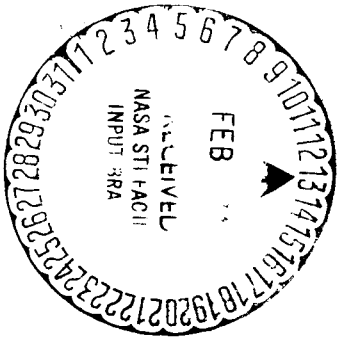
MSC-PA-R-69-1
SUPPLEMENT 1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 8 MISSION REPORT
SUPPLEMENT 1

TRAJECTORY RECONSTRUCTION AND POSTFLIGHT ANALYSIS



MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
NOVEMBER 1969

MSC-PA-R-69-1
Supplement 1

APOLLO 8 MISSION REPORT

SUPPLEMENT 1

TRAJECTORY RECONSTRUCTION AND POSTFLIGHT ANALYSIS

PREPARED BY

TRW Systems Group

APPROVED BY

James A. McDivitt
Manager, Apollo Spacecraft Program

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
November 1969

TRW

69:7254.3-79
Re: Task A-50

12 September 1969

National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas 77058

Attention: D. J. Incerto, Monitor MSC/TRW Task A-50
Mission Planning and Analysis Division

Subject: Transmittal of TRW Report 11176-H317-RO-00, "Apollo Mission 8 Trajectory Reconstruction and Postflight Analysis, Vol. I."

Gentlemen:

Transmitted herewith is report number 11176-H317-RO-00, "Apollo Mission 8 Trajectory Reconstruction and Postflight Analysis, Vol. I."

This report is submitted as the postflight analysis final report for the Apollo 8 Mission and as such partially fulfills the requirements of MSC/TRW Task A-50 for that mission.

Yours very truly,

W. P. Girod

W. P. Girod
MSC/TRW Task A-50

H. L. Moore

H. L. Moore
MSC/TRW Task A-50

Approved by:

for W. F. Heugel, Assistant Project Manager (Acting
Flight Dynamics
Mission Trajectory Control Program

WPG:jb

MSC Distribution:

A. P. Bradley(2), BM6
M. S. Burton (35), FM15
E. Hillje, EX24

11176-H317-R0-00

TRW NOTE NO. 69-FMT-767

PROJECT APOLLO
TASK MSC/TRW A-50

APOLLO MISSION 8, TRAJECTORY RECONSTRUCTION AND POSTFLIGHT ANALYSIS VOLUME I

1 AUGUST 1969

Prepared for
MISSION PLANNING AND ANALYSIS DIVISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
NAS 9-8166

TRW NOTE NO. 69-FMT-767

PROJECT APOLLO
TASK MSC/TRW A-50

APOLLO MISSION 8, TRAJECTORY RECONSTRUCTION AND POSTFLIGHT ANALYSIS VOLUME I

1 AUGUST 1969

Prepared for
MISSION PLANNING AND ANALYSIS DIVISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
NAS 9-8166

Approved by W. P. Girod
W. P. Girod, Manager
MSC/TRW Task A-50

Approved by J. E. Alexander
J. E. Alexander, Manager
Guidance and Control
Systems Department

Approved by H. L. Moore
H. L. Moore, Manager
MSC/TRW Task A-50

Approved by for W. F. Heugel
W. F. Heugel, Assistant
Project Manager (Acting)
Flight Dynamics
Mission Trajectory Control
Program

Approved by L. J. Skidmore
L. J. Skidmore, Manager
Systems Evaluation
Department

Approved by R. P. Parten
R. P. Parten, Chief
Mission Planning Support
Office
NASA Manned Spacecraft
Center

TRW
SYSTEMS GROUP

FOREWORD

This report is submitted to the NASA Manned Spacecraft Center in accordance with Task MSC/TRW A-50 contract NAS 9-8166. This report contains the postflight analysis performed in conjunction with the flight of Apollo mission 8.

The report is issued in two volumes. Volume I contains details of the analysis and results obtained, including appendixes. Volume II contains a listing of the 45-day best estimated trajectory (BET) for the Apollo 8 mission in the NASA Apollo Trajectory (NAT) format. The listing is not generally distributed but is available from NASA/MSC upon request. Requests should be made to:

NASA/MSC Computations and Analysis Division
Central Metric Data File
Code ED-5, Bldg. 12, Room 133
Houston, Texas 77058

TABLE OF CONTENTS

LIST OF TABLES

3. APOLLO MISSION 8 TRAJECTORY RECONSTRUCTION AND POSTFLIGHT ANALYSIS

3.1 INTRODUCTION AND SUMMARY

3.1.1 Apollo 8 Mission

The Apollo 8 Mission was launched from Launch Complex 39A Kennedy Space Center at 12:51:00 Greenwich Mean Time on 21 December 1968. The boost of the Saturn V launch vehicle inserted the S-IVB/CSM payload into earth orbit, and approximately two hours, fifty minutes into the flight, the second burn of the S-IVB stage injected the payload into a free-return circumlunar trajectory. Approximately twenty-five minutes later, the Command and Service Module (CSM) separated from the S-IVB stage of the launch vehicle.

During the translunar coast phase, it was necessary to perform two evasive maneuvers to avoid the possibility of recontact with the S-IVB, and two midcourse corrections were performed. At approximately 69 hours, 8 minutes Ground Elapsed Time (GET), a Service Propulsion System (SPS) burn was performed to insert the CSM into a 60 by 170 nautical mile lunar orbit and two revolutions later the orbit was circularized to approximately 60 nautical miles.

After ten orbits the SPS was again fired to inject the CSM into a transearth trajectory. During transearth coast, one midcourse maneuver was performed.

The Command Module (CM) separated from the Service Module (SM) at 146:29:00 (hours:minutes:seconds) GET, and entered the earth's atmosphere approximately seventeen minutes later. Splashdown occurred at 146:59:49 GET. A more detailed summary of major mission events is given in Table 3.1-1. The times are given in hours, minutes and seconds GET and in December days, hours, minutes and seconds GMT.

3.1.2 Postflight Analysis

The objective of the postflight analysis task was to reconstruct the spacecraft trajectory using available tracking and telemetry data recorded during the period from S-IVB/CSM separation to splashdown. In the Apollo 8 postflight analysis, MSFN (Manned Space Flight Network) and DSN (Deep Space Network) tracking data were used to obtain a best estimate of trajectory (BET over the free-flight segments between thrusting maneuvers). The maneuvers between these segments were then modeled by the G&N Trajectory Program, and combined with the free flight BET's to produce the NAT (NASA Apollo Trajectory). These tracking data fit segments are discussed in Section 3.3 of this report.

The postflight analysis was carried out essentially as planned; however, the second evasive maneuver created a very short free-flight segment which was not reconstructed. The postflight analysis, therefore, began after the second evasive maneuver rather than after CSM/S-IVB separation.

Table 3.1-1

APOLLO 8 SEQUENCE OF EVENTS

Event	GET hr:min:sec	GMT day:hr:min:sec
Insertion	00:11:35	21:13:02:35.0
Translunar Injection Ignition	02:50:36	21:15:41:36
Translunar Injection Cutoff	02:55:42	21:15:46:42
S-IVB/CM Separation	03:20:59.3	21:16:11:9.3
S-IVB/CM Evasive Maneuver #1 (SMRCS) Ignition	03:40:01	21:16:31:01
S-IVB/CM Evasive Maneuver #2 (SMRCS) Ignition	04:45:01	21:17:36:00
Midcourse Correction #1 (MCC-1) Ignition	10:59:59.5	21:23:50.59.5
MCC-1 Cutoff	11:00:01.9	21:23:51:01.9
Water Dump #1 (TL)	11:13:00	22:00:04:00
Water Dump #2 (TL)	29:33:00	22:18:24:00
Midcourse Correction #4 (SMRCS) Ignition	60:59:54	24:01:50:45
Lunar Orbit Insertion #1 (LOI1) Ignition	69:08:20	24:09:59:20
Lunar Orbit Insertion #1 (LOI1) Cutoff	69:12:26.5	24:10:03:26.5
Lunar Orbit Insertion #2 (LOI2) Ignition	73:35:06	24:14:26:06
Lunar Orbit Insertion #2 (LOI2) Cutoff	73:35:16	24:14:26:16
Water Dump #3 (LUN)	80:50:00	24:21:41:00

Table 3.1-1 (Continued)

Event	GET hr:min:sec	GMT day:hr:min:sec
Transearth Injection (TEI) Ignition	89:19:16	25:06:10:16
Transearth Injection (TEI) Cutoff	89:22:39	25:06:13:39
Water Dump #4 (TE)	102:50:00	25:19:41:00
Midcourse Correction #5 Ignition	103:59:53	25:20:50:53
Midcourse Correction #5 Cutoff	104:00:07	25:20:51:07
Water Dump #5 (TE)	120:58:00	26:13:49:00
CSM/SM Separation	146:29:00	27:15:20:00
Entry Interface (400,000 ft)	146:46:13	27:15:37:13
Begin Blackout	146:46:38	27:15:37:38
End Blackout	146:51:44	27:15:42:44
Drogue Deployment	146:54:26	27:15:45:26
Main Parachute Deployment	146:55:20	27:15:46:20
Landing	146:59:49	27:15:50:49

3.2 TRAJECTORY ANALYSIS

3.2.1 Preliminary Analysis

Low speed tracking data were recorded at the RTCC on a total of fifteen magnetic tapes. The first fourteen tapes, covering the mission from launch to approximately fifteen hours before splashdown, were processed in near real time by Task A-212 personnel. The A-212 activity included processing these tapes through the Master Tape Generator (MATAG) and ESPOD Data Generator (EDG) Programs, performing a cursory analysis with the Houston Operations Predictor, Estimator (HOPE) Program and producing preliminary BET's. A complete report on the results of this preliminary analysis is included in Reference 1.

In the course of this preliminary activity, HOPE compatible observation tapes were produced, and copies were made. These copies, together with the preliminary BET's, significant event times, and fit segment definitions, were obtained by Task A-50 in order to begin the postflight analysis. Some data were not included in the fit segments defined by the A-212 real time activities. It was determined that the total reconstruction was not significantly degraded by this omission.

The HOPE compatible observation tapes obtained from Task A-212 were for the most part "cleaned" of gross outliers and anomalous data. For this reason, no analysis or summary of anomalous data could be compiled by Task A-50, and therefore, no discussion of anomalous data will be presented in this report.

The tracking data were processed and prepared for analysis by the MATAG and EDG Programs. A description of these programs, together with the HOPE Program, is presented in Appendix C. Some basic processing techniques applied during this mission are outlined as follows:

a) Only Unified S-Band System (both MSFN and DSN data) was processed.

b) Doppler count intervals were compressed to 60 seconds.

c) Only every tenth range/angle observation was retrieved (no range data is available from three-way stations).

d) Range data refraction errors were corrected.

e) A bias of -191 yards was added to all range observables.

3.2.2 CSM Trajectory Reconstruction

3.2.2.1 Fit Segment Definition

The spacecraft trajectory from the second evasive maneuver to entry interface (400,000 feet altitude above the earth) was reconstructed from MSFN tracking data. The orbit determination program utilized was an interim, free-flight version of the HOPE Program described in Appendix C. Since this version of HOPE was not capable of modeling maneuvers, the definition of fit segments was limited to periods of free-flight between maneuvers.

The basic philosophy of defining fit segments between maneuvers or other trajectory perturbing activities was not the most expedient alternative in several cases. Table 3.2-1 which describes boundries chosen for each of the fit segments, shows that the beginning or end of an observation tape was sometimes the determining factor. In these cases, the data span on the tape was relatively close to a maneuver, and it was determined that the additional data contained on the adjacent tape was not necessary to obtain a representative trajectory. As an example, Segment 3 was defined as the 27 hour free-flight period between the second water dump and the last point on data tape number 6. The first point on tape number 7 was 23:21:51.30 GMT, and Midcourse Correction No. 4 was performed only four hours later. It was determined that the addition of this four hour data span would not significantly refine a BET obtained from the 27 hours of data on tape number 6; therefore, no merge was performed, and the tracking data during this four hours of the mission

Table 3.2-1 FIT SEGMENT DESCRIPTIONS

Segment Number	From	To
1	EVASIVE MANEUVER #2	MIDCOURSE CORRECTION #1
2	MIDCOURSE CORRECTION #1	WATER DUMP #2
3	WATER DUMP #2	END OF DATA TAPE #6
4	MIDCOURSE CORRECTION #4	END OF DATA TAPE #7
5-14	ACQUISITION OF SIGNAL (AOS) LUNAR ORBIT REV 1 THROUGH REV 10	LOSS OF SIGNAL (LOS) LUNAR ORBIT REV 1 THROUGH REV 10
15	TRANSEARTH INSERTION BURN	END OF DATA TAPE #11
16	MIDCOURSE CORRECTION #5	END OF DATA TAPE #12
17	BEGINNING OF DATA TAPE #13	WATER BOILER TEST
18	BEGINNING OF DATA TAPE #15	ENTRY INTERFACE

was ignored in the Task A-50 postflight analysis. As shown in Table 3.2-1, this logic was used in defining the boundries of fit segments 3, 4, 15 and 18. The division between segments 16 and 17 was later found to be unnecessary because data tapes 12 and 13 were actually merged.

