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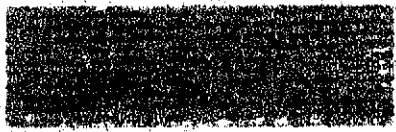
~~J. W. Andrews~~
CR-133997 C.1

E-2785

MISSION SL-3 (AS 207/CM 117/IMU 31)
G&N ERROR ANALYSIS
(SKYLAB 3)

by
S.B. HELFANT

July 1973



The Charles Stark Draper Laboratory, Inc.
Cambridge, Massachusetts 02139

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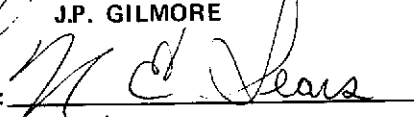
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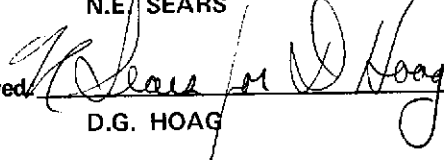
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July 1973

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This volume is the combined effort of the following additional people; Linda Willy who prepared the component performance tabulation and performed the plotting for the inertial components. William Beaton provided the failure rates for the success probability. Their contribution to the preparation of this volume is greatly appreciated.

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The publication of this report does not constitute approval by the National Aeronautics and Space Administration of the findings or the conclusions contained herein. It is published only for the exchange and stimulation of ideas.

E-2785

MISSION SL-3 (AS 207/CM 117/IMU 31)

G&N ERROR ANALYSIS

(SKYLAB 3)

ABSTRACT

This document presents data on G&N system performance and operation for the CM. For data on the effects of Block II and of measured CM IMU test data deviation uncertainties on earth orbit insertion indication uncertainties and on deorbit burn and reentry uncertainties, the reader is referred to E-2760, the G&N error analysis report for Skylab-2.

by: S. B. Helfant
July 1973

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GYRO DRIFT TEST POSITIONS
FOR
SUNDANCE, LUMINARY, COLOSSUS, AND ON

STABLE MEMBER POSITION	STABLE MEMBER ORIENTATION	HORIZONTAL DRIFT	VERTICAL DRIFT
1	X DOWN Y SOUTH Z WEST	NBDY-ADOAY	
2	X DOWN Y WEST Z NORTH	+NBDZ-ADOAZ	-NBDZ+ADIAZ
3	X SOUTH Y WEST Z DOWN	NBDX-ADOAX	
4	X EAST Y SOUTH Z DOWN	+NBDY+ADSRAY	+NBDZ+ADIAZ
5*	X WEST Y UP Z NORTH	+NBDZ-ADSRAZ	
6*	X SOUTH Y DOWN Z EAST	+NBDX+ADSRAX	-NBDY+ADIAZ
7	X NORTH Y UP-WEST Z UP-EAST	-NBDX+(ADSRAX/ $\sqrt{2}$)	
8	X EAST Y UP-NORTH Z UP-SOUTH	$(-NBDZ-NBDY)/\sqrt{2}$ +(ADIAZ-ADIAZ)/2 +(ADSRAY+ADSRAZ)/2	
9	X UP-EAST Y UP-WEST Z SOUTH	-NBDZ+(ADSRAZ/ $\sqrt{2}$)	
10	X UP-NORTH Y UP-SOUTH Z EAST	$(NBDY-NBDX)/\sqrt{2}$ +(ADIAZ-ADIAZ)/2 +ADSRAX/2	
11	X NORTH Y WEST Z UP	-NBDX-ADOAX	
12	X UP Y SOUTH Z EAST	+NBDY+ADOAY	
13	X UP Y EAST Z NORTH	+NBDZ+ADOAZ	

* Positions 5 and 6 are lab test only.

SKYLAB 3
G&N MISSION RELIABILITY ANALYSIS

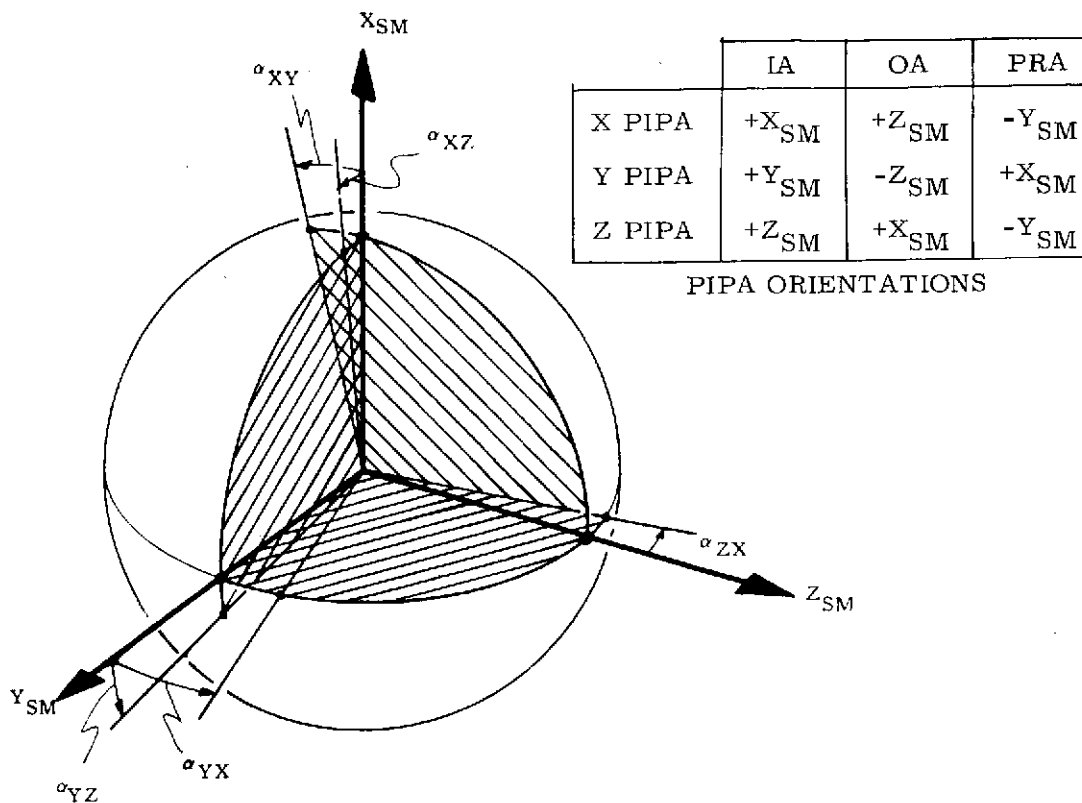
Failure rates used were obtained, for the most part, from observed Apollo field and flight experience of the PGNS. Each reported failure was analyzed with respect to its likelihood of occurrence in flight and the impact on the Mission should such failure occur. The result was to count only those reported failures which could occur in flight and which would degrade the Mission, should they occur. For the D&C Assembly the failure data was insufficient to form a meaningful statistic; therefore, the originally estimated failure rate was used.

SUBSYSTEM	MODE (time/cycles)	FAILURE RATE ($\lambda \times 10^6$)	MISSION DURATION (hrs or cycles)	$e^{-\lambda t}$
AGC	Operate	19.2	37	.99929
	Calendar	2.8	1346	.99624
	Environ.	30.9	.45	.99998
	On/Off	238.1	2	.99952
DSKY*	Operate	1.4	37	.99999
	Calendar	.9	1346	.99999
	Environ.	122.9	.45	.99999
	On/Off	1190.5	2	.99999
IMU CDU**	Operate	20.2	37	.99925
	Calendar	2.4	1346	.99677
	Environ.	62.5	.45	.99997
	On/Off	1666.6	2	.99667
IMU	Operate	94.1	37	.99652
	Calendar	2.6	1346	.99651
	Environ.	18.5	.45	.99999
	On/Off	142.9	2	.99971
IMU Electronics (PSA)	Operate	8.4	37	.99969
	Calendar	1.2	1346	.99839
	Environ.	18.5	.45	.99999
	On/Off	714.3	2	.99857
Optics Assembly	Operate	119.3	37	.99560
	Calendar	1.8	1346	.99758
	Environ.	18.5	.45	.99999
	On/Off	238.1	2	.99952
Optics Electronics	Operate	17.2	37	.99936
	Calendar	7.1	1346	.99049
	Environ.	18.5	.45	.99999
	On/Off	142.9	2	.99971

