NOAA Technical Memorandum NOS NGS 62

United States-Japan Maritime Boundary Determination Survey

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Chief, National Geodetic Survey

Silver Spring, MD
August 1993

U. S. DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL OCEAN SERVICE
COAST AND GEODETIC SURVEY
NAUTICAL CHARTING DIVISION
PHOTOGRAMMETRY BRANCH

Project Report

United States - Japan
Maritime Boundary Determination Survey

Farrallon De Pajaros
Commonwealth of the Northern Mariana Islands

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I. INTRODUCTION

In 1977, the Japanese government declared a 200 nautical mile fishing limit surrounding its possessions. The United States extended fishing limits around the Commonwealth of the Northern Marianas to 200 nautical miles in 1978. These declared fishing limits overlap between Farrallon De Pajaros (Commonwealth of the Northern Marianas) and Minami - Io Shima (Japan) since the islands are separated by approximately 290 nautical miles.

Equidistant lines from points on the coastline that remain exposed at low water are generally to define maritime boundaries. Japan and the United States have agreed to conclude a maritime boundary using this technique. This report includes the technical data that the United States wishes to incorporate in the calculation of the equidistant line.

II LOCATION

The project area extended from the south end of Spain to the Northernmost point of Farrallon De Pajaros, Commonwealth of the Northern Mariana Islands. Transportation to and from Farrallon De Pajaros was provided by Macaw Helicopter Service located on Saipan. Due to the distance involved, the helicopter landed on Pagan Island for refueling on the way north. The survey and helicopter crew refueled and camped out overnight on Pagan Island on the return trip. Both Farrallon De Pajaros and Pagan were volcanically active. Special permission from the Commonwealth Civil Defense was required for landing and working on the islands. Farrallon De Pajaros is a declared wildlife sanctuary and therefore permission is required from the Commonwealth Fish and Wildlife Service.

II CONDITIONS AFFECTING PROGRESS

The survey was conducted under near flawless conditions. The sea state was near dead calm, atmospheric visibility reached 100 miles, and skies were cloud free. Without such conditions, transport to Farrallon De Pajaros would be difficult. Calm seas provided the required margin of safety for transport by single engine helicopter over 50 mile wide expanses of open ocean. Calm winds provided the required margin of fuel for transport from Saipan to Pagan.

IV TECHNICAL INFORMATION

A. Geodetic Datum

The datum for all coastline data and GPS calculations used in these findings are referenced to the World Geodetic Datum 1984 (WGS 84). Any chart references to the North American Datum 1983 should be considered functionally equivalent.

A. United States Basepoints

The National Ocean Service, the agency responsible for producing charts of U.S. waters has established the position of three coastal basepoints that may influence the course of an equidistant line (these points are identified on a copy of the accompanying inset to chart 81086). The following geographic coordinates have been determined by differential GPS techniques described in Section IV.C of this report. These coordinates represent the most seaward limit which could be safely occupied. It is estimated by on-site personnel that no point of land extends more than 20 meters north of Northern Point of Island.

NO 1	20° 32' 56.47"N	144° 54' 04.25"E
NPT 1993	20° 33' 11.14"N	144° 53' 33.16"E
Northern Point of Island	20° 33' 11.37"N	144° 53' 35.30"E

Results of May, 1992 Technical Report Relative to August, 1993

	East (M)	North (M)
NO 1	-109	-15
Northern Point of Island	-104	-49
NPT 1993	No Corresponding Point	

A. Methodology

This project established the geographic position of 4 points on the Farrallon De Pajaros using the Global Positioning System (GPS). Three dual frequency, precise code capable GPS receivers were used simultaneously to collect pseudo-range and carrier phase information broadcast by the GPS satellites. One receiver was equipped with a single frequency antenna limiting its capability to single frequency data collection. This receiver was used for short (1 KM) baselines only. All observations were combined in a double difference solution to compute very precise vectors between the receiver locations.

One receiver was located over a geodetic marker (SPN A 1993) in Saipan, Northern Marianas. A second receiver was located over a geodetic survey marker (JUDYEAGER 1993) on the east end of Farrallon De Pajaros. These receivers collected data from the same satellites for a period of approximately 2 hours and 50 minutes. This data set was used to position JUDYEAGE 1993 relative to SPN A 1993 to a relative accuracy of approximately 1 Part Per Million (PPM).

While the above receivers were operating, a third GPS receiver (with single frequency antenna) was positioned for 20 minutes each over three photo identifiable points on the northeast and northernmost points of the island. These points were positioned relative to JUDYEAGER 1993 to a relative accuracy of approximately 10 PPM.

The points positioned relative to JUDYEAGER 1993 on the Farrallon De Pajaros determine the orientation and northern extent of the island for the purpose of establishing the basepoints for equidistant lines.

A. Time Period

All relative positioning on and between Farrallon De Pajaros and Saipan was performed by simultaneous GPS carrier phase observations on Julian Day 225 (August 13, 1993) from 0424 UTC until 0713 UTC. Station SPN A 1993, on Saipan, was positioned by absolute GPS positioning techniques based upon dual frequency pseudo-range observation using data sets collected on August 13 and 14, 1993. The first data set commenced on Julian Day 224 at 2233 UTC and ended on Julian Day 225 at 1035 UTC. The second session commenced on Julian Day 225 at 2147 UTC and ended on Julian Day 226 at 0625 UTC.

A. Accuracy

Relative Positioning

As stated in IV.C of this report, data collection was designed to obtain Order B relative accuracy (7 mm + 1 PPM) for the position of JUDYEAGE 1993. Considering the distance (607 KM between the two stations, This order of relative proportional accuracy translates to a positional accuracy relative to SPN A 1993 of 0.61 m. Order B relative accuracy is based upon accepted U.S. Standards and Specifications published by the Federal Geographic Data Committee. The Root Mean Square (RMS) error computed as part of the double difference solution is 0.085 M (see Appendix 2 for solution summaries). Double differencing techniques using the carrier phase portion of the GPS signal minimizes the dominant effects of satellite and receiver clock errors and satellite orbit errors. The use of dual frequency observations minimizes the error due to ionospheric refraction (ion free solution) which manifests itself as a signal propagation delay. The use of Precise Code capable receivers enhances the capability of eliminating cyclic ambiguities in the carrier phase signal by incorporating smooth pseudo-range information into the solution.

