



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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HOUSTON, TEXAS 77058

FEB 17 1971

IN REPLY REFER TO: 71-FC54-29

MEMORANDUM TO: Apollo 14 Flight Director
FROM : FC5/Retrofire Officers
SUBJECT : Apollo 14 postflight report

I. Problems/Resolutions.

A. Prelaunch.

1. Late updates to the SODB caused the premission weights to be invalid. The new vehicle dry weights were recomputed. With this data and the new vehicle consumables, the mass properties computations proceeded without incident.

2. Recovery reported undesirable weather in the Mode I/II areas. The decision was made to fly over the bad weather.

3. A decision to hold at T-8 mins for weather prompted a new estimate of GMTLO and redefinition of targets in the RFO Target Table to reflect the new launch azimuth of 75.56°.

B. Launch through Evasive - This portion of the flight was nominal, except for difficulty in docking during the TD and E sequence and the loss of LVDC telemetry.

C. Translunar Coast - A change in LOI ignition time, late in TLC, caused the crew LOI abort chart to be in error by ~ 4 secs for the LOI + 30_m and the LOI + 2-hr abort maneuvers. However, no further update was needed.

D. LOI/DOI - RTA₆ wall clock was in error by 14 secs as a post-LOI acquisition clock. This clock was troublesome for LM deorbit ignition. "Display" and "Network" acknowledged trouble with the hardware and did some work on it. RTA₆ was good for the remainder of the mission after LM deorbit.

E. Predescent Lunar Orbit - No major problems for the RFO.

F. LM Activation through T₃ - No major problems.

G. Lunar Stay - No major RFO problems.

H. Ascent/Rendezvous - Post-insertion (LM tweak) CSM VHF range was in disagreement with the MSFN and LM rendezvous radar by about 18 n.m. long. Retro reported the disagreement to FDO.

I. Post-docking Lunar Orbit - The RTA₆ wall clock was troublesome. See comments under I.D.

J. TEI - No RFO problems.

K. Transearth Coast/Entry.

1. The RTE digitals picked up the wrong weight for MCC₅. When TEI was history deleted from the Mission Plan Table, the RTE processor worked properly. The cause of the problem is being investigated.

2. The operational footprint at 190 hrs contained some bad weather and Raoul Island, but we predicted the final footprint would be satisfactory for landing and recommended no MCC₆ for landing area control.

3. Due to uncertainties in stowage, the final entry aerodynamics were delayed. When stowage was confirmed, the computations proceeded without incident. The waste water dump at 193 hrs was too large, but the resulting L/D was still acceptable.

II. Mission Narrative.

A. Prelaunch.

1. During the CDDT, the CMC clock was observed to have a drift. From KSC readouts, the drift for the CMC clock was determined to be .000562 sec/hr fast. The LGC was determined to be .000653 sec/hr fast. On January 30, 1971, at 00:00 GMT, the CMC was biased .02 sec slow in order that the clock be correct at lift-off.

2. After the computations were done to establish the new dry weights, the lift-off (T-6) mass properties (weights, c.g.'s, and aerodynamics) were generated without incident and loaded into the RTCC by T-3:47 (h, m).

3. Recovery reported undesirable weather for Mode I/II between 77°W (2:10 GET) and 65°W (5:50 GET) for a 72° launch azimuth. It was decided to overfly the weather if the systems were good. When the count was picked up, the undesirable weather on the new launch azimuth of 75.56° was between 76°W (2:15 GET) and 69°W (4:40 GET). The decision was also to overfly.

4. The new launch azimuth resulted in the RFO Target Table being updated.

B. Launch through Evasive.

1. The GMT of first motion was 21:03:02.566. The CMC lift-off was 21:03:02.90, which was put into the RTCC as GMTLO.

2. The launch phase was nominal.

3. The calculation of TLI+90 showed a ΔV of 8440 fps would be required to land at the AOL. This ~ 1000 fps increase over the nominal TLI + 90 (7470 fps) was due to the slip in lift-off. The 8440 solution was used since any reduction in ΔV would cause the landing time to be increased from 12 hrs GET to 22 hrs GET.

4. The RFO received a request to furnish Holloman AFB with telescope pointing data (to view Apollo 14). This request was from Mr. R. L. Schweickart through FDB SPAN.

5. After TLI and before TD and E, TM data was lost from the LVDC.

6. Several attempts and additional +X thrusting and a procedural change to automatic docking mode was required before a hard docking was achieved for TD and E. At this point, an excess of 131 lbs of RCS over the predicted amount had been used. The docking occurred at 4:57:00 GET with the crew reporting a docking angle of $+1.13^\circ$.

