NASA0001

TINDALIGRAMS
JANUARY - JUNE 1968

LOAD FACTOR TIME HISTORIES USING THE CONSTANT ø CONTROL MODE

V = 36 000 FPS ENTRY

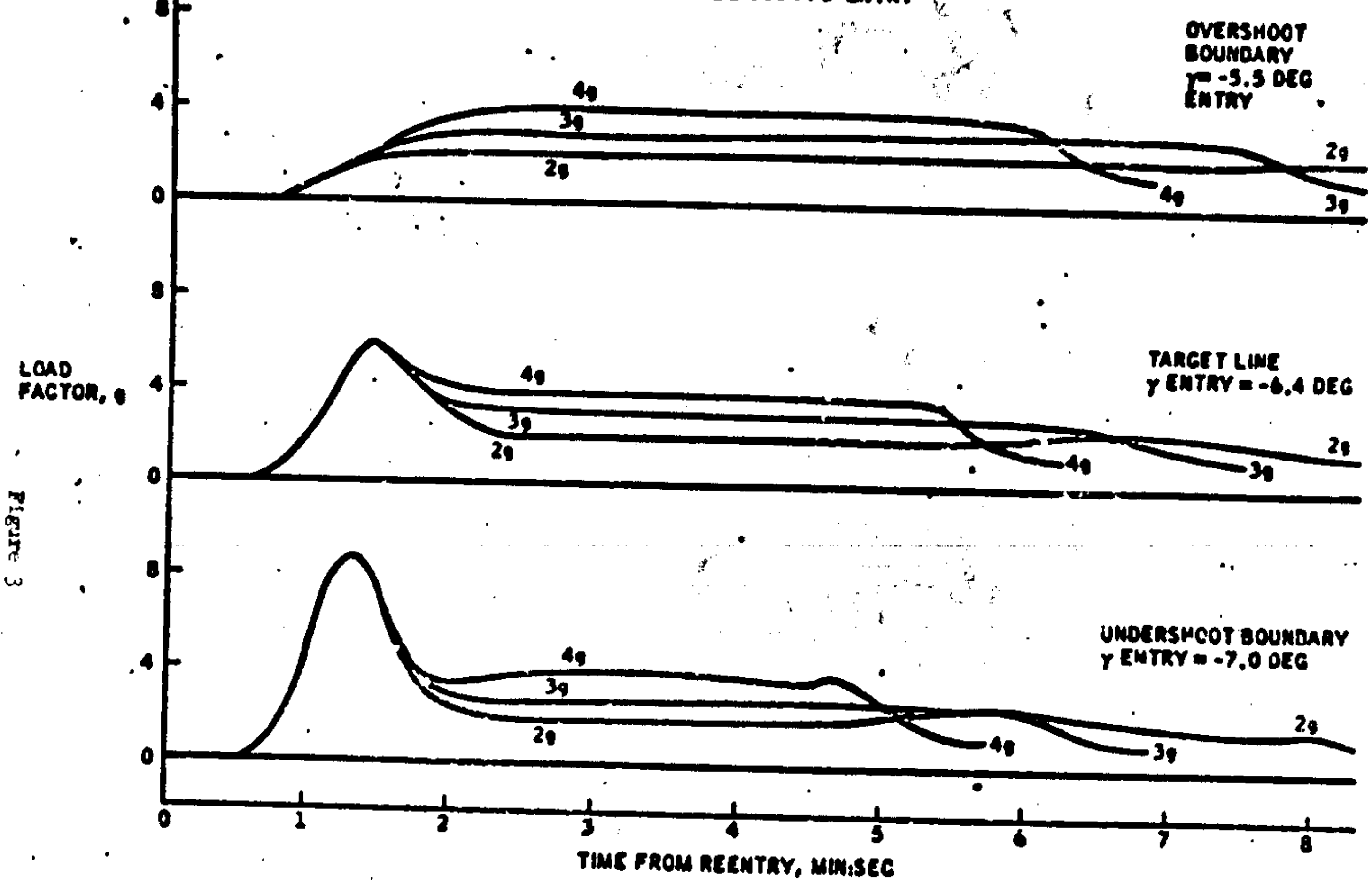


Figure 3

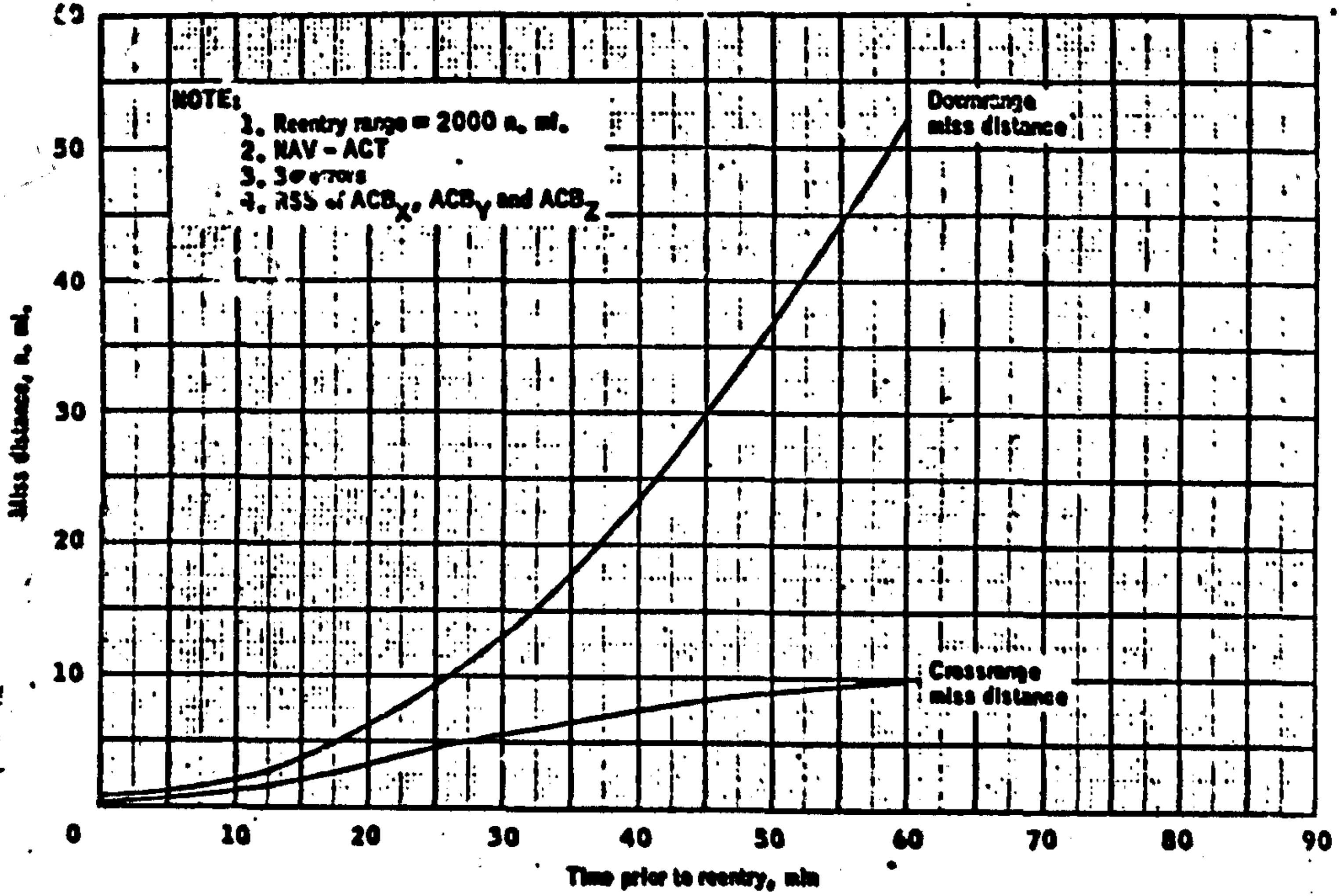


Figure 4.- Effect of time to start processing accelerometer data on miss distances.

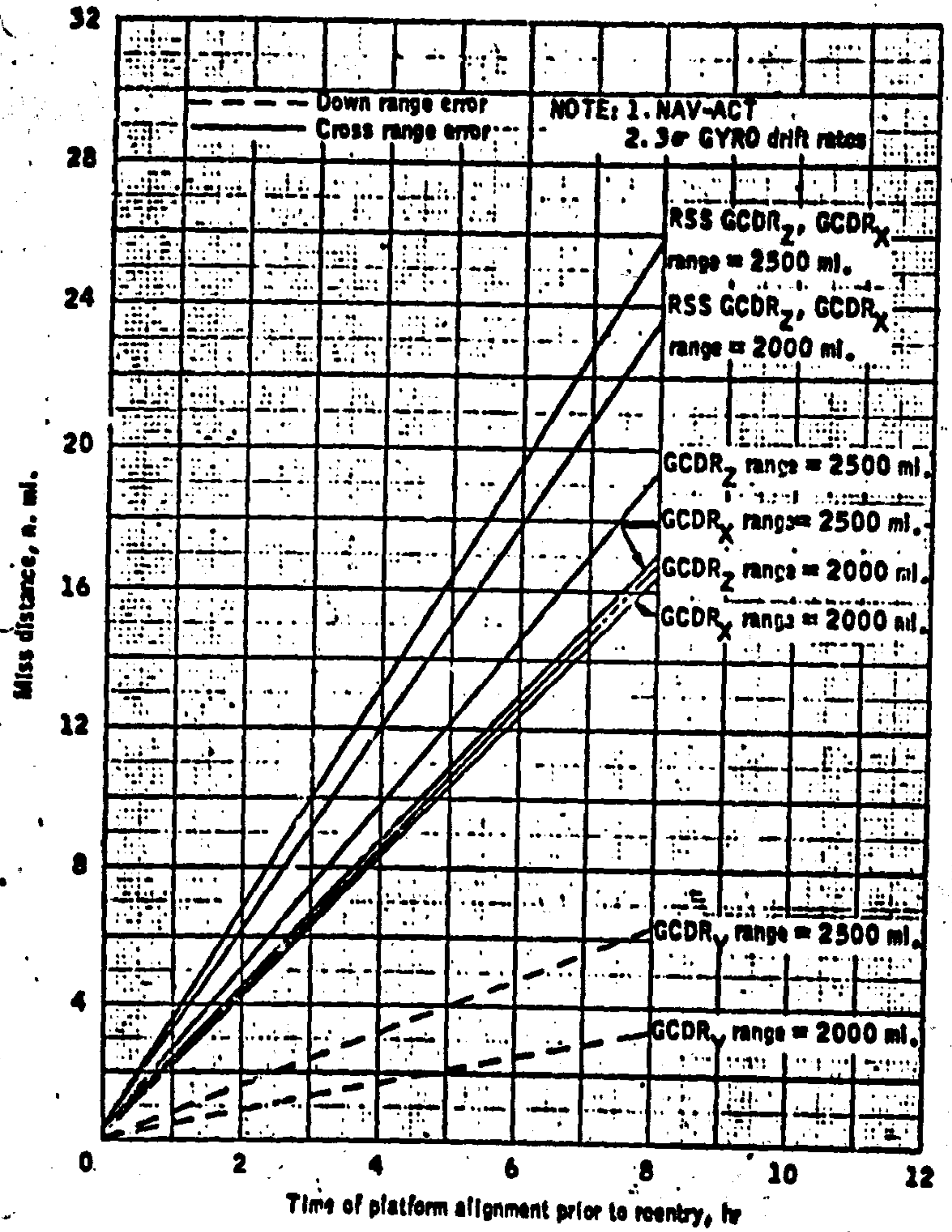


Figure 5 - Effect of platform alignment time on miss distances.

REENTRY PROCEDURES

EVENT	TIME FROM 400 000 FT MIN:SEC	MONITORING PARAMETER	PROCEDURE	CREW FAILURE PROCEDURE
PROGRAM 63	≈ -20:00	CMC PREDICTED V, γ AT ENTRY INTERFACE	COMPARE CMC V, γ WITH GROUND COMPUTED DATA FOR NAVIGATION CHECK	CONSTANT g MODE IS COMPATIBLE WITH PRIMARY G AND N - IN EVENT OF FAILURE FLY CONSTANT g TO PLA 2
.05g	≈ 0:30	● CMC PROGRAM CHANGE FROM 63 to 64 ● CMC CORRIDOR VERIFICATION ● EMS V, g TRACE	● VERIFY PROGRAM SEQUENCING ● COMPARE CMC DECISION WITH GROUND DATA TO DETERMINE INITIAL BANK ATTITUDE ● MONITOR PROGRESS OF EMS V, g TRACE TO DETECT REQUIREMENT TO REVERSE INITIAL BANK ATTITUDE	CONSTANT g MODE IS COMPATIBLE WITH PRIMARY G AND N - IN EVENT OF FAILURE FLY CONSTANT g TO PLA 2
2g	≈ 0:56	● EMS V, g TRACE AND DSKY DISPLAYS	● MONITOR DISPLAY OF BANK COMMANDS, g, AND Ṙ	CONSTANT g MODE IS COMPATIBLE WITH PRIMARY G AND N - IN EVENT OF FAILURE FLY CONSTANT g TO PLA 2
Ṙ = -700FPS	≈1:24	● CMC DSKY DISPLAY OF Ṙ ● EMS V-: TRACE	● MONITOR FOR Ṙ = -700 FPS TO ANTICIPATE PROGRAM CHANGE FROM 64 TO 65 ● MONITOR EMS FOR VIOLATION OF EXCESS g OR SKIP LINE	CONSTANT g MODE IS COMPATIBLE WITH PRIMARY G AND N - IN EVENT OF FAILURE FLY CONSTANT g TO PLA 2

Figure 6

REENTRY PROCEDURES (CONCLUDED)

EVENT	TIME FROM 400 000 FT MIN:SEC	MONITORING PARAMETER	PROCEDURE	CREW FA… PROCE…
VL SOLUTION G AND R – GO – NO GO DECISION MADE AT THIS TIME	~ 1:46	● CMC PROGRAM CHANGE FROM 64 TO 65 ● CMC VALUES OF VL, DL ● EMS V, g TRACE	● VERIFY PROPER CMC PROGRAM SEQUENCING ● COMPARE CMC VL, DL WITH GROUND COMPUTED VALUES FOR ACCEPTABILITY OF SKIP CONDITIONS ● MONITOR EMS SKIP AND g LINES	CONSTANT… COMPATIB… PRIMARY G… IN EVENT C… FLY CONST… TO PLA 2
UPCONTROL	~ 1:46 TO 4:00	● EMS V, g TRACE	● MONITOR EMS V, g TRACE FOR VIOLATION OF SKIP OR g LINES	● FLY CONST… IMPACT BE… PLA 1 AND… ● FLY EMS R… TO PLA 1
KEPLER	~ 4:00 TO 5:40	CMC CALCULATED TRIM ATTITUDE	VERIFY THAT CM IS IN TRIM ATTITUDE FOR SECOND ENTRY	FLY EMS R… TO PLA 1
SECOND ENTRY	~ 5:40 TO ~ 11:00	● EMS EXCESSIVE g LINES ● CMC RANGE ERROR DISPLAYS	● MONITOR FOR HIGH g ENTRY ● MONITOR CAPABILITY TO REACH TARGET	FLY EMS R… TO PLA 1

