(19)	0.041	0.124	30247.323(43)(48)	¯0.003	0.013	0.431
292.1815-292.1821	15	13799.820(10)(19)	0.015	0.098	30247.321(28)(33)	¯0.005	0.011	0.524
MEAN VALUE		13799.805(48)(51)			30247.327(43)(65)			0.612

DIFFERENCE BETTY ISLND - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD_1)(SD_2)	DEL_1	DEL_2	DIFF TDB(SD_1)(SD_2)	DEL_1	DEL_2	RHO
252.1815-252.1817	6	¯23.153(9)(17)	0.005	0.000	90.020(28)(30)	0.002	0.000	0.682
252.1857-252.1859	7	¯23.138(12)(23)	0.020	0.015	89.986(17)(19)	¯0.032	¯0.034	0.670
273.1443-273.1446	8	¯23.160(7)(20)	¯0.002	¯0.007	90.054(10)(23)	0.036	0.034	0.840
292.1258-292.1304	14	¯23.165(11)(24)	¯0.008	¯0.013	90.031(42)(49)	0.013	0.011	0.295
292.1815-292.1821	15	¯23.172(10)(22)	¯0.014	¯0.019	89.998(28)(36)	¯0.020	¯0.022	0.608
MEAN VALUE		¯23.153(13)(25)			90.020(27)(43)			0.619

DIFFERENCE BETTY ISLND - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD_1)(SD_2)	DEL_1	DEL_2	DIFF TDB(SD_1)(SD_2)	DEL_1	DEL_2	RHO
252.1815-252.1817	6	¯23.164(15)(23)	¯0.009	0.000	90.004(31)(34)	0.004	0.000	0.802
252.1857-252.1859	7	¯23.128(12)(23)	0.027	0.036	89.961(20)(25)	¯0.039	¯0.043	0.711
273.1443-273.1446	8	¯23.153(8)(21)	0.001	0.011	90.052(12)(24)	0.051	0.047	0.849
292.1258-292.1304	14	¯23.152(10)(23)	0.003	0.012	90.008(41)(49)	0.007	0.003	0.283
292.1815-292.1821	15	¯23.177(11)(24)	¯0.022	¯0.013	89.977(27)(36)	¯0.023	¯0.027	0.509
MEAN VALUE		¯23.155(18)(29)			90.000(34)(49)			0.631

◊ 14. PEGGY PT.B. STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
252.1825-252.1827	2	13822.890(0)(16)	¯0.062	0.000	30157.300(0)(10)	¯0.002	0.000	1.000
252.1849-252.1851	1	13822.950(0)(20)	¯0.002	0.060	30157.290(0)(20)	¯0.012	¯0.010	0.000
273.1453-273.1456	2	13822.970(1)(18)	0.019	0.080	30157.328(4)(16)	0.026	0.028	0.500
292.1311-292.1314	5	13822.997(13)(21)	0.045	0.107	30157.290(13)(20)	¯0.012	¯0.010	0.729
MEAN VALUE		13822.952(46)(49)			30157.302(18)(25)			0.743

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
252.1825-252.1827	2	13822.900(0)(20)	¯0.049	0.000	30157.315(7)(21)	¯0.003	0.000	1.000
252.1849-252.1851	1	13822.940(0)(20)	¯0.009	0.040	30157.310(0)(20)	¯0.008	¯0.005	0.000
273.1453-273.1456	2	13822.966(2)(17)	0.018	0.066	30157.332(5)(16)	0.014	0.017	0.500
292.1311-292.1314	5	13822.988(11)(19)	0.040	0.088	30157.314(9)(18)	¯0.004	¯0.001	0.794
MEAN VALUE		13822.949(38)(43)			30157.318(10)(21)			0.765

HELICOPTER SITE PEGGY PT.B.

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
252.1825-252.1827	6	13812.748(17)(17)	¯0.093	0.000	30325.070(33)(33)	¯0.071	0.000	0.412
252.1849-252.1851	6	13812.840(15)(15)	¯0.001	0.092	30324.902(329)(329)	¯0.239	¯0.168	¯0.020
273.1453-273.1456	5	13812.751(9)(17)	¯0.090	0.002	30325.242(26)(33)	0.101	0.172	0.699
292.1311-292.1314	8	13813.026(12)(19)	0.184	0.277	30325.350(39)(46)	0.209	0.280	0.622
MEAN VALUE		13812.841(130)(131)			30325.141(197)(259)			0.428

DIFFERENCE PEGGY PT.B. - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
252.1825-252.1827	6	¯10.141(18)(22)	¯0.032	0.000	167.770(33)(34)	¯0.071	0.000	0.392
252.1849-252.1851	6	¯10.107(15)(22)	0.003	0.034	167.610(331)(331)	¯0.231	¯0.160	¯0.068
273.1453-273.1456	5	¯10.219(10)(22)	¯0.110	¯0.078	167.924(33)(60)	0.083	0.154	0.656
292.1311-292.1314	8	¯9.971(14)(25)	0.138	0.170	168.060(45)(52)	0.219	0.290	0.744
MEAN VALUE		¯10.141(104)(106)			167.770(194)(259)			0.431

DIFFERENCE PEGGY PT.B. - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
252.1825-252.1827	6	¯10.151(18)(25)	¯0.044	0.000	167.754(35)(39)	¯0.069	0.000	0.333
252.1849-252.1851	6	¯10.099(17)(23)	0.008	0.053	167.588(330)(330)	¯0.235	¯0.166	¯0.104
273.1453-273.1456	5	¯10.216(10)(22)	¯0.109	¯0.064	167.914(28)(39)	0.090	0.159	0.725
292.1311-292.1314	8	¯9.962(15)(26)	0.145	0.189	168.037(43)(51)	0.213	0.282	0.708
MEAN VALUE		¯10.107(108)(110)			167.823(195)(258)			0.416

◊ 15. HORSHO L.B. STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD$_1$)(SD$_2$)	DEL$_1$	DEL$_2$	MEAN TDB (SD$_1$)(SD$_2$)	DEL$_1$	DEL$_2$	RHO
252.1830-252.1832	2	13822.870(14)(21)	¯0.074	0.000	30157.290(0)(10)	¯0.003	0.000	1.000
252.1845-252.1847	1	13822.940(0)(20)	¯0.004	0.070	30157.300(0)(20)	0.007	0.010	0.000
273.1501-273.1504	3	13822.976(2)(15)	0.032	0.106	30157.300(1)(13)	0.007	0.010	0.333
292.1317-292.1320	5	13822.989(5)(18)	0.045	0.119	30157.281(2)(16)	¯0.012	¯0.009	0.633
MEAN VALUE		13822.944(53)(56)			30157.293(9)(18)			0.655

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD$_1$)(SD$_2$)	DEL$_1$	DEL$_2$	MEAN TDB (SD$_1$)(SD$_2$)	DEL$_1$	DEL$_2$	RHO
252.1830-252.1832	2	13822.870(0)(20)	¯0.068	0.000	30157.315(7)(21)	0.003	0.000	1.000
252.1845-252.1847	1	13822.930(0)(20)	¯0.008	0.060	30157.320(0)(20)	0.008	0.005	0.000
273.1501-273.1504	3	13822.973(5)(18)	0.035	0.103	30157.309(4)(21)	¯0.003	¯0.006	0.455
292.1317-292.1320	5	13822.978(2)(19)	0.040	0.108	30157.304(4)(17)	¯0.008	¯0.011	0.472
MEAN VALUE		13822.938(50)(54)			30157.312(7)(21)			0.642

HELICOPTER SITE HORSHO L.B.

TIME SPAN	NUM	MEAN TDA (SD$_1$)(SD$_2$)	DEL$_1$	DEL$_2$	MEAN TDB (SD$_1$)(SD$_2$)	DEL$_1$	DEL$_2$	RHO
252.1830-252.1832	5	13809.920(27)(27)	¯0.189	0.000	30343.640(29)(29)	¯0.178	0.000	¯0.376
252.1845-252.1847	6	13809.988(12)(12)	¯0.120	0.068	30343.600(28)(28)	¯0.218	¯0.040	¯0.621
273.1501-273.1504	7	13810.144(70)(74)	0.036	0.224	30343.661(23)(31)	¯0.157	0.021	¯0.203
292.1317-292.1320	8	13810.382(31)(36)	0.274	0.462	30344.370(50)(53)	0.552	0.730	¯0.472
MEAN VALUE		13810.109(205)(210)			30343.818(369)(371)			¯0.418

DIFFERENCE HORSHO L.B. - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD$_1$)(SD$_2$)	DEL$_1$	DEL$_2$	DIFF TDB(SD$_1$)(SD$_2$)	DEL$_1$	DEL$_2$	RHO
252.1830-252.1832	5	¯12.952(21)(25)	¯0.117	0.000	186.350(29)(30)	¯0.175	0.000	¯0.214
252.1845-252.1847	6	¯12.945(18)(22)	¯0.110	0.007	186.304(25)(29)	¯0.221	¯0.046	¯0.583
273.1501-273.1504	7	¯12.835(69)(74)	¯0.001	0.117	186.356(18)(30)	¯0.168	0.007	¯0.293
292.1317-292.1320	8	¯12.606(34)(41)	0.228	0.346	187.088(48)(54)	0.564	0.739	¯0.512
MEAN VALUE		¯12.952(161)(168)			186.350(377)(379)			¯0.401

DIFFERENCE HORSHO L.B. - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD$_1$)(SD$_2$)	DEL$_1$	DEL$_2$	DIFF TDB(SD$_1$)(SD$_2$)	DEL$_1$	DEL$_2$	RHO
252.1830-252.1832	5	¯12.951(26)(31)	¯0.124	0.000	186.325(33)(37)	¯0.179	0.000	¯0.410
252.1845-252.1847	6	¯12.931(21)(27)	¯0.104	0.020	186.280(28)(32)	¯0.224	¯0.045	¯0.628
273.1501-273.1504	7	¯12.832(73)(77)	¯0.004	0.119	186.346(17)(31)	¯0.158	0.022	¯0.214
292.1317-292.1320	8	¯12.596(31)(39)	0.231	0.355	187.066(47)(53)	0.561	0.741	¯0.525
MEAN VALUE		¯12.828(163)(170)			186.504(375)(377)			¯0.444

◊ 16. PEARL ISLND STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
252.1838-252.1840	2	13822.930(0)(20)	¯0.022	0.000	30157.295(7)(21)	¯0.034	0.000	1.000
253.1703-253.1707	2	13822.875(7)(21)	¯0.077	¯0.055	30157.355(7)(17)	0.026	0.060	0.500
273.1509-273.1516	9	13822.976(15)(21)	0.024	0.046	30157.349(14)(20)	0.019	0.054	0.879
292.1326-292.1332	8	13823.011(15)(22)	0.059	0.081	30157.335(19)(24)	0.006	0.040	0.801
292.1759-292.1806	9	13822.967(19)(29)	0.015	0.037	30157.313(16)(22)	¯0.016	0.018	0.434
MEAN VALUE		13822.952(52)(56)			30157.329(25)(33)			0.723

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
252.1838-252.1840	2	13822.920(0)(20)	¯0.029	0.000	30157.315(7)(21)	¯0.025	0.000	1.000
253.1703-253.1707	2	13822.890(0)(20)	¯0.059	¯0.030	30157.350(0)(20)	0.010	0.035	1.000
273.1509-273.1516	9	13822.970(13)(20)	0.020	0.050	30157.350(16)(24)	0.010	0.035	0.861
292.1326-292.1332	8	13823.001(16)(23)	0.052	0.081	30157.355(16)(25)	0.015	0.040	0.782
292.1759-292.1806	9	13822.966(19)(26)	0.016	0.046	30157.332(13)(22)	¯0.008	0.017	0.375
MEAN VALUE		13822.949(44)(49)			30157.340(17)(28)			0.804

HELICOPTER SITE PEARL ISLND

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
252.1838-252.1840	6	13768.365(19)(19)	0.001	0.000	30366.825(8)(8)	¯0.028	0.000	¯0.373
253.1703-253.1707	10	13768.294(22)(22)	¯0.070	¯0.071	30366.905(16)(16)	0.052	0.080	¯0.279
273.1509-273.1516	16	13768.386(21)(25)	0.022	0.021	30366.913(13)(22)	0.059	0.088	0.420
292.1326-292.1332	14	13768.402(33)(38)	0.038	0.037	30366.818(15)(24)	¯0.035	¯0.007	¯0.165
292.1759-292.1806	15	13768.373(23)(30)	0.009	0.008	30366.806(14)(23)	¯0.048	¯0.019	0.335
MEAN VALUE		13768.364(42)(50)			30366.853(51)(55)			¯0.012

DIFFERENCE PEARL ISLND - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
252.1838-252.1840	6	¯54.565(19)(26)	0.022	0.000	209.529(11)(20)	0.005	0.000	¯0.551
253.1703-253.1707	10	¯54.579(20)(26)	0.009	¯0.014	209.552(16)(21)	0.027	0.022	¯0.432
273.1509-273.1516	16	¯54.591(18)(26)	¯0.004	¯0.026	209.563(6)(22)	0.038	0.034	¯0.014
292.1326-292.1332	14	¯54.607(24)(34)	¯0.019	¯0.042	209.487(20)(30)	¯0.037	¯0.042	¯0.568
292.1759-292.1806	15	¯54.595(12)(29)	¯0.008	¯0.030	209.492(9)(24)	¯0.033	¯0.037	0.623
MEAN VALUE		¯54.565(16)(32)			209.529(34)(42)			¯0.188

DIFFERENCE PEARL ISLND - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
252.1838-252.1840	6	¯54.555(19)(26)	0.030	0.000	209.509(11)(20)	¯0.004	0.000	¯0.551
253.1703-253.1707	10	¯54.595(22)(27)	¯0.010	¯0.040	209.557(18)(24)	0.044	0.048	¯0.413
273.1509-273.1516	16	¯54.585(19)(27)	0.000	¯0.030	209.562(9)(24)	0.048	0.053	0.097
292.1326-292.1332	14	¯54.597(24)(34)	¯0.012	¯0.042	209.467(19)(31)	¯0.047	¯0.042	¯0.611
292.1759-292.1806	15	¯54.593(12)(26)	¯0.008	¯0.038	209.472(10)(25)	¯0.041	¯0.037	0.609
MEAN VALUE		¯54.585(18)(33)			209.513(45)(52)			¯0.174

◊ 17. MOSHER ISLD STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1719-253.1723	2	13822.875(7)(21)	¯0.066	0.000	30157.345(7)(17)	0.019	0.000	¯0.500
253.2040-253.2045	3	13822.877(6)(18)	¯0.065	0.002	30157.320(0)(17)	¯0.006	¯0.025	0.000
273.1527-273.1533	8	13822.975(10)(20)	0.034	0.100	30157.362(9)(17)	0.036	0.017	0.221
292.1343-292.1349	7	13822.990(11)(20)	0.049	0.115	30157.302(10)(19)	¯0.024	¯0.043	0.771
292.1743-292.1748	7	13822.989(3)(14)	0.048	0.114	30157.302(5)(15)	¯0.024	¯0.043	0.749
MEAN VALUE		13822.941(60)(63)			30157.326(27)(32)			0.310

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1719-253.1723	2	13822.890(14)(24)	¯0.050	0.000	30157.350(0)(20)	0.013	0.000	1.000
253.2040-253.2045	3	13822.887(6)(21)	¯0.053	¯0.003	30157.330(0)(20)	¯0.007	¯0.020	0.000
273.1527-273.1533	8	13822.967(11)(21)	0.027	0.077	30157.360(11)(20)	0.022	0.010	0.132
292.1343-292.1349	7	13822.979(9)(18)	0.039	0.089	30157.323(7)(19)	¯0.014	¯0.027	0.839
292.1743-292.1748	7	13822.976(6)(17)	0.036	0.086	30157.323(5)(18)	¯0.014	¯0.027	0.512
MEAN VALUE		13822.940(47)(51)			30157.337(17)(25)			0.621

HELICOPTER SITE MOSHER ISLD

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1719-253.1723	11	13692.356(19)(19)	¯0.051	0.000	30465.920(15)(15)	0.043	0.000	¯0.675
253.2040-253.2045	13	13692.335(14)(14)	¯0.072	¯0.021	30465.884(19)(19)	0.007	¯0.036	¯0.648
273.1527-273.1533	15	13692.425(20)(24)	0.018	0.069	30465.938(8)(17)	0.061	0.018	¯0.290
292.1343-292.1349	14	13692.456(21)(27)	0.049	0.100	30465.830(17)(22)	¯0.047	¯0.090	¯0.289
292.1743-292.1748	12	13692.462(9)(20)	0.055	0.106	30465.811(19)(27)	¯0.065	¯0.109	¯0.668
MEAN VALUE		13692.407(58)(62)			30465.877(55)(59)			¯0.514

DIFFERENCE MOSHER ISLD - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
253.1719-253.1723	11	¯130.518(21)(27)	0.016	0.000	308.577(16)(22)	0.026	0.000	¯0.699
253.2040-253.2045	13	¯130.540(15)(20)	¯0.006	¯0.022	308.564(19)(23)	0.013	¯0.013	¯0.553
273.1527-273.1533	15	¯130.547(15)(25)	¯0.013	¯0.030	308.578(13)(23)	0.027	0.001	¯0.426
292.1343-292.1349	14	¯130.537(18)(28)	¯0.003	¯0.019	308.525(16)(25)	¯0.026	¯0.052	¯0.692
292.1743-292.1748	12	¯130.528(8)(22)	0.006	¯0.010	308.509(20)(30)	¯0.041	¯0.068	¯0.747
MEAN VALUE		¯130.518(11)(27)			308.577(32)(40)			¯0.623

DIFFERENCE MOSHER ISLD - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
253.1719-253.1723	11	¯130.533(20)(26)	0.000	0.000	308.571(17)(24)	0.032	0.000	¯0.772
253.2040-253.2045	13	¯130.552(13)(20)	¯0.018	¯0.018	308.554(19)(25)	0.015	¯0.017	¯0.644
273.1527-273.1533	15	¯130.540(17)(26)	¯0.007	¯0.007	308.579(13)(24)	0.040	0.008	¯0.428
292.1343-292.1349	14	¯130.527(17)(27)	0.007	0.007	308.503(16)(26)	¯0.036	¯0.068	¯0.599
292.1743-292.1748	12	¯130.515(6)(22)	0.019	0.019	308.488(20)(30)	¯0.051	¯0.083	¯0.633
MEAN VALUE		¯130.533(14)(28)			308.539(41)(49)			¯0.615

◊ 18. COFFIN ISLD STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1759-253.1803	2	13822.865(7)(21)	¯0.071	0.000	30157.330(0)(16)	0.001	0.000	1.000
253.2025-253.2029	2	13822.870(0)(20)	¯0.066	0.005	30157.330(0)(16)	0.001	0.000	1.000
273.1548-273.1552	6	13822.951(4)(14)	0.015	0.086	30157.338(3)(15)	0.009	0.008	0.377
292.1405-292.1409	6	13823.014(3)(16)	0.078	0.149	30157.327(3)(16)	¯0.003	¯0.003	0.183
292.1727-292.1732	6	13822.978(12)(19)	0.042	0.113	30157.322(8)(16)	¯0.008	¯0.008	0.810
MEAN VALUE		13822.936(66)(68)			30157.329(6)(17)			0.674

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1759-253.1803	2	13822.880(0)(20)	¯0.055	0.000	30157.340(0)(20)	¯0.002	0.000	1.000
253.2025-253.2029	2	13822.885(7)(26)	¯0.050	0.005	30157.340(0)(20)	¯0.002	0.000	1.000
273.1548-273.1552	6	13822.942(4)(18)	0.007	0.062	30157.338(4)(19)	¯0.004	¯0.002	0.308
292.1405-292.1409	6	13823.003(7)(16)	0.068	0.123	30157.347(8)(17)	0.005	0.007	0.811
292.1727-292.1732	6	13822.965(12)(20)	0.030	0.085	30157.346(8)(19)	0.004	0.006	0.706
MEAN VALUE		13822.935(53)(57)			30157.342(4)(19)			0.765