C. Translunar Coast.

1. Pre-MCC₂ "free return" γ_{EI} was -31.13° .

2. An SIVB Translunar MCC was required for lunar impact control. The burn was executed at 9 hrs GET as APS MCC₁ (BT $\approx 4:12$).

3. The hybrid transfer ($\Delta V = 71.3$ fps) was executed ontime as the MCC₂ that optimized EOM fuel reserves, as opposed to optimizing L.O. rev 2 prime meridian crossing time. The DPS PC+2 maneuver ΔV required to get back "free-return" was 1448 fps, which was well within the docked DPS ΔV available of 1971 fps. Computed SPS trims were used for MCC₂.

4. A (+40:02.9) GET update was executed at the scheduled opportunity (54:30 GET) in order to have onboard elapsed time and ground elapsed time within the 1-min tolerance at rev 2 prime meridian crossing in lunar orbit. This required a -40:02.9 shift in onboard GMTLO and RTCC GMTLO. The convenience of the odd seconds (in -40:02.9) allowed a return from actual GMTLO = 21:03:029 to the familiar, round number, nominal GMTLO = 20:23:00. The GET update occurred smoothly and all clocks were in sync by 55 + 37.

5. An update to the crew LOI abort chart was read up at 76:15. The following items were updated:

a. LOI GETI.

- b. Mode I 30-min T_{ig} , abort ΔV line and CSM IMU angles.
- c. Mode I 2-hr T_{ig} , abort ΔV line and LM FDAI angles.
- d. Docked DPS ΔV available line.

6. MCC₄ was executed at the scheduled opportunity as a 3.8 fps burn. The SPS burn time was 0.65 sec.

7. Retro return-to-earth status reports were made in writing to the Flight Director during each shift.

8. All TLC data by Retro (including RTE block data and telescope pointing data) were passed on time.

9. There were no significant problems with Retro items during TLC.

D. LOI/DOI.

1. The crew LOI abort chart had been updated at 76:15 and T_{ig} times for the Mode I 30-min and Mode I 2-hr aborts were still within ~ 1 sec of the final LOI time. No further update was needed.

2. LOI was executed at 82:36:43 as a 3023 fps burn. SPS burn time (6+11) was normal and the burn used system parameter SPS engine trims.

3. The AOS clock RTA_6 was wrong showing post LOI AOS 14 secs early. AOS was ontime by the GET clock.

4. Block data TEI_4 was updated because execution of the original TEI_4 would have resulted in a return trajectory outside RCS MCC capability. The post LOI L.O. trajectory was different from what the original TEI_4 was based on, because of a LOI ignition time change and ΔV growth.

5. DOI was executed at 56:50:56 as a very slight underburn. System parameter SPS engine trims were used and burn time was 20.6 secs.

E. Predescent Lunar Orbit.

1. The mass properties and trim data for descent and the circularization burn were generated with no problems.

2. Col. J. A. McDivitt requested, through SPAN, that the RFO study the TEI options to investigate how landing day, return inclination, and revolution of TEI could be varied to allow additional time between CSM/LM docking and TEI for any docking problems that could arise. The study was completed by 94 hrs GET and passed to SPAN. See the enclosure for the study results.

F. LM Activation through T₃.

1. DAP data for CSM circularization and LM PDI were computed and passed to the crew ontime.
2. At 103:25 GET, the LGC clock was updated with a -.21 time increment. This resulted in the clock being -.003 sec off from GET.
3. At 103:32 GET, an AGS K-factor update of 100:00:00.72 was made. This resulted in the AGS clock having no observable error with respect to GET.
4. Prior to PDI, the RTCC predicted throttledown time was 6+36 using a nominal thrust of 9789 lbs. During PDI, the DPS thrust was 9890 lbs. Throttledown time was predicted at 6+40 and the crew reported it as ontime. Stripchart data shows throttledown time to have been 6+21. The discrepancy was determined to be an arithmetical error.
5. Touchdown was recorded as 108:55:15 based on crew callout of contact.

G. Lunar Stay.

1. EVA 1 was carried out nominally and EVA 1 sample weights were used to compute L/D to determine if the alternate plan to bring back CSM spent LIOH canisters as ballast would be required.
2. The preliminary TEI pad was passed to the CSM at 115:10:00. Due to poor communication, the readback verification was delayed until about 121:00:00.
3. A decision was made to bring back the probe for postflight analysis. Through the efforts of the Data Management Group, the FAO, ASPO, and the RFO, the probe CM stowage point and resultant L/D were reasonably determined prior to ascent. This allowed the RFO to determine that the checklist for the retention of the LIOH canisters need not be sent to the crew for implementation.