Figure 7

ATTENDEES

M. Collins	CB
T. Guillory	CF
W. E. Hayes	CF
W. W. Hinton	CF
T. R. Lindsay	CF
J. Rippey	CF
C. T. Hackler	EG
C. Paulk	EG
B. Reina	EG
R. J. Ward	PD
H. W. Tindall, Jr.	PA
W. C. Hendrickson	FC
H. C. Johnson	FC
J. S. Llewellyn	FC
R. F. Polmamteer	FC
H. E. Granger	FL
G. L. Richeson	FL
J. C. Adams	FM
J. H. Boynton	FM
J. K. Burton	FM
R. S. Davis	FM
M. E. Donahoe	FM
J. C. Harpold	FM
C. A. Graves	FM
R. E. McAdams	FM
R. M. Moore	FM
M. P. Frank	FM
J. D. Yencharis	FM
G. R. Sabionski	FS
I. Bogner	Bellcomm
I. S. Johnson	MIT
R. North	MIT
B. C. Johnson	NR
C. R. Belton	TRW
R. Boudreau	TRW
G. C. Hitt	TRW
J. E. Land	TRW

Enclosure 8

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: MAR 13 1968

68-PA-T-79A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Seventh "C" Mission Rendezvous Mission Techniques meeting

1. Except for the first item listed below, the entire "C" Mission Rendezvous Mission Techniques meeting of March 8 was devoted to the terminal phase. Based on the very great importance FCOD is putting on proper lighting during the braking phase, a proposal is being considered for including another little tune up maneuver between NSR and TPI. I mention this here to make sure you don't overlook it since it is a rather significant item.

2. Considerable attention is being given by those responsible to lengthening the "C" mission launch window. Apparently, the constraints for the beginning and end of this window are almost solely associated with lighting, and MPAD is in the process of compiling all of these constraints on a single plot. It will probably be used as a basis of determining nominal lift off time and launch window duration as a function of launch date. One constraint, which should be included, is of particular interest to our "C" Mission Rendezvous Mission Techniques Panel. Namely, a period of darkness is mandatory between the NCC2 and the NSR maneuver in order to provide an opportunity to fine align the spacecraft platform in preparation for the sextant rendezvous navigation and actual execution of the terminal phase. Specifically, darkness must be available during the period from NCC2 plus 5 minutes until NCC2 plus 20 minutes. Of course, if in real time conditions prevent making this platform alignment the rendezvous would not necessarily be abandoned. The point is this constraint should be considered mandatory for launch but not mandatory for rendezvous. This constraint has been relayed to the MPAD mission engineer.

3. Now, on to the terminal phase. Our first discussion dealt with the use of the TPI crew charts. It is FCSD's desire to prepare and utilize TPI charts on the "C" mission rendezvous in very much the same way as they were used on Gemini. That is, they will develop procedures for the crew to obtain an onboard solution for TPI based on both the charts and closed loop PNGCS results. It is this integrated solution which would be compared to the MSFN for determining whether the onboard or ground solution should be utilized for TPI. The exact procedure for all of this will be the subject of further meetings. An important point to be made, however, is that onboard TPI charts do play a part in the "C" mission. This was questioned since apparently on the "D" rendezvous, there is some indication no TPI charts will be used in the command module since the one-man crew is too busy with Sundisk to work them.

4. As you know, it is intended that the TPI solution always be based on a particular elevation angle of the target vehicle with respect to the local horizontal. The value to be used now and forever more on the "G" mission shall be 27.45°. The onboard charts have been developed in accordance with this and it is FCSD's desire that all future reference trajectories, mission planning, etc., use this same value. All other organizations have agreed to go along with this, however, Ed Lineberry's people (OMAB) are emphasizing the fact that using this value of elevation angle will nominally result in a situation where the TPI thrust vector will not be along the line of sight to the target. It is expected to deviate by about 6° from that alignment and everyone should clearly understand that at this time. Furthermore, some consideration had been given to actually modifying the value of elevation angle to be used in real time as noted in last week's minutes. It had been reported that an adjustment in the elevation angle in the order of ½°, to be determined at the beginning of the rendezvous exercise, would insure that the thrust vector for TPI would have been along the line of sight. However, FCSD maintains this would foul up the charts and that they were more anxious to avoid that than to maintain that particular thrust alignment during the mission. Accordingly, no further consideration will be given to changing the elevation angle from 27.45°, either in advance of the mission or during it with the single, possible exception discussed next.

5. In response to last week's action item, FCSD reported that lighting conditions during braking have a higher priority than sticking to the 27.45° TPI elevation angle. The important point to be made here is that trajectory dispersions could cause the TPI time, based on the 27.45° elevation angle, to slip to such an extent that lighting at braking would be unsatisfactory. There are apparently two alternatives which can be considered to avoid this from occurring. One is a real time adjustment in the TPI elevation angle as it becomes apparent that the TPI maneuver has slipped beyond acceptable limits and the other is a new proposal by Ed Lineberry that a small adjustment maneuver be made between NSR and TPI to return conditions to nominal at both TPI and braking. The rest of this memorandum is devoted to these two alternatives.

(a) Alternate One. Immediately after the NSR maneuver the crew takes about 10 sextant observations of the S-IVB to update its state vector, and then calls up the TPI targeting program (P-34) to obtain the TPI time. It is anticipated that this onboard solution for TPI time based on when the CSM will arrive at the position giving the desired elevation angle should be quite accurate. That is, all previous computations were based on ground determined state vectors which have a relatively large error in determination of TPI time. The onboard determination using sextant observations should be an order of magnitude more accurate. Accordingly, at this time in the [illegible] we would have our first accurate indication of TPI time. The crew [illegible] compare this TPI time with the ground relayed [illegible] of darkness [illegible] slipped excessively such that lighting during [illegible] be unacceptable. In the event the slip is excessive the crew would terminate and recall P-34 utilizing the "time option" to determine the elevation angle consistent with an acceptable TPI time. Since it is necessary to utilize the "elevation angle option" in P-34 to permit a comparison of the onboard and ground solutions, the crew would have to terminate and recall P-34 using the elevation angle just determined as an input. They would also have to relay that value of elevation angle to the ground for their computations. Obviously, the thrusting would not be along the line of sight nor would TPI occur at 27.45°, but proper lighting conditions at braking would be assured.

(b) Alternate Two starts out the same way as One. That is, the crew updates the S-IVB state vector using the rendezvous navigation system and determines the TPI time and its slippage. Then, using this value of slippage they should be able to make a simple computation to determine a maneuver to adjust the TPI back to nominal time while retaining the nominal elevation angle. This maneuver would be horizontal and inplane to be made 30 minutes after NSR, probably using the Average G program (P-4_). The Orbital Mission Analysis Branch (formerly Rendezvous Analysis Branch) was given the action item of determining the computational technique or chart giving maneuver magnitude vs. desired change in TPI time. Since it is expected to be in the order of 1/3 fps for each minute TPI time change desired, and since we are talking about TPI time adjustments less than 15 minutes, the maneuver should be less than 5 fps. FCSD was asked to work out a detailed timeline which includes this maneuver to see if it presents any problems. One thing we are particularly interested in is whether it should be done as a standard procedure regardless of whether TPI time slippage was acceptable or not, or if it should only be done if some limit has been exceeded. Assuming the procedure is not too complex, my personal preference would be to make it a standard procedure. Phil Shaffer expects to spend some time next week with the "C" crew at the Florida AMS and will discuss this with them at that time.

6. Consideration has been given to having the crew call up the TPI targeting program (P-34) immediately after NSR in order to determine TPI time in order to set the spacecraft clocks. Currently the concensus is that this is not a useful operation and it should be dropped from the timeline.

7. As you can see, we are really getting into the fine detail on the "C" rendezvous and I predict that if we spend the next two or three sessions going through the mission techniques flow charts, we will be ready to call in the rest of the world and we could then ice this whole thing down within the next couple of months. Right now I expect the next meeting will be devoted to the review of the flow charts.

Howard W. Tindall, Jr.

Enclosure
List of Attendees

Addressees:
(See attached list)

ATTENDEES

D. K. Mosel	CP
D. W. Lewis	CP
S. L. Davis	FC
W. S. Presley	FC
P. C. Shaffer	FC
O. P. Walsh	FC
E. C. Lineberry	FM
R. R. Regelbrugge	FM
K. A. Young	FM
H. W. Tindall, Jr.	PA
W. Haufler	MAC
R. Boudreau	TRW
W. Hetrick	TRW
J. W. Wright	TRW

Enclosure 1

UNITED STATES GOVERNMENT

Memorandum

DATE: MAR 12 1968
68-PA-T-57A

TO : See list below

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Sixth Midcourse Phase Mission Techniques meeting

1. The Midcourse Phase Data Priority meeting of March 6 was devoted to the earth orbital phase evaluation of guidance systems to make the trans-lunar injection (TLI) Go/No Go decision. It was reported at the outset that a new set of ground rules have been established with regard to this subject. They are:

(a) A TLI maneuver will not be attempted if there is any indication that the S-IVB IU guidance system is not working properly.

(b) A properly operating CSM PNGCS is not mandatory for TLI. That is, it is acceptable to make a TLI maneuver with a failed CSM PNGCS if the subsequent alternate mission is considered more valuable than remaining in earth orbit.

Rationale for these ground rules is given in Memorandum No. 68-PA-T-56A (H. W. Tindall), dated March 7, 1968. The manner in which we may detect S-IVB IU failure is also presented in that memo and is partially reproduced in this one to make the rest of it more understandable.

2. There are two sources of S-IVB IU failure indication. The first is by the S-IVB's own failure detection system which indicates failures via telemetry. The second is by comparison with the CSM PNGCS and MSFN tracking. These comparisons, it must be emphasized, are extremely gross. That is, the S-IVB IU is designed to be at least an order of magnitude more precise than the CSM PNGCS and the MSFN. Thus, these monitoring systems---telemetry, CSM, and MSFN---do not provide data to prove that the IU is performing normally but rather are only able to show us when it has degraded very badly---for example, 30 to 100 sigma! Whereas, MSFC's definition of a definitely and absolutely broken IU is anything beyond 3 sigma. Therefore, the actual limits we would select for TLI Go/No Go based on the S-IVB IU performance evaluation can only be the smallest, dependably, detectable failure. That is, we would use the smallest failure which we can confidently attribute to the S-IVB rather than the comparison system itself. Deviations in excess of that amount are certainly true S-IVB IU failures and would result in a No Go for TLI.

3. At this meeting we added another ground rule regarding guidance systems checks prior to TLI. The question was whether or not the sextant and scanning telescope are mandatory for TLI Go/No Go. If they were it would be necessary for the crew to check them out. However, analysis performed by MPAD has shown that LM PNGCS alignment with the AOT and undocked COAS alignment of the PNGCS and SCS can be accomplished with sufficient accuracy to assure safe return to earth after TLI. Accordingly, as of this time we are proceeding under the assumption that checkout of the sextant and telescope need not be performed prior to TLI. If you do not agree with this decision, you should say so immediately.

4. In accepting these ground rules neither a platform alignment nor [illegible] check need be included in the timeline. Therefore, it should be possible to establish a monitoring technique which would permit performing TLI on the first opportunity even for an Atlantic injection (i.e., about 100 minutes after lift off). The technique would be to compare the CSM PNGCS and the S-IVB IU during the launch phase and perhaps in earth parking orbit. If this comparison is favorable, it can be assumed that both the S-IVB IU and the CSM PNGCS are performing well and we would execute TLI. If the comparison were not within those limits, one of the systems must have failed by our definition, but we may have insufficient knowledge to determine which one without performing a CSM PNGCS platform alignment in earth orbit. This would probably require going another revolution and, thus, TLI could not occur until the second opportunity. If the failure turns out to be in the IU, we would not perform TLI.

5. The Guidance and Performance Branch outlined their proposal for processing and displaying launch phase telemetry in the control center to evaluate S-IVB and spacecraft guidance systems performance as the prime TLI Go/No Go data source. They recommend plotting differences in the three components of velocity as determined from the PNGCS and S-IVB IU state vectors. These would be plotted in real time on strip chart recorders in the Mission Control Center. It is felt they would be extremely effective in not only detecting system failures but also for isolating exactly what type of failure has occurred. Limits would be established on these differences based on accuracy of the CSM PNGCS in accordance with the philosophy noted in paragraph 2. There is one big source of "error" in these plots resulting from our inability to align the CSM PNGCS accurately in azimuth on the launch pad. We had a similar problem, you recall, on Gemini and our solution here is about the same. It is proposed that a simple computation be performed similar to the platform alignment update carried out in the Gemini program at 100 seconds after lift off. This computation was based on the assumption that any difference in the horizontal velocity vectors detected when comparing the spacecraft to the S-IVB is due to gyro compassing misalignment of the spacecraft IMU on the launch pad. It is a simple way of determining what this misalignment is in order to improve the comparison by mathematically accounting for it in the plots during the remainder of the launch phase. In addition, it makes the magnitude of the misalignment available for use in later guidance systems performance evaluation tests inflight.

6. Flight Control Division and MPAD are jointly engaged in preparing RTCC program requirements based on this technique including display format and equation formulation. These program requirements should be in a form suitable for transmittal to FSD within 2 weeks, and negotiating will then begin to determine whether or not they can be included in the earlier manned Saturn 5 launches. They would be desirable on the "D" mission, possible mandatory for the "E", and certainly mandatory for "F" and "G".

7. We next discussed the question of whether or not the launch phase systems evaluation for first opportunity TLI Go/No Go described above is sufficient all by itself. That is, platform drift checks based on telemetry gimbal angles from the S-IVB IU and the spacecraft PNGCS have been proposed as a supplement to the launch phase comparison, but there are obvious problems associated with that procedure which may make it rather useless---although I'm sure they will be monitored grossly. For example, the data is not time synchronized nor even homogeneous. As a result, it would be necessary for the spacecraft to maintain minute attitude rates over the measurement period which is almost impossible to achieve. Furthermore, structural bending and thermal warping also create very large errors---comparable to the differences we're looking for. MPAD was given the action item of determining if such a test contributes significantly to our confidence for TLI since if it doesn't we can simplify things a great deal by eliminating the whole procedure.