While the spacecraft was in lunar orbit, each orbit was fit independently as a result of the difficulties encountered in propagating a state vector from one revolution into the next. These errors were exemplified by obtaining a BET from the revolution 4 data, then propagating that vector at regular intervals through the revolution 5 data span. When comparing these propagated state vectors with the revolution 5 BET, the maximum and minimum differences in the downrange components of position were found to be 11,751 feet and 9,468 feet, respectively. Radial differences varied from 94 to -540 feet while cross range differences were 1285 to -1185 feet. The differences found in this particular case were representative of the errors experienced in several such comparisons.

Table 3.2-2 lists the fit segments, the time intervals over which the tracking data used in obtaining the BET extended, and the time interval over which the BET was used to generate the reference trajectory. An indication of the consistency of fit between the given segment and the preceding one is presented in terms of total position difference and velocity difference. This information must be qualified in the sense that several of these comparisons were made between fit segments separated by small thrusting maneuvers. In two of these cases, the delta velocities listed are very close to the actual ΔV's produced by these burns. Midcourse corrections 1 and 5 produced actual ΔV's of 24.5 fps and 5.0 fps respectively. Comparisons of the BET's on either side of these maneuvers produced almost identical resultant delta velocities of 24.4 and 4.55 feet per second. The inconsistencies noted between the data spans and trajectory intervals of several segments are attributed to the data gaps created in the definition of fit segments.

Table 3.2-2 CSM FIT SUMMARY

Segment	Data Interval (GMT) (day:hr:min)	(day:hr:min)	Event Summary	Trajectory Interval (GMT) (day:hr:min)	(day:hr:min)	Delta Position (ft)	Delta Velocity (fps)	Comparison Time (GMT)
1	21:17:45	21:21:20		21:17:36	21:23:50			
			MIDCOURSE CORRECTION #1					
2	21:23:52	22:16:19		21:23:52	22:18:20	19,340	24.40	21:23:50
			WATER DUMP #2					
3	22:18:23	23:21:35		22:18:20	24:01:50	3,893	.49	22:18:20
			MIDCOURSE CORRECTION #4					
4	24:01:53	24:09:22		24:01:50	24:09:58	27,562	5.15	24:01:50
			LUNAR ORBIT INSERTION BURN					
5	24:10:25	24:11:45		24:10:00	24:12:10	NO COMPARISON BECAUSE OF LOI1 BURN		
			LOSS OF SIGNAL BETWEEN REVOLUTIONS 1 AND 2					
6	24:12:32	24:13:54		24:12:10	24:14:25	6,417	12.94	24:12:10
			CIRCULARIZATION BURN					
7	24:14:41	24:15:51		24:14:26	24:16:20	NO COMPARISON BECAUSE OF LOI2 BURN		
			LOSS OF SIGNAL BETWEEN REVOLUTIONS 3 AND 4					
8	24:16:41	24:17:50		24:16:20	24:18:10	10,110	10.79	24:16:20
			LOSS OF SIGNAL BETWEEN REVOLUTIONS 4 AND 5					
9	24:18:39	24:19:48		24:18:10	24:20:10	9,629	8.64	24:18:10
			LOSS OF SIGNAL BETWEEN REVOLUTIONS 5 AND 6					
10	24:20:50	24:21:48		24:20:10	24:22:10	12,535	10.81	24:20:10

Table 3.2-2 (Continued)

Segment	Day Interval (GMT) (day:hr:min)	(day:hr:min)	Event Summary	Trajectory Interval (GMT) (day:hr:min)	(day:hr:min)	Delta Position (ft)	Delta Velocity (fps)	Comparison Time (GMT)
11	24:22:35	24:23:46	LOSS OF SIGNAL BETWEEN REVOLUTIONS 6 AND 7	24:22:10	25:00:10	11,105	10.36	24:22:10
12	25:00:33	25:01:44	LOSS OF SIGNAL BETWEEN REVOLUTIONS 7 AND 8	25:00:10	25:02:10	10,118	9.05	25:00:10
13	25:02:31	25:03:43	LOSS OF SIGNAL BETWEEN REVOLUTIONS 8 AND 9	25:02:10	25:04:10	10,151	8.86	25:02:10
14	25:04:30	25:05:39	LOSS OF SIGNAL BETWEEN REVOLUTIONS 9 AND 10	25:04:10	25:06:09	11,819	9.65	25:04:10
15	25:06:20	25:20:12	TRANSEARTH INJECTION BURN	25:06:10	25:20:50	NO COMPARISON BECAUSE OF TEI BURN		
16	25:21:00	26:05:19	MIDCOURSE CORRECTION #5	25:20:50	26:10:00	17,096	4.55	25:20:00
17	26:05:21	26:21:33		25:10:00	27:01:00	8,684	0.39	26:10:00
18	27:01:18	27:15:30	WATER BOILER TEST	27:01:00	27:15:44	33,118	0.35	27:01:00

3.2.2.2 Analysis Techniques

The large tracking distances involved in the Apollo 8 mission made the use of C-Band radars impossible. In addition, the angle data from S-Band radars was not meaningful due to the large position differences caused by small angular errors at lunar distances. Therefore, the data upon which the trajectory reconstruction was based included only range and doppler observables from the MSFN and DSN tracking radars.

In order to reduce the volume of data to be processed in fitting the long free-flight segments during the translunar and transearth portions of the mission, only range and two-way doppler observables were included in the data sets. This philosophy also eliminated the problem of accounting for the numerous biases caused by transmitter and receiver frequency differences. Each time the primary station (transmitter) is switched, a new set of biases must be considered for the three-way stations. In some segments, several primary station switches were performed, creating a number of receiver-transmitter combinations sufficient to exceed the capacity of the HOPE Program to account for the associated biases.

The good quality of the two-way doppler, and the practice of varying tracking station geometry by switching transmitters, provided primary station fits which were representative of the actual translunar and transearth trajectories. As an example, fits were made to determine the effect of "good" three-way doppler on the fit of segment 2 (MCC #1 to Water Dump #2). The resultant position difference caused by the addition of three-way doppler to the data set was 875 feet. The difference in resultant velocities was .095

feet per second. These differences are well within the uncertainties inherent in trajectory reconstruction of this type of mission.

The data spans of the lunar orbit fit segments were relatively short, and in most cases there was only one primary station. Therefore, it was necessary to use the three-way doppler data in order to obtain better tracking station geometry. Since in these cases, the magnitudes of the doppler residuals were relatively large with respect to the three-way doppler biases, no significant degradation due to these biases was noted in the reconstruction.

Table B-2 of Appendix B lists the means and standard deviations of the residuals compiled from the BET's for each station and segment. The standard deviations of two-way doppler residuals during the translunar and transearth segments were on the order of .03 to .07 cycles per second whereas in lunar orbit (segments 5 through 14) the standard deviations for both two-way and three-way doppler were generally between .3 and .6 cycles per second.

The lunar potential models used are described in Table 3.2-3. The lunar orbit BET's were made using the Boeing R2 model which has proven more accurate than the triax and has since been adopted for use by the RTCC. The triaxial model was used during the translunar and transearth portions of the mission.

Several other parameters used in the orbit determination program are worthy of note. They are the following:

a) The difference between ephermeris time and universal time was 38.5 seconds.

b) The ratio of the mass of the moon to the mass of the earth was .0122998962376619.

c) The value of drag used was zero.

d) Two-way doppler data weighting was 0.1 cycle/sec. Three-way doppler data weighting was 0.2 cycle/sec. Range data weighting was 600 feet.

e) The double-precision, Eckert corrected ephemeris tape (DE 19.1) was used.

Table 3.2-3 LUNAR POTENTIAL MODELS

	Triaxial	Boeing R2
J2	2.07108×10^{-4}	2.07108×10^{-4}
J3	0	-2.1×10^{-5}
C22	2.0716×10^{-5}	2.0716×10^{-5}
C31	0	3.4×10^{-5}

All other harmonics are zero in both models.

3.3 RTCC COMPARISONS

The Flight Support Division provided a list of important RTCC vectors (Reference 2) determined during the mission. These vectors were compared with the BET vectors determined from postflight analysis. Table 3.3-1 presents these comparisons, indicating the anchor time for the RTCC vector, the BET fit segment in which it occurred, and the position and velocity differences between the RTCC and BET vectors. In addition, major trajectory perturbing events are summarized.

The differences shown in Table 3.3-1 could have been caused by combinations of the following major differences between the RTCC and A-50 trajectory reconstruction methods:

a) Data sets were not identical (RTCC used three-way doppler data in translunar and transearth fits, and did not use range observations in lunar orbit).

b) The RTCC did not use the DE 19.1 ephemeris.

c) The RTCC used a triaxial lunar potential model in lunar orbit.

d) The RTCC used a different set of data weights.

The output of the RTCC Comparison Program for each vector appearing in Table 3-5 is included in Appendix A.

Table 3.3-1 RTCC COMPARISON SUMMARY

BET	Description		Anchor Time (d:h:m:s)GMT	ΔR(ft)	ΔV(ft/sec)	Event Summary (d:h:m:s) GMT
1	CMC Nav update for MCC-1	ACNX114 (ECI)	21:17:36:54	3421.	0.4	S-IVB/CM evasive maneuver #2 (SMRCS) ignition at 21:17:36:00
2	Trajectory update	RIDX251 (ECI)	22:00:46:36	23066.	0.2	MCC-1 cutoff at 21:23:51:01
2	CMC Nav update	NBEX241 (ECI)	22:00:46:36	12519.	0.8	Water Dump #1 (TL) at 22:00:00:04
3	Trajectory update	GWMX337 (ECI)	22:19:05:54	17447.	0.3	Water Dump #2 (TL) at 22:18:24:00
3	Trajectory update	GDSX311 (ECI)	22:19:05:54	36386.	0.6	
3	CMC Nav update for MCC-4	GDSX374 (ECI)	23:04:47:48	26698.	0.2	
4	CMC Nav update for LOI1	HSKX417 (MCI)	24:01:57:36	1144.	3.8	Midcourse correction #4 (SMRCS) ignition at 24:01:50:54
5	Lunar orbit Rev 1	HSKX470 (MCI)	24:10:24:00	10128.	1.9	Lunar Orbit Insertion #1 (LOI 1) cutoff at 24:10:03:26.5
6	Lunar orbit Rev 2	ACNX490 (MCI)	24:12:31:24	466.	2.1	
7	Lunar orbit Rev 3	ACNX512 (MCI)	24:14:40:24	14855.	6.6	Lunar Orbit Insertion #2 (LOI 2) at 24:14:26:16
8	Lunar orbit Rev 4	MADX530 (MCI)	24:16:39:06	5926.	1.1	
9	Lunar orbit Rev 5	ACNX545 (MCI)	24:18:37:24	3450.	3.3	
10	Lunar orbit Rev 6	ACNX565 (MCI)	24:20:38:30	1418.	1.8	
11	Lunar orbit Rev 7	GDSX586 (MCI)	24:22:35:18	2468.	1.8	Water Dump #3 (LUN) at 24:21:41:00
12	Lunar orbit Rev 8	ANGX603 (MCI)	25:00:33:18	2973.	2.0	
13	Lunar orbit Rev 9	HAWX626 (MCI)	25:02:31:54	5142	1.2	
14	Lunar orbit Rev 10	GDSX642 (MCI)	25:04:30:24	10344.	1.3	
15	CMC Nav update for MCC-5	BDAX690 (MCI)	25:06:38:36	4171.	0.8	Transearth injection (TEI) ignition at 26:06:10:16
16	Trajectory update	GWMX777 (ECI)	25:20:57:24	5225.	0.1	Transearth injection (TEI) cutoff at 26:06:13:39
17	Trajectory update	CROX856 (ECI)	26:22:16:24	23286.	0.4	Midcourse correction #5 cutoff at 26:20:51:07
17	Trajectory update	NBEX863 (ECI)	27:00:15:42	25418.	0.3	Water boiler test at 26:21:41:34

3.4 ENTRY TRAJECTORY

The entry trajectory, as in all previous Apollo missions, was reconstructed from acceleration measured by the CSM inertial system using an initial state vector derived from MSFN tracking data.

