# MIT/IL PRESENTATION FOR THE

# MISSION "H" APOLLO 12

FLIGHT SOFTWARE READINESS REVIEW
HELD AT NASA/MSC ON 15 OCTOBER 1969

R. LARSON

CONTENTS

# SECTION 1

# CSM PROGRAM

## SUMMARY OF COLOSSUS 2C DEVELOPMENT

| | |
|---|---|
| Establishment of a COLOSSUS 2C Assembly . . . . . | 26 May 1969 |
| Release of COLOSSUS 2C (Comanche 67) for Rope Manufacture . . . . . | 17 July 1969 |
| Completion of Mission "H" Level 6 Testing . . . . . | 8 October 1969* |
| Total Number of PCR/PCNs Accomplished in the COLOSSUS 2C Release . . . . . | 23 |
| Total Number of Anomalies Fixed in the COLOSSUS 2C Release . . . . . | 8 |

* Pending completion of Rendezvous and RTE with "H" trajectory

## COLOSSUS 2C PCR/PCNs IMPLEMENTED

| | |
|---|---|
| 278 | A Fixed DUMPCNT. |
| 781.1 | PIPA Bias Compensation Scale Change. |
| 785 | Reverse V50N18 Logic in P20. |
| 787 | Make N63 Count during P61. |
| 791.1 | Do Not Allow a Proceed Response to a V21, V22 or V23. |
| 798.1 | Reset GLOKFAIL in R00. |
| 799 | V82 Time Option. |
| 801.1 | Make BAILOUT Alarms Start with 3XXXX and POODOO Alarms with 2XXXX. |
| 802.1 | Save Alarm Data after "Error Reset". |
| 803 | Change Entry Final Phase Table. |
| 807.1 | Add Present Time Option to P21. |
| 809 | Error Variance Computation for VHF Range and Alternate Line-of-Sight Measurements. |
| 810 | YAW DAP CDU Sampling. |
| 811 | TVC DAP Gain Change. |
| 812.1 | Resetting and Setting the EXTERNAL $\Delta V$ Flag. |
| 815 | Digital Autopilot Barbecue Mode Routine. |

825.1 Display Option 3 in P52/P54.

826.1 Reverse P76 Display.

831.1 Lambert Overflow Protection.

832.1 Reduce Restriction of Running R05 Only in P00.

833 SWTOVER Check.

835 Change Recycle Point on N63 in P61.

837 Change Constant Drag Controller Gains.

## PCR/PCNs INCORPORATED IN COLOSSUS 2B

773.1 Fix Constants for Planetary Inertial Orientation Subroutine.

776.1 Improve Timing for R2 Lunar Potential Model Integration.

## ANOMALIES FIXED IN COLOSSUS 2C FOR COMANCHE 67

| | |
|---|---|
| COM 12, REV 1 | Improper REPFRAC Values. |
| COM 13 | V78 Does Not Terminate. |
| COM 14 | P17 Does Not Terminate. |
| COM 15 | Coding Error in Restart Tables. |
| COM 16 | $\Delta V \neq 0$ at First Mark. |
| COM 17 | Error at Ranges Greater than 163.83 NM. |
| COM 18 | Software Restart (BAILOUT or POODOO). |
| COM 20 | Anomaly COL 69 Not Completely Fixed. |

## PERFORMANCE TESTING

Boost Takeover during Polynomials.

CSM Active from Insertion (Nominal Tracking Schedule) (LM in 10 x 45 Orbit).

CSM Passive from Insertion (Nominal Tracking Schedule).

CSM Active from Insertion (Optics Only).

CSM Active from Insertion (VHF Only) (Use "H" Pad Load Data).

Rescue #1 - Aborts from $PDI_2$ + 2 Min.

Rescue #2 - Aborts from $PDI_2$ + 2 Sec.

Rescue #3 - Aborts from $PDI_2$ + 700 Sec.

Rescue #4 - Aborts from $PDI_2$ + 21 Min , 24 Sec.

Landing Site (Zero W-matrix) Auto-optics and Downlink Verification.

RTE (EI - 30 Hours) (To Splash).

TEI - No Communication Followed by P23 Out Past Sphere and then P37/P 40 (To Splash).

Entry

## CMC TAKEOVER OF SATURN GUIDANCE DURING BOOST

1. This run was made with padloads for both the "F" and "G" Missions, using Revision 67 of COMANCHE. The L/V switch was set to "CMC" at 40 seconds after liftoff.

   Performance of the simulated Saturn Launch vehicle under CMC control was documented to be stable during all stages of boost.

2. The following items were also documented to be well within acceptable limits:
   (a) Liftoff REFSMMAT calculation.
   (b) P11 - N62 DSKY display.
   (c) State vector errors.

3. No discrepancy in the form of alarm, abort, or loss of downrupts was noted for the 6.1.1 run.

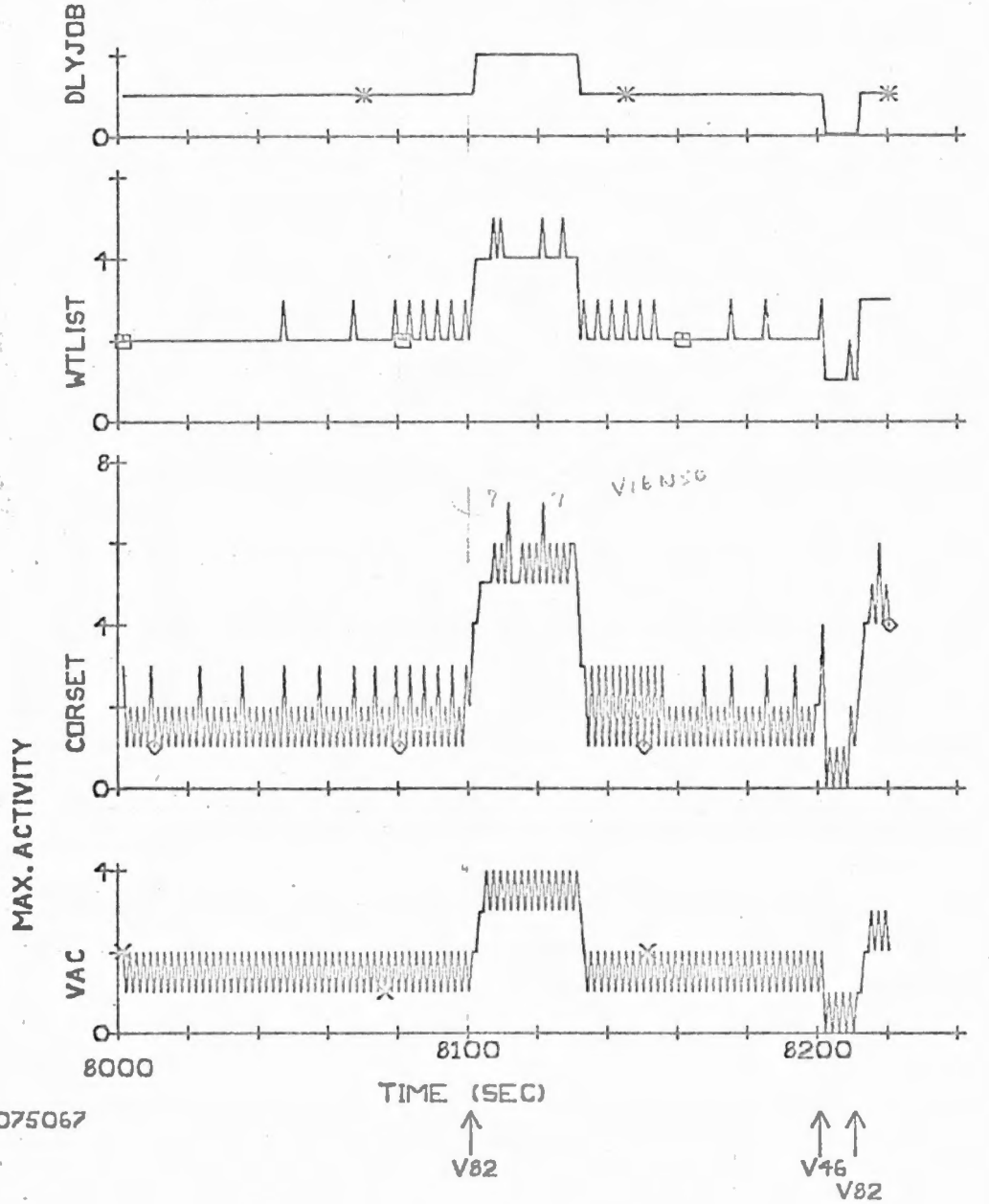
   In order to document the AGC loading during boost and verb 82, plots of AGC Activity and Duty Cycle are attached.

