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UNITED STATES GOVERNMENT

Memorandum

NASA Manned Spacecraft Center

TO : See list attached

DATE: September 29, 1969

69-PA-T-123A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Status report on Apollo 13 Mission Techniques - or "Go for CSM DOI"

Based on the September 23 Mission Techniques meeting, it appears that the command module DOI type mission should be adopted for Apollo 13. At this meeting we reviewed all facets of this approach and could find none that would keep us from going this way; on the other hand, the advantages appeared to be substantial. As a matter of fact, it appears to me that the mission techniques for Apollo involving a CSM DOI are essentially almost complete - long before the mission. I would particularly like to bring your attention to the fine work that Bob Lindsey has done in the development of the detailed flight plan. This had a very important part to play in proving feasibility of this approach and it appears to be in excellent shape. Our next step is to present our plans to the CCB for their approval.

As you recall, it is our desire to place the CSM/LM into the pre-descent orbit on LOI day. In fact, the LOI maneuvers should be designed to accomplish this. There appears to be no reason why they couldn't. In fact, one of the more important decisions made yesterday was to rename the LOI maneuvers: the terminology LOI_1 and LOI_2 will be discontinued and LOI and DOI will be used instead. The current plan is for LOI to do the job of LOI_1 - that is, to provide an intermediate lunar orbit of about 60 by 170 n. mi. DOI will achieve the combined objectives of the old LOI_2 and DOI; that is, it will bring the spacecraft into a 58.5 by 7.5 n. mi. orbit. It is this shape, according to Math Physics Branch (MPB) of MPAD, which will precess to the desired 58.6 by 7.8 n. mi. orbit at the time of PDI about 1 day later. Incidentally, this was a point of particular interest to us. MPB expressed considerable confidence in their estimate and are convinced that the orbital altitudes will never become dangerously low but will only vary a little over this period. MPAD also confirmed that there is no problem in targeting the new DOI maneuver. Apparently, the computational procedures do not differ from those used for LOI_2.

Considerable discussion was devoted to monitoring DOI and providing a contingency bail-out technique for a G&N failure that produces an overspeed. Although this work is not complete, it seems that procedures which guarantee safety can be developed. This is true in spite of the fact that an overburn of only 1 second will result in lunar impact which means there is no way for the crew to insure a safe DOI, at least in the sense that it is insured for the old LOI_1 and LOI_2 maneuvers. On the other hand, since the crew can certainly prevent overspeeds in excess of 40 or 50 fps, it is only necessary to provide a contingency, canned maneuver to be executed which will preclude lunar impact if an overspeed in this range has occurred. Accordingly, we reached agreement that the crew will give the G&N a chance to do its job and will not manually shut the SPS off until burn duration was at least 1 second longer than predicted. If the crew is unsure about whether a G&N failure has occurred, they will properly orient the spacecraft and prepare for the contingency maneuver while awaiting confirmation from the ground after AOS as to whether they have a safe or unsafe situation.

The next question concerned the possible magnitude of the dispersion at PDI if no adjustment (trim) maneuver were provided between DOI and PDI. More to the point, the question was whether a trim maneuver must be included in the nominal flight plan. On lunar missions so far, the altitude dispersion, which is the only one of significance to us, has averaged about 630 feet per revolution. (The largest was 900 ft. per rev.) If this is a one sigma value, the largest dispersion that should be expected in altitude at PDI on a three sigma basis is about 23,000 feet. We tried to think of all the possible adverse effects on descent which could result from a known altitude dispersion at PDI. These included guidance capability, landing radar availability, crew visibility, onboard and ground monitoring, crew training, effects on aborts, and ΔV costs. Of these, only the last seems to be effected significantly, and even that one is not too bad. Specifically, it appears that if we arrive at PDI 20,000 feet higher than we desire, the DPS ΔV penalty is in the order of 35 fps. If we are 20,000 feet low at PDI we actually save about 16 fps. Based on all this, we concluded that it did not seem necessary, or even desirable, to include a trim maneuver in the nominal timeline but we would establish a contingency procedure to handle excessive PDI altitude dispersions. Thus, if during the crew sleep period MCC predicts the altitude at PDI will be outside of acceptable limits, the crew will be awakened 30 minutes early in order that they may make the small CSM RCS maneuver required. Initially, we have established the acceptable region of acceptable PDI altitude to be between 30,000 and 70,000 feet (the nominal, you recall, is 50,000 feet). The RCS burn objective would be to raise the altitude, if too low, to 30,000 feet (since it's wasteful and unnecessary to go higher) or if it is too high, to lower it to 50,000 feet.