The trajectory was initialized at 146:45:52.10 GET (altitude = 496428.7 ft). The initial state vector, in ECI (mean NBY) coordinates was:

$$[P, V]_{ECI} = \begin{bmatrix} -16379409.7 & -19430.2512 \\ 11270585.0 & -23956.4296 \\ 7948921.5 & -18830.7826 \end{bmatrix}$$

The "45 Day" BET assumed an inertial platform misalignment of 22.5 $\widehat{\text{sec}}$ about the Y-axis (ϕ_Y=22.5).

After completion of the Apollo IMU hardware error evaluation, the full set of errors was propagated through the entry trajectory. The results were not significantly different from the "45 Day" BET. The error magnitudes used in this second trajectory reconstruction are given in Table 3.4-1. The IMU error analysis is discussed in detail in the Task E-38B final report (Reference 2).

The coordinates of the splashdown point resulting from the trajectory reconstructions are shown in Figure 3.4. They lie approximately 2 n.m. southeast of the planned SP, and 1 n.m. south of the recovery ship estimate.

Table 3.4-2 compares reconstructed CSM altitudes at drogue chute deployment, main chute deployment, and splashdown with the nominal values. The reconstructed altitudes lie within the uncertainty bands determined for closure of the drogue and main baroswitches. The mean descent rate on the main chute is also very near the nominal value.

Table 3.4-1 APOLLO IMU ERROR PARAMETERS

	Error	Magnitude
Accelerometer Bias	BX	- 18 g x 10^{-6}
	BY	29
	BZ	6
	XSF	-132.0 PPM
Accelerometer Scale Factor	YSF	- 11.4
	ZSF	- 52.8
	XYMSL	- 1.6 sec
	XZMSL	8.5
Accelerometer Sensing	YXMSL	- 1.0
Axis Misalignment	YZMSL	34.2
	ZXMSL	5.8
	ZYMSL	0.4
	XGCDR	- .0199 deg/hr
Gyro Drift Rate	YGCDR	- .0025
	ZGCDR	- .0250
Gyro Drift	XADIA	.107 deg/hr·g
(Prop. to Acc. along	YADIA	.012
Input axis)	ZADIA	- .142
Gyro Drift	XADSR	.037 deg/hr·g
(Prop to Acc. along	YADSR	.155
spin axis)	ZADSR	- .043
Gyro Drift	XADOA	- .001 deg/hr·g
(Prop to Acc. along	YADOA	.059
output axis)	ZADOA	- .170
Platform Misalignment	PHIY	12.4 sec

Table 3.4-2 CSM ALTITUDE CONSTRAINTS DURING ENTRY

EVENT	TIME (GET)	ALTITUDE (FT.)		
		Nominal	"45 Day" BET	Final IMU Errors
Drogue Chute (Baroswitch Closure)	146:54:47.8	24050 (+1850, -1250)	23425	23325
Main Chute (Baroswitch Closure)	146:55:39.0	10950 (+950, -1250)	10520	10400
DSE Off (34 sec before splashdown)	147:00:08.1	952	1050	950
Mean Descent Rate on Main Chute		28 ft/sec	28.0 ft/sec	27.8 ft/sec

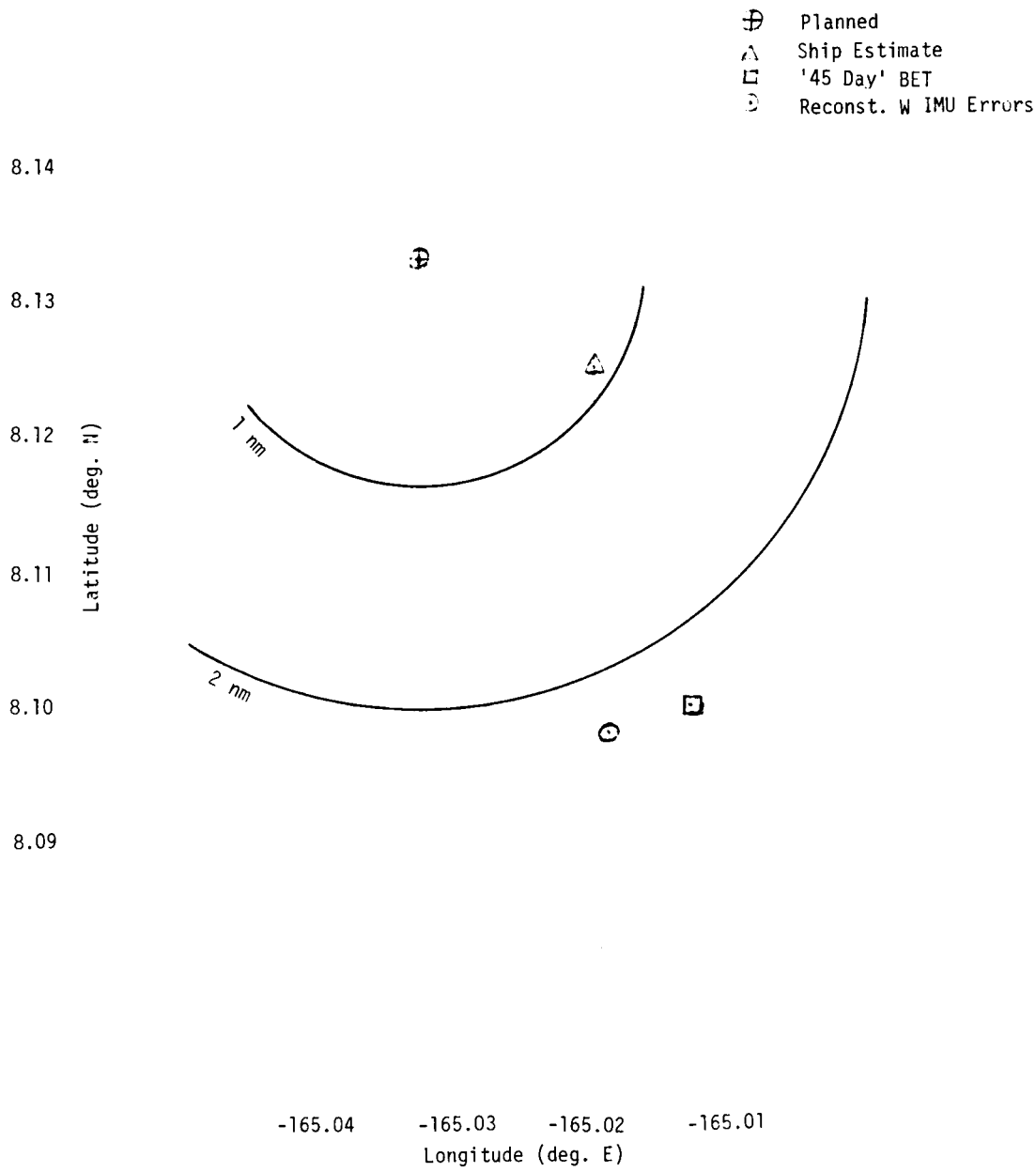


Figure 3.4 APOLLO 8 SPLASHDOWN COORDINATES

APPENDIX A

APOLLO 8 RTCC COMPARISONS

The output of the RTCC Comparison Program is listed for each vector appearing in Table 3-5. The vector comparisons are listed in the order of occurrence. The definitions of the symbols used are as follows:

SYMBOL	DEFINITION OF SYMBOLS FOR RTCC COMPARISON
TITLE	Identification of RTCC state vector.
DATE	Date of RTCC state vector.
TIME (GET)	Anchor time of the RTCC state vector referenced to lift-off.
TIME (GMT)	Anchor time of the RTCC state vector in Universal time.
COORDINATE SYSTEM	Defines the central body and the equator of the coordinate system.
X Y Z XDOT YDOT ZDOT	Components of the position and velocity vector referenced to one of three coordinate systems; ECI, MCI, or ECT. The units are feet and feet/second.
SMA	Semimajor axis (ft).
ECC	Eccentricity of the orbit.
INC	Inclination of the orbit plane to the equator measured positive counterclockwise from the equatorial plane of the orbit plane at the ascending node (deg).

SYMBOL	DEFINITION OF SYMBOLS FOR RTCC COMPARISON
NODE	Right ascension of the ascending node (deg).
ARG PERIAPSIS	Argument of periapsis measured positive in the direction of motion from the ascending node (deg).
TRUE ANOMALY	True anomaly measured positive in the direction of motion from periapsis (deg).
PERIOD	Osculating period of the orbit (min).
APOAPSIS	Altitude of apoapsis above a reference sphere (nautical miles).
PERIAPSIS	Altitude of periapsis above a reference sphere (nautical miles).
VEL-MAG	Magnitude of the inertial velocity vector (ft/sec).
FLIGHT PATH	Flight-path angle measured positive downward from the local vertical (deg).
HEADING	Azimuth of the velocity vector measured positive east of true North (deg).
DEC	Declination (deg).
LONG	Longitude of the vehicle measured positive east of the zero meridian (deg).
HEIGHT	Height of the vehicle above a reference sphere (nautical miles).
DEL U DEL V DEL W DEL UDT DEL VDT DEL WDT	Difference between the RTCC and HOPE-developed components of the position and velocity vector in a vehicle-centered coordinate system where the U-axis is collinear with the earth-centered inertial radius vector and is directed outward. The V-axis lies in the orbit plane and is orthogonal to the U-axis in the direction of motion and the W-axis completes the right-handed system.
DEL POS	Magnitude of the difference between the RTCC position vector and the HOPE-developed position.
DEL VEL	Magnitude of the difference between the RTCC velocity and the HOPE-developed velocity vector.

TITLE- CMC NAV UPDATE FOR MCC-1 ACNX114 (ECI) CSM

DATE- 21 DEC. 1968 TIME(GET)- 0 DAYS 4 HRS 45 MIN 54.000 SEC TIME(GMT)- 17 HRS 36 MIN 54.000 SEC

COORDINATE SYSTEM- ECI

X	.7009101885600919+008	Y	-.9791818362686327+008	Z	.1986783119715735+008	RTCC
	.7009023957641881+008		-.9791676170088617+008		.1986481877708617+008	TRW
XDOT	.1239781389700085+005	YDOT	-.7792484085880250+004	ZDOT	-.9231990610602071+003	RTCC
	.1239809975833132+005		-.7792260382112903+004		-.9233343697822593+003	TRW

COORDINATE SYSTEM- ECT

SMA	.9144579518210602+009	ECC	.9763044462005340+000	INC	.3067055180423135+002	RTCC
	.9144533637197144+009		.9763034980680148+000		.3066757324529990+002	TRW
	.4588101345762610+004		.9481325191976197-006		.2978558931458069-002	RTCC-TRW
NODE	.5211813445806584+002	ARG	.2972115263640969+002	TRUE	.1316727677033235+003	RTCC
	.5211789821042025+002	PERIAPSIS	.2972343017014298+002	ANOMALY	.1316713961636342+003	TRW
	.2362476455906037-003		-.2277533733290454-002		.1371539689309697-002	RTCC-TRW
PERIOD	.2440766775715187+005	APOASIS	.2939933219607910+006	PERIAPSIS	.1248475927047875+003	RTCC
	.2440748406683687+005		.2939916869509867+006		.1249723937221765+003	TRW
	.1836903150034174+000		.1635009804311266+001		-.1248010173890357+000	RTCC-TRW
VEL-MAG	.1467245358349130+005	FLIGHT	.2569442164470136+002	HEADING	.1193388156288288+003	RTCC
	.1467258483835083+005	PATH	.2569512033620653+002		.1193360462102368+003	TRW
	-.1312548595321487+000		-.6986915051737652-003		.2769418592059036-002	RTCC-TRW
DEC	.9366711019426148+001	LONG	.3110207244519212+003	HEIGHT	.1664499812586593+005	RTCC
	.9365438688113088+001		.3110208167748491+003		.1664465601512520+005	TRW
	.1272331313059121-002		-.9232292797323182-004		.3421107407305328+000	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECOND)
DEL U= 2079. DEL V= -1497. DEL W= 2268. DEL UDT= .04 DEL VDT= -.38 DEL WDT= -.06

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 3421. DEL VEL= .4

TITLE- TRAJECTORY UPDATE RIDX251 (ECI) CSM

DATE- 21 DEC. 1968 TIME(GET)- 0 DAYS 11 HRS 55 MIN 36.000 SEC TIME(GMT)- 24 HRS 46 MIN 36.000 SEC

COORDINATE SYSTEM- ECI

X	.30286137382C8454+009	Y	-.207058139402611C+009	Z	-.14769415080352 34+008	RTCC
	.30285668432231 12+009		-.207062264020595 8+009		-.14791619402507 95+008	TRW
XDOT	.7199318757430428+004	YDOT	-.2702416036567140+004	ZDOT	-.1381939510887763+004	RTCC
	.7199390525999047+004		-.2702256513112469+004		-.1381832057196297+004	TRW