HELICOPTER SITE COFFIN ISLD

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1759-253.1803	10	13577.989(9)(9)	¯0.060	0.000	30568.592(10)(10)	0.027	0.000	¯0.199
253.2025-253.2029	10	13577.978(6)(6)	¯0.071	¯0.011	30568.620(7)(7)	0.055	0.028	0.474
273.1548-273.1552	10	13578.051(7)(17)	0.002	0.062	30568.586(6)(18)	0.022	¯0.006	0.399
292.1405-292.1409	10	13578.123(7)(18)	0.074	0.134	30568.511(9)(21)	¯0.053	¯0.081	0.437
292.1727-292.1732	10	13578.106(10)(21)	0.056	0.117	30568.513(9)(19)	¯0.051	¯0.079	0.722
MEAN VALUE		13578.049(66)(68)			30568.565(49)(52)			0.367

DIFFERENCE COFFIN ISLD - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
253.1759-253.1803	10	¯244.876(11)(19)	0.009	0.000	411.265(9)(17)	0.029	0.000	0.016
253.2025-253.2029	10	¯244.892(6)(16)	¯0.006	¯0.016	411.287(7)(15)	0.052	0.023	0.474
273.1548-273.1552	10	¯244.899(6)(20)	¯0.014	¯0.023	411.248(5)(21)	0.013	¯0.016	0.514
292.1405-292.1409	10	¯244.889(8)(23)	¯0.004	¯0.013	411.186(9)(25)	¯0.050	¯0.079	0.334
292.1727-292.1732	10	¯244.872(3)(22)	0.014	0.005	411.191(6)(21)	¯0.044	¯0.073	0.434
MEAN VALUE		¯244.876(12)(23)			411.265(45)(49)			0.354

DIFFERENCE COFFIN ISLD - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
253.1759-253.1803	10	¯244.891(10)(20)	¯0.006	0.000	411.255(9)(19)	0.032	0.000	¯0.008
253.2025-253.2029	10	¯244.908(9)(21)	¯0.023	¯0.017	411.280(7)(17)	0.057	0.025	0.403
273.1548-273.1552	10	¯244.891(7)(23)	¯0.005	0.001	411.249(6)(23)	0.026	¯0.006	0.557
292.1405-292.1409	10	¯244.879(7)(22)	0.007	0.012	411.165(7)(24)	¯0.058	¯0.090	0.208
292.1727-292.1732	10	¯244.859(3)(23)	0.026	0.032	411.167(6)(23)	¯0.056	¯0.088	0.088
MEAN VALUE		¯244.886(18)(28)			411.223(53)(58)			0.250

◊ 19. WHITE PT.B. STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1839-253.1841	1	13822.870(0)(20)	¯0.062	0.000	30157.320(0)(10)	0.009	0.000	0.000
253.2015-253.2017	1	13822.870(0)(20)	¯0.062	0.000	30157.330(0)(20)	0.019	0.010	0.000
292.1511-292.1514	4	13823.011(6)(15)	0.078	0.141	30157.315(6)(16)	0.005	¯0.005	0.617
292.1652-292.1654	4	13822.979(18)(27)	0.047	0.109	30157.277(6)(17)	¯0.033	¯0.043	0.312
MEAN VALUE		13822.932(73)(76)			30157.311(23)(28)			0.464

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1839-253.1841	1	13822.880(0)(30)	¯0.055	0.000	30157.330(0)(20)	0.004	0.000	0.000
253.2015-253.2017	1	13822.890(0)(20)	¯0.045	0.010	30157.340(0)(20)	0.014	0.010	0.000
292.1511-292.1514	4	13823.000(7)(17)	0.065	0.120	30157.334(7)(17)	0.008	0.004	0.651
292.1652-292.1654	4	13822.970(21)(28)	0.035	0.090	30157.301(10)(19)	¯0.026	¯0.029	0.386
MEAN VALUE		13822.935(59)(64)			30157.326(18)(26)			0.519

HELICOPTER SITE WHITE PT.B.

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1839-253.1841	7	13519.474(58)(58)	¯0.093	0.000	30589.971(30)(30)	0.057	0.000	¯0.233
253.2015-253.2017	6	13519.412(8)(8)	¯0.155	¯0.063	30590.003(22)(22)	0.089	0.032	0.478
292.1511-292.1514	8	13519.634(65)(69)	0.067	0.159	30589.862(12)(21)	¯0.052	¯0.109	¯0.505
292.1652-292.1654	7	13519.749(58)(62)	0.182	0.274	30589.819(33)(39)	¯0.095	¯0.152	¯0.231
MEAN VALUE		13519.567(153)(162)			30589.914(88)(92)			¯0.123

DIFFERENCE WHITE PT.B. - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
253.1839-253.1841	7	¯303.401(57)(59)	¯0.034	0.000	432.647(33)(34)	0.045	0.000	¯0.206
253.2015-253.2017	6	¯303.458(8)(18)	¯0.092	¯0.058	432.670(19)(25)	0.069	0.024	0.423
292.1511-292.1514	8	¯303.377(68)(73)	¯0.011	0.024	432.547(11)(24)	¯0.054	¯0.100	¯0.275
292.1652-292.1654	7	¯303.230(67)(72)	0.137	0.171	432.541(30)(40)	¯0.060	¯0.106	¯0.472
MEAN VALUE		¯303.401(97)(114)			432.647(67)(74)			¯0.133

DIFFERENCE WHITE PT.B. - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
253.1839-253.1841	7	¯303.415(56)(59)	¯0.046	0.000	432.640(30)(34)	0.053	0.000	¯0.104
253.2015-253.2017	6	¯303.474(10)(19)	¯0.105	¯0.059	432.663(22)(27)	0.076	0.023	0.570
292.1511-292.1514	8	¯303.368(67)(73)	0.002	0.048	432.527(12)(25)	¯0.060	¯0.113	¯0.244
292.1652-292.1654	7	¯303.221(69)(74)	0.149	0.194	432.518(30)(40)	¯0.069	¯0.122	¯0.472
MEAN VALUE		¯303.370(108)(124)			432.587(75)(82)			¯0.062

◊ 20. LITTLE HOPE STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1848-253.1853	2	13822.875(7)(17)	¯0.072	0.000	30157.320(0)(10)	0.009	0.000	1.000
253.2004-253.2009	3	13822.870(0)(20)	¯0.077	¯0.005	30157.327(6)(15)	0.016	0.007	1.000
292.1520-292.1526	8	13823.032(5)(17)	0.086	0.157	30157.309(9)(17)	¯0.002	¯0.011	0.371
292.1641-292.1646	7	13823.010(4)(16)	0.063	0.135	30157.287(4)(15)	¯0.023	¯0.033	0.136
MEAN VALUE		13822.947(86)(88)			30157.311(17)(23)			0.627

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1848-253.1853	2	13822.890(14)(24)	¯0.059	0.000	30157.330(0)(20)	0.004	0.000	1.000
253.2004-253.2009	3	13822.887(6)(21)	¯0.062	¯0.003	30157.340(0)(20)	0.014	0.010	0.000
292.1520-292.1526	8	13823.019(6)(18)	0.070	0.129	30157.327(4)(17)	0.001	¯0.003	0.064
292.1641-292.1646	7	13823.000(3)(16)	0.051	0.110	30157.308(6)(19)	¯0.018	¯0.022	0.513
MEAN VALUE		13822.949(70)(73)			30157.326(13)(23)			0.526

HELICOPTER SITE LITTLE HOPE

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1848-253.1853	11	13455.486(32)(32)	¯0.068	0.000	30601.355(8)(8)	0.068	0.000	0.203
253.2004-253.2009	12	13455.499(10)(10)	¯0.055	0.013	30601.356(29)(29)	0.070	0.001	¯0.496
292.1520-292.1526	14	13455.616(28)(34)	0.062	0.130	30601.228(12)(22)	¯0.058	¯0.126	0.245
292.1641-292.1646	13	13455.614(12)(24)	0.060	0.128	30601.206(40)(45)	¯0.080	¯0.148	0.623
MEAN VALUE		13455.554(71)(76)			30601.286(80)(85)			0.144

DIFFERENCE LITTLE HOPE - MONITOR (SERIAL NL. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
253.1848-253.1853	11	¯367.389(30)(34)	0.003	0.000	444.035(8)(13)	0.060	0.000	0.231
253.2004-253.2009	12	¯367.370(10)(19)	0.022	0.019	444.029(30)(32)	0.054	¯0.006	¯0.482
292.1520-292.1526	14	¯367.415(24)(33)	¯0.023	¯0.026	443.919(10)(24)	¯0.056	¯0.116	0.454
292.1641-292.1646	13	¯367.395(12)(27)	¯0.003	¯0.006	443.918(40)(46)	¯0.057	¯0.117	0.634
MEAN VALUE		¯367.389(19)(34)			444.035(65)(73)			0.209

DIFFERENCF LITTLE HOPE - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
253.1848-253.1853	11	¯367.404(29)(34)	¯0.009	0.000	444.028(8)(18)	0.067	0.000	0.143
253.2004-253.2009	12	¯367.387(12)(20)	0.007	0.017	444.016(28)(32)	0.056	¯0.011	¯0.468
292.1520-292.1526	14	¯367.402(25)(35)	¯0.007	0.002	443.901(11)(25)	¯0.059	¯0.126	0.371
292.1641-292.1646	13	¯367.386(12)(27)	0.009	0.019	443.897(39)(46)	¯0.064	¯0.131	0.637
MEAN VALUE		¯367.395(10)(31)			443.961(71)(78)			0.171

◊ 21. GULL ROCK STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1907-253.1912	3	13822.867(6)(21)	¯0.070	0.000	30157.317(12)(23)	0.005	0.000	0.333
253.1948-253.1954	3	13822.867(6)(18)	¯0.070	0.000	30157.333(6)(18)	0.022	0.017	0.333
292.1540-292.1546	8	13823.019(9)(17)	0.082	0.152	30157.301(4)(15)	¯0.010	¯0.015	¯0.132
292.1625-292.1631	8	13822.995(6)(15)	0.059	0.129	30157.295(5)(15)	¯0.016	¯0.021	0.513
MEAN VALUE		13822.937(82)(84)			30157.312(17)(25)			0.262

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1907-253.1912	3	13822.877(6)(21)	¯0.062	0.000	30157.320(10)(22)	¯0.002	0.000	0.000
253.1948-253.1954	3	13822.883(6)(15)	¯0.055	0.007	30157.333(6)(21)	0.011	0.013	0.667
292.1540-292.1546	8	13823.007(9)(18)	0.069	0.131	30157.320(6)(18)	¯0.002	0.000	0.437
292.1625-292.1631	8	13822.986(8)(18)	0.048	0.110	30157.314(6)(19)	¯0.007	¯0.006	0.746
MEAN VALUE		13822.938(68)(70)			30157.322(8)(22)			0.617

HELICOPTER SITE GULL ROCK

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1907-253.1912	13	13352.751(13)(13)	¯0.050	0.000	30698.725(18)(18)	0.067	0.000	¯0.498
253.1948-253.1954	13	13352.761(9)(9)	¯0.040	0.010	30698.734(18)(18)	0.076	0.009	0.030
292.1540-292.1546	15	13352.856(20)(27)	0.055	0.105	30698.589(11)(26)	¯0.069	¯0.136	¯0.077
292.1625-292.1631	14	13352.837(14)(21)	0.036	0.087	30698.583(15)(23)	¯0.075	¯0.142	0.756
MEAN VALUE		13352.801(53)(57)			30698.658(83)(86)			0.053

DIFFERENCE GULL ROCK - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
253.1907-253.1912	13	¯470.116(14)(22)	0.019	0.000	541.410(13)(20)	0.064	0.000	¯0.452
253.1948-253.1954	13	¯470.106(10)(17)	0.029	0.010	541.400(21)(25)	0.053	¯0.011	0.185
292.1540-292.1546	15	¯470.162(20)(29)	¯0.026	¯0.046	541.288(11)(28)	¯0.058	¯0.122	¯0.067
292.1625-292.1631	14	¯470.158(12)(23)	¯0.022	¯0.042	541.288(16)(27)	¯0.059	¯0.122	0.784
MEAN VALUE		¯470.116(28)(37)			541.410(68)(72)			0.112

DIFFERENCE GULL ROCK - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
253.1907-253.1912	13	¯470.127(15)(21)	0.010	0.000	541.407(14)(22)	0.072	0.000	¯0.456
253.1948-253.1954	13	¯470.122(10)(16)	0.015	0.004	541.398(23)(28)	0.062	¯0.010	0.114
292.1540-292.1546	15	¯470.150(19)(29)	¯0.013	¯0.024	541.270(10)(29)	¯0.066	¯0.138	¯0.203
292.1625-292.1631	14	¯470.148(12)(24)	¯0.011	¯0.022	541.268(16)(28)	¯0.067	¯0.139	0.831
MEAN VALUE		¯470.137(15)(27)			541.336(77)(82)			0.072

◊ 22. JIG ROCK B. STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1920-253.1922	1	13822.860(0)(20)	¯0.074	0.000	30157.330(0)(10)	0.018	0.000	0.000
253.1940-253.1942	1	13822.870(0)(20)	¯0.064	0.010	30157.320(0)(10)	0.008	¯0.010	0.000
292.1553-292.1556	4	13823.012(14)(22)	0.077	0.152	30157.291(17)(22)	¯0.020	¯0.039	0.685
292.1615-292.1618	4	13822.996(5)(16)	0.061	0.136	30157.305(6)(15)	¯0.006	¯0.025	0.590
MEAN VALUE		13822.934(80)(83)			30157.312(17)(23)			0.638

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1920-253.1922	1	13822.880(0)(20)	¯0.056	0.000	30157.340(0)(20)	0.017	0.000	0.000
253.1940-253.1942	1	13822.880(0)(20)	¯0.056	0.000	30157.320(0)(20)	¯0.003	¯0.020	0.000
292.1553-292.1556	4	13822.998(13)(20)	0.062	0.118	30157.309(13)(20)	¯0.014	¯0.031	0.745
292.1615-292.1618	4	13822.985(4)(15)	0.049	0.105	30157.324(3)(16)	0.001	¯0.016	0.377
MEAN VALUE		13822.936(64)(67)			30157.323(13)(23)			0.561

HELICOPTER SITE JIG ROCK B.

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1920-253.1922	7	13308.840(41)(41)	¯0.134	0.000	30752.491(30)(30)	0.106	0.000	¯0.590
253.1940-253.1942	6	13308.822(17)(17)	¯0.153	¯0.018	30752.467(14)(14)	0.081	¯0.025	0.236
292.1553-292.1556	7	13309.070(48)(53)	0.096	0.230	30752.311(49)(54)	¯0.074	¯0.180	¯0.841
292.1615-292.1618	7	13309.166(49)(54)	0.191	0.326	30752.273(12)(24)	¯0.112	¯0.218	¯0.339
MEAN VALUE		13308.974(171)(176)			30752.386(109)(115)			¯0.383

DIFFERENCE JIG ROCK B. - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
253.1920-253.1922	7	¯514.023(44)(46)	¯0.063	0.000	595.161(30)(32)	0.088	0.000	¯0.598
253.1940-253.1942	6	¯514.048(17)(23)	¯0.088	¯0.025	595.143(12)(16)	0.069	¯0.019	0.201
292.1553-292.1556	7	¯513.941(58)(64)	0.019	0.082	595.021(39)(47)	¯0.052	¯0.140	¯0.733
292.1615-292.1618	7	¯513.830(50)(55)	0.131	0.194	594.969(13)(27)	¯0.105	¯0.193	¯0.324
MEAN VALUE		¯514.023(99)(110)			595.161(94)(99)			¯0.364

DIFFERENCE JIG ROCK B. - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
253.1920-253.1922	7	¯514.043(44)(47)	¯0.081	0.000	595.155(33)(37)	0.094	0.000	¯0.638
253.1940-253.1942	6	¯514.060(18)(24)	¯0.097	¯0.017	595.139(11)(19)	0.078	¯0.015	0.043
292.1553-292.1556	7	¯513.928(56)(62)	0.035	0.115	595.001(41)(49)	¯0.060	¯0.153	¯0.780
292.1615-292.1618	7	¯513.819(52)(57)	0.143	0.224	594.948(11)(27)	¯0.112	¯0.206	¯0.073
MEAN VALUE		¯513.963(112)(123)			595.061(102)(108)			¯0.362

◊ 23. BUDGT RK.B. STATISTICS ◊

MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1928-253.1930	2	13822.865(7)(12)	¯0.069	0.000	30157.340(0)(10)	0.012	0.000	1.000
253.1933-253.1936	1	13822.870(0)(20)	¯0.064	0.005	30157.340(0)(20)	0.012	0.000	0.000
292.1602-292.1605	4	13823.008(3)(14)	0.075	0.143	30157.319(8)(16)	¯0.009	¯0.021	¯0.603
292.1607-292.1610	4	13822.991(3)(14)	0.058	0.126	30157.313(6)(15)	¯0.015	¯0.027	¯0.415
MEAN VALUE		13822.934(77)(78)			30157.328(14)(21)			¯0.006

MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1928-253.1930	2	13822.880(0)(20)	¯0.054	0.000	30157.340(0)(20)	0.002	0.000	1.000
253.1933-253.1936	1	13822.880(0)(30)	¯0.054	0.000	30157.340(0)(20)	0.002	0.000	0.000
292.1602-292.1605	4	13822.995(4)(16)	0.061	0.115	30157.339(7)(18)	0.000	¯0.001	¯0.372
292.1607-292.1610	4	13822.981(5)(17)	0.047	0.101	30157.335(9)(17)	¯0.004	¯0.005	¯0.616
MEAN VALUE		13822.934(63)(66)			30157.338(2)(19)			0.004

HELICOPTER SITE BUDGT RK.B.

TIME SPAN	NUM	MEAN TDA (SD1)(SD2)	DEL1	DEL2	MEAN TDB (SD1)(SD2)	DEL1	DEL2	RHO
253.1928-253.1930	6	13262.883(15)(15)	¯0.129	0.000	30770.567(8)(8)	0.122	0.000	¯0.588
253.1933-253.1936	7	13262.919(19)(19)	¯0.094	0.035	30770.563(24)(24)	0.118	¯0.004	0.659
292.1602-292.1605	8	13263.113(50)(55)	0.101	0.230	30770.334(20)(30)	¯0.111	¯0.233	¯0.325
292.1607-292.1610	7	13263.134(59)(64)	0.121	0.250	30770.315(25)(34)	¯0.130	¯0.252	¯0.158
MEAN VALUE		13263.012(130)(137)			30770.445(139)(141)			¯0.103

DIFFERENCE BUDGT RK.B. - MONITOR (SERIAL NO. 2220)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
253.1928-253.1930	6	¯559.981(18)(20)	¯0.061	0.000	613.227(8)(12)	0.110	0.000	¯0.614
253.1933-253.1936	7	¯559.948(21)(27)	¯0.028	0.032	613.223(24)(27)	0.106	¯0.004	0.710
292.1602-292.1605	8	¯559.893(50)(55)	0.027	0.087	613.017(24)(35)	¯0.100	¯0.210	¯0.562
292.1607-292.1610	7	¯559.857(58)(64)	0.063	0.124	613.001(24)(35)	¯0.116	¯0.225	0.017
MEAN VALUE		¯559.981(55)(71)			613.227(125)(128)			¯0.112

DIFFERENCE BUDGT RK.B. - MONITOR (SERIAL NO. 1017)

TIME SPAN	NUM	DIFF TDA(SD1)(SD2)	DEL1	DEL2	DIFF TDB(SD1)(SD2)	DEL1	DEL2	RHO
253.1928-253.1930	6	¯559.996(15)(23)	¯0.076	0.000	613.227(8)(19)	0.121	0.000	¯0.584
253.1933-253.1936	7	¯559.958(21)(30)	¯0.038	0.038	613.220(20)(26)	0.114	¯0.007	0.706
292.1602-292.1605	8	¯559.881(49)(55)	0.040	0.115	612.997(24)(36)	¯0.109	¯0.230	¯0.490
292.1607-292.1610	7	¯559.847(56)(62)	0.074	0.150	612.980(23)(35)	¯0.126	¯0.247	0.138
MEAN VALUE		¯559.921(69)(83)			613.106(136)(139)			¯0.058

APPENDIX IV

COMPUTER PROGRAM LISTINGS

The software used to generate the results in this report is listed in this appendix. This software is described in sections 2.1, 4.4, and 5.2 of the report. This appendix is in three sections:

IV.1 Data handling software

IV.2 Workspace PLOTCCG - functions for data plotting

IV.3 Workspace CCGSTAT - functions for statistical computations

APPENDIX IV.1

Data Handling Software

```
LIS 1:500
//COPYCCG  JOB '6691,RAF0',WELLS,MSGCLASS=A
/*PASSWORD XTMNCMEY
/*SETUP    DISK=SEGEOF
/*SETUP    TAPE=NLTAPE   SLOT=3745   RING=NO
/*JOBPARM  S=29,R=1024,L=9
//COPY     EXEC  FORTVCG
//FORT.SYSIN DD  *
C
C  PROGRAM TO READ DATA FROM CCG (CANADIAN COAST GUARD) RAW
C   LORAN-C DATA FILES AND REFORMAT IT INTO A STANDARD FORMAT
C   FOR BOTH MONITOR AND REMOTE SITES.  THE DATA IS STORED
C   ON DISK FILE 9 FOR FUTURE USE.
C
C  AUTHOR   :  B.G.NICKERSON
C
C  DATE     :  NOV. 9, 1982
C
C  INPUT    :  FILE OF RAW DATA ON UNIT NO. 8
C              SWITCH SPECIFYING MONITOR (1) OR REMOTE (2) DATA
C              FLAG 'IFIRST' INDICATING WHETHER THIS IS THE FIRST TIME
C                THE OUTPUT FILE(9) HAS BEEN WRITTEN TO. IF IFIRST = 1,
C                THIS INDICATES THIS IS THE FIRST TIME. SEE ROUTINES
C                'MSITE' AND 'RSITE' FOR MORE DETAILS.
C              DATA FORMAT FLAG 'ITYPE'. ITYPE=1 FOR DATA BEFORE DAY 250,
C                1982; ITYPE=2 FOR DATA AFTER DAY 250, 1982.
C              YEAR AND DAY OF START OF DATA IF NO HEADER RECORD
C                PRECEEDS DATA RECORDS.
C              CARDS DEFINING SITE NAMES, AVERAGE TD'S AND SITE
C                COORDINATES (SEE 'MSITE' AND 'RSITE' FORMATS 990
C                AND 950 RESPECTIVELY)
C
C  OUTPUT   :  FILE OF REFORMATTED DATA ON UNIT 9
C
C  LANGUAGE:  FORTRAN 77 (FORTVCLG ON THE IBM)
C
C  EXTERNALS: MSITE,RSITE,GDATE
C
C
      CHARACTER*80 TITLE
      LOGICAL*1 DATE(18)
      DIMENSION LOFILS(10)
      DATA LOFILS/10,11,12,13,14,15,16,17,18,19/
      CALL GDATE(DATE)
C
C  DEFINE INITIAL VARIABLES
C
      LIN=5
      LOUT=6
      LIFIL=8
      LOFIL=9
```

```
LIS 501:1000
      MAXSIT=10
C
C  READ IN TITLE AND SWITCHES
C
      READ(LIN,1000)TITLE,ISWTCH,IFIRST,ITYPE,IYEAR,IDAY
1000  FORMAT(A80,/,3I2,I5,I4)
      WRITE(LOUT,1010)TITLE,DATE,ISWTCH,IFIRST,ITYPE,IYEAR,IDAY
1010  FORMAT('1',A80,1X,18A1/'0','SITE SWITCH=',I2/' FIRST FILE FLAG=',
     1  I2/' DATA FORMAT=',I2/' START YEAR OF DATA=',I5/,
     2  ' START DAY OF DATA=',I4)
      IF(ISWTCH.EQ.2)GO TO 300
C
C  MONITOR SITE DATA
C
      CALL MSITE(LIN,LOUT,LIFIL,LOFIL,IFIRST,ITYPE,IYEAR,IDAY)
      GO TO 500
C
C  REMOTE SITE DATA
C
300   CALL RSITE(LIN,LOUT,LIFIL,LOFILS,IFIRST,MAXSIT,ITYPE)
500   STOP
      END
      SUBROUTINE MSITE(LIN,LOUT,LIFIL,LOFIL,LFIRST,LTYPE,LYEAR,LDAY)
C
C  PURPOSE   :  TO READ RAW DATA FILES OF CANADIAN COAST GUARD
C               LORAN-C DATA RECORDED AT THE MONITOR SITE, REFORMAT
C               THEM, AND RECORD THEM ON A DIFFERENT FILE.
C
C  LANGUAGE  :  FORTRAN 77 (FORTVCLG ON THE IBM)
C
C  AUTHOR    :  B.G.NICKERSON
C
C  DATE      :  NOV. 10, 1982
C
C  VARIABLE  I/O  TYPE     COMMENTS
C  --------  ---  ----     --------
C   LIN       I   I*4      INPUT UNIT NUMBER FOR HEADER DATA
C   LOUT      I   I*4      UNIT NUMBER FOR OUTPUT MESSAGES AND SUMMARY
C   LIFIL     I   I*4      INPUT FILE NO. FOR RAW DATA
C   LOFIL     I   I*4      OUTPUT FILE NO. FOR REFORMATTED DATA
C   LFIRST    I   I*4      FLAG TO INDICATE WHETHER THIS IS THE
C                            FIRST TIME FILE 'LOFIL' HAS BEEN WRITTEN
C                            TO. IF LFIRST = 1, THEN THIS IS THE FIRST
C                            TIME, AND READ THE MONITOR SITE NAME,
C                            AVERAGE TD'S, AND COORDINATES, AND STORE
C                            THEM ON THE FIRST RECORD OF FILE 'LOFIL'.
C   LTYPE     I   I*4      FLAG FOR TYPE OF INPUT DATA.
C                            ITYPE=1 SPECIFIES NO INDENTATION FOR DATA
C                            ITYPE=2 SPECIFIES INDENT 2 SPACES FOR DATA
C   LYEAR     I   I*4      STARTING YEAR OF DATA IF NO HEADER RECORD
```

```
LIS 1001:1500
C                               PRECEEDS DATA RECORDS.
C    LDAY      I    I*4       STARTING DAY OF DATA IF NO HEADER RECORD
C                               PRECEEDS DATA RECORDS.
C
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*2(I-J)
      CHARACTER*1 JUNK
      CHARACTER*80 CARD
      CHARACTER*25 NAME
C
C  IF FIRST TIME FOR THIS SITE, READ AND RECORD HEADER RECORD
C  ----------------------------------------------------------
C
      READ(LIN,990)NAME,TDA,TDB,LATD,LATM,SECLAT,LONGD,LONGM,SECLON
990   FORMAT(A25,2F9.2,2X,2I3,F8.4,I4,I3,F8.4)
      IF(LFIRST.NE.1)GO TO 5
      WRITE(LOFIL)NAME,TDA,TDB
      WRITE(LOFIL)LATD,LATM,SECLAT,LONGD,LONGM,SECLON
      WRITE(LOUT,995)
995   FORMAT('0HEADER RECORD WRITTEN AS FIRST TWO RECORDS')
C
C  PRINT TITLE AND INITIALIZE VARIABLES
C  ------------------------------------
C
5     WRITE(LOUT,1000)NAME,TDA,TDB,LATD,LATM,SECLAT,LONGD,LONGM,SECLON
1000  FORMAT('0',A25,' SITE DATA REFORMAT. AVERAGE TDA=',F9.2,
     1  ' AVERAGE TDB=',F9.2/47X,'POSITION=',2I3,F8.4,' NORTH,',
     2  I4,I3,F8.4,' EAST')
      STDA=0.D0
      STDB=0.D0
      STDC=0.D0
      STDD=0.D0
      IYEAR=0
      EPS=0.005D0
      BLUNDR=100.D0
      TMAX=0.D0
      TMIN=999.D0
      KOUNT=0
      KOUNTR=0
C**WARNING  MUST BE TAKEN OUT AFTER PROCESSING FILE 11. DAD 25 JAN
C     DO 1  I=1,4602
C  1  READ(LIFIL,2,END=100) JUNK
C  2  FORMAT(A1)
C
C  READ ONE RECORD OF THE RAW DATA FILE
C  ------------------------------------
C
10    READ(LIFIL,1010,END=100)CARD
1010  FORMAT(A80)
C
C  INITIAL TIME RECORD
C  -------------------
C
      IF(CARD(1:4).EQ.'   TI')THEN
        IF(CARD(14:15).EQ.'NA')GO TO 10
```

```
LIS 1501:2000
C
C  CHECK FOR CHANGED DATA TYPE WITHIN DATA INPUT FILE
C
          IF(CARD(7:11).EQ.'(GMT)')LTYPE=2
          IF(CARD(10:10).EQ.':'.AND.CARD(13:13).EQ.':')LTYPE=1
C
          IF(LTYPE.EQ.1)READ(CARD,1020)IHR,IMIN,ISEC,IDAY,IYEAR
          IF(LTYPE.EQ.2)READ(CARD,1021)IHR,IMIN,ISEC,IDAY,IYEAR
     1020 FORMAT(7X,I2,1X,I2,1X,I2,14X,I3,13X,I4)
     1021 FORMAT(12X,I2,1X,I2,1X,I2,12X,I3,11X,I4)
          KOUNTR=0
C
C  BASE TD DEFINITION RECORD
C  -------------------------
C
        ELSE IF((CARD(1:4).EQ.' TD-'.AND.CARD(17:19).EQ.'TD-'.
       1       AND.CARD(37:39).EQ.'TD-'. AND .LTYPE.EQ.1) .OR.
       1  (CARD(1:4).EQ.'  TD'.AND.LTYPE.EQ.2))THEN
C
C  CHECK FOR TYPE OF DATA
C
          IF(LTYPE.EQ.1)THEN
            READ(CARD,1030)TDA,TDB,TDC,TDD
     1030   FORMAT(6X,F8.2,7X,F8.2,12X,F8.2,7X,F8.2)
          ELSE IF(LTYPE.EQ.2)THEN
            READ(CARD,1031)TDA,TDB
     1031   FORMAT(6X,F8.2,5X,F8.2)
            READ(LIFIL,1031)TDC,TDD
          END IF
C
C  CHECK FOR CHANGED BASE TD VALUES
C
          DDA=DABS(TDA-STDA)
          DDB=DABS(TDB-STDB)
          DDC=DABS(TDC-STDC)
          DDD=DABS(TDD-STDD)
          IF(DDA.GT.EPS.OR.DDB.GT.EPS.OR.DDC.GT.EPS.OR.DDD.GT.EPS)WRITE(
       1    LOUT,1040)TDA,TDB,TDC,TDD,IHR,IMIN,ISEC,IDAY,IYEAR
     1040 FORMAT('0CHANGE IN BASE TD''S, TDA=',F9.2,' TDB=',F9.2,
       1    ' TDC=',F9.2,' TDD=',F9.2,' TIME=',I3,':',I2,':',I2,
       2    ' DAY',I4,',',I5)
          STDA=TDA
          STDB=TDB
          STDC=TDC
          STDD=TDD
C
C  DATA RECORD
C  -----------
C
        ELSE IF((LTYPE.EQ.1.AND.CARD(3:3).EQ.':'.AND.CARD(6:6).EQ.':')
       1  .OR.(LTYPE.EQ.2.AND.CARD(5:5).EQ.':'.AND.CARD(8:8).EQ.':'))THEN
```

```
LIS 2001:2500
C
C   CHECK FOR GARBAGE CHARACTERS (E,G, '*')
C
            DO 20 I=1,80
              K=13+(LTYPE-1)*2
              IF(((I,GT,(K-13),AND,I,LT,(K-10)),OR,
     1       (I,GT,(K-10),AND,I,LT,(K-7)),OR, (I,GT,(K-7),AND,I,LT,(K-4)),OR
     2       , (I,GT,K,AND,I,LT,(K+10)),OR,(I,GT,(K+14),AND,I,LT,(K+24)),OR,
     3        (I,GT,(K+28),AND,I,LT,(K+38)),OR,(I,GT,(K+42),AND,I,LT,(K+52)))
     4       ,AND,(CARD(I:I),NE,'-'),AND,(CARD(I:I),NE,' '),AND,
     5           (CARD(I:I),LT,'0',OR,CARD(I:I),GT,'9'))GO TO 10
 20         CONTINUE
C
C   READ DATA AND CONVERT TO ACTUAL TD'S
C
            IF(LTYPE,EQ,1)READ(CARD,1050,ERR=10)IHR,IMIN,ISEC,IDA,ISDA,
     1        IDB,ISDB,IDC,ISDC,IDD,ISDD
            IF(LTYPE,EQ,2)READ(CARD,1051,ERR=10)IHR,IMIN,ISEC,IDA,ISDA,
     1        IDB,ISDB,IDC,ISDC,IDD,ISDD
 1050       FORMAT(I2,1X,I2,1X,I2,4(5X,I5,I4))
 1051       FORMAT(2X,I2,1X,I2,1X,I2,4(5X,I5,I4))
C
C   CHECK FOR START OF FILE WITH NO HEADER RECORD YET ENCOUNTERED
C
            IF(IYEAR,GT,0)GO TO 28
            IF(LFIRST,EQ,1)GO TO 10
            IYEAR=LYEAR
            IDAY=LDAY
C
C   CHECK FOR DATA SPAN OVER MIDNIGHT
C
 28         IF(IHR,GT,0,OR,KOUNTR,EQ,0,OR,JHR,EQ,IHR)GO TO 30
            IDAY=IDAY+1
 30         CONTINUE
C
C   COMPUTE ACTUAL TD'S, CONVERT STANDARD DEVIATIONS TO NANOSECONDS
C
            IF(LTYPE,EQ,1)THEN
              DA=TDA+IDA/100,D0
              DB=TDB+IDB/100,D0
              DC=TDC+IDC/100,D0
              DD=TDD+IDD/100,D0
              ISDA=ISDA*10
              ISDB=ISDB*10
              ISDC=ISDC*10
              ISDD=ISDD*10
            ELSE IF(LTYPE,EQ,2)THEN
              DA=TDA+IDA/1000,D0
              DB=TDB+IDB/1000,D0
              DC=TDC+IDC/1000,D0
              DD=TDD+IDD/1000,D0
            END IF
```

```
LIS 2501:3000
C
C  DO A BLUNDER CHECK
C
          DDA=DABS(DA-STDA)
          DDB=DABS(DB-STDB)
          DDC=DABS(DC-STDC)
          DDD=DABS(DD-STDD)
          IF(DDA.GT.BLUNDR.OR.DDB.GT.BLUNDR.OR.DDC.GT.BLUNDR.OR.
     1      DDD.GT.BLUNDR)GO TO 10
C
C  CONVERT TO DAYS, AND RECORD MAX. AND MIN. TIMES
C
          T=IDAY+(IHR+((IMIN+(ISEC/60.D0))/60.D0))/24.D0
          IF(T.GT.TMAX)TMAX=T
          IF(T.LT.TMIN)TMIN=T
C
C  WRITE THE RECORD TO DISK
C
          WRITE(LOFIL)IYEAR,IDAY,IHR,IMIN,ISEC,DA,ISDA,DB,ISDB,
     1      DC,ISDC,DD,ISDD
C         WRITE(LOUT,1055)IYEAR,IDAY,IHR,IMIN,ISEC,DA,ISDA,DB,ISDB,
C    1      DC,ISDC,DD,ISDD
 1055     FORMAT(' ',I4,I4,I3,':',I2,':',I2,4(3X,F10.3,I4))
          KOUNT=KOUNT+1
          KOUNTR=KOUNTR+1
          JHR=IHR
        END IF
        GO TO 10
C
C  PRINT SUMMARY
C  -------------
C
C
C  CALCULATE MAX., MIN, AND SPAN TIMES
C
100     IDAY=TMIN
        IHR=(TMIN-IDAY)*24.D0
        IMIN=(((TMIN-IDAY)*24.D0)-IHR)*60.D0
        JDAY=TMAX
        JHR=(TMAX-JDAY)*24.D0
        JMIN=(((TMAX-JDAY)*24.D0)-JHR)*60.D0
        T=TMAX-TMIN
        IDS=T
        IHS=(T-IDS)*24.D0
        IMS=(((T-IDS)*24.D0)-IHS)*60.D0
C
C  PRINT IT
C
        WRITE(LOUT,1060)KOUNT,IDAY,IHR,IMIN,JDAY,JHR,JMIN,IDS,IHS,IMS
1060    FORMAT(' TOTAL RECORDS COPIED =',I6/
```

```
LIS 3001:3500
     1  ' FROM DAY',I4,',',I3,':',I2,' TO DAY',I4,',',I3,':',I2/
     2  ' SPAN=',I4,' DAYS',I3,' HOURS',I3,' MINUTES')
      RETURN
      END
      SUBROUTINE RSITE(LIN,LOUT,LIFIL,LOFILS,LFIRST,MAXSIT,LTYPE)
C
C  PURPOSE   :  TO READ RAW DATA FILES OF CANADIAN COAST GUARD
C               LORAN-C DATA RECORDED AT REMOTE SITES, REFORMAT
C               THEM, AND RECORD THEM ON A SEPARATE FILES, ONE
C               FILE PER REMOTE SITE.
C
C  LANGUAGE  :  FORTRAN 77 (FORTVCLG ON THE IBM)
C
C  AUTHOR    :  B.G.NICKERSON
C
C  DATE      :  NOV. 13, 1982
C
C  EXTERNALS :  DABS,MOD
C
C  NOTES     :  MAX. OF 25 REMOTE SITES ALLOWED (SEE VAR. 'MAXR')
C
C  VARIABLE  I/O  TYPE     COMMENTS
C  --------  ---  ----     --------
C   LIN       I   I*4      INPUT UNIT NUMBER FOR HEADER DATA
C   LOUT      I   I*4      UNIT NUMBER FOR OUTPUT MESSAGES AND SUMMARY
C   LIFIL     I   I*4      INPUT FILE NO. FOR RAW DATA
C   LOFILS    I   I*4(MAXSIT)  VECTOR OF FILE NUMBERS WHERE THE OUTPUT
C                               DATA IS TO BE RECORDED FOR EACH SITE
C   LFIRST    I   I*4      FLAG TO INDICATE WHETHER THIS IS THE
C                            FIRST TIME FILES 'LOFILS' HAVE BEEN WRITTEN
C                            TO. IF LFIRST = 1, THEN THIS IS THE FIRST
C                            TIME, AND READ THE REMOTE SITE NAME,
C                            AVERAGE TD'S, AND COORDINATES, AND STORE
C                            THEM ON THE FIRST RECORD OF THE OUTPUT FILE.
C   MAXSIT    I   I*4      MAXIMUM NUMBER OF REMOTE SITES.
C   LTYPE     I   I*4      FLAG FOR TYPE OF INPUT DATA
C                            ITYPE=1 MEANS NO INDENTATION FOR DATA
C                            ITYPE=2 MEANS INDENT 3 SPACES FOR DATA
C
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*2(I-J)
      CHARACTER*80 CARD
      CHARACTER*25 NAME,NAMES(25)
      DIMENSION IDAYS(12),LOFILS(MAXSIT),TDAS(25),TDBS(25)
      DATA IDAYS/0,31,59,90,120,151,181,212,243,273,304,334/
C
C  CHECK ON DIMENSIONING LIMITS
C
      MAXR=25
      IF(MAXSIT.LE.MAXR)GO TO 1
```

```
LIS 3501:4000
      WRITE(LOUT,930)MAXSIT,MAXR
930   FORMAT('0**FATAL ERROR (RSITE), MAXSIT SPECIFIED AS',I4,
     1  ' IS LARGER THAN MAXR=',I4)
      STOP 100
C
C  READ THE REMOTE SITE DEFINITION CARDS
C  -------------------------------------
C
1     NSITE=0
2     READ(LIN,950,END=5)NAME,TDA,TDB,LATD,LATM,SECLAT,LONGD,LONGM,
     1  SECLON
950   FORMAT(A25,2F9.2,2X,2I3,F8.4,I4,I3,F8.4)
      NSITE=NSITE+1
      IF(NSITE.LE.MAXSIT.AND.NSITE.LE.MAXR)GO TO 3
      WRITE(LOUT,940)NSITE,MAXSIT,MAXR
940   FORMAT('0**FATAL ERROR (RSITE), NO. OF SITES READ=',I4,
     1  ' LARGER THAN MAXSIT=',I4,' OR MAXR=',I4)
      STOP 100
3     NAMES(NSITE)=NAME
      TDAS(NSITE)=TDA
      TDBS(NSITE)=TDB
C
C  IF THE FIRST TIME, WRITE THIS AS THE HEADER RECORD IN THE APPROPRIATE
C    DATA FILE.
C
      IF(LFIRST.NE.1)GO TO 2
      WRITE(LOFILS(NSITE))NAME
      WRITE(LOFILS(NSITE))TDA,TDB,LATD,LATM
      WRITE(LOFILS(NSITE))SECLAT,LONGD,LONGM,SECLON
      GO TO 2
C
C  PRINT TITLE AND INITIALIZE VARIABLES
C  ------------------------------------
C
5     WRITE(LOUT,1000)
1000  FORMAT('0REMOTE SITES DATA REFORMAT')
      STDA=0.D0
      STDB=0.D0
      EPS=2.D0
      BLUNDR=100.D0
      KOUNTS=0
      KOUNTR=0
      ISTOP=0
      NOTFND=0
      ISDA=0
      ISDB=0
C
C  READ ONE RECORD OF THE RAW DATA FILE
C  ------------------------------------
C
```

```
LIS 4001:4500
10    READ(LIFIL,1010,END=100)CARD
1010  FORMAT(A80)
C
C  INITIAL TD RECORD
C  -----------------
C
      IF(CARD(1:4).EQ.'  TD')THEN
        READ(CARD,1020)TDA,TDB
1020    FORMAT(7X,F8.2,12X,F8.2)
C
C  CHECK FOR CHANGED TD'S, INDICATING A NEW SITE
C
        DDA=DABS(TDA-STDA)
        DDB=DABS(TDB-STDB)
        IF(DDA.GT.EPS.OR.DDB.GT.EPS)THEN
C
C  SEARCH FOR THE SITE IN THE LIST OF SITE DEFINITIONS
C
          DO 15 I=1,MAXSIT
            DDA=DABS(TDA-TDAS(I))
            DDB=DABS(TDB-TDBS(I))
            IF(DDA.LE.EPS.AND.DDB.LE.EPS)GO TO 17
15        CONTINUE
C
C  SITE NOT FOUND
C
          WRITE(LOUT,1025)TDA,TDB
1025      FORMAT('0**WARNING (RSITE), REMOTE SITE WITH TDA=',F9.2,
     1      ' TDB=',F9.2,' CANNOT BE FOUND. DATA SKIPPED.')
          NOTFND=1
          GO TO 10
C
C  SITE FOUND. PRINT SUMMARY FROM THE PREVIOUS SITE.
C
17        CONTINUE
          NOTFND=0
          NSITE=I
          IF(KOUNTS.EQ.0)GO TO 18
          IDAY=TMIN
          IHR=(TMIN-IDAY)*24.D0
          IMIN=(((TMIN-IDAY)*24.D0)-IHR)*60.D0
          JDAY=TMAX
          JHR=(TMAX-JDAY)*24.D0
          JMIN=(((TMAX-JDAY)*24.D0)-JHR)*60.D0
          T=TMAX-TMIN
          IDS=T
          IHS=(T-IDS)*24.D0
          IMS=(((T-IDS)*24.D0)-IHS)*60.D0
          WRITE(LOUT,1030)KOUNTR,IDAY,IHR,IMIN,JDAY,JHR,JMIN,
     1      IDS,IHS,IMS
```

```
LIS 4501:5000
1030      FORMAT(' TOTAL RECORDS COPIED=',I5,
     1      ' FROM DAY',I4,',',I3,':',I2,' TO DAY',I4,',',I3,':',I2/
     2      ' SPAN=',I4,' DAY(S)',I3,' HOUR(S)',I3,' MINUTE(S)')
          IF(ISTOP.EQ.1)RETURN
C
C  PRINT HEADER FOR NEXT SITE
C
18        WRITE(LOUT,1040)NSITE,NAMES(NSITE),TDA,TDB
1040      FORMAT('0SITE NO.',I3,', ',A25,' TDA=',F9.2,' TDB=',F9.2)
C
C
C  RESET RECORD COUNT, STORE NEW TDA, TDB
C
          KOUNTS=KOUNTS+1
          KOUNTR=0