8. Finally, we investigated how we would determine which system had failed if the launch evaluation shows disagreement. It appears necessary to perform a platform alignment, or at least a determination of its orientation. This would probably force delay of TLI until the second opportunity. We are currently investigating the following approach:

(a) Evaluate the CSM platform torquing angles. The x and y axis should be near zero and the z axis should equal the pad misalignment as detected in the launch phase. If not within limits it has failed.

(b) Using MSFN tracking for orbit determination, compare the actual trajectory against the S-IVB IU insertion state vector trajectory. This requires 1½ revolutions of tracking. Disagreement beyond limits indicates S-IVB IU failure.

9. Obviously, we have a lot to do. But if the ground rules are accepted it is mostly a matter of implementing a technique we understand. Believe it or not, I think we've got this TLI thing pretty nearly licked. I hope so!

Howard W. Tindall, Jr.

Enclosure
List of Attendees

Addressees:
(See attached list)

ATTENDEES

T. Guillory	CP
C. T. Buckler	BG
D. V. Massaro	FC
G. E. Paules	FC
E. L. Pavelka	FC
C. R. Huss	FM
C. T. Hyle	FM
R. M. Moore	FM
R. O. Nobles	FM
J. Yencharis	FM
G. R. Sabionski	FS
H. W. Tindall, Jr.	PA
R. Boudreau	TRW
J. N. Dashiell	TRW
M. Fox	TRW
R. Kidd	TRW

Enclosure 1

UNITED STATES GOVERNMENT

Memorandum

SUBJECT: [illegible] ground rules for [illegible]

[illegible] the guidance system [illegible] in the development of mission [illegible] Translunar Injection (TLI) Go/No Go decision [illegible]. Effective immediately, it is intended that all [illegible] displays and decision limit lines, crew and ground [illegible] mission rules, and related matter will be based on [illegible]. They represent a change from the tentative ground rules previously [illegible] this work. Accordingly, it is important that you understand them and make your views known right now if you do not concur. [illegible] specifically applies to the "F" and "G" missions. In summary:

(a) A TLI maneuver will not be attempted [illegible] any indication that the S-IVB IU guidance system is not working [illegible].

(b) A properly operating CSM PNGCS is not [illegible] it is acceptable to make a TLI maneuver with a failed CSM PNGCS [illegible] subsequent alternate mission is considered more valuable than remaining in earth orbit.

The remainder of this memo presents the rationale for these ground [illegible] and outlines the manner in which the guidance [illegible] evaluated in flight.

Degraded S-IVB IU in earth orbit.

Analysis has shown that even with a greatly degraded guidance system the S-IVB is able to perform a TLI maneuver which would permit some sort of lunar operations. Depending on the extent of degradation the lunar operation could take the form of a hybrid (nonfree return) lunar landing mission, an "F" type lunar rendezvous mission, or a lunar flyby. In all cases, the mission would certainly at least start out on a nonfree return trajectory. The alternate to this is to not perform the TLI maneuver but rather to remain in earth orbit and conduct a rendezvous mission (probably "D" type) with the LM and CSM. The priority of these alternate [illegible] is currently in the order listed above; that is, [illegible] preferable to obtain lunar operations experience [illegible]

[illegible] the [illegible] documents [illegible] where previous [illegible] of that type, but we have [illegible] account for the real problem. Namely, if [illegible] extent we would have very little [illegible] to perform any sort of TLI. That is, [illegible] during TLI is very frequent. If this were [illegible] would [illegible] lunar operations but would lose the [illegible] mission as well. And, on top of that, [illegible] TLI would leave us in a difficult non-nominal situation [illegible] us to the conclusion that we should [illegible] there is any indication that the S-IVB IU [illegible]

[illegible] There are two sources of failure indications [illegible] failure detection system which indicates failures [illegible] by comparison with the CSM PNGCS and MSFN [illegible], it must be emphasized, are extremely gross [illegible] IU is designed to be at least an order of magnitude more precise than the CSM PNGCS and the MSFN. Thus, these monitoring systems [illegible] and MSFN--do not provide data to prove that the IU is performing [illegible] but rather are only able to show us when it has degraded very badly--for example, 30 to 100 sigma! Whereas, MSFC's definition of a definitely and absolutely broken IU is anything beyond 3 sigma. Therefore, the actual [illegible] we would select for TLI Go/No Go based on the S-IVB IU performance evaluation can only be the smallest, dependably detectable failure [illegible] we would use the smallest failure which we can confidently attribute to the S-IVB rather than the comparison system itself. [illegible] of that amount are certainly true S-IVB IU failures and would [illegible] in a No Go for TLI, and the alternate mission [illegible] orbital.

8. CSM PNGCS failure, detected in earth orbit on the first [illegible] attempt (F or G).

If CSM PNGCS failure is detected, the options [illegible]

(1) Perform a lunar flyby performing [illegible]

[illegible]

(2) [illegible] earth orbit and [illegible]

[illegible]

It is not clear at this time which of these options is preferable. In fact, this will probably not be known until after completion of the mission prior to the one under discussion here. However, this is not important since, as far as we could determine, there is no reason why either of these alternate missions could not be performed. For example, it was noted that we can expect the lunar flyby to be on a free return trajectory since the S-IVB is assumed to be working normally. There apparently is adequate redundancy in the SCS to be tolerant of further system failures. Also, consideration may be given to using the PNGCS even if it has failed to the extent that the platform is drifting at the rate of 5° per hour. For example, that is just equivalent to the SCS. Indications from all knowledgeable lunar return entry people are that no crew safety problems are involved in that mission phase using the backup systems, although, of course, the spacecraft may not land as close to the recovery ships as we've become accustomed to. There is some question as to whether or not the acceleration time history during a backup, constant g entry is tolerable to the crew. All indications to date are that it is acceptable. To my knowledge, there is only one loose end to track down. And that is, is the SXT/SCT mandatory for TLI, or are alternate sighting devices adequate for guidance and control system alignment? We think they are. If not, the SXT will have to be checked before the burn.

5. By accepting these ground rules, it should be possible to establish a monitoring technique which would permit performing TLI on the first opportunity even for an Atlantic injection (i.e., about 100 minutes after lift off). The technique would be to compare the CSM PNGCS and the S-IVB IU during the launch phase and earth parking orbit. If this comparison is favorable, that is, to within the tolerance to be specified as described in paragraph 3, it can be assumed that both the S-IVB IU and the CSM PNGCS are performing well and we would execute TLI. If the comparison were not within those limits, one of the systems must have failed by our definition, but we have insufficient knowledge to determine which one without performing a CSM PNGCS platform alignment in earth orbit. This would be carried out as soon after the failure was detected as possible, but would certainly necessitate going another revolution and TLI could not occur until the second opportunity. If the failure turns out to be in the IU, we would not perform TLI but would carry out a CSM/LM long duration mission with rendezvous in earth orbit. If the failure is in the CSM PNGCS, we have the option (to be determined preflight) of doing TLI at the second opportunity and performing a lunar flyby, or of scrubbing TLI for that flight and remaining in earth orbit.

6. I would like to conclude by expressing my appreciation to Carl Huss and his Alternate Mission Review Panel for helping us at his February 29 "F" and "G" Lunar Mission meeting. Our last TLI Mission Techniques

meeting got stalled on top dead center in the absence of a clear understanding of alternate mission priority, among other things, and they gave us the needed push to get going again.

Howard W. Tindall, Jr.

[illegible]
([illegible] list)

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: MAR 7 1968
68-PA-T-55A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: First "E" Mission Rendezvous Mission Techniques meeting - March 4

1. On March 4 we had the first "E" Mission Rendezvous Mission Techniques meeting. It was devoted almost exclusively to understanding what the mission requirements and mission plans are for this phase of the flight. The discussion raised a few questions and some action items were assigned to get them answered.

2. It is evident that activities prior to the rendezvous such as the big S-IVB maneuver simulating translunar injection (TLI) will substantially perturb conditions at the start of the rendezvous unless compensation is provided. This, of course, means that the logic and capability to plan this "compensation" in real time must be designed and implemented. Ed Lineberry and his people were asked to look into this. (They're doing a similar job for Mission "D" already.)

3. The "E" mission is typical of any involving LM operations. It starts with an undocking and visual inspection. This is followed by a small RCS maneuver by one vehicle or the other to provide a controlled mini-distance separation trajectory to avoid costly station keeping. This is followed in turn by a larger separation maneuver which kicks off whatever is to be done. In this case, the larger separation maneuver, called a "Phasing maneuver", places the LM ahead and above the command module properly located to execute the CDH coelliptic maneuver about 2 hours and 40 minutes later. It is intended that these Phasing and CDH maneuvers will be computed in real time in the RTCC utilizing the so-called NCC/NSR rendezvous maneuver logic developed for Gemini. This targeting will force the CDH maneuver to occur at spacecraft apogee over Hawaii, with the proper differential altitude and phase angle.

4. The entire rendezvous will be carried out with a single inertial platform orientation (REFSMMAT) for each spacecraft. They will be computed and relayed to the spacecraft from the ground. Of course, more than one platform alignment will be performed. The point is they will all be carried out to achieve the same inertial platform orientation. Furthermore, it is anticipated that the REFSMMAT on Mission "E" will be selected essentially the same as for the "D" and "C" missions. That is, they will be tied to TPI and will provide an FDAI 8-ball display of 0, 0, 0 when the spacecraft is aligned in-plane, horizontal, wings level, heads up.

5. It was agreed that an undocked platform alignment would be made between the separation and Phasing maneuvers. In order to permit this we established that separation will occur 5 minutes before the start of the darkness period prior to the Phasing maneuver. Since this will result in almost a complete revolution between the separation and Phasing maneuvers a small radial separation burn such as planned for missions "D" and "G" may not work out too well here, and the Rendezvous Analysis Branch was given the action item of selecting an optimum separation burn to be illustrated at the next meeting with the standard relative motion plot. Flight Planning was requested to work out the crew timeline in detail for the period between undocking and the Phasing maneuver. We want to make sure that the various crew activities associated with LM checkout and trajectory control do not conflict nor are unduly crowded. I'm sure someone will also be interested in determining the consumables required during this period since apparently both electric power and RCS propellant are at a premium.

6. Finally, the crew procedures people were requested to evaluate and report at the next meeting the preferred lighting conditions for the TPI maneuver when it is executed by a spacecraft approaching from ahead and above. This will be the situation for the first TPI opportunity on the "E" mission. Although that maneuver would not actually be executed as long as everything is still going along okay, we should be prepared to do it if we have to. And the preferred lighting conditions influence scheduling of the Phasing maneuver itself.

7. The current rendezvous plan provides two opportunities to perform a CSI maneuver, both of which are nominally zero. However, it was questioned as to whether the first opportunity really exists since it occurs only 36 minutes after the Phasing maneuver with insufficient ground tracking and communications to support it. It may be desirable for the crew to perform rendezvous navigation and target this maneuver; the question is whether they would ever really execute it. The point is, if it turns out to be small there seems to be no disadvantage in delaying until the next CSI opportunity one revolution later, and if the onboard systems indicate that a large CSI maneuver is needed there is reason to suspect some systems malfunction. This is based on the assumption there had been no indication of non-nominal performance during the Phasing burn, which implies that CSI should be near zero. It seems we ought to obtain some MSFN confirmation before making a big burn that might screw up the situation. In conjunction with all this, the Rendezvous Analysis Branch was given the action item of determining parametrically the effects of residuals in the Phasing maneuver in terms of CSI maneuver magnitude and other trajectory dispersions such as TPI time slippage.

8. It has been stated that a primary mission objective on this flight is to perform a comprehensive AGS systems test. This, of course, must involve rendezvous navigation and targeting as well as maneuver guidance and control.

This can be done in a number of ways. For example, the AGS could be allowed to operate continuously without PNGCS update throughout the entire rendezvous exercise. Or the test could be broken down into a number of individual tests with re-initialization provided periodically. It is also necessary to specify when and under what conditions radar data should be input into the AGS. G&C Division was requested to amplify their mission requirement by providing a more detailed description of exactly what they would like accomplished and if possible how they would like to do it.

5. That is about all we covered dur ng this short meeting. One nice thing apparent was the substantial carryover from the "C" and "D" mission techniques meetings which should permit us to complete work on "E" in a considerably shorter period than would otherwise be the case. It was agreed that Monday afternoon is a good meeting time and so, if possible, we intend to get together every other week at that time. The next meeting is scheduled at 1:00 p.m., March 18, in Building 4, Room 396. That's 1300 for you, Frank.

Howard W. Tindall, Jr.

Enclosure
List of Attendees

Addressees:
(See attached list)

ATTENDEES

E. Aldrin, Jr.	CB
W. A. Anders	CB
N. Armstrong	CB
F. Borman	CB
M. C. Contella	CF
G. L. Doerre	CF
T. Guillory	CF
T. H. Kaiser	CF
C. M. Neily	CF
E. B. Pippert	CF
C. T. Hackler	EG
J. L. Petersen	PD
J. G. Zarcaro	PD
W. E. Fenner	FC
G. C. Guthrie	FC
M. G. Kennedy	FC
J. G. Renick	FC
K. W. Russell	FC
W. J. Strahle	FC
D. Toups	FC
G. R. Sabionski	FS
D. D. DeAtkine	FM
E. C. Lineberry	FM
R. L. McHenry	FM
P. T. Pixley	FM
R. R. Regelbrugge	FM
J. Shreffler	FM
A. Woronow	FM
K. A. Young	FM
R. Boudreau	TRW
K. L. Baker	TRW
J. E. Sheppam	TRW
H. W. Tindall, Jr.	PA

Enclosure 1

MAY 1962 EDITION
GSA GEN. REG. NO. 27
UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: MAR 7 1968
68-PA-T-54A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Sixth "C" Mission Rendezvous Mission Techniques meeting

1. This March 1 meeting conflicted with the President's speech but a few of us dedicated jokers pressed on as follows.

2. It had been stated that all "C" mission SPS burns would be performed in a heads down attitude (that is, 180° roll). This presents a problem on one or two of the SPS burns in the rendezvous sequence--NCC_1 and maybe NCC_2--since to constrain ourselves in that way would make it impossible to do the final sextant/star burn attitude check. These burns are expected to be within 15° radial which makes heads up/heads down rather meaningless anyway, except for the FDAI 8-ball presentation. Phil Shaffer checked with Tom Stafford and got agreement that the attitude check was of more value than the standard 180° roll indication. Accordingly, it is our plan to make NCC_1 and NCC_2 (if it is downward) in a heads up attitude and include the sextant/star check in the sequence.