Similar observing and processing techniques were used for stations NO 1, NPT 1993, and Northern Point on Island relative to JUDYEAGER 1993. Due to shorter observing sessions as noted in IV.C, and single frequency data, the positions for the above stations is assigned a relative accuracy of First Order (10 mm + 10 PPM). This order of relative proportional accuracy translates to a

positional accuracy relative to JUDYEAGER 1993 of 0.023 m. First Order relative accuracy is based upon accepted U.S. Standards and Specifications published by the Federal Geographic Data Committee. The Root Mean Square (RMS) error computed as part of the double difference solution is 0.012 m (see Appendix 2 for solution summaries).

Absolute Positioning

The position for SPN A 1993 was computed form pseudo-range observations obtain from two separate sessions. The broadcast ephemeris was used for determining the positions of the satellites. The computed position differed by 5.9 m between the first and second session. The mean position of these two data sets represents the adopted WGS 84 position for SPN A 1993. The absolute accuracy for SPN A 1993 is estimated to be 3 m based on the statistics of the solution and predicted orbital accuracies obtainable from the broadcast ephemeris.

V. FIELD WORK

A. Chronology

Refer to IV.D. of this report for the project chronology.

B. Survey Personnel

Captain Lewis A. Lapine, NOAA
Chief, National Geodetic Survey

Lieutenant William B. Kearse, NOAA
Aircraft Operations Center

William McLemore
Chief, Photogrammetry Branch Planning Section

C. Instrumentation

The instrumentation used for this project was 3 Trimble Navigation model 4000SSE carrier phase and precise coded pseudo range dual frequency GPS receivers (serial numbers 2686, 2733, and 2736). Two of the three antennas were Trimble Model 4000SSE dual frequency ground plane antennas. The third antenna was a Trimble Kinematic single frequency antenna.

D. Survey Monumentation

Station SPN A 1993 was monumented using a standard National Ocean Service brass disk stamped as above and cemented in a drill hole in a cement foundation at the Saipain International airport. Stations JUDYEAGER 1993 and NPT 1993

were monumented using a standard National Ocean Service brass disk stamped as above and cemented in a drill hole in large volcanic boulders. JUDYEAGER 1993 is the largest single boulder located on the west side of the island. Stations NO 1 and North Point of Island were not witnessed by brass disks but are the centers of large boulders which can be photo identified in subsequent aerial photography.

E. Data Processing

Data was logged into each receiver's internal memory using a 15 second collection rate. The data was stored using Trimble compressed format to maximize mission time. At the conclusion of Julian Day 225 the data files were downloaded to the hard drive of a portable laptop computer. The files were backed up to 3.5 inch floppy disks formatted to 1.44 megabytes. The position of SPN A 1993 was computed with National Geodetic Survey software package PSEUDOT. The baseline solutions for JUDYEAGE 1993, NPT 1993, NO 1, and North Point of Island were computed with National Geodetic Survey software OMNI.

F. Mathematical Adjustment

No network adjustment was performed. The vector between SPN A 1993 and JUDYEAGER 1993 was computed independently using an ion-free solution. Stations NO 1, NPT 1993 and North Point of Island were occupied one at a time using the same receiver and therefore their solutions are independent of any network design.

VI RECOMMENDATIONS

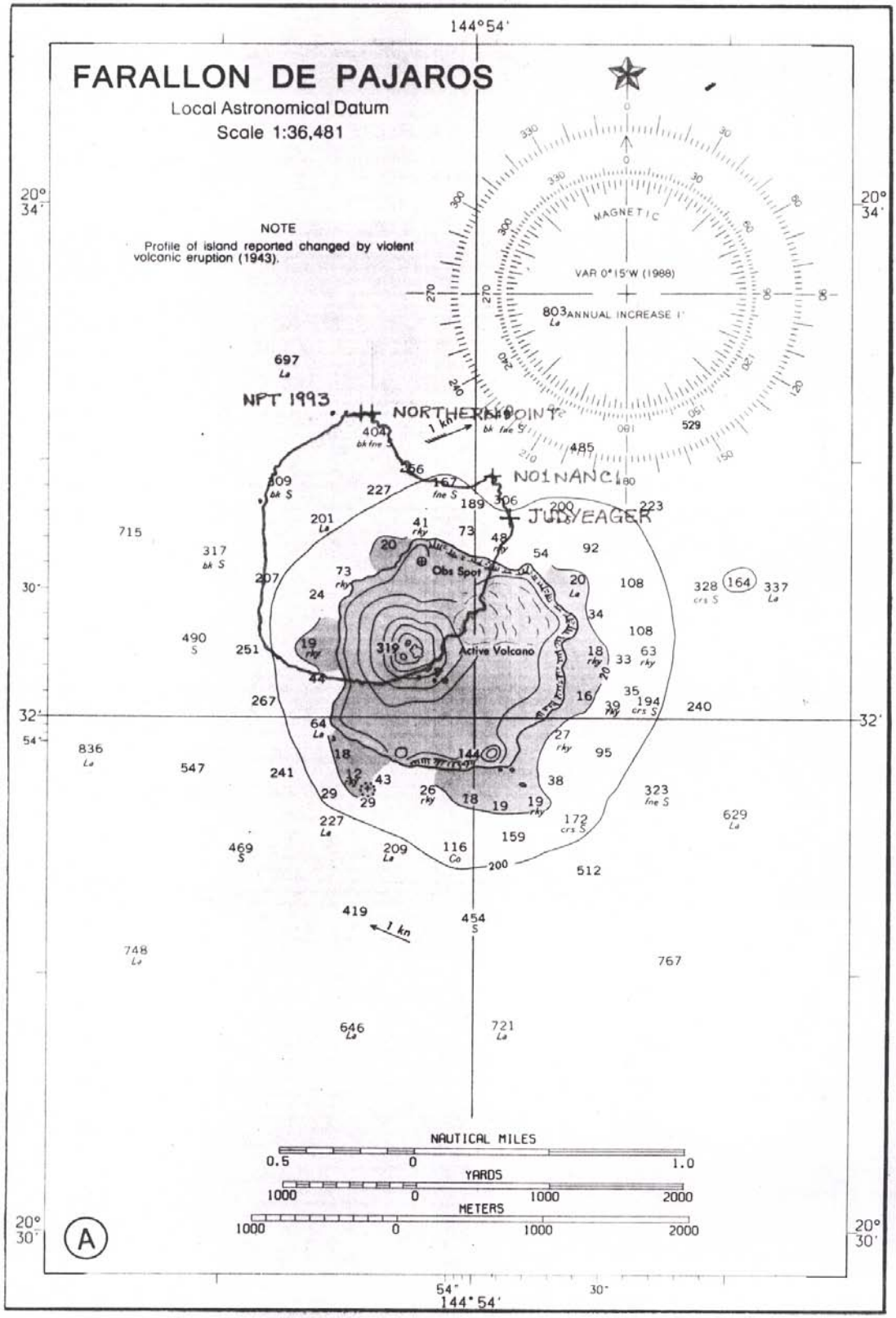
It is recommended that the position for North Point of Island be accepted as northernmost point of Farrallon De Pajaros for purpose of the basepoint for determining the equidistant line. Although some point may exist up to 20 meters north, its precise location would be difficult if not impossible to occupy. It is recommended that the United States State Department submit ths data as positive proof for the determination of the equidistant line.

