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

UNITED STATES GOVERNMENT

Memorandum

NASA Manned Spacecraft Center

TO : See list attached

DATE: September 24, 1969

69-PA-T-122A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Apollo 12 Mission Techniques

On September 15 and 16 we had the second (and last) Mission Techniques meeting for Apollo 12. It was advertised to be a "catchall" and it was. It all went smoothly enough considering how many people were there - the place was stuffed (even the projection room!) - and the exhaustion and emotion these things bring. Personally, I think it was productive - lot's of agreements - and complete. This memo is to record what happened - as well as I can remember. Please excuse the length. I've drawn arrows in the margin by the things which fascinated me the most. If you don't want to read it all, follow the arrows.

Cislunar Navigation

On all lunar missions so far, the crew has performed on-the-job training of cislunar navigation (P23) while on the way to the moon. This had the additional objective of establishing the earth horizon altitude that the current command module pilot was using. Although it was suggested that this activity is unnecessary, the crew elected to include it in their flight plan as on previous flights. In fact, they may even try some star/horizon tracking on the return-to-earth phase of the mission to see how badly the sun interferes. Another associated agreement was that Apollo 12 would revert to the Apollo 10 technique for storage of spacecraft state vectors in the CMC. That is, the values transmitted from the ground would be stored in both the command module and LM slots.

LOI Targeting

It was agreed that the LOI targeting would be biased to provide a 60 n. mi. circular orbit at the time of the CDH maneuver in the nominal rendezvous, just as was done on Apollo 11. You recall there were some people who felt that aiming for a circular orbit at DOI would have been preferable. In fact, it was even suggested that procedures be developed to provide a circular orbit on both occasions.

LOI Aborts

The 15 minute SPS aborts from LOI have been dropped just like the TLI 10 minute jobby-dos.

Starting with Apollo 12, most Apollo missions do not have a complete DPS backup abort capability throughout the entire LOI burn. For example, on Apollo 12 there is a period of about 100 seconds in the LOI burn during which the DPS alone would not be able to provide a return-to-earth capability. It is possible to close this gap on Apollo 12 by augmenting the DPS with an APS docked burn. Procedures for doing this were discussed and settled upon, and a checklist is under development. One important agreement was that the crew would ordinarily use what they refer to as the "quick and dirty" procedure to execute the docked DPS burn. It is estimated to take about one-half hour to go through it. If more time is available, they will use the same procedures but will proceed at a more relaxed rate. The only exception to this occurs when two DPS maneuvers are required, the second of which is at least 15 hours after the first. In this case, they might as well go through the full-blown process of aligning the PGNCS and carrying out a targeted burn.

MIT was given the action item of confirming that the CSM DAP was okay for an SPS burn with a fully loaded LM ascent stage since under certain circumstances, it may be desirable to attempt an SPS burn before falling back on the APS.

Pre-DOI Stuff

The crew has currently scheduled four times at which they will obtain CDU angles simultaneously in both spacecraft to be voiced to the ground for precise determination of the LM platform orientation while docked to the CSM. The ground support programs and displays are said to be in working order. It is intended that prior to LOS before the undocked LM IMU alignment (P52), the MCC will relay the anticipated gyro torquing angles for comparison with the crew's P52 results. If the torquing angles they actually experience differ from these values by more than 0.5°, the PGNCS will be considered NO-GO for DOI. (Rick Nobles has the action item of confirming acceptability of that limit or of proposing a better value ASAP.) Because this procedure provides an accurate IMU drift check before DOI, we have agreed to delete the post-DOI sun check used on Apollo 11.

The crew has changed the AGS targeting procedures for the DOI burn such that they use the ground relayed pad values rather than the PGNCS N86 values. The importance of this change is that the AGS will now be targeted correctly and post-burn AGS residuals will have meaning.

DOI

The flight controllers requested that the crew call up P40 for the DOI burn before LOS and hesitate long enough for the MCC to obtain the actual intended PGNCS DOI maneuver on the downlink. They need this data when confirming the burn in the LM state vector after DOI.

