OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached DATE: MAY 9 1969

FROM : FS/Chief, Flight Support Division

SUBJECT: Minutes of the Flight Software Readiness Review (FSRR) for the F mission LUMINARY (LUM69 R2) Lunar Module Program

1. The F mission FSRR for the Lunar Module Program LUMINARY (LUM69 R2) was held on April 29, 1969, at 9:00 a.m. in building 2, room 660. The agenda followed at this meeting is enclosed in this memorandum as enclosure 1. Also enclosed is the list of attendees as enclosure 2.

2. The meeting was opened by Mr. T. G. Price of the Flight Support Division (FSD), who briefly described the agenda to be covered. Then Mr. J. W. Jurgensen of FSD reported on the status of the erasable memory load.

3. The MIT/IL portion of the meeting was opened by Mr. J. Kernan who discussed the development of the F mission LUMINARY Program from SUNDANCE through the LUMINARY 69 release on November 21, 1968, and then the release of LUM69 R2 on April 2, 1969. Mr. Kernan gave a status of the LUMINARY GSOP's which showed Section 4 being delivered on May 15, 1969. MIT/IL agreed to send preliminary computer printout copies of Section 4 prior to the May 15, 1969 date.

4. The MIT/IL presentations were continued with discussions of the testing performed in the different major areas (listed below), results of the tests, and in each of the major areas a statement that the F mission LUMINARY Program (LUM69 R2) is capable of flying the F mission. The major areas listed chronologically along with the individuals making the presentations were as follows:

Rendezvous and Navigation	G. Muller
DAP and Powered Flight	C. Work
Systems Test Lab	G. Edmunds
Procedural Testing	S. Davis
	S. Drake

The slides presented during these presentations were not handed out at the FSRR so, therefore, are enclosed here as enclosures 3 through 6.

5. At this time, Mr. Kernan returned to discuss the LUMINARY F mission anomalies and program notes. Mr. Kernan mentioned the number of anomalies and then said that some of these have been fixed, some are not considered anomalies, and others were caused by simulator or procedural problems. The total remaining anomalies in LUMINARY (LUM69 R2) number about thirty.

The slide showing this breakdown of the anomalies is presented in enclosure 7 along with descriptions of the three anomalies considered to be the most serious.

6. After breaking for lunch, Mr. F. Hughes opened the afternoon session with a discussion of the LMS training at the Kennedy Space Center (KSC). He said that they have run every case of rendezvous and are now running the Boeing R2 lunar potential model. He said that KSC is ready to go for the F mission.

7. Next on the agenda was a report by Mr. W. Peters of Guidance and Control Division (G&CD) on the readiness of the Digital Autopilot (DAP) to fly the F mission. Mr. Peters enumerated certain non-critical DAP problems for the F mission that have been fixed for the LUMINARY 1A Program and then introduced Mr. R. Lee of TRW Systems who discussed the DAP testing on the bit-by-bit computer simulation done by TRW. The slides used for this and the following presentations were handed out at the FSRR so, therefore, will not be enclosed in this memorandum. If more detail is desired by the readers of this memorandum, the author has copies of all slides presented at the LUMINARY FSRR. Mr. Peters then stated that the DAP for the F mission is flight ready.

8. The next presentation was given by Mr. P. Hoffman of the Grumman Aircraft Engineering Corporation (GAEC) who gave the results of the testing of the LUMINARY software plus the LM GN&C hardware which showed that the two systems can perform the F mission. Mr. R. Simpson of G&CD then discussed the open Simulator Discrepancy Reports (SDR). Some of the open SDR's seemed to be the result of a bad set of core ropes being used when these tests were made. Mr. Simpson accepted the action to resolve these open items. Other open items are the result of official program notes not having been distributed. Mr. Price accepted the action to write the program notes concerning these items.

9. The last item on the agenda was the presentation of the results of the TRW supplemental testing and analysis. An introduction was given by Mr. T. Fujawa, followed by the presentation of the powered flight results by Mr. R. Harwood and then the inflight alignment and rendezvous targeting and navigation by Mr. J. Drexler. Mr. Fujawa then concluded that within the limitations of the scope of the TRW testing and analysis the LUMINARY Program is flight ready.

10. Action items assigned at the FSRR and the responsible organization were as follows:

a. MIT/IL was to send to MSC preliminary printout copies of Section 4 of the LUMINARY GSOP.

b. MIT/IL is to repeat tests with LUM69 R2 in all cases where believed pertinent.

c. MIT/IL is to eliminate any future SOR runs from the procedural testing.

d. MIT/IL is to check the crew procedures with regard to LNY-61 anomaly report (described in enclosure 7).

e. MIT/IL is to make P37 targeting run for DPS return to earth.

f. G&CD is to resolve open SDR's.

If there is no response to the above action items, the Flight Support Division will assume the responsible organizations have completed the action items and that there are no adverse mission effects.

11. The overall opinion of the organizations making the presentations at the FSRR was that the LUMINARY (LUM69 R2) Program is flight ready. Any questions or requests for copies of slides should be directed to the Luminary Program Engineer, Mr. T. Price, at extension 6247.

Lynwood C. Dunseith

Enclosures 7

FS55:TGPrice:beb

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MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: APR 24 1969

FROM : FS/Chief, Flight Support Division

SUBJECT: Flight Software Readiness Review (FSRR) for the F mission LUMINARY (LUM69 R2) lunar module program

1. The F mission FSRR for the Lunar Module Program LUMINARY will be held on April 29, 1969 at 9:00 a.m. in building 2, room 660.

2. The agenda will be as follows:

Time	Subject	Responsible Organization
0900	Introduction	FSD
0905	Status of Erasable	FSD
0915	LUMINARY Development	MIT/IL
1000	Rendezvous	MIT/IL
1030	Powered Flight	MIT/IL
1100	Systems Test Lab	MIT/IL
1115	Procedural Testing	MIT/IL
1130	Anomalies and Program Notes	MIT/IL
1200	Lunch	
1300	KSC LM Mission Simulator	KSC
1330	DAP Testing	G CD
1400	GAEC Testing and Simulator Discrepancy Reports	G CD
1430	TRW Bit-By-Bit Supplemental Testing	TRW

Lynwood C. Dunseith

FS55:TGPrice:bjm

Enc 1

Enc 2

NASA – MANNED SPACECRAFT CENTER

PRESENTATION ROOM INFORMATION SHEET

Preliminary Software Readiness Review
TITLE OF BRIEFING OR PRESENTATION

☐ 9th FLOOR PRESENTATION ROOM

4/29/69 | 9:00 – | none
DATE | TIME | CLASSIFICATION

☒ OTHER 6th Floor

Sabionski - Gibson
SPONSOR OR CONTACT INDIVIDUAL

☐ 2x2 SLIDE PROJECTOR
☐ 3x4 SLIDE PROJECTOR
☐ 16mm MOVIE PROJECTOR
☒ VU GRAPH

☐ TAPE RECORDER
☐ BLACK BOARD
☐ EASEL
☐ OTHER

6247
OFFICE OR EXTENSION

	ATTENDEES NAME (PRINT) AND SIGNATURES	AGENCY	SECURITY CLEARANCE (C-S-TS)
1	G Edmonds	MIT	S
2	C. Thomas	NASA-CF22	S
3	R A. Harwood	TRW	S
4	J F KERNAN	MIT	S
5	T T FUJAWA	TRW	S
6	CLINT TILLMAN	GAEC	S
7	P ADLER	MIT	S
8	T.F. LEWIS	FC 41	S
9	W G HEFFRON	Bellcomm	S
10	D A Corey	Bellcomm	S
11	J F GIBSON	MSC FSD	S
12	T. G. PRICE	MSC FSD	S
13	S H DRAKE	MIT	S
14	B J McCarty	MIT/MSC	S
15	V F Orlando	MIT - SDC	S
16	C A Olsson	MIT	S
17	R. N. Aiyagari	MIT	S
18	C.C. WORK	MIT IL	S
19	J JURGENSEN	MSC-FS5	S
20	K R Goodwin	MIT-MSC	S

COORDINATING OFF APPROVAL _____ 10 _____
SIGNATURE DATE

MSC Form 540 (Rev Mar 64)

NASA – MANNED SPACECRAFT CENTER

PRESENTATION ROOM INFORMATION SHEET

Summary Software (Pge 2)
TITLE OF BRIEFING OR PRESENTATION

☐ 9th FLOOR PRESENTATION ROOM

4/29/69
DATE

9:00 –
TIME

CLASSIFICATION

☒ OTHER 6th floor

SPONSOR OR CONTACT INDIVIDUAL

OFFICE OR EXTENSION

☐ 2x2 SLIDE PROJECTOR
☐ 3x4 SLIDE PROJECTOR
☐ 16mm MOVIE PROJECTOR
☒ VU GRAPH

☐ TAPE RECORDER
☐ BLACK BOARD
☐ EASEL
☐ OTHER

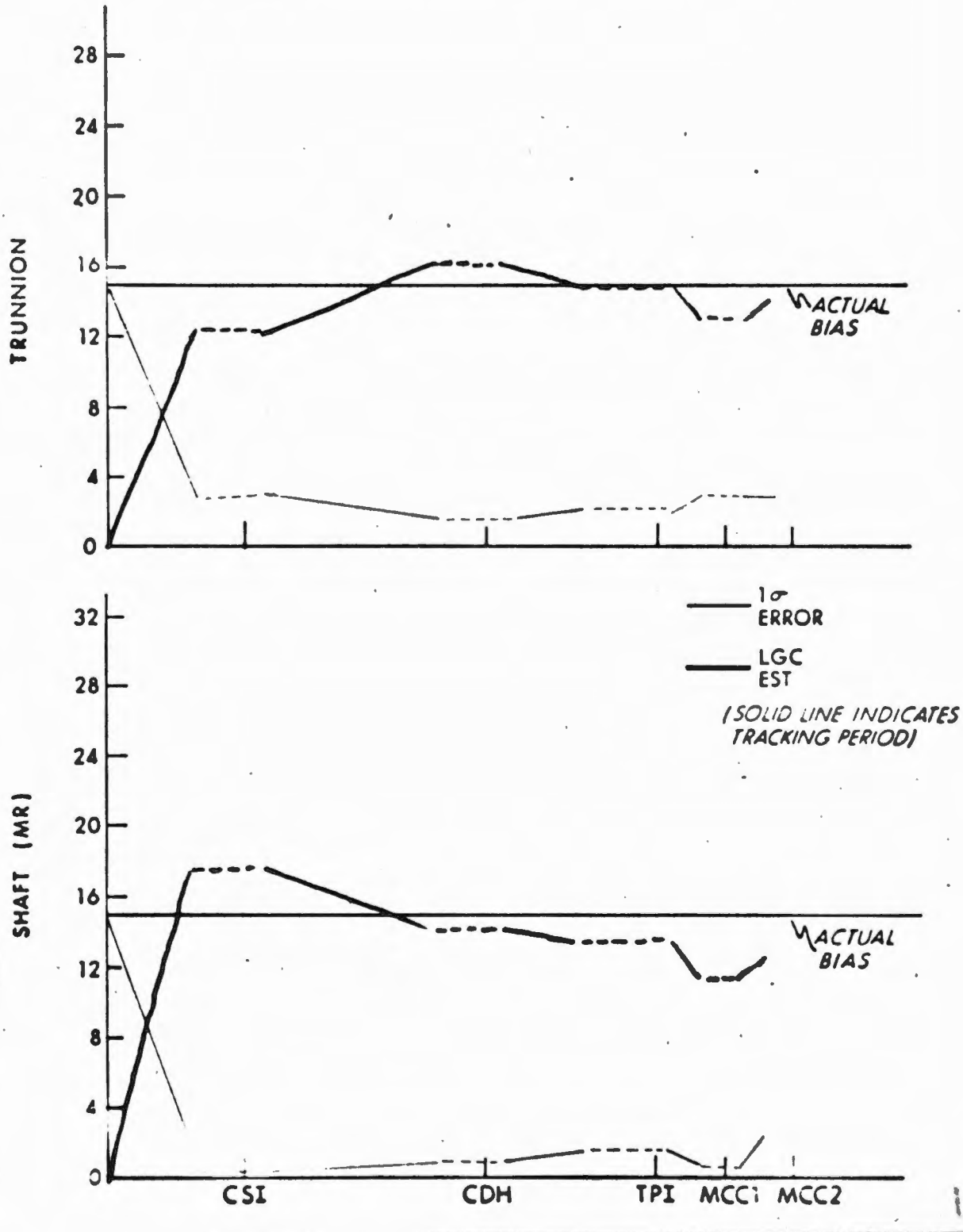
	ATTENDEES NAME (PRINT) AND SIGNATURES	AGENCY	SECURITY CLEARANCE (C-S-TS)
1	K. W. Mountree	TRW	Secret
2	J. H. Degler	TRW	S
3	W. N. Laurence	TRW	S
4	S C Crigler	TRW	S
5	R L Wiedinger	TRW	S
6	W. F. Harwood	TRW	S
7	T. W. Chang	TRW	S
8	R. Nativi	TRW	S
9	J n Ritter	TRW	S
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

COORDINATING OFF APPROVAL _____ SIGNATURE _____ DATE

MSC Form 540 (Rev Mar 64)

	ATTENDEES NAME (PRINT) AND SIGNATURES	AGENCY	SECURITY CLEARANCE (C-S-TS)
21	S.P. MANN	FM7	S
22	JC Norton	TR4	S
23	T. H BARRIE	TRW	S
24	J. F. Gifford	TRW	C
25	F. H. MARTIN	MIT	—
26	W. B. Goechler	PD6	S.
27	F W KUBICKI	FD12	S
28	BF COCKRELL	FM4	S
29	R W Simpson	EG27	S
30	E. PETERS	TRW	S
31	S. DAVIS	MIT	S
32	F Hughes	CFK	S
33	B.A. DURAND	NASA FC4	S
34	W W. FINK	"	S
35	I. JOHNSON	MIT	S
36	R.T. SAVELY	FM4	S
37	B B WHITE	TRW	S
38	R.W. JOHNSTON	MIT	S
39	B.D. WEBER	FM3	S
40	J.C. CHEATHAM	EG	S
41	Peter Hoffman	Grumman	S
42	W.H. PETERS	EG23	S
43	Roscoe Lee	TRW	S
44	F.L. Haken	TRW	S
45	W.E. HAMER	TRW	S
46	D.W. GILBERT	EG-27	S
47			

MISSION F RENDEZVOUS NAVIGATION
BIAS ESTIMATION
LUMINARY– ZERO INITIAL STATE ERRORS



Enc 3

TEST OBJECTIVES

- DEMONSTRATE PERFORMANCE OF LUMINARY PROGRAM DURING F MISSION RENDEZVOUS
  - NOMINAL MISSION
  - STATE ERROR VARIATIONS
  - DEGRADED SYSTEM ERRORS
  - STABLE ORBIT RENDEZVOUS
  - WITH NO R_2 POTENTIAL MODEL ON BOARD

DESCRIPTION OF LUMINARY TESTS

TEST DESCRIPTION	OBJECTIVE
Nominal run { 1 σ errors; R_2 (two pass); initial state errors }	Demonstrate program performance under average conditions.
Zero initial State errors	Examine effect of sensor errors on performance.
Triax initial state errors; 3 σ IMU drift; 3 σ PIPA biases }	Demonstrate program performance under degraded conditions.
No R_2 potential model on board	Examine need for on-board R_2 modeling during rendezvous.
Stable orbit rendezvous	Test performance of SOR programs.

- RELATIVE POSITION & VELOCITY ERRORS
- BIAS ESTIMATION ERRORS
- BURN UNCERTAINTIES (ON-BOARD TARGETED BURNS)
- ΔV MAGNITUDES
- TPI TIG SLIP FROM NOMINAL
- TPI TIG ERROR (TARGETED TIG VS. TRUE TIG)
- CLOSEST POINT OF APPROACH

LUMINARY - LEVEL 6
INITIAL CONDITION ERRORS
(FT, FT/SEC, MR)

STATE VECTOR ERRORS
(AGC EST. - ENVIRONMENT)

LM (14640, 6930, -1440, -7.93, -9.83, 2.23) ft & fps
CSM (2086, 1788, 4058, 5.31, -1.65, -5.92) ft & fps

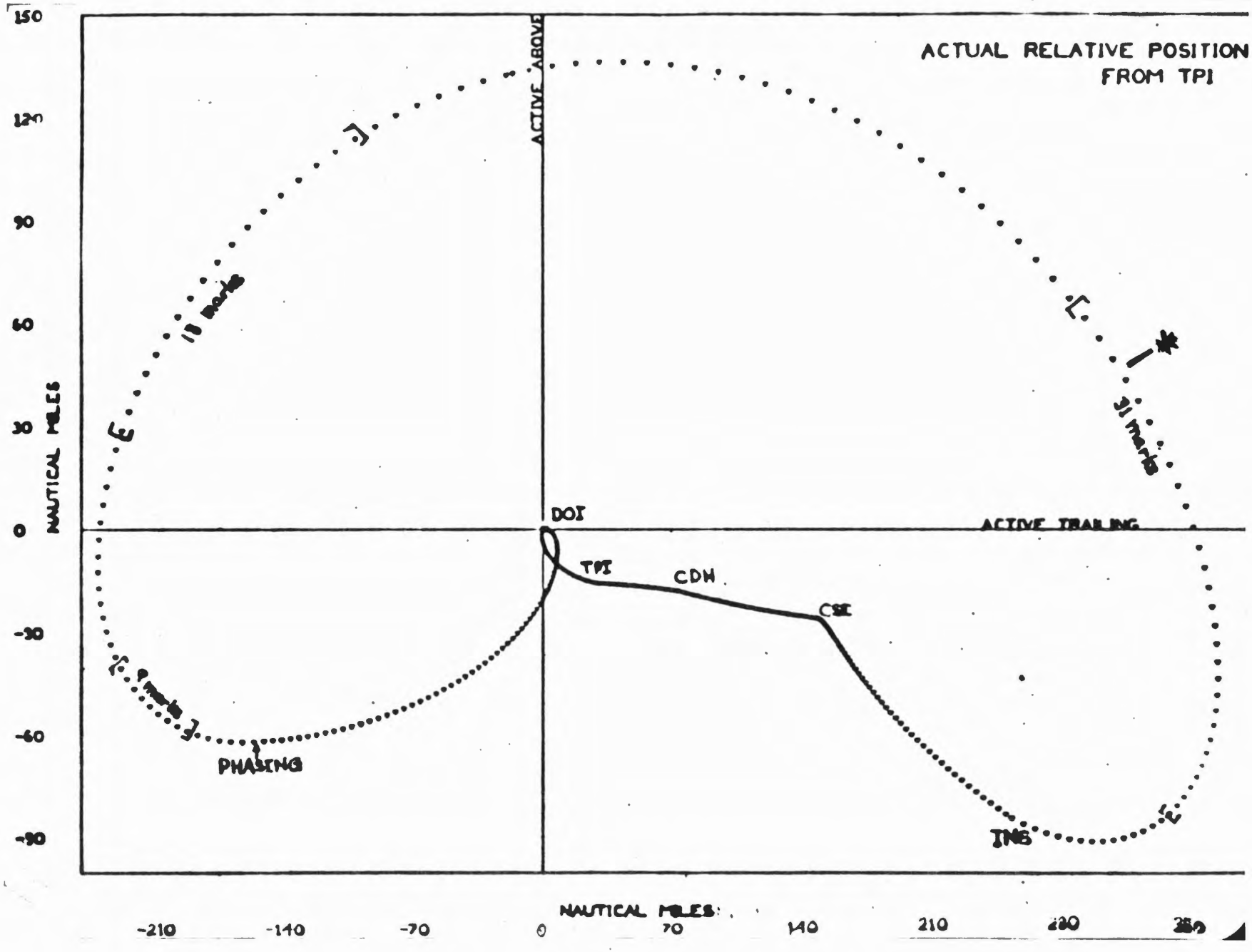
CSM (8013, 8911, 5759, 11, -7.5, -3.53) ft & fps
(Triax)