H. Ascent/Rendezvous.

1. LM ascent stage lunar lift-off weight was well within allowed limits at 10,744 lbs.
2. AGS K-factor was computed, passed, and loaded as 140:00:00.36.
3. Lunar ascent was initiated at 142:25:42 (PNGS control) and the burn time (7+12) was normal.
4. A 10-fps LM "tweak" maneuver was executed at 142:36:51 and the LM was GO for APS TPI.

5. Post-insertion LM rendezvous radar R and R agreed fairly well with the ground, but CSM VHF R was long (by ~ 18 n.m. at 142:52).

6. LM rendezvous and docking was completed satisfactorily with a good capture and "hard-dock" by 144:13.

I. Post-docking Lunar Orbit.

1. LM ascent jettison was executed without difficulty at 146:25:00 and CSM SEP (1 fps retrograde) was normal at 146:30:00.

2. LM ascent stage deorbit was initiated at 147:54:19 at an ascent stage weight of 5103 lbs.

3. The RTA₆ deorbit ignition clock was wrong three times before LM deorbit. "Network" asked for some time to fix it. The clock was set up for the fourth time to use for LM deorbit. This clock was wrong by 14 secs as a post-LOI acquisition clock.

J. TEI.

1. New LM and CM "weight transfers" and c.g.'s were generated for TEI SPS engine trims and CM entry aerodynamics.

2. EOM TEI₃₄ and backup rev TEI₃₅ were computed with GDS X 560. The pads were ready for reading up at AOS₃₅ rev 34.

3. TEI₃₄ for 171:30W was executed as a G&N burn with computed SPS engine trims. Actual burn time (2+29) was about 1 sec long.

4. Post-TEI, MCC₅ estimate was $\Delta V = 5$ fps with the confirmed maneuver vector.

5. MCC₅ ΔV was ≈ 1 fps with a TEI + 20_m vector.

6. Recovery was "GO" to release the AOL ship because SPS ΔV remaining was insufficient to move the landing point to the AOL.

K. Transearth Coast/Entry.

1. After TEI, the landing point moved some 68 miles west from the planned landing point. This was probably due to some uncertainties and small dispersions in the TEI.

2. MCC₅ was executed to correct the entry flightpath angle from -6.97° to -6.50° . The CMC slipped the MCC₅ Tig by 8.45 sec, but the crew executed the burn at the proper ignition time although the RFO advised that a slip in ignition would be satisfactory.

3. Following MCC₅, a scheduled O₂ flow test was performed. As it was a propulsive vent, an attitude for the dump was picked to reduce trajectory effects and maintain high gain antenna acquisition. It was predicted that the vent would change the flightpath angle at entry by $+0.02^\circ$, however, the test was terminated near the midpoint of the dump. A less sensitive thrust attitude was discovered in real time, but there was insufficient time to determine and verify the corresponding spacecraft attitude, which would have changed the O₂ flow test attitude.

4. An MCC₆ was not required for corridor control. The southern constant g landing area contained bad weather. Raoul Island was at the extreme back of the northern constant g landing area. This part of the constant g landing area is based on a steep flightpath angle (-6.6°) and we were indicating -6.28° to -6.35° which would avoid Raoul Island. Since it would take a trajectory change, and failures of the G&N and the EMS, the RFO recommended that we take no action to change the landing area by using a weather avoidance SPS burn. If required, the constant g area could have been moved by flying 3.5 g's instead of 4 g's.

5. Since the probe helped to increase the L/D, the decision was made not to allow the waste water tank to be 60 lbs at EI-3 hrs but to plan the waste water dump at 193:10 to have 50 lbs at EI-3 hrs. The crew was not advised that waste water dump would be different than any other dump, and they dumped to the standard value at the flight plan time. To gain back 7 lbs of water, it was decided to close the potable tank inlet valve when the crew woke up on entry day. This procedure was passed to the crew on time, however, they did use some potable water without closing the inlet valve. The waste water at entry was about 34 pounds.

6. An MCC₇ was not required as the entry flightpath angle was -6.39° . A slightly shallow flightpath angle actually helps overcome the problems that arise due to a low L/D, i.e., possible sequencing to P65 even for short entry ranges, and CMC entry errors for the nominal weather avoidance ranges. Also, the northern constant g area was clear of Raoul Island with the final entry flightpath angle.