S/360 JOBNAME IS A075067 10/07/69 4:04

MARSROT 28004032 BOOST

AGC ACTIVITY

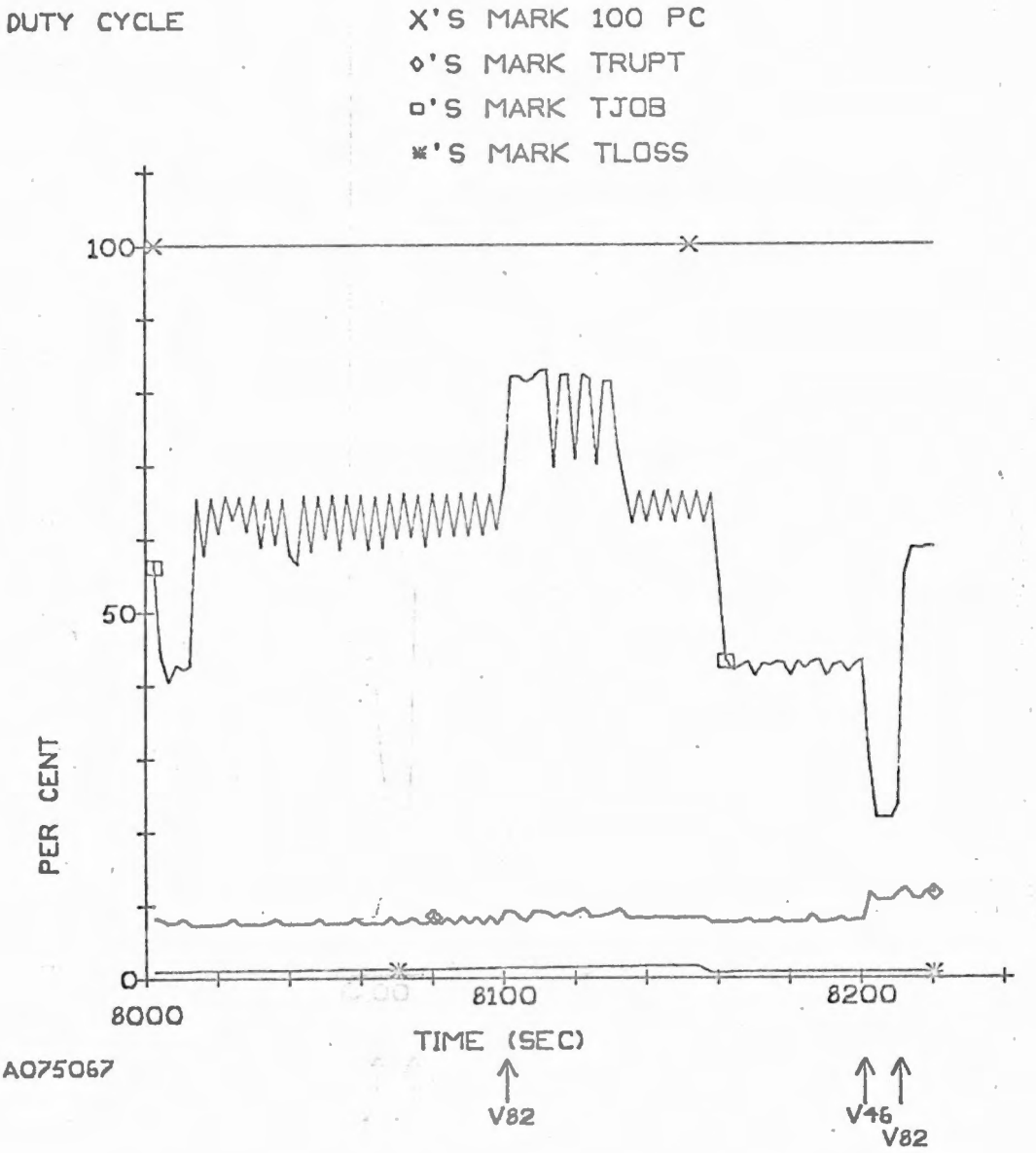
X'S MARK VAC
◇'S MARK CORSET
□'S MARK WTLIST
✱'S MARK DLYJOB




A075067

S/360 JOBNAME IS A075067 10/07/69 4:04

MARSROT 28004032 BOOST



COLOSSUS 2C COMANCHE 67
RENDEZVOUS TESTS

1. All the G Mission level 6 tests (except RVARMIN study) were run with the H1 rope. The navigation and targeting results were all satisfactory and negligibly different from G rope results.

   The trajectories were G Mission as were the state error vectors. These still represent valid tests for H1 Mission since the relative geometry is identical and the LM state errors will be basically the same. The CSM state errors for H1 should be slightly smaller so that the above tests are conservative.

2. One of the above tests was run with the H1 Mission pad load. This was the VHF only CSM active mission and the results differed negligibly from G rope test.

3. The H1 pre-CSI tracking schedule (VHF + optics all the way) was used in the tests with no serious degradation in CSI targeting accuracy.

4. The nominal CSM active mission will be run with H1 trajectories and state errors.

COLOSSUS 2C COMANCHE 67
TEI CONTINGENCY BURN

LM ASCENT STAGE (EMPTY OR FULL) DOCKED TO CSM

I. Use of the nominal CSM/LM high-bandwidth filter will result in Slosh Instability in SPS sump tanks.

   A. Light weight vehicle means high acceleration and high slosh frequency (up to 4.5 rad/sec for an empty Ascent stage).

   B. Large moment arm from vehicle c.g. to slosh mass attach point increase the divergence rate of the slosh instability.

II. The recommended procedure for this case is to use the CSM DAP. This is done by using routine 03 (the DAP data load) as follows:

   A. Load N46 DAPDATR1 with ( 1XXXX).

   B. Load N47 CSMMASS with total vehicle mass (this insures the correct central angle calculation in the P40 targeting).

   C. Load N48 PTRIM and YTRIM.

   D. All other procedures remain unchanged.

III. Performance using CSM DAP.

A. TVC performance will be roughly equivalent to undocked TEI burn.

1. TVC DAP filter gain will be in error by a maximum of about -36% (full Ascent stage) but gain margin is more than adequate.

2. The bending frequencies and slopes are satisfactory for CSM DAP compensation.

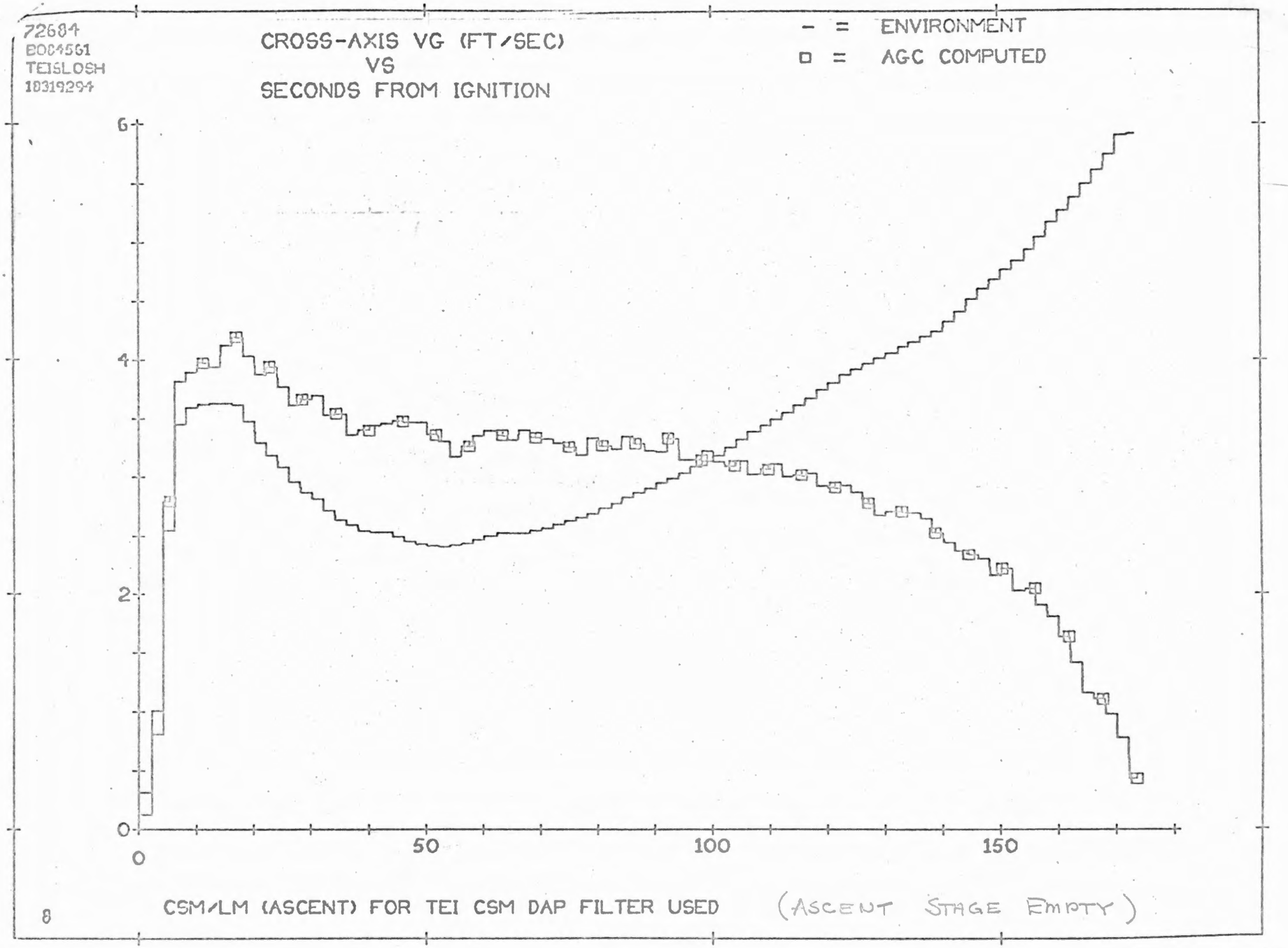
3. The slosh modes are stabilized well beyond the expected frequency range for this contingency case.

B. RCS performance should be close to nominal.

1. The MASSPROP mismatch produces errors of up to -60% (full Ascent stage) in the moments of inertia, but because the errors are on the low side the RCS DAP is stable.