RADAR ERRORS

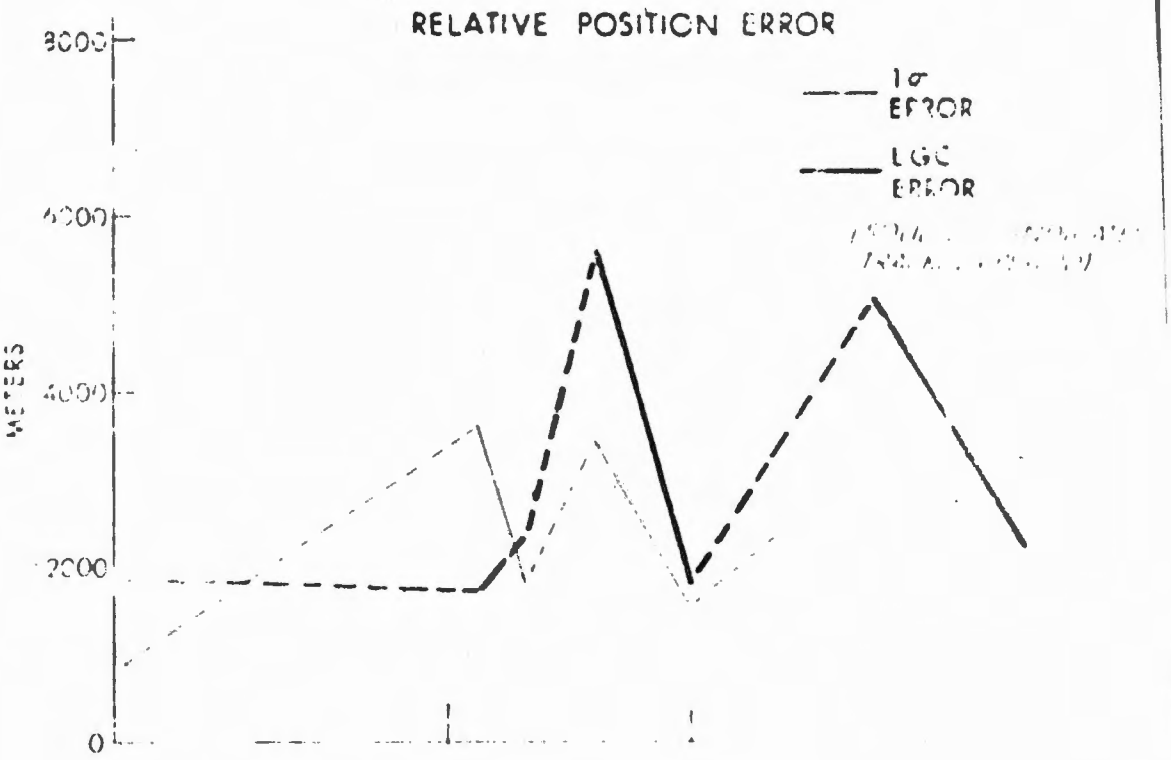
	(STD. DEV. OF NOISE)		BIAS
RANGE:	.0033 X R	R>50.8 mi:	800 ft.
		R<50.8 mi:	80 ft.
RANGE RATE:	the larger of { .004333 X $\dot{R}$; .00433 ft/sec		.3 ft/sec
SHAFT:	1 mr.	15 mr	
TRUNNION:	1 mr	15 mr	

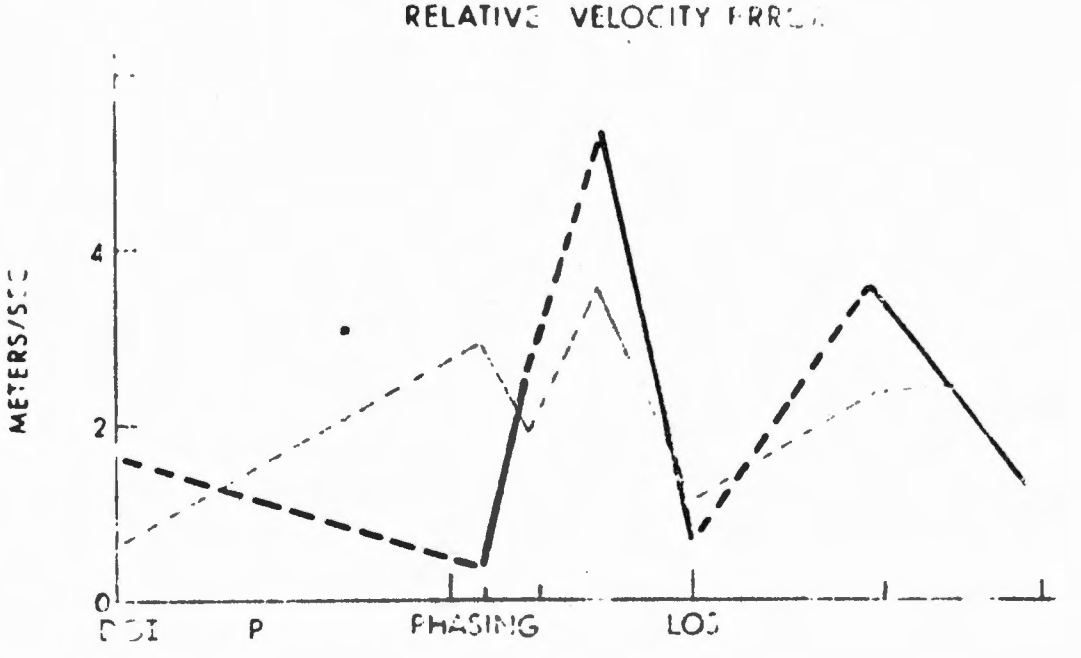
IMU ERRORS

	X	Y	Z
MISALIGNMENT:	1 mr.	1 mr	1 mr
UNCOMPENSATED DRIFT:	.03 deg/hr	.03 deg/hr	.03 deg/hr
ACCELEROMETER BIAS	0.007 ft/s^2	0.007 ft/s^2	0.007 ft/s^2

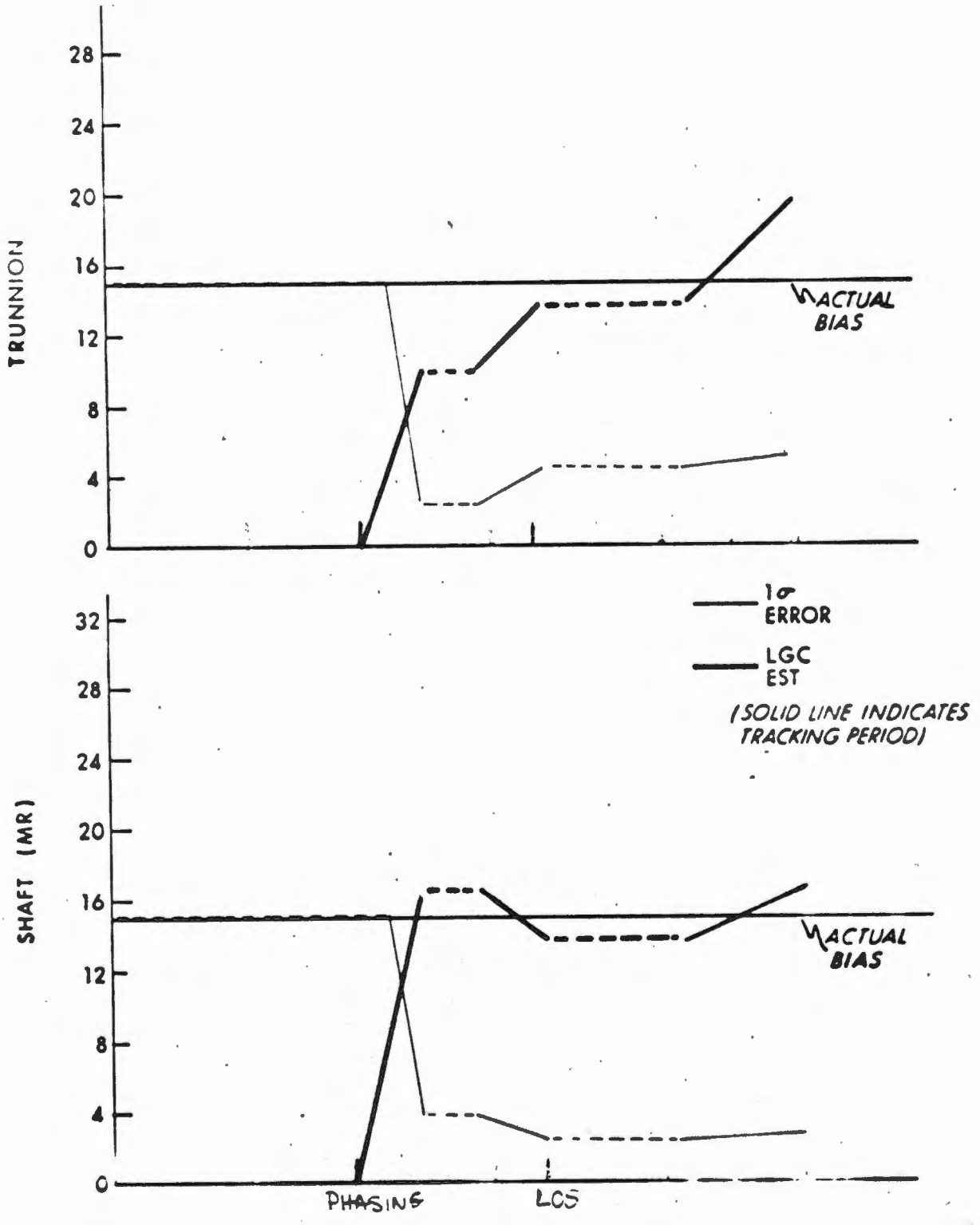

ACTUAL RELATIVE POSITION
FROM TPI
ACTIVE ABOVE
ACTIVE TRAILING
DOI
TPI
CDH
CSI
PHASING
INS
NAUTICAL MILES
NAUTICAL MILES
150
120
90
60
30
0
-30
-60
-90
-210
-140
-70
0
70
140
210