          STDA=TDA
          STDB=TDB
          TMIN=999.D0
          TMAX=0.D0
        END IF
C
C  DATE RECORD
C  -----------
C
      ELSE IF(CARD(1:4).EQ.'DATE')THEN
        IF(NOTFND.EQ.1)GO TO 10
        READ(CARD,1045)IDAY,IMONTH,IYEAR
1045    FORMAT(6X,I2,2X,I2,2X,I4)
C
C  COMPUTE DAY OF YEAR
C
        ILEAP=0
        LYEAR=IYEAR
        IF(MOD(LYEAR,4).EQ.0)ILEAP=1
        IDAY=IDAYS(IMONTH)+IDAY
        IF(IMONTH.GT.2)IDAY=IDAY+ILEAP
        KOUNTQ=0
C
C  OBSERVATION RECORD
C  ------------------
C
      ELSE IF((CARD(1:5).EQ.'TIME='.AND.LTYPE.EQ.1).OR.
     1  (CARD(4:8).EQ.'TIME='.AND.LTYPE.EQ.2))THEN
        IF(NOTFND.EQ.1)GO TO 10
C
C  CHECK FOR GARBAGE CHARACTERS (E.G. '*')
C
        IF(LTYPE.EQ.2)GO TO 22
        DO 20 I=1,60
          IF(((I.GT.31.AND.I.LT.40).OR.(I.GT.51.AND.I.LT.60)).AND.
```

```
LIS 5001:5500
      1       (CARD(I:I).NE.','.AND.(CARD(I:I).NE.' ').AND.
      2       (CARD(I:I).LT.'0'.OR.CARD(I:I).GT.'9'))GO TO 10
 20         CONTINUE
            GO TO 27
 22         DO 25 I=1,80
              IF(((I.GT.43.AND.I.LT.53).OR.(I.GT.56.AND.I.LT.60).OR.
      1         (I.GT.63.AND.I.LT.73).OR.(I.GT.76.AND.I.LT.80)).AND.
      2         (CARD(I:I).NE.',').AND.(CARD(I:I).NE.' ').AND.
      3         (CARD(I:I).LT.'0').AND.(CARD(I:I).GT.'9'))GO TO 10
 25         CONTINUE
C
C  DECODE DATA
C
 27         CONTINUE
            IF(LTYPE.EQ.1)READ(CARD,1050)IHR,IMIN,ISEC,TDA,TDB
            IF(LTYPE.EQ.2)READ(CARD,1051)IHR,IMIN,ISEC,TDA,ISDA,TDB,ISDB
 1050       FORMAT(5X,I2,1X,I2,1X,I2,18X,F8.2,12X,F8.2)
 1051       FORMAT(8X,I2,1X,I2,1X,I2,27X,F9.3,4X,I3,4X,F9.3,4X,I3)
C
C  DO A BLUNDER CHECK
C
            DDA=DABS(TDA-STDA)
            DDB=DABS(TDB-STDB)
            IF(DDA.GT.BLUNDR.OR.DDB.GT.BLUNDR)GO TO 10
C
C  CHECK FOR DATA SPAN OVER MIDNIGHT
C
            IF(IHR.GT.0.OR.KOUNTQ.EQ.0.OR.JHR.EQ.IHR)GO TO 30
            IDAY=IDAY+1
 30         CONTINUE
C
C  COMPUTE DECIMAL TIME, AND RECORD MAXIMUM AND MINIMUM
C
            T=IDAY+(IHR+(IMIN+(ISEC/60.D0))/60.D0)/24.D0
            IF(T.GT.TMAX)TMAX=T
            IF(T.LT.TMIN)TMIN=T
            KOUNTR=KOUNTR+1
            KOUNTQ=KOUNTQ+1
            JHR=IHR
C
C  WRITE THE DATA TO DISK
C
            WRITE(LOFILS(NSITE))IYEAR,IDAY,IHR,IMIN,ISEC,TDA,ISDA,TDB,
      1       ISDB
C           WRITE(LOUT,1060)IYEAR,IDAY,IHR,IMIN,ISEC,TDA,ISDA,TDB,ISDB
  1060      FORMAT(' ',2I4,I3,':',I2,':',I2,' TDA=',F10.3,' ISDA=',I4,
      1       ' TDB=',F10.3,' ISDB=',I4)
          END IF
          GO TO 10
C
```

```
LIS 5501:6000
5510 C  END OF FILE
5520 C
5530 100    ISTOP=1
5540        GO TO 17
5550        END
5560 //GO.FT08F001  DD    VOL=SER=NLTAPE,UNIT=TAPE1600,DISP=(OLD,KEEP),
5570 //             LABEL=(14,NL,,IN),DCB=(RECFM=FB,BLKSIZE=3200,LRECL=80)
5580 //GO.FT09F001  DD    DSN=DEW.CCG.LORAN.KETCH.MONITOR,DISP=(MOD,KEEP),
5590 //             UNIT=M2314,VOL=SER=SEGEOP,SPACE=(TRK,(50,50),RLSE),
5600 //             DCB=(RECFM=VBS,BLKSIZE=7294,LRECL=54)
5610 //GO.FT10F001  DD    DSN=DEW.CCG.LORAN.LOWER.PROSPECT,DISP=(MOD,KEEP),
5620 //             UNIT=M2314,VOL=SER=SEGEOP,SPACE=(TRK,(10,10),RLSE),
5630 //             DCB=(RECFM=VBS,BLKSIZE=7276,LRECL=34)
5640 //GO.FT11F001  DD    DSN=DEW.CCG.LORAN.PEGGYS.COVE,DISP=(MOD,KEEP),
5650 //             UNIT=M2314,VOL=SER=SEGEOP,SPACE=(TRK,(10,10),RLSE),
5660 //             DCB=(RECFM=VBS,BLKSIZE=7276,LRECL=34)
5670 //GO.FT12F001  DD    DSN=DEW.CCG.LORAN.BLANDFRD,DISP=(MOD,KEEP),
5680 //             UNIT=M2314,VOL=SER=SEGEOP,SPACE=(TRK,(10,10),RLSE),
5690 //             DCB=(RECFM=VBS,BLKSIZE=7276,LRECL=34)
5700 //GO.FT13F001  DD    DSN=DEW.CCG.LORAN.BATTERY.POINT,DISP=(MOD,KEEP),
5710 //             UNIT=M2314,VOL=SER=SEGEOP,SPACE=(TRK,(10,10),RLSE),
5720 //             DCB=(RECFM=VBS,BLKSIZE=7276,LRECL=34)
5730 //GO.FT14F001  DD    DSN=DEW.CCG.LORAN.DUBLIN.SHORE,DISP=(MOD,KEEP),
5740 //             UNIT=M2314,VOL=SER=SEGEOP,SPACE=(TRK,(10,10),RLSE),
5750 //             DCB=(RECFM=VBS,BLKSIZE=7276,LRECL=34)
5760 //GO.FT15F001  DD    DSN=DEW.CCG.LORAN.MEDWAY.HEAD,DISP=(MOD,KEEP),
5770 //             UNIT=M2314,VOL=SER=SEGEOP,SPACE=(TRK,(10,10),RLSE),
5780 //             DCB=(RECFM=VBS,BLKSIZE=7276,LRECL=34)
5790 //GO.FT16F001  DD    DSN=DEW.CCG.LORAN.WHEAD.LIVRPOOL,DISP=(MOD,KEEP),
5800 //             UNIT=M2314,VOL=SER=SEGEOP,SPACE=(TRK,(10,10),RLSE),
5810 //             DCB=(RECFM=VBS,BLKSIZE=7276,LRECL=34)
5820 //GO.FT17F001  DD    DSN=DEW.CCG.LORAN.PORTJOLI.WHARF,DISP=(MOD,KEEP),
5830 //             UNIT=M2314,VOL=SER=SEGEOP,SPACE=(TRK,(10,10),RLSE),
5840 //             DCB=(RECFM=VBS,BLKSIZE=7276,LRECL=34)
5850 //GO.FT18F001  DD    DSN=DEW.CCG.LORAN.WHEAD.LOCKPORT,DISP=(MOD,KEEP),
5860 //             UNIT=M2314,VOL=SER=SEGEOP,SPACE=(TRK,(10,10),RLSE),
5870 //             DCB=(RECFM=VBS,BLKSIZE=7276,LRECL=34)
5880 //GO.FT19F001  DD    DSN=DEW.CCG.LORAN.INGOMAR,DISP=(MOD,KEEP),
5890 //             UNIT=M2314,VOL=SER=SEGEOP,SPACE=(TRK,(10,10),RLSE),
5900 //             DCB=(RECFM=VBS,BLKSIZE=7276,LRECL=34)
5910 //GO.SYSIN     DD    *
5920 COPY CCG LORAN-C DATA FROM TAPE (SLOT3745,FILE14) TO DISK SEGEOP
5930  1 0 2 1982 288
5940 KETCH HARBOUR MONITOR     13822.92 30157.23   44 29 03.994  -63 33 36.005
```

```
LIS 1:500
//MAKETSIO  JOB  '6691,RAF0',WELLS,MSGCLASS=A
/*PASSWORD  XTMNCMEY
/*JOBPARM   S=99,R=1024,L=9
//          EXEC  FORTVCG,REGION=1024K
//FORT.SYSIN  DD  *
C
C  JOB TO CREATE A TSIO FILE TO BE READ FROM APL. TWO MODES ARE
C    1) MONITOR DATA (ISWTCH=1)
C    2) REMOTE DATA  (ISWTCH=2)
C
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*2(I-J)
      CHARACTER*80 TITLE
      LOGICAL*1 DATE(18)
      KOUNT=0
      LIM=999999
C
C  READ TITLE AND SWITCH
C
      READ(5,1020)TITLE
 1020 FORMAT(A80)
      READ(5,1030)ISWTCH
 1030 FORMAT(I1)
      CALL GDATE(DATE)
      WRITE(6,1040)TITLE,DATE
 1040 FORMAT('1',A80,18A1/)
C
C  MONITOR DATA
C  ------------
C
      IF(ISWTCH.EQ.1)THEN
C
C  SKIP FIRST TWO RECORDS
C
        READ(8,END=100)IYEAR
        READ(8,END=100)IYEAR
 10     READ(8,END=100)IYEAR,IDAY,IHR,IMIN,ISEC,TDA,ISDA,TDB,ISDB,
     1    TDC,ISDC,TDD,ISDD
        KOUNT=KOUNT+1
        IF(KOUNT.GT.LIM)GO TO 100
        HOUR=IHR+(IMIN/60.D0)+(ISEC/3600.D0)
        WRITE(9,1000)IDAY,HOUR,TDA,ISDA,TDB,ISDB,
     1    TDC,ISDC,TDD,ISDD
 1000   FORMAT(I4,F9.5,4(F10.3,I4))
        IF(MOD(KOUNT,250).EQ.1)WRITE(6,1010)KOUNT,IYEAR,IDAY,IHR,IMIN,
     1    ISEC,TDA,ISDA,TDB,ISDB,TDC,ISDC,TDD,ISDD
 1010   FORMAT(' KOUNT=',I6,' RECORD= ',I4,1X,I4,3I3,4(3X,F9.3,I4))
        GO TO 10
 100    CONTINUE
        WRITE(6,1010)KOUNT,IYEAR,IDAY,IHR,IMIN,ISEC,
```

```
LIS 501:1000
      1     TDA,ISDA,TDB,ISDB,TDC,ISDC,TDD,ISDD
          STOP
C
C  REMOTE SITE
C  -----------
C
        ELSE IF(ISWTCH.EQ.2)THEN
C
C  SKIP FIRST THREE RECORDS
C
          READ(8,END=200)IYEAR
          READ(8,END=200)IYEAR
          READ(8,END=200)IYEAR
20        READ(8,END=200)IYEAR,IDAY,IHR,IMIN,ISEC,TDA,ISDA,TDB,ISDB
          KOUNT=KOUNT+1
          IF(KOUNT.GT.LIM)GO TO 200
          HOUR=IHR+(IMIN/60.D0)+(ISEC/3600.D0)
          WRITE(9,1000)IDAY,HOUR,TDA,ISDA,TDB,ISDB
          IF(MOD(KOUNT,250).EQ.1)WRITE(6,1010)KOUNT,IYEAR,IDAY,IHR,IMIN,
      1     ISEC,TDA,ISDA,TDB,ISDB
          GO TO 20
200       CONTINUE
          WRITE(6,1010)KOUNT,IYEAR,IDAY,IHR,IMIN,ISEC,
      1     TDA,ISDA,TDB,ISDB
        STOP
        END IF
        END
//GO.FT08F001  DD  DSN=A.M1212.DEW.CCG.LORAN.COFFIN.ISLAND.MAR16,
//  DISP=SHR
//GO.FT09F001  DD  DSN=TSIO.AAGGBILJ.CCGLORAN.COFFINLO,
//  DISP=(NEW,CATLG),DCB=(RECFM=F,LRECL=69),
//  SPACE=(TRK,(2,2),RLSE),UNIT=SYSDA
  MAKETSIO FILE 'TSIO.AAGGBILJ.CCGLORAN.COFFINLO' FROM ONLINE FILE
2
//
```

```
LIS 1:500
//DUMP     JOB  '6691,RAF0',WELLS,MSGCLASS=S
/*PASSWORD XTMNCMEY
/*JOBPARM  S=59,R=1024,L=99
//         EXEC FORTVCG,REGION=1024K
//FORT.SYSIN DD *
C
C  PROGRAM TO DUMP FILES OF CANADIAN COAST GUARD DATA FROM DISK
C   TO THE LINE PRINTER.  TWO MODES ARE:
C    1) DUMP MONITOR SITE DATA (ISWTCH=1)
C    2) DUMP REMOTE SITE DATA (ISWTCH=2)
C
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*2(I-J)
      CHARACTER*80 TITLE
      LOGICAL*1 DATE(18)
      LIFIL=8
      LOUT=6
      LIN=5
      LPAGE=0
      LINE=0
C
C  READ TITLE AND SWITCH
C
      READ(LIN,1000)TITLE
1000  FORMAT(A80)
      READ(LIN,1010)ISWTCH
1010  FORMAT(I1)
      CALL GDATE(DATE)
C
C  MONITOR DATA
C
10    IF(ISWTCH.EQ.1)THEN
C
C  SKIP FIRST TWO RECORDS
C
        READ(LIFIL,END=200)IYEAR
        READ(LIFIL,END=200)IYEAR
20      READ(LIFIL,END=200)IYEAR,IDAY,IHR,IMIN,ISEC,DA,ISDA,
     1    DB,ISDB,DC,ISDC,DD,ISDD
        LINE=LINE+1
        IF(MOD(LINE,50).NE.1)GO TO 30
        LPAGE=LPAGE+1
        WRITE(LOUT,1020)TITLE,DATE,LPAGE
1020    FORMAT('1',////,A80,18A1,2X,'PAGE:',I4/)
30      WRITE(LOUT,1030)IYEAR,IDAY,IHR,IMIN,ISEC,DA,ISDA,
     1    DB,ISDB,DC,ISDC,DD,ISDD
        GO TO 20
C
C  REMOTE DATA
C
```

```
LIS 501:1000
      ELSE IF(ISWTCH.EQ.2)THEN
C
C  SKIP FIRST THREE RECORDS
C
        READ(LIFIL,END=200)IYEAR
        READ(LIFIL,END=200)IYEAR
        READ(LIFIL,END=200)IYEAR
40      READ(LIFIL,END=200)IYEAR,IDAY,IHR,IMIN,ISEC,TDA,ISDA,
     1    TDB,ISDB
        LINE=LINE+1
        IF(MOD(LINE,50).NE.1)GO TO 50
        LPAGE=LPAGE+1
        WRITE(LOUT,1020)TITLE,DATE,LPAGE
50      WRITE(LOUT,1030)IYEAR,IDAY,IHR,IMIN,ISEC,TDA,ISDA,
     1    TDB,ISDB
1030    FORMAT(' ',2I5,I3,':',I2,':',I2,4(2X,F10.3,I4))
        GO TO 40
      END IF
200   WRITE(LOUT,1040)LINE
1040  FORMAT('0TOTAL RECORDS =',I8)
      STOP
      END
//GO.FT08F001  DD  DSN=A.M1212.DEW.CCG.LORAN.KETCH.MONITOR.SEQ,
//    DISP=SHR
  CONTENTS OF 'A.M1212.DEW.CCG.LORAN.KETCH.MONITOR.SEQ' ONLINE DISK
1
//
```

```
LIS 1:500
//COPZCCG JOB '1212,PNF0',DAVEWELLS,MSGCLASS=A
/*JOBPARM  S=29,R=1024,L=9,C=50
//*  EXPORT VSPC FILE TO OS TEMP FILE
//STEP2  EXEC VSPCCOPY,PRINT=NOLIST
//TEMPDS      DD DSN=(TEMP,
//    UNIT=DASD,DISP=(NEW,PASS),
//    SPACE=(TRK,(1,1),RLSE),
//     DCB=(RECFM=FB,LRECL=80,BLKSIZE=6160),VOL=SER=USER22
//SYSIN  DD  *
AUTH 1212001/WELLS
EXPORT KETCH2 TO (TEMPDS)
//* REFORMAT OS FILE TO PERMANENT FILE
//STEP3      EXEC  FORTVCG
//FORT.SYSIN DD  *
C
C  MONITOR DATA VERSION OF
C  PROGRAM TO READ DATA FROM CCG (CANADIAN COAST GUARD) RAW
C  LORAN-C DATA FILES AND REFORMAT IT INTO A STANDARD FORMAT
C
C  AUTHOR  B.G.NICKERSON + D.WELLS
C
C  DATE     1983-02-05
C
C  INPUT   RAW DATA ON UNIT 8
C
C  OUTPUT  REFORMATTED DATA ON UNIT 10
C          SUMMARY LISTING ON  UNIT 6
C
C  LANGUAGE:  FORTRAN 77 (FORTVCLG ON THE IBM)
C
C  EXTERNALS: GDATE
C
C
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*2(I-J)
      CHARACTER*25 NAME
      CHARACTER*80 TITLE
      LOGICAL*1 DATE(18)
C
C  DEFINE INITIAL VARIABLES
C
      LOUT=6
      LIFIL = 8
      LOFIL = 10
      KOUNTR = 0
      TMIN = 9999999D0
      TMAX = 0D0
C
C  PRINT TITLE AND DATE
C
```

```
LIS 501:1000
         CALL GDATE(DATE)
         WRITE(LOUT,1000) DATE
    1000 FORMAT('1 COPY CCG LORAN-C MONITOR DATA FROM VSPC',
        $  ' (ACCT 1212) TO ONLINE DISK  ',18A1)
C
C  READ HEADER INPUT RECORD
C
         READ(LIFIL,1010) NAME,STDA,STDB
        $   ,LATD,LATM,SECLAT,LONGD,LONGM,SECLON
    1010 FORMAT(A25,2F9.2,/,2I3,F8.4,I4,I3,F8.4)
         WRITE(LOUT,1020) NAME,STDA,STDB
    1020 FORMAT('0MONITOR AT ',A25,' TDA=',F9.2,' TDB=',F9.2)
         WRITE(LOFIL) NAME,STDA,STDB
         WRITE(LOFIL)LATD,LATM,SECLAT,LONGD,LONGM,SECLON
C
C  READ ONE INPUT DATA RECORD
C
    10   READ(LIFIL,1030,END=100)
        $   IYEAR,IDAY,IHR,IMIN,ISEC,
        $   IDA,ISDA,IDB,ISDB,IDC,ISDC,IDD,ISDD
    1030 FORMAT(2I4,3I3,2I4,I2,3(I4,I3,I2))
         TDA = STDA + IDA / 100D0
         TDB = STDB + IDB / 100D0
         TDC = STDA + IDC / 100D0
         TDD = STDB + IDD / 100D0
         ISDA = ISDA * 10
         ISDB = ISDB * 10
         ISDC = ISDC * 10
         ISDD = ISDD * 10
C
C  COMPUTE DECIMAL TIME, AND RECORD MAXIMUM AND MINIMUM
C
           T=IDAY+(IHR+(IMIN+(ISEC/60.D0))/60.D0)/24.D0
           IF(T.GT.TMAX)TMAX=T
           IF(T.LT.TMIN)TMIN=T
           KOUNTR=KOUNTR+1
C
C  WRITE THE DATA TO DISK
C
           WRITE(LOFIL)IYEAR,IDAY,IHR,IMIN,ISEC,TDA,ISDA,TDB,ISDB
        $   ,TDC,ISDC,TDD,ISDD
C          WRITE(LOUT,1060)IYEAR,IDAY,IHR,IMIN,ISEC,TDA,ISDA,TDB,ISDB
C       $  ,TDC,ISDC,TDD,ISDD
    1060  FORMAT(' ',2I4,I3,':',I2,':',I2,4(3X,F10.3,I4))
         GO TO 10
C
C  END OF FILE
C
    100  IDAY =TMIN
             IHR=(TMIN-IDAY)*24.D0
```

```
LIS 1001:~500
INVALID CHARACTER '~'
LIS 1001:1500
               IMIN=(((TMIN-IDAY)*24.D0)-IHR)*60.D0
               JDAY=TMAX
               JHR=(TMAX-JDAY)*24.D0
               JMIN=(((TMAX-JDAY)*24.D0)-JHR)*60.D0
               T=TMAX-TMIN
               IDS=T
               IHS=(T-IDS)*24.D0
               IMS=(((T-IDS)*24.D0)-IHS)*60.D0
               WRITE(LOUT,1070)KOUNTR,IDAY,IHR,IMIN,JDAY,JHR,JMIN,
      1          IDS,IHS,IMS
 1070          FORMAT(' TOTAL RECORDS COPIED=',I5,
      1          ' FROM DAY',I4,',',I3,':',I2,' TO DAY',I4,',',I3,':',I2/
      2          ' SPAN=',I4,' DAY(S)',I3,' HOUR(S)',I3,' MINUTE(S)')
       END
//GO.FT08F001  DD  DSN=(TEMP,UNIT=DASD,DISP=(OLD,DELETE),
//              VOL=SER=USER22
//GO.FT10F001  DD    DSN=A.M1212.DEW.CCG.LORAN.KETCH.MONITOR.DAY218,
//              UNIT=P3350,SPACE=(TRK,(1,1),RLSE),
//              DCB=(RECFM=VBS,BLKSIZE=7276,LRECL=34),DISP=(NEW,CATLG)
//
```

```
LIS 1:450
//MERGE    JOB  '6691,RAFO',WELLS,MSGCLASS=X
/*PASSWORD XTMNCMEY
/*JOBPARM  S=59,R=1024,L=99
/*SETUP    DISK = SEGEOF
//         EXEC FORTVCG,REGION=1024K
//FORT.SYSIN DD *
C
C SEQUENCE ; CHECK TIME SEQUENCE OF COPYCCG TYPE FILE ON SEGEOF.
C    SOME TIME SEQUENCE ERRORS SPOTTED ON PLOTTING
C LU 10..OLD FILE WITH SEQUENCE ERRORS,        ( LU 12...CORRECTED TIMES)
C
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*2(I-J)
      CHARACTER*25 NAME
      NUMBER=0
      OLDTM=0.0D0
      IFLAG=0
      READ(10) NAME,TDA,TDB
      READ(10) LATD,LATM,SLAT,LOND,LONM,SLON
      WRITE(6,6000) NAME,TDA,TDB, LATD,LATM,SLAT, LOND,LONM,SLON
 6000 FORMAT('  CHECK TIME SEQUENCE. D218.D292.CCG.LORAN.KETCH.MONITOR',
     A       /,2X,A25,2(1X,F9.2),/,2I3,F8.4,I4,I3,F8.4)
C
C TO BE USED WHEN ALL ERRORS HAVE BEEN FOUND
      WRITE(12) NAME,TDA,TDB
      WRITE(12) LATD,LATM,SLAT, LOND,LONM,SLON
   10 READ(10,END=998) IYEAR,IDAY,IHR,IMIN,ISEC,
     A         TDA,ISDA,TDB,ISDB,TDC,ISDC,TDD,ISDD
      IF(IDAY.EQ.252.AND.IHR.EQ.11.AND.IMIN.EQ.42.AND.ISEC.EQ.15)
     A   IFLAG=1
      IF(IDAY.EQ.292.AND.IHR.EQ.14.AND.IMIN.EQ.0.AND.ISEC.EQ.0)
     A   IHR=15
      IF(IDAY.EQ.292.AND.IHR.EQ.17.AND.IMIN.EQ.23.AND.ISEC.EQ.0)
     A   IMIN=24
      IF(IFLAG.EQ.0)GO TO 40
      IF(IDAY.EQ.252)IDAY=253
      IF(IDAY.GT.253)IFLAG=0
40    CONTINUE
      WRITE(12) IYEAR,IDAY,IHR,IMIN,ISEC,TDA,ISDA,TDB,ISDB,
     A   TDC,ISDC,TDD,ISDD
      NUMBER=NUMBER+1
      TIME= (IDAY)+( (IHR)+( (IMIN)+ (ISEC)/60.0D0)
     A                          /60.0D0)    /24.0D0
   20 IF(TIME.GT.OLDTIM) GO TO 30
      WRITE(6,6001) IYEAR,IDAY,IHR,IMIN,ISEC
```

```
LIS 451:1000
 6001 FORMAT(' ***WARNING, OUT OF SEQUENCE: ',2I4,I3,':',I2,':',I2)
C      TIME= (IDAY)+( (IHR)+( (IMIN)+ (ISEC)/60.0D0)
C     A                          /60.0D0)    /24.0D0
C      GO TO 20
   30  OLDTIM=TIME
       GO TO 10
  998  WRITE(6,6002) NUMBER
 6002 FORMAT('  NUMBER OF DATA POINTS: ',I6)
       STOP
       END
/*
//GO.FT10F001 DD DSN=D218.D292.CCG.LORAN.KETCH.MONITOR,DISP=SHR
//GO.FT12F001 DD DSN=D218.D292.SEQUENCE.KETCH.MONITOR,UNIT=M2314,
//       DISP=(,CATLG,DELETE),VOL=SER=SEGEOP,SPACE=(TRK,(50,50),RLSE),
//       DCB=(RECFM=VBS,BLKSIZE=7294,LRECL=54)
//
```