2. The extra fuel usage due to the inertia mismatch is 1 - 2 lbs. or less for the pre-burn attitude maneuver and ullage.

72684
B004561
TEISLOSH
10319294



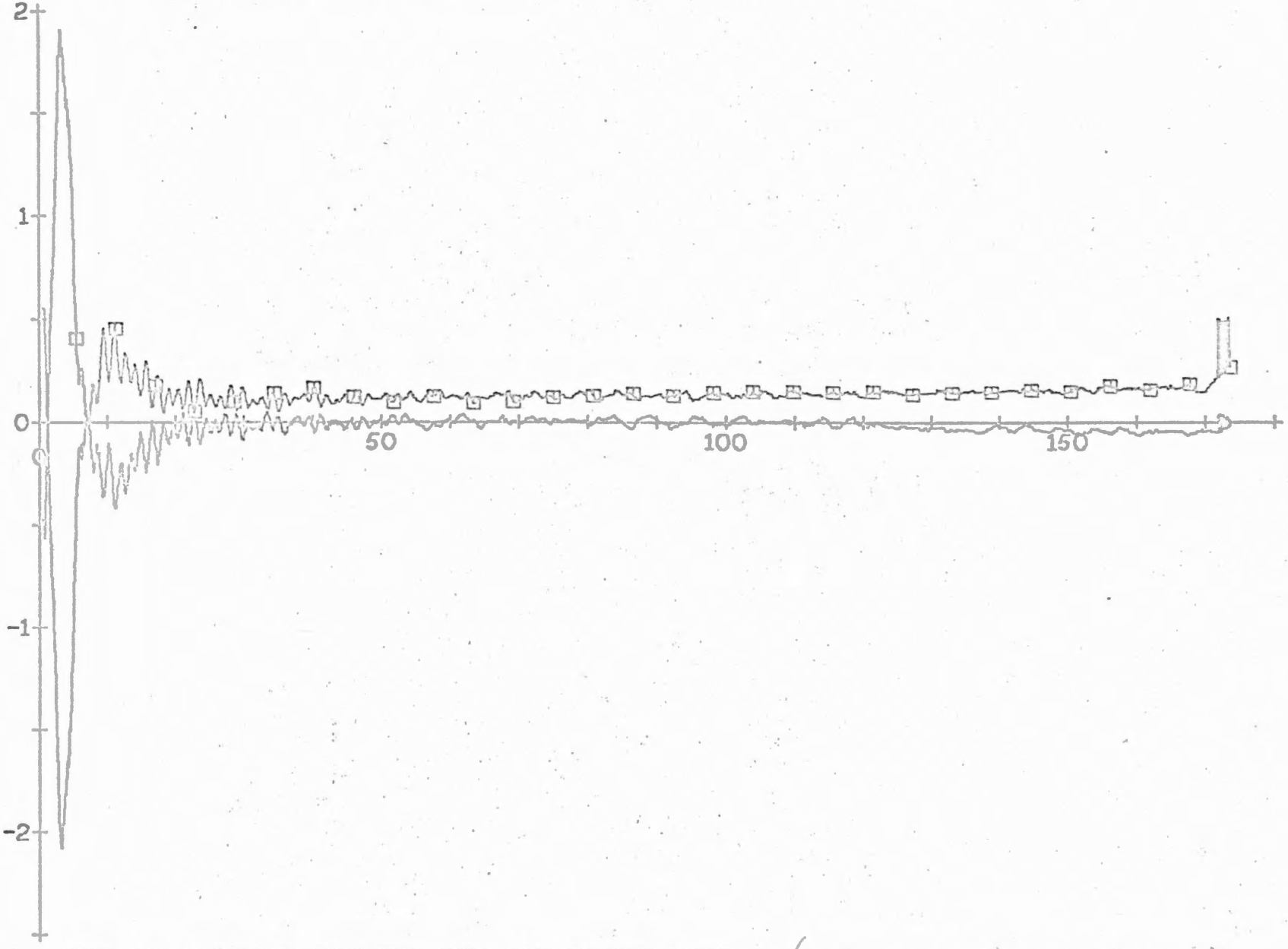

CSM/LM (ASCENT) FOR TEI CSM DAP FILTER USED (ASCENT STAGE EMPTY)

8

72684
GO84561
TEICLOGH
10315294

ATTITUDE ERROR (DEG)
VS
SECONDS FROM IGNITION

– = PITCH
□ = YAW




3

CSM/LM (ASCENT) FOR TEI CSM DAP FILTER USED (ASCENT STAGE EMPTY)

## PASSIVE THERMAL CONTROL

R64 - V79

General

In N79

R1 rate: max value that can be loaded ±8.9999 deg/sec. Pinball constraint.

R2 deadband: max value 30 deg because DAP becomes unpredictable at larger values.
min value .4 deg because DAP phase plane becomes distorted at smaller values.

R3 option: ± 0 ⇒ PTC
any nonzero ⇒ Y axis

Independent of rate selected PROCEEDING on N79 will command a forced firing; roll for PTC option, pitch for Y axis option.

R64 - V79

For PTC

R64 eliminates the direct erasable loading to start PTC motion. It does not eliminate the need to damp rates and disable and enable jets in the proper sequence to establish the proper physical conditions for PTC.

V37EXXE does a STOPRATE and resets deadband so will kill PTC if any jets are enabled

R64 - V79

Y- axis

The rotation is about Y stable member and CDUX should = 7.25 deg and CDUZ should = 0 deg in order that Y RCS CONTROL be aligned with $Y_{S.M.}$

Using R64 at other CDUX and CDUZ values will degrade performance and increase fuel consumption as a function of CDUX, CDUZ, and command rate values. For certain combinations instability probably will result.

c.f. Colossus Memo #217

R64 - V79

For changing deadbands

Load RATE = 0

All R64's in PTC option will command a roll forced firing.

All R64's in Y axis option will command a pitch forced firing.
To inhibit these firings, disable the appropriate channel or jets.

R64 does not recenter the DAP deadband. To decrease deadband

go to FREE

use R64

go to HOLD

## MISSION PROCEDURAL TESTING

LOI-1

Docked DPS TEI Monitor

LM Initiation, Undocking and SEP

CSM Lunar Oribt Plane Change

Post Insertion to TPF-CSM Passive

Post Insertion to TPF-CSM Active

CSI to TPF - CSM Active

CDH to TPF - CSM Active

TPI to TPF - CSM Active

P22 LM Tracking (Landing Site)

P37 RTE - Inbound - Longitude Control

Earth Orbit Abort (P37) and Entry

High Velocity Entry

High Velocity Entry (-P65-)

High Velocity Entry (-P65-P66-)

## COLOSSUS 2C MISSION PROCEDURAL TESTING

| | |
|---|---|
| LOI: | Test completed: no procedural problems. |
| Docked DPS Burn: | Test not completed. |
| Undocking and Separation Maneuver: | Test completed; no procedural problems. |
| Plane Change: | No procedures available. |
| Rendezvous: | Testing incomplete - V64 (R05) during VHF marking sequence causes 31201 alarm. |
| P22 Landmark Tracking: | Testing completed. Anomaly V79 performed on V06 N92 display. |
| P37 Longitude Control: | Test not completed. |
| Earth Orbit Abort (P37) and Entry: | Test completed; no procedural problems. |
| High Velocity Entries: | Tests completed; recommend that coarse align of optics be performed at N60 display in P61 (no extended verbs allowed at N61 display). |

# SYSTEM TEST LAB TESTING

Test of P20

Test of P52

Test of P22

Test of IMU Compensation

Alarm Test

SYSTEM TEST LAB. VERIFICATION OBJECTIVE COLOSSUS 2C

1. Demonstrate continuing compatibility of Software and Real Hardware.
   A. Software control of IMU and Optics.
   B. Hardware inputs to Software for polarity, approximate scaling, and proper operation.

2. Demonstrate operation of the Prelaunch Alignment Programs in nominal and stressed environment.

3. Verify that System Test Programs for spacecraft checkout work as intended in nominal and stressed environment.

4. Demonstrate compatibility of system with simulators.

## SYSTEM TEST LABORATORY VERIFICATION TEST CATEGORIES

1. Prelaunch checkout systems tests (lab hardware).
2. Stress test of system test (digital simulator).
3. Prelaunch alignment functional test (lab hardware).
4. Prelaunch alignment performance and stress test (digital simulation).
5. Optics operational programs (lab hardware).
6. Alarms test (lab hardware).
7. IMU operational programs.
8. Hardware control extended verbs.
9. Gyro and accelerometer compensation.

# SYSTEM TEST LAB. PROGRAM VERIFICATION

## TEST EQUIPMENT USED - LAB TESTS

1. Block II system nearly identical to flight system. Mounted fixed in roll but rotatable in pitch.

2. Core rope simulator with COLOSSUS 2C (similar to that used in hybrid simulation).

3. Collimated targets carefully aligned with respect to fixture.

4. K- start tape reader simulation - allows convenient loading of E- memory and simulates ACE uplink used in spacecraft testing.

5. Simulated VHF ranging input circuits.

SPECIAL EMPHASIS ON:

| | |
|---|---|
| PIPA | Compensation Scale Factor Changed so that as much as $\pm$ 9 cm/sec$^2$ can be compensated. |
| New | Octal Loads Given in STG Memo No. 1366. |
| Tested | ICP 4 and Special Test (STG Memo No. 1365). |

# SYSTEM TEST LAB PROGRAM VERIFICATION

CONCLUSIONS:

1. Prelaunch alignment programs shown to work in nominal environment in lab and on simulator with "stress".
2. System test checkout programs shown to work in nominal environment in lab and with stress on digital simulator.
3. Polarities and scaling between program and real hardware verified.
4. Inflight compensation correctly compensates selected IMU errors.
5. Complete test documentation available in STG Memo No. 1401.

COLOSSUS 2C REVISION 67
MISSION "H" RTCC TESTING

POWERED FLIGHT

- DOI (DPS)
- PDI (DPS)
- TEI Backup (DPS)
- ASC for CSM Inplane (APS)
- ASC for CSM Out-of-Plane (APS)

Run on G data with G Engine Model – No Problems – Yet to run on (new) H engine model

ALIGNMENT

- P57 Star and Gravity (Deleted)
- P57 2 Stars

run on H data

RENDEZVOUS

- Pre-CSI (CDH: 1/2T, 3/2T)
- Pre-CDH
- Pre-TPI

run on G data

UPLINK

- All Options (9)

Ext ΔV
LM NAV (2)
CM NAV
RLS
TIME (2)
BLOCK

PREF REFSMMAT

# COMANCHE 67 DOCUMENT REVIEW CHRONOLOGY

1. CSM 108 AOH Vol. 2 dated 8/13/69.
   Received 9/18/69.
   Informal Transmittal of Comments 10/3/69.
   Formal Transmittal (POPC 500-504) 10/7/69.

2. CSM 108 Operations Checklist dated 9/8/69.
   CSM 108 Launch Operations Checklist dated 9/8/69.
   CSM 108 Alternate and Contingency Checklist dated 9/8/ 69.
   CSM 108 Operations Checklist dated 9/8/69.
   Checklists Received 9/13/69.
   Informal Transmittal of Comments Not Completed.
   Formal Transmittal (Not Required).
   Updated to Apollo 12 Baselines Checklist dated 9/26/69.
   Received 9/29/69.
   Informal Transmittal Not Completed.

3. H-1 CSM Rendezvous Procedures Document dated 9/22/69.
   Received 10/6/69.
   Informal Transmittal 10/10/69.
   Formal Transmittal (Est) 10/15/69.