COORDINATE SYSTEM- ECT

SMA	.9004846029654807+009	ECC	.9756423152610960+000	INC	.3060270471793131+002	RTCC
	.9004695599631090+009		.9756426890082770+000		.3058594941172944+002	TRW
	.1504300237177778+005		-.3737471809565559-006		.1675530620187337-001	RTCC-TRW
NODE	.5112335751369131+002	ARG	.2984587118562513+002	TRUE	.1546890716577168+003	RTCC
	.5111390367337881+002	PERIAPSIS	.2985451696542948+002	ANOMALY	.1546895131212200+003	TRW
	.9453840312501238-002		-.8645779804345721-002		-.4414635032321534-003	RTCC-TRW
PERIOD	.2385036934723926+005	APOASIS	.2893502516977528+006	PERIAPSIS	.1684827879197351+003	RTCC
	.2384977170293239+005		.2893454158704679+006		.1683670954688727+003	TRW
	.5976443068635717+000		.4835827284972310+001		.1156924508623369+000	RTCC-TRW
VEL-MAG	.7813001972155935+004	FLIGHT	.1579824962087759+002	HEADING	.1205240426829454+003	RTCC
	.7812993923125689+004	PATH	.1579803669531129+002		.1205069971848184+003	TRW
	.8049070245284895-002		.2129255662964429-003		.1704549812693412-001	RTCC-TRW
DEC	-.2306871461378734+001	LONG	.2233468809142208+003	HEIGHT	.5698760944986824+005	RTCC
	-.2310343267537853+001		.2233459359292082+003		.5698750276096190+005	TRW
	.3471806129119237-002		.9449850126141967-003		.1066889063318567+000	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECOND)

DEL U= 648. DEL V= -6081. DEL W= 22240. DEL UDT= .04 DEL VDT= -.09 DEL WDT= -.18

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 23066. DEL VEL= .2

TITLE- CMC NAV UPDATE NBEX241 (ECI) CSM

DATE- 21 DEC. 1968 TIME(GET)- 0 DAYS 11 HRS 55 MIN 36.000 SEC TIME(GMT)- 24 HRS 46 MIN 36.000 SEC

COORDINATE SYSTEM- ECI

X	.3028629870278540+009	Y	-.2070539895357676+009	Z	-.1478465221939260+008	RTCC
	.3028566843223112+009		-.2070622640205958+009		-.1479161940250795+008	TRW
XDOT	.7199212751128380+004	YDOT	-.2702414159752343+004	ZDOT	-.1382574920927902+004	RTCC
	.7199390525999047+004		-.2702256513112469+004		-.1381832057196297+004	TRW

COORDINATE SYSTEM- ECT

SMA	.9004925280823858+009	ECC	.9756416845962456+000	INC	.3061238391045382+002	RTCC
	.9004695599631090+009		.9756426890082770+000		.3058594941172944+002	TRW
	.2296811927686445+005		-.1004412031379263-005		.2643449872438430-001	RTCC-TRW
NODE	.5112150355267283+002	ARG	.2984975879450845+002	TRUE	.1546885752369721+003	RTCC
	.5111390367337881+002	PERIAPSIS	.2985451696542948+002	ANOMALY	.1546895131212200+003	TRW
	.7596879294021474-002		-.4758170921028065-002		-.9378842478835469-003	RTCC-TRW
PERIOD	.2385068420667255+005	APOASIS	.2893527350751447+006	PERIAPSIS	.1686080236088417+003	RTCC
	.2384977170293239+005		.2893454158704679+006		.1683670954688727+003	TRW
	.9125037401598774+000		.7319204676852223+001		.2409281399689540+000	RTCC-TRW
VEL-MAG	.7813016072875530+004	FLIGHT	.1579851647849437+002	HEADING	.1205335894903214+003	RTCC
	.7812993923125689+004	PATH	.1579803669531129+002		.1205069971848184+003	TRW
	.2214974984013906-001		.4797831830772869-003		.2659230550297519-001	RTCC-TRW
DEC	-.2309253548741743+001	LONG	.2233475581912302+003	HEIGHT	.5698754422490118+005	RTCC
	-.2310343267507853+001		.2233459359292082+003		.5698750276096190+005	TRW
	.1089718766110834-002		.1622262022022091-002		.4146393927254621-001	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECOND)
DEL U= 252. DEL V= 5405. DEL W= 11290. DEL UDT= -.03 DEL VDT= .18 DEL WDT= -.76

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 12519. DEL VEL= .8

TITLE- TRAJECTORY UPDATE GWMX337 (ECI) CSM

DATE- 21 DEC. 1968 TIME(GET)- 1 DAYS 6 HRS 14 MIN 54.000 SEC TIME(GMT)- 43 HRS 5 MIN 54.000 SEC

COORDINATE SYSTEM- ECI

X	.6667998537303794+009	Y	-.3186791704143134+009	Z	-.9665110157397467+008	RTCC
	.6667926132537843+009		-.3186938854054637+009		-.9665705494381913+008	TRW
XDOT	.4438685189768659+004	YDOT	-.1123518118521038+004	ZDOT	-.1119123143856043+004	RTCC
	.4438575670193168+004		-.1123784938222042+004		-.1119101345376002+004	TRW

COORDINATE SYSTEM- ECT

SMA	.9049018112047614+009	ECC	.9759686906551417+000	INC	.3118199023320164+002	RTCC
	.9048790268885810+009		.9759769763307964+000		.3118450525480161+002	TRW
	.2278431618040986+005		-.8285675654675674-005		-.2515021599976297-002	RTCC-TRW
NODE	.5136215067134944+002	ARG	.2958941374162289+002	TRUE	.1649175056595347+003	RTCC
	.5136135177181227+002	PERIAPSIS	.2958627694681518+002	ANOMALY	.1649204686456691+003	TRW
	.7988995371658313-003		.3136794807711340-002		-.2962986134447342-002	RTCC-TRW
PERIOD	.2402607663837084+005	APOASIS	.2908351085144952+006	PERIAPSIS	.1375839799271708+003	RTCC
	.2402516922343242+005		.2908289329303372+006		.1362599314688276+003	TRW
	.9074149384234715+000		.6175584157978391+001		.1324048458343234+001	RTCC-TRW
VEL-MAG	.4713454761385848+004	FLIGHT	.1279009657589138+002	HEADING	.1203659049856431+003	RTCC
	.4713410059460967+004	PATH	.1278783074450749+002		.1203684010990862+003	TRW
	.4470192488167867-001		.2265831383888222-002		-.2496113443020808-002	RTCC-TRW
DEC	-.7452072753624515+001	LONG	.3165848113213813+003	HEIGHT	.1192245434136420+006	RTCC
	-.7452528454085391+001		.3165835399779926+003		.1192246399009217+006	TRW
	.4557004608758130-003		.1271343388653534-002		-.9648727967976356-001	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECOND)

DEL U= -586. DEL V= 11152. DEL W= 13405. DEL UDT= -.01 DEL VDT= .26 DEL WDT= .13

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 17447. DEL VEL= .3

TITLE- TRAJECTORY UPDATE GDSX311 (ECI) CSM

DATE- 21 DEC. 1968 TIME(GET)- 1 DAYS 6 HRS 14 MIN 54.000 SEC TIME(GMT)- 43 HRS 5 MIN 54.000 SEC

COORDINATE SYSTEM- ECI

X	.6668051568983574+009	Y	-.3186756717564425+009	Z	-.9662816060349402+008	RTCC
	.6667926132537843+009		-.3186938854054637+009		-.9665705494381913+008	TRW
XDOT	.4438790917060864+004	YDOT	-.1123238079829711+004	ZDOT	-.1119346177348918+004	RTCC
	.4438575670193168+004		-.1123784938222042+004		-.1119101345376002+004	TRW

COORDINATE SYSTEM- ECT

SMA	.9049496624666712+009	ECC	.9759506477472175+000	INC	.3119128357711576+002	RTCC
	.9048790268885810+009		.9759769763307964+000		.3118450525480161+002	TRW
	.7063557809023931+005		-.2632858357894118-004		.6778322314145379-002	RTCC-TRW
NODE	.5137028064733581+002	ARG	.2958831766048190+002	TRUE	.1649111070128557+003	RTCC
	.5136135177181227+002	PERIAPSIS	.2958627694681518+002	ANOMALY	.1649204686456691+003	TRW
	.8928875523543822-002		.2040713666725341-002		-.9361632813406739-002	RTCC-TRW
PERIOD	.2402798241411957+005	APOASIS	.2908479826401917+006	PERIAPSIS	.1404604645062047+003	RTCC
	.2402516922343242+005		.2908289329303372+006		.1362599314688276+003	TRW
	.2813190687151148+001		.1904970985443242+002		.4200533037377081+001	RTCC-TRW
VEL-MAG	.4713540543382140+004	FLIGHT	.1279502156869682+002	HEADING	.1203759017733070+003	RTCC
	.4713410059460967+004	PATH	.1278783074450749+002		.1203684010990862+003	TRW
	.1304839211731234+000		.7190824189335628-002		.7500674220791925-002	RTCC-TRW
DEC	-.7450291434041511+001	LONG	.3165852332722596+003	HEIGHT	.1192245885070246+006	RTCC
	-.7452528454085391+001		.3165835399779926+003		.1192246399009217+006	TRW
	.2237020043880308-002		.1693294266997380-002		-.5139389716725872-001	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECOND)
DEL U= -313. DEL V= 4133. DEL W= 36149. DEL UDT= -.01 DEL VDT= .63 DEL WDT= .08

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 36386. DEL VEL= .6

TITLE- CMC NAV UPDATE FOR MCC4 GCSX374 (ECI) CSM

DATE- 21 DEC. 1968 TIME(GET)- 1 DAYS 15 HRS 56 MIN 48.000 SEC TIME(GMT)- 52 HRS 47 MIN 48.000 SEC

COORDINATE SYSTEM- ECI						
X	.8095798116060003+009	Y	-.3525155018494783+009	Z	-.1340804859433953+009	RTCC
	.8095709038172642+009		-.3525393794565915+009		-.1340725307381011+009	TRW
XDOT	.3778990371256117+004	YDOT	-.8391382200501079+003	ZDOT	-.1029421049341403+004	RTCC
	.3779060108570510+004		-.8390720820831634+003		-.1029237566792482+004	TRW
COORDINATE SYSTEM- ECT						
SMA	.9094827982068403+009	ECC	.9764624988415093+000	INC	.3223108660948964+002	RTCC
	.9094853757765620+009		.9764574545183445+000		.3221635872724206+002	TRW
	-.2577569721724838+004		.5044323164774509-005		.1472788224758375-001	RTCC-TRW
NODE	.5192065394080554+002	ARG	.2903673462819625+002	TRUE	.1673143755912316+003	RTCC
	.5191176330756378+002	PERIAPSIS	.2904399009379788+002	ANOMALY	.1673129764934413+003	TRW
	.8890633241756429-002		-.7255465601626515-002		.1399097790303782-002	RTCC-TRW
PERIOD	.2420875224317667+005	APOASIS	.2923987715617205+006	PERIAPSIS	.8178797877445900+002	RTCC
	.2420885515846729+005		.2923988549590427+006		.8255300831759043+002	TRW
	-.1029152906205865+000		-.8339732220974838-001		-.7650295431314333+000	RTCC-TRW
VEL-MAG	.4005574724708361+004	FLIGHT	.1245789831918289+002	HEADING	.1211735637544134+003	RTCC
	.4005579512632004+004	PATH	.1245923905924116+002		.1211583448373473+003	TRW
	-.4787923642183500-002		-.1340740058268133-002		.1521891706608380-001	RTCC-TRW
DEC	-.8635389958757937+001	LONG	.1727260610835965+003	HEIGHT	.1435473916879419+006	RTCC
	-.8634872303938370+001		.1727244097684873+003		.1435474173719176+006	TRW
	-.5176548195673508-003		.1651315109238549-002		-.2568397568506952-001	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECCND)
DEL U= -156. DEL V= 25953. DEL W= 6262. DEL UDT= -.01 DEL VDT= .02 DEL WDT= -.21

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 26698. DEL VEL= .2

TITLE- CMC NAV UPDATE FOR LOI1 HSKX417 (MCI) CSM

DATE- 21 DEC. 1968 TIME(GET)- 2 DAYS 13 HRS 6 MIN 36.000 SEC TIME(GMT)- 73 HRS 57 MIN 36.000 SEC

COORDINATE SYSTEM- MCI

X	-.2040511865131031+008	Y	.1053210316162362+009	Z	.7702548516859442+008	RTCC
	-.2040465293202604+008		.1053203262150037+009		.7702625589464466+008	TRW
XDOT	.1029293268646228+004	YDOT	-.3195724207390687+004	ZDOT	-.2363166451485381+004	RTCC
	.1029513805422553+004		-.3193549510667568+004		-.2366227803356801+004	TRW