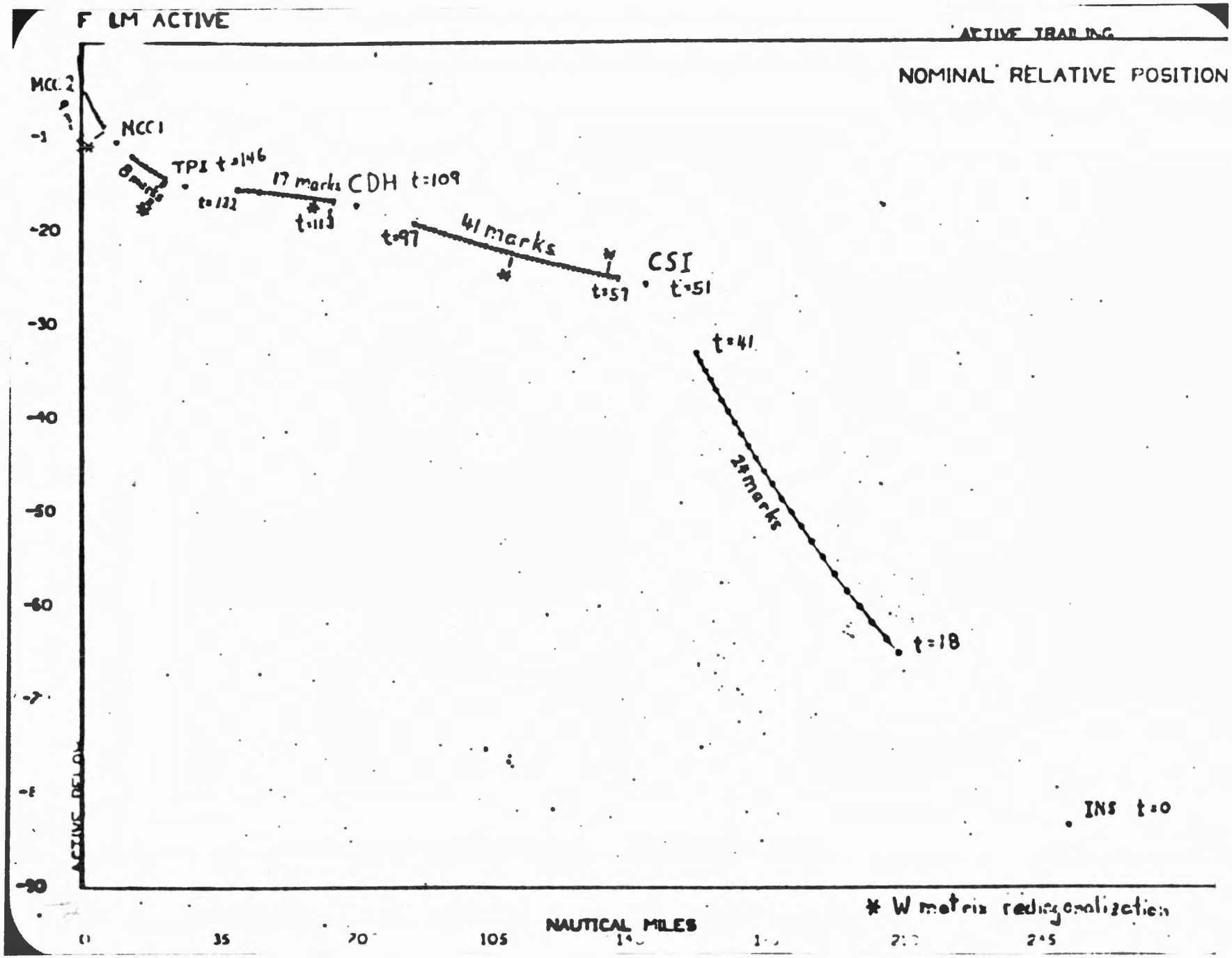
MISSION F RENDEZVOUS NAVIGATION ERRORS



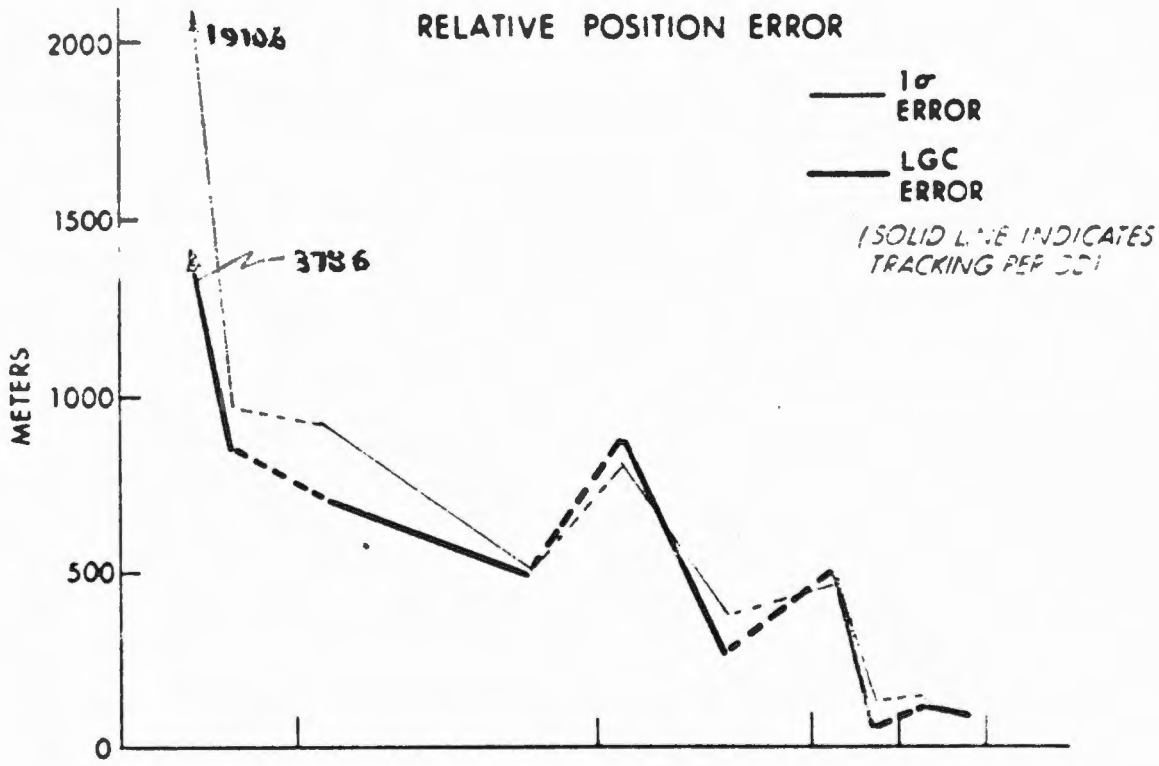


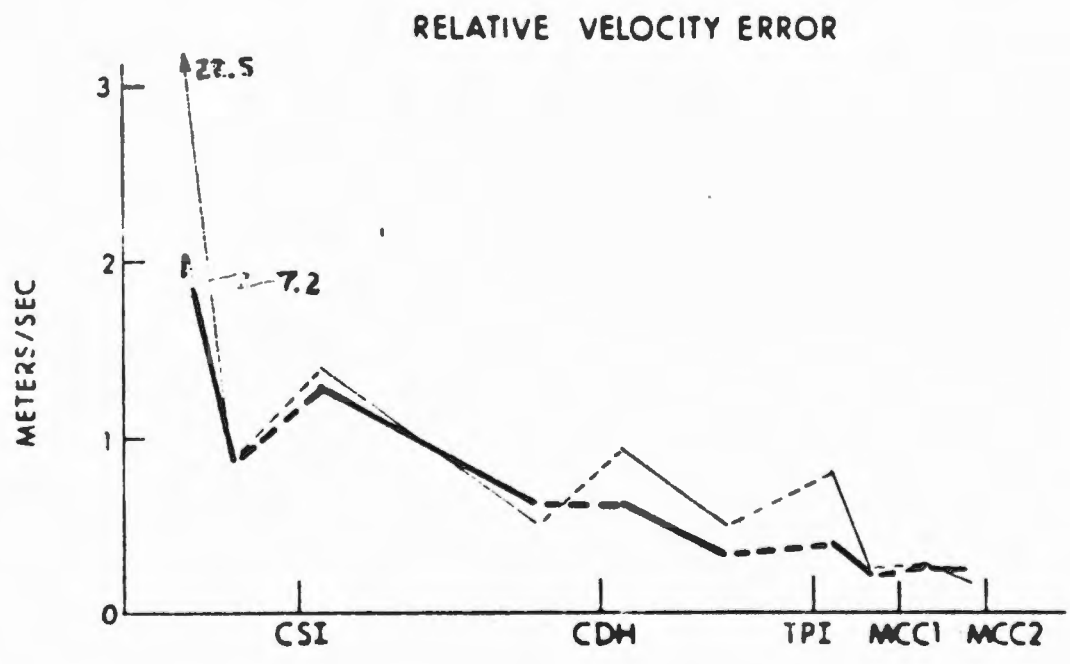
MISSION F RENDEZVOUS NAVIGATION
BIAS ESTIMATION
LUMINARY- DOI TO INSERTION



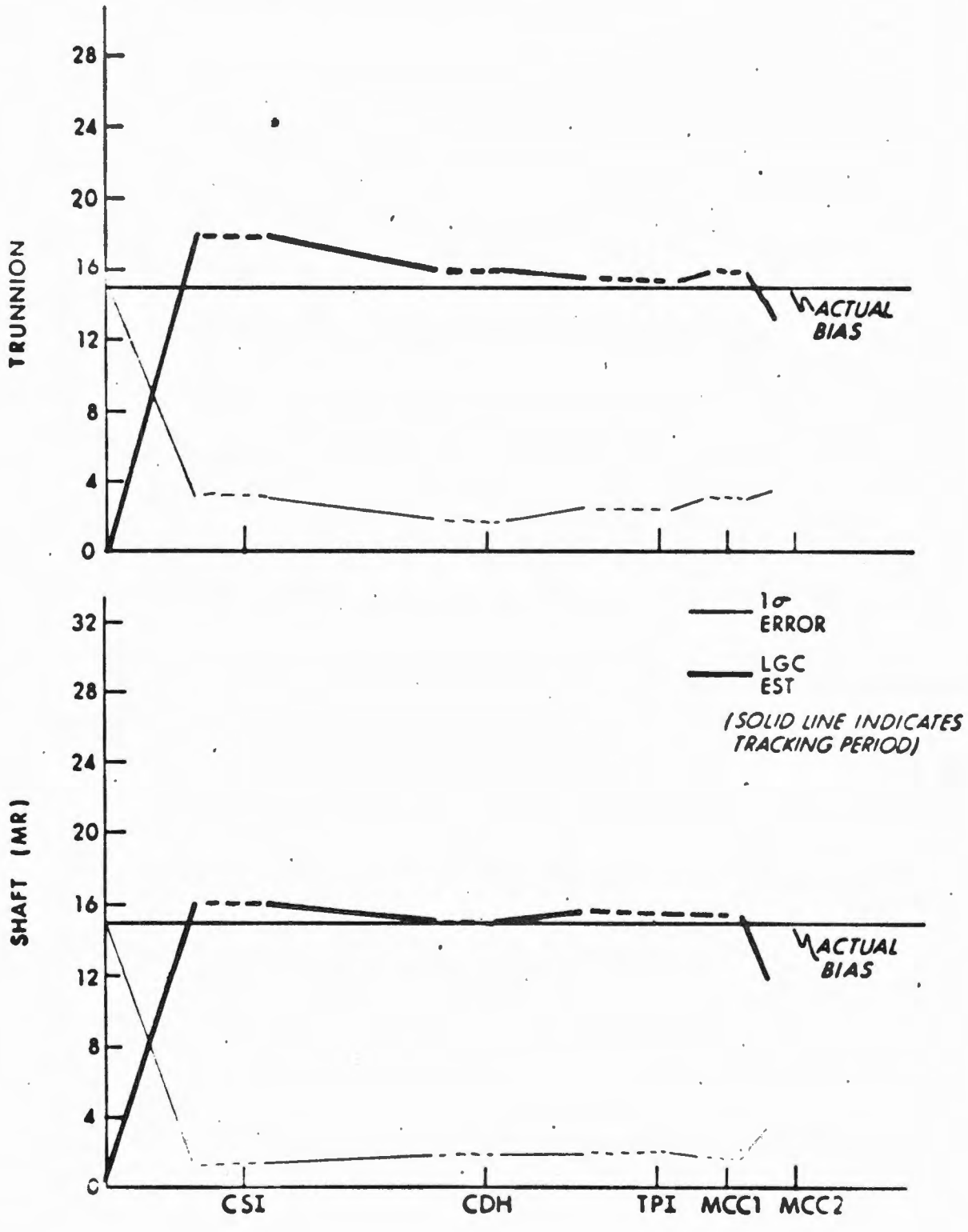

F LM ACTIVE
ACTIVE TRAJ ING
NOMINAL RELATIVE POSITION
MCC 2
MCC 1
TPI t=146
6 marks
t=132
17 marks
CDH t=109
t=113
t=97
41 marks
CSI
t=57
t=51
t=41
24 marks
t=18
INS t=0
-1
-20
-30
-40
-50
-60
-7
-8
-80
ACTIVE DELCO
* W matrix reinitialization
NAUTICAL MILES
0
35
70
105
245

MISSION F RENDEZVOUS NAVIGATION ERRORS
LUMINARY- NOMINAL RUN

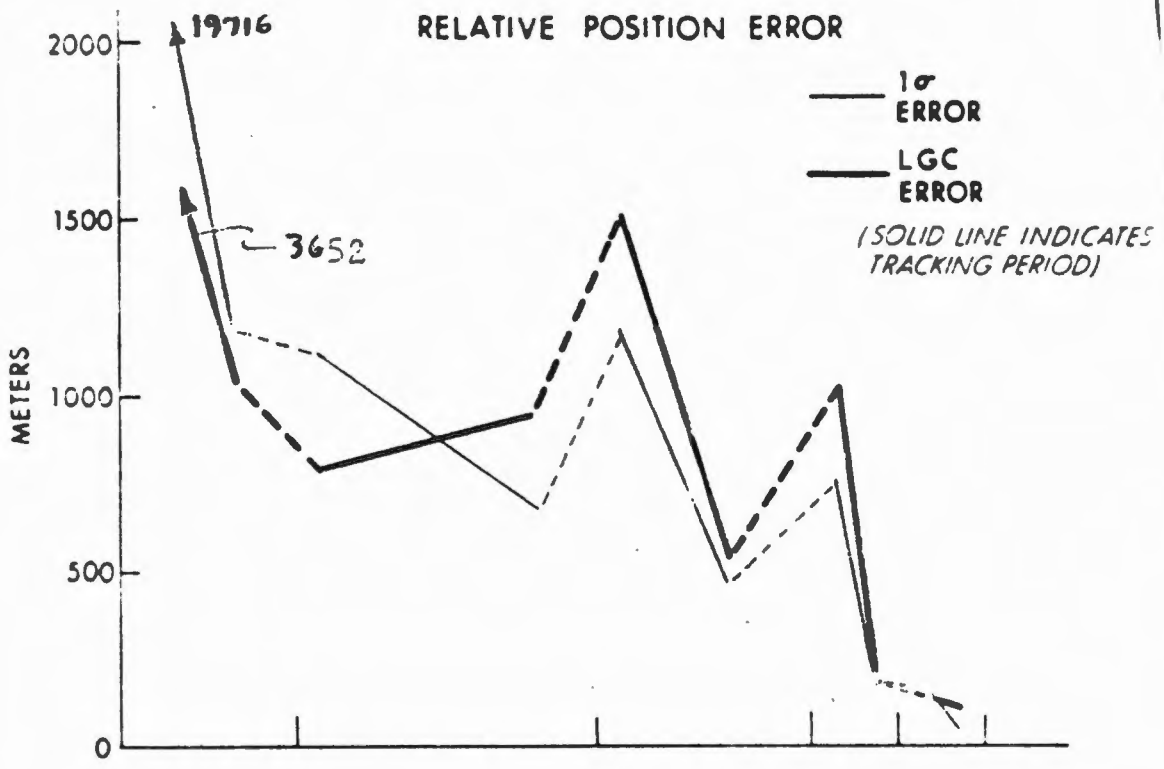


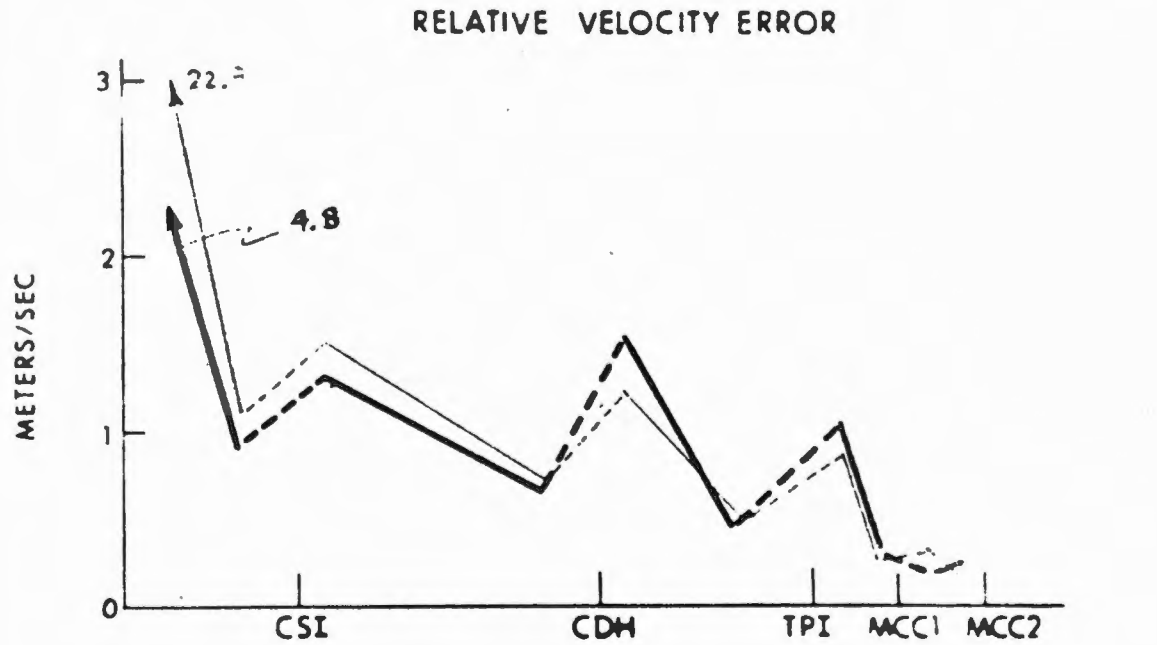


MISSION F RENDEZVOUS NAVIGATION
BIAS ESTIMATION
LUMINARY– NOMINAL RUN

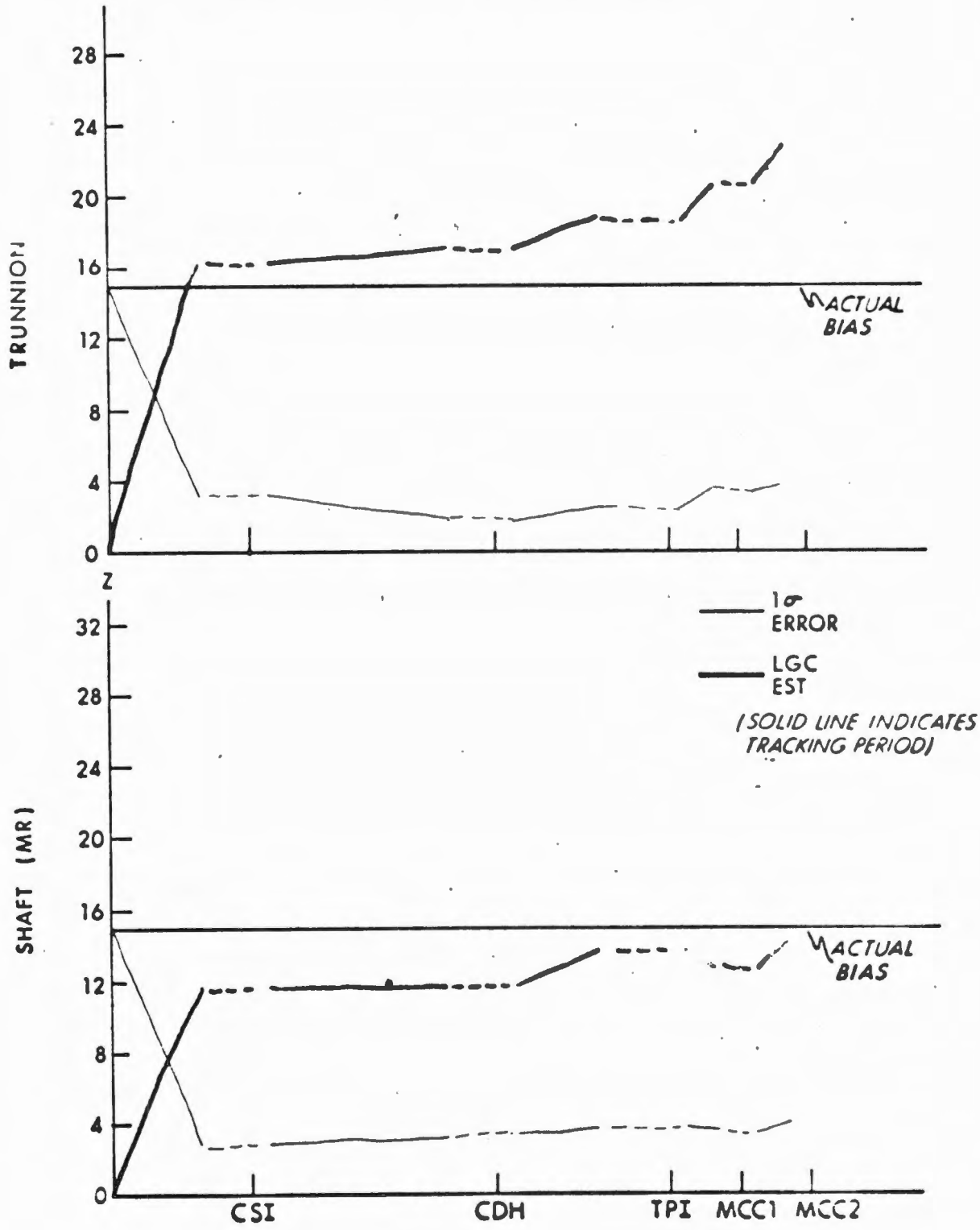


MISSION F RENDEZVOUS NAVIGATION ERRORS
LUMINARY- TRIAX INITIAL STATE ERRORS

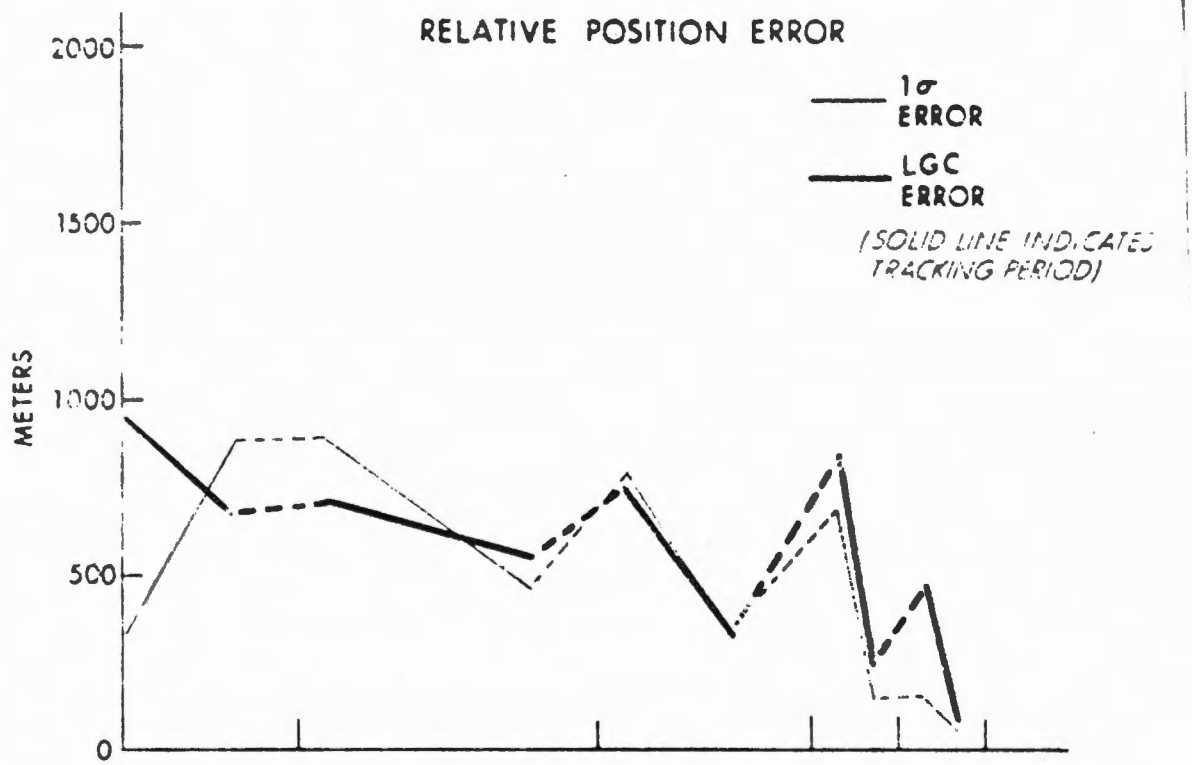




MISSION F RENDEZVOUS NAVIGATION
BIAS ESTIMATION
LUMINARY-TRIAX INITIAL STATE ERRORS



MISSION F RENDEZVOUS NAVIGATION ERRORS
LUMINARY- ZERO INITIAL STATE ERRORS



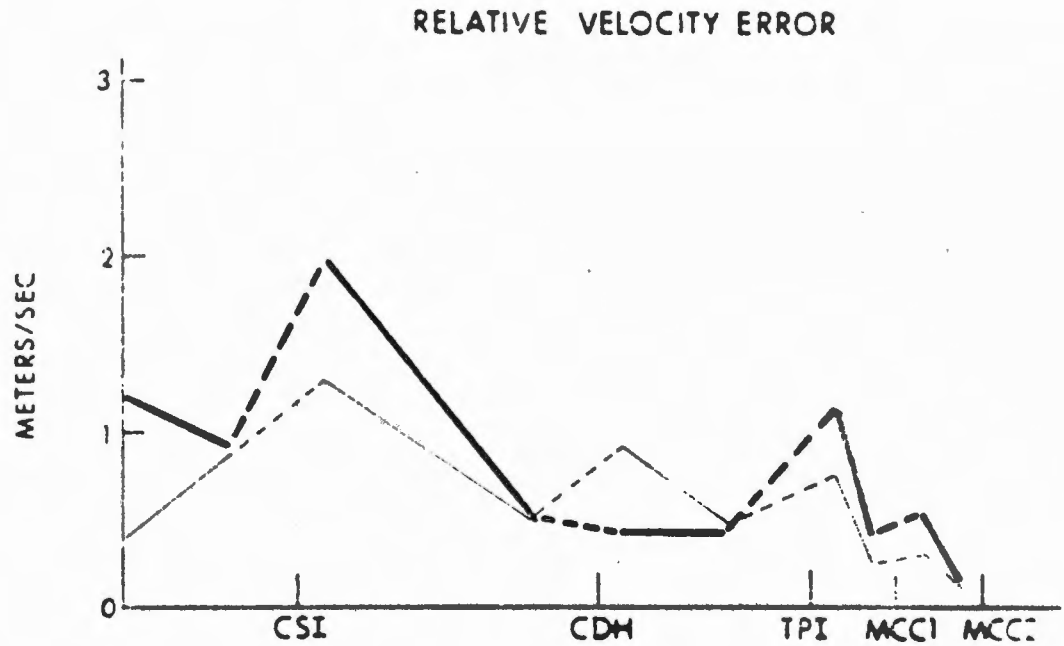
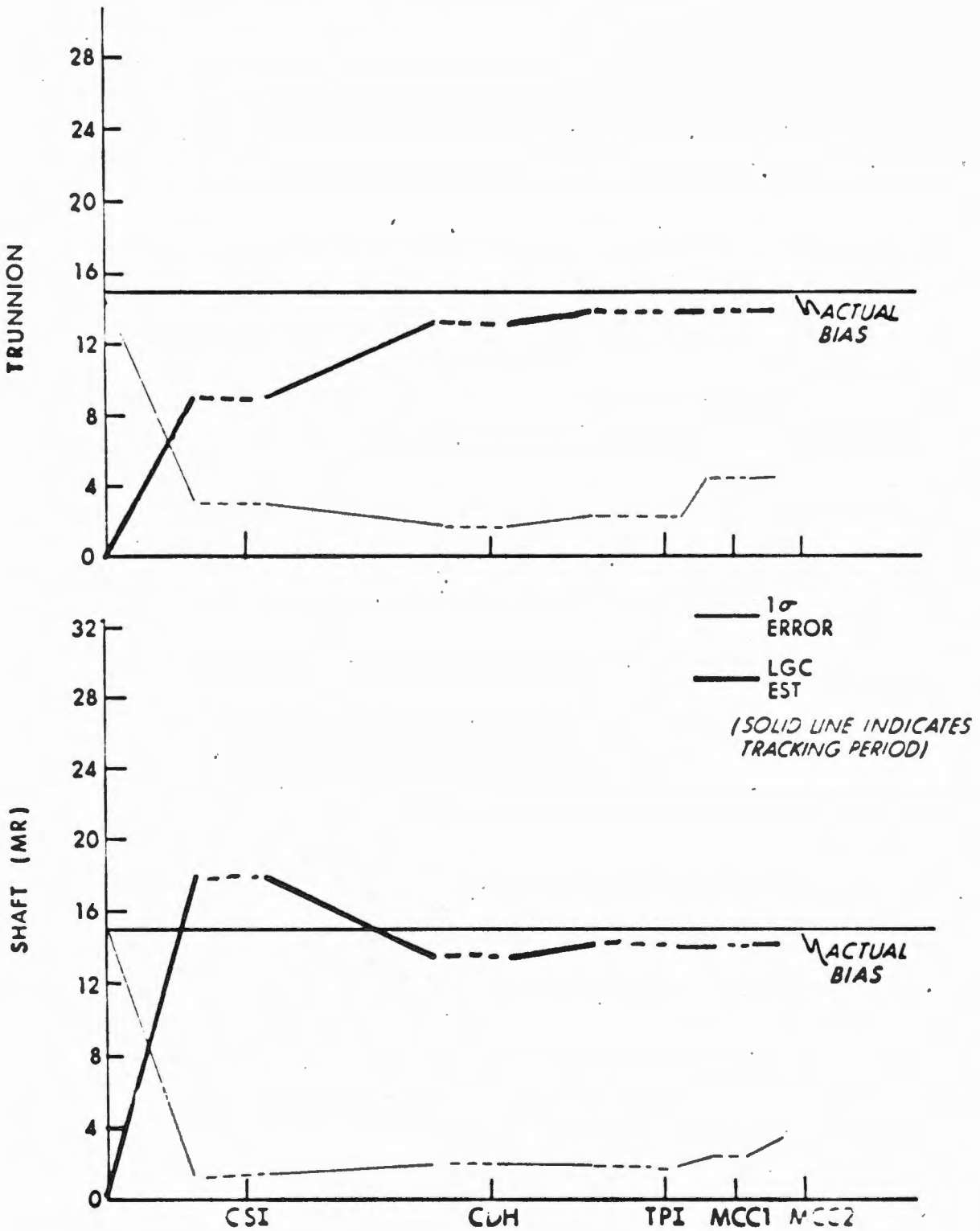