4. H-1 Entry Summary Document dated 9/15/69.
   Received 10/6/69.
   Informal Transmittal 10/10/69.
   Formal Transmittal (Est) 10/15/69.

## ANOMALIES EXISTING IN COLOSSUS 2C (COMANCHE 67)

| Anomaly | Description | Disposition |
|---|---|---|
| COM 21 | Backwards Integration Can Occur in P27 Uplink. | Program Note (Fix for 2D) |
| COM22 | V79, V41, V55 and V42. Do Not Perform CCS New Job. | Program Note (Fix for 2D) |
| COM 23 | Optics in CMC Mode during TVC Use of DACs. | Program Note |
| COM 24 | Coding Error in Iterator. | (Fix for 2D) |
| COM 26 | V92 FLAGWD 6 is Changed While the Job is Not in Inhint. | (Fix for 2D) |
| COM 27 | V32E Response to FLV16N45 in P37 will Result in Indeterminate Program Transfer. | Program Note (Fix for 2D) |
| COM 28 | GSOP Section 4 Does Not Indicate Constant Change from 1.3 to 2.4 in R52. | Correct GSOP Section 4 for 2D (PCR 960) |
| COM 29 | N70 instead of N71 Display In P23. | |

# CONCLUSION

BASED ON THE PRECEDING DATA, MIT/IL RECOMMENDS THE USE OF COLOSSUS 2C (COMANCHE 67) FOR MISSION "H".

# SECTION 2

# LM PROGRAM

## SUMMARY OF LUMINARY 1B DEVELOPMENT

| | |
|---|---|
| Establishment of a LUMINARY 1B Assembly | 2 June 1969 |
| Release of LUMINARY 1B (Revision 116) for Rope Manufacture | 12 August 1969 |
| Completion of Mission "H" Level 6 Testing | 15 October 1969 |
| Total Number of PCR/PCNs Accomplished in the LUMINARY 1B (Revision 116) Release | 40 |
| Total Number of Anomalies Fixed in the LUMINARY 1B (Revision 116) Release | 25 |

## LUMINARY 1B PCR/PCNs IMPLEMENTED

| | |
|---|---|
| 277 | Affixed DUMPCNT. |
| 279 | Variable Insertion Computation. |
| 284 | VGTIGs on C/A Downlist. |
| 773.2 | Fix Constants for Planetary Inertial Subroutine. |
| 776.2 | Improved R2 Model Timing. |
| 779 | Leave Track Enable Set when R29 is Terminated. |
| 780 | Provide Pure RR Range, Range Rate and Time Lag during P20, P22, and P25. |
| 781.2 | PIPA Bias Compensation Scale. |
| 791.2 | Do Not Allow a PROCEED Response to V21, V22 or V23. |
| 798.2 | Reset GLOKFAIL in R00. |
| 801.2 | Make BAILOUT Alarms Start with 3XXXX and POODOO Alarms with 2XXXX. |
| 802.2 | Save Alarm Data after "Error Rest ". |
| 805 | Don't Allow V66 on the Surface. |
| 807.2 | Add Present Time to P21. |
| 812.2 | Resetting and Setting of the External ΔV Flag. |
| 814 (Rev.) | Reduce Keystrokes Required to Check and Approve LR Data. |

| | |
|---|---|
| 816 | Modify R03 to Permit Astronaut Setting of $1^{o}$ Deadband. |
| 817 | Eliminate Undesirable LR Position Alarms from R12. |
| 818 | Permit Rejection of Individual Measurement Incorporations in P20. |
| 820 | Eliminate Lighting of ALT Light when Low Scale Discrete is Absent. |
| 823 | Delete P31 from LUMINARY 1B. |
| 825.2 | Display Option 3 in P52/P54. |
| 826.2 | Reserve P76 Display. |
| 827 | Add ΔDOTD to Ascent-Descent Downlist. |
| 830 | Supplementary ASTEER Modification. |
| 831.2 | Lambert Overflow Protection. |
| 832.2 | Define Actual Restrictions on Running R05. |
| 838 | Prevent RCS Jet on Lunar Surface. |
| 839 | R12 and LR Repositioning Routines Improvements. |
| 840 | Reduce Oscillation in P64/P65. |
| 841 | PGNCS Derived Vehicle Attitude Rate on FDAI Error Needle. |
| 842 | Modification of Criteria Used to Determine DAP Phase Plan Parabola Intercept. |
| 844 | Deletion of P38/P78 and P39/P79. |
| 845 | Do Not Turn on R29 during P70/P71. |
| 847 | Eliminate Possible Lockout of Pitchover from P12, P70 and P71. |

| | |
|---|---|
| 848 | Prevent RR ECDU's from Stealing LGC Memory Cycles. |
| 853 | Restrict V35 to P00. |
| 854 | Provide a Flexible Method for Crew to Modify RLS. |
| 855 | Begin Reading LR Velocity as soon as Velocity Data Good Appears. |
| 856 | Change 1502/1206 from POODOO's to BAILOUTS. |
| --- | Provide CH13STAL Coding |

ANOMALIES FIXED IN LUMINARY 1B FOR REV 116

| | |
|---|---|
| 55 | Errors in Fixed Constants |
| 58 | RDRUSECK Bug R76. |
| 61 | Restart Protection P20 and P22. |
| 62 | P70 and P71 Select $1^{o}$ Deadband. |
| 63 | P40 Recycle. |
| 64 | Restart in P63. |
| 66 | R04 Erasable Conflict with R65. |
| 67 | Make ATTSTALL 1210 into BAILOUT Instead of POODOO. |
| 68 | P57 IMU Compensation Conflict. |
| 69 | Coding Error, Downward Jet Firing. |
| 71 | P22 Lunar Surface Navigation. |
| 72 | 511 Alarm after V32E. |
| 73 | Correct Location of V06N61. |
| 74 | Erasable Conflict. |
| 76 | Wrong Erasable in Pinball. |
| 78 | Non-zero Attitude Errors near Orbit Insertion. |
| 79 | Crossplane Vertical Oscillations during P64/P65. |
| 80 | V63E with LR Power Off Causes Improper RADMODES BIT 6. |

| | |
|---|---|
| 81 | Erasables Shared between Radar Tasks and Jobs. |
| 82 | Max DB only when P68 Running. |
| 87 | Coding Error in P22. |
| 88 | Landing Radar Repositioning Routine is Not Restart Protected. |
| 89 | Backwards Integration can Occur in P27. |
| 90 | V97N63 Display Overwritten by V06N63 Display. |
| 91 | CDU Fail Program Alarm in P20 When Not an Alarm Condition. |

# PERFORMANCE TESTING

## RENDEZVOUS

LM Active-Nominal

P00, P52, P20, P32, P41, P30, P41, P33, P41, P34, P41, P35, P41, P35, P41, P47

Abort Insertion Profile to Rendezvous

P00, P52, P20, P32, P41, P32, P41, P33, P41, P34, P41, P35, P41, P35, P41.

Lunar Surface Ascent

P68, P00, P12, P57 (2 Stars), P06, P57 (Gravity/Star), P57 (Gravity/Refsmmat), P22, P12, P20, P32 (Initialized with 5° Pitch, 15° Yaw).

Aborts from Descent

Early - P00, P63, P70 (at 30 kft), P20 (11 mks), P32 (1st solution).

Mid - P00, P63, P70 (at 10 kft), P71 (at FV97), P20 (11 mks), P32 (1st solution).

Late - P00, P63/P64, P71 (at 500 ft), P20 (11 mks), P32 (1st solution).

Landing

Enter P66 at 700 ft altitude; null all velocity components
Redesignations and Noun 69 Deltas
Nominal Error-free Run-automatic
LR Position Check

All runs with H | data except where noted

## LEVEL 6 TEST DESCRIPTION

### LANDINGS

A. Noun 69 alone - loaded at PDI+3 Min.

| | | |
|---|---|---|
| Down Range | +5kft | +10kft |
| Cross Range | +5kft | +5kft |
| P66 at 700 ft | | P65 |

2 RUNS

No state errors initially

stayed on Surface 500 sec in PGNCS ALTO

B. ACA Redesignations

| | 1 | 2 |
|---|---|---|
| Down Range | +5kft | +4kft |
| Cross Range | -5kft | -3.5kft |

2 RUNS

P65

No state errors initially

C. Noun 69/ACA Redesignations

1. Noun 69 (+35kft DR) (+10kft CR) — PDI + 3 Min

   ACA (-3kft DR) (-5kft CR) higher

1 RUN

1 ~~of~~ state errors - ~~lower~~ than estimated

P65

please note

2. Noun 69 (+25kft DR) } PDI - 3 Min.
(+5kft CR)
1 RUN
(+10kft DR) } PDI + 3 Min.
(+5kft CR)
ACA (-3kft DR)
(-6kft CR)
No state errors

3. Noun 69 (-35kft DR) } PDI + 3 Min.
(-5kft CR)
1 RUN ACA (-3.5kft DR)
(-8.5kft CR)
1σ state errors - higher than estimated

D. TLOSS Effects
10% TLOSS until H = 12kft
1 RUN 5% TLOSS to TD
ACA (+4kft DR)
(-3.5kft CR)
(31201 ↗ at 6K ft with high ACA activity (2/sec))

E. Nominal Landing
No state errors
ACT PLOT 1 RUN P65
No Redesignations

F. Landing Radar Fail W/W*/TLOSS 10% T LOSS + V57 (stole 2 VAC AREAS) and not problem at high gate
ACT PLOT 2 RUN Alarm 523 at HIGATE.
V58E, PROCEED

HA-101

(HP-10)

HA-61

HA 37

ABORTS

A. DPS Abort at 30kft altitude
   Lock-on w/RR and CSI solution
B. DPS Abort at 10kft altitude
   APS Abort at DPS fuel depletion
   RR lock-on and CSI solution
C. APS Abort at 500 ft altitude
   RR lock-on and CSI solution

early abort
target J1 K1
11 marks for CSI
Solution
late target J2 K2

SURFACE OPERATIONS

A. Realignments
B. Alignments after IMU power down/up
C. RR tracking.
D. Ascent to Insertion; +20° Yaw at TIG+4 Min
   RR lock-on and CSI solution
   Initialized with -5° P, 15° Y. RT
   NO CSM P.C.!

