R. Larson

Mission Techniques Memo #35B

TO: Distribution
FROM: Malcolm W. Johnston
DATE: July 14, 1969
SUBJECT: "G" Odds and Ends

1. Contingency Procedures - This document was not re-issued for "G". One is to be published, however, for mission "H".

2. Manual Ascent - This document will not be published until after lift off. A draft copy has been reviewed and it accurately reflects MIT's suggestions to date. One important additional step in preparation for a manual ascent with a PGNCS accelerometer failure is to zero the ADIA and ADSRA compensation registers. Large acceleration inputs (Pipa failed on) could cause platform misalignments if this were not done.

   MTM #34 discusses the specific MIT recommendations for these contingencies, and enclosed DG memo #1390 summarizes some preliminary hybrid simulation results.

3. Earth Parking Orbit and TLI - Final changes not received as of "G" liftoff!

4. TEI, MCC (TE), and Entry - Final changes not received as of "G" liftoff!

5. Enclosed AG #345-69 and ISS #826 memos discuss in-flight compensation of the LM5 X-axis accelerometer. (Deadzone etc., like on Apollo #7).

Malcolm W. Johnston

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M. Johnston

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MIT Instrumentation Laboratory

DG Memo No. 1390

TO: M. Johnston

FROM: I. Johnson

DATE: July 10, 1969

SUBJECT: Rate Command Attitude Hold PGNCS Ascent Capability Verification on Hybrid with failed Accelerometers

Several hybrid tests were executed to verify a manually-controlled rate cmd att hold capability during lunar ascent with various accelerometer failures. The primary effort was to detect any program alarms and/or DAP problems as a result of thrust guidance incapability. The effect of loaded mass values in R03 was also investigated.

Table 1 is a time history of the manually-controlled pitch att followed in these tests. Basically, it consists of a 15-sec vertical rise phase followed by four discrete attitude changes at specified time intervals. This technique is documented in the "Manual Launch Techniques" handout from the Data Priority Meeting of 11 June as Technique II. Yaw and roll at liftoff was zero and maintained at zero throughout each ascent sequence.

Table 2 is a summary of tests executed with comments on the attitude behavior during ascent. Runs 1 and 6 may be considered calibration runs. All burns were to depletion (4% remaining on cockpit meter, 2% on 2nd floor meter), except run 3, which was a PGNCS guided burn.

Table I

TIME	
0:00	Liftoff, Vertical Rise
0:15	Pitch to 305°
1:50	Pitch to 295°
3:28	Pitch to 284°
5:46	Pitch to 262°
	Maintain this att to depletion at ~7:22

Table 2

RUN	PIPA FAILURE	DAP MASS (lbs)	RESULTANT ORBITS (nm) LGC	RESULTANT ORBITS (nm) ENVIRONMENT	COMMENTS
1	NONE	10500	482 x 9	570 x 8.8	Att Cont and procedures satisfactory
2	X SATURATED	10500	---	----	Good att hold during ascent and after insertion; bad edit
3	Y ZEROED (auto ascent)	10500	33 x 9.4	39 x 8.8	Att stability as good as nominal case
4	Z SATURATED	10500	---	80 x -11	402 Alm at TIG +10 sec V82E at 2:15 resulted in 1302 Alm and FL V37 V 16 N63 → non-static display V16 N85 → static display V82E at 4:40 → 99999 x 420 After manual Pitch to 262°, drifted to 245° (twice); att hold after third manual drive to 262° Att Stable at engine cutoff (ECO)
5	Z SATURATED	10500	----	130 x 21	402 Alm at TIG +40 sec Roll drift cw, ~10° When manually return roll to zero, get R/P cross-coupling (also occurred in run 4) V82E → no alm @ 7:00 Good att hold @ ECO
6	NONE	10500	160 x 5.6	190 x 4.9	No R/P Cross coupling No Roll or Pitch att drift from manually specified att ECO @ 7:25 N85 @ ECO = -71/-74/239

TABLE 2 (cont'd)

RUN	PIPA FAILURE	DAP MASS (lbs)	RESULTANT ORBIT (nm) LGC	RESULTANT ORBIT (nm) ENVIRONMENT	COMMENTS
7	Z Zeroed	10500	-	180 x -8.4	3 402 alarms R/P Cross coupling; some roll, pitch att drift @ECO: Pegged roll rate needle at 2 cps (fuel slosh oscillation?) N47 @ECO 8300 lbs
8	Z Zeroed	4860**	-	180 x -.3	3 402 alarms R/P Cross coupling; same roll, pitch att drift Good att hold @ ECO N47 = 4850 @ ECO
9	Z Zeroed	10500	-	205 x -10.5	402 alarm Good att hold min R/P cross coupling @ ECO: Roll att oscillation as in Run 7
10	Z Zeroed	4860**	-	190 x - 23	N47 (MASS) = 4850 at 30 sec 402 Alarm Stable att hold @ ECO

**Approximately LOASCENT

Results

(1) Z pipa failed saturated (Runs 4 & 5)

Nominal mass load and nominal procedures satisfactory for rate cmd att hold. Mass is decremented to LOASCENT within 30 seconds and attitude control is subsequently somewhat less lively than nominal. There is some roll and pitch drift evidenced and some R/P crosscoupling (not noticed with no pipa failures), but these are minor disturbances. Attitude hold at engine cutoff is nominal. 402 alarms occur.