VII ATTACHMENTS

Appendix 1 - Project Sketch
Appendix 2 - Field Logs
Appendix 3 - Processing Summaries from Program OMNI
Appendix 4 - Technical Report dated May 5, 1992

Respectfully Submitted;

Lewis A. Lapine
Captain, NOAA
Chief, National Geodetic Survey


144°54'
FARALLON DE PAJAROS
Local Astronomical Datum
Scale 1:36,481
NOTE
Profile of island reported changed by violent volcanic eruption (1943).
MAGNETIC
VAR 0°15'W (1988)
ANNUAL INCREASE 1'
NPT 1993
NORTHERN POINT
NO1NANC1
JUVEAGER
Obs Spot
Active Volcano
1 kn
NAUTICAL MILES
0.5
0
1.0
YARDS
1000
0
1000
2000
METERS
1000
0
1000
2000
20° 34'
20° 30'
30'
32'
54'
144°54'
A

PACIFIC PHOTOGRAMMETRIC PARTY - GPS STATION OBSERVATION LOG

STATION:	DATE:	JULIAN DAY:
PAGAN 1 USGS	8-14-93 (LOCAL)	225

STATE: QUAD:	SESSION ID:
N. Marinas	2733 - 225-2

REFERENCE POSITION: (DDD,MM,SS.SSSSS)	ELEVATION:
LAT: 18 07 33.491	MSL: 30.0 m
LONG: 145 45 25.852	GEOID HT: 46.0 m
	SUM = HT: 76.0 m

STATION ID:	ANTENNA HEIGHT ABOVE MARK
SESSION (utc): (START) 2105 UTC (END) 0215 UTC	TO TRIPOD HEAD:
DATA LOGGER VERSION: 5.46	HEAD TO ANT BASE:
LOCATION: Pagan Island	ANTENNA CONSTANT: 0.069
OBSERVER: LAC	SUM = ANTENNA HI =
RECEIVER S/N: 2733 4000SSE	MARK TO TOP GND PLANE EDGE = (Slope): 1.028 m
ANTENNA S/N: 3311A67284	ANTENNA WIDTH: 0.2334
BATTERY USED:	(SLOPE^2 - ANT WIDTH^2)$^{1/2}$ = 1.0022
FIXED HEIGHT TRIPOD = 2.069	PHASE HT ABOVE TOP OF GND PL: 0.0063
OTHER:	SUM SQRT + PHASE = ANT HI: 1.0085 m

WEATHER	START	MID	STOP	MEAN	
TIME UTC OR LOC	8/14 0737 (LOC)				
PRESSURE (Mbars)	in 29.85/1011				
WET/DRY TEMP °C	27.5/29.5				
REL HUM %	77 86				

WEATHER COMMENTS:

NOTES: (PUT RUBBING OR SKETCH OF MARK ON BACK)

This session is run currently with rcvr on SAIPAN
This pos'n will be used to establish Datum ties on Asuncion, Agrihan, Saipan

PPP6/28/93

PACIFIC PHOTOGRAMMETRIC PARTY - GPS STATION OBSERVATION LOG

STATION: Sarigan Datum	DATE: Local 8-14-93	JULIAN DAY: 226
STATE: N. Marinas QUAD:	SESSION ID: 2733 226 0	
REFERENCE POSITION: (DDD,MM,SS.SSSSS) LAT: ~~42°~~ 16° ~~20'~~ 42' 00" N LONG: 145° 47' 00" E	ELEVATION: MSL: 50m GEOID HT: -46 m SUM = HT: 4m	

STATION ID: ~~2733 226 0~~ SARI226A	ANTENNA HEIGHT ABOVE MARK
SESSION (utc): (START) 0430 (END) 0456	TO TRIPOD HEAD:
DATA LOGGER VERSION: 5.64	HEAD TO ANT BASE:
LOCATION: Sarigan Island	ANTENNA CONSTANT: 0.069
OBSERVER: LAR	SUM = ANTENNA HI =
RECEIVER S/N: 2733 4000SSE	MARK TO TOP GND PLANE EDGE = (Slope):
ANTENNA S/N: 331A67884	ANTENNA WIDTH: 0.2334
BATTERY USED:	$(SLOPE^2 - ANT\ WIDTH^2)^{1/2}$ =
FIXED HEIGHT TRIPOD = ~~2.069~~ Tripod 1.974 + Ant. 0.052	PHASE HT ABOVE TOP OF GND PL: 0.0063
OTHER: 2.026	SUM SQRT + PHASE = ANT HI:

WEATHER	START	MID	STOP	MEAN
TIME UTC OR LOC	0445 UT			
PRESSURE (Mbars)	29.95			
WET/DRY TEMP °C	26.5/32.8			
REL HUM %	57			

WEATHER COMMENTS:

NOTES: (PUT RUBBING OR SKETCH OF MARK ON BACK)

No mark set - point selected can be photo identified.