G&N MISSION RELIABILITY
CM = .95999

*Considers parallel redundancy $(1-(1-e^{-\lambda t})^2)$

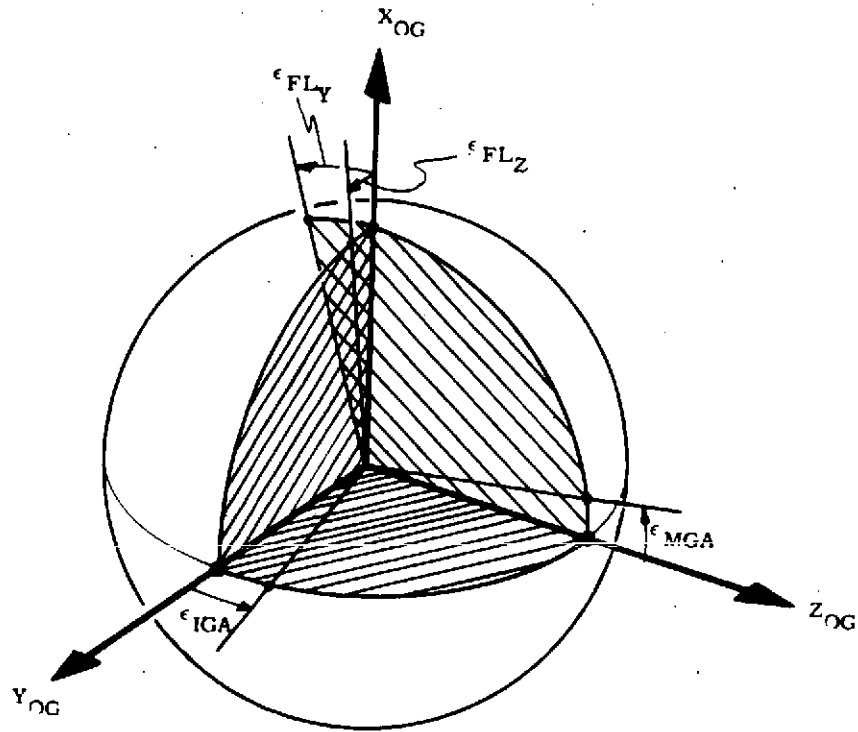
**Includes CM Optics CDU



PIPA Misalignments from Ideal Stable Member Axes

Term	(Angle in Sec) CM-IMU 31
α_{XY}	+24
α_{XZ}	0
α_{YZ}	-18
α_{YX}	-16
α_{ZX}	-19

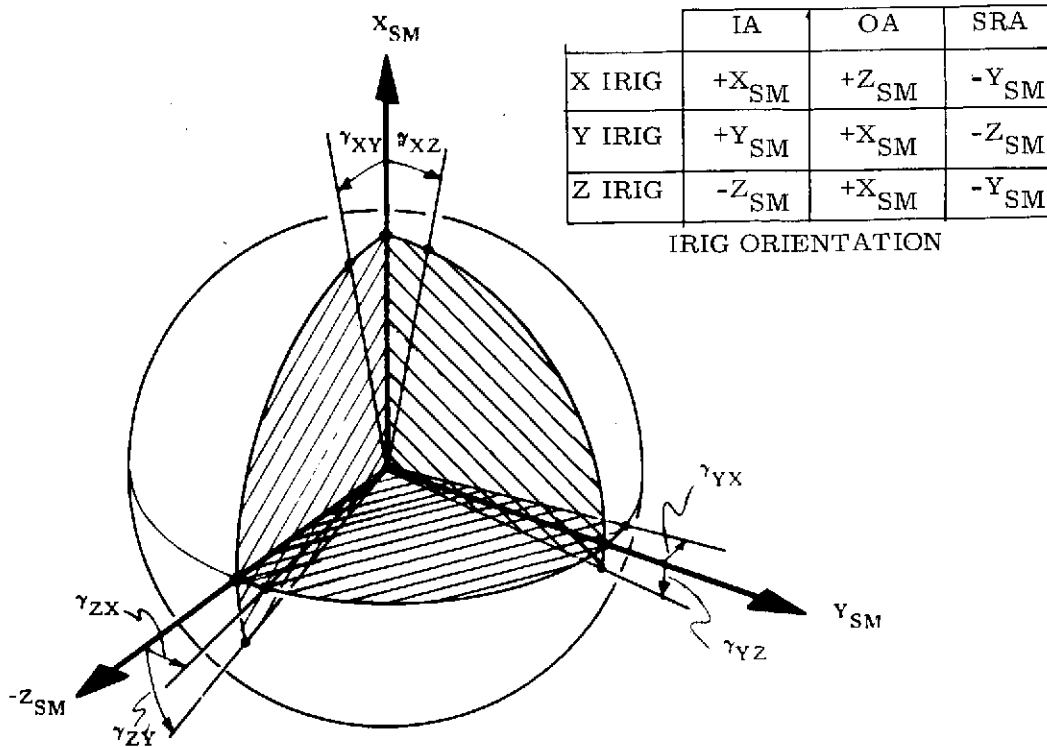
DEFINITION OF POSITIVE SENSE
PIPA INPUT-AXIS MISALIGNMENTS
with respect to
IDEAL STABLE MEMBER AXES



Gimbal Axis Orthogonality Errors and Outer Gimbal Misalignment from Casemounting Axes

Term	(Angle in Sec) CM-IMU 31
ϵ_{IGA}	-18
ϵ_{MGA}	-2
ϵ_{FLY}	+6
ϵ_{FLZ}	-8

DEFINITION OF POSITIVE SENSE
 GIMBAL AXIS ORTHOGONALITY
 and
 OUTER GIMBAL ALIGNMENT
 with respect to
 CASE MOUNTING ALIGNMENT



IRIG Misalignments from Ideal Stable Member Axes

Term	(Angle in Sec) CM-IMU 31
γ_{XY}	-34
γ_{XZ}	+12
γ_{YZ}	+22
γ_{YX}	+5
γ_{ZX}	-91
γ_{ZY}	+23