COORDINATE SYSTEM- MCT

SMA	-.1216291460768234+008	ECC	.1532258890391690+001	INC	.1658881719709641+003	RTCC
	-.1216203926195801+008		.1533236116535088+001		.1658474638406246+003	TRW
	-.8753457243287266+003		-.9772261433983638-003		.4070813033947784-001	RTCC-TRW
NODE	.4836086755316720+002	ARG	.2182137582005344+003	TRUE	-.1248633292820171+003	RTCC
	.5050715284619773+002	PERIAPSIS	.2202576697261749+003	ANOMALY	-.1248257320041070+003	TRW
	-.2146285293030530+001		-.2043911525640442+001		-.3759727791007716-001	RTCC-TRW
PERIOD	.0000000000000000	APOASIS	.0000000000000000	PERIAPSIS	.1269610904029504+003	RTCC
	.0000000000000000		.0000000000000000		.1288404412129743+003	TRW
	.0000000000000000		.0000000000000000		-.1879350810023941+001	RTCC-TRW
VEL-MAG	.4105686640503776+004	FLIGHT	.1743614156667202+003	HEADING	.2691582356132532+003	RTCC
	.4105811854849685+004	PATH	.1743555011681880+003		.2686326059491892+003	TRW
	-.1252143459090504+000		.5914498532167522-002		.5256296640639814+000	RTCC-TRW
DEC	.1408720905718853+002	LONG	.5496154052891030+001	HEIGHT	.2079701650792684+005	RTCC
	.1408766646293033+002		.5496150904143177+001		.2079698606336248+005	TRW
	-.4574057418029187-003		.3148747853010114-005		.3044456435756615-001	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECOND)
DEL U= 185. DEL V= -378. DEL W= 1064. DEL UDT= .08 DEL VDT= -.44 DEL WDT= -3.73

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 1144. DEL VEL= 3.8

TITLE- LUNAR ORBIT-REV 1 HSKX470 (MCI) CSM

DATE- 21 DEC. 1968 TIME(GET)- 2 DAYS 21 HRS 32 MIN 60.000 SEC TIME(GMT)- 82 HRS 24 MIN .000 SEC

COORDINATE SYSTEM- MCI

X	-.650030141937604 5+006	Y	-.514114628585734 5+007	Z	-.333175730107041 0+007	RTCC
	-.650478781807324 9+006		-.514687926649793 7+007		-.332341955188032 6+007	TRW
XDOT	-.536847989237602 2+004	YDOT	.882800976013488 7+002	ZDOT	.552153753073718 3+003	RTCC
	-.536804372797857 1+004		.884428831113800 2+002		.554043193831390 1+003	TRW

COORDINATE SYSTEM- MCT

SMA	.639512967094121 2+007	ECC	.513395530915674 2-001	INC	.167681831812800 1+003	RTCC
	.639523674238975 8+007		.512951050934292 6-001		.167759049637002 4+003	TRW
	-.107071448546172 1+003		.444479981381535 9-004		-.772178242023067 1-001	RTCC-TRW
NODE	.526640991163978 0+002	ARG	.250631752529521 9+003	TRUE	.465424460279872 9+002	RTCC
	.529190251288621 8+002	PERIAPSIS	.250887445283735 9+003	ANOMALY	.465469665233347 9+002	TRW
	-.254926012464385 9+000		-.255692754214039 6+000		-.452049534750681 4-002	RTCC-TRW
PERIOD	.128709074172259 5+003	APOASIS	.168045455255792 4+003	PERIAPSIS	.599753861577832 6+002	RTCC
	.128712306583188 9+003		.168017199205019 1+003		.600388855979756 1+002	TRW
	-.323241092937420 7-002		.282560507732689 8-001		-.634994401923538 7-001	RTCC-TRW
VEL-MAG	.539752195203485 9+004	FLIGHT	.879385006128397 3+002	HEADING	.275695153426903 0+003	RTCC
	.539728442783226 6+004	PATH	.879400633876772 0+002		.275708251647877 7+003	TRW
	.237524202593341 7+000		-.156277483747602 1-002		-.130982209746917 1-001	RTCC-TRW
DEC	-.109406548081059 5+002	LONG	.200615214398433 7+001	HEIGHT	.754323474619769 8+002	RTCC
	-.108465276195926 7+002		.200612056390799 4+001		.754867804026574 6+002	TRW
	-.941271885132761 5-001		.315800763429005 5-004		-.544329406804839 8-001	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECOND)
DEL U= -339. DEL V= -1197. DEL W= 10052. DEL UDT= 1.20 DEL VDT= .19 DEL WDT= 1.52

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 10128. DEL VEL= 1.9

TITLE- LUNAR ORBIT-REV 2 ACNX490 (MCI) CSM PAGE 3

DATE- 21 DEC. 1968 TIME(GET)- 2 DAYS 23 HRS 40 MIN 24.000 SEC TIME(GMT)- 84 HRS 31 MIN 24.000 SEC

COORDINATE SYSTEM- MCI

X	-.2516319598832736+006	Y	-.5134989159429534+007	Z	-.3365321473652071+007	RTCC
	-.2516298243736627+006		-.5134912527914067+007		-.3365781553890073+007	TRW
XDOT	-.5394906797878791+004	YDOT	-.1945153039738351+003	ZDOT	.3700471967764662+003	RTCC
	-.5394922360081716+004		-.1933742010575220+003		.3683200100741720+003	TRW

COORDINATE SYSTEM- MCT

SMA	.6395030433610505+007	ECC	.5145568833868626-001	INC	.1676673331812685+003	RTCC
	.6395071268760358+007		.5143327777469088-001		.1676723584880530+003	TRW
	-.4083514985352667+002		.2241056399538402-004		-.5025306784474103-002	RTCC-TRW
NODE	.5155867336139775+002	ARG	.2511003083987173+003	TRUE	.4241143593831948+002	RTCC
	.5145786750118094+002	PERIAPSIS	.2509912563943346+003	ANOMALY	.4242161042822181+002	TRW
	.1008058602168064+000		.1090520043827230+000		-.1017448990233410-001	RTCC-TRW
PERIOD	.1287060782919416+003	APOASIS	.1681505151960729+003	PERIAPSIS	.5983766148812333+002	RTCC
	.1287073110633346+003		.1681339946399870+003		.5986762324732938+002	TRW
	-.1232771393049558-002		.1652055608592561-001		-.2996175920604482-001	RTCC-TRW
VEL-MAG	.5411080334959059+004	FLIGHT	.8808508111308114+002	HEADING	.2749847593781320+003	RTCC
	.5410937107842274+004	PATH	.8808550086782465+002		.2749630014131277+003	TRW
	.1432271167851908+000		-.4197547435166315-003		.2175796500426363-001	RTCC-TRW
DEC	-.1129467595135584+002	LONG	.2051699158887332+001	HEIGHT	.7278806876480938+002	RTCC
	-.1129865632365123+002		.2051700084395575+001		.7281898746243006+002	TRW
	.3980372295382783-002		-.9255082426481986-006		-.3091869762067833-001	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECOND)
DEL U= -188. DEL V= 42. DEL W= -425. DEL UDT= .01 DEL VDT= .14 DEL WDT= -2.07

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 466. DEL VEL= 2.1

TITLE- LUNAR ORBIT-REV 3 ACNX512 (MCI) CSM

DATE- 21 DEC. 1968 TIME(GET)- 3 DAYS 1 HRS 49 MIN 24.000 SEC TIME(GMT)- 86 HRS 40 MIN 24.000 SEC

COORDINATE SYSTEM- MCI

X	-.2949455803678234+006	Y	-.5075212695715980+007	Z	-.3306469257942893+007	RTCC
	-.2947512562438770+006		-.5067299260059092+007		-.3319039402078825+007	TRW
XDOT	-.5322923473360548+004	YDOT	-.9901042088123724+001	ZDOT	.4902842737755806+003	RTCC
	-.5323247356311789+004		-.7281166456860098+001		.4842708614898975+003	TRW

COORDINATE SYSTEM- MCT

SMA	.6069691773331317+007	ECC	.8645552481342053-003	INC	.1677589484987666+003	RTCC
	.6069649024147694+007		.8187141437979148-003		.1676596874463687+003	TRW
	.4274918362264725+002		.4584110433629049-004		.9926105239795202-001	RTCC-TRW
NODE	.5080163118629581+002	ARG	.2961923463196770+003	TRUE	.3581843091898171+003	RTCC
	.5023626723558396+002	PERIAPSIS	.2968039055629539+003	ANOMALY	.3570075693696903+003	TRW
	.5653639507118518+000		-.6115592432769210+000		.1176739820126785+001	RTCC-TRW
PERIOD	.1190104481112996+003	APOASIS	.6131387056049005+002	PERIAPSIS	.5958658803462247+002	RTCC
	.1190091908175034+003		.6126103654700037+002		.5962535082608034+002	TRW
	.1257293796268932-002		.5283401348967231-001		-.3876279145786298-001	RTCC-TRW
VEL-MAG	.5345464486820948+004	FLIGHT	.9000156814722510+002	HEADING	.2751169430028208+003	RTCC
	.5345234632452077+004	PATH	.9000244683110595+002		.2750475319522064+003	TRW
	.2298543688711802+000		-.8786838808565455-003		.6941105061434615-001	RTCC-TRW
DEC	-.1113511952100575+002	LONG	.2023287792360272+001	HEIGHT	.5958702090195759+002	RTCC
	-.1127544468054953+002		.2023293927424246+001		.5962646418046699+002	TRW
	.1403251595437741+000		-.6135063974666704-005		-.3944327850940521-001	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECOND)
DEL U= -258. DEL V= 1343. DEL W= -14792. DEL UDT= -1.12 DEL VDT= .23 DEL WDT= -6.47

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 14855. DEL VEL= 6.6

TITLE- LUNAR ORBIT-REV 4 MADX530 (MCI) CSM

DATE- 21 DEC. 1968 TIME(GET)- 3 DAYS 3 HRS 48 MIN 6.000 SEC TIME(GMT)- 88 HRS 39 MIN 6.000 SEC

COORDINATE SYSTEM- MCI

X	-.2219481515628747+006	Y	-.5066114498637041+007	Z	-.3323216628434067+007	RTCC
	-.2220576482315643+006		-.5069563904132732+007		-.3318399786624090+007	TRW
XDOT	-.5327174723080408+004	YDOT	-.6278346322793148+002	ZDOT	.4537341239086353+003	RTCC
	-.5327003864683254+004		-.6177114089281650+002		.4532294755987967+003	TRW

COORDINATE SYSTEM- MCT

SMA	.6069667113276939+007	ECC	.1141046809405311-002	INC	.1676515623928905+003	RTCC
	.6069654588852792+007		.1102267862855214-002		.1677067726716310+003	TRW
	.1252442414707184+002		.3877894655009687-004		-.5521027874047512-001	RTCC-TRW
NODE	.4939276746954154+002	ARG	.3049635817498686+003	TRUE	.3483960075160661+003	RTCC
	.4945209224886013+002	PERIAPSIS	.3062787033375978+003	ANOMALY	.3471441162731083+003	TRW
	-.5932477931859558-001		-.1315121587729267+001		.1251891242957880+001	RTCC-TRW
PERIOD	.1190097228353094+003	APOASIS	.6158600666802464+002	PERIAPSIS	.5930633488084136+002	RTCC
	.1190093544804763+003		.6154520534770533+002		.5934301369078598+002	TRW
	.3683548330634112-003		.4080132031930894-001		-.3667880994461647-001	RTCC-TRW
VEL-MAG	.5346831430463129+004	FLIGHT	.9001313568492646+002	HEADING	.2749609700700317+003	RTCC
	.5346066066333733+004	PATH	.9001403693754729+002		.2749507578592344+003	TRW
	.2248241293962323+000		-.9012526208318494-003		.1021221079729750-001	RTCC-TRW
DEC	-.1132228071849891+002	LONG	.2016572635293044+001	HEIGHT	.5932957915450488+002	RTCC
	-.1126633493202497+002		.2016564795164361+001		.5937055505677247+002	TRW
	-.5594578647394361-001		.7840128683326425-005		-.4097590226759439-001	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECOND)
DEL U= -252. DEL V= -557. DEL W= 5894. DEL UDT= .58 DEL VDT= .22 DEL WDT= -.96