As a result of the briefing by MPAD on the effects of PDI dispersions on the powered descent trajectory, it was concluded that there is never a need to trim any component of the DOI burn. This decision modifies a previous proposal that any ΔX residual in excess of 1 fps was to be trimmed. Essentially, we have established that as long as the residuals at DOI are small enough to indicate that the PGNCS/DPS is not broken (currently set at 5 fps) we are willing to absorb the residual dispersion in the descent trajectory.

DOI Abort

The Apollo 12 crew was completely unhappy with the procedure we had developed for the DOI aborts on the last two flights. It is their intention to use a guided rendezvous in this situation instead of the old brute force technique. Specifically, they will use the AGS rendezvous programs executing a TPI type maneuver at DOI + 10 minutes with a transfer time of 20 minutes. Use of this technique will result in a braking maneuver of no greater than about 30 fps, which is much smaller than the brute force technique yields and which was their major objection with it. Bob Carlton (FCD) was asked to resolve the open item of whether or not it is acceptable to attempt braking with the Z-axis RCS jets without having staged the DPS. Specifically, it was thought that this would cause considerable X-axis thrusting for attitude control which might exceed thermal constraint limits. If that turns out to be the case, we will probably modify the procedure to include jettisoning the DPS before TPI.

Point Landing

There are several new things we learned with regard to our attempt at point landing on Apollo 12. Analysis based on a typical spacecraft attitude time history shows that an estimated 0.16-lb. thrust from the LM water boiler will result in a 6,000-ft. miss. Grumman is now reporting that it may actually be more like a .25-lb. thrust. If this data is right, we are in deep trouble with a capital "S".

This basic spacecraft design deficiency, along with other unknown perturbative effects, have forced us to accept a proposal which worries a lot of us. Namely, it is now felt necessary that a final correction to the descent targeting be carried out <u>during</u> powered descent through use of the new program capability (ΔRLS) that we requested at our last meeting. Furthermore, this manual input will <u>only</u> be done at that time, never before entering P63 as we had previously planned. We put preliminary upper and lower limits in the magnitude of this correction. Specifically, it will only be applied in the downrange direction if the correction falls between 2,000 and 20,000 feet. It was felt that the accuracy was not sufficient to support smaller corrections and that the effect on the guidance makes larger corrections unacceptable. Two action items were issued on this subject. One was for me to schedule a Data Select meeting to work out precise procedures for determining the ΔRLS correction. (It was held September 17.) The other item was for MIT to concentrate heavily on testing this program change during the powered flight phase to develop high confidence that this procedure won't blow the whole mission.

Allen Klump (MIT) has recommended that some procedure be developed to determine a crossrange correction to be computed as a function of measured platform drift. And, he was promptly given the action item of finding out how to do this. I would like to emphasize that if a way can be found, it may be the solution to one of our more serious problems because current indications are that we are much worse off crossrange than downrange. It is Klump's feeling that the biggest contributor to that is platform misalignment.

It was reported that the crew set the updating AGS altitude at 7,000 feet rather than 2,000 feet which the Apollo 11 crew used. (This was a CPCB action endorsed at our meeting.)

Descent Trajectory Changes

Mission Analysis Branch briefed us on recommended descent trajectory changes, some of which have been incorporated and some of which still enjoy "proposal" status.

a. Most of the changes which could be considered for improving the DPS ΔV situation were so ineffective that they were rejected. One which deserves considerable attention, however, is the elimination of the descent trajectory constraint which provides insensitivity to a failure in the DPS propellent valves. A potential saving of about 52 fps can be obtained from this, and first indications are that most concerned organizations will agree to it. (ASPO is working on this.)

b. The only other trajectory change involves increasing the LM targeted horizontal velocity at 500 ft. altitude from 60 fps to 80 fps to increase the LPD redesignation capability. The vertical velocity at 500 ft. will remain unchanged at 16 fps. This trajectory change creates no real difference in the ΔV budget.

One particularly interesting item that came from this presentation was the refutation of a commonly held belief that it was impossible to redesignate short. MPAD shows that to the contrary substantial redesignation short is possible without unacceptable loss in visibility of the landing point. I believe this fact has quite a bearing on choosing the PGNCS target location with respect to where we really want to land and should cause a significant change in the way people have been treating this subject.