APPENDIX IV.2

Workspace PLOTCCG

Functions for Data Plotting

```
      ∇DEFRHW[⎕]∇
      ∇ DEFRHW INT;MTDA;MTDB
[1]   ⍝  DEFINE HELICOPTER DATA WINDOWS  B.G.N. FEB., 1983
[2]   ⍝  TDA MEAN VALUES
[3]    MTDA← 13866.7 13802.1 13799.7 13812.9 13810.3 13768.3 13692.4
[4]    MTDA←MTDA, 13578.1 13519.6 13455.5 13352.8 13309.1 13263.1
[5]   ⍝  TDB MEAN VALUES
[6]    MTDB← 30121.1 30154.2 30247.4 30324.9 30344.4 30366.9 30465.9
[7]    MTDB←MTDB, 30569.1 30589.9 30601.3 30698.7 30752.5 30770.5
[8]   ⍝  DEFINE PLOTTING WINDOWS
[9]    RWA[10+⍳13;]← 13 4 ⍴((13,1)⍴0),[2]((13,1)⍴MTDA-INT÷2),[2]((13,1)⍴24),[2]((13,1)
       ⍴MTDA+INT÷2)
[10]   RWB[10+⍳13;]← 13 4 ⍴((13,1)⍴0),[2]((13,1)⍴MTDB-INT÷2),[2]((13,1)⍴24),[2]((13,1)
       ⍴MTDB+INT÷2)
      ∇
```

```
      ∇DEFSVP[⎕]∇
      ∇ HSVP←DEFSVP WIDE;NUM;XSVP;TWIDE;ONED;ONEB;I
[1]   ⍝  DEFINE SVP'S FOR HELICOPTER DATA PLOTS (CCG DIFFERENTIAL LORAN-C PROJECT 1327
      59).
[2]   ⍝  WIDE = WIDTH IN CM. OF ONE PLOTTING BLOCK
[3]   ⍝  NUM  = TOTAL NUMBER OF PLOTTING BLOCKS
[4]   ⍝  TWIDE= TOTAL WIDTH OF PLOTTING AREA IN CM.
[5]   ⍝  HSVP = RETURNED MATRIX (NUM,4) OF SVP'S FOR PLOTTING      B.G.N. FEB, 1983
[6]    NUM←5
[7]    TWIDE←19.4
[8]    XSVP←SVP[3]-SVP[1]
[9]    HSVP←(NUM,4)⍴0
[10]   ONED←(WIDE÷TWIDE)×XSVP
[11]   ONEB←(((TWIDE-(WIDE×NUM))÷(NUM-1))÷TWIDE)×XSVP
[12]   I←0
[13]  LOOP:HSVP[I+1;]←(SVP[1]+I×ONEB+ONED),SVP[2],(ONED+SVP[1]+I×ONEB+ONED),SVP[4]
[14]   →LOOP×⍳NUM>I←I+1
      ∇
```

```
      ∇DIFF[⎕]∇
      ∇ DDAT←DIFF DAT;BTIM;ETIM;MDAT;I;J;T;TM1;TM2;FAC;MA1;MB1;MA2;MB2;FNAM
[1]   ⍝  GET THE DIFFERENCES BETWEEN DATA AT A REMOTE SITE AND THE MONITOR.
[2]   ⍝   DATA FOR REMOTE SITE IS ASSUMED TO EXIST IN VARIABLE 'DAT'.
[3]   ⍝   FIND SPAN OF REMOTE SITE DATA AND ADD 0.5 HOURS ON EACH SIDE
[4]   ⍝                  B.G.NICKERSON, DEC.,1982
[5]    BTIM←DAT[1;1]+(DAT[1;2]-0.1)÷100
[6]    ETIM←DAT[(1↑⍴DAT);1]+((DAT[(1↑⍴DAT);2]+0.1)÷100)
[7]   ⍝  GET MONITOR DATA FOR THIS TIME SPAN
[8]    DDAT←(0,6)⍴0
[9]    FNAM←FILNAM
[10]   FILNAM←'CCGLORAN.KETCH'
[11]   MDAT←10 GETLOR(BTIM,ETIM)
[12]   FILNAM←FNAM
[13]   ⍎(2>1↑⍴MDAT)/'→0,⍴⎕←''ERROR. NO MONITOR DATA FOR THIS TIME SPAN.'''
[14]  ⍝  INITIALIZE
[15]   J←1
[16]   I←1
[17]  ⍝  LOOP FOR REMOTE SITE DATA POINTS
[18]  NEXTJ:T←DAT[J;1]+DAT[J;2]÷24
[19]  ⍝  LOOP TO INTERPOLATE MONITOR DATA POINTS
[20]  NEXTI:TM1←MDAT[I;1]+MDAT[I;2]÷24
[21]   TM2←MDAT[I+1;1]+MDAT[I+1;2]÷24
[22]   →(TM1≤T)/OK
[23]   'WARNING.  MONITOR DATA BEGINS AFTER REMOTE DATA.'
[24]   J←J+1
[25]   →NEXTJ
[26]  OK:→INT×⍳TM2≥T
[27]   →NEXTI×⍳(1↑⍴MDAT)>I←I+1
[28]   →0,⍴⎕←'WARNING.  MONITOR DATA ENDS BEFORE REMOTE DATA.'
[29]  INT:FAC←(T-TM1)÷(TM2-TM1)
[30]   MA1←(FAC×MDAT[I+1;3]-MDAT[I;3])+MDAT[I;3]
[31]   MA2←(FAC×MDAT[I+1;7]-MDAT[I;7])+MDAT[I;7]
[32]   MB1←(FAC×MDAT[I+1;5]-MDAT[I;5])+MDAT[I;5]
[33]   MB2←(FAC×MDAT[I+1;9]-MDAT[I;9])+MDAT[I;9]
[34]  ⍝  STORE DIFFERENCES
[35]   DDAT←DDAT,[1] DAT[J; 1 2],(DAT[J;3]-MA1),(DAT[J;5]-MB1),(DAT[J;3]-MA2),(DAT[J;5
       ]-MB2)
[36]   →NEXTJ×⍳(1↑⍴DAT)≥J←J+1
      ∇
```

```
      ∇GETLOR[⎕]∇
      ∇ Z←NCOL GETLOR TIM;T;TZ;TIME;BTIM;ETIM;I;IMAX;IMIN;BEGIN;TEMP
[1]   ⍝
[2]   ⍝  GET LORAN-C DATA BETWEEN STARTING DECIMAL DAY TIM[1] AND ENDING
[3]   ⍝   DECIMAL DAY TIM[2]. NCOL IS THE NO. OF COLUMNS OF DATA STORED
[4]   ⍝   ON FILE 'FILNAM'.
[5]   ⍝
[6]    ⎕IO←1
[7]    Z←(0,NCOL)⍴0
[8]    BTIM←(⌊TIM[1])+((TIM[1]-⌊TIM[1])×100)÷24
[9]    ETIM←(⌊TIM[2])+((TIM[2]-⌊TIM[2])×100)÷24
[10]   ((2,3)⍴'IN REC') TRY 'IR DSN= ',FILNAM,' ,CODE=S'
[11]   TIMER←⎕AI[2 3]
[12] ⍝  BINARY SEARCH FOR BEGINNING TIME RECORD
[13]   IMIN←0
[14]   IMAX←((NCOL=10),(NCOL=6))/24061,RMAX[RSITE]
[15] NEXT:I←⌊0.01+(IMAX+IMIN)÷2
[16]   IN←(0,I)
[17]   →((1⍴0)≢TEMP←IN)/ERR
[18]   TZ←2↑NCOL⍴⍎REC
[19]   T←TZ[1]+TZ[2]÷24
[20]   →(I=IMIN)/FOUND
[21]   →(T=BTIM)/FOUND
[22]   ⍎(T<BTIM)/'IMIN←I'
[23]   ⍎(T>BTIM)/'IMAX←I'
[24]   →NEXT
[25] ERR:'ERROR IN READING FILE ',FILNAM,'. CTL=',⍕,TEMP
[26]   →0
[27] FOUND:BEGIN←I+T<BTIM
[28] ⍝  READ IN REQUIRED RECORDS
[29]   I←0
[30] LOOP:IN←0,(BEGIN+I)
[31]   →(24=IN)/DONE
[32]   TZ←2↑NCOL⍴⍎REC
[33]   TIME←TZ[1]+TZ[2]÷24
[34]   →(TIME>ETIM)/DONE
[35]   Z←Z,[1] NCOL⍴⍎REC
[36]   I←I+1
[37]   →LOOP
[38] DONE:(TIMER),' FOR ',(⍕I),' RECORDS (GETLOR).'
      ∇
```

```
      ∇HAXIS[⎕]∇
    ∇ ARG HAXIS DAT;ID;I;SVP;NAME;AX;BX;CX;AY;BY;CY;AL;BL;CL;LDAT;J;DI;TICX;TICY;NX
      ;NY;NY2;NY3;TD;NY4;OFF
[1]   ⍝  DRAW AXES FOR LORAN-C HELICOPTER DATA PLOTS
[2]   ⍝                             B.G.N. FEB, 1983
[3]    DI←'D'∊ARG
[4]    HYINT←W̲[4]-W̲[2]
[5]    ⍎(~'H'∊ARG)/'→ERROR'
[6]    NAME←RNAME[RSITE;]
[7]    SETHW RSITE
[8]   ⍝  FIGURE OUT WHERE DATA BREAKS ARE
[9]    ID←+\0,0.03<|(1↓DAT[;2])-¯1↓DAT[;2]
[10]   HNUM←0
[11]   I←¯1
[12]  ⍝  LOOP THROUGH DATA ONE BLOCK AT A TIME
[13]  LOOP:→(ID[1↑⍴DAT]<I←I+1)/DONE
[14]   →((1↑⍴HSVP)<HNUM←HNUM+1)/DONE
[15]   SVP←S̲V̲P̲
[16]   S̲V̲P̲←HSVP[HNUM;]
[17]   LDAT←(ID=I)⌿DAT
[18]   W̲[1 3]←START,(START←((⌊(1||LDAT[1;2])×60)÷60)+⌊LDAT[1;2])+HWIDE
[19]   ⍎('A'∊ARG)/'W̲[2 4]←(4⍴(~DI),DI)/RWA[RSITE;2],(J-HYINT÷2 ),RWA[RSITE;4],(J←RWA[R
       SITE;2]-TDAW[2])+HYINT÷2'
[20]   ⍎('B'∊ARG)/'W̲[2 4]←(4⍴(~DI),DI)/RWB[RSITE;2],(J-HYINT÷2),RWB[RSITE;4],(J←RWB[RS
       ITE;2]-TDBW[2])+HYINT÷2'
[21]   TICX←(3,NX+1)⍴(START+(¯1+⍳NX+1)×CX),(NX⍴AL,(NX-1)⍴CL),AL,((NX+1)⍴W̲[2])
[22]   ⍎(HNUM=1)/' TICY←(3,NY+1)⍴(W̲[2]+(¯1+⍳NY+1)×CY),(NY⍴AL,(NY2-1)⍴CL),AL,((NY+1)⍴W̲[
       1])'
[23]   ⍎(HNUM>1)/'TICY←(3,NY4+1)⍴(W̲[2]+(¯1+⍳NY4+1)×AY),((NY4+1)⍴BL),((NY4+1)⍴W̲[1])'
[24]   0 0 1.3 WRITE ''
[25]   ⍎(~DI)/'USE COLOR 2'
[26]   ⍎(DI)/'USE COLOR 1'
[27]   TICX AXIS TICY
[28]  ⍝  LABEL AXES
[29]   OFF←HWIDE×2÷25
[30]   ((3,2)⍴((START+OFF),START+HWIDE-OFF),(2⍴0.03),(2⍴W̲[2])) LBLX(⌊((1||START)×60)+
       0.5),(⌊((1||START+HWIDE)×60)+0.5)
[31]   0 0 1.7 WRITE ''
[32]   ⍎(HNUM=1)/'((NY3+1)⍴W̲[2]+(¯1+⍳NY3+1)×AY) LBLY 0'
[33]   0 ANNX(⍕LDAT[1;1]+(⌊START)÷100)
[34]   ⍎(HNUM=1)/'0 ANNY ''MICROSECONDS'''
[35]   S̲V̲P̲←SVP
[36]   →LOOP
[37]  DONE:TD←(('A'∊ARG),('B'∊ARG))/'AB'
[38]   S̲V̲P̲[4]←S̲V̲P̲[4]+1
[39]   ⍎(~DI)/'(0,0,0,0,1) TITLE ''TD'',TD,'' '',NAME,'' HELICOPTER DATA'''
[40]   ⍎(DI)/'(0,0,0,0,1) TITLE ''TD'',TD,'' DIFFERENCE '',NAME,'' - MONITOR'''
[41]   S̲V̲P̲[4]←S̲V̲P̲[4]-1
[42]   →0
[43]  ERROR:⎕←'ERROR,  MUST INCLUDE ''H'' IN ARG FOR HELICOPTER AXIS PLOTS.'
    ∇
```

```
    ∇HDIFF[⎕]∇
    ∇ DDAT←HDIFF DAT;ID;I;TDAT
   ⍝  GET DIFFERENCES FROM MONITOR FOR HELICOPTER DATA PLOTTING
   ⍝                                              B.G.N. FEB, 1983
    DDAT←(0,6)⍴0
   ⍝  FIGURE OUT WHERE DATA BREAKS ARE
    ID←+\0,0.03<|(1↓DAT[;2])-¯1↓DAT[;2]
    I←¯1
   ⍝  LOOP THROUGH DATA ONE BLOCK AT A TIME
   LOOP:→(ID[1↑⍴DAT]<I←I+1)/DONE
    TDAT←(ID=I)⌿DAT
    DDAT←DDAT,[1] DIFF TDAT
    →LOOP
   DONE:⎕←'TOTAL OF ',(⍕1↑⍴DDAT),' DIFFERENCE RECORDS'
    ∇
```

```
      ∇HPLOT[⎕]∇
      ∇ ARG HPLOT DAT;HINT;ID;I;SVP;HNUM;NAME;IB
[1]   ⍝  CONTROLLER FOR PLOTTING HELICOPTER DATA (CCG DIFFERENTIAL LORAN-C PROJECT 132
      759).
[2]   ⍝  USED TO PLOT MANY GROUPS OF DATA SIMULTANEOUSLY. IMPORTANT GLOBAL VARIABLES:
[3]   ⍝   HSVP  = SCALING VIEWPORTS DEFINED BY FUNCTION 'DEFSVP'
[4]   ⍝   HWIDE = WIDTH OF A SINGLE PLOTTING BLOCK IN HOURS
[5]   ⍝   HYINT = VERTICAL HEIGHT OF DATA WINDOW IN MICROSECONDS
[6]   ⍝  LOCAL VARIABLE HINT = INTERVAL TO CONSIDER DATA AS FROM A NEW BLOCK (HOURS)
[7]   ⍝                                                               B.G.N. FEB, 1983
[8]    NAME←RNAME[RSITE;]
[9]    IB←(NAME[10]='B')∧(NAME[11]='.')
[10]   →(IB)/BUOY
[11]  ⍝  STATIONARY PLOT WINDOW DEFINITION
[12]   DEFRHW 0.4
[13]   HWIDE←8÷60
[14]   →PLOT
[15]  ⍝  BUOY PLOT WINDOW DEFINITION
[16]  BUOY:⍎(RSITE=14)/'DEFRHW 1.2'
[17]   ⍎(RSITE=15)/'DEFRHW 1.0'
[18]   ⍎(RSITE>15)/'DEFRHW 0.5'
[19]   HWIDE←4÷60
[20]  PLOT:HYINT←RWA[RSITE;4]-RWA[RSITE;2]
[21]   HINT←0.03
[22]   ID←+\0,HINT<|(1↓DAT[;2])-¯1↓DAT[;2]
[23]  ⍝  LOOP THROUGH DATA TO BE PLOTTED
[24]   HNUM←0
[25]   I←¯1
[26]  LOOP:→(ID[1↑⍴DAT]<I←I+1)/DONE
[27]   HNUM←HNUM+1
[28]   →(HNUM>1↑⍴HSVP)/ERROR
[29]   SVP←S̲V̲P̲
[30]   S̲V̲P̲←HSVP[I+1;]
[31]   ARG LPLOT(ID=I)⌿DAT
[32]   S̲V̲P̲←SVP
[33]   →LOOP
[34]  DONE:→0
[35]  ERROR:⎕←'ERROR.  MORE DATA GROUPS TO BE PLOTTED. NO MORE PLOTTING BLOCKS AVAILAB
      LE.'
      ∇
```

```
∇INITSUM[⎕]∇
∇ ARG INITSUM ARG;MARG;I;J;K;RSTAT;BSTAT;M;STAT;MUD;MUD1;MUD2;MU1;MU2;IV;MUR
⍝  GET DATA AND INITIALIZE FOR SUMMARY PLOTS   B.G.N. MARCH, 1983
 H1←('H'∊ARG)∧('1'∊ARG)
 H2←('H'∊ARG)∧('2'∊ARG)
 H3←('H'∊ARG)∧('3'∊ARG)
 V←'V'∊ARG
 R←'R'∊ARG
 S←'S'∊ARG
 A←'A'∊ARG
 B←'B'∊ARG
 MARG←(V,H1,H2,H3)/ 0 1 2 3
⍝  GET MEAN VALUES FOR EACH VISIT
 SUMU MARG
 ⍎(R)/'MUD←MUD1'
 ⍎(S)/'MUD←MUD2'
 ⍎(A)/'MUD←,MUD[;1]'
 ⍎(B)/'MUD←,MUD[;2]'
⍝  VISIT INDICES
 VIS1←23ρ1
 VIS2←23ρ1
 VIS3←(10ρ1),0,0,(6ρ1),5ρ0
 VIS4←(9ρ1),0,13ρ1
 VIS5←(10ρ0),(3ρ1),0,0,8ρ1