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 5926. DEL VEL= 1.1

TITLE- LUNAR ORBIT-REV 5 ACNX545 (MCI) CSM

DATE- 21 DEC. 1968 TIME(GET)- 3 DAYS 5 HRS 46 MIN 24.000 SEC TIME(GMT)- 90 HRS 37 MIN 24.000 SEC

COORDINATE SYSTEM- MCI

X	-.213802870749631 7+005	Y	-.5066261501947825+007	Z	-.3327724388177742+007	RTCC
	-.2124722194391985+005		-.5064474710127877+007		-.3330672193438378+007	TRW
XDOT	-.5331649913075131+004	YDOT	-.2118350492064736+003	ZDOT	.3612016721734663+003	RTCC
	-.5331749044578386+004		-.2103409860441590+003		.3582654993419848+003	TRW

COORDINATE SYSTEM- MCT

SMA	.6069614732070445+007	ECC	.1419848393271103-002	INC	.1677373224622466+003	RTCC
	.6069507459686900+007		.1382987454948181-002		.1677202616680916+003	TRW
	.1072723835443321+003		.3686093832292205-004		.1706079415504957-001	RTCC-TRW
NODE	.4871266084859917+002	ARG	.3106104856840408+003	TRUE	.3412492948857147+003	RTCC
	.4850297549747779+002	PERIAPSIS	.3108361512751371+003	ANOMALY	.3408149404041464+003	TRW
	.2096853511213812+000		-.2256655910962312+000		.4343544815683073+000	RTCC-TRW
PERIOD	.1190081822583797+003	APOASIS	.6185587930018171+002	PERIAPSIS	.5901922057236635+002	RTCC
	.1190050273048459+003		.6180137861697612+002		.5903841172685537+002	TRW
	.3154953533796911-002		.5450068320559164-001		-.1919115448901997-001	RTCC-TRW
VEL-MAG	.5348067959528477+004	FLIGHT	.9002611535928764+002	HEADING	.2746267739959674+003	RTCC
	.5347910315333975+004	PATH	.9002600569360084+002		.2745914675073650+003	TRW
	.1576441945017634+000		.1096656868008194-003		.3530648860243434-001	RTCC-TRW
DEC	-.1136873011779097+002	LONG	.2031425263596877+001	HEIGHT	.5909428892927420+002	RTCC
	-.1140129428727353+002		.2031446295970728+001		.5911493036938794+002	TRW
	.3256416948255189-001		-.2103237385073231-004		-.2064144011374402-001	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECOND)

DEL U= -126. DEL V= 400. DEL W= -3424. DEL UDT= -.37 DEL VDT= .16 DEL WDT= -3.27

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 3450. DEL VEL= 3.3

TITLE- LUNAR ORBIT-REV 6 ACNX565 (MCI) CSM

DATE- 21 DEC. 1968 TIME(GET)- 3 DAYS 7 HRS 47 MIN 30.000 SEC TIME(GMT)- 92 HRS 38 MIN 30.000 SEC

COORDINATE SYSTEM- MCI

X	-.7158922079058361+006	Y	-.5057044488527443+007	Z	-.3260511021740153+007	RTCC
	-.7161949588836101+006		-.5058401565805641+007		-.3260232016845155+007	TRW
XDOT	-.5295391561001836+004	YDOT	.3030432156002885+003	ZDOT	.6971802965622343+003	RTCC
	-.5294682897264634+004		.3045200684609456+003		.6963954034741073+003	TRW

COORDINATE SYSTEM- MCT

SMA	.6069297035382081+007	ECC	.1682339270912793-002	INC	.1677048195078628+003	RTCC
	.6069701389144063+007		.1625136389488056-002		.1677199087832206+003	TRW
	-.4043537619816852+003		.5720288142473706-004		-.1508927535772430-001	RTCC-TRW
NODE	.4756677229099305+002	ARG	.3141280198981272+003	TRUE	.3442954381661714+003	RTCC
	.4752460520577325+002	PERIAPSIS	.3192903430154846+003	ANOMALY	.3390943672817313+003	TRW
	.4216708521980039-001		-.5162323117357435+001		.5201070884440142+001	RTCC-TRW
PERIOD	.1189988386643514+003	APOASIS	.6206571523589007+002	PERIAPSIS	.5870481233230248+002	RTCC
	.1190107309220287+003		.6207523276652431+002		.5882839094718688+002	TRW
	-.1189225767724200-001		-.9517530634234994-002		-.1235786148843969+000	RTCC-TRW
VEL-MAG	.5349679134555925+004	FLIGHT	.9002604863093701+002	HEADING	.2759226455248096+003	RTCC
	.5348959292676537+004	PATH	.9003317529070980+002		.2759078623159007+003	TRW
	.7198418793878644+000		-.7126659772790588-002		.1478320890883955-001	RTCC-TRW
DEC	-.1079397949526563+002	LONG	.1895135731615716+001	HEIGHT	.5876733645666431+002	RTCC
	-.1078477066090494+002		.1895108861122863+001		.5893492630469418+002	TRW
	-.9208834360683815-002		.2687049285240300-004		-.1675898480298725+000	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECOND)

DEL U= -1318. DEL V= -259. DEL W= 952. DEL UDT= .89 DEL VDT= .72 DEL WDT= -1.41

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 1418. DEL VEL= 1.8

TITLE- LUNAR ORBIT-REV 7 GDSX586 (MCI) CSM

DATE- 21 DEC. 1968 TIME(GET)- 3 DAYS 9 HRS 44 MIN 18.000 SEC TIME(GMT)- 94 HRS 35 MIN 18.000 SEC

COORDINATE SYSTEM- MCI

X	-.3956322598318530+005	Y	-.5063577776024958+007	Z	-.3325559808893630+007	RTCC
	-.3947529717009345+005		-.5065076308056270+007		-.3323600637742382+007	TRW
XDOT	-.5334068910971780+004	YDOT	-.1985268551754339+003	ZDOT	.3734039176903443+003	RTCC
	-.5334029885071549+004		-.1973672980214284+003		.3719660594885604+003	TRW

COORDINATE SYSTEM- MCT

SMA	.6069148431358435+007	ECC	.1981010216872661-002	INC	.1677161673410068+003	RTCC
	.6069089423448522+007		.1952140210316947-002		.1677450855414433+003	TRW
	.5900790991266694+002		.2887000655571435-004		-.2891820043646786-001	RTCC-TRW
NODE	.4663733678471175+002	ARG	.3155606741706461+003	TRUE	.3365698578659320+003	RTCC
	.4659319929302016+002	PERIAPSIS	.3164177205555531+003	ANOMALY	.3356706693195515+003	TRW
	.4413749169159542-001		-.8570463849070533+000		.8991885463804489+000	RTCC-TRW
PERIOD	.1189944682410833+003	APOASIS	.6233954550399679+002	PERIAPSIS	.5838206790878160+002	RTCC
	.1189927328416592+003		.6230097818825431+002		.5840121231789402+002	TRW
	.1735399424080186-002		.3856731574248506-001		-.1914440911241932-001	RTCC-TRW
VEL-MAG	.5350806883447708+004	FLIGHT	.9004505058371710+002	HEADING	.2746892711029868+003	RTCC
	.5350624936980303+004	PATH	.9004599798082229+002		.2746695135950966+003	TRW
	.1819464674052895+000		-.9473971051883189-003		.1975750789020569-001	RTCC-TRW
DEC	-.1136629343372537+002	LONG	.1990371528043091+001	HEIGHT	.5854460504204066+002	RTCC
	-.1134302894978199+002		.1990387794589282+001		.5857373164034563+002	TRW
	-.2326448394337947-001		-.1626654619092324-004		-.2912659830496799-001	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECOND)
DEL U= -177. DEL V= -104. DEL W= 2460. DEL UDT= .18 DEL VDT= .18 DEL WDT= -1.83

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 2468. DEL VEL= 1.8

TITLE- LUNAR ORBIT-REV 8 ANGX603 (MCI) CSM

DATE- 21 DEC. 1968 TIME(GET)- 3 DAYS 11 HRS 42 MIN 18.000 SEC TIME(GMT)- 96 HRS 33 MIN 18.000 SEC

COORDINATE SYSTEM- MCI

X	.252702813609 4086+006	Y	-.5047007793016421+007	Z	-.3339416518836975+007	RTCC
	.2527256417221813+006		-.5048858305744082+007		-.3337089243126346+007	TRW
XDOT	-.5330578393212997+004	YDOT	-.41447176005 13589+003	ZDOT	.2333185106335825+003	RTCC
	-.5330521327115206+004		-.4131138690526986+003		.2318188831088186+003	TRW

COORDINATE SYSTEM- MCT

SMA	.6069174064656078+007	ECC	.2261480545973899-002	INC	.1677304014268992+003	RTCC
	.6069180244270134+007		.2234150236753506-002		.1677638242837974+003	TRW
	-.6179614055450656+001		.2733030922039339-004		-.3342285689815827-001	RTCC-TRW
NODE	.4567823443120115+002	ARG	.3174853217562695+003	TRUE	.3319908564944521+003	RTCC
	.4562763904653658+002	PERIAPSIS	.3183962182095481+003	ANOMALY	.3310326148683907+003	TRW
	.5059538466457547-001		-.9108964532785979+000		.9582416260614072+000	RTCC-TRW
PERIOD	.1189952221089144+003	APOASIS	.6262392248569123+002	PERIAPSIS	.5810612832382751+002	RTCC
	.1189954038498053+003		.6259764270392164+002		.5813444217301258+002	TRW
	-.1817408908749706-003		.2627978176959011-001		-.2831384918507051-001	RTCC-TRW
VEL-MAG	.5351755812084762+004	FLIGHT	.9006072795979791+002	HEADING	.2741473104445627+003	RTCC
	.5351528807818617+004	PATH	.9006187450146142+002		.2741260706987497+003	TRW
	.2270042661449735+000		-.1146541663507472-002		.2123974581296383-001	RTCC-TRW
DEC	-.1155754612080657+002	LONG	.2020779882004814+001	HEIGHT	.5836958257528126+002	RTCC
	-.1152952851111614+002		.2020778514109641+001		.5841245816550431+002	TRW
	-.2801760969043334-001		.1367895172861566-005		-.4287559022304776-001	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECOND)

DEL U= -261. DEL V= -221. DEL W= 2954. DEL UDT= .30 DEL VDT= .23 DEL WDT= -1.99

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 2973. DEL VEL= 2.0

TITLE- LUNAR ORBIT-REV 9 HAWX626 (MCI) CSM

DATE- 21 DEC. 1968 TIME(GET)- 3 DAYS 13 HRS 40 MIN 54.000 SEC TIME(GMT)- 98 HRS 31 MIN 54.000 SEC

COORDINATE SYSTEM- MCI

X	.3519431688269600+006	Y	-.5037108851639903+007	Z	-.3342321869253013+007	RTCC
	.3517538246708167+006		-.5040010609202442+007		-.3338081539469758+007	TRW
XDOT	-.5327417159382749+004	YDOT	-.4885985660594548+003	ZDOT	.1872484461234141+003	RTCC
	-.5327330388939259+004		-.4887178404005151+003		.1884533754424721+003	TRW

COORDINATE SYSTEM- MCT

SMA	.6068742078352865+007	ECC	.2521197209410657-002	INC	.1677217023117042+003	RTCC
	.6068796054233396+007		.2522214213508349-002		.1677637474207653+003	TRW
	-.5397588053067738+002		-.1017004097691713-005		-.4204510906101854-001	RTCC-TRW
NODE	.4470652536250116+002	ARG	.3177517679841223+003	TRUE	.3308913911904258+003	RTCC
	.4483117111929765+002	PERIAPSIS	.3180029279619880+003	ANOMALY	.3307677336463749+003	TRW
	-.1246457567964855+000		-.2511599778656616+000		.1236575440509173+000	RTCC-TRW
PERIOD	.1189825177299895+003	APOASIS	.6281206740373032+002	PERIAPSIS	.5777579179715159+002	RTCC
	.1189841050936538+003		.6282198886703579+002		.5778363690936752+002	TRW
	-.1587363664287355-002		-.9921463305471611-002		-.7845112215921545-002	RTCC-TRW
VEL-MAG	.5353051813849860+004	FLIGHT	.9007011754755072+002	HEADING	.2739798368555873+003	RTCC
	.5353018631344262+004	PATH	.9007041769144517+002		.2739918939023530+003	TRW
	.3318250559780011-001		-.3001438944487677-003		-.1205704676575125-001	RTCC-TRW
DEC	-.1162477947303291+002	LONG	.2018614273179631+001	HEIGHT	.5809233564496138+002	RTCC
	-.1157618909450140+002		.2018572827399959+001		.5810294903111184+002	TRW
	-.4859037853151393-001		.4144577967156448-004		-.1061338815045598-001	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECOND)
DEL U= -67. DEL V= -603. DEL W= 5106. DEL UDT= .56 DEL VDT= .03 DEL WDT= 1.08