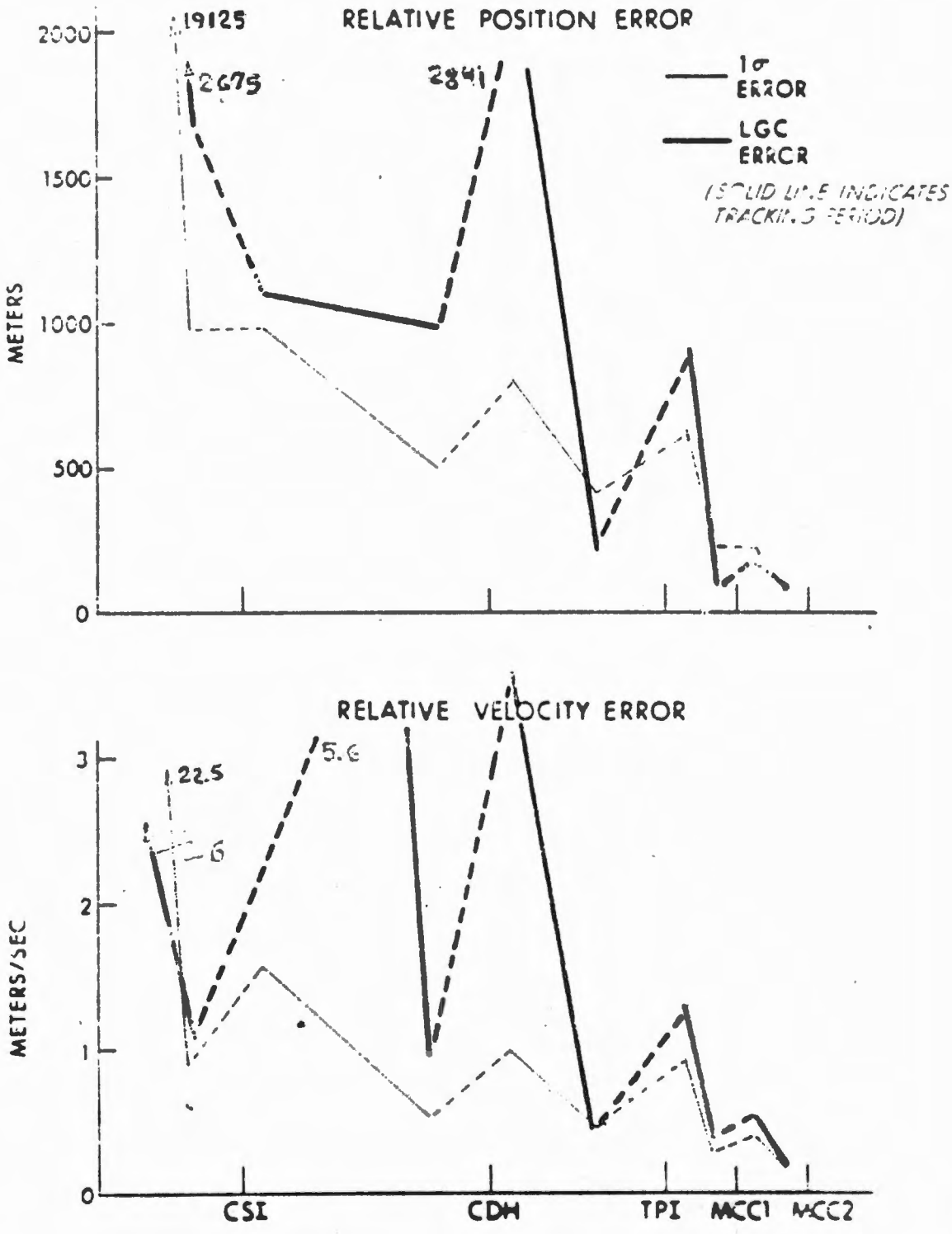
TABLE 1
LUMINARY BURN PERFORMANCE (# Engineering Sim 1σ results ( ))

INITIAL STATE ERRORS	EVENT	BURN UNCERTAINTY (fps) Range	Track	Alt.	Mag.	|ΔV| (fps)	MISS (meters)
NOMINAL (R2-two pass)	CSI	-0.3 (0.94)	0 (0)	0 (0)	0.3 (0.94)	50.2 (50.6)	—
	CDH	1.0 (0.5)	0 (0)	-0.9 (1.45)	1.35 (1.53)	12.0 (10.0)	—
	TPI	-0.1 (0.62)	-0.8 (1.0)	-0.2 (2.3)	1.3 (2.6)	24.8 (28)	377 (1800)
	MCC1	0.6 (0.3)	-0.6 (0.7)	0.6 (0.7)	1.02 (1.0)	0.9 (7.7)	379 (326)
	MCC2	-0.6 (0.2)	-0.1 (0.26)	-1.5 (0.6)	1.6 (0.7)	4.0 (1.3)	139 (74)
TPI TIG: (a) slip = -2 MIN (4.5mm); (b) error = 29 sec (46 sec)							
TRIAX (MSFN MODEL)	CSI	-0.3 (0.94)	0 (0)	0 (0)	0.3 (0.94)	50.4 (50.7)	—
	CDH	0.9 (0.93)	0 (0)	-3.0 (1.2)	3.3 (1.3)	9.3 (9.2)	—
	TPI	0.8 (0.9)	-1.1 (0.95)	-3.6 (2.5)	3.9 (2.8)	27.4 (28.5)	3764 (2000)
	MCC1	0.3 (0.4)	-0.7 (0.6)	-0.6 (0.7)	0.97 (1.0)	9.3 (7.3)	266 (330)
	MCC2	0.2 (0.2)	0.1 (0.25)	-0.9 (0.6)	0.92 (0.7)	1.6 (1.4)	81 (72)
TPI TIG: (a) slip = -1.9 min (4.5 min); (b) error = -26 sec (62 sec)							
ZERO ERRORS	CSI	-0.1 (0.91)	0 (0)	0 (0)	0.1 (0.91)	50.7 (50.5)	—
	CDH	0.1 (0.5)	0 (0)	-0.5 (1.4)	0.5 (1.5)	12.3 (10.3)	—
	TPI	0.5 (0.56)	-1.2 (1.0)	-1.8 (2.4)	2.2 (2.6)	26.9 (27.9)	3067 (1880)
	MCC1	0.9 (0.3)	0.5 (0.63)	-1.9 (0.7)	2.2 (1.0)	6.4 (5.7)	711 (314)
	MCC2	0.2 (0.2)	0 (0.25)	-0.5 (0.6)	0.54 (0.68)	7.1 (3.0)	93 (72)
TPI TIG: (a) slip = -3.7 min (4 min); (b) error = 32 sec (42 sec)							

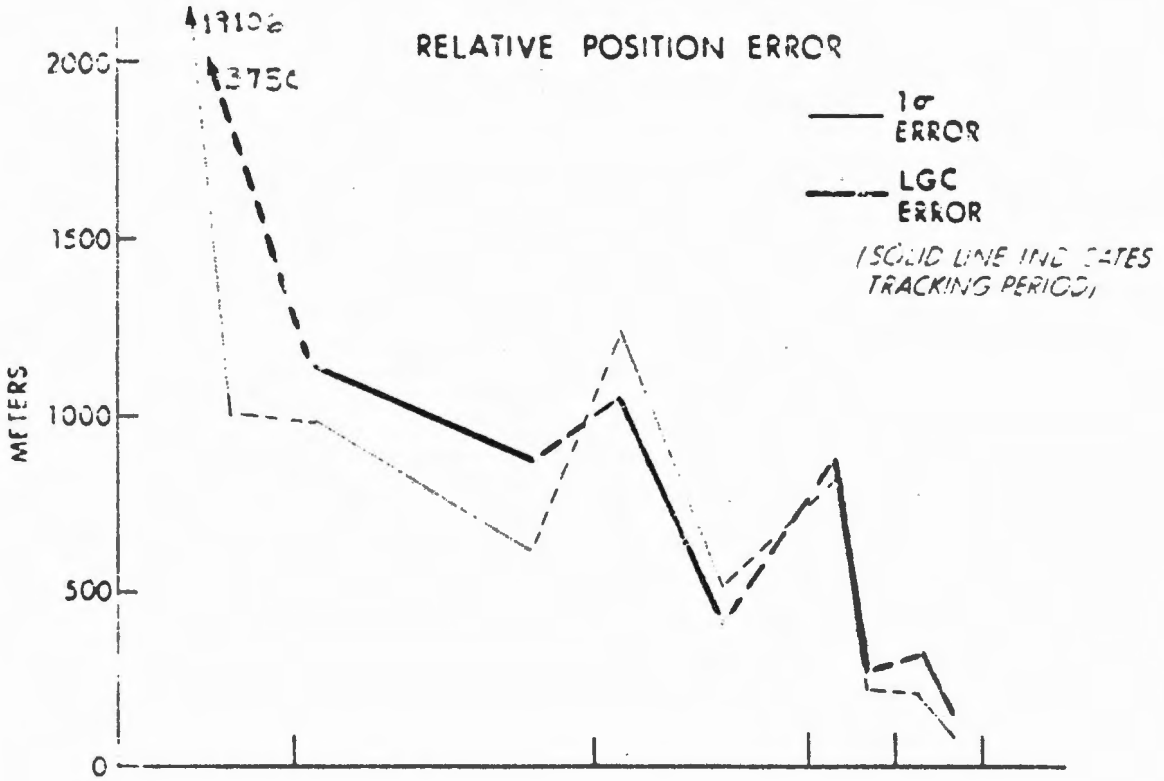
MISSION F RENDEZVOUS NAVIGATION
BIAS ESTIMATION
LUMINARY- 3σ PIPA ERRORS



MISSION F RENDEZVOUS NAVIGATION ERRORS
PRELIMINARY- 3σ PIPA BIASES



MISSION F RENDEZVOUS NAVIGATION ERRORS
LUMINARY - 3σ IMU DRIFT



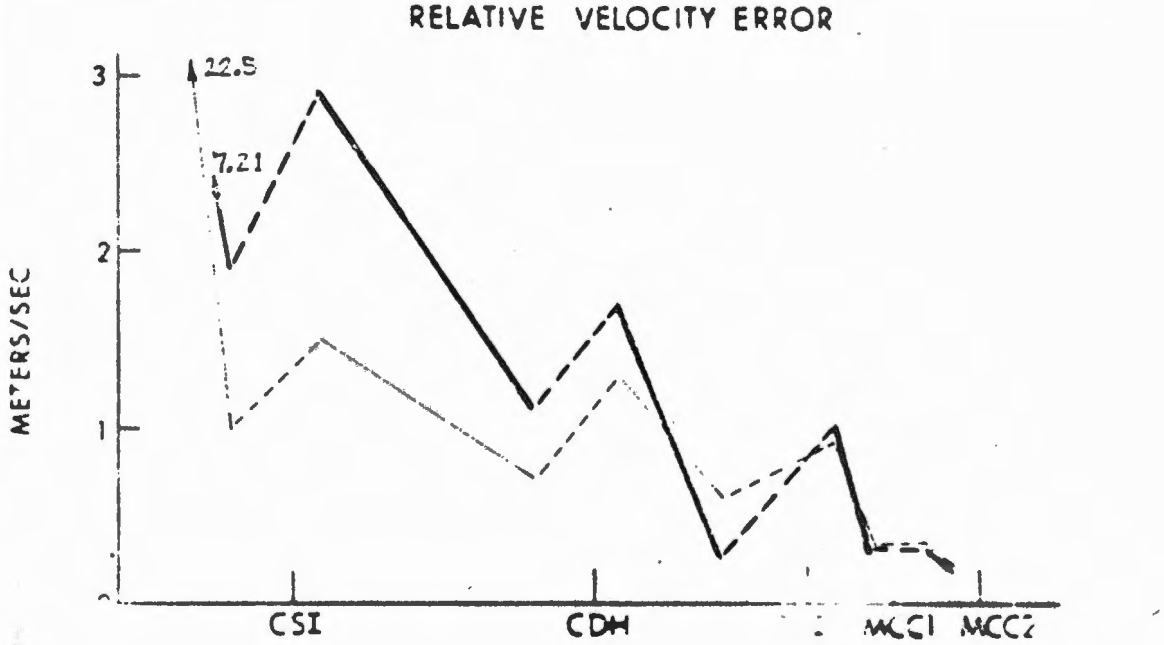
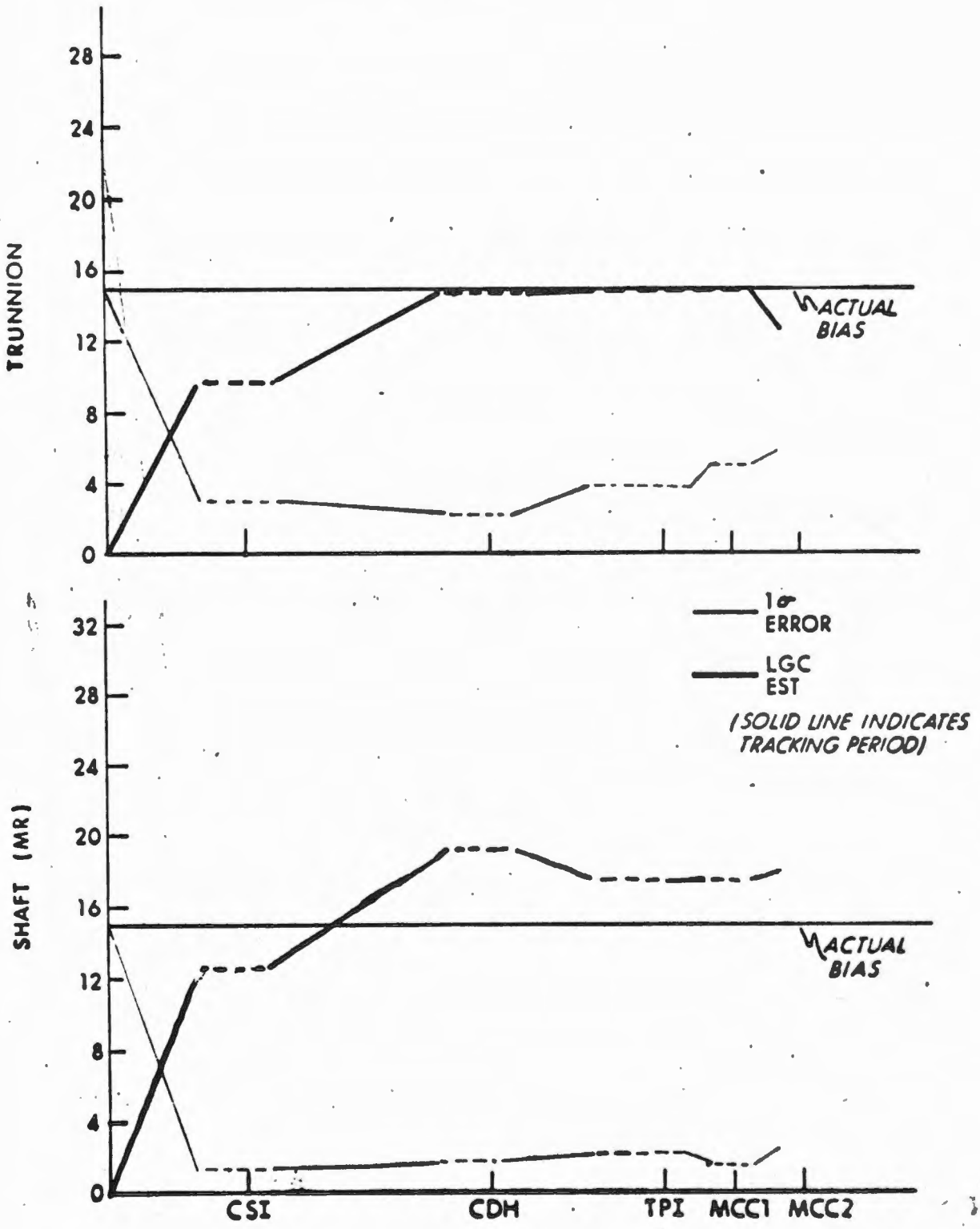


TABLE 2

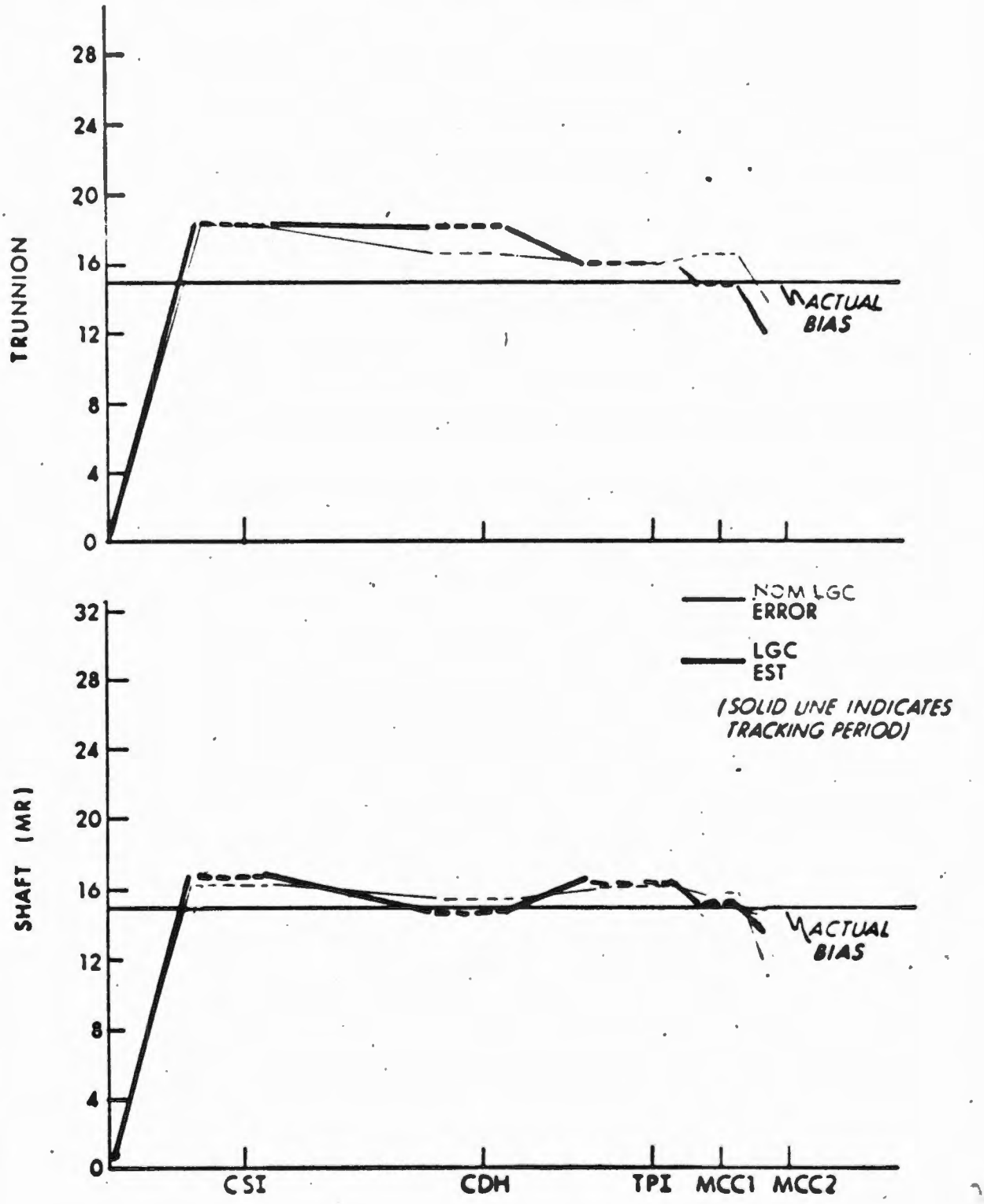
LUMINARY BURN PERFORMANCE (* Engineering 1σ results ( ) Sim)