3. As reported in the last meeting's minutes it is our proposal that if a platform failure is detected just prior to NCC_1, it will be necessary to delay the rendezvous exercise a day. This ruling does not necessarily apply to the PNGCS attitude tests prior to NCC_2 and NSR since after NCC_1 has been performed we are committed to the rendezvous exercise. Accordingly, if we can assume the GDC is aligned we probably should press on with the rendezvous using the SCS, at least through NCC_2 and NSR.

4. Apparently, consideration is being given by someone to extending the launch window. In particular, it is apparently being proposed to launch earlier in the day. It appears to us that to launch prior to local noon would preclude making a platform alignment between NCC_2 and NSR. This alignment is thought to be essential for terminal phase. Accordingly, we would like to request that very serious attention be given to this matter prior to choosing a launch time earlier than currently planned.

5. An item came up concerning real time selection of the elevation angle to be utilized in determining TPI time. As you recall, it is intended to utilize the elevation angle option in the TPI targeting processors such that if everything works properly TPI will occur when the line-of-sight to the target vehicle coincides with the maneuver thrust vector (spacecraft x-axis). According to Ed Lineberry, if dispersions in the

[illegible] are not taken into account in designating this elevation angle, the thrust direction at TPI will be substantially off the line-of-sight. The elevation angle adjustment should be less than 10°. Apparently, the RTCC/MCC is capable of determining the optimum value by means of manual iteration. Since the effect of this on crew TPI backup charts may be unacceptable, FCSD was given the action item of checking into that.

[illegible]. Another action item assigned the FCSD was to establish which was more [illegible]---lighting conditions during the braking maneuver or thrust [illegible] with the line-of-sight at TPI. If the lighting conditions [illegible] critical, it may be necessary to include a decision point in [illegible] to assure proper lighting at braking by not allowing the [illegible] to slip more than some specified amount---probably about 10 minutes. [illegible] TPI time based on the elevation angle option slips too much the crew [illegible] have to utilize the TPI "time option" for targeting. Obviously, the [illegible] would have to be made onboard the spacecraft after sextant data [illegible] been incorporated into the PNGCS.

[illegible]. There have been a number of comments regarding the TPI backup charts [illegible] their usefulness on the "C" and "D" missions. At the next meeting, [illegible] scheduled at 1:00 p.m. on March 8, we will review this subject [illegible] try to establish the role of the PNGCS, MSFN and backup charts for [illegible] maneuvers. The primary questions to be answered are: shall there [illegible] backup charts, and if there are, should they or the MSFN [illegible] computation for TPI be used in the event of a PNGCS failure. It is evident that in either case the subsequent midcourse correction will have to be based on charts, since the MSFN has no capability for computing that maneuver.

Howard W. Tindall, Jr.

[illegible]
(See attached list)

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27
5010-107

UNITED STATES GOVERNMENT

Memorandum

NASA - Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: MAR 7 1968
68-FM-T-53

FROM : FM/Deputy Chief

SUBJECT: Apollo Spacecraft Software Configuration Control Board notes for March 4 meeting

1. Close to half the meeting was devoted to discussion of the Delta V monitor. It was reported that the propulsion people have concurred in writing that the Delta V monitor program should not shut off the SPS engine on the Spacecraft 020 and 101 missions. It was also reported that MIT is still working on the basic delta V mode design for Colossus, the primary goal being to maintain the PNGCS in a workable state. Tom Price was given the task of organizing the work from MSC's viewpoint and coordinating it with MIT in detail. In the LM programs there are apparently serious implications regarding ullage arising from the 15 second limit for the RCS jets impinging on the DPS. It is still not clear what will be done about that.

2. In response to a previous action item (10.1.4) G&C reported that ullage as commanded by the AGS is DEDA accessible, that is, the crew can change its duration if that is necessary.

3. I withdrew our PCR No. 33 dealing with the lunar surface navigation program in Luminary. This PCR was to obtain radar data on the downlink at a higher frequency than is currently programmed. It became clear that there were a number of unresolved questions dealing with how we want to use both this program and the Ascent program (P-12), which should be resolved before we finalize our PCR description. We were told that we may delay this PCR for another month with no additional program delivery impact and we have some analyses and meetings scheduled which should illuminate the subject considerably.

4. PCR No. 50 deals with changes in Colossus preentry computations and displays (P-61 and P-62). After considerable discussion, MIT was directed to remove the processors in Colossus which provide an automatic maneuver to the command module/service module separation attitude. The other part of this PCR requesting prediction of gimbal angles at .05 g's would cost 4 days schedule impact and, since Tom Stafford agreed it was not mandatory, this part of the change was not approved.

5. PCR No. 57 was not discussed at this meeting.

6. PCR No. 63, to delete command module steering of the S-IVB during the TLI maneuver, was finally approved.

7. PCR No. 70, which adds the jerk term to the Descent Abort programs (P-70 and P-71), was not discussed at this meeting since MIT has not completed their detailed evaluation yet. It is supposed to be ready for the next meeting.

8. PCR No. 72, a LM DAP change to Sundance dealing with attitude rate limits, was disapproved.

9. PCR No. 80 was an MIT initiated change to provide state vector synchronization with no schedule impact for Colossus, Luminary and Sundance. It was approved.

10. PCR No. 81 dealt with a change MIT made in the Auge-Kugel coefficients in Colossus. This was done without MSC concurrence and this approved PCR directed MIT to return to the Sundisk values.

11. PCR's 83 and 85 both dealt with x-axis override in Sundance and Luminary. It was agreed that PCR No. 85 as prepared by MIT was the better, so it was approved; and PCR No. 83 was disapproved.

12. PCR No. 88 provides the capability of changing range variances, whatever they are, in Colossus and Luminary based on more up-to-date analyses and actual flight experience by putting both of them in erasable. This change was approved for Colossus and Luminary with no schedule impact. A visibility impact on Sundance was requested.

13. PCR Nos. 90 and 91 deal with downlink changes to Sundance requested by FCD, both of which were approved.

14. PCR No. 92, to add a valid data indicator to the Colossus landmark tracking downlink data, was postponed until the next meeting.

15. PCR No. 94 requested a change in the Colossus entry guidance logic such that it will work for reduced L/D vehicles. It was approved.

16. PCR No. 95 which changes the DSKY display polarity for the rendezvous radar trunion angle in Sundance to be consistent with standard pilot sign convention was approved.

17. PCR No. 96, which provides the capability in Sundance of moving the rendezvous radar gyro package out of the view of the AOT, was approved with a one day impact.

18. PCR No. 97 removes a program alarm in Sundance associated with the rendezvous radar which was certain to occur during perfectly nominal LM rendezvous operations. It was approved.

19. PCR No. 98 provides a capability of moving the rendezvous radar antenna out of the field of view of the AOT while the rendezvous navigation program is in operation. Discussion of this change was delayed until the next meeting.

20. PCR No. 99 deals with making the DSKY display of shaft and trunion angles of the rendezvous radar in Mode II more meaningful to the crew. It was disapproved for Sundance and will be discussed for Luminary the next time.

21. PCR No. 103 authorizes MIT to do no level 5 testing of the Sundance programs which provide rendezvous maneuver targeting to the CSM, since the P-70 series will not be used on the "D" and "E" missions. This was approved.

22. PCR No. 104 would have deleted the requirement for the P-21 program in Sundance. It provides a display of latitude, longitude and height. When it was understood how the crew intends to use it, the PCR was disapproved.

23. Three changes dealing with the throttling of the DPS in the Luminary program were requested by MPAD and are to be discussed at the next meeting.

24. This memorandum is to give a very brief rundown of what happened at this meeting. It is obvious from the great number of items under discussion that if you are interested in any specific one in detail, you will have to check in person with someone that was there, or await distribution of the formal minutes of the meeting.

Howard W. Tindall, Jr.

Addressees:
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/R. P. Parten
J. R. Gurley
E. D. Murrah
A. Nathan
FM4/P. T. Pixley
R. T. Savely
FM5/R. E. Ernull
R. Berry
FM6/B. Becker
FM7/S. P. Mann
R. O. Nobles
FM/Branch Chiefs

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: MAR 3 1968

68-PA-T-51A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Lunar Rendezvous Abort Mission Techniques meeting

1. As you know, a great deal of work has been done on lunar abort rendezvous throughout the Center. This note is to inform you of a Data Priority Coordination meeting on this subject on March 28, 1968, in Building 2, Room 966. I expect it will take most of the day.

2. What we are interested in determining is what are the ground and crew procedures based on the current rendezvous abort plan. The first part of the meeting will be devoted to a review of abort plans from any part of the descent trajectory, both coasting and powered flight, and from the lunar surface. Of course, it involves LM active, and command module active and in some cases both vehicles active. We are particularly interested in establishing those procedures associated with lunar abort rendezvous which must be included in the nominal time-line. For example, targeting of the CSM to perform LM rescue maneuvers prior to the abort situation and targeting of the LM on the lunar surface for lift off on a CSM revolution earlier than planned.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: MAR 1 1968
68-PA-T-49A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Fifth "D" Mission Rendezvous Mission Techniques meeting---don't miss Paragraph 5; it's great.

1. We spent just about the entire February 26 meeting discussing the way the AGS and PNGCS should be used during the "D" Mission rendezvous. I feel as though we have accomplished quite a lot in this area having reached agreement on how the AGS should be used throughout that mission phase, with one minor exception. It is all based on the ground rule that on this mission the AGS should be maintained in that state which makes it most useful to perform the rendezvous in the event of PNGCS failure. It was noted that if, after having established the preferred techniques in accordance with that ground rule, it is possible to include some AGS systems tests without jeopardizing crew safety or other mission objectives, they would be considered.

2. Nominal situation: PNGCS seems to be working properly and is prime; AGS must be maintained in optimum state to take over in the event the PNGCS fails. This applies to all maneuvers---CSI, CDH, TPI.

(a) Checking of the PNGCS will be by comparison with the ground computed solution only. That is, comparisons of maneuver targeting from other sources, such as the AGS, backup charts or the CSM, will not be made to commit to the PNGCS. The PNGCS solution will be used providing it is within acceptable limits of the MSFN solution. One possible exception here is that, since the CSM optics provide very strong solutions to the TPI delta V components perpendicular to the line of sight, comparison with them may be advantageous.

(b) The state vectors in the AGS will be updated each time PNGCS is confirmed to be acceptable. This will likely be at each time it is committed to make the next maneuver using the PNGCS.

(c) AGS alignments will be made each time the PNGCS is realigned and each time the state vector in the AGS is updated from the PNGCS.

(d) No radar data will be input into the AGS as long as the PNGCS is working. In effect, it is obtaining benefit of the radar via the PNGCS state vector updates since the PNGCS is processing the radar data.

(c) There is no need to prepare or learn to use backup charts for CSI and/or CDH maneuvers for this mission. Terminal phase charts are essential in the LM.

3. In the event of a PNGCS failure: CSI and CDH only.

(a) For CSI and CDH, use the AGS in almost the identical manner in which the Gemini spacecraft was flown. That is, use ground targeted maneuvers executed with the AGS External delta V mode.

(b) No radar data would be input into the AGS prior to CSI and CDH.

4. By far the most extensive discussion dealt with the Terminal Phase Initiation (TPI) maneuver and subsequent midcourse maneuvers in the event of a PNGCS failure, but with the radar still working. This was the one area still lacking agreement. It is all based on the assumption that a rendezvous radar failure is obvious as opposed to insidious. Clarke Hackler (OCD) and Al Nathan (GAEC) were given the action item to determine if this assumption is reasonable. Our alternate plans for TPI---PNGCS out, radar working---are as follows:

(a) Compare the onboard chart solution for TPI with the MSFN. If the comparison is favorable, execute the chart solution and, if not, use the MSFN delta V's and the maneuver execution time based on the onboard solution. The maneuver would be made using the AGS external delta V mode---this procedure to be amplified later in this memo. Do not input radar data into the AGS. OR.....

(b) As soon as PNGCS failure is apparent (but not sooner than CDH) start updating AGS state vectors with rendezvous radar data inputs. Proceed using AGS in place of PNGCS. That is, compare TPI solution with MSFN (and maybe CSM for components perpendicular to the line of sight). Use AGS solution if acceptable. If not, execute MSFN delta V's using AGS External Delta V mode. The argument for inputting rendezvous radar in the AGS and using its solution is that it is a closed loop system which analysis shows should work well using rendezvous radar and more analysis is on the way to prove it further. In addition, Flight Crew is concerned that the arithmetic associated with the charts make its solution more susceptible to crew error, whereas the AGS does the arithmetic for them. The arguments against use of radar in the AGS for TPI is that to attempt to maintain both the AGS and charts solutions is likely to create an excessive work load upon the crew, particularly when considering the henderences of the spacesuits and the zero g environment. Furthermore, we have considerable confidence in the charts and expect that if the charts and AGS (with radar) solutions differ we would be inclined to believe the charts and use that solution instead of the AGS anyway.

5. The following is the most startling conclusion reached today! If the LM PNGCS is working but rendezvous radar has failed, we have a serious problem with the LM since no external data will be input to the spacecraft systems---PNGCS, AGS or charts. In this case, it is our recommendation that the command module execute the TPI and subsequent midcourse correction maneuvers and the LM do the braking maneuvers.

(a) The command module would compare its TPI solution with the MSFN. If the comparison is favorable that maneuver would be executed; if not, the command module would execute the MSFN delta V's using its own time of ignition.

(b) The command module would voice relay to the LM the maneuvers it has executed in order that the LM crew could update the command module state vectors in the LGC using the Target Delta V program.

6. I would like to present here the rationale for making the command module active for TPI and midcourse when only the rendezvous radar has failed. The justification is based on assuring ourselves the capability of making a good midcourse correction subsequent to TPI which is extremely important since with no ranging device the braking maneuver is going to be very difficult for the LM to do. The whole point is that only the command module is able to maintain a closed loop knowledge of the situation (with its sextant) and maintain an up-to-date set of state vectors in the computer to target the midcourse correction maneuver. Furthermore, it is only able to do this well if it makes the TPI maneuver, so that its PNGCS senses that too. It should be noted that this does not use a great deal of CSM RCS propellant. Nowhere near that budgeted for LM rescue. All of the other maneuvers are carried out by the LM and the really large RCS drinker---braking---will also be carried out by the LM. The reason for that, of course, is that since the LM will be coming in from below, viewing the command module against a star background, it will be in a much better position to do the braking maneuver. In addition, we would prefer to save CSM fuel where possible.

7. An obvious additional advantage to this is that it keeps the procedures as simple as possible in this critical situation. In fact, it is a standard CSM TPI for which a great deal of planning and training will have been carried out. On the other hand, for the LM to make those two maneuvers would require a great deal of coordination and communication between the spacecraft crews in real time which is undesirable. And, it avoids having to prepare procedures and training for this special situation.