PPP6/28/93

PACIFIC PHOTOGRAMMETRIC PARTY - GPS STATION OBSERVATION LOG

STATION: RON SANFORD 1990	DATE: 8-13-93 (Local)	JULIAN DAY: 225
STATE: N. Marinas QUAD:	SESSION ID: 2733-225-0	
REFERENCE POSITION: (DDD,MM,SS.SSSSS) LAT: 18° 07' 50" N LONG: 145° 46' 08" E	ELEVATION: MSL: ~34 ft GEOID HT: SUM = HT:	

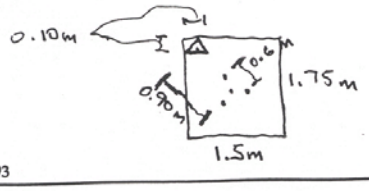
STATION ID: RONS 225A		ANTENNA HEIGHT ABOVE MARK	
SESSION (utc): (START) 2037	(END) 0137	TO TRIPOD HEAD:	
DATA LOGGER VERSION: 5.46		HEAD TO ANT BASE:	
LOCATION: Pagan Is - N. Marinas		ANTENNA CONSTANT:	0.069
OBSERVER: LAL		SUM = ANTENNA HI =	
RECEIVER S/N: 2733	4000 SSE	MARK TO TOP GND PLANE EDGE = (Slope):	1.884
ANTENNA S/N: 3311A67884		ANTENNA WIDTH:	0.2334
BATTERY USED: Internal #3		$(\text{SLOPE}^2 - \text{ANT WIDTH}^2)^{1/2}$ =	1.8695
FIXED HEIGHT TRIPOD = 2.069		PHASE HT ABOVE TOP OF GND PL:	0.0063
OTHER:		SUM SQRT + PHASE = ANT HI:	1.8758

WEATHER	START	MID	STOP	MEAN
TIME UTC OR LOC				1200 Lcl
PRESSURE (Mbars)				1011 mbars 29.85 in
WET/DRY TEMP °C				27.7/31.7 ~~29.86~~
REL HUM %				74%

WEATHER COMMENTS: Clear, warm, humid

NOTES: (PUT RUBBING OR SKETCH OF MARK ON BACK)

Station set over a small shell in concrete base of NOAA automated weather station on Pagan Is. "Ron Sanford 6-22-90" scratched into cement.



PPP6/28/93

PACIFIC PHOTOGRAMMETRIC PARTY - GPS STATION OBSERVATION LOG

STATION: AGRIHAN DATUM	DATE: 8-14-93	JULIAN DAY: 226
STATE: N. Marinas	QUAD:	SESSION ID: 2736 226 0
REFERENCE POSITION: (DDD,MM,SS.SSSSS) LAT: 18° 44' 00 N LONG: 145° 40' 00 E		ELEVATION: MSL: 75m GEOID HT: 46 m

STATION ID: 2736 226 0	
SESSION (utc): (START) 0058 (END) 0	
DATA LOGGER VERSION: 5.46	
LOCATION: Agrihan Isla	0.069
OBSERVER: LAZ	
RECEIVER S/N: 2736 40	
ANTENNA S/N: Kinematic	ANTENNA WIDTH: 0.2334
BATTERY USED:	(SLOPE^2 - ANT WIDTH^2)$^{1/2}$ =
FIXED HEIGHT TRIPOD = ~~2.069~~ TRI 1.974 ANT +0.052	PHASE HT ABOVE TOP OF GND PL: 0.0063
OTHER: 2.026	SUM SQRT + PHASE = ANT HI:

WEATHER	START	MID	STOP	MEAN
TIME UTC OR LOC	0115 UTC			
PRESSURE (Mbars)	29.85			
WET/DRY TEMP °C	32.4 / 32.5			
REL HUM %	100			

WEATHER COMMENTS:

NOTES: (PUT RUBBING OR SKETCH OF MARK ON BACK)

PPP6/28/93

LeW,

I computed 9 positions for various islands in the Pacific using the data we collected in the fall. I compared the position for SPNAAA that you used for the computations for Farrallon De Pajaros and what I computed holding to Kokee Park ITRF92 published position.

Yours from your report:
15 06 56.55501
145 42 59.65103
125.4259

Mine 15 06 56.7228
145 42 59.8783
118.166

Pam

FROM STATION LATITUDE:
15 6 56.55501

FROM STATION LONGITUDE:
15 6 56.55501

TO STATION LONGITUDE:
145 42 59.65193

FORWARD AZIMUTH FROM SOUTH =127 14 1.60
BACK AZIMUTH FROM SOUTH = 307 14 1.54
DISTANCE IN METERS = 8.5233

GPS22 VERSION: 06JAN93 (gps22-v3.23)

DATE AND TIME THIS SOLUTION: 1993/ 8/17 13:49:43

ANALYST'S NAME: L. Lapine

CURRENT GPS22 SETUP

DB NAME: B225 PROCESSING MODE: SOLUTION CORRELATIONS: YES

	DOY:HR:MN	SEC		DOY:HR:MN:	SEC
START	1 0 0	0.00	STOP:	365 23 59	60.00

FREQUENCY: L1 TROPO CORR: YES ION MODEL: NO

OMITTED Svs: 15 27
ADJUSTED SV ARC ELEMENTS:0 0 0 0 0 0

REF SV: 7

STATION SUMMARY

NAME	STAT	CLK	SHT	NAME	STAT	CLK	SHT
Saipan_A_199	OMIT	NO	FIX	NPT_1993	SLV	NO	SLV
JUDYEAGER_19		RIF	NO SLV	NorthernPoint	SLV	NO	SLV
NO1ANCI	SLV	NO	SLV				

