UNITED STATES GOVERNMENT

Memorandum

NASA Manned Spacecraft Center

TO : See list attached

DATE: December 17, 1969
69-PA-T-149A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Apollo 13 Mission Techniques are in good shape

On December 5 we had what I expect to be our last full-blown Mission Techniques meeting for Apollo 13. This memo is to tell you about it.

As you probably know, the recovery people would like to move the end-of-mission landing point closer to their support base in Samoa. Accordingly, the TEI and entry targeting will be aimed at 172° W rather than the 165° W longitude used on previous missions. The Retrofire Officer pointed out that this change does not apply to the targeting for all the block data nor will it be used if due to a G&N failure it is necessary to perform the TEI maneuver with the SCS. In these cases they want the landing point well clear of any land at all and they'll use the old mid Pacific line. A more important change, from the crew's standpoint, was their agreement to be prepared to fly the EMS and 4 g manual backup techniques, banking either to the north or south. On previous missions they have only been prepared to go north. The reentry planning people (MPAD) felt that this additional capability was required since the more westerly landing site is close to a bunch of islands and could get us in a bind if we were not prepared to go either way. Unlike previous missions, steering to the south will be the prime mode unless land or weather is unacceptable there. I would like to reemphasize that all this only applies to entry without the G&N.

One of the techniques that is significantly changed on Apollo 13 deals with LM IMU alignments and drift checks. The change is due to: a) we are undocking 1 rev earlier, which makes it impossible to carry out an accurate inertial alignment while docked like we did on Apollo 12, but it does permit two undocked AOT alignments; b) the smaller size of the acceptable landing site makes it necessary to reduce the allowable drift rate about the vertical (x) axis since that results in an out-of-plane dispersion at landing. Until this flight we used a limit selected to protect against continuing the mission with a broken IMU. We must reduce this limit now to make sure the guidancesystem will deliver the LM to within the 1 kilometer radius of the desired landing point for both crew safety and mission success reasons. The final result of our deliberations, at this meeting and at a subsequent meeting, yielded the following technique. We concluded that by far the most accurate drift determination could be carried out by comparing the LM system to the CSM while still docked to the CSM. Accordingly, we will use that data to determine whether or not it is necessary to update the IMU drift compensation in the LGC and to determine the new compensation values. If new compensation is required, it will be uplinked from the ground prior to the first undocked AOT alignment. We will then confirm that the IMU is operating acceptably to proceed with descent based on the torquing angles calculated at the second undocked AOT alignment. (I am writing a detailed description of all this for those interested in more detail.)

As a result of the excellent landmark tracking the Apollo 12 crew carried out, we feel confident we know the Apollo 13 landing site location accurately enough to recommend the following mission rule: landmark tracking is not mandatory for descent. Obviously we intend to use whatever landmark tracking is obtained and plans call for attempts to be made in both revs 12 and 13. The point is that if for some reason we do not get this tracking, the landing should not be delayed. Although this data will significantly reduce dispersion, we do not need it badly enough to go an extra rev thereby clobbering both crew and ground procedures.

By far the most emotional discussion of all involved monitoring of the CSM DOI maneuver. The basic question was, should the EMS be included in the monitoring techniques? Our final resolution was that it should not and that the CSM DOI monitoring would be carried out exactly as was done during LOI_2 on all previous lunar missions. Namely, the G&N will be given every opportunity to do its job and the crew will manually command engine off if either the predicted burn time is exceeded by 1 second or the G&N itself indicates that an overburn is occurring because the automatic cutoff failed to get through for some reason. In the event the burn is apparently completed satisfactorily but the EMS indicates an overburn, it will obviously be necessary to convince ourselves beyond a question of a doubt that the EMS is wrong and that the G&N has achieved the targeted orbit. This determination will be made by the crew's observation of time of earth rise above the lunar horizon compared to a prediction provided by the ground before DOI. The details involved in this ground determination must be worked out and the technique will be rehearsed in flight during the lunar orbits before DOI. (For your information, a 1 second overburn will produce an extra 10 fps which just results in lunar impact. Earth acquisition time will be delayed 14 seconds due to a 1 second overburn thus it is this kind of time difference the crew must be able to discern with absolute confidence.) If an overburn actually occurs, the crew is to make canned SCS/SPS posigrade maneuver of 100 fps. Execution time is 30 minutes after DOI.

MPAD currently predicts that the perigee and apogee altitude should only change about $\frac{1}{4}$ mile between DOI and PDI. It is their estimate that at DOI they will be able to predict the PDI altitude to within 9,000 feet. Associated with this was a discussion regarding necessity for trimming DOI residuals, which also affects the PDI altitude. It was decided to trim x to within .2 fps and z to within 1 fps. However, since then we have reconsidered and agreed that the rule should be to trim both x and z to within 1 fps. Out-of-plane (y) is not to be trimmed at all. The objective of this is to make it almost certain that trimming will not be required since we want to save the RCS and it is not really necessary.

You are probably well aware of the special effort we have been making to reduce trajectory perturbations as much as we could. Our objective was to improve the ground targeting for the descent to provide a pinpoint landing capability. We have now proven, both analytically and on Apollo 12, that we are able to compensate for these perturbations by use of the targeting update (ΔRLS) during powered descent. It also seems unlikely that we are ever really going to be able to eliminate the perturbations. That is, we must plan on continued use of ΔRLS. If we accept this as a fact of life, there is no justification for fixing the LM vent in an attempt to make it non-propulsive. It is also possible to live with venting from the CSM water boiler if the systems people decide it's necessary to run it, although it is certainly better if we don't have to. One thing for sure. If the CSM G&N performance degrades due to the higher operating temperatures, we must make sure that that is not worse than venting on the overall trajectory control problem.

Although the Apollo 13 LM LPD is supposed to have been fixed to compensate for the effects of LM bloating, we concluded that it is still desirable to check it in flight as was done on Apollo 12. A change had been made in the LM's computer program to take into account misalignment of the LPD. We established a rule that if the in-flight check shows that the LPD is off by more than 1^{o}, in either pitch or yaw, the ground will update the parameters in the erasable memory. MIT was requested to inform the MCC Guidance Officer exactly how this is to be done.

We discussed establishing an alternate flight plan to be used in the event LM/CSM separation is delayed for some reason, but finally concluded that it could best be worked out in real time. It seems, as a rule of thumb, that delays in separation of up to 40 minutes could be tolerated fairly well - beyond that would probably require delay of the descent for an extra rev.

Descent aborts are a little different than on Apollo 12 because the earlier undocking changes the CSM/LM separation distance substantially. Actually, the situation is better. During the first 5 minutes and 40 seconds of descent a 2-rev rendezvous is required; after that it changes to 1 rev through T_1. T_2 is 2-rev and occurs at about 20 minutes and 45 seconds after PDI. (This compares favorably to Apollos 11 and 12 when we had a 1-rev rendezvous through 10 minutes, then 2 revs through T_1 and 3 revs for T_2!)

Aside from some rumbles about knocking 2 hours out of the rendezvous, Apollo 13 techniques seem pretty firm. Although I'm sure there'll be the typical diddling til the flight, we probably won't get together again.

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