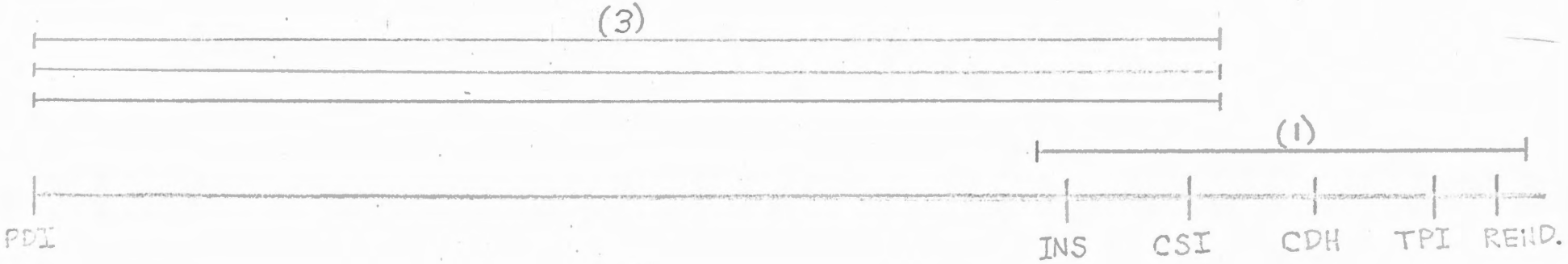
RENDEZVOUS

A. Nominal LM-active from "G"
   Trajectory; Insertion to TPF
B. Rendezvous from "G" Abort
   Trajectory; Insertion to TPF

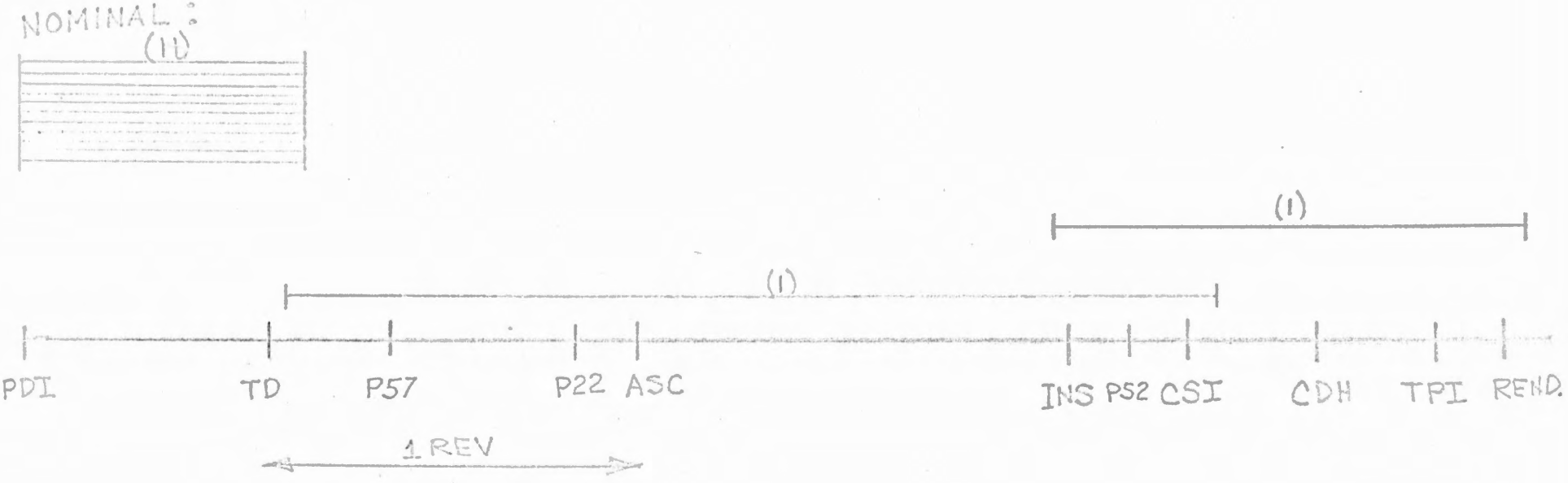
results similar to 1A

# LUMINARY SIMULATION TIMELINE COVERAGE

ABORT:




NOMINAL:



George Kalan

I. DAP RELATED DIFFERENCES BETWEEN LUMINARY 1A AND LUMINARY 1B

A. ANOMALY LMY-69 (" A SPURIOUS COMMANDED FIRING OF A DOWNWARD FORCING RCS JET IN POWERED ASCENT") CORRECTED

B. CRITERIA USED TO DETERMINE DAP PHASE PLANE PARABOLA INTERCEPTS MODIFIED (PCR 842)

C. 3° DEADBAND SET AT INITIATION OF P-64 (PCR 840)

D. DAP DERIVED RATE DISPLAY PROVIDED WITH FDAI ERROR NEEDLES (PCR 841)

E. R 03 MODIFIED TO PERMIT SELECTION OF 1° DEADBAND (PCR 816)

F. CHANNEL 13 STALL ROUTINE CALLED BEFORE WRITING INTO CHANNEL 13 - ALSO ONE UNNECESSARY RESETTING OF CHANNEL 13 BIT 15 IN T6RUPT ELIMINATED

G. ATTITUDE ERROR AND DESIRED RATES ZEROED ON PROCEED IN P-65, P-66, P-67. ALSO PULSES BIT SET IN P-68 AND RESET AT TIG FOR ALL BURN PROGRAMS (PCR 838)

II. · TESTING

A. VERIFICATION AND PERFORMANCE TESTS RUN FOR LMY-69, PCR 842, PCR 841, and PCR 816 (PERFORMANCE TESTING OF OTHER DAP RELATED CHANGES INCLUDED IN SPECIAL STUDIES)

B. DAP PERFORMANCE DURING ASCENT AND LANDING TESTS OF FINAL LUMINARY 1B ASSEMBLY EXAMINED

77313

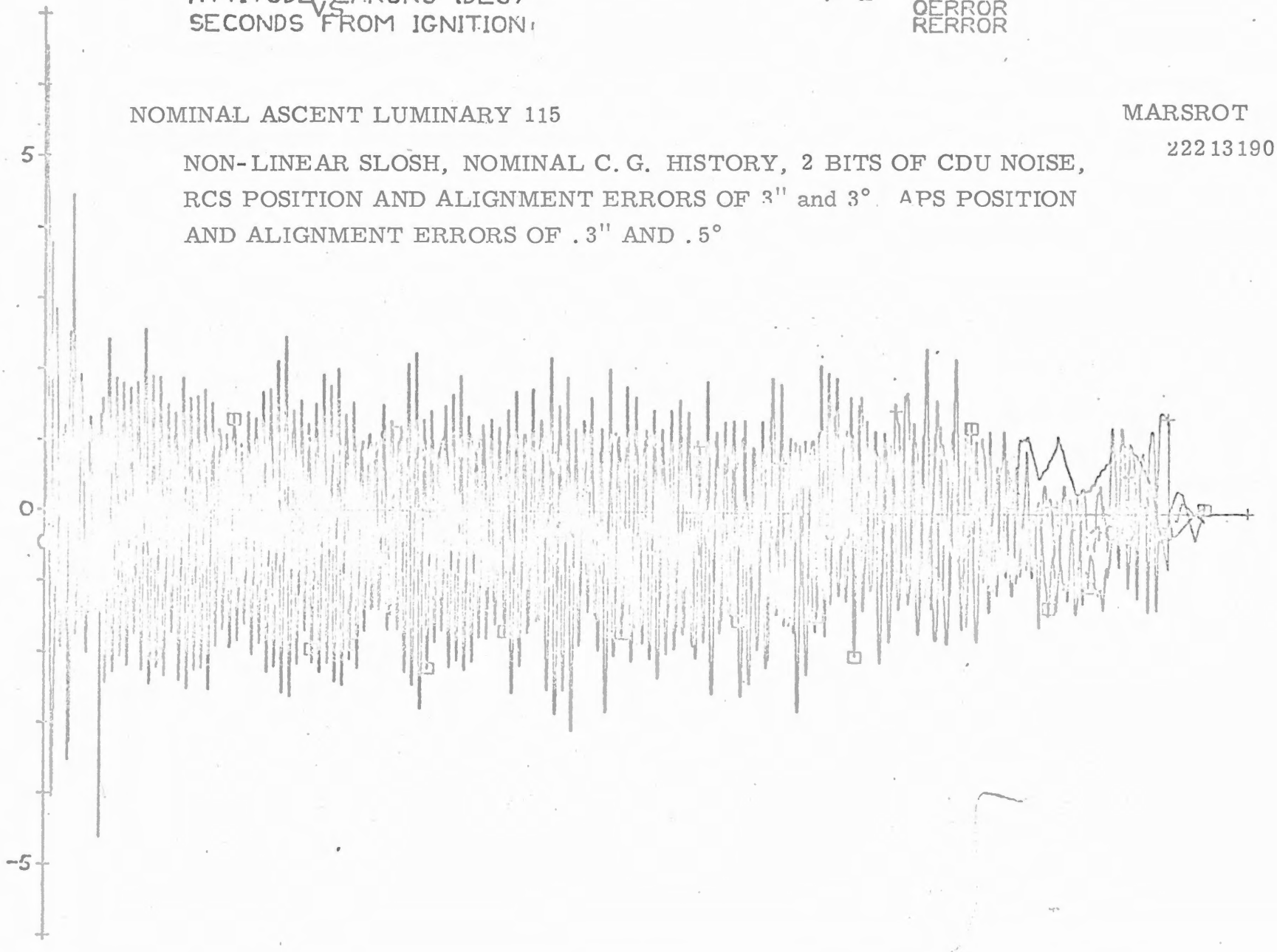
ATTITUDE ERRORS (DEG) VS SECONDS FROM IGNITION

− =
□ =
\+ = PERROR
QERROR
RERROR

NOMINAL ASCENT LUMINARY 115

MARSROT
22213190

NON-LINEAR SLOSH, NOMINAL C.G. HISTORY, 2 BITS OF CDU NOISE, RCS POSITION AND ALIGNMENT ERRORS OF 3" and 3° APS POSITION AND ALIGNMENT ERRORS OF .3" AND .5°