DATABASE HISTORY:

M: : PROGRAM MERGE WAS RUN BY: L. Lapine DATE: 1993/8/16
M: : ORBIT TYPE: BROADCAST FILE: SPNA224A.ORB DATABASE: a225
• TSTRT: 93 225 4 24 15.00
TSTOP: 93 225 7 13 45.02

SETUP SUMMARY

CLOCK TERMS: 0
INTEGER TERMS: 45
SCL HGT TERMS: 4
SAT ARC TERMS: 0
COORDINATES: 9

TOTAL TERMS: 58

REFERENCE SATELLITE SCENARIO

JREF	DOY	HR	MN	SEC
7	225	4	24	45.0

RMS VALUES (m):

OVERALL RMS OF FIT= 0.0116

STATION		2	3	7	9	13	14
STA	1	0.000	0.000	0.000	0.000	0.000	0.000
STA	2	0.000	0.000	0.000	0.000	0.000	0.000
STA	3	0.003	0.000	0.000	0.000	0.003	0.002
STA	4	0.018	0.000	0.000	0.000	0.022	0.024
STA	5	0.000	0.000	0.000	0.000	0.003	0.000

STATION		15	16	18	19	22	24
STA	1	0.100	0.000	0.000	0.000	0.000	0.000
STA	2	0.100	0.000	0.000	0.000	0.000	0.000
STA	3	0.100	0.000	0.003	0.000	0.000	0.000
STA	4	0.100	0.000	0.029	0.000	0.000	0.000
STA	5	0.100	0.007	0.006	0.006	0.000	0.006

STATION		26	27	28	29	31
STA	1	0.000	0.100	0.000	0.000	0.000
STA	2	0.000	0.100	0.000	0.000	0.000
STA	3	0.000	0.100	0.000	0.003	0.000
STA	4	0.000	0.100	0.000	0.003	0.000
STA	5	0.000	0.100	0.000	0.007	0.000

= =

STATION: JUDYEAGER_19 DATE: 8/13/93 DB NAME: B225

		INPUT	CORR (m)	ADJ	SIMGA (m)
ANTENNA					
	X	-4888552.4280	0.0000	-4888552.4280	0.0000
	Y	3435417.5899	0.0000	3435417.5899	0.0000
	Z	2224451.4573	0.0000	2224451.4573	0.0000
OFFSET					
	NORTH	0.0000			
	EAST	0.0000			
	UP	1.3000			
	L1-L2		0.0020		
MONUMENT					
	X	-4888551.4320	0.0000	-4888551.4320	0.0000
	Y	3435416.8900	0.0000	3435416.8900	0.0000
	Z	2224451.0010	0.0000	2224451.0010	0.0000
	LAT	20 32 46.54239	0.0000	20 32 46.54239	0.0000
	LON	144 54 8.88553	0.0000	144 54 8.88553	0.0000
	ELV	72.3447	0.0000	7.3447	0.0000

TROPOSHPERIC SCALE HEIGHT CORRECTION = 1.39 (+- 0.87)

BASELINES WRT: JUDYEAGER_19

NAME	X	Y	Z	L
NO1NANCI	159.0711	52.3068	288.6725	333.7236
NPT_1993	818.1351	690.0160	705.8925	1282.0887
Northern Point	784.0765	638.2598	712.7409	1236.9927

= =

= =

STATION: NO1NANCI   DATE: 8/13/93   DB NAME: B225

	INPUT	CORR (m)	ADJ	SIGMA (m)
ANTENNA				
X	-4888397.0031	3.0901	-4888393.9130	0.0149
Y	3435469.4558	0.8318	3435470.2876	0.0095
Z	2224738.8001	1.5845	2224740.3846	0.0059
OFFSET				
NORTH	0.0000			
EAST	0.0000			
UP	2.0260			
L1-L2	0.0040			
MONUMENT				
X	-4888395.4510	3.0901	-4888392.3609	0.0149
Y	3435468.3650	0.8318	3435469.1968	0.0095
Z	2224738.0890	1.5845	2224739.6735	0.0059
LAT	20 32 56.40234	2.2032	20 32 56.47398	0.0018
LON	144 54 4. 33551	-2.4573	144 54 4.25068	0.0020
ELV	81.3220	-1.3634	79.9596	0.0184

L1 FIXED INTEGERS - JREF SV# = 7

SV#	INTEGER
2	2.0
13	-3541996.0
14	240.0
18	-52.0
29	237.0

TROPOSHERIC SCALE HEIGHT CORRECTION = 1.40 (+- 0.87)

BASELINES WRT: NO1NANCI

NAME	X	Y	Z	L
JUDYEAGER_19	-159.0711	-52.3068	-288.6725	333 .7236
NPT_1933	659.0640	637.7092	471.2200	1007. 5271
NorthernPoin	652.0054	585.9530	424.0684	955.9323

= =
= =

STATION: NPT_1993   DATE: 8/13/93   DB NAME: B225

	INPUT	CORR (m)	ADJ	SIGMA (m)

ANTENNA X -4887736.2379 1. 3891 -4887734.8488 0.0094
Y 3436101.8570 6. 1400 3436107.9970 0.0066
Z 2225154.8523 2 .7525 2225157.6047 0.0057

OFFSET
NORTH 0.0000
EAST 0.0000
UP 2.0260
L1- L2 0.0040
MONUMENT

X -4887734.6860 1.3891 -4887733.2969 0.0094
Y 3436100.7660 6.1400 3436106.9060 0.0066
Z 2225154.1410 2.7525 2225156.8935 0.0057

LAT 20 33 11.08951 1.7365 20 33 11.14598 0.0023
LON 144 53 33.35653 -5.8219 144 53 33.15554 0.0026
ELV 61.7116 3.2087 64. 9203 0.0124

L1 FIXED INTEGERS - JREF SV# = 7

SV#	INTEGER
2	14997.0
13	-3541837.0
14	15379.0
18	-44.0
29	202.0

TROPOSHERIC SCALE HEIGHT CORRECTION = 1.38 (+-.087)