⍝  GET DATA TO BE PLOTTED. J = SITE NO., I = VISIT NO., K = VALID SITE COUNTER
 D1←D2←D3←D4←D5←0ρ0
 K←J←0
⍝  LOOP ON SITES
LOOPD:→(23<J←J+1)/DONE
 →(INDX[J]=0)/LOOPD
 RSTAT←MRSTAT[M←(+/MRINDX[⍳J-1])+⍳MRINDX[J];(A,B)/(17,20)]
 BSTAT←MBSTAT[M;(A,B)/(17,20)]
 ⍎(R)/'STAT←,RSTAT'
 ⍎(S)/'STAT←,BSTAT'
 M←(|STAT)>0.01
 STAT←M/STAT
 K←K+1
 IV←I←0
⍝  LOOP ON VISITS
LOOPV:→((1↑ρVISITS)<I←I+1)/LOOPD
 →(1>+/VISITS[I]=⍳5)/LOOPV
 →(V1,V2,V3,V4,V5)[(1,2,3,4,5)⍳VISITS[I]]
⍝  VISIT 1
V1:⍎(J=1)/'STAT←0 1 1 1 1/STAT'
 →(VIS1[J]=0)/LOOPV
 D1←D1,STAT[IV←IV+1]-MUD[K]
 →LOOPV
⍝  VISIT 2
V2:⍎(J=6)/'STAT←(1,0,1,1,1)/STAT'
 →(VIS2[J]=0)/LOOPV
 D2←D2,STAT[IV←IV+1]-MUD[K]
 →LOOPV
⍝  VISIT 3
V3:→(VIS3[J]=0)/LOOPV
 D3←D3,STAT[IV←IV+1]-MUD[K]
 →LOOPV
⍝  VISIT 4
V4:→(VIS4[J]=0)/LOOPV
 D4←D4,STAT[IV←IV+1]-MUD[K]
 →LOOPV
⍝  VISIT 5
V5:→(VIS5[J]=0)/LOOPV
 D5←D5,STAT[IV←IV+1]-MUD[K]
 →LOOPV
DONE:→0
∇
```

```
      ∇LAXIS[⎕]∇
      ∇ ARG LAXIS DAT;YRANGE;TICX;YINT;TICY;TI;NT;DAY;NAME;TD;MR;D
[1]   ⍝  DRAW AXES FOR LORAN-C DATA PLOTS
[2]   ⍝           B.G.NICKERSON, DEC.,1982
[3]    MR←('M'∊ARG)∧∼'4'∊ARG
[4]    D←('D'∊ARG)∨('R'∊ARG)∨('4'∊ARG)
[5]    NAME←'MONITOR'
[6]    ⍎(('R'∊ARG)∨('D'∊ARG))/'NAME←RNAME[RSITE;]'
[7]    YINC←0.05
[8]    DAY←DAT[1;1]
[9]    ⍎(MR)/'TICX←(3,25)⍴(¯1+⍳25),(24⍴(0.04 0.02 0.02 0.02)),0.04,25⍴W̲[2]'
[10]   ⍎(D)/'TICX←(3,17)⍴((⌊DAT[1;2])+(¯1+⍳17)÷4),(16⍴(0.04 0.02 0.02 0.02)),0.04,17⍴W̲
       [2]'
[11]   YRANGE←W̲[4]-W̲[2]
[12]   YINT←⌊(YRANGE÷YINC)+0.5
[13]   TI←¯1+⌊(YINC÷0.01)+0.5
[14]   NT←YINT×TI+1
[15]   YRANGE←(0.04,(TI⍴0.01),0.02,(TI⍴0.01))
[16]   TICY←(NT+1)⍴(W̲[2]+0.01×(¯1+⍳NT+1))
[17]   TICY←(3,NT+1)⍴TICY,(NT⍴YRANGE),0.04,(NT+1)⍴W̲[1]
[18]   0 0 1.7 WRITE ''
[19]   USE COLOR(1+'R'∊ARG)
[20]   TICX AXIS TICY
[21]   ⍎(MR)/'(4×(¯1+⍳7)) LBLX 0'
[22]   ⍎(D)/'((⌊DAT[1;2])+(¯1+⍳5)) LBLX 0'
[23]   (W̲[2]+YINC×(¯1+⍳YINT+1)) LBLY 0
[24]   0 ANNX 'HOURS'
[25]   0 ANNY 'MICROSECONDS'
[26]   TD←(('A'∊ARG),('B'∊ARG))/'AB'
[27]   MR←((('M'∊ARG)∨('R'∊ARG))∧(∼'D'∊ARG))
[28]   D←'D'∊ARG
[29]   ⍎(MR)/'(((W̲[3]+W̲[1])÷2),(W̲[4]+0.01),0,0,0) TITLE ''TD'',TD,'' '',NAME,'' DATA F
       OR DAY '',⍕DAY'
[30]   ⍎(D)/'(((W̲[3]+W̲[1])÷2),(W̲[4]+0.01),0,0,0) TITLE ''TD'',TD,'' DIFFERENCE '',NAME
       ,'' - MONITOR, DAY '',⍕DAY'
      ∇
```

```
      ∇LPLOT[⎕]∇
    ∇ ARG LPLOT DAT;ID;I;J;IDAT
[1]  ⍝  PLOT LORAN-C DATA IN MATRIX 'DAT'.  LIFT PEN IF THERE IS A BREAK
[2]  ⍝   OF MORE THAN 0.10 HOURS (360 SECONDS).
[3]  ⍝   REMOTE SITE NUMBER DEFINED BY GLOBAL VARIABLE 'RSITE'
[4]  ⍝   REMOTE SITE DATA WINDOWS DEFINED BY GLOBAL VARIABLES 'RWA' AND 'RWB'
[5]  ⍝                    B.G.NICKERSON, DEC.,1982
[6]   →(0=⍴ARG)/ERROR
[7]   S̲V̲P̲← 19 7 96 65
[8]   ⍎('H'∊ARG)/'W̲[1 3]←J,(J←((⌊(1||DAT[1;2])×60)÷60)+⌊DAT[1;2])+HWIDE'
[9]   →('A'∊ARG)/TDA
[10]  →('B'∊ARG)/TDB
[11] ERROR:'ERROR (LPLOT), LEFT ARGUMENT MUST INCLUDE ''A'' OR ''B'''
[12]  →0
[13] TDA:IDAT←(1,('M'∊ARG))/(3,7)
[14]  ⍎('D'∊ARG)/'IDAT←IDAT,5'
[15]  ⍎(~'H'∊ARG)/'W̲←((4⍴''M''∊ARG),(4⍴(''R''∊ARG)))/TDAW,RWA[RSITE;]'
[16]  ⍎('H'∊ARG)/'W̲[2 4]←RWA[RSITE;2 4]'
[17]  ⍎(('D'∊ARG)∧(~'H'∊ARG))/'W̲←(⌊DAT[1;2]),(J-0.15   ),((⌊DAT[1;2])+4),((J←RWA[RSIT
     E;2]-TDAW[2])+0.15)'
[18]  ⍎(('H'∊ARG)∧('D'∊ARG))/'W̲[2 4]←(J-HYINT÷2),(J←RWA[RSITE;2]-TDAW[2])+HYINT÷2
[19]  ⍎('R'∊ARG)/'W̲[1 3]←(⌊DAT[1;2]),((⌊DAT[1;2])+4)'
[20]  ⍎(('M'∊ARG)∧('4'∊ARG))/'W̲[1 3]←(⌊DAT[1;2]),((⌊DAT[1;2])+4)'
[21]  →PLOT
[22] TDB:IDAT←(1,('M'∊ARG))/(5,9)
[23]  ⍎('D'∊ARG)/'IDAT←4 6'
[24]  ⍎(~'H'∊ARG)/'W̲←((4⍴''M''∊ARG),(4⍴(''R''∊ARG)))/TDBW,RWB[RSITE;]'
[25]  ⍎('H'∊ARG)/'W̲[2 4]←RWB[RSITE;2 4]'
[26]  ⍎(('D'∊ARG)∧(~'H'∊ARG))/'W̲←(⌊DAT[1;2]),(J-0.15   ),((⌊DAT[1;2])+4),((J←RWB[RSIT
     E;2]-TDBW[2])+0.15)'
[27]  ⍎(('H'∊ARG)∧('D'∊ARG))/'W̲[2 4]←(J-HYINT÷2),(J←RWB[RSITE;2]-TDBW[2])+HYINT÷2'
[28]  ⍎('R'∊ARG)/'W̲[1 3]←(⌊DAT[1;2]),((⌊DAT[1;2])+4)'
[29]  ⍎(('M'∊ARG)∧('4'∊ARG))/'W̲[1 3]←(⌊DAT[1;2]),((⌊DAT[1;2])+4)'
[30] PLOT:J←1
[31]  ID←+\0,0.1<((1↓DAT[;2])-¯1↓DAT[;2]
[32] ⍝  LOOP THROUGH DATA TO BE PLOTTED
[33] NEXT:I←¯1
[34]  USE COLOR J
[35] LOOP:→(ID[1↑⍴DAT]<I←I+1)/MORE
[36]  ('AS') SPLOT(ID=I)⌿DAT[;(2,IDAT[J])]
[37]  →LOOP
[38] MORE:→((⍴IDAT)<J←J+1)/DONE
[39]  →NEXT
[40] DONE:→0
    ∇
```

```
      ∇RINDX[⎕]∇
      ∇ RINDX N;BLANK
[1]   BLANK←(N,3)⍴' '
[2]   (⍕(N,1)⍴⍳N),[2] BLANK,[2] RFNAME,[2] BLANK,[2] RNAME,[2] BLANK,[2](⍕(N,1)⍴RMAX)
      ,[2](⍕RWA),[2](⍕RWB)
      ∇
```

```
      ∇SETHW[⎕]∇
      ∇ SETHW RSITE;IBUOY;NAME
[1]   ⍝  SET AXIS SPECIFICATION WINDOWS FOR HELICOPTER DATA PLOTTING
[2]   ⍝                                                    B.G.N. FEB, 1983
[3]    NAME←RNAME[RSITE;]
[4]    IBUOY←(NAME[10]='B')∧(NAME[11]=',')
[5]    AL←BL←0.03
[6]    CL←0.02
[7]    AX←BX←HWIDE
[8]    CX←1÷60
[9]    →(IBUOY)/BUOY
[10]  ⍝  STATIONARY DATA WINDOWS
[11]   AY←BY←0.1
[12]   CY←0.01
[13]   →WINDOW
[14]  BUOY:BY←0.1
[15]   ⍎(RSITE>15)/'AY←0.1'
[16]   ⍎(RSITE≤15)/'AY←0.2'
[17]   ⍎(RSITE>15)/'CY←0.01'
[18]   ⍎(RSITE≤15)/'CY←0.02'
[19]  WINDOW:NX←⌊(HWIDE÷CX)+0.5
[20]   NY←⌊(HYINT÷CY)+0.5
[21]   NY2←⌊(AY÷CY)+0.5
[22]   NY3←⌊(HYINT÷AY)+0.5
[23]   NY4←⌊(HYINT÷AY)+0.5
      ∇
```

```
      ∇SUMAXIS[⎕]∇
      ∇ ARG SUMAXIS VISITS;T;T1;T2;T3;I;AV;PA
[1]   ⍝  PLOT AXES, LABELS AND TITLES FOR THE DATA SUMMARY PLOTS.  B.G.N. MARCH, 1983
[2]    0 0 1.7 WRITE ''
[3]    USE STYLE 1
[4]    IM← 0 0
[5]    AXES
[6]    0 LBLX 0
[7]    0 LBLY 0
[8]    0 ANNX 'KILOMETRES FROM MONITOR'
[9]    0 ANNY 'MICROSECONDS'
[10]   SVP[4]←SVP[4]+1
[11]   ⍎(H1)/'T1←''H, LANDING'''
[12]   ⍎(H2)/'T1←''H, BUOY'''
[13]   ⍎(H3)/'T1←''H, ALL'''
[14]   ⍎(V)/'T1←''VAN SITE'''
[15]   ⍎(R)/'T2←''2220'''
[16]   ⍎(S)/'T2←''1017'''
[17]   ⍎(A)/'T3←''A'''
[18]   ⍎(B)/'T3←''B'''
[19]   (0,0,0,0,1) TITLE T1,' VISITS - MONITOR ',T2,' TD',T3
[20]   SVP[4]←SVP[4]-1
[21]   I←0
[22]   0 0 1.2 WRITE ''
[23]   T←'¨'
[24]  LOOP:→((⍴VISITS)<I←I+1)/LEGEND
[25]   T←T,'⊂   ⊃ VISIT ',(⍕VISITS[I]),'¨'
[26]   →LOOP
[27]  LEGEND:T←T,' '
[28]   PA←PA
[29]   PA←STYLE VISITS
[30]   (180,(W[4]-((W[4]-W[2])×0.093)),1,0,0,0) TITLE T
[31]   PA←PA
      ∇
```

```
∇SUMPLOT[⎕]∇
∇ ARG SUMPLOT VISITS;DIST;X;D1;D2;D3;D4;D5;I;DAT
⍝  PLOT DATA SUMMARIES FOR C.C.G. LORAN - C PROJECT (132759).
⍝  VISITS CONTAINS THE VISITS TO BE PLOTTED (ANY COMBINATION OF 1,2,3,4,5).
⍝  ARG CONTAINS CHARACTERS DESCRIBED AS FOLLOWS;
⍝   'A' MEANS PLOT TDA DATA; 'B' MEANS PLOT TDB DATA
⍝   'R' MEANS PLOT S.N. 2220 DATA; 'S' MEANS PLOT S.N. 1017 DATA
⍝   'V' MEANS PLOT VAN SITE DATA; 'H' MEANS PLOT HELICOPTER DATA
⍝   '1' MEANS PLOT HELICOPTER LANDINGS ONLY
⍝   '2' MEANS PLOT HELICOPTER BUOY VISITS ONLY
⍝   '3' MEANS PLOT ALL HELICOPTER SITE DATA    B.G.N. MARCH, 1983
⍝  INITIALIZE AND GET DATA TO BE PLOTTED
 ARG INITSUM VISITS
⍝  DISTANCE OF POINTS FROM MONITOR (KM.)
 DIST← 15.2 29.8 46.3 61.5 69.7 90.6 102 128 156.5 178.4
 DIST←DIST, 11.4 6.3 19 30.4 35.5 42.5 67.8 100.1 114.7 124.8 155.2 162.8 182.5
 W̲[1 3]← 0 200
 W̲[4]←(I+(10-10|(I←⌈⌈/(1000×(D1,D2,D3,D4,D5)))))÷1000
 W̲[2]←(I-(10+¯10|(I←⌊⌊/(1000×(D1,D2,D3,D4,D5)))))÷1000
 S̲V̲P̲← 14 7 96 65
⍝  LOOP FOR PLOTTING EACH VISIT AT A TIME
 I←0
 USE COLOR 1
LOOP:→((1↑⍴VISITS)<I←I+1)/DONE
 →(1)+/VISITS[I]=⍳5)/LOOP
 →(S1,S2,S3,S4,S5)[(1,2,3,4,5)⍳VISITS[I]]
⍝  VISIT 1
S1:USE STYLE 1
 DAT←(((⍴D1),1)⍴((INDX∧VIS1)/DIST)),[2]((⍴D1),1)⍴D1
 →PLOT
⍝  VISIT 2
S2:USE STYLE 2
 DAT←(((⍴D2),1)⍴((INDX∧VIS2)/DIST)),[2]((⍴D2),1)⍴D2
 →PLOT
⍝  VISIT 3
S3:USE STYLE 3
 DAT←(((⍴D3),1)⍴((INDX∧VIS3)/DIST)),[2]((⍴D3),1)⍴D3
 →PLOT
⍝  VISIT 4
S4:USE STYLE 4
 DAT←(((⍴D4),1)⍴((INDX∧VIS4)/DIST)),[2]((⍴D4),1)⍴D4
 →PLOT
⍝  VISIT 5
S5:USE STYLE 5
 DAT←(((⍴D5),1)⍴((INDX∧VIS5)/DIST)),[2]((⍴D5),1)⍴D5
PLOT:⍎(DAT[1;1]<DAT[2;1])/'→OK'
 X←DAT[1;]
 DAT[1;]←DAT[2;]
 DAT[2;]←X
OK:'AS' SPLOT DAT
 →LOOP
DONE:→0
∇
```

```
      ∇SUMU[⎕]∇
      ∇ SUMU ARG;I;MAX;DAT;BX;HX;LX;VX;RSTAT;BSTAT;M;M1;M2
[1]   ⍝  COMPUTE MEANS OF VISITS TO SITES (VAN OR HELICOPTER)
[2]   ⍝  ARG=3 MEANS ALL HELICOPTER DATA
[3]   ⍝  ARG=2 MEANS HELICOPTER BUOY SITES ONLY
[4]   ⍝  ARG=1 MEANS HELICOPTER LANDING SITES ONLY
[5]   ⍝  ARG=0 MEANS ALL VAN SITES    B,G,N, MARCH, 1983
[6]    DAT←'B,'∘.=RNAME[; 10 11]
[7]    BX←DAT[1;;1]∧DAT[2;;2]
[8]    HX←(10⍴0),13⍴1
[9]    LX←∼BX
[10]   LX[⍳10]←∼LX[⍳10]
[11]   VX←(10⍴1),13⍴0
[12]   INDX←,((ARG=3),(ARG=2),(ARG=1),(ARG=0))/[1](4,23)⍴HX,BX,LX,VX
[13]   MU1←MU2←MUD1←MUD2←MUR←(0,2)⍴0
[14]   I←0
[15]  LOOP:→(23<I←I+1)/DONE
[16]   →(INDX[I]=0)/LOOP
[17]   RSTAT←MRSTAT[M←(+/MRINDX[⍳I-1])+⍳MRINDX[I];]
[18]   BSTAT←MBSTAT[M;]
[19]   M2←+/M1←(,RSTAT[;5])>0.01
[20]   M←1↑⍴RSTAT
[21]   MU1←MU1,[1]((+/M1/,RSTAT[;5])÷M2),((+/M1/,RSTAT[;8])÷M2)
[22]   MU2←MU2,[1]((+/M1/,BSTAT[;5])÷M2),((+/M1/,BSTAT[;8])÷M2)
[23]   MUR←MUR,[1]((+/RSTAT[;11])÷M),((+/,RSTAT[;14])÷M)
[24]   MUD1←MUD1,[1]((+/M1/,RSTAT[;17])÷M2),((+/M1/,RSTAT[;20])÷M2)
[25]   MUD2←MUD2,[1]((+/M1/,BSTAT[;17])÷M2),((+/M1/,BSTAT[;20])÷M2)
[26]   →LOOP
[27]  DONE:→0
      ∇
```