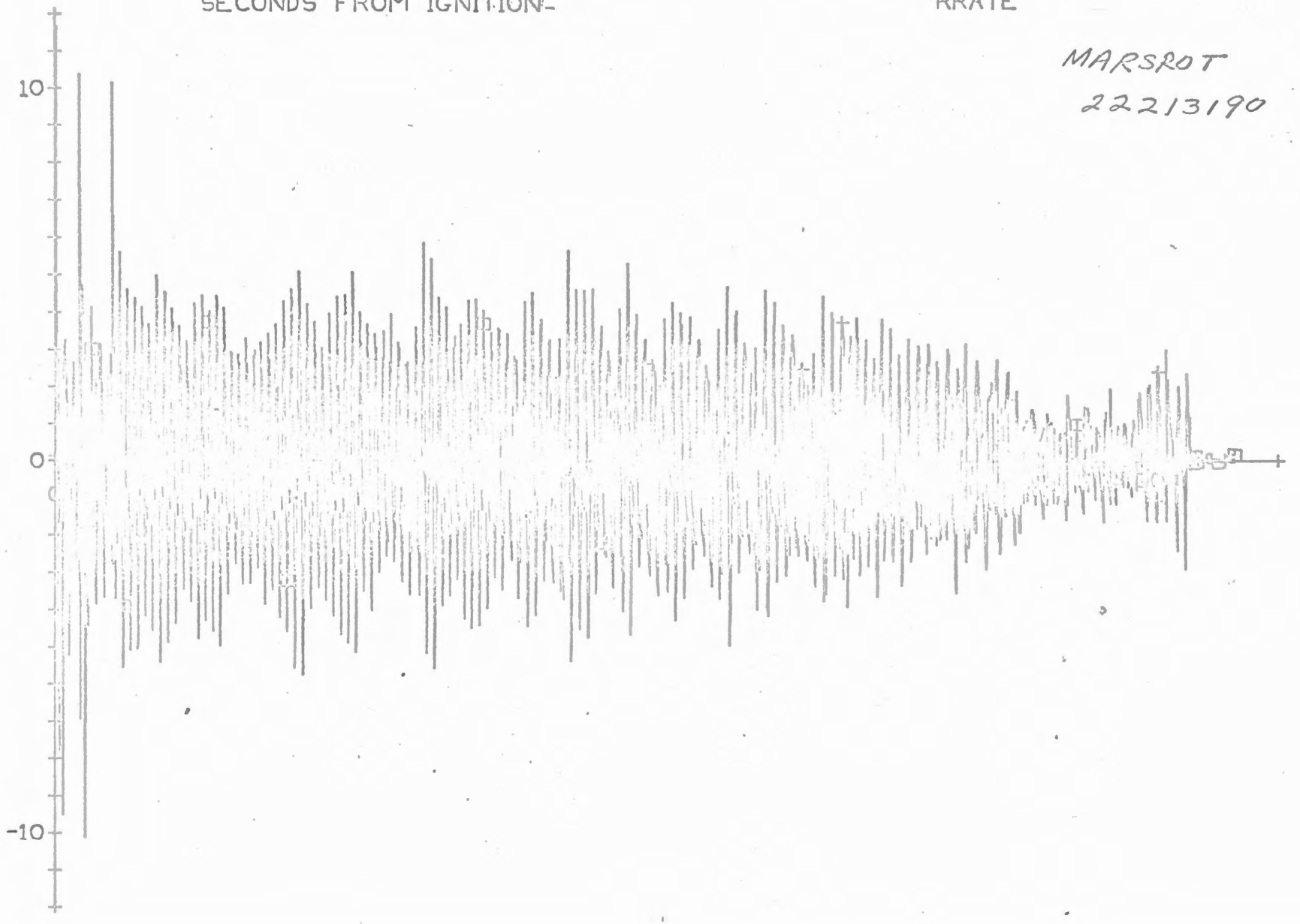

3

77313

ERROR RATES (DEG/SEC)
SECONDS FROM IGNITION

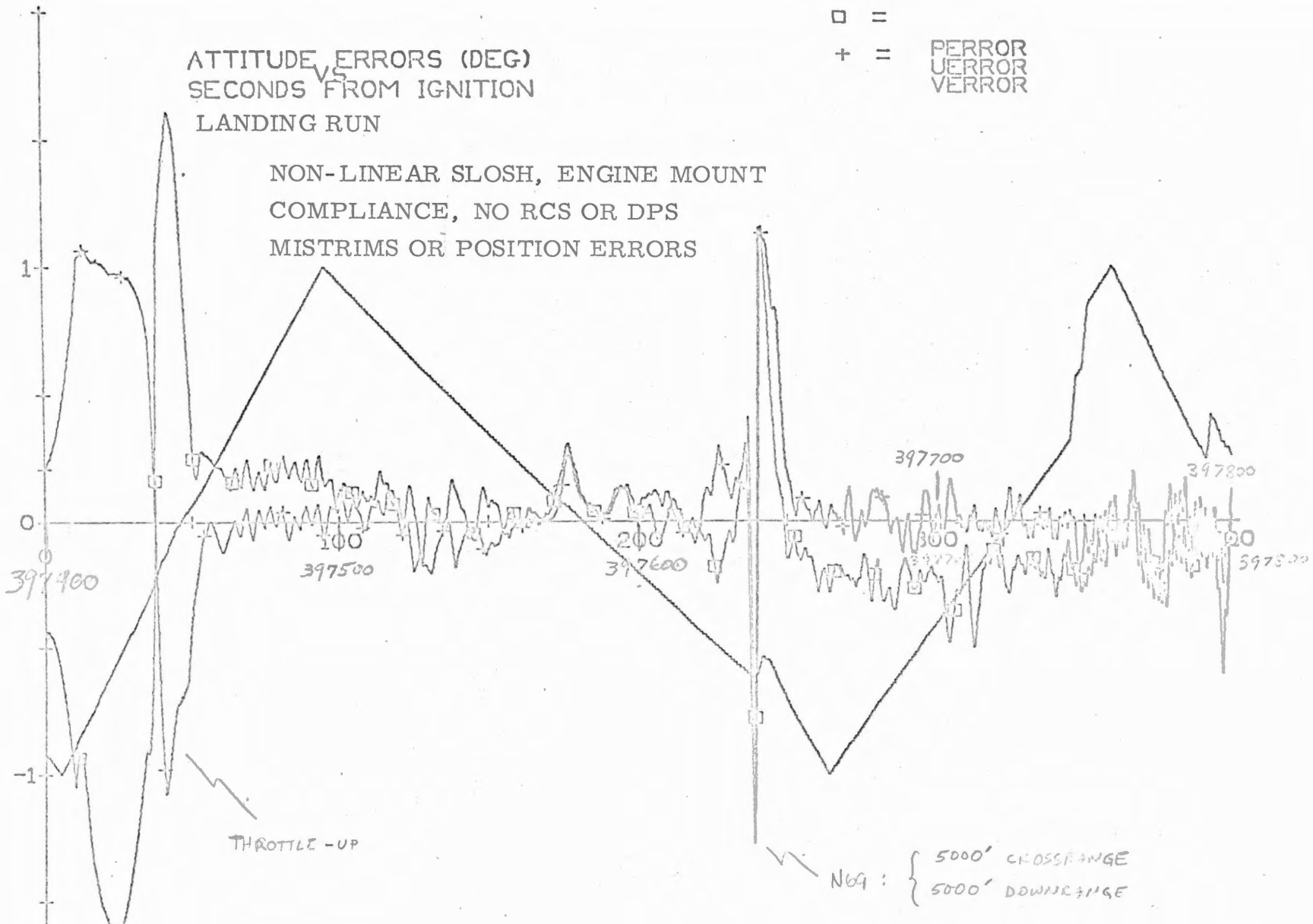
- =
□ =
+ = PRATE
ORATE
RRATE

MARSROT
22213190




2

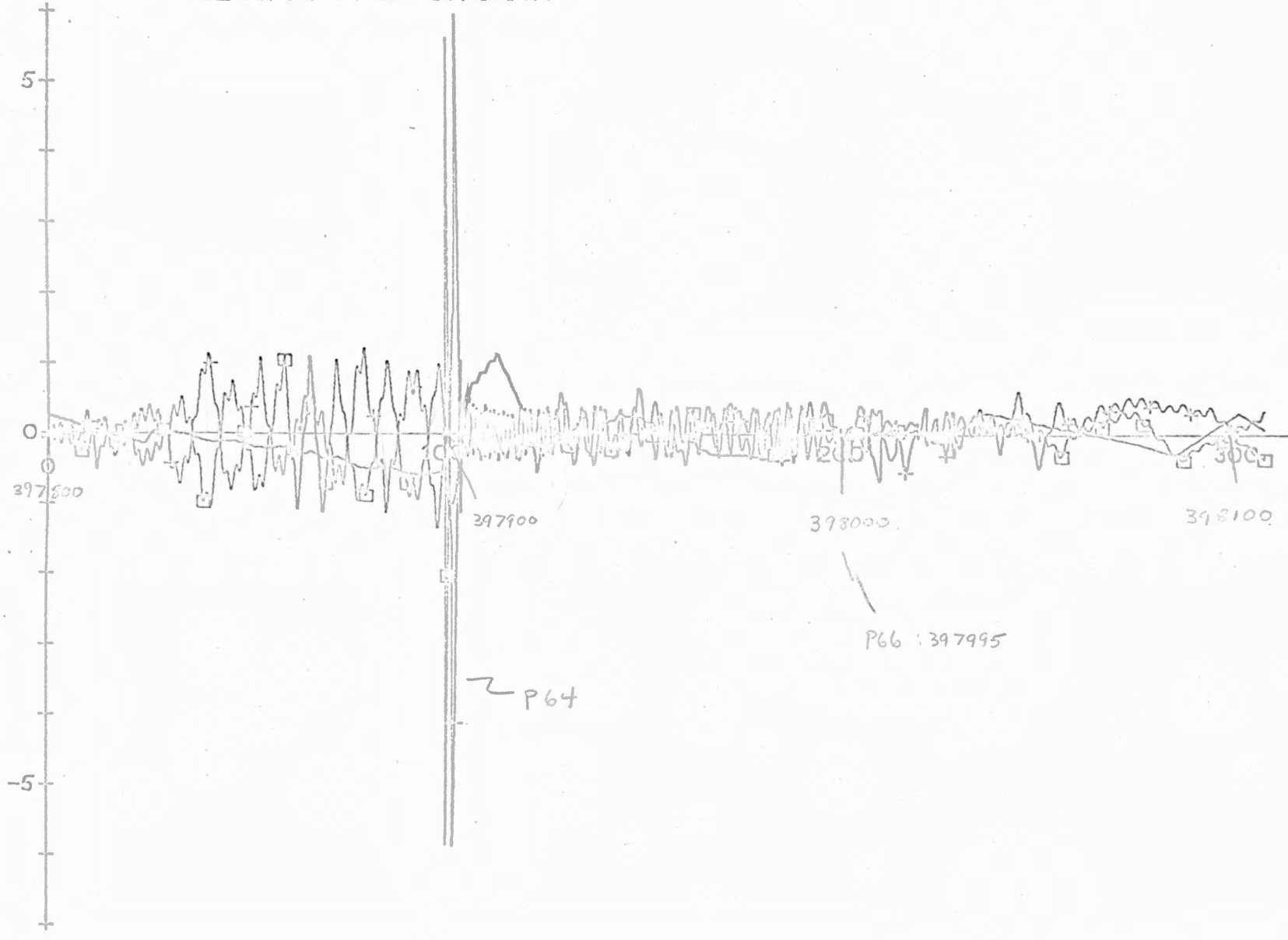
L-16


ATTITUDE ERRORS (DEG)
SECONDS FROM IGNITION
LANDING RUN
NON-LINEAR SLOSH, ENGINE MOUNT
COMPLIANCE, NO RCS OR DPS
MISTRIMS OR POSITION ERRORS
− =
□ =
+ = PERROR
UERROR
VERROR
1
0
-1
397400
100
397500
200
397600
300
397700
397800