DEGRADED SYSTEM ERRORS	EVENT	BURN UNCERTAINTY (fps) Range	Track	Alt.	Mag.	|ΔV| (fps)	MISS (meters)
NOMINAL	CSI	-0.3 (0.94)	0 (0)	0 (0)	0.3 (0.94)	50.2 (50.6)	—
	CDH	1.0 (0.5)	0 (0)	-0.9 (1.45)	1.35 (1.53)	12.0 (10.0)	—
	TPI	-0.1 (0.62)	-0.8 (1.0)	-0.2 (2.3)	1.3 (2.6)	24.8 (28)	377 (1800)
	MCC1	0.6 (0.3)	-0.6 (0.7)	0.6 (0.7)	1.02 (1.0)	0.9 (7.7)	379 (326)
	MCC2	-0.6 (0.2)	-0.1 (0.26)	-1.5 (0.6)	1.6 (0.7)	4.0 (1.3)	139 (74)
TPI TIG: (a) slip = -2 min (4.5 min); (b) error = 29 sec (46 sec)							
3σ PIPA BIASES	CSI	-0.5 (0.94)	0 (0)	0 (0)	0.5 (0.94)	50.6 (50.6)	—
	CDH	0.9 (0.5)	0 (0)	-5.7 (1.46)	5.76 (1.54)	10.0 (8.5)	—
	TPI	0.4 (0.5)	-0.7 (1.0)	-1.1 (2.2)	1.36 (2.5)	27.3 (30)	1216 (2250)
	MCC1	0.5 (0.7)	-1.2 (0.8)	0.4 (0.8)	1.36 (1.3)	4.5 (9.4)	350 (420)
	MCC2	0.2 (0.2)	0.5 (0.36)	-0.8 (0.6)	0.96 (0.7)	6.0 (4)	295 (80)
TPI TIG: (a) slip = -3.3 min (4.5 min); (b) error = 25 sec (50 sec)							
3σ IMU DRIFT	CSI	-1.0 (0.94)	0 (0)	0 (0)	1.0 (0.94)	49.4 (50.6)	—
	CDH	0.3 (0.54)	0 (0)	0.8 (1.25)	0.85 (1.36)	14.3 (11)	—
	TPI	0.7 (0.64)	-0.3 (1.7)	-2.4 (2.7)	2.5 (3.3)	26.6 (31)	3298 (2150)
	MCC1	-0.3 (0.3)	-0.6 (0.9)	-0.9 (0.75)	1.1 (1.2)	7.8 (7.95)	425 (390)
	MCC2	-0.2 (0.2)	-0.4 (0.36)	-1 (0.6)	1.1 (0.7)	1.9 (2.2)	28 (70)
TPI TIG: (a) slip = -6 min (4.5 min); (b) error = -29 sec (54 sec)							

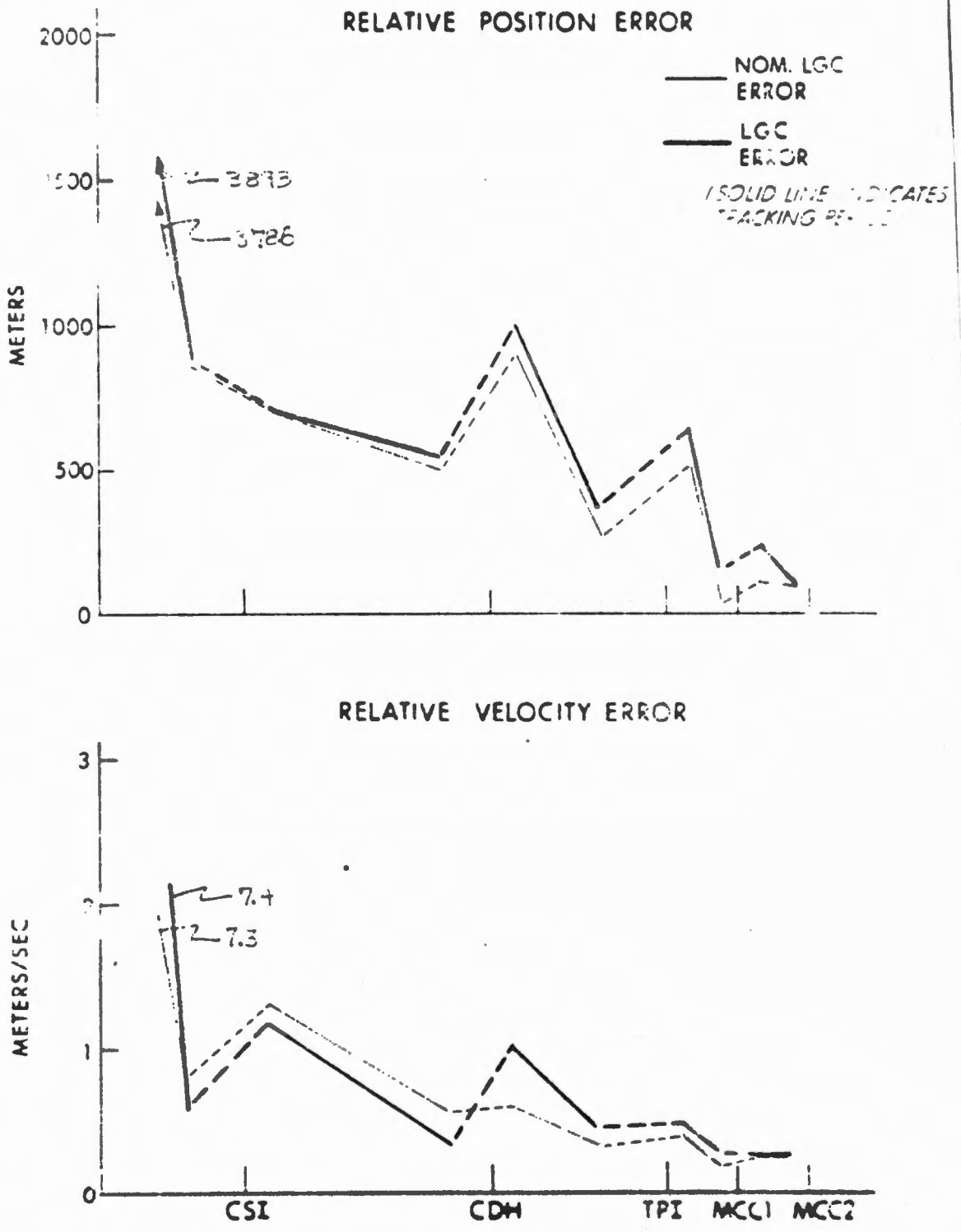
MISSION F RENDEZVOUS NAVIGATION
BIAS ESTIMATION
LUMINARY– 3σ IMU DRIFT



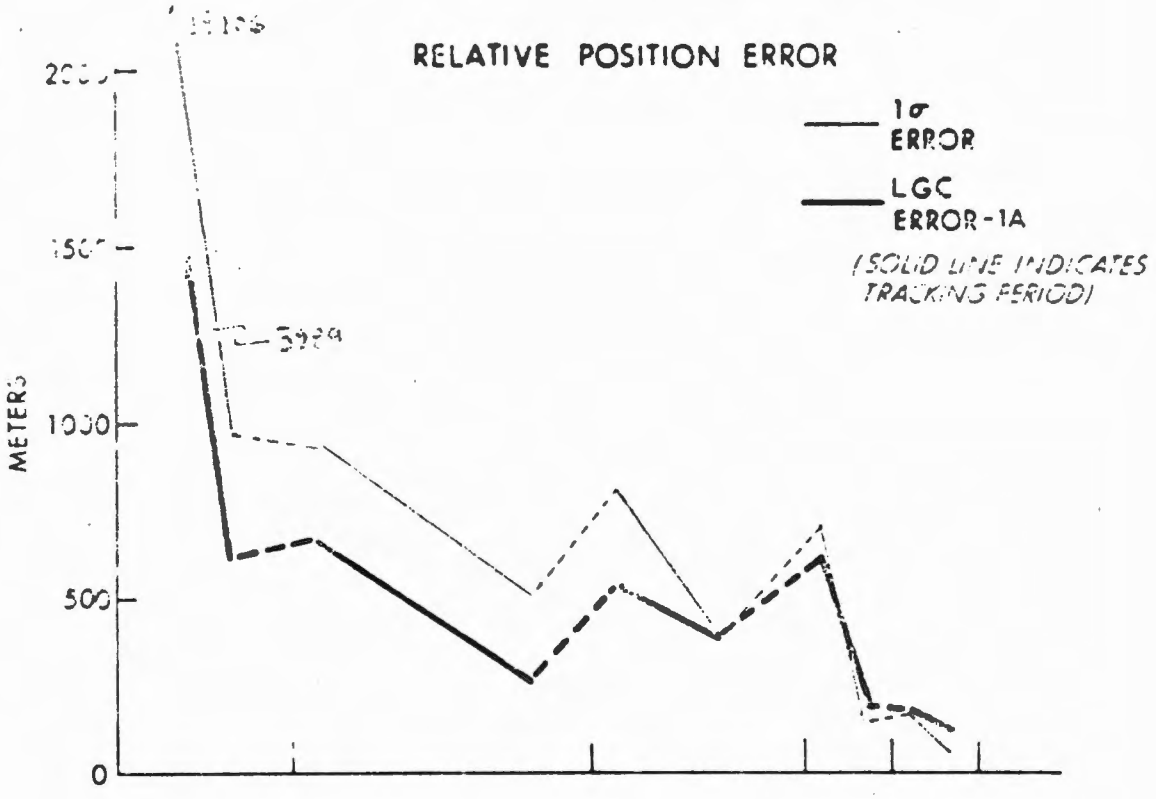
MISSION F RENDEZVOUS NAVIGATION
BIAS ESTIMATION
LUMINARY- NO R2 MODEL ON BOARD

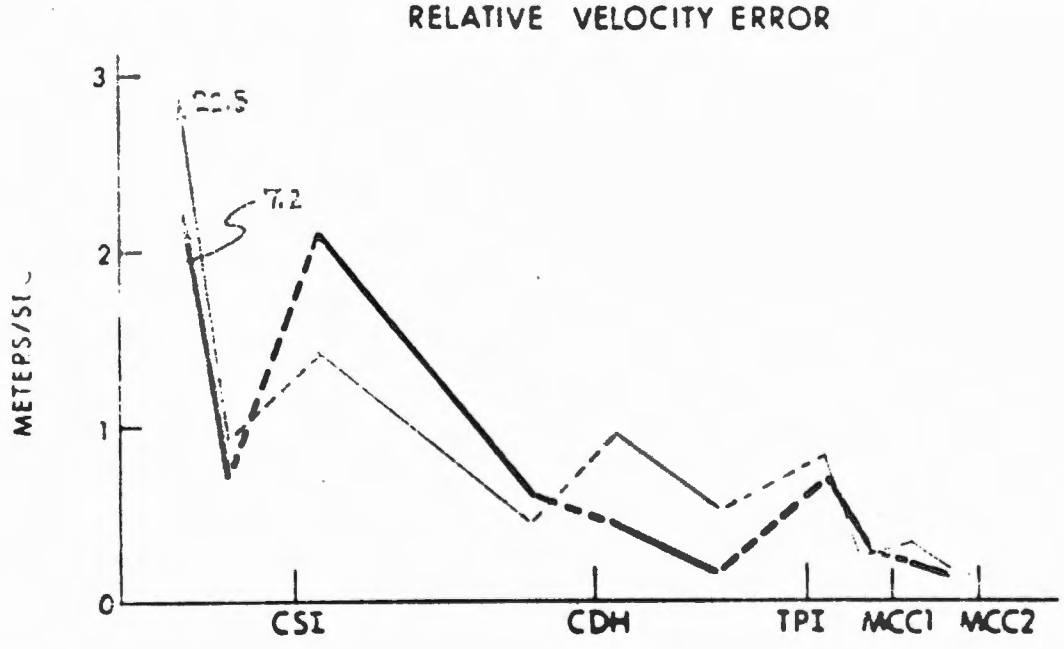


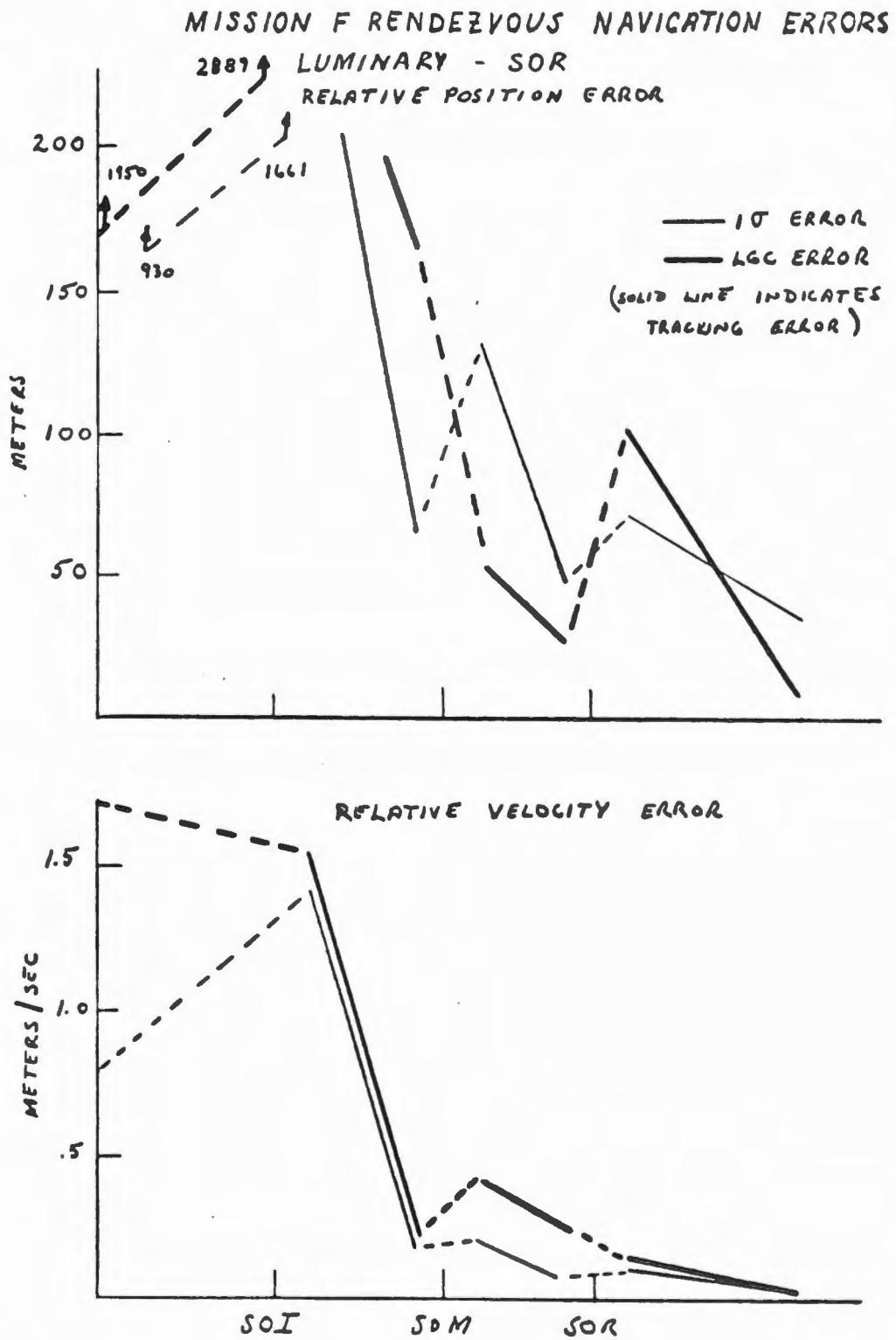
MISSION F RENDEZVOUS NAV GAT ON ERRORS
LUMINARY- N.C R2 ON BOARD



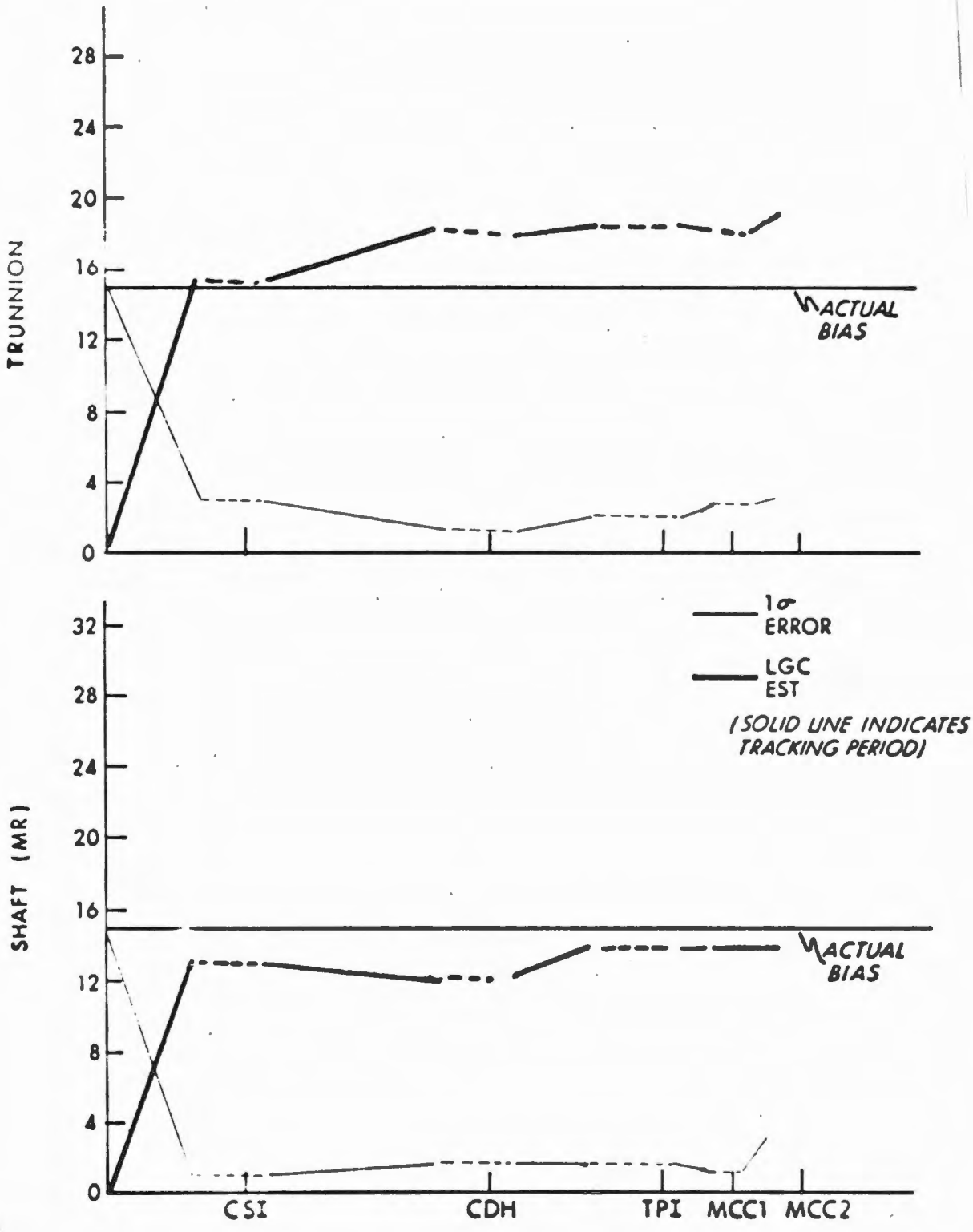
...ON F RENDEZVOUS NAVIGATION ERRORS
...MINARY 1A – NOMINAL