Landing Radar Operation

Four significant changes are being made to the crew procedures involving the landing radar.

a. During the pre-DOI landing radar test, the crew will not drive the antenna to determine if it will move properly. (This is an endorsement

of a recent CPCB action.)

b. The crew will not normally backup the landing radar antenna reposition command from the LGC in P64, as was done on Apollo 11. However, if the antenna fails to reposition automatically, they will attempt to manually command it. Regardless of whether this works or not, if they get a 523 alarm, it is the consensus that they should enable landing radar data to be processed during the rest of the descent by hitting "proceed".

c. A modification to the Apollo 11 procedures was previously recommended to include a landing radar test at about 9 minutes before PDI. It was for early evaluation of the landing radar as well as a direct measurement of spacecraft altitude at that time. After considerable discussion at this meeting, it was concluded that this landing radar test was really not worthwhile, and it is now recommended that it be deleted from the procedures. Because a specific LM attitude had been selected to support this test, it may be advisable to pick a new optimum value. Accordingly, Rocky Duncan was requested to work with Ed Fendell to determine this new LM attitude to be relayed to the flight planning guys.

d. The Apollo 12 crew - bless their hearts - are anxious to avoid any unnecessary diddling with the DSKY during powered descent. In line with this splendid goal, they have requested that the flight controllers monitor Δh (the difference between landing radar-measured and PGNCS-estimated altitude) and advise them when they should inhibit and when they should enable the landing radar data so that they do not have to call up that parameter on the DSKY.

Low Level DPS Propellent

The Apollo 12 crew has requested that the flight controllers call out the DPS propellent situation during hover somewhat differently than was done on Apollo 11. Whereas the Apollo 11 crew wanted a countdown of time remaining, the Apollo 12 crew has requested a call out of time since low level. Specifically, they would like reports at 30 seconds, 60 seconds, and 90 seconds since the low level indication and "commit time" - all properly biased for communication delays.

Descent Aborts

Although there were a lot of words spoken on the subject, it was obvious that descent abort techniques have been changed very little since Apollo 11. In fact, the only significant difference is the substitution of the variable insertion targeting for aborts after PDI + 10 minutes in place of a variable phasing burn one-half rev after insertion. This simplification was possible

due to a program change made to the Apollo 12 version of LUMINARY. All descent abort targeting is based on the assumption that the LM will perform some perigee-raising maneuver before going through perigee again. For aborts after PDI + 10 minutes it will be a 10 fps burn performed 50 minutes after insertion.

The tweak vs. trim rules were discussed again and it was agreed that the MCC would only relay a tweak maneuver in the event of one or the other of the following circumstances:

a. An abort after PDI + 10 minutes on the AGS (because the AGS program discontinues variable insertion targeting after that point).

b. If the PGNCS is degraded but is still working well enough to avoid switchover. (We define the PGNCS as being degraded if its trim maneuver differs from the ground computed value by more than 10 fps.)

Although all of the abort rendezvous procedures follow a pattern very similar to the nominal rendezvous there are slight differences which could create problems if they are missed. As a result, the command module pilot intends to carry along the same "Descent Abort Rendezvous Cookbook" originally developed for Mike Collins on Apollo 11. This handbook of assorted rendezvous procedures is essentially unchanged from the last flight except to reflect slight changes in the descent trajectory and new MSFN coverage times.

Lunar Surface Activities

After considerable discussion, a proposal for extending the lunar stay two hours was rejected. The advantages cited for this proposal were better MSFN coverage during ascent and a timeline less sensitive to real time extension of the EVA. On the other hand, we would either have to reduce the subsequent sleep period or delay TEI one rev in order to satisfy the photographic objective. In addition it is said to violate a mission directive limiting the stay to 32 hours, which we would have to get changed, and would delay development of the operational trajectory, crew training data package, etc. Since the current MSFN coverage is operationally adequate (although the ALSEPscientists may not agree) and the other advantages were of marginal benefit, we decided to leave it as is except to recommend that the IMU be kept powered up throughout the lunar stay as long as real time computations of electrical power confirm it is adequate. Accordingly, the Apollo 11 IMU lunar surface alignment procedures will be used without change on Apollo 12. If in real time it is necessary to power down the IMU, the only modification to the alignment procedures would be to change the first Alignment Technique 3 performed after powering up the IMU from a REFSMMAT option (3) to a T align option (4).