BASELINES WRT: NPT_1993

NAME	X	Y	Z	L
JUDYEAGER_19	-818.1351	-690.0160	-705.8925	1282.0887
NO1NANCI	-659.0640	-637.7092	-417.2200	1007.5271
NorthernPoin	-34.0586	-51.7562	6.8484	62.3346

= =

STATION: NorthernPoin DATE: 8/13/93 DB NAME: B225

INPUT CORR (m) SIGMA (m)

ANTENNA

X -4887769.6260 2.2705 -4887768.9074 0.0182
Y 3436043.3720 12.8688 3436056.2408 0.0121
Z 2225158.4239 6.0239 2225164.4531 0.0088

OFFSET
NORTH 0.0000

EAST 0.0000
UP 2.0260
L1 - L2 0.0040

MONUMENT

X	-4887769.6260	2.2705	-4887767.3555	0.0182
Y	3436042.2810	12.8688	3436055.1498	0.0121
Z	2225157.7180	6.0239	2225163.7419	0.0088
LAT	20 33 11.25609	3.6943	20 33 11.37621	0.0030
LON	144 53 35.70203	-11.8335	144 53 35.29350	0.0037
ELV	58.2376	7.3054	65.5429	0.0231

L1 FIXED INTEGERS - JREF SV# = 7

SV#	INTEGER
13	-3541872.0
16	-18784068.0
18	213.0
19	-20465247.0
24	-19166052.0
29	115.0

TROPOSPHERIC SCALE HEIGHT CORRECTION = 1.39 (+- 0.86)

BASELINES WRT: NorthernPoin

NAME	X	Y	Z	L
JUDYEAGER	-784.0765	-638.2598	-712.7409	1236.9927
NO1NANCI	-625.0054	-585.9530	-424.0648	955.9323
NPT_1993	34.0586	-51.7562	-6.8484	62.3346

GPS22 VERSION: 06JAN93 (gps22-v23.23)

DATE AND TIME OF THIS SOLUTION: 1993/ 8/18 00:01:48

ANALYST'S NAME: L. Lapine

CURRENT GPs22 SETUP

DB NAME: Q225 PROCESSING MODE: SOLUTION

CORRELATIONS: YES

DOY:HR:MN: SEC DOY:HR:MN: SEC

START: 1 0 0 0.0 STOP 365 23 59 60:00

FREQUENCY: L3 TROPO CORR:YES ION MODEL: NO

OMITTED Svs:

ADJUSTED SV ARC ELEMENTS: 0 0 0 0 0 0

REF SV: 31

STATION SUMMARY

NAME	STAT	CLK	SHT	NAME	STAT	CLK	SHT
PAGAN_1_USGS	SLV	NO	SLV	Saipan_A_199	REF	NO	FIX
MACAW1993	OMIT	NO	SLV	SARIGANDATUM	OMIT	NO	SLV
AGRIHANDATUM	OMIT	NO	SLV				

DATABASE HISTORY:

M: : PROGRAM MERGE WAS RUN BY: L. Lapine DATE: 1993/ 8/17
M: : ORBIT TYPE: BROADCAST FILE: SPNA225A.ORB DATABASE: p225
* TSTRT: 93 225 21 38 45.00 TSTOP: 93 226 4 56 45.00

SETUP SUMMARY

#CLOCK TERMS: 0
#INTEGER TERMS: 16
#SCL HGT TERMS: 1
#SAT ARC TERMS: 0
#COORDINATES: 3

#TOTAL TERMS: 20

REFERENCE SATELLITE SCENARIO

JREF	DOY	HR	MN	SEC
31	225	21	39	15.0
14	226	4	31	15.0

RMS VALUES(m):

OVERALL RMS OF FIT= 0.0541

STATION	2	7	13	14	15	16
STA 1	0.000	0.000	0.000	0.038	0.051	0.000
STA 2	0.000	0.000	0.000	0.000	0.000	0.000
STA 3	0.000	0.000	0.000	0.000	0.000	0.000
STA 4	0.000	0.000	0.000	0.000	0.000	0.000

STA	5	0.000	0.000	0.000	0.000	0.000	0.000

STATION		17	18	19	21	22	25
STA	1	0.039	0.000	0.031	0.039	0.048	0.079
STA	2	0.000	0.000	0.000	0.000	0.000	0.000
STA	3	0.000	0.000	0.000	0.000	0.000	0.000
STA	4	0.000	0.000	0.000	0.000	0.000	0.000
STA	5	0.000	0.000	0.000	0.000	0.000	0.000

STATION		27	28	29	31
STA	1	0.090	0.061	0.044	0.000
STA	2	0.000	0.000	0.000	0.000
STA	3	0.000	0.000	0.000	0.000
STA	4	0.000	0.000	0.000	0.000
STA	5	0.000	0.000	0.000	0.000

= =

STATION: PAGAN1USGS DATE: 8/13/93 DB NAME: Q225

		INPUT	CORR (m)	ADJ	SIGMA (m)
ANTENNA					
	X	-5012586.5139	-1.1104	-5012587.6243	0.0233
	Y	3412021.2241	-0.5040	3412020.7200	0.0130
	Z	1971658.9056	1.0994	1971660.0050	0.0073

OFFSET

NORTH	0.0000	
EAST		0.0000
UP		1.0080
L1 -L2		0.0020

MONUMENT

X	-5012585.7220	-1.1104	-5012586.8324	0.0233
Y	3412021.2241	-0.5040	3412020.7200	0.0130
Z	1971658.9056	1.0994	1971660.0050	0.0073

OFFSET

NORTH	0.0000	
EAST		0.0000
UP		1.0080
L1-L2	0.0020	

MONUMENT

X	-5012585.7220	-1.1104	-5012586.8324	0.0233
Y	3412020.6850	-0.5040	3412020.1810	0.0130
Z	1971658.5920	1.0994	1971659.6914	0.0073