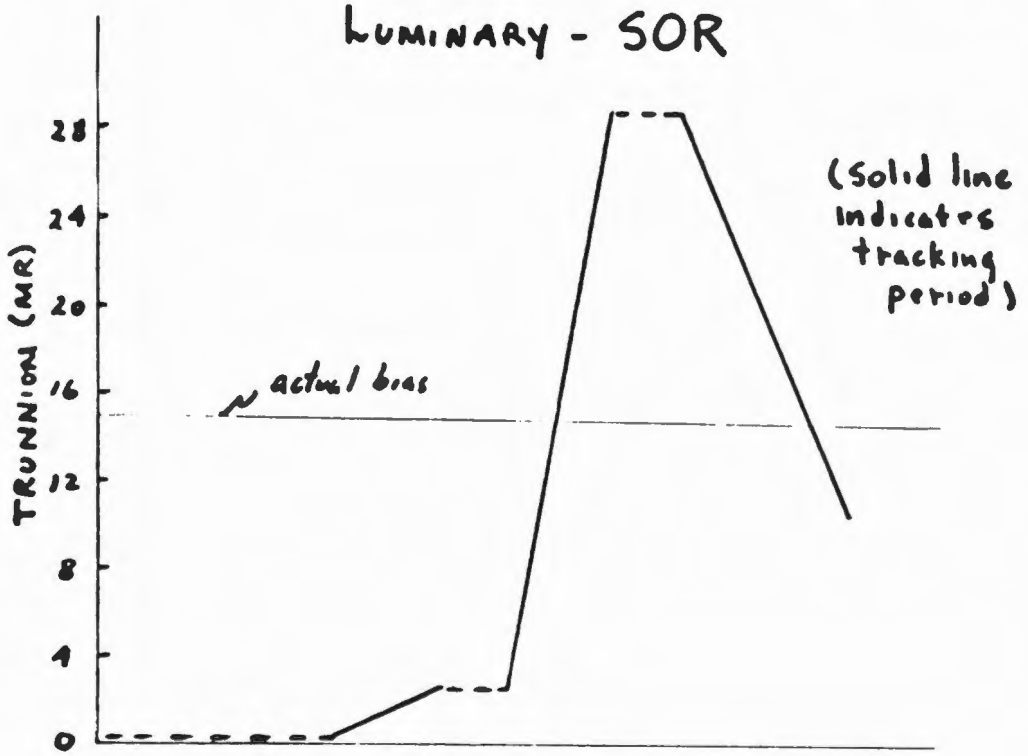

MISSION F RENDEZVOUS NAVICATION ERRORS
2889
LUMINARY - SOR
RELATIVE POSITION ERROR
200
150
100
50
METERS
1950
1661
930
1σ ERROR
LGC ERROR
(SOLID LINE INDICATES TRACKING ERROR)
RELATIVE VELOCITY ERROR
1.5
1.0
.5
METERS/SEC
SOI
SOM
SOR

MISSION F RENDEZVOUS NAVIGATION
BIAS ESTIMATION
LUMINARY- 1A



MISSION F BIAS ESTIMATION

LUMINARY - SOR



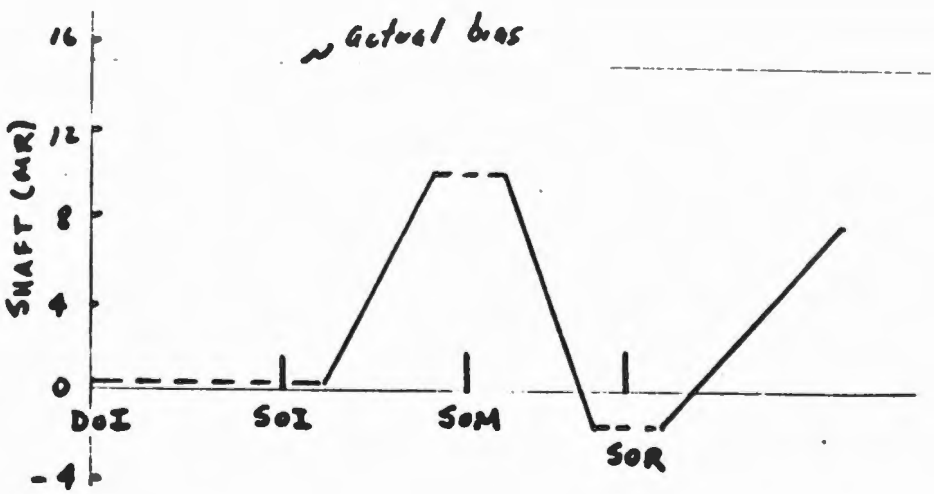


TABLE 3

LUMINARY BURN PERFORMANCE (* Engineering Sim / IG results ( ))

SPECIAL CASES	EVENT	BURN UNCERTAINTY (fps) Range	Track	Alt.	Mag.	|ΔV| (fps)	MISS (meters)
NO R2 MODELING ON BOARD ([ ] indicates LGC RESULTS WITH R2 MODEL ON-BOARD)	CSI	-0.6 [-0.3]	0 [0]	0 [0]	0.6 [0.3]	49.7 [50.2]	—
	CDH	0.5 [1.0]	0 [0]	-2.0 [-0.9]	2 (1.35]	10.8 [12.0]	—
	TPI	0.3 [-0.1]	-0.8 [-0.8]	-0.5 [-0.2]	1.0 [1.3]	25.9 (24.0]	405 [377]
	MCC1	1.0 [0.6]	0 [-0.6]	0.5 [0.6]	1.1 [1.02]	0.8 [0.9]	366 (378]
	MCC2	-0.8 [-0.6]	0.3 [-0.1]	-1.2 [-1.5]	1.47 [1.6]	2.4 [4.0]	173 [139]
	TPI TIG: SLIP= -2 MIN [-2 MIN]; (b) ERROR = 24 sec [29 sec]						
	CSI	-0.6 (0.94)	0 (0)	0 (0)	0.6 (0.94)	50.2 (50.6)	—
	CDH	0 (0.5)	0 (0)	-0.1 (1.45)	0.1 (1.53)	13.4 (10.0)	—
LUMIA	TPI	0.1 [illegible]	-1.3 (1.0)	-1.2 (2.3)	1.75 (2.6)	26 (20)	1353 (1000)
	MCC1	0.5 (0.3)	-0.8 (0.7)	-0.5 (0.7)	1.07 (1.0)	3.1 (7.7)	259 (326)
	MCC2	0 (0.2)	-0.2 (0.26)	-0.6 (0.6)	0.63 (0.7)	1.5 (1.3)	50 (74)
TPI TIG: SLIP = -4.8 min (4.5 min); (b) error = 13 sec (46 sec)							
	SOI	3.5 (1.9)	1.5 (0.25)	3.0 (3.3)	4.8 (3.8)	206.7 (205)	—
STABLE ORBIT REND. a) Initials at DOI + 20 min b) WC = 90° c) R = 2 NM	SDM	0.1 (0.1)	0.5 (0.4)	-0.5 (0.4)	0.7 (0.56)	7.7 (6.5)	—
	SOR	0.3 (0.2)	-0.6 (0.3)	-0.9 (0.6)	1.1 (0.73)	47.4 (50)	—
	SR=	[illegible] 2.04 NM		[illegible] 2.09 NM		[illegible] 3.3 NM	
	Ṙ =	-0.073 fps		0 fps		3.6 fps	
	APOG:	[illegible] 59.40 NM		[illegible] 60 NM			
	PER.	57.94 NM		59.93 NM			

CONCLUSIONS

- THE LUMINARY PROGRAM SATISFACTORILY MEETS THE FOLLOWING RENDEZVOUS PERFORMANCE FIGURES OF MERIT:
  - NAVIGATION ERRORS FOLLOW EXPECTED TRENDS
  - NAVIGATION & TARGETING PERFORMANCE IS WITHIN PREDICTED STATISTICAL LIMITS
  - A SATISFACTORY RENDEZVOUS IS ACHIEVED AS EVIDENCED BY
    - SMALL CLOSET POINT OF APPROACH
    - REASONABLE ΔV EXPENDITURE
- R_2 POTENTIAL MODELING ON BOARD IS NOT REQUIRED FOR RENDEZVOUS BUT YIELDS SLIGHTLY IMPROVED PERFORMANCE

Observable DAP changes from

SUNDANCE to LUMINARY

FINDCDUW replaces FINDCDUD as the powered flight steering routine.

State verify bit dependence eliminated.

1. Routine 3 (DAP data load) rewritten to display, accept and use APSFLAG.
2. Stage-monitor routine deleted.
3. 1/ACCS uses APSFLAG and does not set it.
4. APSFLAG indicates favoring of upwards firing jets.
5. APSFLAG also cleared in landing and abort (P68, P71).

Pause of approximately 80 msec. inserted when reversing GTS drives to avoid triggering the GDA failure indicator.

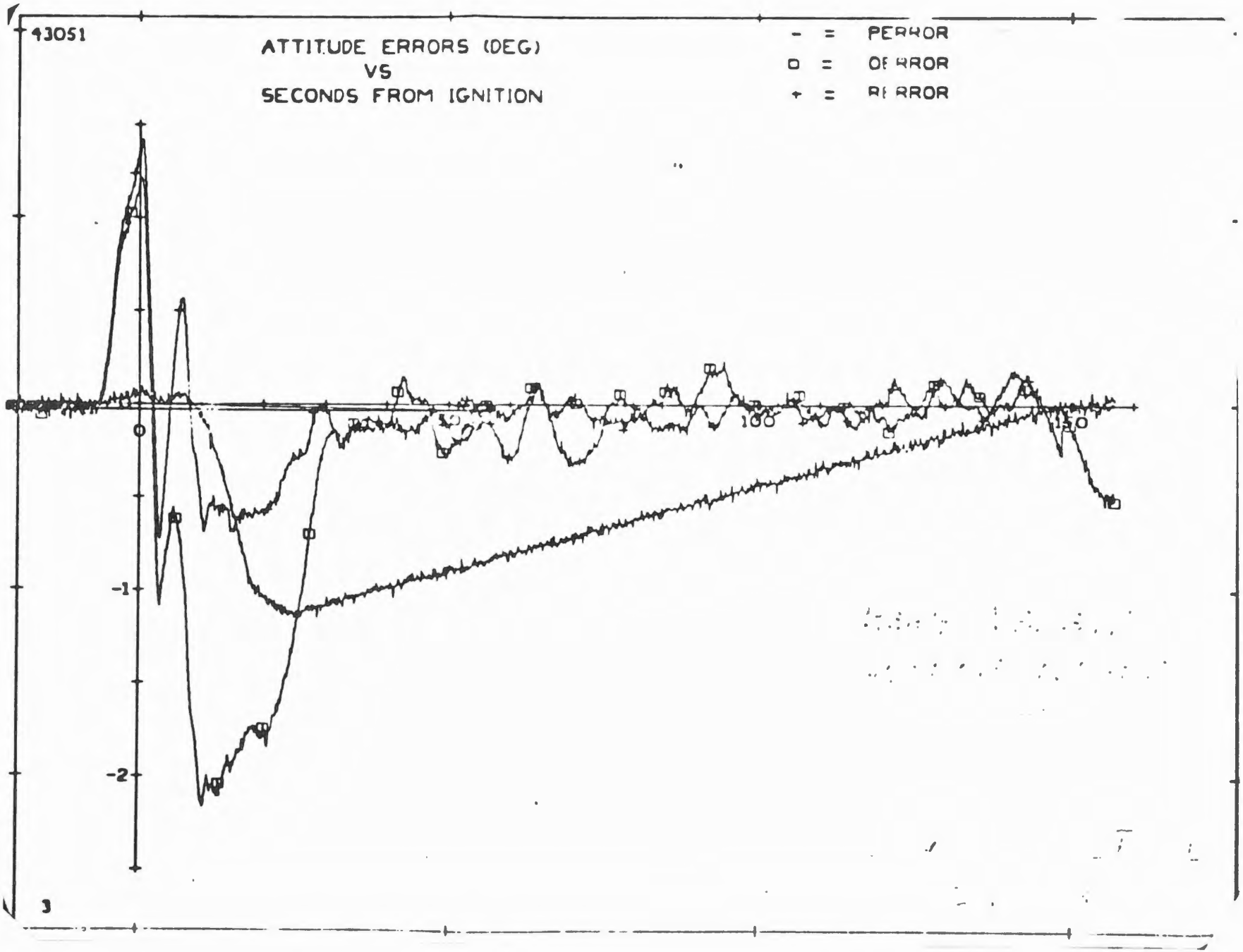
SNUFFER effective for both LM-alone and CSM-docked descent configurations, depending only on DRIFTBIT and APSFLAG.

Uprated manual rate command mode implemented.

Commands from ACA are quadratic function of stick displacement.

Accumulated jet torquing information added to downlink.

Enc 4


43051
ATTITUDE ERRORS (DEG)
VS
SECONDS FROM IGNITION
- = PERROR
□ = QERROR
+ = RERROR
0
-1
-2
100
150
3

MISSION F - LEVEL 6 SIMULATION - 26 April 1969

POWERED DESCENT

Time (sec.)		ΔRCS lb.	RCS lb.
42.0	P30, delta-V = 72 fps, P40	0	592.3
90	Initiate automatic maneuver	0	592.3
164.6	Terminate automatic maneuver	1.1	591.2
892.5	Ullage request	0.2	590.9
900.0	IGNITION request, DOI		
927.7	ENGINEOFF request, ullage used 5.6 lb. RCS fuel	6.0	584.9
947.2	Nulling completed VG = (0.3, 0.1, -0.4)	0.1	584.8
3900.0	P30, delta-V = 175 fps, P40	1.1	583.7
3962.0	Initiate automatic maneuver	0	583.7
3985.0	Terminate automatic maneuver	1.3	582.4
4756.5	Ullage request	0.1	582.3
4764.0	IGNITION request, PHASING		
4804.4	ENGINOFF request, ullage used 5.6 lb RCS fuel	6.6	575.7
4847.0	Nulling completed	4.5	571.2
5124.0	P20	0	571.2

MISSION F - LEVEL 6 SIMULATION - 25 April 1969

POWERED ASCENT

Time (sec)		ΔRCS lb	RCS lb
370157	P30, delta-V	0	592.3
370410	Stage	0	592.3
370862	P42	0	592.3
370928	Terminate auto maneuver	0.1	592.2
371002.5	Ullage request	0	592.2
371010.	IGNITION request, INSERTION		
371024.	ENGINEOFF request, ullage used 5.3 lb. RCS.	8.0	584.2
371035	Nulling completed, VG = (0.2, -0.5, -1.5)	0.5	583.7
371310	P25, REALIGN	0.6	583.1

MANUAL CONTROL PROGRAM CHANGE REQUESTS

PROGRAM CHANGE REQUEST	APPROVAL DATE	TITLE OF CHANGE
140	4/9/68	INCORPORATE UPRATED MANUAL RCAH MODE FOR LM DAP
551	10/8/68	ROTATIONAL HAND CONTROLLER SCALING
618	10/31/68	MAKE THE DAP RATE COMMAND A NON-LINEAR FUNCTION OF LM HAND CONTROLLER DEFLECTION (SUPERCEDES PCR 551)

GOALS OF THE LUMINARY MANUAL CONTROL CHANGES

1) Precise rate control, especially at low rates.

2) Attitude hold about uncommanded axes.

3) Improved handling qualities during docking and lunar landing.

4) Improved control with unmodelled accelerations.

5) Spurious hand motion filtering.

6) Manual control with the CSM-docked.

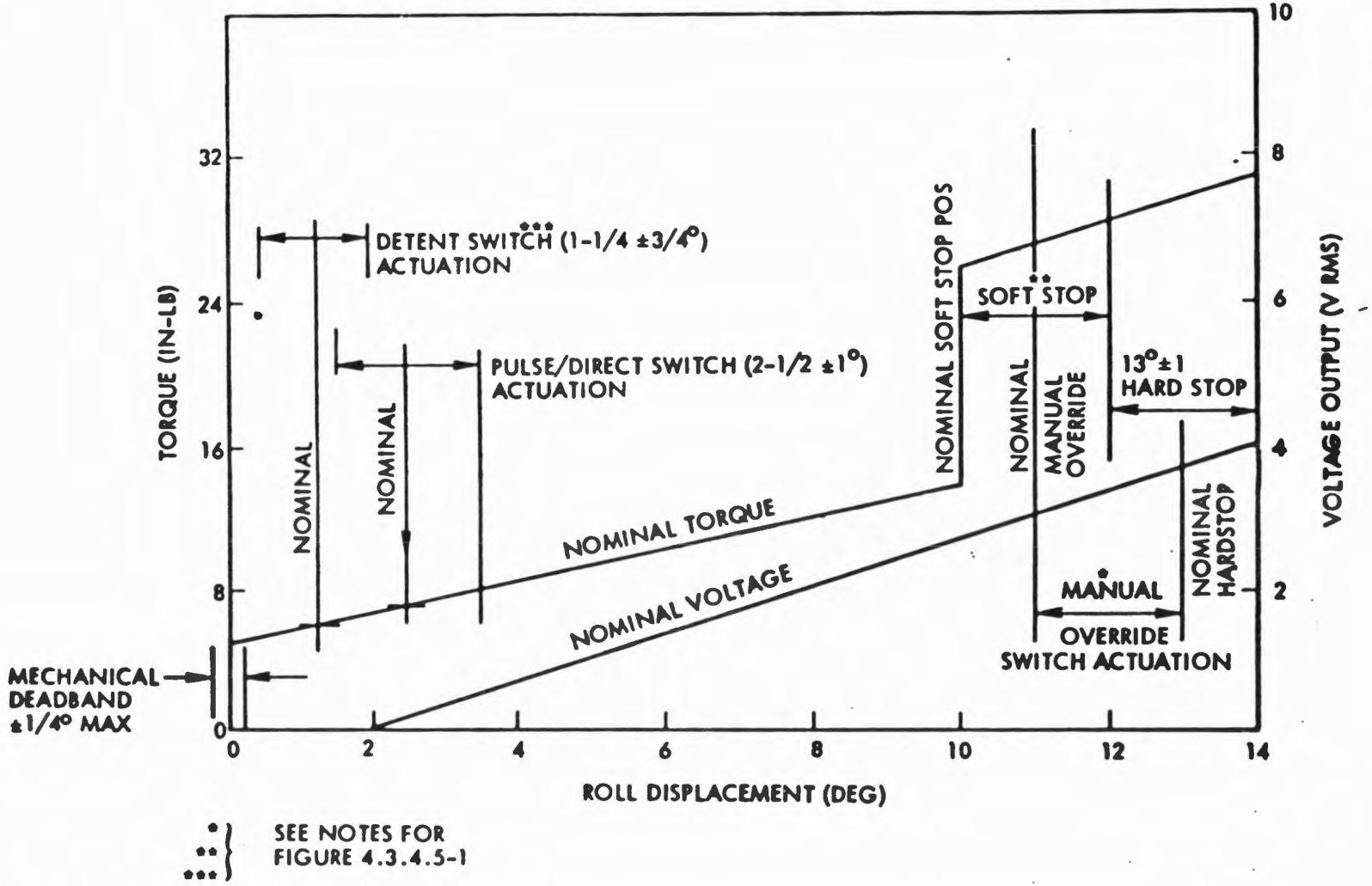
7) Reduced jet exhaust impingement on the descent stage during manual lunar landing.