THROTTLE-UP
NOM: { 5000' CROSSRANGE
5000' DOWNRANGE

85165

ATTITUDE ERRORS (DEG) VS SECONDS FROM IGNITION

− =
□ =
+ = PERROR
UERROR
VERROR




3

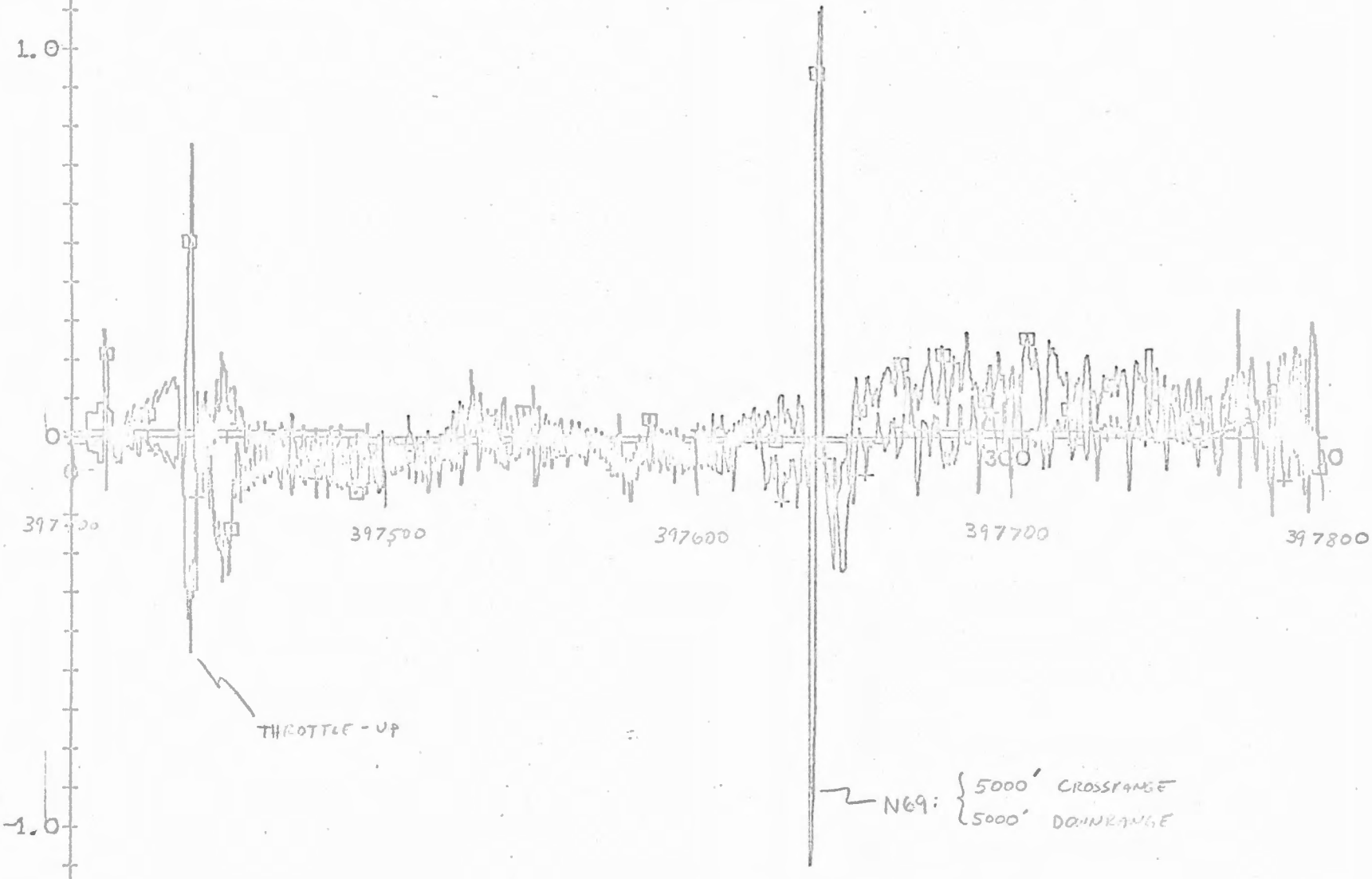
84123

ERROR RATES (DEG/SEC) VS SECONDS FROM IGNITION

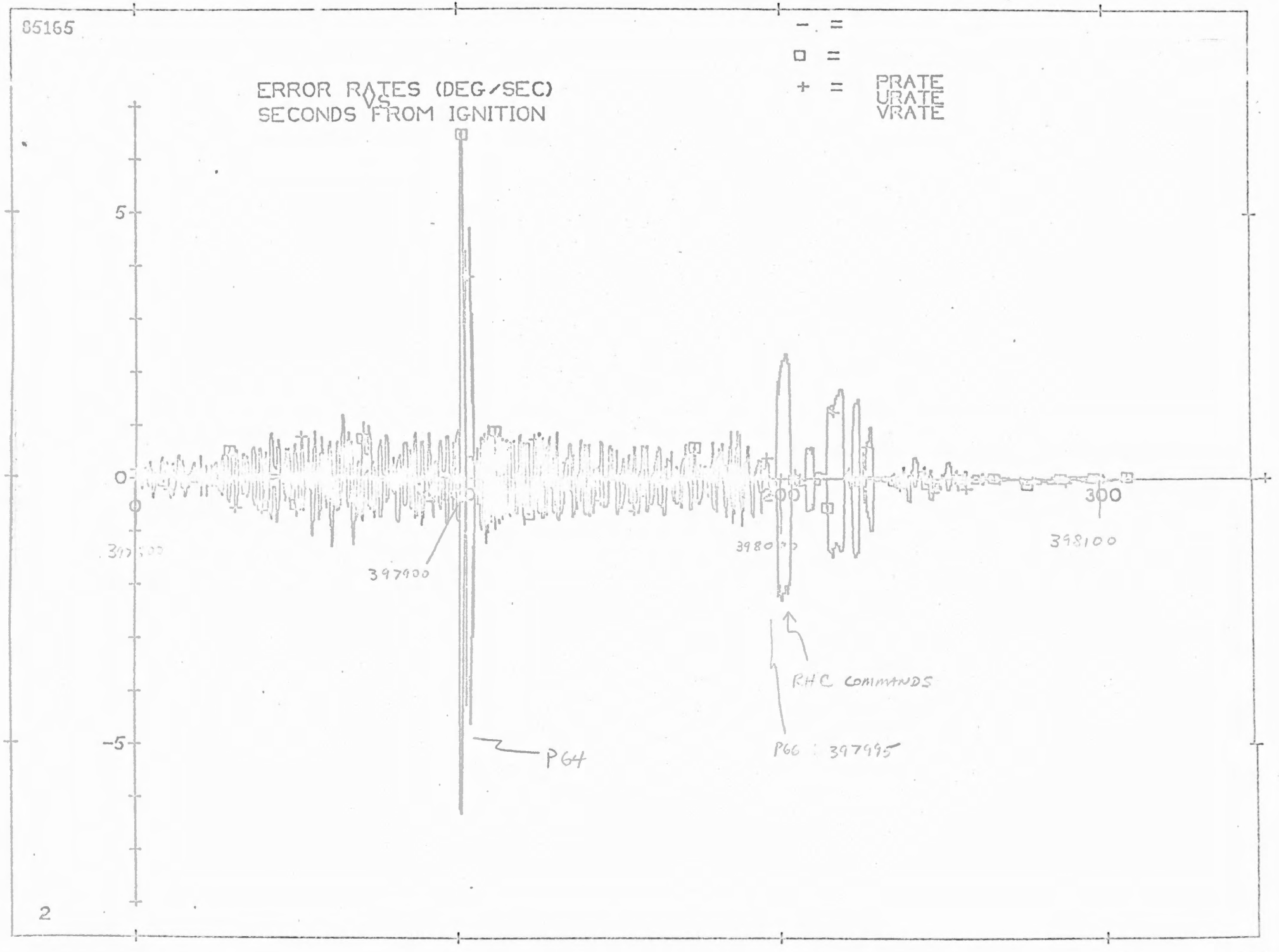
− =

□ =

\+ = PRATE
URATE
VRATE




2


85165
ERROR RATES (DEG/SEC)
SECONDS FROM IGNITION
− =
□ =
+ = PRATE
URATE
VRATE
5
0
-5
397900
398100
300
RHC COMMANDS
P64
P66 : 397995
2