LAT	18 7 33.37795	0.8475	18 7 33.40552	0.0042
LON	145 45 26.07789	1.0415	145 45 26.11332	0.0078
LAV	71.0131	0.9448	71.9579	0.0262

ADJUSTED BIAS TERMS FOR REF SV# 31 AND LFRQ = 3

SV#	BIAS	SIGMA
14	2263138.058	0.007
15	678861.940	0.005
17	-6.161	0.018
19	1062317.018	0.007
21	958946.435	0.010
22	-3.684	0.009
25	-6.804	0.011
27	1932606.970	0.011
28	-1.576	0.005
29	2.205	0.007

TROPOSPHERIC SCALE HEIGHT CORRECTION = 0.03 (+- 0.03)

BASELINES WRT: PAGAN1USGS

NAME	X	Y	Z	L
Saipan_A_199	-76342.7246	57256.1990	-319163.2524	333124.0994

= =

STATION: Saipan_A_199 DATE: 8/13/93 DB NAME: Q225

		INPUT	CORR (m)	ADJ	SIGMA (m)
ANTENNA					
	X	-5088930.8054	0.0000	-5088930.8054	0.0000
	Y	3469277.2310	0.0000	3469277.2310	0.0000
	Z	1552496.4390	0.0000	1652496.4390	0.0000

OFFSET

NORTH	0.0000
EAST	0.0000
UP	0.0000
L1 - L2	0.0020

MONUMENT					
	X	-5088929.5570	0.0000	-5088929.5570	0.0000
	Y	3469276.3800	0.0000	3469276.3800	0.0000
	Z	1652496.8471	0.0000	1652496.4390	0.0000

LAT	15 6 56.55599	0.0000	15 6 56.55599	0.0000
LON	145 42 59.64802	0.0000	145 42 59.64802	0.0000
ELV	125.3494	0.0000	125.3494	0.0000

BASELINES WRT: Saipan_A_199

NAME	X	Y	Z	L
PAGAN1USGS	76342.7246	-57256.1990	319163.2524	333124.0994

GPS22 VERSION: 06JAN93 (gp22-v3.23)

DATE AND TIME OF THIS SOLUTION: 1993/ 8/17 13:25:34

ANALYST'S NAME: L. Lapine

CURRENT GPs22 SETUP

DB NAME:B225 PROCESSING MODE:SOLUTION CORRELATIONS:YES

	DOY:HR:MN		SEC			DOY:HR:MN			SEC
SART	1	0	0	0.0	STOP:	365	23	59	60.00

FREQUENCY: L3 TROPO CORR:YES ION MODEL: NO

OMITTED Svs: 15 27

ADJUSTED SV ARC ELEMENTS:0 0 0 0 0 0

REF SV: 7

DATABASE HISTORY:

M: : PROGRAM MERGE WAS RUN BY: L. Lapine DATE: 1993/ 8/16
M: : ORBIT TYPE: BROADCAST FILE: SPNA224A.ORB DATABASE: a225
* TSTRT: 93 225 4 24 15.00 TSTOP: 93 225 7 13 45.02

SETUP SUMMARY

#CLOCK TERMS: 0
#INTEGER TERMS: 15
#SCL HGT TERMS: 1
#SAT ARC TERMS: 0
#COORDINATES: 3

#TOTAL TERMS: 19

REFERENCE SATELLITE SCENARIO

JREF	DOY	HR	MN	SEC
7	225	4	24	45.0

RMS VALUES (m):

OVREALL RMS OF FIT = 0.0848

STATION		2	3	7	9	13	14
STA	1	0.000	0.000	0.000	0.000	0.000	0.000
STA	2	0.121	0.000	0.000	0.000	0.000	0.000
STA	3	0.000	0.000	0.000	0.000	0.000	0.000
STA	4	0.000	0.000	0.000	0.000	0.000	0.000
STA	5	0.000	0.000	0.000	0.000	0.000	0.000

STATION		15	16	18	19	22	24
STA	1	0.100	0.000	0.000	0.000	0.000	0.000
STA	2	0.100	0.075	0.072	0.057	0.000	0.000
STA	3	0.100	0.000	0.000	0.000	0.000	0.000
STA	4	0.100	0.000	0.000	0.000	0.000	0.000
STA	5	0.100	0.000	0.000	0.000	0.000	0.000

STATION		26	27	28	29	31
STA	1	0.000	0.100	0.000	0.000	0.000
STA	2	0.000	0.100	0.000	0.000	0.000
STA	3	0.000	0.100	0.000	0.000	0.000
STA	4	0.000	0.100	0.000	0.000	0.000
STA	5	0.000	0.100	0.000	0.000	0.000

= =

STATOPM: Saipan_A_199 DATE: 8/13/93 DB NAME: B225

		INPUT	CORR (m)	ADJ	SIGMA (m)
ANTENNA					
	X	-5088930.8054	0.0000	-5088930.8054	0.0000
	Y	3469277.2310	0.0000	3469277.2310	0.0000
	Z	1652496.8471	0.0000	1652496.8471	0.0000

OFFSET

NORTH	0.0000
EAST	0.0000
UP	1.5650
L1 -L2	0.0020

MONUMENT

X	-5088929.5570	0.0000	-5088929.5570	0.0000
Y	3469276.3800	0.0000	3469276.3800	0.0000

Z	1652496.4390	0.0000	1652496.4390	0.0000	
LAT	15 6 56.55599	0.0000	15 6 56.55599	0.0000	
LON	45 42 59.64802	0.0000	145 42 59.64802		0.0000
ELV	125.3494	0.0000	125.3494		0.0000

BASELINES WRT: Saipan_A_199

NAME	X	Y	Z	L
JUDYEAGER_19	200378.1254	-33859.4895	571954.5618	606984. 2493

= =

STATION: JUDYEAGER_19 DATE: 8/13/93 DB NAME: B225

		INPUT	CORR (m)	ADJ	SIGMA (m)
ANTENNA					
	X	-4888554.0680	1.6404	-48885522.4276	0.0403
	Y	3435414.7799	2.8105	3435417.5904	0.0620
	Z	2224448.7183	2/7388	2224451/4570	0/0202