Due to the high inclination being used on this flight the AGS lunar surface calibration drift estimation can be in error as much as 1.3° per hour. TRW has recommended that the AGS lunar surface calibration be dropped unless the crew is able to apply some biases to the corrections, which they must input into the AGS during this procedure. It is currently planned that the crew will apply these corrections which will be provided them within a week by TRW.

Ascent

One particularly interesting piece of information reported at this meeting was that the current ascent profile assures us of losing S-band steerable antenna lock-on for the last three minutes of ascent! Wouldn't that have been a surprise? Anyway, it has been agreed that the crew will yaw right 20°, four minutes after lift-off (I now hear this should be two minutes) in order to provide solid high-gain coverage. (This, incidentally, also applies to late aborts from descent.) There is some question as to what should be done about the AGS since it does not provide a manual yaw attitude override feature like the PGNCS and thus we would lose high-gain coverage if we switch over to the AGS which would be undesirable. The crew will work with Jerry Thomas (TRW) to sort out the AGS operation. Specifically, they will input new vaues for W_b which controls spacecraft yaw attitude during a burn even though this screws up the FDAI ball. There are some obviously horrible implications on manual ascent when high-gain coverage and a window view of the horizon are both particularly necessary.

Another ascent agreement is that the targeted radial velocity at insertion will be adjusted to compensate for CSM orbital dispersions to provide a nominally zero CDH maneuver.

Rendezvous

Consideration has been given to deleting the platform alignments (P52) by one or both of the spacecraft immediately after LM insertion into orbit. Although it is agreed that these alignments are not by any means mandatory, we have decided to leave them in the flight plan. That is, both spacecraft will continue to do the post-insertion P52. To assure adequate rendezvous navigation at this critical time it was emphasized that the LM should discontinue the P52 if it has not been completed within 38 minutes before CSI. Pete Conrad indicated that they had also modified the checklist to continue rendezvous navigation to within 8 minutes instead of 12 minutes of CSI providing about four more marks.

Also associated with the rendezvous navigation was the agreement that in all cases the crew would reinitiate the W-matrix immediately after each maneuver before taking any additional observations. This applies to both spacecraft not only in the nominal case but even when the instrumentation

is operating in a degraded mode. (This is another endorsement of a CPCB action.)

The rendezvous maneuver voting logic has been changed slightly to reflect fully active participation of the AGS in place of the manual charts. In order of decreasing priority, the maneuvers will be performed as follows:

a. Burn PGNCS if it agrees with the CMC.

b. Burn PGNCS if it agrees with the AGS (or charts).

c. Burn CMC solution using whichever LM guidance system is better.

In all cases, the same ΔV comparison values are to be used as on Apollo 10 and Apollo 11.

Post-Rendezvous

After the rendezvous, the CSM makes a plane change in order to obtain photographic coverage of future landing sites. It was agreed that the crew would monitor this plane change burn using the same attitude and attitude rate limits as other maneuvers and a manual backup of engine cutoff if the burn exceeds the predicted value by more than 1 second. The EMS is not included in this shutdown logic.

Entry

G&N program changes have been made which result in a guided entry that more nearly approximates the ideal 4g tragectory. As a result of these changes, it is necessary to reduce the nominal entry range to 1250 n. mi. to assure no "up control".

Once committed to a G&N entry, we have decided not to change the target point even if the G&N subsequently fails. In order to make the landing point obtained with EMS guidance consistent with this, the EMS procedures are being modified for this specific case to include a bank reversal at 20,000 fps velocity. If the G&N has failed earlier than about EI - 10 hours, there is time to move the recovery force the 70 or 80 miles north and no EMS bank reversal will be used. This makes this EMS entry compatible with its backup - the 4g constant manual technique.

That's it for Apollo 12. Bring on 13!

Howard W. Tindall, Jr.

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