Block II G&N
 DEFINITION OF POSITIVE SENSE
 IRIG INPUT-AXIS MISALIGNMENTS
 with respect to
 IDEAL STABLE MEMBER AXES

IMU S/N 31
AS207/CM 117/G&N 221

IRIGs

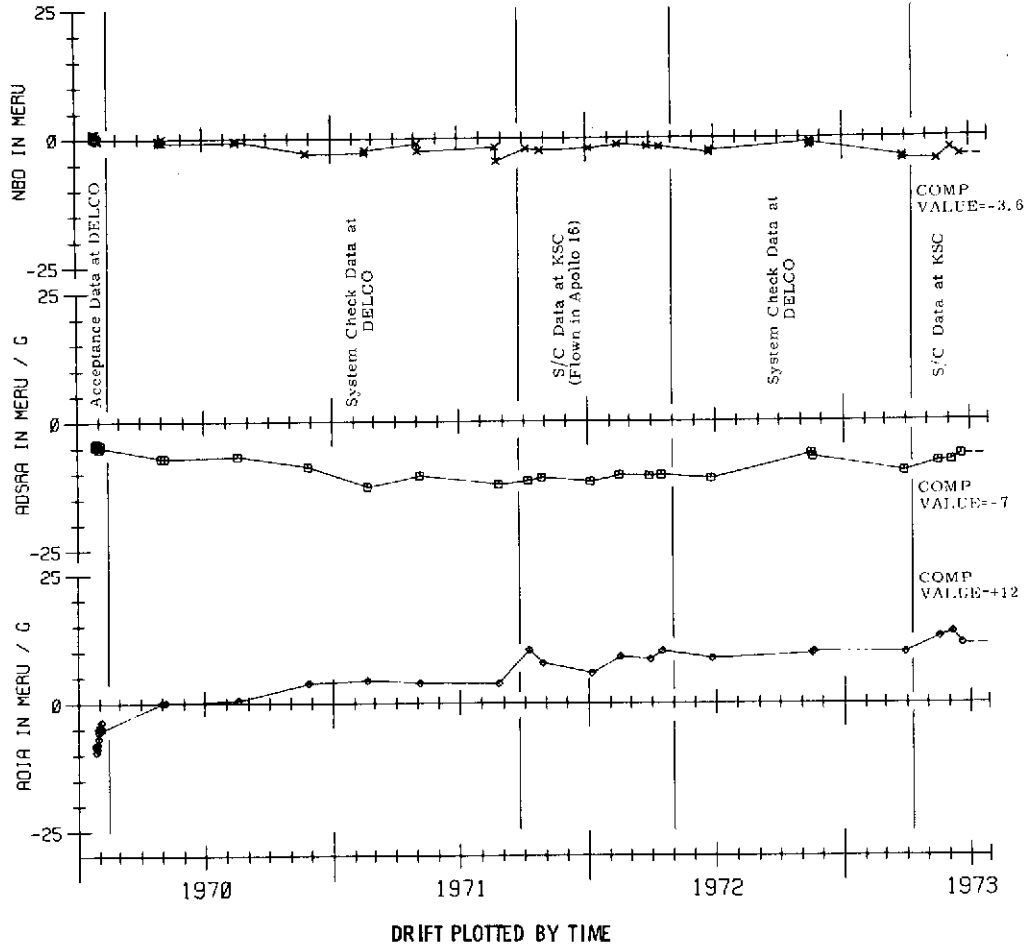
X = 8A211
Y = 8A212
Z = 8A210

PIPAs

X = 2AP82R
Y = 2AP264R
Z = 2AP91R

DATE	LOC	TST TYP	IMU ASSN	GEN SYS	NBD	ADSRA	ADIA	DELSF+	DELSF-	WHEEL RDT HOURS	I+	I-	ID	ADDA
18FE71	A03	SPO X	29		- 2.8		4.4							
19FE71	A03	SPO X	29		- 2.3	- 12.7		294	584		85.020			- 0.5
21FE71	A03	SPO X	29							C138				
26FE71											969			
84R71											871			
44Y71	A01	SPO X	29		- 1.0		3.9							
54Y71	A01	SPO X	29		- 2.5	- 10.6								- 0.5
64Y71	A01	SPO X	29					307	534		85.011			
124Y71	NO FLUID TRANSIENTS DETECTED DURING GRAVITY TRANSIENT TEST.													
174Y71											972			
16JE71	IMU S/N 29 SHIPPED FROM DEL/MKE TO KSC													
9AU71	IMU 29 SHIPPED FROM KSC TO DELCO/MKE.													
24AU71	A01	SPO X	29		- 1.8		3.8							
25AU71	A01	SPO X	29		- 4.5	- 12.3				C133				- 1.1
26AU71	A01	SPO X	29					350	561	C140	85.013			
31AU71											1072			
22SE71	IMU 29 SHIPPED FROM DELCO/MKE TO KSC.													
60C71	K0B	G&N X	29 216		- 2.0	- 11.6	10.3	- 19	- 45					- 0.1
260C71	K0B	G&N X	29 216		- 2.4	- 11.0	7.8	70	- 150					- 0.4
4JA72	K9A	G&N X	29 216		- 2.0	- 11.8	5.8							- 0.5
14FE72	K9A	G&N X	29 216		- 1.3	- 10.6	9.0							- 0.5
29FE72											1249			
28MR72	K9A	G&N X	29 216		- 1.7	- 10.7	8.5							- 0.4
14AP72	K9A	G&N X	29		- 1.8	- 10.6	10.1							0.0
14AP72	PRE-LAUNCH COMPENSATIONS: NBD 1.1 ADSRA -11.0 ADIA 8.0													
16AP72	IMU-29 GEN-216 CH-113 LAUNCHED APOLLO 16.													
17AP72	NBD COMPENSATION UPDATE = -1.17 AT 30 HRS. 06 MIN. GET													
27AP72	IMU-29 GEN-216 CH-113 RECOVERED APOLLO 16.													
24JE72	A01	SPO X	29		- 3.0		8.7							
24JE72	A01	SPO X	29		- 2.5	- 11.2		417	617		85.003			
9NO72	UNIT REMOVED FROM IMU-29.													
9NO72	UNIT ASSIGNED TO IMU-31, X-POS. REPLACES 9A-013.													
15NO72	SB5	SPO X	31		- 0.8		9.7	7	273		85.006			
15NO72	SB5	SPO X	31		- 1.7	- 6.4				C133				
17NO72	SB5	SPO X	31		- 1.3		10.0							
17NO72	SB5	SPO X	31		- 1.1	- 7.1								
18NO72	NO FLUID TRANSIENTS DETECTED DURING GRAVITY TRANSIENT TEST													
20NO72											1898			
284R73	SB5	SPO X	31		- 3.8		9.9	265	480	C131	85.005			- 0.5
28MR73	SB5	SPO X	31		- 4.3	- 9.9				C131				
3AP73	IMU-31 SHIPPED FROM DELCO TO KSC.													
12AP73	INSTALLED IN CH-117 AT KSC.													
30AP73											1967			
164Y73	K0B	G&N X	31 221		- 4.5	- 8.0	12.9	172	26					0.4
4JE73	K0B	G&N X	31 221		- 2.3	- 7.9	13.8	204	255					0.4
18JE73	K9B	G&N X	31 221		- 3.6	- 6.7	11.6							0.4

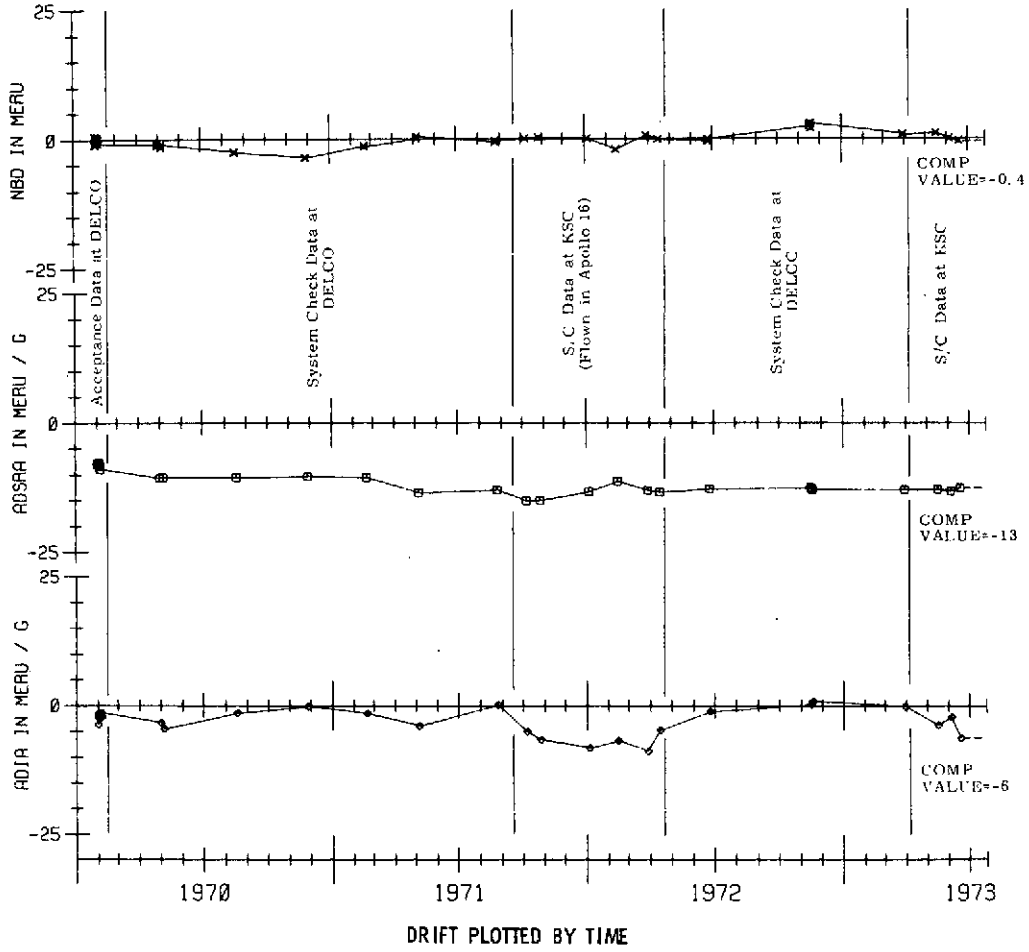
G&N 221, CM 117, IMU 31, APOLLO IRIG 8A211, X AXIS



DATE	LOC	TST TYP	IMU ASSN	G&N SYS	NRD	ADSRA	ADIA	DELSF+	DELSF-	WHEEL PDT	HOURS	I+	I-	ID	ADDA
6JA70	A44	CSS								C134					
7JA70	A44	CSS		(	6.8)	(-	1.0)	(-	1.0)	C131				5.0	
7JA70	SG	84.5,	70.2,	59.3	TG	56.9,	70.3,	80.8	REF H5421						
13JA70	A44	CSS		(	7.7)	(-	3.2)	(-	0.7)	186				6.9	
16JA70	A45	CSS		(	7.7)	(-	3.2)	(-	0.7)	184				4.7	
16JA70	A45	CSS								187					
28JA70	COMP	SELECT													
28JA70	A45	CSS						-	294	290	176	84.997	84.996		
28JA70	COMP	VERIF													
28JA70	A45	CSS						-	218	122		84.997	84.996		
29JA70	DEMO	T/P = 1223													
29JA70	A45	CSS						-	239	321	178	84.997	84.996		
29JA70	VIB	IA ALIGN = +1.0													
31JA70	A45	CA1		-	0.9	-	8.0	-	1.6						
31JA70	A45	CA2		-	1.1	-	8.0	-	2.3	-	249	642	84.998	84.996	6.3
31JA70	A45	CA3			0.6	-	8.0	-	3.7		185				
2FE70	A45	CB1			0.0	-	8.3	-	2.4						
2FE70	A45	CB2		-	0.2	-	8.3	-	2.3	-	28	639	84.998	84.996	5.2
2FE70	A45	CB3			0.4	-	7.7	-	1.5		188				
4FE70	A45	CC1		-	0.1	-	8.5	-	2.0						
4FE70	A45	CC2		-	0.1	-	8.4	-	2.3	-	180	471	84.997	84.999	6.1
4FE70	A45	CC3		-	0.8	-	9.0	-	1.4		187	697			
10FE70	ACC.	E N/O TO 0814													
18MR70	UNIT	ASSIGNED TO IMU 29 Y POSITION. REPLACES 7A-198.													
31MR70											704				
30AP70	A03	SPO Y 29		-	1.1			-	3.3						
30AP70	A03	SPO Y 29		-	0.7	-	10.7			C133	730			-	1.1
1MY70	A03	SPO Y 29						-	50	684		85.018			
5MY70	A03	SPO Y 29		-	1.5			-	4.5						
5MY70	A03	SPO Y 29		-	1.0	-	10.6				795			-	1.2
17AU70	A03	SPO Y 29		-	2.4			-	1.4						
17AU70	A03	SPO Y 29		-	2.6	-	10.6							-	1.2
18AU70	A03	SPO Y 29							127	784		869	85.019		
24AU70	NO FLUID TRANSIENTS DETECTED DURING GRAVITY TRANSIENT TEST.														
25AU70											898				
26NO70	A03	SPO Y 29		-	3.6			-	0.1		C130				
27NO70	A03	SPO Y 29		-	3.6	-	10.4							-	1.3
30NO70	A03	SPO Y 29							227	794		85.012			
9DE70											988				
5JA71	IMU S/N 29 SHIPPED FROM DEL/MKE TO KSC.														
3FE71	IMU S/N 29 SHIPPED FROM KSC TO DELCO/MKE.														
19FE71	A03	SPO Y 29		-	1.3			-	1.5						
19FE71	A03	SPO Y 29		-	1.5	-	10.6							-	1.2
21FE71	A03	SPO Y 29								C136					
22FE71	A03	SPO Y 29							273	951		85.020			
26FE71											1053				
8MR71											1055				
5MY71	A01	SPO Y 29			0.1			-	3.9						
5MY71	A01	SPO Y 29			0.5	-	13.5							-	0.8
6MY71	A01	SPO Y 29							343	955					