APPENDIX IV.3

Workspace CCGSTAT

Functions for Statistical Computations

```
     ∇CDIFF[⎕]∇
     ∇ DDAT←CDIFF DAT;BTIM;ETIM;MDAT;I;J;T;TM1;TM2;FAC;MA1;MB1;MA2;MB2;FNAM
[1]   ⍝  GET THE DIFFERENCES BETWEEN DATA AT A REMOTE SITE AND THE MONITOR.
[2]   ⍝   DATA FOR REMOTE SITE IS ASSUMED TO EXIST IN VARIABLE 'DAT'.
[3]   ⍝   FIND SPAN OF REMOTE SITE DATA AND ADD 0.1 HOURS ON EACH SIDE
[4]   ⍝                 B.G.NICKERSON, DEC.,1982
[5]    BTIM←DAT[1;1]+(DAT[1;2]-0.1)÷100
[6]    ETIM←DAT[(1↑⍴DAT);1]+((DAT[(1↑⍴DAT);2]+0.1)÷100)
[7]   ⍝  GET MONITOR DATA FOR THIS TIME SPAN
[8]    DDAT←(0,10)⍴0
[9]    FNAM←FILNAM
[10]   FILNAM←'CCGLORAN.KETCH'
[11]   MDAT←10 GETLOR(BTIM,ETIM)
[12]   FILNAM←FNAM
[13]   ⍎(2>1↑⍴MDAT)/'→0,⍴⎕←''ERROR. NO MONITOR DATA FOR THIS TIME SPAN.'''
[14]  ⍝  INITIALIZE
[15]   J←1
[16]   I←1
[17]  ⍝  LOOP FOR REMOTE SITE DATA POINTS
[18]  NEXTJ:T←DAT[J;1]+DAT[J;2]÷24
[19]  ⍝  LOOP TO INTERPOLATE MONITOR DATA POINTS
[20]  NEXTI:TM1←MDAT[I;1]+MDAT[I;2]÷24
[21]   TM2←MDAT[I+1;1]+MDAT[I+1;2]÷24
[22]   →(TM1≤T)/OK
[23]   'WARNING.  MONITOR DATA BEGINS AFTER REMOTE DATA.'
[24]   J←J+1
[25]   →NEXTJ
[26]  OK:→INT×⍳TM2≥T
[27]   →NEXTI×⍳(1↑⍴MDAT)>I←I+1
[28]   →0,⍴⎕←'WARNING.  MONITOR DATA ENDS BEFORE REMOTE DATA.'
[29]  INT:FAC←(T-TM1)÷(TM2-TM1)
[30]  ⍝  COMPUTE AND STORE DIFFERENCES AND THEIR STANDARD DEVIATIONS
[31]   CSDIFF
[32]   →NEXTJ×⍳(1↑⍴DAT)≥J←J+1
     ∇
```

```
     ∇CSDIFF[⎕]∇
     ∇ CSDIFF;DA1;DA2;DB1;DB2;SA1;SA2;SB1;SB2;VMA1;VMA2;VMB1;VMB2
[1]  ⍝  COMPUTE AND STORE DIFFERENCES AND THEIR STANDARD DEVIATIONS FOR
[2]  ⍝   DIFFERENTIAL LORAN-C STATISTICS TABLES.       B.G.N. FEB, 1983
[3]  ⍝  DIFFERENCES
[4]   DA1←DAT[J;3]-(FAC×MDAT[I+1;3]-MDAT[I;3])+MDAT[I;3]
[5]   DA2←DAT[J;3]-(FAC×MDAT[I+1;7]-MDAT[I;7])+MDAT[I;7]
[6]   DB1←DAT[J;5]-(FAC×MDAT[I+1;5]-MDAT[I;5])+MDAT[I;5]
[7]   DB2←DAT[J;5]-(FAC×MDAT[I+1;9]-MDAT[I;9])+MDAT[I;9]
[8]  ⍝  VARIANCES OF INTERPOLATED MONITOR VALUES
[9]   VMA1←(((1-FAC)*2)×(MDAT[I;4]*2))+(FAC*2)×MDAT[I+1;4]*2
[10]  VMA2←(((1-FAC)*2)×(MDAT[I;8]*2))+(FAC*2)×MDAT[I+1;8]*2
[11]  VMB1←(((1-FAC)*2)×(MDAT[I;6]*2))+(FAC*2)×MDAT[I+1;6]*2
[12]  VMB2←(((1-FAC)*2)×(MDAT[I;10]*2))+(FAC*2)×MDAT[I+1;10]*2
[13] ⍝  STANDARD DEVIATIONS OF DIFFERENCES
[14]  SA1←((DAT[J;4]*2)+VMA1)*0.5
[15]  SA2←((DAT[J;4]*2)+VMA2)*0.5
[16]  SB1←((DAT[J;6]*2)+VMB1)*0.5
[17]  SB2←((DAT[J;6]*2)+VMB2)*0.5
[18] ⍝  ASSIGN DATA TO THEIR PROPER PLACE IN DIFFERENCE DATA ARRAY
[19]  DDAT←DDAT,[1] DAT[J; 1 2],DA1,SA1,DB1,SB1,DA2,SA2,DB2,SB2
     ∇
```

```
      ∇CSTAT[⎕]∇
      ∇ CSTAT;BTIM;ETIM;M;BTIM2;ETIM2;S
[1]   ⍝  SERVICE FUNCTION FOR 'STAT', ASSIGN MEANS AND STANDARD DEVIATIONS TO
[2]   ⍝   RSTAT AND BSTAT.                              B.G.N.  JAN.1983
[3]    BTIM←RDAT[1;1]+((⌊RDAT[1;2])÷100)+((1|RDAT[1;2])×60)÷10000
[4]    M←1↑⍴RDAT
[5]    ETIM←RDAT[M;1]+((⌊RDAT[M;2])÷100)+((1|RDAT[M;2])×60)÷10000
[6]    M←1↑⍴DIFDAT
[7]    S←1000*2
[8]    ⍎(M=0)/'BTIM2←ETIM2←0'
[9]    ⍎(M=0)/'→NEXT'
[10]   BTIM2←DIFDAT[1;1]+((⌊DIFDAT[1;2])÷100)+((1|DIFDAT[1;2])×60)÷10000
[11]   ETIM2←DIFDAT[M;1]+((⌊DIFDAT[M;2])÷100)+((1|DIFDAT[M;2])×60)÷10000
[12]  NEXT:RSTAT←RSTAT,[1] 25⍴0
[13]   BSTAT←BSTAT,[1] 25⍴0
[14]   M←1↑⍴RSTAT
[15]   RSTAT[M; 1 2]←BTIM,ETIM
[16]   RSTAT[M; 3 4]←BTIM2,ETIM2
[17]   →RSITE×⍳0=1↑⍴MDAT
[18]   RSTAT[M; 5 6]←MUSIG(,MDAT[;3])
[19]   RSTAT[M;7]←((S×RSTAT[M;6]*2)+(+/(,MDAT[;4])*2)÷(1↑⍴MDAT))*0.5
[20]   RSTAT[M; 8 9]←MUSIG(,MDAT[;5])
[21]   RSTAT[M;10]←((S×RSTAT[M;9]*2)+(+/(,MDAT[;6])*2)÷(1↑⍴MDAT))*0.5
[22]   RSTAT[M; 17 18]←MUSIG(,DIFDAT[;3])
[23]   RSTAT[M;19]←((S×RSTAT[M;18]*2)+(+/(,DIFDAT[;4])*2)÷(1↑⍴DIFDAT))*0.5
[24]   RSTAT[M; 20 21]←MUSIG(,DIFDAT[;5])
[25]   RSTAT[M;22]←((S×RSTAT[M;21]*2)+(+/(,DIFDAT[;6])*2)÷(1↑⍴DIFDAT))*0.5
[26]  RSITE:RSTAT[M; 11 12]←MUSIG(,RDAT[;3])
[27]   RSTAT[M;13]←((S×RSTAT[M;12]*2)+(+/(,RDAT[;4])*2)÷(1↑⍴RDAT))*0.5
[28]   RSTAT[M; 14 15]←MUSIG(,RDAT[;5])
[29]   RSTAT[M;16]←((S×RSTAT[M;15]*2)+(+/(,RDAT[;6])*2)÷(1↑⍴RDAT))*0.5
[30]   BSTAT[M; 1 2 3 4]←BTIM,ETIM,BTIM2,ETIM2
[31]   →BSITE×⍳0=1↑⍴MDAT
[32]   BSTAT[M; 5 6]←MUSIG(,MDAT[;7])
[33]   BSTAT[M;7]←((S×BSTAT[M;6]*2)+(+/(,MDAT[;8])*2)÷(1↑⍴MDAT))*0.5
[34]   BSTAT[M; 8 9]←MUSIG(,MDAT[;9])
[35]   BSTAT[M;10]←((S×BSTAT[M;9]*2)+(+/(,MDAT[;10])*2)÷(1↑⍴MDAT))*0.5
[36]   BSTAT[M; 17 18]←MUSIG(,DIFDAT[;7])
[37]   BSTAT[M;19]←((S×BSTAT[M;18]*2)+(+/(,DIFDAT[;8])*2)÷(1↑⍴DIFDAT))*0.5
[38]   BSTAT[M; 20 21]←MUSIG(,DIFDAT[;9])
[39]   BSTAT[M;22]←((S×BSTAT[M;21]*2)+(+/(,DIFDAT[;10])*2)÷(1↑⍴DIFDAT))*0.5
[40]  BSITE:BSTAT[M; 11 12 13 14 15 16]←RSTAT[M; 11 12 13 14 15 16]
[41]  ⍝  COMPUTE AND STORE CORRELATIONS BETWEEN TDA'S AND TDB'S
[42]   BSTAT[M;24]←RSTAT[M;24]←((+/(,RDAT[;3]-RSTAT[M;11])×(,RDAT[;5]-RSTAT[M;14]))÷1↑
       ⍴RDAT)÷RSTAT[M;12]×RSTAT[M;15]
[43]   ⍎(1<1↑⍴MDAT)/'→OKAY'
[44]   RSTAT[M;23]←BSTAT[M;23]←0
[45]   →CHEKDIF
[46]  OKAY:RSTAT[M;23]←((+/(,MDAT[;3]-RSTAT[M;5])×(,MDAT[;5]-RSTAT[M;8]))÷1↑⍴MDAT)÷
        RSTAT[M;6]×RSTAT[M;9]
[47]   BSTAT[M;23]←((+/(,MDAT[;7]-BSTAT[M;5])×(,MDAT[;9]-BSTAT[M;8]))÷1↑⍴MDAT)÷BSTAT[M
       ;6]×BSTAT[M;9]
[48]  CHEKDIF:⍎(1<1↑⍴DIFDAT)/'→OKAYD'
[49]   RSTAT[M;25]←BSTAT[M;25]←0
[50]   →0
[51]  OKAYD:RSTAT[M;25]←((+/(,DIFDAT[;3]-RSTAT[M;17])×(,DIFDAT[;5]-RSTAT[M;20]))÷1↑⍴
        DIFDAT)÷RSTAT[M;18]×RSTAT[M;21]
[52]   BSTAT[M;25]←((+/(,DIFDAT[;7]-BSTAT[M;17])×(,DIFDAT[;9]-BSTAT[M;20]))÷1↑⍴DIFDAT)
       ÷BSTAT[M;18]×BSTAT[M;21]
      ∇
```

```
     ∇GETLOR[⎕]∇
     ∇ Z←NCOL GETLOR TIM;T;TZ;TIME;BTIM;ETIM;I;IMAX;IMIN;BEGIN;TEMP
    ⍝
    ⍝  GET LORAN-C DATA BETWEEN STARTING DECIMAL DAY TIM[1] AND ENDING
    ⍝   DECIMAL DAY TIM[2]. NCOL IS THE NO. OF COLUMNS OF DATA STORED
    ⍝   ON FILE 'FILNAM'.
    ⍝
     ⎕IO←1
     Z←(0,NCOL)⍴0
     BTIM←(⌊TIM[1])+((TIM[1]-⌊TIM[1])×100)÷24
     ETIM←(⌊TIM[2])+((TIM[2]-⌊TIM[2])×100)÷24
     ((2,3)⍴'IN REC') TRY 'IR DSN= ',FILNAM,' ,CODE=S'
     TIMER←⎕AI[2 3]
    ⍝  BINARY SEARCH FOR BEGINNING TIME RECORD
     IMIN←0
     IMAX←((NCOL=10),(NCOL=6))/24061,RMAX[RSITE]
    NEXT:I←⌊0.01+(IMAX+IMIN)÷2
     IN←(0,I)
     →((1⍴0)≢TEMP←IN)/ERR
     TZ←2↑NCOL⍴⍎REC
     T←TZ[1]+TZ[2]÷24
     →(I=IMIN)/FOUND
     →(T=BTIM)/FOUND
     ⍎(T<BTIM)/'IMIN←I'
     ⍎(T>BTIM)/'IMAX←I'
     →NEXT
    ERR:'ERROR IN READING FILE ',FILNAM,'. CTL=',⍕,TEMP
     →0
    FOUND:BEGIN←I+T<BTIM
    ⍝  READ IN REQUIRED RECORDS
     I←0
    LOOP:IN←0,(BEGIN+I)
     →(24=IN)/DONE
     TZ←2↑NCOL⍴⍎REC
     TIME←TZ[1]+TZ[2]÷24
     →(TIME>ETIM)/DONE
     Z←Z,[1] NCOL⍴⍎REC
     I←I+1
     →LOOP
    DONE:(TIMER),' FOR ',(⍕I),' RECORDS (GETLOR).'
     ∇
```

```
    ∇MOVE[⎕]∇
    ∇ MOVE;I;M;M1;M2;RSTAT;BSTAT;DELA1;DELA2;DELB1;DELB2;HX;HY;AX;AY;RX1;RX2;VIS;A;
      DP1;DP2;COMP;DELA;DELB;RX3;DP3
     ⍝  COMPUTE MOVEMENT OF REMOTE SITES IN METRES BASED
     ⍝   ON TDA, TDB CHANGES IN MICROSECONDS   B.G.N. MARCH, 1983
     ⍝  LOOP ON SITES
     I←0
     VIS←VIS1,VIS2,VIS3,VIS4,VIS5
     VIS←⍉(5,23)⍴VIS
     R1←R2←R3←(0,(5×7))⍴''
     MTD←(0,6)⍴0
    LOOP:→(23<I←I+1)/DONE
     RSTAT←MRSTAT[M←(+/MRINDX[⍳I-1])+⍳MRINDX[I];]
     BSTAT←MBSTAT[M;]
     M2←+/M1←(,RSTAT[;5])>0.01
     M←1↑⍴RSTAT
    ⍝  SPECIAL CASES
     COMP←M2⍴1
     ⍎(I=1)/'COMP←0 1 1 1 1'
     ⍎(I=6)/'COMP←1 0 1 1 1'
    ⍝  COMPUTE THE VECTORS OF TD DIFFERENCES FROM THE MEAN VALUES
     DELA1←COMP/(M1/,RSTAT[;17])-(+/M1/,RSTAT[;17])÷M2
     DELA2←COMP/(M1/,BSTAT[;17])-(+/M1/,BSTAT[;17])÷M2
     DELB1←COMP/(M1/,RSTAT[;20])-(+/M1/,RSTAT[;20])÷M2
     DELB2←COMP/(M1/,BSTAT[;20])-(+/M1/,BSTAT[;20])÷M2
     ⍎((I≠6)∧(I≠1))/'COMP←M⍴1'
     DELA←COMP/(,RSTAT[;11])-(+/,RSTAT[;11])÷M
     DELB←COMP/(,RSTAT[;14])-(+/,RSTAT[;14])÷M
    ⍝  DEFINE RMS VALUES FOR DIFFERENCES FOR ALL VISITS
     SA1←1000×((+/,DELA1*2)÷M2)*0.5
     SA2←1000×((+/,DELA2*2)÷M2)*0.5
     SB1←1000×((+/,DELB1*2)÷M2)*0.5
     SB2←1000×((+/,DELB2*2)÷M2)*0.5
     SA←1000×((+/,DELA*2)÷M)*0.5
     SB←1000×((+/,DELB*2)÷M)*0.5
     MTD←MTD,[1] SA,SB,SA1,SB1,SA2,SB2
    ⍝  DEFINE A MATRIX TO TRANSFORM FROM TD TO N,E
     HX←150×1÷1○(SITANG[I;2]÷2)×○÷180
     HY←150×1÷1○(SITANG[I;3]÷2)×○÷180
     AX←(SITANG[I;1]-SITANG[I;2]÷2)×○÷180
     AY←(SITANG[I;1]+(SITANG[I;3]÷2)-180)×○÷180
     A←(2,2)⍴((1○AX)÷HX),(-(2○AX)÷HX),(-(1○AY)÷HY),((2○AY)÷HY)
    ⍝  LOOP ON VISITS
     RX1←RX2←RX3←''
     J←0
     K←0
    LOOPV:→(5<J←J+1)/SAVE
     ⍎(VIS[I;J]=1)/'K←K+1'
     →STOREB×⍳VIS[I;J]=0
     DP1←,(⌹A)+.×(2,1)⍴DELA1[K],DELB1[K]
     DP2←,(⌹A)+.×(2,1)⍴DELA2[K],DELB2[K]
     DP3←,(⌹A)+.×(2,1)⍴DELA[K],DELB[K]
    STORE:RX1←RX1,,'F7.1'⍕((DP1[1]*2)+(DP1[2]*2))*0.5
     RX2←RX2,,'F7.1'⍕((DP2[1]*2)+(DP2[2]*2))*0.5
     RX3←RX3,,'F7.1'⍕((DP3[1]*2)+(DP3[2]*2))*0.5
     →LOOPV
    STOREB:RX1←RX1,7⍴' '
     RX2←RX2,7⍴' '
     RX3←RX3,7⍴' '
     →LOOPV
    ⍝  SAVE DATA FOR PRINTING
    SAVE:R1←R1,[1] RX1
     R2←R2,[1] RX2
     R3←R3,[1] RX3
     →LOOP
    ⍝  PRINT DATA
    DONE:PRINTD
    ∇
```

```
      ∇MUSIG[⎕]∇
      ∇ VAL←MUSIG DAT;N
[1]   ⍝  COMPUTE MEAN AND STANDARD DEVIATION FOR VECTOR DAT, B.G.N. JAN.1983
[2]     N←⍴DAT