The Flight Crew Support people have revised the LM activation and checkout timeline extensively from the Apollo 11/12 baseline. Since we are undocking one rev earlier, a special attempt has been made to move as many activities as possible from before undocking to after undocking. By doing this, and slightly reducing the crew eat period, it is only necessary for the crew to start their work period 30 minutes earlier than on Apollo 12. Those of you interested in specific details should get in touch with Bob Lindsey.

Some of the activities we spent a good deal of time reviewing dealt with undocking, LM inspection by the CMP, and the separation burn. It had already been agreed that the LM inspection by the CMP could be substantially reduced unless there had been some earlier indication of problems in landing-gear deployment. This being the case, it seemed desirable to combine the separation burn with the undocking. Accordingly, we proposed that with the spacecraft in the undocking attitude (i.e., X-axis along the local vertical with the CSM below the LM) a soft undocking would be executed, followed by a CSM -X RCS 1 fps by the command module using P47 to set up a separation rate. It is noted that the sun will be behind the LM but this was felt to be acceptable. Separating like this will place the CSM in front and above the LM three-quarters of a rev later at the time of his circularization burn.

Having moved the separation maneuver earlier like that, the CSM is relatively free to perform landmark tracking on the landing site while in the pre-PDI low orbit two revs before PDI. The longest discussion of the day dealt with whether or not they should do this. It was clear from the start that it would not contribute much, if anything, to the Apollo 13 operation, but on the other hand, it provides sort of a free opportunity to gain valuable experience which could be used for planning a future mission. Final resolution was that it would be included in the current timeline with the understanding that it was not a mandatory requirement. If simulations show that it interferes with required activities, it will be dropped.

It is very interesting to note the relatively unbusy timeline the LM crew has after undocking. And that's nice. In spite of that, we are proposing to delete two other activities from this period. The first is the LM rendezvous navigation (P20), primarily because it requires extra LM attitude changes with the possibility of perturbing its orbit. The second was a test of the landing radar during the last pass over the landing site which would also provide an opportunity for mapping out the lunar terrain on the approach path to the landing site. Although, intuitively, it sounded like nice data to get, nobody could offer a concrete use for it and so it was dropped.

One item that I am sure will be getting plenty of attention by the time you read this deals with the crew's request to change the mission profile in order to provide a higher sun-elevation angle during descent. Everyone, Jim Lovell in particular, is concerned about using the old minimum sun-elevation angle constraint when going into a mountainous region like Fra Mauro. The whole area is likely to be bathed in shadows and that sounds poetic but like bad news. MPAD and others should be looking into the tradeoffs in terms of SPS ΔV required and translunar transient time, etc. to relieve this undesirable characteristic.

Another thing that gets changed by the CSM DOI is descent abort. This is brought about by the fact that we really do not have confidence that CSM landmark tracking can be done in the low orbit. Accordingly, we have scheduled CSM circularization $1\frac{1}{2}$ revs before PDI. This makes the abort situation from powered descent different from on previous flights. Specifically, it will be essentially identical to descent aborts from the second PDI opportunity on Apollo 11/12. I don't feel that this is a particularly bad situation. As a matter of fact, aborts from hover are actually better - that is the resulting rendezvous is more nearly nominal than aborts from hover on a first opportunity Apollo 11/12 descent. One thing we are looking into is a use of the variable insertion targeting capability such that aborts early in powered descent would take an extra rev to rendezvous, in order to obtain navigation tracking data before CSI.

In summary, I think we can proceed with this plan with confidence. There is plenty of detailed work to do primarily regarding the DOI monitoring and contingency procedures. However, many products like the flight plan are in good shape today. Unusual, but nice, this far before the flight date.

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