DATE	LOC	TST IMU TYP ASSN	G&N SYS	NBD	ADSRA	ADIA	DELSF+	DELSF-	WHEEL RDT HOURS	I+	I-	ID	ADDA
12NY71		NO FLUID TRANSIENTS DETECTED DURING GRAVITY TRANSIENT TEST.											
17NY71													
16JE71		IMU S/N 29 SHIPPED FROM DEL/MKE TO KSC											
9AU71		IMU 29 SHIPPED FROM KSC TO DELCO/MKE.											
25AU71		A01 SPO Y 29		- 0.6		0.2							
25AU71		A01 SPO Y 29		- 0.3	- 13.0				C134				- 0.9
26AU71		A01 SPO Y 29					474	985	C139	85.018			
31AU71													
22SE71		IMU 29 SHIPPED FROM DELCO/MKE TO KSC.											
6JC71		KOB G&N Y 29 216		0.1	- 15.1	- 5.0	88	755					0.5
7JC71		ADIA Y POSITION 8				- 10.8							
26JC71		KOB G&N Y 29 216		0.3	- 15.0	- 6.6	36	640					- 0.3
26JC71		ADIA Y POSITION 8				- 1.6							
4JA72		K9A G&N Y 29 216		0.1	- 13.3	- 8.2							- 0.1
4JA72		ADIA Y POSITION 8				- 7.5							
14FE72		K9A G&N Y 29 216		- 2.0	- 11.3	- 6.8							0.5
14FE72		ADIA Y POSITION 8				- 3.5							
29FE72													
28MR72		K9A G&N Y 29 216		0.7	- 13.1	- 8.8				1432			- 0.3
28MR72		ADIA Y POSITION 8				- 7.0							
14AP72		K9A G&N Y 29		- 0.1	- 13.4	- 4.7							0.0
14AP72		ADIA Y POSITION 8				- 6.4							
14AP72		PRE-LAUNCH COMPENSATIONS: NBD -0.4 ADSRA -14.0 ADIA -7.0											
16AP72		IMU-29 GEN-216 CM-113 LAUNCHED APOLLO 16.											
17AP72		NBD COMPENSATION UPDATE = -0.13 AT 30 HRS. 06 MIN. GET											
27AP72		IMU-29 GEN-216 CM-113 RECOVERED APOLLO 16.											
24JE72		A01 SPO Y 29		- 0.5		- 1.1							
24JE72		A01 SPO Y 29		- 0.0	- 12.8		441	1152		85.004			
9NO72		UNIT REMOVED FROM IMU-29.											
9NO72		UNIT ASSIGNED TO IMU-31, Y-POS. REPLACES 9A-012.											
15NO72		SB5 SPO Y 31		2.5		0.3	150	694		85.006			
15NO72		SB5 SPO Y 31		2.9	- 12.6				C137				
17NO72		SB5 SPO Y 31		2.0		0.9							
17NO72		SB5 SPO Y 31		3.0	- 13.0								
18NO72		NO FLUID TRANSIENTS DETECTED DURING GRAVITY TRANSIENT TEST											
20NO72													
29MR73		SB5 SPO Y 31		0.9		- 0.1	350	1070	C125	85.005			- 1.5
29MR73		SB5 SPO Y 31		0.8	- 13.0				C133				
3AP73		IMU-31 SHIPPED FROM DELCO TO KSC.											
12AP73		INSTALLED IN CM-117 AT KSC.											
30AP73													
16NY73		KOB G&N Y 31 221		1.1	- 12.9	- 3.8	148	993		2150			- 0.6
16NY73		ADIA Y POSITION 8				- 5.6							
4JE73		KOB G&N Y 31 221		0.1	- 13.2	- 2.2	124	1124					- 0.4
4JE73		ADIA Y POSITION 8				- 6.2							
18JE73		K9B G&N Y 31 221		- 0.4	- 12.6	- 6.3							- 0.3
18JE73		ADIA Y POSITION 8				- 4.9							

G&N 221, CM 117, IMU 31, APOLLO IRIG 8A212, Y AXIS

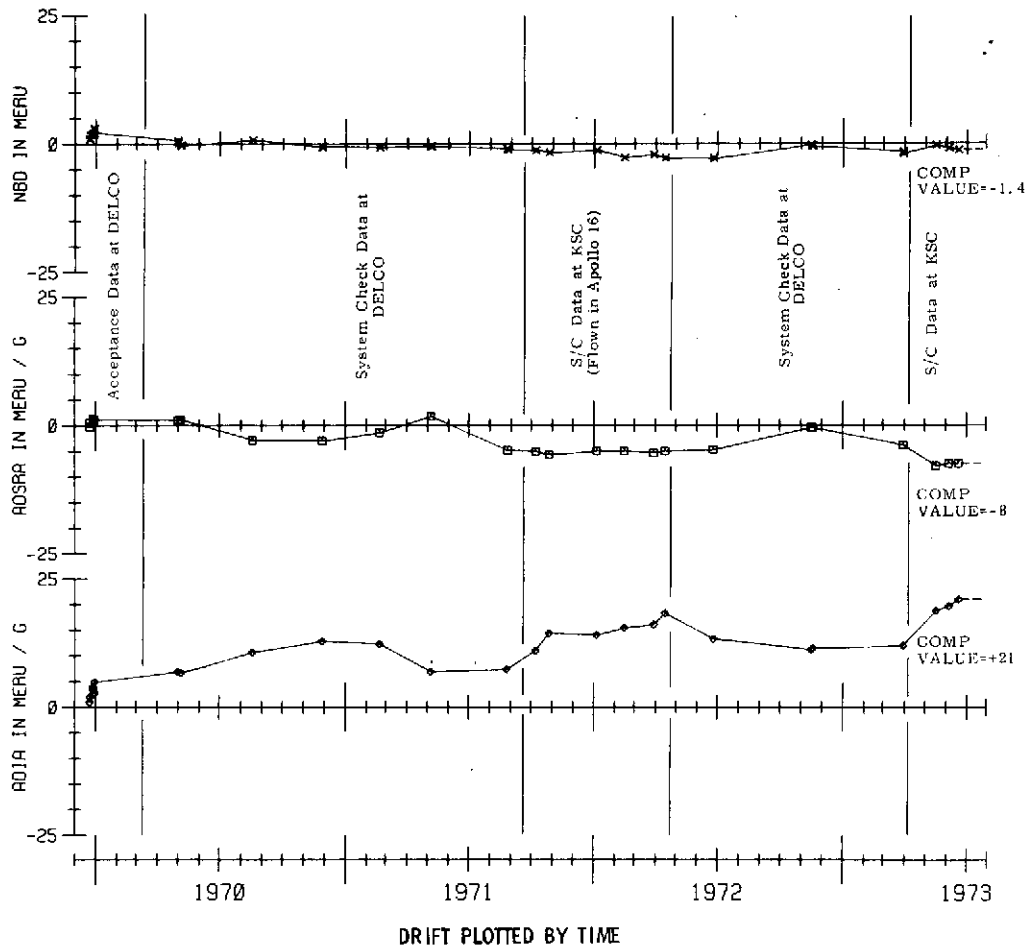


DATE	LOC	TST TYP	IMU ASSN	G&N SYS	NBD	ADSRA	ADIA	DELSF+	DELSF-	WHEEL RDT	HOURS	I+	I-	ID	ADDA
3DE69	A45	CSS								C122					
4DE69	A45	CSS			(36.0)	(- 1.8)	(2.0)			C119				16.5	
4DE69	SG	86.4, 67.3, 50.3			TG 50.5, 67.4, 87.3				REF H5418						
5DE69	A45	CSS			(35.8)	(- 1.5)	(2.6)			C122				16.2	
5DE69	3	SERVO RERUN WITH CW VALUE AT 0.0493 - STILL OOS													
5DE69	A45	CSS			(34.6)	(- 0.4)	(3.6)			C122				17.0	
10DE69	A41	CSS			(36.1)	(- 1.9)	(2.0)			177				16.6	
16DE69	A41	CSS			(34.4)	(- 1.4)	(3.2)			179				14.7	
17DE69	A41	CSS								180					
21DE69	COMP SELECT														
21DE69	A43	CSS						44	146	173		85.010	85.010		
22DE69	COMP VERIF														
22DE69	A43	CSS						13	105			85.010	85.010		
22DE69	DEMO	T/F = 1182.6													
22DE69	A43	CSS						- 114	88	177		85.009	85.009		
22DE69	VIB	IA ALIGN = -1.15													
22DE69	A43	CA1			0.9		0.6	2.0							
22DE69	A43	CA2			1.0	- 0.3	0.9	37	263			85.011	85.011	15.3	
22DE69	A43	CA3			1.8		0.6	1.0		171					
27DE69	A43	CB1			1.8		0.8	4.0							
27DE69	A43	CB2			2.0		1.3	3.4	93	379		85.012	85.012	14.9	
27DE69	A43	CB3			1.8		0.8	3.8		175					
29DE69	A44	CC1			2.9		1.2	2.8							
29DE69	A44	CC2			3.1		1.2	2.6	- 211	215		85.004	85.006	14.8	
29DE69	A44	CC3			2.1		1.1	4.9		180	494				
7JA70	ACC ON WAIVER C1276														
18MR70	UNIT ASSIGNED TO INU 29 Z POSITION. REPLACES 7C-180.														
31MR70															
30AP70	A03	SPO Z 29			0.6		6.9			C124	501				
1MY70	A03	SPO Z 29			0.2	1.0			150 - 184		527	85.018			0.0
5MY70	A03	SPO Z 29			- 0.3		6.7								
5MY70	A03	SPO Z 29			- 0.4	1.1					597				- 0.1
17AU70	A03	SPO Z 29			0.7		10.7								
17AU70	A03	SPO Z 29			0.7	- 2.9									- 0.5
18AU70	A03	SPO Z 29							240 - 140		666	85.020			
24AU70	NO FLUID TRANSIENTS DETECTED DURING GRAVITY TRANSIENT TEST.														
25AU70															
26NO70	A03	SPO Z 29								C127	696				
27NO70	A03	SPO Z 29			- 0.7		12.9								
27NO70	A03	SPO Z 29			- 0.6	- 3.0									0.6
30NO70	A03	SPO Z 29							140 - 150			85.010			
9DE70															
5JA71	IMU S/N 29 SHIPPED FROM DEL/MKE TO KSC.														
3FE71	IMU S/N 29 SHIPPED FROM KSC TO DELCO/MKE.														
19FE71	A03	SPO Z 29			- 0.7		12.3								
19FE71	A03	SPO Z 29			- 0.7	- 1.4									0.0
21FE71	A03	SPO Z 29								C126					
22FE71	A03	SPO Z 29						350 - 83				85.019			
26FE71															
8MR71															