8. It was stated by FCOD that the command module pilot will be unable to computer onboard chart solutions for TPI due to the press of other activity and so they will not be available as a data source.

9. The manner in which the AGS can be used to execute LM chart solutions is by loading a zero magnitude maneuver into its External Delta V processor which zeros the registers and permits it to be used like the PNGCS Average G program (P-47). The crew would thrust sequentially along each of the three body axes, probably burning the largest component first. The sequential operation is necessary since there is only one digital readout on the DEDA register.

10. I expect that at the next meeting we will review all this and tune it up a little. We should then probably apply these techniques to the earlier "pseudo-TPI" maneuver which occurs half way through the exercise including special considerations associated with a TPI maneuver that we do not really intend to execute.

Howard W. Tindall, Jr.

Enclosure
List of Attendees

Addressees:
(See attached list)

ATTENDEES

E. E. Aldrin	CB
J. A. McDivitt	CB
R. L. Schweickart	CB
D. R. Scott	CB
M. C. Contella	CF
S. H. Gardner	CF
S. G. Paddock	CF
J. V. Rivers	CF
C. T. Hackler	EG
J. M. Palfe	EG
J. Craven	FC
W. E. Fenner	FC
M. V. Jenkins	FM
E. C. Lineberry	FM
A. Nathan	GAEC
J. Shreffler	FM
K. L. Baker	TRW
R. Boudreau	TRW
C. R. Shook	TRW
J. E. Scheppan	TRW
H. W. Tindall, Jr.	PA

Enclosure 1

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27
5010-107

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: MAR 4 1968
68-PA-T-48A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Ascent Phase Mission Techniques meeting - February 27, 1968

1. In the absence of Charley Parker, our beloved leader, I inherited the job of chairing this meeting which probably accounts for why we didn't really get an awful lot done. However, there are a couple of things that are probably worth reporting.

2. We discussed the importance of the "stage verify" discrete to the spacecraft computer. Apparently, its sole purpose is to initialize the DAP such that it may perform properly. For example, it stops sending steering commands to the DPS trim gimbals. It also changes the spacecraft mass used in DAP operations from the ascent stage, plus whatever remains of the descent stage, to ascent mass only. Based on this information it computes jet firing duration for attitude control differently, of course. I had been concerned that failure to get this signal during Ascent would cause poor attitude control and we are initiating a program change request to back up "stage verify" with the "lunar surface flag" since whenever that event occurs use of the ascent stage only is a certainty. Jack Craven (FCD) pointed out that due to the design of the system the much more probable failure is to get a "stage verify" signal prematurely. If that happened, when we are still operating on the DPS, it would stop DPS steering and would make the RCS attitude control extremely sluggish. That would be bad news! All that is required to do this is for either of two relays to inadvertently open.

3. As you know, we are planning to devote a short period of time immediately after landing on the lunar surface to checkout of critical systems. This would be done both onboard and in the MCC leading to a GO/NO GO for one CSM revolution (about 2 hours). This is exactly the same sort of thing as the GO/NO GO for one revolution following earth launch. Jack Craven accepted the action item, which I had previously discussed with Gene Kranz, to establish how long it should take to do this systems check in order that we may make all other mission planning and crew procedures consistent. It is expected to be in the order of 3 minutes, unless it takes a long time to really detect an APS pressure leak. Until the GO/NO GO we intend to remain in a state from which we can instantly "abort stage" and go. After that it will take much longer.

4. Almost all the rest of our discussion dealt with what the command module should be doing during and immediately following LM ascent from the lunar surface. One unresolved question was whether or not the command module should attempt to observe the LM ascent with the sextant. It was not clear what purpose would be served other than more rapid acquisition for rendezvous navigation tracking after insertion. It seemed to us the most important thing, of course, was for the command module to take whatever steps are necessary to assure getting a good LM state vector in its computer for rendezvous maneuver targeting as soon as possible. It seems almost certain that we should load the nominal LM insertion state vector in the CMC from the ground prior to LM ascent to guard against subsequent communication breakdown. It was also agreed that we should probably prepare the MCC to automatically take the LM post-insertion state vector from the LM telemetry and transmit it back to the command module. Whether we would actually do this or not depends on whether we lose more by forcing the command module to stay in the Uplink Command program (P-27) thereby preventing rendezvous tracking and onboard navigation for a substantial period of time. That is, analysis may show that with good VHF ranging and/or sextant tracking the command module may be able to converge on an acceptable LM state vector better without this ground participation, if it gets going more quickly.

5. I guess I am attacking the old "MIT mc" in stating that we are seriously handicapped by having no reliable definition of the Luminary lunar surface and ascent programs (e.g., GSOP Chapters 4 and 5). I understand review copies of these should be available within 3 to 6 weeks and I am sure nothing can be done to speed them up. We'll eat'em raw when they get here!

Howard W. Tindall, Jr.

Enclosure
List of Attendees

Addressees:
(See attached list)

ATTENDEES

E. E. Aldrin	CB
E. B. Pippert	CF
C. T. Hackler	MG
J. B. Craven	FC
E. L. Pavelka	FC
D. Beggs	FM
H. W. Tindall	PA
R. Boudreau	TRW
P. Hanna	TRW
J. R. Henson	TRW

Enclosure 1

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: MAR 1 1968
68-PA-T-46A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Fifth "C" Mission Rendezvous Mission Techniques meeting

1. We had another "C" Mission Rendezvous Mission Techniques meeting on February 23. We resolved a few things and reworked the flow charts some more at this meeting.

2. The first item discussed was a carryover from a previous meeting dealing with how the primary guidance system aligns the SPS engine prior to each SPS maneuver. As you know, engine gimbal trim angles are stored in the DAP data load which are used to align the engine prior to ignition. Initial values will probably be loaded prior to launch to align the thrust vector through the best estimate of spacecraft cg position for the first SPS burn. The current 1 sigma estimate is that these values should be within 0.4° in pitch and yaw. Of course, as the engine operates it is possible for the computer to determine better values to trim the engine thrust through the cg based on actual performance, and the program can automatically store these updated engine gimbal trim angles in the DAP data load for use on the next maneuver. However, it has been found it will only do this if the maneuver is greater than about 13.5 seconds in duration. During the "C" Mission rendezvous exercise none of the three SPS burns are as long as 13.5 seconds, and so the PNGCS will not automatically update these critical parameters. The original values remain in memory to be used again on each subsequent maneuver.

3. As has been reported previously, it is unnecessary to trim delta V residuals resulting from attitude excursions on the first maneuver, and so misalignment on that burn is not too critical. However, they must be trimmed on the second and third maneuvers of the rendezvous exercise (see next paragraph) and so failure to update gimbal trim angles would result in excessive RCS costs. Therefore, the flight controllers are establishing a new standard operational procedure whereby they will ascertain from telemetry optimum trim angles during the first burn to be relayed to the crew for input into the DAP data load prior to the following burns.

4. Ed Lineberry and his rendezvous analysis crew presented data to show the great sensitivity of Terminal Phase Initiation (TPI) time and burn attitude due to dispersions in the second and third SPS maneuvers---NCC$_2$ and NSR. It was agreed that all residuals on these maneuvers must be trimmed out since not to do so would jeopardize the rendezvous exercise and would probably result in excessive RCS costs during a terminal phase by not having established optimum initial conditions for it. For example, a 1 fps horizontal, in plane residual on either NCC$_2$ or NSR produces a 4 minute shift in TPI time.

5. Milt Contella (FCSD) presented the results of their study to determine optimum lighting conditions for the terminal phase. This work is being completely documented. The points of particular interest to us, however, are that they have established that the ground targeted maneuvers should be determined to cause TPI to occur at local sunset plus 7 minutes to within $\pm$ 10 minutes. It was interesting to note that the lighting constraints are primarily associated with the braking maneuver, whereas on Gemini consideration was also given to the lighting conditions at TPI itself. Specifically, they wanted to assure that the spacecraft breaks into daylight no later than the time at which they have approached to within one mile of each other, and preferably 3 or 4 miles. They also want to assure at least 10 minutes in daylight following the impulsive braking time (TPF).

6. Review of the flow charts caused us to reverse a decision reported in the last meeting minutes. Namely, it was stated that if it were determined the PNGCS had failed just prior to the first SPS burn, we would continue on with the rendezvous exercise using SCS for that maneuver. Based on the data presented by the Orbital Rendezvous Analysis people showing the extreme sensitivity of the terminal phase conditions to small dispersons in these SPS burns, it is evident that the rendezvous is almost certain to fail without PNGCS. Rather than embark on an exercise under those conditions, we concluded the best course of action was to delay it to the next day and do it then if the PNGCS can be made to work in the interim. The S-IVB battery lifetime will have been exhausted by then, but with the relatively short ranges involved it is still possible the sextant will be able to provide adequate observations without the S-IVB light. Without PNGCS we might as well quit since we are almost assured of exceeding the RCS redline which would force abandonment of the rendezvous before completion anyway.

7. I contacted Neil Townsend (PPD) and confirmed that making the three SPS burns now planned within one revolution does not violate any SPS systems constraints. He is preparing a memo in support of this, and I report with appreciation that the Systems Engineering Division

(Dutch von Ehrenfried) has also sent me a note okaying it. I also asked about the importance of the fuel slosh test that they have included in the timeline following the first SPS burn. This requires maintaining a period of no attitude control for a considerable period of time which conflicts with our desire to immediately initiate sextant observations of the S-IVB for rendezvous navigation. Townsend readily agreed that the fuel slosh test could be performed on a later maneuver in the mission and, thus, there was no need to trade off one of these activities against the other.

8. It was noted that the Flight Crew people are considering adding a second midcourse correction in the terminal phase at 12 minutes after TPI, in addition to the current one 20 minutes after TPI. We'll hear more about that at the next meeting which will be at 9:00 a.m. on Friday, March 1, 1968. We'll probably start in the middle of the data flows this time to see if we can get to the end just once. Maybe there's something interesting in that part of it.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: FEB 29 1968
68-PA-T-45A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Lunar Orbit Navigation and Targeting Mission Techniques meeting

1. A Mission Techniques Data Priority meeting is scheduled on March 14, 1968, at 9:00 a.m. in Building 30, Room 3044, to discuss lunar orbit navigation and ascent and descent targeting. As you are no doubt aware, there are many unresolved problems associated with these operations on the lunar landing mission involving the lunar orbit timeline, how the spacecraft and ground systems should be used, the data flow between them, the mathematical procedures and displays required, and anticipated performance and accuracies. Our discussion will touch on all these as well as a status report on MSFN capability based on Lunar Orbiter data.

2. Participation by your organization is requested.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27
5010-107

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: FEB 28 1968
68-PA-T-4 ?A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: We will start Data Priority Mission Techniques meetings on the Mission "E" Rendezvous.

Just as the headline proclaims---we will have our first "E" rendezvous meeting at 10:00 a.m. on Monday, March 4, 1968, in Room 390, Building 4. It will be a short kickoff affair with emphasis on getting up to date on the mission and flight plans as they exist today.

You're invited. Please excuse the short notice.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27

5010-107

UNITED STATES GOVERNMENT

Memorandum

TO : PC5/Chairman, Ascent Phase Mission [illegible] Working Group

DATE: MAR 1 1968
68-PA-T-[illegible]A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Some things about the LM computer [illegible] program and how it should be changed

1. This memo is in response to [illegible] picked up at your [illegible] meeting on February [illegible] dealing with [illegible] the spacecraft computer works while on the lunar surface. It recommends [illegible] PCR's too!

2. The first was to obtain MIT's [illegible] to how long before lift off the ascent programs, P-[illegible] and P-[illegible], should be called up. George Cherry stated that [illegible] immediately after the CSM pass, [illegible] before lift off [illegible] programs should be initiated.

3. Another question [illegible] whether [illegible] possible to utilize the [illegible] capability of the Ascent [illegible] later [illegible] in order to [illegible] modules, etc. Of course, [illegible] town. According to Cherry, [illegible] not [illegible] while [illegible] Ascent [illegible] It would be a simple [illegible] position into the [illegible] register. [illegible] that you have someone prepare a PCR to have [illegible] the luminary program.

4. During our discussion, there was [illegible] crew would check the DAP data load [illegible] prior to lift off. Naturally, [illegible] would not permit this since the [illegible] DAP [illegible] "stage verify" discrete [illegible] spacecraft. This [illegible] serious deficiency to me in that failure to [illegible] that signal for some reason during the actual ascent could be catastrophic. And, it is so unnecessary since any time after landing on the moon it is [illegible] that all further thrusting would be with the ascent stage only. In discussing this with Cherry, he pointed out that it would be a rather

simple matter to use the "lunar surface" flag as a backup to stage verify which would mean any time after landing the DAP would be set to the ascent parameters. Unfortunately, here again, a PCR is required and I urge that you have one prepared for that program change.

Howard W. Tindall, Jr.

cc:
(See attached list)

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27
5010-104

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: FEB 21 1968
68-PA-T-41A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Fourth Mission "C" Rendezvous Mission Techniques meeting

1. As a result of our deliberations today (February 16) I think we have finally determined what to do about delta V residuals on the NCC_1 maneuver. Previously, it had been stated that we would probably trim out small values but, in order to save RCS, would allow larger values to propogate to the subsequent maneuvers, NCC_2 and NSR. The question to be answered was what is the dividing line between large and small residuals? We concluded today, based on material presented by Ed Lineberry, that we would never trim any residuals at NCC_1. The rationale was as follows: NCC_1 and NSR are approximately one revolution apart. As a result any out-of-plane residual establishes a node at NSR. Therefore, it may be eliminated at virtually no cost by making it part of the NSR maneuver. Ed Lineberry's data (see attached curves) shows that a horizontal, in-plane residual grows by approximately an order of magnitude to NCC_2. That is, 1 fps at NCC_1 results in about a 9 fps (radial) maneuver at NCC_2. Since MSFN orbit determination uncertainty and targeting of that quantity at NCC_1 is in the order of 2 fps (1 sigma), it is almost certain we will have to make an NCC_2 maneuver. And, it is almost equally certain that it will be of a magnitude requiring an SPS burn. Accordingly, there seems to be no sense in trimming small NCC_1 residuals. Their effect would be lost in the noise.

2. We next questioned the magnitude of the NCC_2 maneuver below which we use RCS rather than SPS. It is proposed that the smallest SPS maneuvers be made a ½ second, minimum impulse burn, which is the order of 15 fps. The question which now arises is which residuals, if any, should be trimmed at NCC_2 and NSR? Ed Lineberry accepted the action item of determining the effect of those residuals propogating into dispersion in TPI time and differential altitude, and other bad things like that.