OFFSET

NORTH	0.0000
EAST	0.0000
UP	1.3000
L1 -L2	0.0020

MONUMENT

X	-4888553.0720	1.6404	-488551.4316	0.0403
Y	3435414.0800	2.8105	343516.8905	0.0620
Z	2224448.2620	2.7388	2224451.0008	0.0202
LAT	20 32 46.46212	2.4685	20 32 46.54238	0.0092
LON	144 54 8.99745	-3.2427	144 54 8.88551	0.0530
ELV	71.1270	1.2176	72.3446	0.0547

ADJUSTED BIAS TERMS FOR REF SV# 7 AND LFRQ = 3

SV#	BIAS	SIGMA
2	-10.618	0.023
13	-325998.176	0.009
14	6.939	0.039
16	1053431.087	0.046
18	-6.669	0.029
19	1701008.856	0.046
24	666348.909	0.027
29	4.647	0.049

TROPOSHERIC SCALE HEIGHT CORRECTION = 0.03 (+- 0.01)

BASELINES WRT: JUDYEAGER_19

NAME	X	Y	Z	L
Saipan_A_199	-200378.1254	33859.4895	-571954.5618	606984.2493

MEMORANDUM FOR THE RECORD

FROM: Pamela J. Fromhertz
Photogrammetry Branch

SUBJECT: American Samoa Shift

The final datum shift has been computed by the National Geodetic Survey (NGS) from American Samoa Datum of 1962 to North American Datum of 1983 (NAD 83). The values in the previou Memorandum for the Record were incorrect. The correct values follow. This correction will not effect the shift for mapping purposes. Also, please note NAD 83 is the correct datum for purposes of this shift, not WGS 84. For mapping and charting purposes, NAD 83 and WGS 84 are identical.

American Samoa Datum of 1962 to NAD 83:

NGS developed a shift between the American Samoa Datum of 1962 and NAD 83 for Tutuila Island and the Manua Islands (Ofu, Olosega, and Tau) based on points in the NGS database that were computed on the American Samoa Datum of 1962 and were re-observed in 1993 and computed on NAD 83. Seven points were used for Tutuila Island and five points for the Manua Islands. These stations and their positions and the shift are attached.

The shifts listed below are average of shifts based on the surveyed coordinates of these sets of points.

Tutuila Island	Latitude:	-17.83406"	$\sigma \varsigma\phi = 0.00775"$
	Longitude:	+4.37866"	$\sigma \varsigma\lambda = 0.00148"$
Manua Islands	Latitude:	-18.32515"	$\sigma \varsigma\phi = 0.02022"$
	Longitude:	+4.43134"	$\sigma \varsigma\lambda = 0.00874"$

Attachment

cc: N/CG1 - L. Lapine
N/CG12 - E. McKay
N/CG121 - C. Craig
N/CG13 - R. Floyd

N/CG13 - B. Rodkey
N/CG133 - G. Tolzman
N/CG14 - D. Doyle
N/CG22 - D. MacFarland
N/CG3 - C. Beaver

American Samoa
Geodetic Control Stations Used for Computation of Shift Values

Tutuila Island

Designation	American Samoa Datum of 1962	NAD 83	Shift
BM NO 1	14° 16' 52.89091"S 170° 40' 46.26882"W	14° 16' 35.06186"S 170° 40' 50.64533"W	-17.82905" + 4.37651"
BREAKERS POINT RESET ET	14° 17' 41.06229"S 170° 39' 44.81681"S	14° 17' 23.23096"S 170° 39' 49.19461"W	-17.83133" +4.37780"
LEPISI	14° 20' 12.78108"S 170° 49' 00.75839"W	14° 19' 54.94006"S 170° 49' 05.13712"W	-17.84102" + 4.37873"
SATELLITE TRIANG STA 022	14° 20' 12.21614"S 170° 42' 46.75786"W	14° 19' 54.37534"S 170° 44' 51.13727"W	-17.84080" + 4.37941"
TAFUNA 1A RESET ET	14° 19' 55.28840"S 170° 42' 07.81667"W	14° 19' 37.44924"S 170° 42' 12.19688"W	-17.83916" +4.38021"
TULA	14° 15' 47.246622"S 170° 33' 38.74951"W	14° 15' 29.42627"S 170° 33' 43.12698"W	-17.81995" + 4.37747"
OLOTELE 2 ET	14° 19' 21.47745"S 170° 45' 47.00908"W	14° 19' 03.64037"S 170° 45' 51.38960"W	-17.83708"

		+4.38052"
	Mean Shift:	-17.83406"
		+4.37866"
	σ ςø = 0.00775"	(0.237 m)
	σ ςλ = 0.00148"	(0.044 m)

American Samoa
Geodetic Control Stations Used for Computation of Shift Values

Manua Islands
(Ofu, Tau, and Olosega)

Designation	American Samoa Datum of 1962	NAD 83	Shift
FITIUTA ET	14° 13' 00.72214"S 169° 25' 33.72683"W	14° 12' 42.38125"S 169° 25' 38.16655"W	-18.34089" 4.43972"
OLOSEGA ET	14° 11' 13.55796"S 169° 37' 12.93814"W	14° 10' 55.25963"S 169° 30' 47.51223"W	-18.29833" 4.42044"
TAU ET	14° 14' 33.66300"S 169° 30' 43.08500"W	14° 14' 15.34481"S 169° 30' 47.51223"W	-18.31819" 4.42044"
TIAFOU ET	14° 13' 25.73304"S 169° 25' 04.52758"W	14° 13' 07.38376"S 169° 25' 08.96845"W	-18.34928" 4.44087"
TIDE GAGE ET	14° 14' 46.59449"S 169° 30' 30.28375"W	14° 14' 28.27541"S 169° 30' 34.71218"W	-18.31908"

4.42843"

Mean Shift -18.32515"
+4.43134"

σ ςø = 0.02022" (0.621 m)
σ ςλ = 0.00874" (0.262 m)