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DATE	LOC	TST TYP	IMU ASSN	G&N SYS	NBD	ADSRA	ADIA	DELSF+	DELSF-	WHEEL RDT HOURS	I+	I-	ID	ADDA
5MY71	A01	SPO Z	29		- 0.4		6.9							
5MY71	A01	SPO Z	29		- 0.6	1.8								- 0.1
6MY71	A01	SPO Z	29					340	- 140		85.012			
12MY71	NO FLUID TRANSIENTS DETECTED DURING GRAVITY TRANSIENT TEST.													
17MY71										952				
16JE71	IMU S/N 29 SHIPPED FROM DEL/MKE TO KSC													
9AU71	IMU 29 SHIPPED FROM KSC TO DELCO/MKE.													
25AU71	A01	SPO Z	29		- 0.9		7.4							
26AU71	A01	SPO Z	29		- 1.2	- 4.9				C125				- 0.3
27AU71	A01	SPO Z	29					407	7	C127	85.013			
31AU71										1053				
22SE71	IMU 29 SHIPPED FROM DELCO/MKE TO KSC.													
6JC71	KOB	GEN Z	29 216		- 1.3	- 5.1	11.0	- 17	- 535					0.2
26JC71	KOB	GEN Z	29 216		- 1.7	- 5.7	14.4	- 83	- 534					0.2
4JA72	K9A	GEN Z	29 216		- 1.3	- 5.0	14.1							0.3
14FE72	K9A	GEN Z	29 216		- 2.7	- 5.0	15.5							0.2
29FE72										1230				
28MR72	K9A	GEN Z	29 216		- 2.1	- 5.4	16.1							0.0
14AP72	K9A	GEN Z	29		- 2.8	- 5.0	18.3							0.1
14AP72	PRE-LAUNCH COMPENSATIONS: NBD -1.7 ADSRA -5.0 ADIA 14.0													
16AP72	IMU-29 GEN-216 CM-113 LAUNCHED APOLLO 16.													
17AP72	NBD COMPENSATION UPDATE = -2.45 AT 30 HRS. 06 MIN. GET													
27AP72	IMU-29 GEN-216 CM-113 RECOVERED APOLLO 16.													
24JE72	A01	SPO Z	29		- 2.8		13.3							
24JE72	A01	SPO Z	29		- 2.9	- 4.7		461	- 83		85.003			
9NO72	UNIT REMOVED FROM IMU-29.													
9NO72	UNIT ASSIGNED TO IMU-31, Z-POS. REPLACES 9A-011.													
15NO72	SB5	SPO Z	31		- 0.2		11.2	60	- 351		85.003			
15NO72	SB5	SPO Z	31		- 0.3	- 0.4				C124				
17NO72	SB5	SPO Z	31		- 0.5		11.5							
17NO72	SB5	SPO Z	31		- 0.6	- 0.5								
18NO72	NO FLUID TRANSIENTS DETECTED DURING GRAVITY TRANSIENT TEST													
20NO72										1869				
29MR73	SB5	SPO Z	31		- 1.7		12.0	339	- 165	C126	85.007			0.0
29MR73	SB5	SPO Z	31		- 2.0	- 3.9				C128				
3AP73	IMU-31 SHIPPED FROM DELCO TO KSC.													
12AP73	INSTALLED IN CM-117 AT KSC.													
30AP73										1947				
16MY73	KOB	GEN Z	31 221		- 0.5	- 8.0	18.8	- 19	- 448					0.4
4JE73	KOB	GEN Z	31 221		- 1.0	- 7.5	19.7	158	- 427					0.2
18JE73	K9B	GEN Z	31 221		- 1.4	- 7.5	21.0							0.2

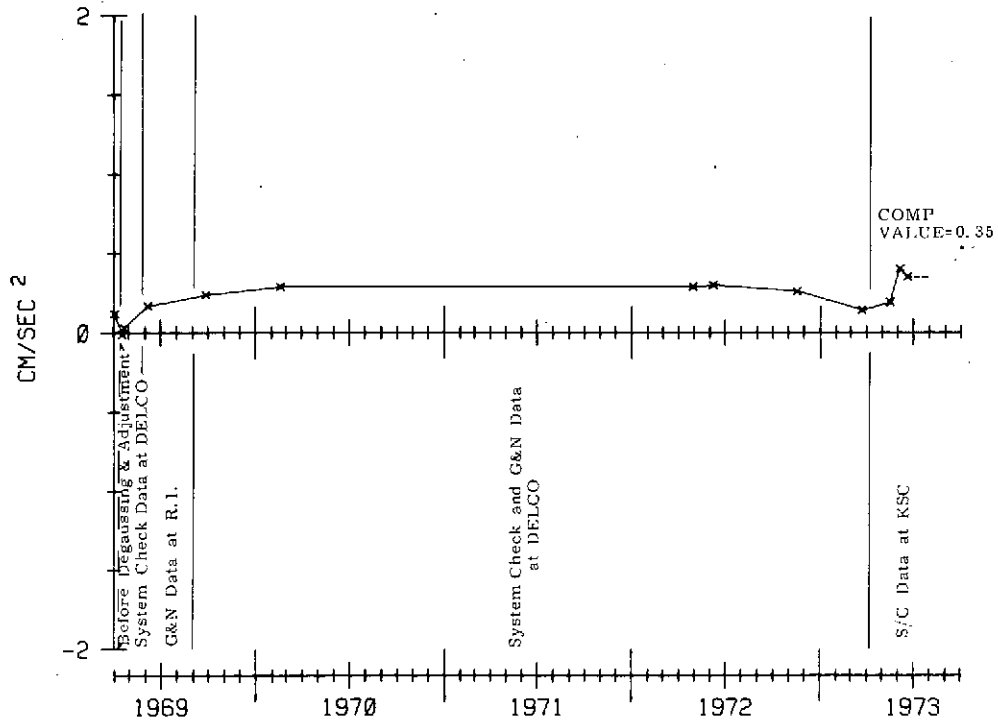
G&N 221, CM 117, IMU 31, APOLLO IRIG 8A210, Z AXIS