3. We next proceeded to go through the mission techniques logical flow charts updated based on discussions at our last meeting. As usual, we failed to get more than half way through and it seems like slow going. On the other hand, I feel as though we did make some progress. For example, we settled the question of whether the crew or the ground would carry out the operation of setting the spacecraft computer REFSMMAT flag such that the desired alignment relayed from the ground would be used by the guidance system. It is a messy operation but it was concluded that the crew would have to do it since we could not depend on sufficient station coverage to accomplish it. The operation would be monitored from the ground if within sight of a station but this was not to be a constraint on the operation.

4. We again discussed at length the pre-phasing maneuver which may be required to avoid collision of the CSM with the S-IVB prior to initiation of the rendezvous exercise. Previously, we had included this in the timeline as a standard guided burn with ground targeting and state vector updating, etc. Since it is extremely unlikely that the maneuver will be required and since it will be only a small RCS maneuver, it was felt to be preferable to use the Average G Monitor Program (P-47) along with inertial gimbal angles relayed from the ground. This procedure is simpler and less time consuming with acceptable accuracy. And doesn't undesirably distort the timeline.

5. The next subject we got hung up on was what to do if the pre-NCC_1 guidance system tests fail associated with final P-52 fine alignment and the star/sextant check in the inertial burn attitude. It seemed we had three choices:

a) continue on with the rendezvous exercise using the SCS for NCC_1 and the rest of the maneuvers as necessary with ground targeting.

b) slip the rendezvous exercise one revolution which degrades station coverage (i.e., no coverage of NSR).

c) slip the rendezvous exercise one day resulting in exhaustion of S-IVB power and attendant loss of the tracking light and C-band beacon.

After long and painful discussions, consensus was to do the first, that is, there would not seem to be much to be gained by delaying or dropping the rendezvous exercise entirely, whereas it was possible that we could get some rendezvous experience and, at the very least, we would accomplish some of the SPS propulsion test.

6. Since everyone was having such a good time we decided not to wait two weeks for the next meeting. Accordingly, it is now scheduled for Friday, February 23, at 1 p.m. in Building 30, Room 3068.

Howard W. Tindall, Jr.

Enclosures 2

Addressees:
(See attached list)

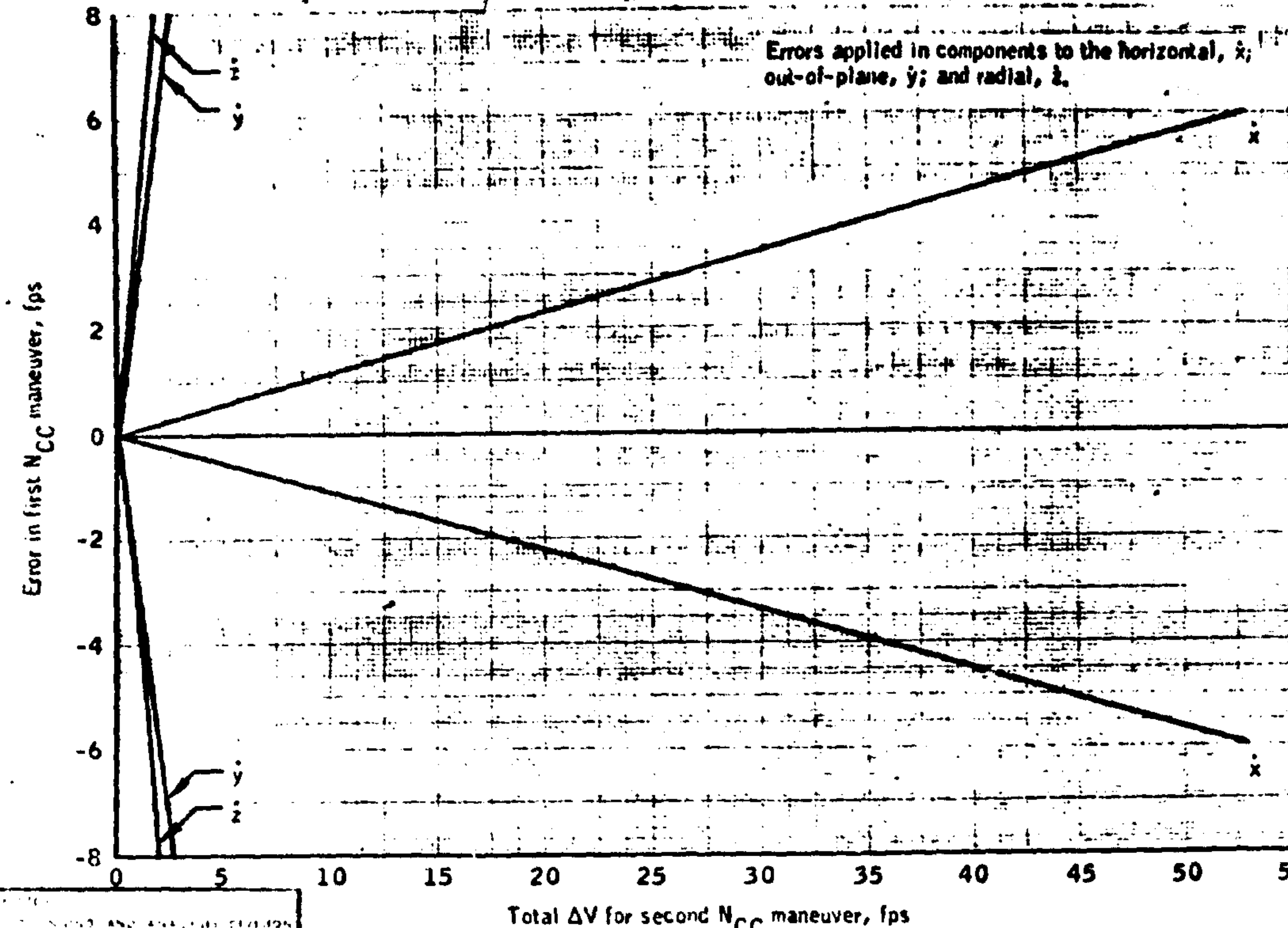


Figure 1.- Error in first N_{CC} maneuver versus total ΔV for second N_{CC} maneuver.

ATTENDEES

D. W. Lewis	CF
D. K. Mosel	CF
M. H. von Ehrenfried	FD
D. B. Pendley	FC
J. C. Bostick	FC
S. L. Davis	FC
J. L. Hall	FC
G. E. Paules	FC
W. S. Presley	FC
P. C. Shaffer	FC
E. C. Lineberry	FM
P. T. Pixley	FM
R. R. Regelbrugge	FM
J. L. Wells, Jr.	FM
R. Boudreau	TRW
D. L. Rue	TRW
J. W. Wright	TRW
H. W. Tindall, Jr.	PA

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: 23 FEB 1968
68-PA-T-40A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Lunar Mission Reentry Mission Techniques meeting

1. A Mission Techniques Data Priority meeting is scheduled on March 7, 1968, at 9:00 a.m. in Building 2, Room 716, to discuss entry from a lunar mission. This mission phase begins 8 to 10 hours before landing and includes final midcourse maneuvers if required, preparation for reentry, and reentry itself. We expect to pay particular attention to data flow between the ground and the spacecraft, crew monitoring techniques to evaluate performance of the guidance systems and the crew procedures for controlling reentry both nominally and in the event of systems failures.

2. Your participation is requested.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27

5010-107

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: FEB 21 1968
68-PA-T-37A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: TLI platform alignment

Something came out of Don Berry's Midcourse Mission Techniques meeting of February 7 that I think should be advertised widely. Apparently, we now have agreement among all parties, including FCOD and FOD, that the proper platform orientation for the TLI maneuver on a lunar mission is the one established prelaunch on the pad for use during the launch phase. Of course, this does not produce zeros on the 8-ball during TLI. The reason I am sending this note around is just to make sure that everyone knows and is working in accordance with that monumental decision.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

How about that!

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27
5010-107

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: FEB 20 1968
68-PA-T-36A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Spacecraft computer programs controlling DPS throttling need some changes.

1. On February 14 we had a meeting with everyone at MSC, plus MIT and Grumman, who are interested in the way the spacecraft computer program throttles the Descent Propulsion System (DPS). There has been concern that the throttling programs as currently designed are not adequate for the Descent Orbit Insertion (DOI) maneuver on a lunar landing mission, as well as being rather inflexible for DPS maneuvers on the development flights. It was the purpose of our discussion to really understand how the PNGCS is being programmed now and, by considering this subject from all aspects---DPS constraints, crew procedures, guidance accuracy, etc.--- to figure out what we should do. As expected, it turned out a number of program changes are highly desirable, if not mandatory, at least for the lunar landing mission. Fortunately, it appears that those considered most necessary are expected to have little schedule impact.

2. As I understand it, this is how the general purpose DPS thrusting program (P-40) works. As currently defined for both Sundance and Luminary this program determines, prior to ignition, if the burn duration at 10% thrust will be greater or less than 95 seconds based on spacecraft weight and delta V. If it is less than 95 seconds the program will not make a throttle change throughout the maneuver, that is, it would maintain and steer the entire maneuver at 10% thrust. If the burn duration is expected to be in excess of 95 seconds it will command 10% thrust for a duration of time loaded in erasable memory and then will advance the throttle to the fixed high thrust setting of about 92½% thrust. This 10% thrust duration, which is now in erasable memory due to a recent Program Change Request (PCR), must be long enough to permit the engine to reach fuel feed and pressurization system stability (that is, about 5 to 10 seconds) and also to insure that adequate engine gimbal trimming would have occurred to direct the thrust vector through the cg, at least close enough to be within RCS attitude control under full thrust conditions (as much as 26 seconds).

3. The first proposed program change, which is considered mandatory, deals with how the 10% thrust trim duration is set into the computer. It is almost certain that during a lunar landing mission this quantity must be changed by the crew. For example, it will probably be set initially

to some value consistent with use of the DPS as a backup to the SPS. Then it will have to be reset once in preparation for the DOI maneuver and again prior to powered descent initiation. At present these settings must be made by the crew using a universal service program for loading into an octal address. The proposed PCR is to make this quantity a standard display/crew-input parameter in the digital autopilot (DAP) data load routine (R03). George Cherry (MIT) suggests use of a blank register available during display of DPS gimbal angles in which 10% thrust trim duration would be displayed and/or input in units of centiseconds. This parameter would be used to control the time at which the throttle would be advanced by setting it to a small value. It could also be used to insure that the throttle is never advanced by input of a time known to be in excess of the required burn duration at 10%. Rick Nobles, Floyd Bennett (FM), and Tom Price (FS) will prepare this PCR which George Cherry anticipates will create little impact.

4. A second PCR, to be prepared by those same guys, requests removal of the 95 second burn duration test described above. This PCR is also considered mandatory since the present logic would prevent an automatic throttle increase for DOI and other maneuvers of similar magnitude. For example, at 10% thrust the DOI maneuver takes about 60 seconds. Since this is less than 95 seconds, the entire maneuver would be carried out at 10% thrust. On the other hand, propulsion people feel it most desirable to make this maneuver as short as possible in order to avoid excessive super critical helium pressure build up.

5. The third PCR deals with crew input of the thrust level the PNGCS would automatically call for after satisfying the 10% requirement. As noted above, the program currently will only advance the throttle to the 92½% point. For a maneuver such as DOI some lower throttle setting must be used in order to provide steady state conditions for a long enough period at the high thrust level to give accurately guided cut off conditions. The proposal is to make it possible to obtain an automatic throttle setting at some intermediate value under astronaut control. It was noted that there is another blank register in the DAP data load routine (R03) display of LM and command module masses. This program change may require more time to implement than we are willing to accept and it is not considered mandatory. However, it is only possible to get along without it if we accept manual throttle control by the crew, overriding the PNGCS. The operational procedure would be to select the manual throttle mode and, after adequate time at 10% thrust, the crew would advance the throttle. It is anticipated they could hit the throttle setting desired to within about 5% which is probably okay. The computer would steer and cut off the engine properly as long as the throttle setting is left undisturbed after the initial advance. Incidentally, this procedure provides a manual throttling test during DOI which we felt might be nice prior to having to

use it during the final stages of powered descent. Thus, even if the automatic mode provided by this PCR were available, it is likely we would use the manual operational mode for DOI. In addition to preparing this PCR, Rick Nobles and Floyd Bennett will attempt to determine the inaccuracies associated with the manual throttle control procedure to insure that dispersions are within acceptable bounds. Experience gained in the simulator is essential for this analysis.

6. We next discussed whether or not the three PCR's noted above should also be included in the Powered Descent DPS Thrust program (P-63). The 95 second logic is not in P-63 now so obviously there is no need to remove that. The other two program changes should be made the same as P-40 in order to standardize procedures and to permit use of common routines.

7. The only other DPS thrust program is P-70 which is used for DPS aborts. What to do with P-70 is not at all clear. For one thing, as now programmed aborts early in powered descent result in a DPS shutdown followed by an attitude change of about 160° and then a complete reignition sequence. No one likes the idea of shutting off the engine at a time like that. Furthermore there is concern that the engine should not be stopped and started again so quickly due to freezing problems. However, to fix the program to leave the engine on is a substantial change and so we're going to have to look at this one some more. Another problem associated with P-70 is that Chapters 4 and 5 of the GSOP are not in agreement and the way the program is currently coded it does not work. These are internal MIT problems. However, I expect once they figure out what to do we will get involved.

8. In summary, there are two program changes which really must be made, neither of which should impact the schedule significantly, at least on Luminary. We confirmed that there should be no problem in controlling the throttle manually during DOI and there is some advantage to doing it that way. However, an approval of a third PCR would provide the flexibility needed for automatic DPS control to lower than full thrust. Whether or not it is reasonable to turn off and then restart the DPS as currently programmed in the abort program remains to be seen. And, finally, there are some design problems in the abort program itself which MIT must resolve themselves.

Howard W. Tindall, Jr.

Enclosure
List of Attendees

Addressees:
(See attached list)

ATTENDEES

C. Conrad	CB
K. J. Cox	EG
H. J. G. Kaupp, Jr.	EG
T. M. Lawton	EG
K. Lindsay	EG
J. D. Montgomery	EG
Z. Kirkland	EP
B. Polifka	EP
R. L. Carlton	FC
W. E. Fenner	FC
J. Alphin	FM
F. V. Bennett	FM
O. Graf	FM
E. C. Lineberry	FM
A. Nathan	FM
R. O. Nobles	FM
J. Paine	FM
T. G. Price	FS
J. E. Williams	FS
H. W. Tindall, Jr.	PA
H. Byington	FD
J. Salck	GAEC
G. Cherry	MIT
S. L. Copps	MIT
D. G. Hoag	MIT
R. A. Larson	MIT
N. E. Sears	MIT

Enclosure 1

UNITED STATES GOVERNMENT

NASA Manned Spacecraft Center
Mission Planning & Analysis Division

Memorandum

TO : FC4/Chief, GNC Section

DATE: FEB 20 1968
68-FM-T-35

FROM : FM/Deputy Chief

SUBJECT: Landing radar reasonableness

1. Here is another request for information---this time dealing with landing radar reasonableness. The basic question is how well can the crew evaluate the quality of the landing radar data from the displays available to them prior to permitting the data to be accepted by the PNGCS? For example, is it possible for it to read out the wrong altitude but give every indication that it is performing in a perfectly normal manner? Or can we be confident that if we see the displays moving smoothly that the data is probably right?