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 5142. DEL VEL= 1.2

TITLE- LUNAR ORBIT-REV10 GDSX642 (MCI) CSM

DATE- 21 DEC. 1968 TIME(GET)- 3 DAYS 15 HRS 39 MIN 24.000 SEC TIME(GMT)- 100 HRS 30 MIN 24.000 SEC

COORDINATE SYSTEM- MCI

X	.4814807076027356+006	Y	-.5023048680744137+007	Z	-.3345798659727544+007	RTCC
	.4812071432852657+006		-.5029102273898210+007		-.3337414886073662+007	TRW
XDOT	-.5320531824241172+004	YDOT	-.5835101637854309+003	ZDOT	.1248306717957629+003	RTCC
	-.5320383292260812+004		-.5822186099546879+003		.1249980326128732+003	TRW

COORDINATE SYSTEM- MCT

SMA	.6068950308324265+007	ECC	.2807564675048685-002	INC	.1677170409570008+003	RTCC
	.6069058980692329+007		.2786132932769227-002		.1678115292112350+003	TRW
	-.1086723680638024+003		.2143174227945828-004		-.9448825423416962-001	RTCC-TRW
NODE	.4363881430029980+002	ARG	.3196339364859615+003	TRUE	.3277919185739533+003	RTCC
	.4375062426463759+002	PERIAPSIS	.3207475349400175+003	ANOMALY	.3267982560183154+003	TRW
	-.1118099643377860+000		-.1113598454055957+001		.9936625556379463+000	RTCC-TRW
PERIOD	.1189886415539555+003	APOASIS	.6313245383293132+002	PERIAPSIS	.5752394586189568+002	RTCC
	.1189918375354709+003		.6312898236568567+002		.5756318767351203+002	TRW
	-.3195981515454637-002		.3471467245644177-002		-.3924181161634709-001	RTCC-TRW
VEL-MAG	.5353888783158214+004	FLIGHT	.9008553527701722+002	HEADING	.2737305200486189+003	RTCC
	.5353604467680086+004	PATH	.9008721020643127+002		.2737256222906237+003	TRW
	.2843154781283843+000		-.1674929414047454-002		.4897757995130813-002	RTCC-TRW
DEC	-.1171105050162062+002	LONG	.2021619063773878+001	HEIGHT	.5795323875180788+002	RTCC
	-.1161332070769363+002		.2021542069076211+001		.5801518270330912+002	TRW
	-.9772979392699456-001		.7699469766784747-004		-.6194395150123366-001	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECOND)
DEL U= -385. DEL V= -1127. DEL W= 10276. DEL UDT= 1.15 DEL VDT= .29 DEL WDT= -.55

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 10344. DEL VEL= 1.3

TITLE- CMC NAV UPDATE FOR MCC-5 BDAX69? (MCI) CSM

DATE- 21 DEC. 1968 TIME(GET)- 3 DAYS 17 HRS 47 MIN 36.000 SEC TIME(GMT)- 102 HRS 38 MIN 36.000 SEC

COORDINATE SYSTEM- MCI

X	-.4514872025422723+007	Y	-.9673074022523472+007	Z	-.6183341083551337+007	RTCC
	-.4511502607516625+007		-.9671049645875872+007		-.6184736295872389+007	TRW
XDOT	-.6064523962043475+004	YDOT	-.3171951958472816+004	ZDOT	-.1631713969719616+004	RTCC
	-.6064646424494871+004		-.3172193518595104+004		-.1632447371373528+004	TRW

COORDINATE SYSTEM- MCT

SMA	-.8077980580371649+007	ECC	.1750857408933546+001	INC	.1670442647412567+003	RTCC
	-.8077759778711904+007		.1750990199298378+001		.1670332852554045+003	TRW
	-.2208016597446985+003		-.1327903648320784-003		.1097948585215324-001	RTCC-TRW
NODE	.3899340408113068+002	ARG	.2316858464511391+003	TRUE	.7838489137154376+002	RTCC
	.3898578643159415+002	PERIAPSIS	.2316805245145474+003	ANOMALY	.7836907769229034+002	TRW
	.7617649536533266-002		.5321936591633491-002		.1581367925341414-001	RTCC-TRW
PERIOD	.0000000000000000	APOASIS	.0000000000000000	PERIAPSIS	.5974579807164330+002	RTCC
	.0000000000000000		.0000000000000000		.5989504772600330+002	TRW
	.0000000000000000		.0000000000000000		-.1492496543600045+000	RTCC-TRW
VEL-MAG	.7035781370580470+004	FLIGHT	.3826052962430348+002	HEADING	.2784239167118770+003	RTCC
	.7036165951448127+004	PATH	.3827029784258723+002		.2784275543950355+003	TRW
	-.3845808676564885+000		-.9768218283755403-002		-.3637683158539406-002	RTCC-TRW
DEC	-.9878983879241933+001	LONG	.1539263953086017+001	HEIGHT	.1091813586685277+004	RTCC
	-.9890393482808721+001		.1539479588670330+001		.1091464575522116+004	TRW
	.1140960356678751-001		-.2156355843127184-003		.3490111631606005+000	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECOND)

DEL U= 2120. DEL V= 2952. DEL W= -2946. DEL UDT= -.60 DEL VDT= .14 DEL WDT= -.48

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 4171. DEL VEL= .8

TITLE- TRAJECTORY UPDATE GWMX777 (ECI) CSM

DATE- 21 DEC. 1968 TIME(GET)- 4 DAYS 8 HRS 6 MIN 24.000 SEC TIME(GMT)- 116 HRS 57 MIN 24.000 SEC

COORDINATE SYSTEM- ECI

X	.1016315147348728+010	Y	-.1812222096834394+009	Z	-.1022694679406591+009	RTCC
	.1016315067211594+010		-.1812193264817876+009		-.1022738247798749+009	TRW
XDOT	-.4018885713523305+004	YDOT	.1284804826676237+004	ZDOT	.8435568814881932+003	RTCC
	-.4018871086836336+004		.1284904495108059+004		.8434695804246686+003	TRW

COORDINATE SYSTEM- ECT

SMA	.1632179672801280+010	ECC	.9883302011244592+000	INC	.3773458479950685+002	RTCC
	.1632177265642452+010		.9883293399997591+000		.3772244355418469+002	TRW
	.2407158827731385+004		.8611247001230615-006		.1214124532215238-001	RTCC-TRW
NODE	.2676195278988375+003	ARG	.1578571797219344+003	TRUE	.1928721184665820+003	RTCC
	.2676232432136639+003	PERIAPSIS	.1578537521194150+003	ANOMALY	.1928725842917197+003	TRW
	-.3715314826444604-002		.3427602519388450-002		-.4658251376326028-003	RTCC-TRW
PERIOD	.5820129113149939+005	APOASIS	.5306683608536843+006	PERIAPSIS	-.3065759340176733+003	RTCC
	.5820116237756769+005		.5306673418251660+006		-.3063492403104656+003	TRW
	.1287539317010555+003		.1019028518319828+001		-.2266937072077688+000	RTCC-TRW
VEL-MAG	.4302761210352995+004	FLIGHT	.1705855847148718+003	HEADING	.5262941407135138+002	RTCC
	.4302760196346031+004	PATH	.1705852396381357+003		.5264174753709624+002	TRW
	.1014006964155100-002		.3450767360808626-003		-.1233346574485533-001	RTCC-TRW
DEC	-.5658179222398154+001	LONG	.3011104768432886+003	HEIGHT	.1672926057013087+006	RTCC
	-.5658421858368239+001		.3011106336072185+003		.1672925805782682+006	TRW
	.2426359700857111-003		-.1567639299002721-003		.2512304050992497-001	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECOND)
DEL U= 153. DEL V= 421. DEL W= 5206. DEL UDT= -.01 DEL VDT= -.03 DEL WDT= .13

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 5225. DEL VEL= .1

TITLE- TRAJECTORY UPDATE CROX856 (ECI) CSM

DATE- 21 DEC. 1968 TIME(GET)- 5 DAYS 9 HRS 25 MIN 24.000 SEC TIME(GMT)- 142 HRS 16 MIN 24.000 SEC

COORDINATE SYSTEM- ECI

X	.5793411134249913+009	Y	-.5115267687009499+008	Z	-.1862137658606085+008	RTCC
	.5793444929023794+009		-.5113631859592215+008		-.1860515310667912+008	TRW
XDOT	-.5984266391387524+004	YDOT	.1582063761351456+004	ZDOT	.9905498224071284+003	RTCC
	-.5984232775170963+004		.1582027185393696+004		.9909381772491766+003	TRW

COORDINATE SYSTEM- ECT

SMA	.1549201046948618+010	ECC	.9864510011335345+000	INC	.3717649581947859+002	RTCC
	.1549263881221574+010		.9864421365227806+000		.3719219606917155+002	TRW
	-.6283427295697107+005		.8864610753961214-005		-.1570024969295480-001	RTCC-TRW
NODE	.2677483054337901+003	ARG	.1571999416732136+003	TRUE	.1997636690575466+003	RTCC
	.2677464460220281+003	PERIAPSIS	.1571966595399076+003	ANOMALY	.1997707025860326+003	TRW
	.1859411761999218-002		.3282133305950285-002		-.7033528485946405-002	RTCC-TRW
PERIOD	.5381983284092490+005	APOASIS	.5030355463678554+006	PERIAPSIS	.1318671498384492+002	RTCC
	.5382310720389122+005		.5030538283750220+006		.1558709122338505+002	TRW
	-.3274362966326464+001		-.1828200716664468+002		-.2400376239540126+001	RTCC-TRW
VEL-MAG	.6268616987720861+004	FLIGHT	.1678759418445211+003	HEADING	.5286225252955667+002	RTCC
	.6268637044357009+004	PATH	.1678717630025492+003		.5284646250859333+002	TRW
	-.2005663614815489-001		.4178841971917535-002		.1579002096334325-001	RTCC-TRW
DEC	-.1834260540225838+001	LONG	.2853851448057351+003	HEIGHT	.9232593307713306+005	RTCC
	-.1832657783792041+001		.2853867793049122+003		.9232616479336718+005	TRW
	-.1602756433796608-002		-.1634499177120662-002		-.2317162341275889+000	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECOND)
DEL U= -1408. DEL V= -23055. DEL W= -2953. DEL UDT= -.02 DEL VDT= -.21 DEL WDT= -.33

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 23286. DEL VEL= .4

TITLE- TRAJECTORY UPDATE N8EX863 (ECI) CSM

DATE- 21 DEC. 1968 TIME(GET)- 5 DAYS 11 HRS 24 MIN 42.000 SEC TIME(GMT)- 144 HRS 15 MIN 42.000 SEC

COORDINATE SYSTEM- ECI

X	.5353918922668272+009	Y	-.3972826880786872+008	Z	-.1150160687704205+008	RTCC
	.5353954099656968+009		-.3971679590261612+008		-.1147919975199305+008	TRW
XDOT	-.6304215580623974+004	YDOT	.1608486121318874+004	ZDOT	.9994594262706302+003	RTCC
	-.6304180924232723+004		.1608610632608729+004		.9997617266342311+003	TRW

COORDINATE SYSTEM- ECT

SMA	.1547115266614554+010	ECC	.9864213869786712+000	INC	.3717391777185055+002	RTCC
	.1547248031331910+010		.9864117609434533+000		.3718568302605592+002	TRW
	-.1327647173558715+006		.9626035217897600-005		-.1176525420537694-001	RTCC-TRW
NODE	.2677495319539920+003	ARG	.1571935554218799+003	TRUE	.2007744033759200+003	RTCC
	.2677469285697278+003	PERIAPSIS	.1571895464628723+003	ANOMALY	.2007829290895412+003	TRW
	.2603384264206809-002		.4008959007608225-002		-.8525713621254649-002	RTCC-TRW
PERIOD	.5371117823182953+005	APOASIS	.5023461063641076+006	PERIAPSIS	.1607610646110904+002	RTCC
	.5371809216629806+005		.5023870589791158+006		.1882401758214583+002	TRW
	-.6913934468528793+001		-.4095261500820333+002		-.2747911121036786+001	RTCC-TRW
VEL-MAG	.6582498069442840+004	FLIGHT	.1674771250742331+003	HEADING	.5284343327112961+002	RTCC
	.6582541211632804+004	PATH	.1674722346878047+003		.5283159294679470+002	TRW
	-.4314218996382379-001		.4890386428429094-002		.1184032433491793-001	RTCC-TRW
DEC	-.1227669926906107+001	LONG	.2562804826985317+003	HEIGHT	.8493536327555835+005	RTCC
	-.1225273546726339+001		.2562817314412698+003		.8493572191023074+005	TRW
	-.2396380179767169-002		-.1248742738112706-002		-.3586346723857332+000	RTCC-TRW

DIFFERENCE BETWEEN RTCC AND TRW VECTORS IN UVW COORDINATES (FEET,FEET PER SECOND)
DEL U= -2190. DEL V= -22893. DEL W= -10828. DEL UDT= -.02 DEL VDT= -.28 DEL WDT= -.16

MAGNITUDE OF VECTOR DIFFERENCE (FEET,FEET PER SECOND) DEL POS= 25418. DEL VEL= .3

APPENDIX B

SUPPLEMENTARY DATA

Information which is too detailed for the body of this report is presented in the Appendix. This information includes a summary of the primary station timeline, a summary of the radar data used in each BET fit segment, and a summary of the MSFN and DSN station locations.