(2) Z pipa failed zeroed, nominal mass (runs 7 & 9)

Same as (1), except a violent roll oscillation was encountered at engine shutdown, which was very difficult to damp manually or in AUTO. This is tentatively ascribed to fuel slosh with a vehicle lighter than the DAP thinks (since DAP mass decrements very slowly with zeroed Z pipa).

(3) Z pipa failed zero, mass = LOASCENT (Runs 8 + 10).

Same as (1)

(4) Auto ascent with y pipa zeroed (out of plane)

This ascent run indicated totally nominal insertion behavior.

Conclusions:

For X or Z pipas failed zero or saturated, manual ascent with P12 is satisfactorily performed with nominal procedures with two exceptions:

(a) Load N47, R1 with LOASCENT (~4850 lbs)

(b) Switch to ATT HOLD before ignition

Postscript

It has been observed in digital runs of those cases where the Zpipa is failed zero that the PGNCS will attempt to shutdown the APS at ~TIG +30 sec because its Tgo comp has reached zero. This premature off signal will not be recognized by the APS since the manual engine start pb was depressed after PGNCS ignition was verified. Further, this PGNCS off signal is sent only once, so the arm switch off* should not shut down the APS. But since these are burns to depletion, anyhow, such considerations appear to be of academic interest only.

* at Vg = 50 fps, nominally

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AG#345-69
11 July 1969

Through: NASA Resident Apollo Spacecraft Program Office
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75 Cambridge Parkway
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TO: National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas 77058

Attention: Mr. W. Kelley, (PP7)
Mr. C. Frasier

Subject: In-Flight Compensation of LM5 X-Axis Accelerometer

Ref: ISS MEMO #826, dated 11 July 1969

Gentlemen:

In response to your request on 5 July 1969 we have reviewed the possible changes to the accelerometer bias updating philosophy necessitated by the large deadzone in the LM5 X-axis PIPA. The concensus at MIT is that due to the high bias level there is a good probability no changes to the update policy are required. The recommended action in case either the bias shifts to within the deadzone limits, or the deadzone increases to levels higher than the present bias, is to perform a ΔV maneuver with no net velocity change and compare AGS and PGNCS accelerometer outputs. If this test indicates a deadzone shift, no action is necessary; if a bias change is indicated, new best-guess bias value should be loaded. The referenced memo supplies the details.

Very truly yours,

Ain Laats

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Instrumentation Laboratory
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TO: Ain Laats ISS MEMO #826

FROM: George Bukow

DATE: 11 July 1969

SUBJECT: Test Recommendations for In-Flight Compensation of LM5 X-Axis Accelerometer

The presence of a deadzone in the LM X PIPA in Apollo 11 gives rise to the possibility of no output ΔV's during the free-fall portion of the flight. This phenomenon was discussed in detail in ISS Memo #721, based on the flight experience in Apollo 7.

The last bias measurement on the LM X PIPA was +0.7 cm/sec^2. A bias of this magnitude should assure that an output will result from the PIPA during free-fall flight, even with a deadzone of 0.3 cm/sec^2. However, although improbable, bias or deadzone changes may occur such that no output will result.

In the event of no output ΔV's from the X PIPA after activation of the PGNCS in lunar orbit, an uncertainty will exist as to the operational state of the instrument and as to the proper bias value to be used during lunar landing. The following test is suggested to remove these uncertainties:

1. Thrust for 20 seconds duration[1] at low input level (2-6 cm/sec^2) along the plus LM X-axis.
2. Repeat thrust along the negative LM X-axis -- total ΔV imparted to the vehicle in (1) and (2) equal to zero.

3. During both thrusting maneuvers measure the total input ΔV on both the PGNCS and AGS systems[1].

The data obtained during the indicated thrusting maneuvers will permit a determination of the LM X PIPA bias to within a maximum error of ± 0.15 cm/sec^2. This bias value can then be compared to the prelaunch bias level and correlated with the PIPA deadzone at launch. A valid determination will thus be afforded as to the operational state of the X PIPA.

With regard to the effect of PIPA deadzone on the accuracy of lunar thrusting maneuvers, the thrusting levels are high enough to effectively mask any deadzone effects and no discrepancies are expected.

George J. Bukow

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:ctc

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1. The 20 second thrusting time requirement is necessary to put practical limits on the quantization uncertainties in the PGNCS and AGS outputs. The quantization uncertainty in the PGNCS output is ± 1 cm/sec. Per information received from Mr. Ted Broderick, TRW Systems, Inc., Los Angeles, Calif., the astronaut readout from the AGS DEDA has a readout resolution of ± 1.5 cm/sec.