2. The thing I am afraid of is that the altitude it indicates may be quite different than the navigated PNGCS displayed value, since I would not be surprised if the latter could be substantially in error due to errors in the initialization, terrain uncertainty, navigation error, etc. The point is it sure would be nice to be able to tell if the radar was working even in the face of a large altitude difference, since it is in that case we need the radar data the most.

Howard W. Tindall, Jr.

cc:
CB/E. Aldrin, Jr.
N. Armstrong
C. Conrad
EG2/M. Kayton
C. T. Hackler
PA/G. M. Low
PD4/A. Cohen
FA/C. C. Kraft, Jr.
S. A. Sjoberg
C. C. Critzos
R. G. Rose
FC/E. G. Kranz
FC5/C. B. Parker
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/R. P. Parten
A. Nathan
FM/Branch Chiefs
TRW (Houston)/R. Boudreau

FM:HWTindall, Jr.:pj

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: FEB 21 1968
68-PA-T-34A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Landmarks for lunar tracking

1. [On February 1 a bunch of us who had been working on operational procedures associated with lunar landmark tracking got together with some of the Lunar Mapping people who have the responsibility for selecting and precisely locating the lunar landmarks to be used. This was a rather refreshing get together since, as strange as it may seem, neither group knew much about what the other was doing in any detail.] The thing that prompted the meeting was concern over the recent move to reduce the sun angle lower limit required during the final descent phase of a lunar landing mission.

2. Since the conclusions of this meeting were later presented at an FOP meeting and a subsequent ad hoc panel called by Morris Jenkins, I won't go into them in detail here. I'm sure minutes of those discussions will be much more comprehensive than anything I could write.

3. This note is just to record--for me and you--several items of interest.

a) It was pointed out that when working near the terminator one-half of the view in the telescope will be in sunlight and the other in earthshine which could present some type of a problem to the viewer.

b) It is impossible to use the scanning telescope in earthshine due to its poor light-gathering capability for landmarks of any reasonable size, therefore, the sextant would have to be utilized.

c) The Lunar Mapping people intend to prepare charts which are roughly 30 miles in latitude by 45 miles in longitude with the landing site close to the center. It is anticipated that the relative location from one feature to another will be accurate to the order of 50 meters in latitude and longitude and 200 meters vertically. (These are 1 sigma values.)

d) Each of the landmarks selected will be located within a cluster of larger recognizable landmarks to assist in acquisition. It was emphasized to the Lunar Mapping people that these larger landmarks should be assigned identification and precise coordinates such that, if in real time it is impossible for the crew to find the smaller landmarks, it would be possible for them to observe the larger ones and permit descent targeting even though with somewhat reduced accuracy. Mike Conway (FMD) will coordinate this with Dick Nance to make sure the RTCC is set up to handle them.

e) The Lunar Mapping people felt it preferable to choose landmarks within 3 or 4 miles of the landing site ellipse.

f) It is their goal to provide at least 3 of these clusters per site.

Howard W. Tindall, Jr.

Enclosure
List of Attendees

Addressees:
(See attached list)

ATTENDEES

P. Kramer	CF
C. T. Hackler	EG
C. D. Parker	FC
F. V. Bennett	FM
J. R. Elk	FM
J. C. McPherson	FM
R. T. Savely	FM
R. D. Allen	FS
T. M. Conway	FS
H. W. Tindall, Jr.	PA
R. L. Nance	TH

Enclosure 1

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27

5010-106

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: FEB 16 1968
68-PA-T-33A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Fourth Mission "D" Rendezvous Mission Techniques meeting

1. The first item discussed at this February 12 meeting really involved all Apollo rendezvous, which accounts for the long attendance list. The subject was whether or not to change the orbital travel between Terminal Phase Initiation (TPI) and theoretical braking from 140° to 130°. It was stated that this change would make necessary reworking the crew procedures for the 101 "C" mission flight which would delay accurate crew rendezvous training about 9 weeks. This was considered unacceptable and so the change is not being made on that flight. For all other Apollo rendezvous exercises it is intended to change to a 130° transfer angle. This change is said to have very little effect on the amount of work required to prepare for the missions; there are no changes required in spacecraft or ground guidance programs, or anything else we could think of. The only disadvantage uncovered was a slightly larger theoretical RCS propellant cost which must be cleared with the ASPO Configuration Control Board (Tindall and Contella have the action). The advantages are primarily associated with the fact that the 130° transfer angle provides nominally zero line-of-sight rates during the braking phase. This permits the crew to make those maneuvers earlier, more efficiently, and more easily. Another advantage is that it results in a higher energy transfer which reduces effect of TPI dispersions. This is particularly important in the event of failure of the ranging device--- radar or VHF. Also, 130° is more consistent with making the midcourse correction at 90° after TPI as is currently proposed to take care of out-of-plane conditions more efficiently. The period following a 90° midcourse correction is thought to be about optimum. It should be noted that the 140° value had more merit some time ago when it was considered acceptable to utilize large differential altitude. More recent work on CSM rescue and other non-nominal rendezvous situations has shown it possible to maintain the Delta h below 25 miles which makes the theoretical fuel saving for the 140° transfer rather insignificant. All mission planning, crew procedures, training, etc., associated with the "D" mission and subsequent will utilize the new 130° transfer angle unless, and until, we are unable to convince the Configuration Control Board that it's the right thing to do.

2. Associated with the "D" mission we finally all agreed to proceed assuming the nominal LM/command module separation will be made under the control of the AGS with residuals trimmed based on PNGCS. It is

felt to be a safe, accurate procedure which the crew has found easy to do in their simulators.

3. We had what I thought to be an extremely fruitful discussion on how the AGS should be used throughout the rendezvous exercise on the "D" mission. Althought it was obvious we did not reach agreement, I think the discussion brought this subject clearly into focus and two weeks of contemplation plus some rather simple analytic studies should make it pretty easy to decide what to do the next time we get together. It was agreed that the role of the AGS on this mission should be to make most probable the return of the LM to the command module in the event of PNGCS failure. It is not intended to use it to monitor the PNGCS nor should it be compromised to get an optimum systems test on it. Therefore, the questions to be answered deal with how to keep the AGS in the best state of readiness to carry on a successful rendezvous in the event the PNGCS has failed. For example, at what times should the AGS be re-initialized from the PNGCS and when, if ever, should radar data be fed into the AGS? To give an idea of what sort of thing we are thinking about, I would like to present my proposal emphasizing that this has, by no means, been agreed upon. It is based on the assumption that the PNGCS is still thought to be working properly with an objective to keep the AGS prepared to take over in the event the PNGCS fails.

(a) Checking of the PNGCS would be by comparison with the ground computed solution only. That is, comparisons of maneuver targeting from other sources, such as the AGS, backup charts or the CSM, would not be made to commit to the PNGCS. The PNGCS solution would be used providing it was within acceptable limits of the MSFN solution.

(b) The state vectors in the AGS would be updated each time PNGCS was confirmed to be acceptable. This will likely be at each time it is committed to make the next maneuver using the PNGCS.

(c) AGS alignments would be made each time the PNGCS is realigned and each time the state vector in the AGS is updated from the PNGCS.

(d) No radar data would ever be input into the AGS as long as the PNGCS is working. This is the same procedure as I expect will be used in the lunar mission.

(e) There is no need to prepare or learn to use back up charts for CSI and/or CDH maneuvers.

In the event of a PNGCS failure I would use the AGS in almost the identical manner in which the Gemini spacecraft was flown. That is, ground targeted maneuvers up to TPI, then use of radar data in the AGS to make onboard computed maneuvers from TPI on in. And, of course, the command module could play a role here, too, possibly making the TPI maneuver and/or the braking maneuver and, of course, it can compute targeting for the TPI for both itself and the LM. ---Just a proposal. Incidentally, it was interesting to many of use to learn the LM has a C-band Radar beacon. This tends to increase confidence in the ground quite a bit.

4. TRW distributed copies of their first cut at the mission techniques logical flow for the rendezvous exercise up to and including the so-called insertion maneuver made by the LM to break out of the initial football rendezvous trajectory. These flow charts will probably be reviewed in detail at the next meeting.

Howard W. Tindall, Jr.

Enclosure
List of Attendees

Addressees:
(See attached list)

ATTENDEES

E. Aldrin	CB
J. A. McDivitt	CB
R. L. Schweickart	CB
T. P. Stafford	CB
J. W. Young	CB
D. R. Blue	CF
D. E. Boling	CF
J. C. Callihan	CF
M. C. Contella	CF
W. Haufler	CF
D. Lewis	CF
J. Monroe	CF
D. K. Mosel	CF
J. V. Rivers	CF
C. T. Hackler	FC
J. C. Elliott	FC
W. E. Fenner	FC
H. D. Reed	FC
M. V. Jenkins	FM
E. C. Lineberry	FM
A. Nathan	FM
P. T. Pixley	FM
K. A. Young	FM
H. W. Tindall, Jr.	FA
R. Boudreau	TRW
J. E. Scheppan	TRW

Enclosure 1

UNITED STATES GOVERNMENT

Memorandum

TO : PA/Manager, Apollo Spacecraft Program

DATE: FEB 16 1968

68-PA-T-9A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Deletion of TLI steering by the spacecraft

You did better than you thought. The request for the change was prepared by ASPO, concurred on by Slayton, Kraft and yourself, and forwarded to Headquarters over the Director's signature in the middle of January. My Headquarters spies tell me Phillips is only awaiting Mueller's concurrence before issuing the directive, and it is my understanding this probably has already occurred.

Howard W. Tindall, Jr.

Enclosure
Memorandum 68-PA-T-9A,
dated 1-16-68

PA:HWTindall, Jr.:pj

UNITED STATES GOVERNMENT

Memorandum

JAN 17 1 55 PM '68

DATE: JAN 16 1968
68-PA-T-9A

TO : See list below

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Latest on TLI

1. It looks like all we need now is Headquarter's concurrence to eliminate command module steering of the S-IVB during the TLI maneuver. Unbeknownst to me, MIT was directed to stop work on this program (P-15) shortly before Christmas. They estimated that P-15 would become pacing if they did not start working again by January 15 and they have been told not to start. Work going on within MPAD and TRW associated with this spacecraft capability is also being terminated and I recommend RTCC program and associated MCC display requirements be dropped immediately, too. (Of course, all effort required to make the TLI GO/NO GO decision must be continued.)

2. During the many recent discussions of TLI, crew monitoring when the S-IVB is guided by the Saturn system has repeatedly come up. It is our current intention to use the average g program (P-47) from which it will be possible to call up displays of velocity, attitude and attitude rate---the same parameters that are available during the launch phase. This will require a small program change which the Flight Software Branch is coordinating with MIT in preparation of the total PCR. I have been told there is no schedule impact.

[illegible] JAN-2-[illegible]
[illegible] requested [illegible]
[illegible] 24 1968

Howard W. Tindall, Jr.

Addressees:
(See attached list)

BILL TINDALL — I sure dropped behind on reading my mail during Apollo 5. Question:
1) Does CA now agree?
2) Who is preparing letter to obtain OMSF approval?
GML
2-6

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27

UNITED STATES GOVERNMENT

Memorandum

NASA - Manned Spacecraft Center
Mission Planning & Analysis Division

TO : FC/Chief, Flight Control Division

DATE: FEB 7 1968
68-FM-T-31

FROM : FM/Deputy Chief

SUBJECT: Problem of S-band during lunar landmark tracking

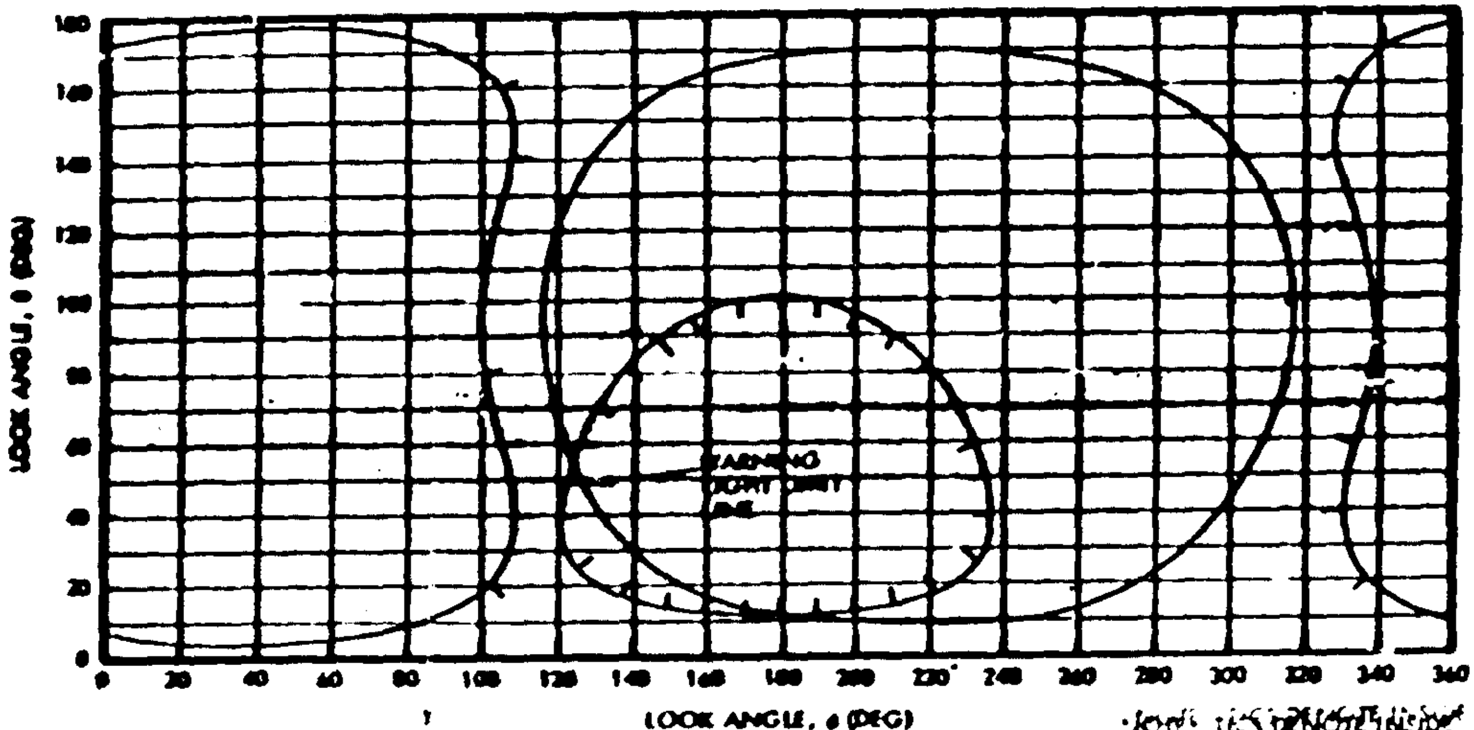
1. Attached are the "antenna" patterns for the S-band and the sextant I refered to during the Configuration Control Board last week. The spacecraft is constrained to point such that the sextant is within that small circle in the middle (with the hair on the inside). The bigger circle that it is superimposed on is the coverage the S-band antenna can provide which you see is in the same direction as the sextant plus a good bit more. The little region surrounding that is supposedly within the coverage of the S-band, but would cause the warning light to come on. The big area to the left and the small area on the right are where the S-band cannot go at all.