[3]     VAL←2⍴0
[4]     →0×⍳N=0
[5]     VAL[1]←(+/DAT)÷N
[6]     ⍎(N>1)/' VAL[2]←((+/(DAT-VAL[1])*2)÷(N-1))*0.5'
      ∇
```

```
      ∇PRINTD[⎕]∇
      ∇ PRINTD
[1]  ⍝  PRINT METRE MOVEMENTS OF REMOTE SITES
[2]   '                                         REMOTE SITE MOVEMENT IN METRES'
[3]   '                                         -------------------------------'
[4]   ' '
[5]   '        ----DIFFERENCE SERIAL NO. 2220----  ----DIFFERENCE SERIAL NO. 1017----
       -------------RAW DATA-------------'
[6]   ' SITE  ',108ρ' VISIT1 VISIT2 VISIT3 VISIT4 VISIT5 '
[7]   ((23,1)ρ' '),[2](⍕(23,1)ρ⍳23),[2]((23,2)ρ' '),[2] R1,[2]((23,1)ρ' '),[2] R2,[2]
      ((23,1)ρ' '),[2] R3
      ∇


      ∇PRINTTD[⎕]∇
      ∇ PRINTTD
[1]  ⍝  PRINT TD SUMMARY
[2]   '      RMS OF ALL VISITS IN NANOSECONDS'
[3]   '      --------------------------------'
[4]   ' '
[5]   ' SITE  RAW DATA    DIFF. 2220   DIFF. 1017'
[6]   '       TDA  TDB     TDA  TDB     TDA  TDB'
[7]   'I4,X1,2I5,X3,2I5,X3,2I5'⍕((23,1)ρ⍳23),[2] MTD
      ∇
```

```
      ∇RINDX[⎕]∇
      ∇ RINDX N;BLANK
[1]   BLANK←(N,3)⍴' '
[2]   (⍕(N,1)⍴⍳N),[2] BLANK,[2] RFNAME,[2] BLANK,[2] RNAME,[2] BLANK,[2](⍕(N,1)⍴RMAX)
      ∇
```

```
      ∇SPRINT[⎕]∇
      ∇ SPRINT;F1;F2;F3;IVEC;DELA1;DELB1;M;M1;M2;DELA2;DELB2;MU1;MU2;SA1;SA2;SB1;SB2;
        F4;RM;T
[1]   ⍝  PRINT STATISTICS FOR LORAN-C STATISTICS TABLE, RSTAT= RED MONITOR (S,N, 2220)
[2]   ⍝   STATISTICS; BSTAT= BLUE MONITOR (S,N, 1017) STATISTICS, B,G,N, JAN,1983
[3]    RSTAT←MRSTAT[M←(+/MRINDX[⍳RSITE-1])+⍳MRINDX[RSITE];]
[4]    BSTAT←MBSTAT[(+/MBINDX[⍳RSITE-1])+⍳MBINDX[RSITE];]
[5]    NR←NUMR[M]
[6]    ND←NUMD[M]
[7]    NM←NUMM[M]
[8]    M←1↑⍴RSTAT
[9]    M1←29+RSITE>9
[10]   ('X35,',(⍕M1),'A1')⍕(1,M1)⍴'-'
[11]   ('X35,',(⍕M1),'A1')⍕(1,M1)⍴'⋄ ',(⍕RSITE),', ',RNAME[RSITE;],' STATISTICS ⋄'
[12]   ('X35,',(⍕M1),'A1')⍕(1,M1)⍴'¯'
[13]   ' '
[14]   ' '
[15]   '                                             MONITOR (SERIAL NO, 2220)'
[16]   F2←'     TIME SPAN      NUM | MEAN TDA (SD1)(SD2)    DEL1    DEL2 | MEAN TDB (SD1)(
       SD2)    DEL1    DEL2 |    RHO'
[17]   F2
[18]   IVEC← 6 9 12 15 18 21
[19]   F3←'F8.4,"-",F8.4,X1,I3," | ",F9.3,"(",I3,")(",I3,")",2(X1,F6.3)," | ",F9.3,"("
       ,I3,")(",I3,")",2(X1,F6.3)," | ",F6.3'
[20]   M2←+/M1←(,RSTAT[;5])>0.01
[21]   DELA1←(M2,1)⍴(M1/,RSTAT[;5])-MU1←(+/M1/,RSTAT[;5])÷M2
[22]   DELA2←(M2,1)⍴(M1/,RSTAT[;5])-(1↑M1/,RSTAT[;5])
[23]   DELB1←(M2,1)⍴(M1/,RSTAT[;8])-MU2←(+/M1/,RSTAT[;8])÷M2
[24]   DELB2←(M2,1)⍴(M1/,RSTAT[;8])-(1↑M1/,RSTAT[;8])
[25]   RSTAT[;IVEC]←1000×RSTAT[;IVEC]
[26]   F3⍕(M1/[1] RSTAT[; 3 4]),[2]((M2,1)⍴M1/NM),[2](M1/[1] RSTAT[; 5 6 7]),[2] DELA1
       ,[2] DELA2,[2](M1/[1] RSTAT[; 8 9 10]),[2] DELB1,[2] DELB2,[2](M1/[1] RSTAT[;23
       ])
[27]   SA1←1000×((+/,DELA1⋆2)÷M2-1)⋆0.5
[28]   SA2←((SA1⋆2)+(+/M1/,RSTAT[;7]⋆2)÷(M2))⋆0.5
[29]   SB1←1000×((+/,DELB1⋆2)÷M2-1)⋆0.5
[30]   SB2←((SB1⋆2)+(+/M1/,RSTAT[;10]⋆2)÷(M2))⋆0.5
[31]   RM←(+/T)÷+/1E¯6<|T←M1/,RSTAT[;23]
[32]   F4←'X3,"MEAN VALUE",X9,2("| ",F9.3,"(",I3,")(",I3,")",X15),"| ",F6.3'
[33]   F4⍕ 1 7 ⍴MU1,SA1,SA2,MU2,SB1,SB2,RM
[34]   DELA1←(M2,1)⍴(M1/,BSTAT[;5])-MU1←(+/M1/,BSTAT[;5])÷M2
[35]   DELA2←(M2,1)⍴(M1/,BSTAT[;5])-(1↑M1/,BSTAT[;5])
[36]   DELB1←(M2,1)⍴(M1/,BSTAT[;8])-MU2←(+/M1/,BSTAT[;8])÷M2
[37]   DELB2←(M2,1)⍴(M1/,BSTAT[;8])-(1↑M1/,BSTAT[;8])
[38]   ' '
[39]   '                                             MONITOR (SERIAL NO, 1017)'
[40]   F2
[41]   BSTAT[;IVEC]←BSTAT[;IVEC]×1000
[42]   F3⍕(M1/[1] BSTAT[; 3 4]),[2]((M2,1)⍴M1/NM),[2](M1/[1] BSTAT[; 5 6 7]),[2] DELA1
       ,[2] DELA2,[2](M1/[1] BSTAT[; 8 9 10]),[2] DELB1,[2] DELB2,[2](M1/[1] BSTAT[;23
       ])
[43]   SA1←1000×((+/,DELA1⋆2)÷M2-1)⋆0.5
[44]   SA2←((SA1⋆2)+(+/M1/,BSTAT[;7]⋆2)÷M2)⋆0.5
[45]   SB1←1000×((+/,DELB1⋆2)÷M2-1)⋆0.5
[46]   SB2←((SB1⋆2)+(+/M1/,BSTAT[;10]⋆2)÷M2)⋆0.5
[47]   RM←(+/T)÷+/1E¯6<|T←M1/,BSTAT[;23]
[48]   F4⍕ 1 7 ⍴MU1,SA1,SA2,MU2,SB1,SB2,RM
[49]   SPRINT2
      ∇
```

```
      ∇SPRINT2[⎕]∇
      ∇ SPRINT2;T
[1]   ⍝  SERVICE FUNCTION FOR SPRINT ROUTINE
[2]   ' '
[3]   ⍎(RSITE≤10)/'''                                                      VAN SITE '',RNAME[RSI
      TE;]'
[4]   ⍎(RSITE>10)/'''                                               HELICOPTER SITE '',RNAME[RSI
      TE;]'
[5]   DELA1←(M,1)⍴(,RSTAT[;11])-MU1←(+/,RSTAT[;11])÷M
[6]   DELA2←(M,1)⍴(,RSTAT[;11])-(RSTAT[1;11])
[7]   DELB1←(M,1)⍴(,RSTAT[;14])-MU2←(+/,RSTAT[;14])÷M
[8]   DELB2←(M,1)⍴(,RSTAT[;14])-RSTAT[1;14]
[9]   F2
[10]  F3⍕RSTAT[; 1 2],[2]((M,1)⍴NR),[2] RSTAT[; 11 12 13],[2] DELA1,[2] DELA2,[2]
       RSTAT[; 14 15 16],[2] DELB1,[2] DELB2,[2] RSTAT[;24]
[11]  F2←'    TIME SPAN      NUM |  DIFF TDA(SD1)(SD2)    DEL1    DEL2 |  DIFF TDB(SD1)(
      SD2)    DEL1    DEL2 |    RHO'
[12]  SA1←1000×((+/,DELA1*2)÷M-1)*0.5
[13]  SA2←((SA1*2)+(+/,RSTAT[;13]*2)÷M)*0.5
[14]  SB1←1000×((+/,DELB1*2)÷M-1)*0.5
[15]  SB2←((SB1*2)+(+/,RSTAT[;16]*2)÷M)*0.5
[16]  RM←(+/,RSTAT[;24])÷M
[17]  F4⍕ 1 7 ⍴MU1,SA1,SA2,MU2,SB1,SB2,RM
[18]  ' '
[19]  '                                   DIFFERENCE ',RNAME[RSITE;],' - MONITOR (SERIAL N
      O. 2220)'
[20]  DELA1←(M2,1)⍴(M1/,RSTAT[;17])-(+/M1/,RSTAT[;17])÷M2
[21]  DELA2←(M2,1)⍴(M1/,RSTAT[;17])-MU1←(1↑M1/,RSTAT[;17])
[22]  DELB1←(M2,1)⍴(M1/,RSTAT[;20])-(+/M1/,RSTAT[;20])÷M2
[23]  DELB2←(M2,1)⍴(M1/,RSTAT[;20])-MU2←(1↑M1/,RSTAT[;20])
[24]  F2
[25]  F3⍕(M1/[1] RSTAT[; 3 4]),[2]((M2,1)⍴M1/ND),[2](M1/[1] RSTAT[; 17 18 19]),[2]
       DELA1,[2] DELA2,[2](M1/[1] RSTAT[; 20 21 22]),[2] DELB1,[2] DELB2,[2](M1/[1]
       RSTAT[;25])
[26]  SA1←1000×((+/,DELA1*2)÷M2-1)*0.5
[27]  SA2←((SA1*2)+(+/M1/,RSTAT[;19]*2)÷M2)*0.5
[28]  SB1←1000×((+/,DELB1*2)÷M2-1)*0.5
[29]  SB2←((SB1*2)+(+/M1/,RSTAT[;22]*2)÷M2)*0.5
[30]  RM←(+/T)÷+/1E¯6<|T←M1/,RSTAT[;25]
[31]  F4⍕ 1 7 ⍴MU1,SA1,SA2,MU2,SB1,SB2,RM
[32]  ' '
[33]  '                                   DIFFERENCE ',RNAME[RSITE;],' - MONITOR (SERIAL N
      O. 1017)'
[34]  DELA1←(M2,1)⍴(M1/,BSTAT[;17])-MU1←(+/M1/,BSTAT[;17])÷M2
[35]  DELA2←(M2,1)⍴(M1/,BSTAT[;17])-(1↑M1/,BSTAT[;17])
[36]  DELB1←(M2,1)⍴(M1/,BSTAT[;20])-MU2←(+/M1/,BSTAT[;20])÷M2
[37]  DELB2←(M2,1)⍴(M1/,BSTAT[;20])-(1↑M1/,BSTAT[;20])
[38]  F2
[39]  F3⍕(M1/[1] BSTAT[; 3 4]),[2]((M2,1)⍴M1/ND),[2](M1/[1] BSTAT[; 17 18 19]),[2]
       DELA1,[2] DELA2,[2](M1/[1] BSTAT[; 20 21 22]),[2] DELB1,[2] DELB2,[2](M1/[1]
       BSTAT[;25])
[40]  SA1←1000×((+/,DELA1*2)÷M2-1)*0.5
[41]  SA2←((SA1*2)+(+/M1/,BSTAT[;19]*2)÷M2)*0.5
[42]  SB1←1000×((+/,DELB1*2)÷M2-1)*0.5
[43]  SB2←((SB1*2)+(+/M1/,BSTAT[;22]*2)÷M2)*0.5
[44]  RM←(+/T)÷+/1E¯6<|T←M1/,BSTAT[;25]
[45]  F4⍕ 1 7 ⍴MU1,SA1,SA2,MU2,SB1,SB2,RM
[46]  BSTAT[;IVEC]←BSTAT[;IVEC]×0.001
[47]  RSTAT[;IVEC]←RSTAT[;IVEC]×0.001
      ∇
```

```
      ∇STAT[⎕]∇
      ∇ RSITE STAT TINT;TZ;TIM;PTIM;RDAT;MDAT;DIFDAT;BTIM;ETIM;IDONE;M;I;TEMP
[1]   ⍝  COMPUTE STATISTICS FOR C.C.G. DIFFERENTIAL LORAN-C
[2]   ⍝   INVESTIGATION. RSITE= REMOTE SITE NO.; TINT= TIME INTERVAL TO
[3]   ⍝   TREAT AS NEW DATA (DAYS).               B.G.N.  JAN.1983
[4]    FILNAME←RFNAME[RSITE;]
[5]   ⍝  OPEN REMOTE DATA FILE
[6]    ⎕IO←1
[7]    ((2,3)⍴'JN RED') TRY 'IR DSN= ',FILNAME,' ,CODE=S'
[8]   ⍝  GET FIRST RECORD
[9]    I←0
[10]   PTIM←-99
[11]   RDAT← 0 6 ⍴0
[12]   RSTAT← 0 25 ⍴0
[13]   BSTAT← 0 25 ⍴0
[14]   ND←NR←NM←0⍴0
[15]   IDONE←1
[16] NEXTREC:JN←(0,I)
[17]   →((1⍴0)≠TEMP←JN)/ERR
[18]   TZ←6⍴⍎RED
[19]   TIM←TZ[1]+(TZ[2]÷24)
[20] ⍝  CHECK IF DATA SPAN WAS LARGER THAN 'TINT'
[21]   RDAT←RDAT,[1] TZ
[22]   →((TINT<TIM-PTIM)∧(I≠0))/NEWSPAN
[23]   →(RMAX[RSITE]<I←I+1)/DONE
[24]   PTIM←TIM
[25]   →NEXTREC
[26] ⍝  ERROR IN READING
[27] ERR:'ERROR IN READING FILE ',FILNAME ', CTL=',⍕,TEMP
[28]   →0
[29] ⍝  FILE COMPLETED, SET FLAG
[30] DONE:IDONE←0
[31] ⍝  DATA SPAN COMPLETED , GET MONITOR DATA FOR THIS SPAN.
[32] NEWSPAN:⍎(IDONE)/'RDAT←((¯1+1↑⍴RDAT),6)⍴,RDAT'
[33]   BTIM←RDAT[1;1]+RDAT[1;2]÷100
[34]   ETIM←RDAT[(1↑⍴RDAT);1]+RDAT[(1↑⍴RDAT);2]÷100
[35]   MDAT←10 GETLOR(BTIM,ETIM)
[36]   M←1↑⍴MDAT
[37]   ⍎(M=0)/'DIFDAT←0 10⍴0'
[38]   →(M=0)/COMP
[39] ⍝  GET DIFFERENCE DATA FOR THIS TIME SPAN
[40]   DIFDAT←CDIFF RDAT
[41] ⍝  COMPUTE MEANS AND STANDARD DEVIATIONS, AND STORE IN APPROPRIATE PLACES
[42] COMP:CSTAT
[43]   PTIM←TIM
[44]   ND←ND,1↑⍴DIFDAT
[45]   NM←NM,1↑⍴MDAT
[46]   NR←NR,1↑⍴RDAT
[47]   RDAT← 0 6 ⍴0
[48]   →(IDONE)/NEXTREC
      ∇
```

```
      ∇STATS[⎕]∇
      ∇ STATS;I
[1]   ⍝  STATISTICS CONTROLLER
[2]    I←0
[3]   LOOP:→(23<I←I+1)/DONE
[4]    ⍎(I=5)/'1'
[5]    RSITE←I
[6]    RSITE STAT((I<11),(I>10))/0.01,0.002
[7]    UPDATE
[8]    SPRINT
[9]    →LOOP
[10]  DONE:→0
      ∇
```

```
      ∇UPDATE[⎕]∇
      ∇ UPDATE;MR;MB
[1]   ⍝  UPDATE THE MASTER STATISTICS MATRICES 'MRSTAT' AND 'MBSTAT',
[2]   ⍝   ALONG WITH THEIR INDEX VECTORS 'MRINDX' AND 'MBINDX'.  B.G.N. JAN. 1983
[3]    MRSTAT←MRSTAT,[1] RSTAT
[4]    MBSTAT←MBSTAT,[1] BSTAT
[5]    MRINDX←MRINDX,1↑⍴RSTAT
[6]    MBINDX←MBINDX,1↑⍴BSTAT
[7]    NUMR←NUMR,NR
[8]    NUMD←NUMD,ND
[9]    NUMM←NUMM,NM
      ∇
```