III. SPECIAL STUDIES

A. DETERMINE FUEL PENALTY FOR USING .3° DEADBAND DURING AND AFTER P-64

B. DETERMINE IF THERMAL CONSTRAINTS ARE EXCEEDED DURING LANDING DUE TO USE OF .3° DEADBAND DURING AND AFTER P-64

C. DETERMINE THE EFFECTS OF AN ACCIDENTAL ZEROING OF ATTITUDE ERROR AND DESIRED RATED IN P-66 OR P-65

→ D. TEST GIMBAL FAIL LOGIC

E. TEST DAP RESPONSE TO LARGE MANUAL RATE COMMANDS

## IV. SPECIAL STUDY RESULTS

### A. RCS FUEL CONSUMPTION

1. NOMINAL AUTOMATIC LANDING

   .3° DEADBAND SET IN P-64 - 22.1 LB

   1° DEADBAND RETAINED - 15.8 LB

2. LANDING WITH P-66, P67

   .3° DEADBAND SET IN P-64 - 16 LB

   1° DEADBAND RETAINED - 30.4 LB

### B. TOTAL JET ON TIME DID NOT EXCEED 16 SEC. IN ALL LEVEL 6 LANDING RUNS OBSERVED

### C. THE ACCIDENTAL ATTITUDE ERROR AND DESIRED RATE ZEROING HAD NO HARMFUL EFFECTS IN P 65 OR P 66

### D. DAP LOGIC FUNCTIONS PROPERLY WITH GIMBALS DISABLED

### E. DAP RESPONDS TO LARGE MANUAL RATE COMMANDS WITHOUT OVERSHOOTING

## MISSION PROCEDURAL TESTING

Docked DPS, SPS Backup.
Pre-DOI to Touchdown.
Auto Landing.
Manual Attitude Control Landing.
Full Manual Landing.
Redesignate Landing.
N69 Revision of Landing Site.
DPS Abort from Descent.
DPS-APS Abort from Descent.
Pre-Liftoff to Rendezvous.
Pre-CSI to Rendezvous.
Pre-CDH to Rendezvous.
Pre-TPI to Rendezvous.
Lunar Surface Operations.

# LUMINARY 1B MISSION PROCEDURAL TESTING

HLMV 2.0 Docked DPS, SPS Backup

Low priority run. Has not yet been performed.

HLMV 3.0 Pre-DOI to Touchdown

All DOI burns were nominal; see the following simulations for powered descent comments.

HLMV 3.1 Auto (P65) Landing

31201 Alarm: With one less VAC area than normal in the LGC, a 31201 alarm can be generated at the transition of P63 and P64 by entering R31 or V57.

Cross Pointers: Anomaly L-1B-04 was observed.

HLMV 3.1A Rate-of-Descent (P66) Landing

ROD Switch: The ROD switch was cycled as quickly as the pilot was able. All ROD pulses were accepted by RODCOUNT, and H-DOT changed accordingly.

HLMV 3.1B Manual (P67) Landing

Nominal run.

HLMV 3.1C Redesignation Landing

Nominal run.

HLMV 3.1D N69 Revision of Landing Site

Nominal run.

HLMV 3.2 and 3.2A Aborts from Powered Descent

Nominal run.

HLMV 4.0 Lift-off thru Rendezvous

31201 Alarm: With one less VAC area than normal in the LGC, a 31201 Alarm can be generated by entering R05 while a targeting program and P20 are running.

HLMV 4.01 Post Insertion thru Rendezvous (Linked Run)

Not run.

HLMV 10.0 Lunar Surface Operations

Nominal runs.

## SYSTEM TEST LAB TESTING

Polarity and Scaling Test for Accelerometers.
Alarm Code Test.
Anti-Max Limit and Remode.
LR + RR Data R04.
P20 Options.
Operations of Lunar Surface Prog. P22.
R29 Test.
R77 Test.
LGC/CMC Clock Synch.(R33) Including V55.
AGS Initialization Prog.
Nominal Turn On.
Turn On with Failures Test.
Gimbal Lock Protection Test.
Cage Test.
IMU Error Monitor Test.
P51-IMU Orientation Determination.
P51 Options Case.

## SYSTEM TEST LAB TESTING

P52 - IMU Realign Prog.
P52 - Options Case.
AOT Bias Calibration Test.
P57 - Lunar Surface Align.
Verb 40 Zero IMU-CDU.
Verb 41 Coarse Align IMU.
Verb 42 IMU to Inertial Mode.
Verb 43 Load IMU Error Needles.
Free Fall Bias Comp. Test.
Thrusting and Comp. Test.
Gyro Drift and Acceler. Comp. Test.

# SYSTEM TEST LAB VERIFICATION LUMINARY 1B

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.

# 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
4. System operation extended verbs.
5. System test programs.
6. IMU in-flight compensation polarity.
7. Alarm and abort branches.

# SYSTEM TEST LAB VERIFICATION OF LUMINARY 1B

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. Landing radar interface simulator.

4. Core rope simulator LUMINARY program (similar to that used in hybrid simulation).

5. K-start tape reader simulation. Allows convenient loading of E-memory and simulates ACE uplink used in spacecraft testing.

SPECIAL EMPHASIS ON:

1. PIPA Compensation Scale Factor Changed so that as much as $\pm$ 9 $cm/sec^2$ Can Be Compensated.

   New Octal Loads Given in STG Memo No. 1366.

   Tested ICP 4 and Special Test (STG Memo No. 1365).

2. CH13STAL Routine

   Tested Special Glitch Detector and Program to Write into Channel 13 often (STG Memo No. 1388).

3. RR CDU Zero when Mode Switch Not in LGC.

   Tested Proper Setting of Bits Observed and CDU Zero Obtainer (STG Memo No. 1388).

# SYSTEM TEST LAB VERIFICATION OF LUMINARY 1B

CONCLUSIONS:

1. The compatibility between the LUMINARY program and the G&N hardware was again demonstrated (except for reported anomalies).

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.

4. Complete documentation of results is available in STG Memo No. 1405.

LUMINARY 1B REVISION 116
MISSION "H" RTCC TESTING

POWERED FLIGHT

- Abort (SPS 20 Hours GET)
- LOI 1 (SPS)
- LOI 2 (SPS)
- TEI (SPS)
- PC (RCS, Deleted)
- TEMCC (RCS)

ALIGNMENT DETERMINATION

- P51 (Two Cases)

BOOST

- Nominal Liftoff
- Delayed Liftoff

ENTRY

- Lo-speed Deorbit
- Hi-speed Lunar

UPLINK

- All Options

# DOCUMENTATION REVIEW FOR LUMINARY 116

The following documents have been reviewed by MIT/IL to ensure inclusion of software changes which updated LUMINARY 99 to LUMINARY 116:

LM6 AOH Vol. 2 dated 8/18/69.

LM6 Flight Crew G&N Dictionary dated 8/26/69.

Activation Checklist dated 8/27/69.

Contingency Checklist dated 9/2/69.

LM Rendezvous Procedures dated 9/26/69.

The following H-1 Mission Procedures Documents will be reviewed upon their receipt:

LM Descent/Ascent Procedures.

Lunar Surface Procedures (G&N).

In addition, the inclusion of information related to outstanding anomalies and current program notes (published by FSB on 9/18/69) has been assured.

For Detailed Status of Documentation Reviewed, See DG Memo #1444 dated 10/9/69.

# LUMINARY 116 DOCUMENTATION REVIEW CHRONOLOGY

1. LM6 AOH Vol. 2 dated 8/18/69.
   Received 9/9/69.
   Informal Transmittal of Comments 9/22/69 and 10/3/69.
   Formal Transmittal (POPC LUM 300) 10/7/69.

2. LM6 Flight Crew G&N Dictionary dated 8/26/ 69.
   Activation Checklist dated 8/27/69.
   Contingency Checklist dated 9/2/69.
      Checklists received 9/13/69.
      Informal transmittal 9/29/69.
      Formal transmittal (not required).
   Update dated 9/19/69.
   Received 10/1/69.
   Transmittal 10/3/69.

3. LM Rendezvous Procedures dated 9/26/69.
   Received 10/9/69.
   Informal Transmittal 10/10/69.
   Formal Transmittal 10/15/69.

## ANOMALIES EXISTING IN LUMINARY 1B (REVISION 116)

| Anomaly | Description | Disposition |
|---|---|---|
| 12 | V06 Flash during V97NXX | Program Note |
| 31 | Use of V30 and V31 | Program Note |
| 75 | Radar Self-test Routine | Work Around in 1B<br>Fix in Subsequent |
| 83 | Inconsistency between N63 and N43 (in P68) | Insufficient Data |
| ~~84~~ | $H_a$ and $H_p$ Discrepancy in P30 versus DOI | Insufficient Data |
| ~~85~~ | Restart and Alarms at TIG (PDI) - 4:30 | Insufficient Data |
| 92 | V41 and V42 Do Not Perform CCS New Job before Final Display | Fix for 1C |
| L-1B-01 | Selection of P22 before CSM is within RR Coverage | Work Around in 1B<br>Fix for 1C |
| L-1B-02 | R20 Will Not Achieve RR Lock-on | Work Around in 1B<br>Fix for 1C |
| L-1B-03 | Quantity COEFFR Discrepancy when 1JACCQ and 1JACCR are Equal | Fix for Subsequent Programs |
| L-1B-04 | Switching RR Mode Control into LGC Disables X-pointer | Fix for 1C |
| L-1B-05 | R60 Mode 11 Attitude Errors Placed in FDAI Needles before Desired Attitude. | Fix for 1C |

| Anomaly | | Disposition |
|---|---|---|
| L-1B-06 | LR Had Been Failed in Position One Causing a 523 Alarm in P64. | |
| L-1B-07 | Problems Occurred in LM Descent Prior to PD1. | |
| L-1B-08 | 520 Alarm Occurred at Time of Abort (to P70). | |

## CONCLUSION

BASED ON THE PRECEDING DATA, MIT/IL RECOMMENDS THE USE OF LUMINARY 1B (REVISION 116) FOR MISSION "H".