7. The CMC was nominal pre-entry and flew the entry nominally. The event times from 90K feet down were about 20 secs later than predicted. This difference is probably due to atmospheric and L/D uncertainties and will be investigated by the Postflight Analysis personnel. The CMC target was 27.02S and 172.65W. The CMC navigated landing point was 27.01S and 172.66W. Recovery places the landing point, using satellite navigation, at 27.013S and 172.658W.

L. General.

1. Summary of clock updates:

<u>GET OF UPDATE</u>	<u>CMC</u> <u>ΔT OF UPDATE</u>	<u>REASON FOR UPDATE</u>
54:30	+40:02.9 (M:S)	GET update to control lift-off, rev 2 prime meridian crossing time.
57:30	-.06 secs	Drift compensation for landmark tracking.
137:00	-.02 secs	Drift compensation for TEI.
194:00	-.04 secs	Drift compensation for entry.
	<u>LGC</u>	
103:25	-.21 secs	To sync LGC clock to GET.
	<u>AGS K-FACTOR</u>	
103:32	100:00:00.72	To sync AGS to LGC for descent.
141:40	140:00:00.36	To sync AGS to LGC for ascent.

2. The telescope data for observing the spacecraft and SIVB impact was generated and passed as planned. However, Denver museum of Natural History had not picked up any messages from Lowery AFB as of February 8, 1971.

3. The online mass properties is a vast improvement over the procedures used prior to Apollo 14. Control and computation in this area were exceedingly smooth.

III. Recommendations.

A. Improvements to the online RTCC mass properties processor should be considered as follows:

1. Provide the capability to input minus (-) X c.g. values on MSK0371 (LM input I) and MSK 376 (c.g. summation).

2. Provide input/output definition of c.g. to the nearest hundredth of an inch for MSK 376 (c.g. summation). This would preclude the need for offline calculations for CM c.g. definition for L/D.

3. Provide an internal c.g. transfer from MSK 376 to MSK 1620 (aerodynamics processor).

B. The LOI abort chart which is generated by MPAD premission and updated by the RFO in real time should have a formal signoff by FCD before transmittal to FCSD. This signoff should include the DPS ΔV available line (by LSB).

C. The MOCR RTA 5 and RTA 6 wall clock should be handled by the O&P for all phases except possibly lunar stay.

D. ASPO and FCSD should consider L/D during premission stowage planning. This L/D awareness could also avoid unnecessary CM ballasting. (Apollo 15 is already performance critical.) Also, ASPO should affix realistic weights to the nominal lunar samples; for example, the Apollo 14 SRC's were planned to be 65 lbs each but actually weighed 43 lbs and 29 lbs, respectively. The source of real time spacecraft component c.g. locations should lie with SPAN, however, the resulting spacecraft c.g. definition should be the responsibility of the Data Management Group.

E. Users of telescope pointing data should be required to update their requirements on a mission-by-mission basis.

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Enclosure

cc:

FC/Flight Directors

Staff

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FC5/All FDB Personnel

FM/J. P. Mayer

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FC541:CFD:JEI:BTS:ldw

Predicted SPS ΔV available is 3900 fps after the circ burn and the plane change. 300 fps should be saved for weather avoidance during transearth coast leaving 3600 fps for TEI. The following conclusions are presented:

1. TEI 36 (2 Revs late) at 153:18:00 costs 3591 fps and lands at 216 hrs. (same as TEI 34) with incl. = 40° .

2. TEI 37 at 155:17:00, with a return inclination of 60° , costs 3619 fps and lands at 216 hrs.

3. TEI 47 at 175:01:00 (1 day late) costs 3607 fps and lands at 240 hrs. at the MPL with inclination = 40° . Any TEI prior to 175:00:00 can land at 240 hours with a ΔV less than 3600 fps.

4. TEI 58 at 196:43:00 (2 days late) costs 3616 fps and lands at 265 hrs. at the MPL with inclination = 40° . Any TEI prior to 196:00 can land at 265 hrs. with a ΔV less than 3600 fps.

Chuck Deiterich Retro
94 hrs GET

151 156 161 166 171 176 181 186 191 196

GET

TEI'S to MPL

5000

1000

TEI
ΔV

3000

2000

1000

216 GETL

240 GETL

266 GETL

SPS ΔV Available

Weather Avoidance TEI Lim

○ 40° incl.
x 60° incl.

GET = 94 hrs

Chuck DeTarrich

35

40

45

50

55

60

65