Table B-1 lists the start and stop transmission times for the primary stations throughout the mission.

Table B-2 lists the stations used in each BET fit, the type and number of observables, and the mean and standard deviations retrieved from the residuals calculated in the final fit. The range statistics are in feet while the doppler units are cycles per second.

Table B-3 lists the tracking stations and their locations as used in the Apollo 8 postflight analysis. The surface refractivity is also listed.

A summary of all the low speed radar data sent to the RTCC may be found in Reference 2.

Table B-1 TWO-WAY STATION TIMELINE

Station	Start Time (day:hour:min:sec) GMT	Stop Time (day:hour:min:sec) GMT
GDS	21:14:21:53	21:15:47:00
PIR	21:15:47:00	21:17:21:00
MAD	21:17:21:00	21:19:16:00
GDS	21:19:16:00	22:01:31:00
PIR	22:01:31:00	22:02:31:00
NBE	22:02:31:00	22:07:01:00
GWM	22:07:01:00	22:08:41:00
NBE	22:08:41:00	22:11:31:00
RID	22:11:31:00	22:12:31:00
MAD	22:12:31:00	22:14:31:35
RID	22:14:31:35	22:14:51:40
MAD	22:14:51:40	22:18:01:00
ACN	22:18:01:00	22:19:36:30
GDS	22:19:36:30	22:21:49:30
HAW	22:21:49:30	23:00:31:00
GDS	23:00:31:00	23:02:47:00
NBE	23:02:47:00	23:06:30:00
GWM	23:06:30:00	23:08:31:24
NBE	23:08:31:24	23:12:16:01
MAD	23:12:16:01	23:15:01:00
ACN	23:15:01:00	23:17:01:00
MAD	23:17:01:00	23:19:51:00
GDS	23:19:51:00	24:02:51:00
NBE	24:02:51:00	24:08:04:10
GWM	24:08:04:10	24:08:18:17
NBE	24:08:18:17	24:12:30:00
MAD	24:12:30:00	24:16:41:05
RID	24:16:41:05	24:16:55:00

Table B-1 TWO-WAY STATION TIMELINE (Continued)

Station	Start Time (day:hour:min:sec) GMT	Stop Time (day:hour:min:sec) GMT
MAD	24:16:55:00	24:20:35:00
GDS	24:20:35:00	25:02:30:00
NBE	25:02:30:00	25:12:31:00
MAD	25:12:31:00	25:20:01:00
GDS	25:20:01:00	26:03:46:00
NBE	26:03:46:00	26:07:16:00
CRO	26:07:16:00	26:09:16:00
NBE	26:09:16:00	26:12:36:00
MAD	26:12:36:00	26:20:16:00
GDS	26:20:16:00	27:04:01:00
NBE	27:04:01:00	27:05:27:00
CRO	27:05:27:00	27:07:15:00
NBE	27:07:15:00	27:12:06:00
CRO	27:12:06:00	27:13:18:00
RID	27:13:18:00	27:13:50:00
CRO	27:13:50:00	27:14:51:00
GWM	27:14:51:00	Splashdown

TABLE B-3. USBS STATION LOCATIONS

Station	Antenna	Identification	Latitude* (deg)	Longitude* (deg)	Altitude* (ft)	Surface Refractivity
Antigua	30'	ANG	17.01692	298.24715	141.08	366
Ascension	30'	ACN	-7.95506	345.67242	1843.83	357
Bermuda	30'	BDA	32.35129	295.34182	68.90	338
Canary Island	30'	CYI	27.76454	344.36519	567.59	336
Canberra	85'	HSK	-35.58349	148.97829	3755.25	301
Canberra Wing	85'	NBE	-35.40099	148.98176	2196.85	301
Carnarvon	30'	CRO	-24.90665	113.72604	82.02	339
Goldstone	85'	GDS	35.34159	243.12680	2976.05	279
Goldstone Wing	85'	PIR	35.38957	246.15103	3186.02	279
Grand Bahama	30'	GBM	26.63286	281.76234	16.40	356
Guam	30'	GWM	13.30924	144.73441	416.67	379
Guaymas	30'	GYM	27.96321	249.27915	62.34	321
Hawaii	30'	HAW	22.12490	200.33501	3772.97	302
Madrid	85'	MAD	40.45499	355.83201	2553.81	296
Madrid Wing	85'	RID	40.42829	355.75147	2527.56	296
Merritt Island	30'	MIL	28.50827	279.30658	32.81	339
Texas	30'	TEX	27.65375	262.62153	32.81	334

* All quantities are referenced to the Fischer Ellipsoid of 1960.

Table B-2 BET RADAR DATA SUMMARY

SEGMENT 1

STATION	DATA TYPE	NUMBER OF OBS	MEAN	σ
MAD	2-Way Doppler	78	-.01459	.04318
AN3	3-Way Doppler	184	-.02672	.09801
MI3	" "	86	.00805	.06147
GD3	" "	66	.07529	.06446
GDS	2-Way Doppler	102	.00752	.06587
	SEGMENT 2			
GDS	Range	102	187.54	454.91
GDS	2-Way Doppler	88	-.04165	.06203
PIR	Range	48	-704.07	26.76
PIR	2-Way Doppler	54	-.02275	.05929
NBE	Range	426	-62.778	326.48
NBE	2-Way Doppler	397	-.00943	.05058
GWM	Range	70	721.5031	64.2417
GWM	2-Way Doppler	67	.2125	.04554
RID	Range	56	-248.5506	95.6618
RID	2-Way Doppler	62	.01216	.03517
MAD	Range	192	7.0727	396.98
MAD	2-Way Doppler	195	-.04756	.04161

SEGMENT 3

STATION	DATA TYPE	NUMBER OF OBS	MEAN	σ
ACN	Range	133	259.4432	229.2485
ACN	2-Way	167	-.005655	.06697
GDS	Range	356	-103.7851	574.2929
GDS	2-Way	303	-.05214	.05058
HAW	Range	22	73.1619	12.7889
HAW	2-Way	140	.072018	.05979
NBE	Range	331	-155.9552	174.4321
NBE	2-Way	331	-.04468	.04731
GWM	Range	111	120.1540	100.3421
GWM	2-Way	110	.2422	.03624
MAD	Range	323	79.7356	514.5033
MAD	2-Way	315	-.01795	.05834
		SEGMENT 4		
GDS	Range	57	-233.1561	41.1273
GDS	2-Way	57	-.0291	.07279
NBE	Range	336	38.9949	229.2352
NBE	2-Way	331	-.002161	.04649
GWM	2-Way	10	.1623	.007257

SEGMENT 5

STATION	DATA TYPE	NUMBER OF OBS	MEAN	σ
HS3	3-Way	72	.004434	.3235
CR3	3-Way	80	-.10146	.3307
GW3	3-Way	80	-.079915	.3235
NBE	Range	78	-447.5555	27.7185
NBE	2-Way	80	-.039506	.3357
AC3	3-Way	19	-.03468	.1339
MA3	3-Way	5	.0009746	.1311
		SEGMENT 6		
MAD	Range	23	-228.029	204.3337
MAD	2-Way	82	-.03346	.3669
CR3	3-Way	81	-.08149	.3547
AC3	3-Way	76	-.01782	.3584
CY3	3-Way	68	-.2122	.3279
		SEGMENT 7		
MAD	Range	15	-781.7893	398.9321
MAD	2-Way	70	.05789	.5743
AC3	3-Way	64	-.03778	.5816
CY3	3-Way	69	-.02817	.5795
AN3	3-Way	43	.038808	.5958

SEGMENT 8

STATION	DATA TYPE	NUMBER OF OBS	MEAN	σ
RID	Range	2	230.9975	.1157
RID	2-Way	4	-.1764	.4013
BD3	3-Way	65	-.08684	.5586
MI3	3-Way	59	-.01558	.5663
AC3	3-Way	61	-.03588	.5647
MA3	3-Way	12	-.4783	.3764
AN3	3-Way	63	-.07345	.5704
MAD	Range	35	-106.0987	28.7219
MAD	2-Way	51	-.02359	.5583

SEGMENT 9

AN3	3-Way	60	-.04646	.5776
MAD	Range	26	-164.9397	32.5280
MAD	2-Way	70	-.08559	.5692
TE3	3-Way	67	-.07086	.5807
GY3	3-Way	65	-.1085	.5738
AC3	3-Way	64	-.06636	.5746
GD3	3-Way	33	-.01211	.5581

SEGMENT 10

STATION	DATA TYPE	NUMBER OF OBS	MEAN	σ
PI3	3-Way	58	-.05805	.4030
AC3	3-Way	56	.02425	.4383
AN3	3-Way	56	.003103	.3996
GDS	Range	40	-981.7332	44.8449
GDS	2-Way	57	.07719	.4141
CY3	3-Way	57	-.2448	.3841
MA3	3-Way	57	-.01618	.3821

STATION	DATA TYPE	NUMBER OF OBS	MEAN	σ
		SEGMENT 11		
BD3	3-Way	69	-.07464	.5929
GDS	Range	36	-830.9168	32.4612
GDS	2-Way	66	-.09833	.5885
HA3	3-Way	68	-.1175	.5913
AC3	3-Way	63	.2140	.6183
		SEGMENT 12		
GDS	Range	21	-839.7875	40.4155
GDS	2-Way	62	-.02324	.5552
BD3	3-Way	68	-.09448	.5656
PI3	3-Way	67	-.1221	.5549
HA3	3-Way	63	-.1216	.5651
AN3	3-Way	65	.06755	.5691
		SEGMENT 13*		
NBE	Range	233	-618.9271	57.7781
NBE	2-Way	685	-.09795	.6329
HS3	3-Way	682	-.02083	.6305
MI3	3-Way	678	-.08069	.6357
GD3	3-Way	639	-.02559	.6312
HA3	3-Way	599	-.1339	.6263

*Fit was made with uncompressed data (10 samples/minute)

SEGMENT 14

STATION	DATA TYPE	NUMBER OF OBS	MEAN	σ
NBE	Range	24	-535.8994	37.7327
NBE	2-Way	66	-.05305	.6268
HA3	3-Way	67	-.1045	.6185
HS3	3-Way	65	-.09652	.6129
		SEGMENT 15		
NBE	Range	95	-12.7434	15.2778
NBE	2-Way	330	-.002643	.04776
MAD	Range	253	80.9801	415.7219
MAD	2-Way	415	-.01595	.04950
GDS	Range	10	-481.8276	14.0915
GDS	2-Way	10	.3462	.02811

SEGMENT 16

STATION	DATA TYPE	NUMBER OF OBS	MEAN	σ
GDS	Range	311	-6.9974	49.7630
GDS	2-Way	340	.001881	.04840
NBE	Range	61	33.2529	41.4022
NBE	2-Way	77	-.004272	.08292
		SEGMENT 17		
NBE	Range	203	-156.7728	118.3254
NBE	2-Way	283	-.08172	.04193
CRO	Range	70	660.0146	41.1068
CRO	2-Way	95	.04689	.05894
MAD	Range	295	-65.7960	60.7203
MAD	2-Way	332	.08467	.05208
GDS	2-Way	49	-.09728	.05534

SEGMENT 18

STATION	DATA TYPE	NUMBER OF OBS	MEAN	σ
GDS	Range	145	-344.3323	147.9816
GDS	2-Way	150	-.2031	.04026
NBE	Range	274	-428.1714	251.6157
NBE	2-Way	293	-.0689213	.07004
CRO	2-Way	124	.4321	.3338
RID	2-Way	26	.7447	.06876
GWM	Range	131	-108.2969	59.0690
GWM	2-Way	85	-.1880	.2295

REFERENCES

1. "Summary of the RTACF/MSFN Processing During the Apollo 8 Mission," 05952-H121-RO-00, TRW Note No. 69-FMT-731, P. Norris, 4 February 1969.

2. "Apollo VIII Guidance, Navigation and Control System Performance Analysis Final Report," 11176-H200-RO-00, 15 April 1969.