NASA 2AP-82R

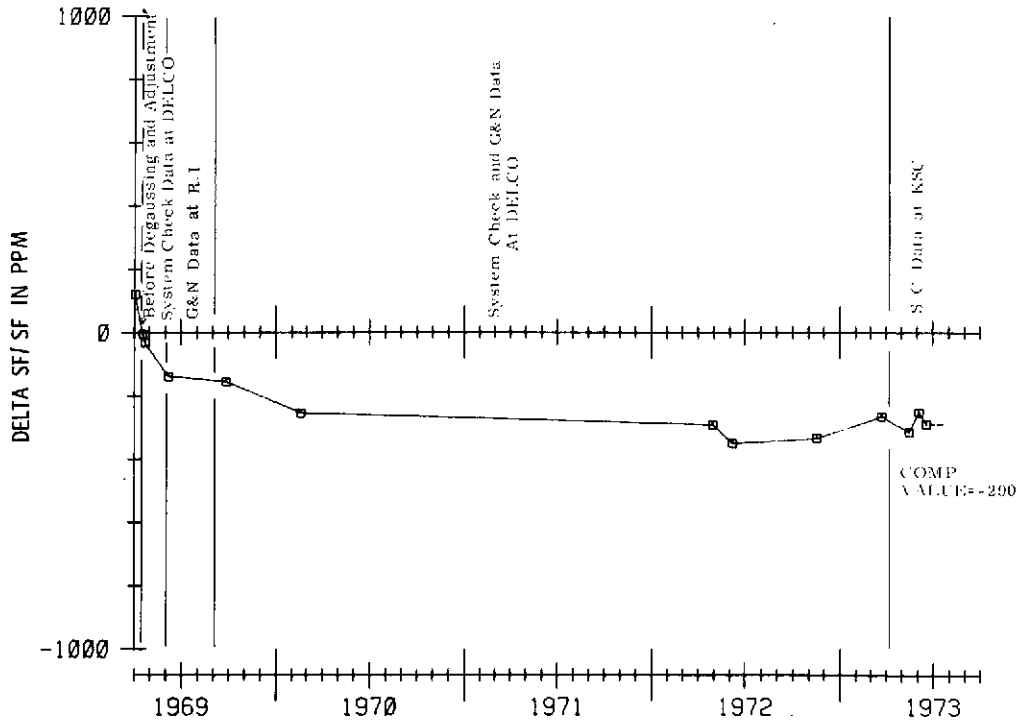
DATE	LOC	TST TYP	IMU ASSN	GEN SYS	DELTA SF	IG BIAS	NULL BIAS	ROT-AL-WOB ANGLE	TRANS.	TORQ MON CURRENT
UNIT INTERNALLY REPAIRED, REBUILT TO P/N 2001730-2										
17DE68	S42	ACC			- 65	0.00			0.02	105.6074
REPAIRED UNIT DELIVERED TO AC-MKE										
2AP69	A44	PST			119	0.12		- 4 8		
UNIT ASSIGNED TO IMU S/N 31X										
16AP69	A05	SPO X 31			(2)	(-0.11)	(-0.14)			105.5872
17AP69	A05	SPO X 31			- 6	-0.01	-0.02			105.5838
AFTER DEGAUSSING & ADJUSTMENT										
21AP69	A05	SPO X 31			- 33	0.03	-0.01			105.5838
22AP69	A05	SAL X 31					(-0.03)	17 29		
IMU S/N 31 SHIPPED TO NR										
6JE69	NO2	G&N X 31	218		- 140	0.17				
IMU S/N 31 SHIPPED TO AC-MKE										
26SE69	A03	SPO X 31			- 157	0.24	0.21			105.5760
RAN EO 3596- NULL COINCIDENCE CHECK										
26SE69	A03	SAL X 31					(0.23)	11 26		
17FE70	A01	SPO X 31			- 256	0.29	0.29			105.5650
18FE70	A01	SAL X 31					(0.24)	3 33		
28AP72	A03	SPO X 31			- 293	0.29	0.28		0.03	105.5660
2MY72	A03	SAL X 31					(0.25)	2 26		
6JE72	A01	G&N X 31	213		- 351	0.30				
16NO72	SB5	SPO X 31			- 334	0.26	0.26		0.03	105.5696
16NO72	SB5	SAL X 31					(0.28)	3 32		
22MR73	SB5	SPO X 31			- 265	0.14	0.20		0.03	105.5672
27MR73	SB5	SAL X 31					(0.34)	0 24		
RAN EO 3700-PIPA NULL RESOLUTION TEST										
3AP73 IMU-31 SHIPPED FROM DELCO TO KSC.										
12AP73 INSTALLED IN CH-117 AT KSC.										
16MY73	K0B	G&N X 31	221		- 315	0.19				
4JE73	K0B	G&N X 31	221		- 252	0.40				
18JE73	K9B	G&N X 31	221		- 289	0.35				

G&N 221, CM 117, IMU 31, APOLLO PIPA 2AP82R, X AXIS



1-G BIAS DRIFT PLOTTED BY TIME

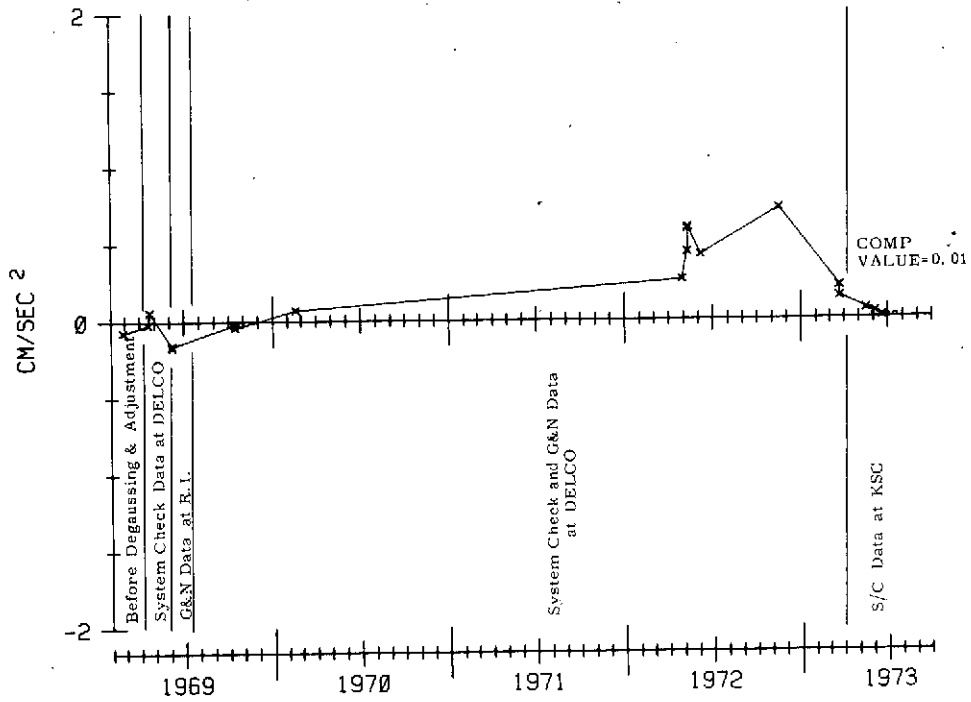
G&N 221, CM 117, IMU 31, APOLLO PIPA 2AP82R, X AXIS



SCALE FACTOR DRIFT PLOTTED BY TIME

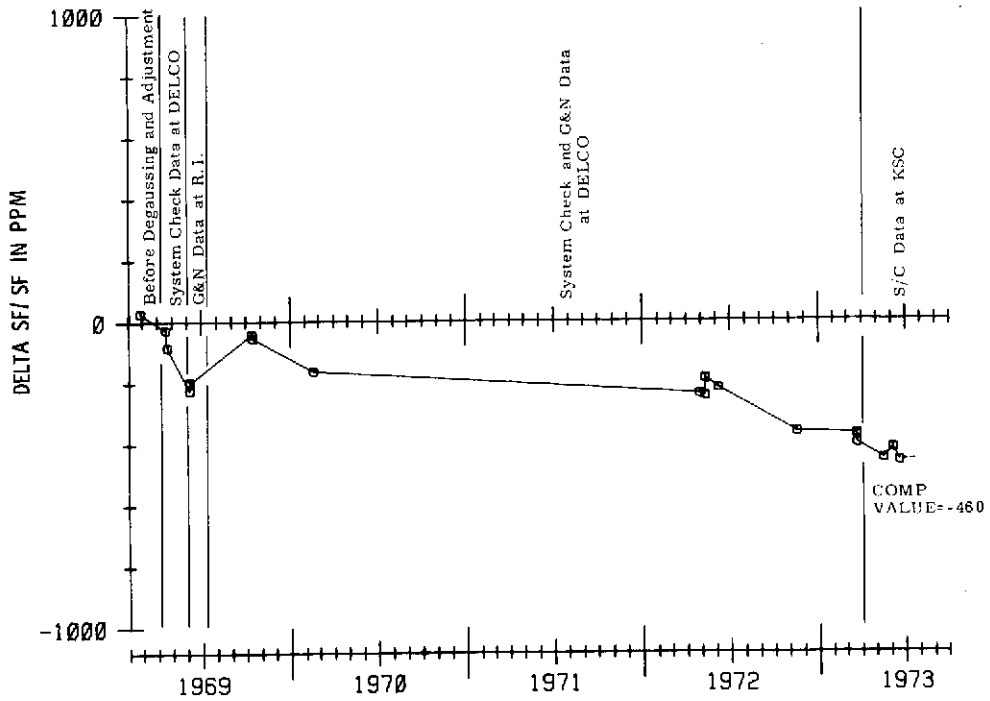
DATE	LOC	TST TYP	IMU ASSN	GEN SYS	DELTA SF	IG BIAS	NULL BIAS	ROT-AL-WOB ANGLE	TRANS.	TORQ MON CURRENT
UNIT INTERNALLY REPAIRED, REBUILT TO P/N 2001730-2										
30J68	S42	ACC			- 81	0.00			0.06	103.1200
REPAIRED UNIT DELIVERED TO AC-MKE										
25F69	A44	FST			27	-0.07		- 4 - 6		
31MR69 NULLING PROBLEMS ENCOUNTERED DURING PRA DOWN										
31MR69 PERFORMED OPEN LOOP NULLING & TRANSIENT TEST - IN SPEC										
2AP69 UNIT ASSIGNED TO IMU S/N 31Y										
16AP69	A05	SPO Y 31			(118)	(-0.51)	(-0.48)			103.1580
17AP69	A05	SPO Y 31			- 27	-0.02	0.03			103.1398
17AP69 AFTER DEGAUSSING & ADJUSTMENT										
21AP69	A05	SPO Y 31			- 84	0.06	0.10			103.1410
22AP69	A05	SAL Y 31					(0.07)	- 15 - 13		
IMU S/N 31 SHIPPED TO NR										
6JE69	NO2	GEN Y 31	218		- 225	-0.16				
6JE69	NO2	GEN Y 31	218		- 196	-0.17				
6JE69	NO2	GEN Y 31	218		- 201	-0.16				
IMU S/N 31 SHIPPED TO AC-MKE										
15JL69	A03	SCK Y 31					0.44			
15JL69 RUN EO 3596. Y PIP NULL COINCIDENCE CHECK										
17JL69 EO 3596. NULL COINCIDENCE CHECK										
18JL69	A03	SCK Y 31					0.43			
26SE69 RAN EO 3596- NULL COINCIDENCE CHECK										
26SE69 RESELECTED NULL COINCIDENCE RESISTORS.										
11JC69	A03	SAL Y 31					(2.15)	- 25 - 17		
13JC69 AFTER ADJUSTMENT										
13JC69	A03	SPO Y 31			- 42	-0.02	-0.07			103.1380
14JC69	A03	SPO Y 31			- 55	-0.04	-0.09			103.1370
17FE70	A01	SPO Y 31			- 164	0.07	0.02			103.1380
18FE70	A01	SAL Y 31					(0.01)	- 25 - 13		
28AP72	A03	SPO Y 31			- 239	0.26	0.18		0.05	103.1384
2MY72	A03	SAL Y 31					(0.60)	- 20 - 14		
9MY72	A03	SPO Y 31			- 245	0.44	0.40			103.1292
9MY72	A03	SPO Y 31			- 190	0.59	0.57		0.03	103.1364
10MY72	A03	SPO Y 31			- 187	0.60	0.54			103.1219
6JE72	A01	GEN Y 31	213		- 220	0.42				
16VO72	SB5	SPO Y 31			- 364	0.72	0.67		0.03	103.1380
16NO72	SB5	SAL Y 31					(0.69)	- 24 - 16		
22MR73	SB5	SPO Y 31			- 370	0.21	0.17			103.1380
22MR73	SB5	SPO Y 31			- 377	0.21	0.16			103.1365
22MR73	SB5	SPO Y 31			- 402	0.14	0.09		0.04	103.1311
27MR73	SB5	SAL Y 31					(0.13)	- 18 - 16		
28MR73 RAN EO 3700-PIPA NULL RESOLUTION TPST										
3AP73 IMU-31 SHIPPED FROM DELCO TO KSC.										
12AP73 INSTALLED IN CM-117 AT KSC.										
16MY73	K0B	GEN Y 31	221		- 452	0.06				
4JE73	K0B	GEN Y 31	221		- 418	0.04				
18JE73	K9B	GEN Y 31	221		- 460	0.01				