1) Rate command with deadband
2) Attitude hold upon:
   a) Return to detent in all axes
   b) Simultaneous damping of rate errors in all axes to less than the rate deadband
3) 3-Axis control with guidance select switch in "Attitude Hold"
4) X-Axis control with guidance select switch in "Automatic"
5) Maximum commanded rate = $\begin{cases} 20^{0}/s \text{ in Normal Scaling} \\ 4^{0}/s \text{ in Fine Scaling} \end{cases}$
6) Rate deadband = $\begin{cases} 1.4^{0}/s \text{ in Normal Scaling} \\ .4^{0}/s \text{ in Fine Scaling} \end{cases}$
7) Estimated bias acceleration included in jet on-time calculation.
8) 10 samples per second (less "skips")
9) Transportation lag of .13 to .25 seconds
10) Control torque supplied by RCS thrusters.

LUMINARY MANUAL CONTROL LOGIC

1) Rate command in Direct Rate and Pseudo-Auto modes:
   a) Direct rate mode affords immediate control without overshoot
   b) Pseudo-Auto mode provides precise rate control and attitude hold
   c) Mode switching for P-Axis is separate from that in Q, R-Axes

2) Attitude hold:
   a) About all axes in Pseudo-Auto mode with zero command
   b) About X (or P)-Axis during Y, Z (or Q, R)-Axes command and vice versa
   c) About Y-Axis during slow Z-Axis command and vice versa
   d) Upon return to detent
      i) with rate errors less than the target deadband, or
      ii) after 4 seconds
3) Direct Rate mode is entered only if the change in commanded rate exceeds the breakout level ($.6^{\circ}$/sec for LM-Alone, $.3^{\circ}$/sec for CSM-Docked)
4) The breakout level and the target deadband are numerically equal
5) Linear-quadratic scaling of rate commands, for high maximum commanded rate and low sensitivity at small controller deflection
6) Reduced controller scaling with the CSM docked
7) Guidance select switch, jet on-time calculation, sampling rate, transport lag, and control torque as in SUNDANCE control

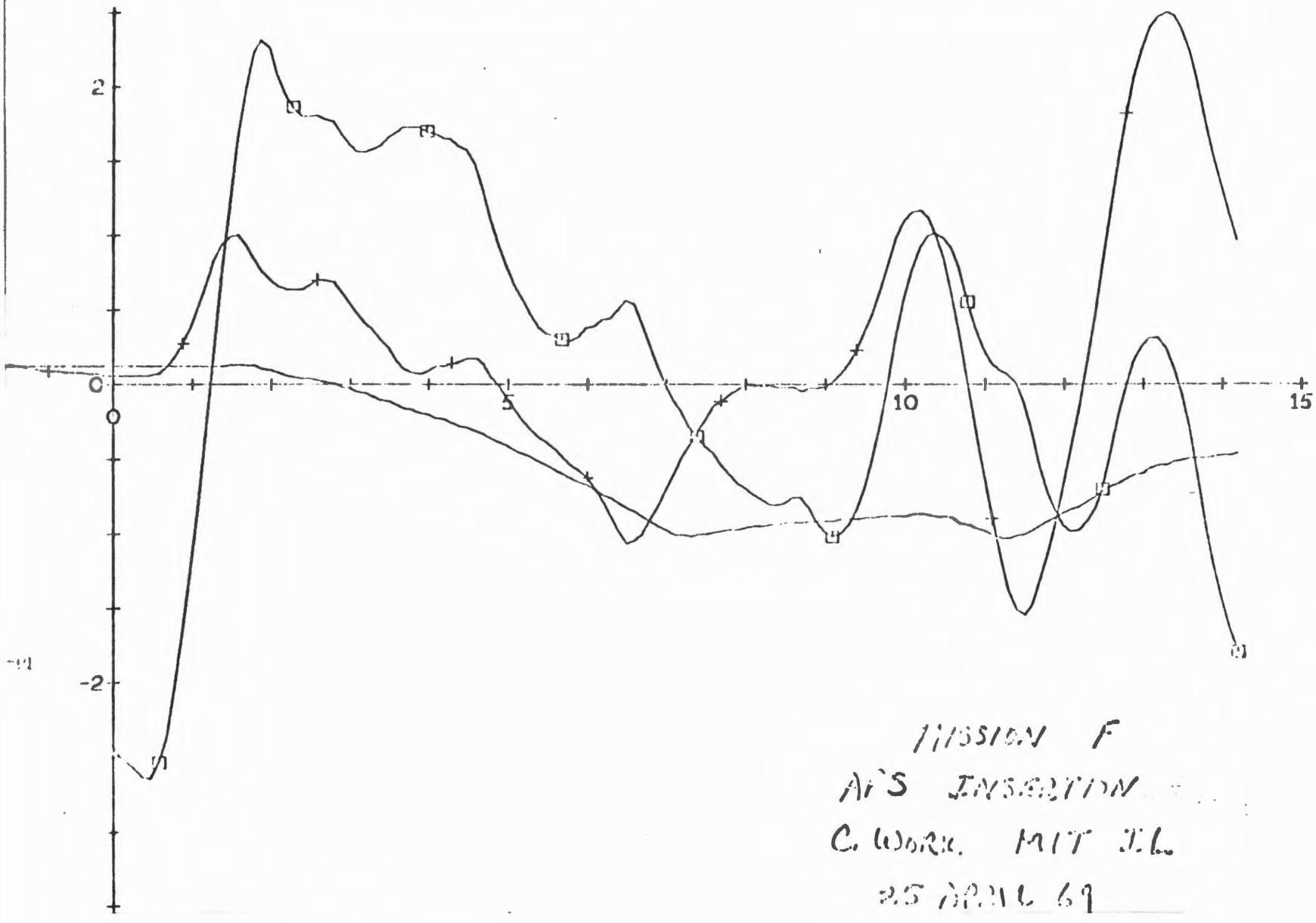


47

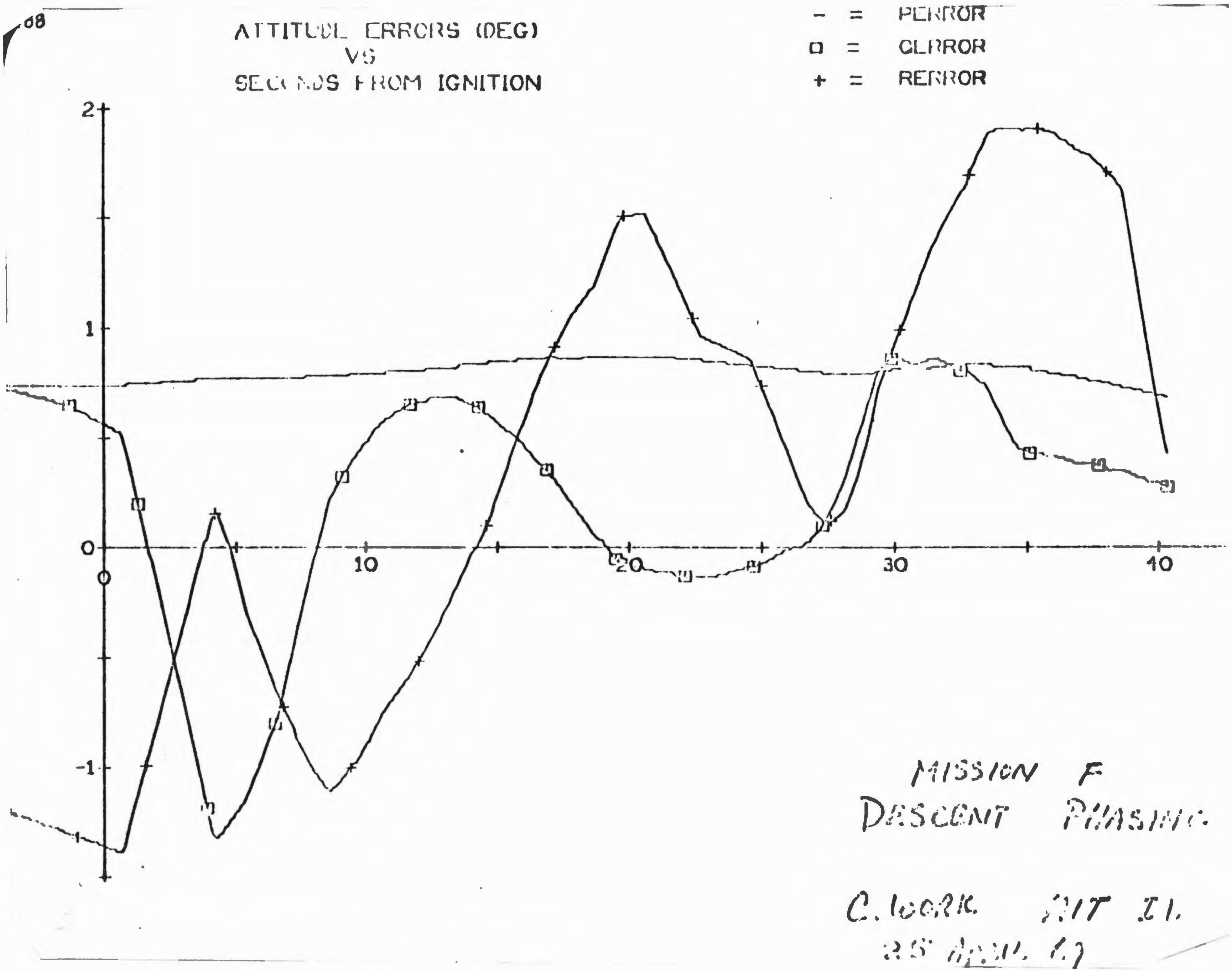
Figure 4. 3. 4. 5-2. Torque and Voltage Output versus Roll Displacement

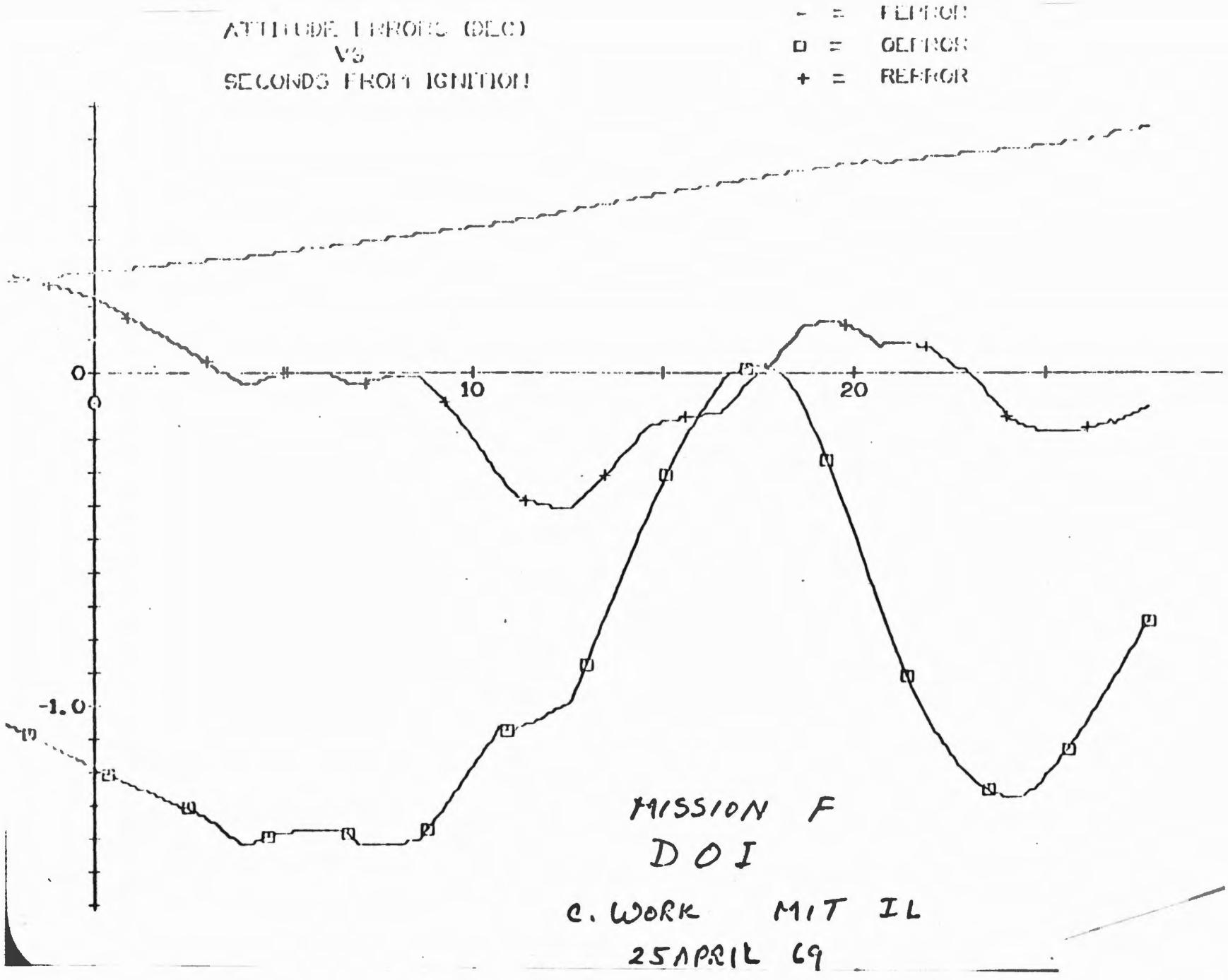
ATTITUDE ERRORS (DEG)
VS
SECONDS FROM IGNITION

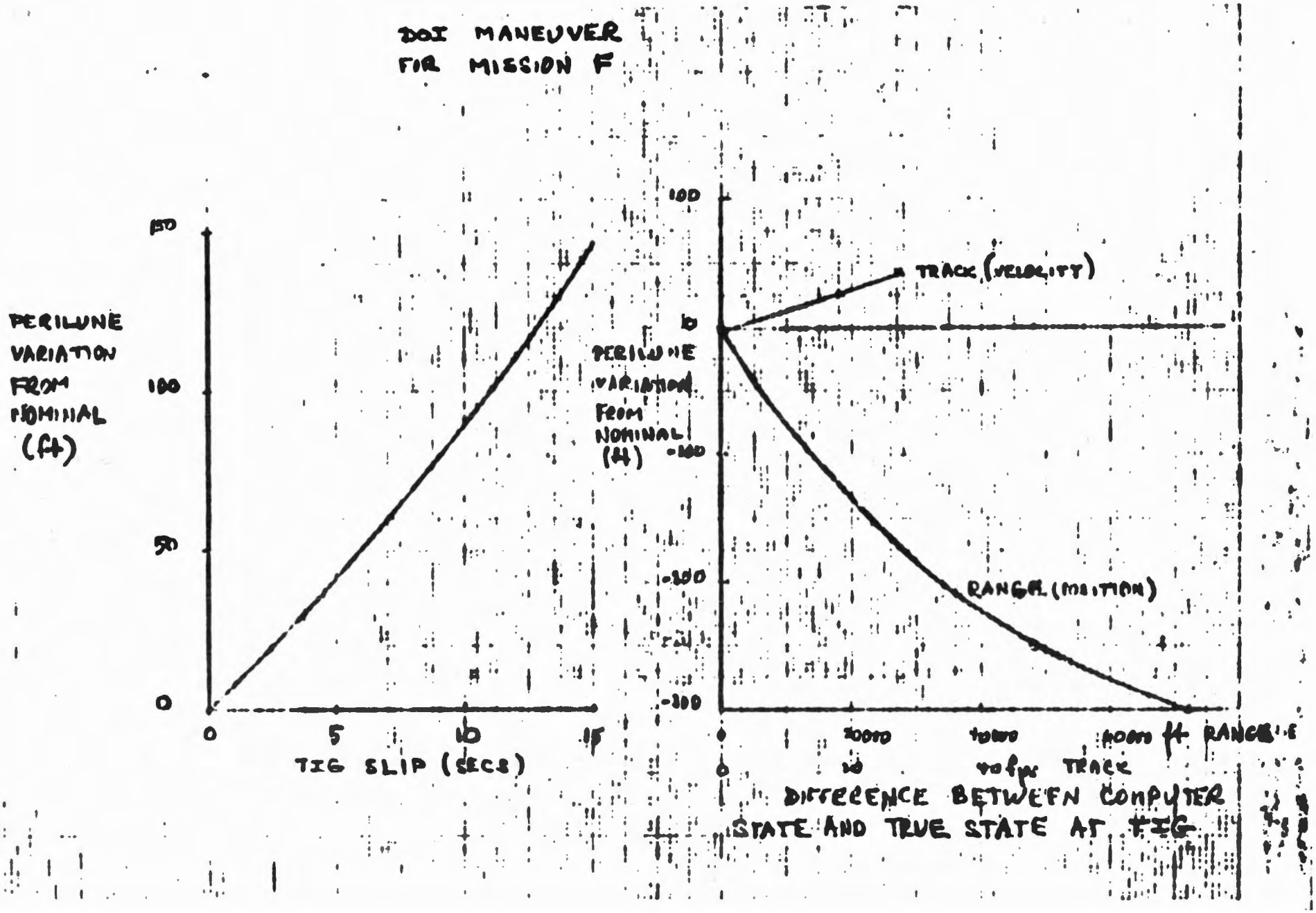
- = PERROR
□ = QERROR
+ = RERROR

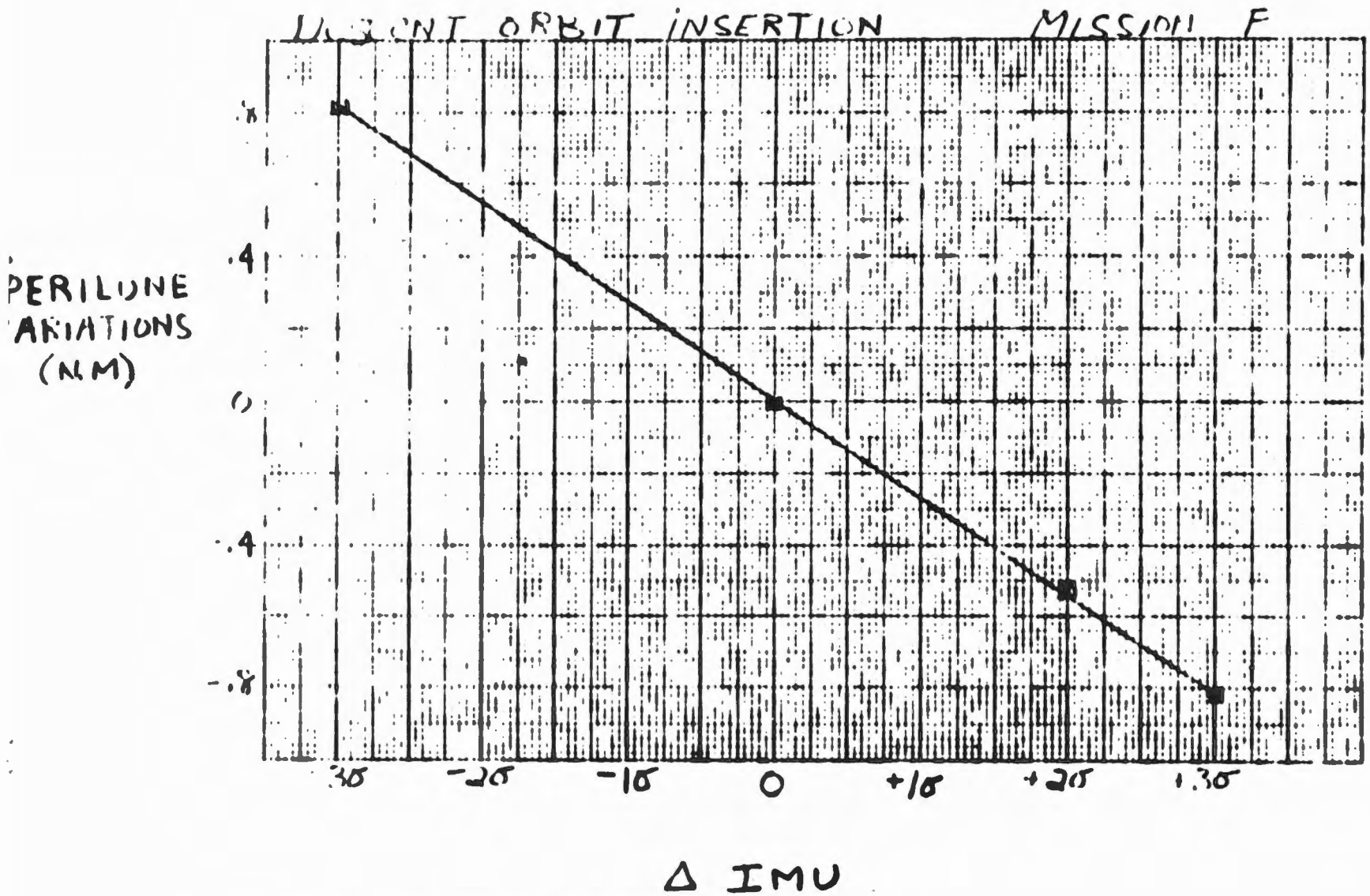


MISSION F
AFS INSERTION
C. WORK. MIT I.L.
25 APRIL 69


ATTITUDE ERRORS (DEG)
VS
SECONDS FROM IGNITION
– = PERROR
□ = QERROR
+ = RERROR
2
1
0
-1
0
10
20
30
40
MISSION F
DESCENT PHASING


ATTITUDE ERRORS (DEG)
V3
SECONDS FROM IGNITION
- = PERROR
□ = QERROR
+ = RERROR
0
-1.0
10
20
MISSION F
D O I
C. WORK MIT IL
25APRIL 69


DOI MANEUVER
FOR MISSION F
PERILUNE
VARIATION
FROM
NOMINAL
(ft)
150
100
50
0
0
5
10
15
TIG SLIP (SECS)
100
0
-100
-200
-300
PERILUNE
VARIATION
FROM
NOMINAL
(ft)
TRACK (VELOCITY)
RANGE (POSITION)
20000
40000 ft RANGE
10
TRACK
DIFFERENCE BETWEEN COMPUTER
STATE AND TRUE STATE AT TIG



* APOLUNE IS UNAFFECTED

SYSTEM TEST LAB. VERIFICATION LUMINARY

Objectives

1. Demonstrate continuing compatibility of software and real hardware
   A) Software control of IMU and Radar
   B) Hardware inputs to software for polarity, approximate scaling, and proper operation

2. Verify that system test programs for spacecraft checkout work as intended in nominal and stressed environment.

3. Demonstrate compatibility of system with simulators.

Eng 5

SYSTEM TEST LAB. VERIFICATION OF LUMINARY

TEST EQUIPMENT USED

1. LAB SYSTEM NEARLY IDENTICAL TO FLIGHT SYSTEM MOUNTED ON A ROTARY TABLE OR ON RADAR FIXTURE
2. RENDEZVOUS RADAR SIMULATOR
3. FLIGHT TYPE RADAR
4. LANDING RADAR INTERFACE SIMULATOR
5. CORE ROPE SIMULATOR LUMINARY PROGRAM (SIMILAR TO THAT USED IN HYBRID SIMULATION)
6. K-START TAPE READER SIMULATION. ALLOWS CONVENIENT LOADING OF E-MEMORY AND SIMULATES ACE UPLINK USED IN SPACECRAFT TESTING.

SYSTEM TEST LABORATORY

"LUMINARY" PROGRAM VERIFICATION

DESCRIPTION OF TEST CATEGORIES

1. IMU FUNCTIONS AND I/O.
2. IMU ALIGNMENT USING AOT
3. RADAR FUNCTIONS AND I/O (INCLUDING NASA REQUESTED ADDITIONS)
4. COMPATIBILITY OF FLIGHT TYPE RADAR
5. SYSTEM OPERATION EXTENDED VERBS
6. SYSTEM TEST PROGRAMS
7. IMU IN-FLIGHT COMPENSATION POLARITY
8. ALARM AND ABORT BRANCHES

OBJECTIVES OF TESTS WITH FLIGHT TYPE RADAR

1. VERIFICATION OF COMPATIBILITY OF PROGRAM AND RADAR VOTING LOGIC WITH GOOD RADAR GYROS
2. A COMPARISON OF RR BASELINE PERFORMANCE AGAINST PERFORMANCE WITH SIMULATED GYRO FAILURES WHEN THE RR WAS UNDER LGC ANGLE CONTROL USING THE SUNDANCE AND LUMINARY PROGRAMS
3. CONFIRM ADEQUACY OF RADAR ANGLE INTERFACE SIMULATOR FOR ROUTINE SOFTWARE VERIFICATION

FLIGHT RADAR TEST RESULTS

1. Reported on at Radar Integration Meeting #13
2. Summary of results:
   (1) Voting between good gyro pairs may induce angle transients of several degrees amplitude during designate.
   (2) LGC control loop corrects transients, usually in less than one second.
   (3) Transients do not occur near final designate position.
   (4) With good gyros, base motion reversal
      (a) has little effect on voting characteristics.
      (b) produces negligible angle disturbance during designate.
   (5) Only minor differences exist between operation using AC or BD gyros and only minor direction dependent differences were observed.

Conclusions:

1. With good gyros, and under conditions of normal LGC-RR usage, voting does not impair ultimate capability of LGC and RR to accomplish angle designate
2. Except for a stoppage of A, B or D wheels the chances of completion of radar angle control functions are reasonably good.
3. Reconfirmed previous STL interface and software compatibility tests.

SYSTEM TEST LAB. VERIFICATION OF LUMINARY

CONCLUSIONS:

1 The compatibility between the LUMINARY program and the G&N hardware was again demonstrated

2. The compatibility of the flight type radar with the LUMINARY radar programs was demonstrated

3. The prelaunch checkout programs continue to function as intended.

MISSION VERIFICATION OF LUMINARY 69
REV 2 FOR APOLLO 10 ON MIT
HYBRID FACILITY

Eng 6

M.I.T. INSTRUMENTATION LABORATORY • Cambridge, Massachusetts •

TEST OBJECTIVES

Verify Current G &N Procedures

1. No Violation of G &N Constraints
2. Sufficient time to Perform Tasks

Verify Operation of Luminary 69 Under Flight condition within Limitations of Simulation.

TEST FACILITY

1. Cockpit Mock-up
2. LGC
3. Some flight Hardware (e.g. FDAI)
4. SDS 9300 Digital Computer
5. Beckman 2200 Analog Computers (2)
6. Required Interfaces

SIMULATOR ADVANTAGES

1. Use of Real AGC (A Flight Hardware Computer with A Special Erasable "Fixed" Memory) - This allows study of actual calculation times of AGC.
2. Proximity to AGC Software Development Groups
3. Flexability of Operation
4. Can run "Linked" with CSM (Both Vehicles Active)

SIMULATION LIMITATIONS

1. Not all Systems Simulated
   e.g. AGS, Manual Radar
2. One G, Shirt Sleeve Environment
3. Time Lag in Communication of Procedure Definitions
4. May 17 Launch trajectories and Targets only
5. No "Out the window" Displays for Mission F
6. Boeing R2 Lunar Gravitation Model not used in Simulation for Mission F

TESTS PERFORMED ON HYBRID SIMULATOR

*DPS Trans-Earth Insertion	FLMV 1.0
*LM Initialization	FLMV 2.0
Pre-DOI thru Phasing	FLMV 3.0
Pre-DOI thru DOI Abort (Direct Return)	FLMV 3.0A
Pre-Phasing thru Five Impulse Abort (LM Active)	FLMV 3.1
Stable Orbit Rendezvous Abort	FLMV 3.1A
*Pre-Insertion thru Rendezvous	FLMV 4.0
Pre-Insertion thru Rendezvous with 1 Sigma SV Errors	FLMV 4.0 & 1 SIG
*Pre-CSI thru Rendezvous	FLMV 4.1
Pre-CDH thru Rendezvous	FLMV 4.2

* Linked Runs

TESTS NOT PERFORMED

1. Docked Alignment
2. Undocking and Separation
3. APS to Depletion Burn
4. MCC, DPS Backup

SOURCES

1) IC's, TIG's and ΔV's

NASA File No. 69-FMI3-45, Preliminary Apollo 10(F) Mission Operation Trajectory Simulator Data Package

2) Procedures

MSC Internal Note CF-R-69-12, LM Rendezvous Procedures, F Mission, Final, March 17, 1969

Reference Mission F Flight Plan, AS-505/106/LM-4, Nov. 22, 1968

MSC Internal Note 69-FM-34, Prelim. LM Abort and Rescue Procedure for Apollo Mission F, Vol. I, Non-Time Critical Procedures, Feb. 11, 1969

MSC Internal Note No. S-PA-9T-044
Apollo Mission Techniques, Missions F and G Lunar Orbit Activities, Vol. I, Feb. 28, 1969

*"Contingency Docked DPS Burn Checklist" March 13, 1969

Word of Mouth

FEED BACKS

George Cherry - Software

James Kernan -

Russell Larson - Procedures

COELLIPTIC RENDEZVOUS SIMULATIONS

RUN	DATE	ΔV CSI fps	ΔV PC fps	ΔH CDH NM	ΔV CDH fps	ΔT TPI min:sec	ΔV TPI fps	ΔV MCC_1 fps	ΔV MCC_2 fps	ΔV TPF fps	ΔV TOTAL fps	CPA	PROCEDURE USED	NOTES
FLMV 4.2	3/17/69			15.0	5.7	-0:20	25.2	4.9	1.6	32.0		440	2/24/69	
FLMV 4.0	3/25/69	46.0	10.6	19.9	8.7	-20:00	33.9	5.8	4.6	42.1	151.7	1000	2/24/69	1
FLMV 4.0	3/26/69	50.9	0.5	14.2	3.8	+12:43	22.0	9.1	1.7	27.1	115.1	225	2/24/69	2,3
FLMV 4.0	4/2/69	50.5	2.2	14.4	4.4	+16:17	22.7	3.1	6.5	25.7	115.1	58	3/17/69	4,5
FLMV 4.1	4/7/69	50.0	0.0	13.9	7.7	+2:57	23.0	1.2	1.5	31.2	114.6	50	3/17/69	
FLMV 4.1	4/9/69	50.0	3.0	14.0	7.1	+3:08	22.8	4.6	4.0	31.1	122.6	210	3/17/69	6
FLMV 4.0	4/14/69	49.0	1.9	18.1	8.0	-13:24	30.2	1.7	2.1	37.8	130.7	800	3/17/69	
FLMV 4.0	4/15/69	38.1	2.4	18.9	36.7	-2:26	33.1	5.5	5.6	38.6	160.0	610	3/17/69	7
FLMV 4.0	4/23/69	53.2	2.3	14.1	25.8	+1:20	25.2	8.1	8.8	33.0	156.8	1000	3/17/69	6

NOTES:

1 Bad values for RMAX, VMAX - may have accepted excessive updates

2 Used new values for RMAX and VMAX (10,000 ft and 10 fps) on this and subsequent runs

3 Received several excessive update displays - marks rejected

4 Used new K-start tape values on this and all subsequent runs

5 Procedures of 3/17/69 labeled LM Mission F Final Rendezvous Procedures

6 Successful linked runs

7 Used 1 sigma errors received from Gene Miller

DOI DIRECT RETURN ABORT

RUN	DATE	ΔV DOI fps	DR CLOSING RATE fps	ΔV TPI fps	CENTANG	ΔV TPF fps	CPA ft	NOTES
FLMV 3.0A	4/22/69	100	30	27.6	70°	6.1	300	1,
FLMV 3.0A	4/25/69	100	55	46.7	30°	13.8	235	2
FLMV 3.0A	4/25/69	100	65	62.0	30°	10.9	6000	3
FLMV 3.0A	4/25/69	100	55	49.2	30°	11.4	280	

NOTES:

1 Used rule of burning until closing rate of 30 fps obtained

2 Used rule of burning until closing rate in fps equals 10 times range in nautical miles on this and subsequent runs

3 Did not burn TPI

FIVE IMPULSE ABORT

RUN	DATE	ΔV CSI fps	ΔH CDH NM	ΔV CDH fps	ΔT TPI min:sec	ΔV TPI fps	ΔV MCC$_1$ fps	ΔV MCC$_2$ fps	ΔV TPF fps	ΔV FINAL fps	CPA ft	NO
FLMV 3.1	4/16/69	48.2	17.2	119.4	-4:08	27.5	10.0	1.7	34.5	241.3	160	1,2
FLMV 3.1	4/17/69	52.8	16.8	121.4	-2:00	24.1	12.6	9.8	33.0	253.7	490	

NOTES:

1 Starts with a 96.6 fps prograde burn at pericynthion near phasing

2 Procedures adapted from Mission F Final Rendezvous Procedures

SOR SIMULATIONS

RUN	DATE	ΔV SOI fps	ΔV MCC fps	ΔV SOR fps	ΔV TOTAL fps	RANGE ft	RANGE RATE FPS	Ha/Hp LM NM	Ha/Hp LM NM	NOTES
FLMV 3.1A	4/9/69	851.7	14.2	650.8	1516.7	22,000	-18			1,2
FLMV 3.1A	4/10/69	851.7	5.2	650.8	1507.8	17,000	-20	63.2/58.3	61.7/57.7	
FLMV 3.1A	4/10/69	851.7	3.6	650.8	1506.1	3,500	0	59.1/57.2	61.7/57.7	
FLMV 3.1A	4/25/69	850.5	5.2	655.6	1511.3	4,500	0	158.5		3
FLMV 3.1A	4/25/69	850.5	6.8	650.5	1507.8	6,000	+6	158.4		3

NOTES:

1 No formal NASA procedure for SOR

2 Post SOR orbital parameters not taken

3 LM pericynthion taken from N58 display

RESULTS - PROBLEMS

RENDEZVOUS

[20] Alarms may occur during burn programs if P20 is running in background - this destroys part of REFSMAT - best solution is to enter P00 before burn programs and thus kill P20

[30] Alarms (ARCSIN, ARCCOS Argument too large) may be seen during P20, P25. Reset and proceed on.

[40] Alarm (MGA $>70^{0}$) During R60 for plane change - nominal should not do maneuver

[703] Alarm (TIG slipped) for MCC_1 if ATIEINC is set to 3 minutes - solution is to increase ATIEINC to 4 minutes

V06N75 Display (ΔH CDH, ΔT CDH, ΔT TPI) will show a truncated value in R2 or R3 if value is greater than 59 min 59 sec (i.e. 1 Hr 2 Min will be displayed as 2 Min

V06N49 Display (Excessive Update) what to do if state vector error is actually this large

When P20 is running in background and information is being entered on keyboard the final enter will sometimes cause a loss of display for about 15 sec if mark is being displayed

When in P20 with auto attitude control, ROLL is free to drift - However KALCMANU will prevent drift into Gimbal lock

SOR

In general programs work well - however usually results in very large burns

May display a negative pericynthion for SOI targeting in the case we simulated this point is after SOR so is not critical. However in some situations SOI can target the LM for a flight thru the moon - program cannot be used indiscriminately

Best bias for TIG_{SOR} from our testing was

$$TIG_{SOR} = TF_{SOR} - \left[(T_{SOI} - 26\ SEC) \cdot \frac{1}{2} - \frac{\Delta V_{SOR}}{\Delta V_{SOI}} + 26\ SEC\right]$$

DOI DIRECT RETURN ABOUT

We found it useful to target for a TPI after the direct return burn. Used a smaller value for CENTANG

P52

If terminated during R60 display with V34 no flashing V37 is displayed - simply key in V37E BBE

POST FSRR TESTING

Try to resolve problems with docked DPS Simulation and verify DPS Trans-Earth insertion.

SOR-Define regions of LM active operations (region where LM active SOR may be safely initiated)

Evaluate crew program notes & workarounds within simulator capability

Non zero error linked rendezvous sequences

Date 4/24/69

LUMINARY ANOMALIES (Through Rev. 97)

61

30 - Anomalies remaining in LUMINARY 1 (LUM 69 Rev 2)

8 - Anomalies fixed in LUMINARY 1 (Rev 69) before release

11 - Anomalies not applicable to MISSION "F"

5 - Anomalies reported, but found not to be anomalies

4 - Anomalies caused by simulator or procedural difficulties

0 - Unused anomaly numbers

End 7

LUMINARY ANOMALY 44

DESCRIPTION: IF P40, P41, P42 OR P47 IS ENTERED WITH AUTO-Z AXIS TRACK (P20, P25) RUNNING, A 1201 PROGRAM ALARM MAY OCCUR.

IT MAY OCCUR IF P47 IS ENTERED OR IF THE AUTO MANEUVER IS COMPLETED OR BYPASSED WITHIN 42 SECONDS OF ENTERING P40, P41 OR P42.

EFFECT:

1. STATE VECTORS ARE RECTIFIED (NOT SERIOUS).
2. OVERWRITES REFSMMAT +7 AND 8 (LOCATIONS 1742, 1743) (SERIOUS).
3. MAY OVERWRITE OTHER ERASABLE (NOT PREDICTABLE) (VERY SERIOUS).

AVOIDANCE: (IN CREW CHECKLIST)
ENTER P00 TO TERMINATE TRACKING BEFORE ENTERING P40, P41, P42 OR P47.

NOTE: THIS PROBLEM DOES NOT EXIST IN LUMINARY 1A.

LUMINARY ANOMALY 61

DESCRIPTION	An incorrect state vector update from the shaft or trunnion measurement (if a restart occurs during these incorporations).
EFFECT	A Noun 49 excessive state vector update display will occur if the incorrect update exceeds the RMAX, VMAX thresholds.
RECOVERY	Reject the excessive update by recycling on the Noun 49 display. If the incorrect update is not large enough to trigger a Noun 49 display, subsequent navigation should eliminate the error.
AVOIDANCE	Trouble from software restarts can be avoided by not selecting a new program while P20 is incorporating a mark. (Wait for mark counter to increment in V16N45 display). The program is vulnerable for about 3 seconds out of every minute.

		PROCEED	ENTER	TERMINATE
V99	Response JOR first	V99N40 remains flashing for up to 1 second after response.	1502 ABORT - alarm light on V37 flashing CLOKTASK off AVERAGE G still on No guidance Any extended verb activity lost	V99N40 flashing continues CLOKTASK off AVERAGE G and guidance still going
	Display JOB first	V99N40 remains flashing for up to 1 second after response.	1502 ABORT - alarm light on V37 flashing CLOKTASK off AVERAGE G still on No guidance Any extended verb activity lost	1502 ABORT - alarm light on V37 flashing CLOKTASK off AVERAGE G still on No guidance Any extended verb activity lost
	Normal Conditions	V06N40 non-flashing	V16N40 flashing	V37 flashing
V97	Response JOB first	V97N40 remains flashing for up to 1 second after response.	V99N40 flashing	V97N40 flashing continues CLOKTASK off AVERAGE G still on
	Display JOB first	V97N40 remains flashing for up to 1 second after response.	V99N40 flashing	1502 ABORT - alarm light on V37 flashing CLOKTASK off AVERAGE G still on No guidance Any extended verb activity lost
	Normal Conditions	V06N40 non-flashing	V99N40 flashing	V37 flashing

Susceptability: 5 ms every 1 second.

Action: Repeat response; reselect program if desired following abort.