G&N 221, CM 117, IMU 31, APOLLO PIPA 2AP264R, Y AXIS



1-G BIAS DRIFT PLOTTED BY TIME

G&N 221, CM 117, IMU 31, APOLLO PIPA 2AP264R, Y AXIS

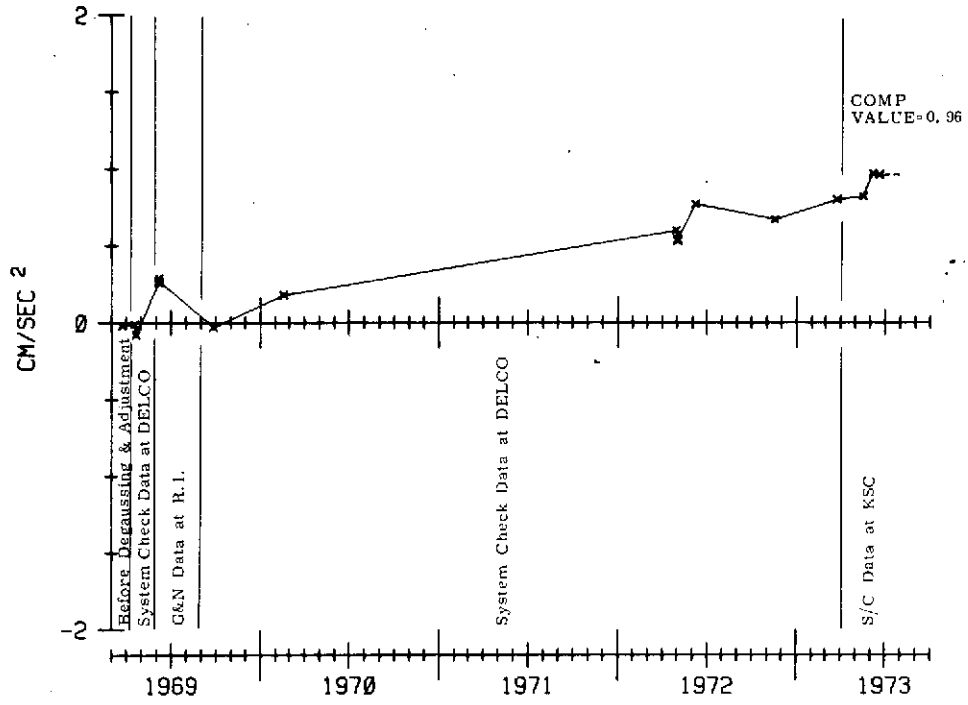


SCALE FACTOR DRIFT PLOTTED BY TIME

NASA 2AP-91R

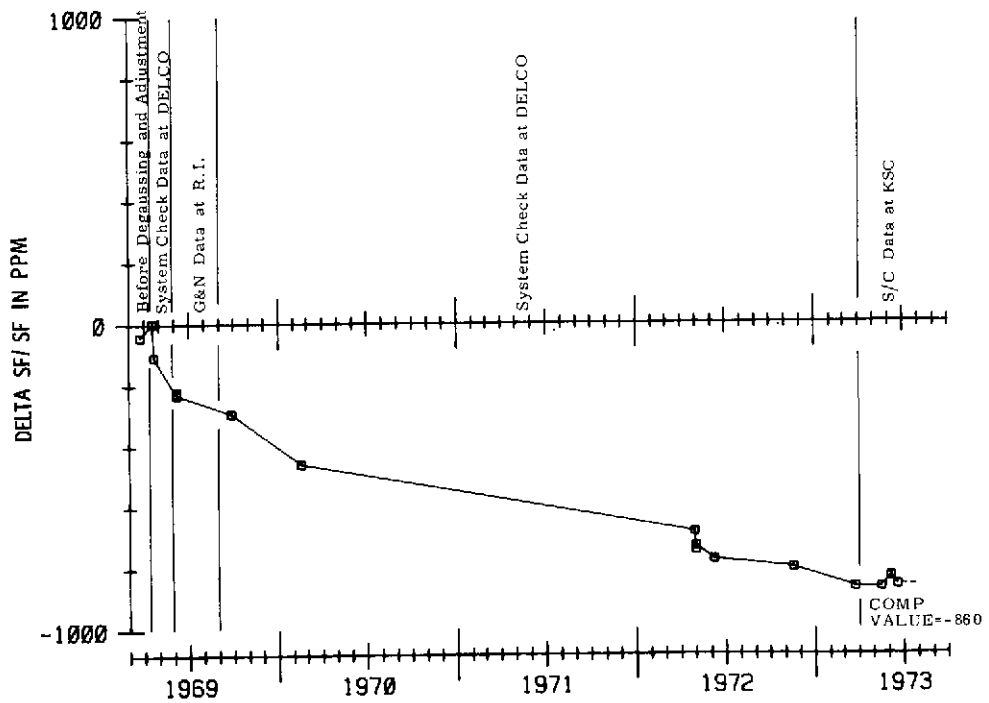
DATE	LOC	TST TYP	IMU ASSN	G&N SYS	DELTA SF	IG BIAS	NULL BIAS	ROT-AL-WOB ANGLE	TRANS.	TORQ MON CURRENT
UNIT INTERNALLY REPAIRED, REBUILT TO P/N 2001730-2										
12DE68	S42	ACC			172	0.00			0.05	104.3540
REPAIRED UNIT DELIVERED TO AC-MKE										
23MR69	A44	FST			- 42	-0.02		8 - 7		
2AP69 UNIT ASSIGNED TO IMU S/N 31Z										
16AP69	A05	SPO Z 31			(410)	(-1.19)	(-1.16)			104.3980
17AP69	A05	SPO Z 31			3	-0.01	0.01			104.3820
17AP69 AFTER DEGAUSSING & ADJUSTMENT										
21AP69	A05	SPO Z 31			- 108	-0.08	0.01			104.3803
22AP69	A05	SAL Z 31					(0.00)	- 16		
IMU S/N 31 SHIPPED TO NR										
6JE69	NO2	G&N Z 31	218		- 232	0.26				
6JE69	NO2	G&N Z 31	218		- 222	0.29				
6JE69	NO2	G&N Z 31	218		- 232	0.27				
IMU S/N 31 SHIPPED TO AC-MKE										
26SE69	A03	SPO Z 31			- 294	-0.03	0.02			104.3700
26SE69 RAN EO 3596- NULL COINCIDENCE CHECK										
26SE69	A03	SAL Z 31					(0.02)	- 14		
17FE70	A01	SPO Z 31			- 461	0.18	0.21			104.3710
18FE70	A01	SAL Z 31					(0.23)	- 15		
28AP72	A03	SPO Z 31			- 683	0.60	0.62			104.3694
11Y72	A03	SPO Z 31			- 744	0.53	0.56			104.3600
11Y72	A03	SPO Z 31			- 731	0.54	0.58		0.03	104.3607
24Y72	A03	SAL Z 31					(0.58)	- 26		
44Y72 RAN EO 3700-PIPA NULL RESOLUTION TEST										
44Y72	A03	SPO Z 31					0.64			
6JE72	A01	G&N Z 31	213		- 774	0.77				
16NO72	SB5	SPO Z 31			- 802	0.67	0.71		0.05	104.3683
16NO72	SB5	SAL Z 31					(0.71)	- 20		
23MR73	SB5	SPO Z 31			- 864	0.80	0.82		0.03	104.3625
27MR73	SB5	SAL Z 31					(0.87)	- 19		
3AP73 IMU-31 SHIPPED FROM DELCO TO KSC.										
12AP73 INSTALLED IN CM-117 AT KSC.										
164Y73	K0B	G&N Z 31	221		- 865	0.82				
4JE73	K0B	G&N Z 31	221		- 831	0.97				
18JE73	K9B	G&N Z 31	221		- 858	0.96				

G&N 221, CM 117, IMU 31, APOLLO PIPA 2AP91R, Z AXIS



1-G BIAS DRIFT PLOTTED BY TIME

G&N 221, CM 117, IMU 31, APOLLO PIPA 2AP91R, Z AXIS



SCALE FACTOR DRIFT PLOTTED BY TIME

STANDARD DEVIATION (1) OF THE IRIG AND PIPA
PARAMETER UNCERTAINTIES USED FOR
MISSION PERFORMANCE SUMMARY
CM 116; IMU S/N 22

PARAMETER

IMU Axis	<u>X</u>	<u>Y</u>	<u>Z</u>
PIPAs			
Data Compilation Period			
5/16/73-6/18/73			
Accelerometer Bias (cm/sec ²)	0.09	0.02	0.07
Scale Factor (SF/SF ppm)	26	18	15
IRIGs			
Data Compilation Period			
5/16/73-6/18/73			
Bias Drift (MERU)	0.9	0.6	0.4
ADSRA (MERU/g)	0.6	0.2	0.2
ADIA (MERU/g)	0.9	1.7	0.9
ADOA (MERU/g)	0.0	0.1	0.1

Data is based upon performance in the IMU. Point-to-point stability operation is much better than the above data.

PROPOSED GYRO AND ACCELEROMETER
PERFORMANCE COMPENSATIONS

PARAMETER

IMU Axis	<u>X</u>	<u>Y</u>	<u>Z</u>
PIPAs			
Accelerometer Bias (cm/sec ²)	+0.35	+0.01	+0.96
Scale Factor (SF/SF ppm)	-290	-460	-860
IRIGs			
Bias Drift (MERU)	-3.6	-0.4	-1.4
ADSRA (MERU/g)	-7	-13	-8
ADIA (MERU/g)	+12	-6	+21

Dictionary of Terms

ACC	Acceptance Test Data
ACD	After Cooldown
ACE	A. C. Electronics (presently Delco Electronics)
ADJ	Adjusted
ADOA	Acceleration Sensitive Drift Due to Acceleration along the OA
BCSW	Binary Current Switch
BIA	Bias Adjusted
BUSS	High, Low, or Nominal Direct Current Test
CDN	Post Cooldown
CQL	Component Qualification
CRQ	Component Requalification
CRR	Retest After minor adjustment or Resistor Changes
CRT	Retest Data
CSS	Short Servo Test
CVR	Component Verification
DGI	Degaussed IRIG
DGS	Degaussed
F/F	Float Freedom
FST	Final Stability
GAL	Guidance & Navigation PIPA Alignment
G&N	Guidance & Navigation System Measurement
GP	Gaussed PIPAs
HBS	Hi Bus Voltage
I&A	Inspection and Acceptance
ISS	Inertial Sub-System Data
KSC	Kennedy Space Center
LBS	Lo Bus Voltage
MW	Milliwatt
NAR	North American Rockwell (presently Rockwell International, Inc.)
NBS	Nominal Bus Voltage
OOS	Out of Spec
RDT	Wheel Rundown Time, Seconds
RI	Rockwell International

PRECEDING PAGE NUMBER

APPENDIX

ELECTRICAL POWER REQUIREMENTS

This section was extracted from the MIT/IL Report E-1142 (Rev. 59) "SYSTEM STATUS REPORT". It is included in this report for convenience.

Electrical power and energy reporting is based upon the inflight spacecraft sequence of events for the Design Reference Mission as developed by the Apollo Mission Planning Task Force (AMPTF). (Reference GAEC Report Volume III - LED-540-12, dated October 30, 1964).

The accompanying diagrams present the power drawn through the spacecraft circuit breakers. It is assumed that power is drawn from the spacecraft's primary +28VDC supply and a 400 cps-115 VAC single phase inverter.

Intermittent power peaks can exist, particularly during operation of displays and controls at random times. The energy content in these peaks is considered negligible.

All values (except those mentioned above) are actual expected levels of power at 28.0 VDC. They are based on measured values on G&N systems 207 and 208 for the Block II Command Module. No margin factor has been applied to protect against possible differences between G&N systems and spacecrafts. Thus, these values should not be taken as "not to exceed" extremes.

The following Interface Control Documents serve as the guidelines for reporting power figures.

CM Block II MH01-01327-216 "G&N Electrical Input Power" signed 15 July 1965.

BLOCK II GUIDANCE & NAVIGATION LOAD ON PRIMARY +28 VDC COMMAND MODULE

BASED UPON 196.5 HOURS (8.27 DAY) LUNAR ORBIT MISSION
DESIGN REFERENCE MISSION

STATUS OCTOBER 1967

REFERENCE GAFC REPORT - LED 540-12, 30 OCTOBER 1964
APOLLO MISSION PLANNING TASK FORCE

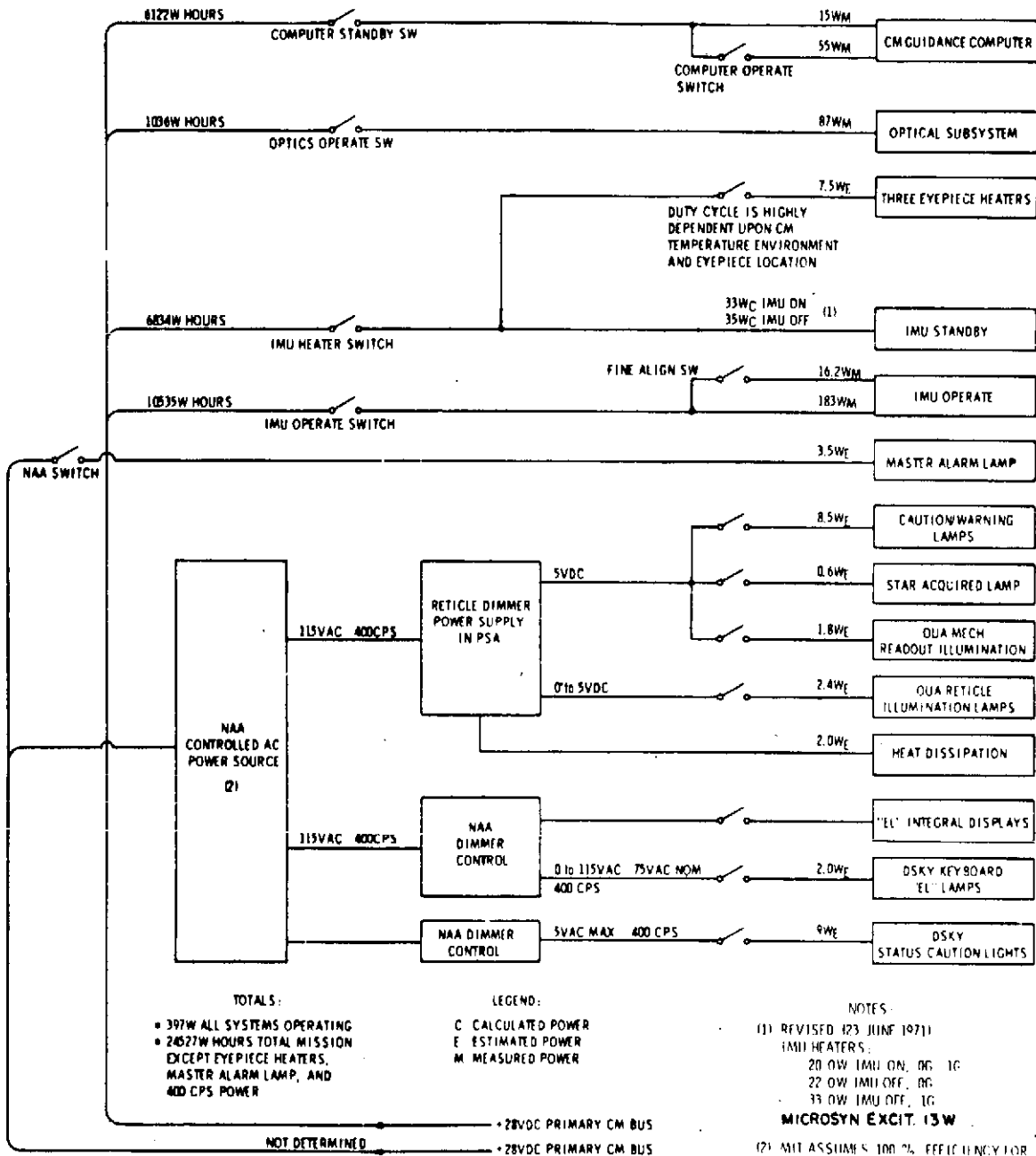


Figure A-1