2. Marty Jenness, over here, is working on precise attitude time history profiles to show what the actual situation is during a landmark tracking pass. When he finishes within the month we will go over it with you if you are interested.

Howard W. Tindall, Jr.

Enclosure

FM:HWTindall, Jr.:pj



LOOK ANGLE, θ (DEG)
LOOK ANGLE, φ (DEG)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27
5010-107

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: FEB 8 1968
68-PA-T-30A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Third "D" Mission Rendezvous Mission Techniques meeting

1. We had our third "D" Mission Rendezvous Mission Techniques meeting on January 29. I am afraid it was a rather frustrating meeting for everyone. But on second thought---what's new?

2. One thing we did accomplish, which I consider significant, is that everyone agrees the command module should be operated during the LM active rendezvous as proposed in the last minutes, that is, target the CSM to make slightly delayed mirror image LM rendezvous maneuvers. Ed Lineberry reported that for the CSM mirror image LM maneuvers with one minute time delays are quite acceptable for maintaining the rendezvous situation. Accordingly, it is proposed that as a nominal procedure we target the command module with the LM computed maneuvers to be executed with a one minute time delay in the event the LM is unable to maneuver. There is a refinement under consideration to be made in the procedure. Namely, we will establish preflight small delta V biases to be added by the CSM crew to the LM maneuver relayed to him by voice. It is anticipated these do not add significant complexity to the operation and may avoid dispersions which, although acceptable, are probably unnecessary. If future study shows this refinement to be a poor one, it will be dropped.

3. Morris Jenkins reported that the mission plan should probably be changed to make the two short APS burns with RCS interconnect instead since they contribute little useful knowledge to APS or PNGCS performance and do introduce some minor disadvantages. He stated that these maneuvers are not necessary to meet any mission requirement. This is someone else's business. Of course, we'll be interested in the results.

4. It has been proposed that the initial separation of the command module from the LM be performed in a manner similar to that currently planned for the lunar landing mission. On that mission one-half revolution before DOI the command module will make a radial 1 fps maneuver downward which puts it slightly in front of and at the same altitude as the LM at the time of DOI. On the "D" mission this separation maneuver would occur one-half a revolution before the initiation of the rendezvous sequence which starts with a 40 fps LM maneuver radially upward. The big question was which vehicle

should make this 1 fps maneuver---the command module as on the lunar landing mission or the LM to avoid perturbing the command module state vector. Of these two relatively weak considerations, the latter seems more valid and so I propose that we carry this maneuver as LM active until some overwhelming disadvantage is uncovered. Obviously, the maneuver would be carried out using RCS propulsion and the Average G program (P-47). The command module would update its version of the LM state vector with the Target Delta V routine (R-32).

5. Considerable discussion centered on spacecraft activities between this small separation maneuver and the initialization of the football rendezvous one-half revolution later. Everyone agreed that the LM should carry out an undocked fine alignment of its platform during the darkness period it enters about 15 minutes after separation. It is probable that some LM radar checks should also be made, but it was agreed that these checks should be performed in some way that avoids modifying the state vectors in the LGC. It was the consensus that these rendezvous radar observations could potentially do harm to the state vector, but could certainly not improve it.

6. By far the most time at this meeting was spent on selection of the desired platform orientation for this exercise. Everyone agrees it must be in plane, but it soon became evident that the final choice of the in-plane components must be rather arbitrary, since there is no really significant advantage to any of those currently proposed. This is particularly true since it is intended to utilize the ORDEAL to drive the ball, thus obscuring the alignment used. In the absence of agreement, then, I would like to propose the following:

a) that a single inertial orientation (REFSMMAT) be used throughout the entire rendezvous sequence,

b) that the orientation be specified by ground computations using the "desired REFSMMAT" mode as opposed to using some onboard computed alignment,

c) that the orientation be determined associated with the final LM TPI of the entire rendezvous exercise,

d) that the platform alignment be similar to that encountered in the lunar landing mission, that is, 0, 0, 0 on the inertial ball when the LM is oriented to coincide with local vertical at TPI or some soon-to-be specified number of minutes prior to TPI. The value "10" was suggested,

e) that command module alignment be either identical to or different from the LM by an integer number of 90° increments.

It is to be noted that, with both vehicles operating, voice communications between them and the ground and command uplink capability will be difficult at best during station passes and the objective in this proposal is to keep the operation-voice communications, procedures, etc., ---as simple as possible---to avoid situations where a clear understanding by all parties involved is jeopardized.

7. There was a brief discussion of clock synchronization of the two spacecraft. It was not clear what the effect of non-synchronization is, although it was reputed possible for the ground to synchronize them within fractions of a second. This matter requires more thought.

8. If anyone comes, we'll get together again at 1:00 p.m. on February 12. One thing to be discussed is the proposed change of the terminal phase transfer angle (wt) from 140° to 130° ---which probably applies to all flights.

Howard W. Tindall, Jr.

Enclosure
List of Attendees

Addressees:
(See attached list)

ATTENDEES

E. Aldrin, Jr.	CB
C. Conrad	CB
R. F. Gordon	CB
J. A. McDivitt	CB
R. L. Schweickart	CB
D. R. Blue	CF
M. C. Contella	CF
S. H. Gardner	CF
T. W. Holloway	CF
J. V. Rivers	CF
C. T. Hackler	EG
J. F. Hanaway	EG
R. H. Lefler	EG
R. Simpson	EG
E. Smith	EG
S. L. Davis	FC
G. E. Paules	FC
J. D. Alexander	FM
E. C. Lineberry	FM
M. V. Jenkins	FM
P. T. Pixley	FM
R. R. Regelbrugge	FM
R. T. Savely	FM
J. Shreffler	FM
R. Boudreau	TRW
J. E. Scheppan	TRW
H. W. Tindall	PA

Enclosure 1

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: FEB 7 1968
68-PA-T-29A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Third Mission "C" Rendezvous Mission Techniques meeting

1. Based on our two previous meetings, TRW had prepared the first version of the mission techniques flow diagrams for the "C" Mission Rendezvous. This meeting on February 2 was devoted to going through that flow. As usual, in spite of the fact we thought we had everything all worked out, we ran into numerous items requiring further resolution.

2. The first discussion involved the logic associated with determining whether or not a pre-phasing maneuver need be made prior to the actual rendezvous exercise itself. This maneuver is only necessary if dispersions are far in excess of expected. It is intended to assure no collision of the CSM and the S-IVB regardless of whether the first maneuver in the rendezvous sequence, NCC_1, is performed or not. In the nominal flight plan the closest approach is something like 60 miles, and after finally finding out what this was all about we set the GO/NO GO test for this maneuver based on the criteria that the predicted closest approach should never become less than 5 miles. This value was made small in order to make the likelihood of the maneuver extremely small but was made large enough to compensate for any inaccuracy in orbit determination and maneuver dispersions.

3. A number of us were surprised to find that a Sextant tracking rendezvous navigation exercise has been planned by Flight Crew Support people prior to the first maneuver in the rendezvous sequence (NCC_1). Apparently, it had been in the timeline all along but somehow we had not noticed it. Previously, we had all agreed on the desirability of rendezvous navigation with the sextant following the NCC_1 maneuver as a spacecraft systems test and, perhaps more important, as on-the-job training for the crew prior to the real thing an orbit later. I guess they are going to keep the earlier exercise in the timeline too, but it was emphasized that it is a low priority activity and if it interferes with anything else it should be the first to go.

4. In the sequence of preparing for the NCC_1 maneuver which occurs within a few minutes of exiting a darkness period, we have included a final fine alignment of the platform followed by a sextant/star check made with the spacecraft in the inertial NCC_1 maneuver attitude.

The objective of this star check was to provide assurance that the whole guidance system is operating correctly, at least to the extent of having gotten the spacecraft into the proper attitude for the maneuver. It was agreed by everyone that on-time execution of the NCC_1 maneuver is of highest priority and the crew people felt that no less than 13 minutes should be allotted to prepare for it. Accordingly, a ground rule was established that the crew would do this fine alignment of the platform and then proceed to the sextant/star spacecraft inertial attitude check, if time permitted, but that either or both would be terminated or eliminated completely when the Time-to-Go to the maneuver reached 13 minutes. It was also agreed if the sextant/star check was performed and inertial attitude error exceeded .9° that this was indication enough that something was wrong and the entire rendezvous sequence would be delayed at least one rendezvous revolution.

5. Considerable discussion ensued regarding the NCC_1 and NCC_2 maneuvers, particularly with regard to whether or not residuals should be trimmed. As of now it is planned that in order to save RCS fuel only small residuals in NCC_1 would be trimmed and large residuals would be left to be taken care of by NCC_2, more than likely utilizing the SPS engine. As reported previously, Ed Lineberry's people are in the process of analyzing the situation parametrically to permit selection of the actual test numbers defining "small" and "large residuals." Two things agreed on were:

a) Since the NCC_1 and NSR maneuvers are approximately one revolution apart it is probable that any out-of-plane residual in NCC_1 can be easily and cheaply removed at NSR. Therefore, it does not seem reasonable to do any trimming in the out-of-plane direction at NCC_1.

b) The matter of how small an NCC_2 maneuver should be made with the SPS was tentatively resolved by saying that the SPS would be used for any maneuver it could handle including use of the minimum impulse mode. Thus, it would be used for maneuvers in the order of 10 to 15 fps and greater. It was emphasized, too, that whatever residuals do occur at NCC_2 must be trimmed with the RCS in order to maintain an optimum rendezvous situation.

6. There is some concern about use of the SPS on this first manned mission, particularly these first maneuvers. For example, is there any problem in making three SPS burns within one revolution? And, can one of them be a minimum impulse burn? That is, is there a freezing problem or something? Any comments on this would be appreciated.

7. That is all I can remember that happened. The next meeting is scheduled for Friday, February 16, at 9:00 a.m. in Building 30, Room 203PR.

Howard W. Tindall, Jr.

Enclosure

Addressees:
(See attached list)

ATTENDEES

D. Eisele	CB
D. W. Lewis	CF
D. K. Mosel	CF
M. Kayton	EG
W. J. Boone	FC
S. L. Davis	FC
O. E. Paules	FC
W. S. Presley	FC
E. C. Lineberry	FM
P. T. Pixley	FM
R. R. Regelbrugge	FM
K. A. Young	FM
Howard W. Tindall	PA
W. W. Haufler	MAC
R. Boudreau	TRW
D. L. Rue	TRW
J. W. Wright	TRW

Enclosure 1

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: FEB 5 1968
68-PA-T-28A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Rendezvous radar will be available during critical mission phases.

1. Something rather astounding happened at the Apollo Spacecraft Software Configuration Control Board meeting on Tuesday, January 30. It was so shocking the word spread like wildfire! But just in case you have not already heard, it looks like we are going to get rendezvous radar data on the downlink during the critical LM powered flight mission phases. Previously, MIT had estimated that it would cause a three week impact on Luminary delivery to provide the capability of automatically boresighting the rendezvous radar on the command module and getting its data on the downlink during the descent, ascent and abort programs. As a result, it had been anticipated this program change request would not be approved. Their more detailed analyses, however, showed they could provide these capabilities with no impact at all, and so we're going to get it.

2. During as Ascent Data Priority meeting a while back, we had concluded that we would do no rendezvous radar tracking of the command module immediately prior to liftoff nor until the pitchover maneuver shortly after liftoff, at which time the command module would be within the field of view of the radar antenna in mode II. It is probable we will align the antenna prior to liftoff to the shaft and trunion angles which we anticipate would direct the antenna toward the CSM and it will have been powered up to whatever condition is necessary to permit acquisition at that time. There is still some question as to how well the antenna will maintain that position when in the standby mode, but that seems relatively immaterial.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27

5010-108

UNITED STATES GOVERNMENT

Memorandum

NASA - Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: FEB 8 1968
68-PA-T-17

FROM : FM/Deputy Chief

SUBJECT: Some Sundisk idiosyncrasies

1. Here are a couple of things we learned during the Sundisk Pre-DARR meeting at MIT on January 25 dealing with preparation to make a guided maneuver. One dealt with the procedure for updating the permanent state vector in the command module computer (CMC). As you know, the CMC idling program (P00) updates the state vector routinely based on the following test. When P00 is entered, it checks to see if the current state vector is older than 9 minutes. If it is, it causes it to be integrated up to the present time but if the time is less than 9 minutes (for example, 8 minutes and 45 seconds), it does not do anything except set a timer which will cause it to check the state vector age again in 9 minutes. Obviously, this means that if P00 is used to update it, the state vector can grow almost 18 minutes old. In preparation for some critical mission phases such as late in a thrust program, like P-40, it is necessary to bring the state vector up to date. Accordingly, it is recommended we utilize Verb 83 to do this as a standard procedure, since that procedure does not have the inherent uncertainty of P00.

2. The other matter dealt with use of the External Delta V program (P-30). As you know, targeting for P-30 is done impulsively, that is, 3 components of Delta V to be added at an instant of time. This time tag is ordinarily chosen to be the middle of the finite thrusting period. In order to compensate for orbital travel during this period, a rotation of the thrust vector is performed in the thrust programs (P-40). It was reported that if P-30 is ever entered after this rotation is done in P-40, it is done again on reentering P-40 doubling the rotation. Thus, if this program sequence is ever followed, as would happen if we updated the state vector after entering P-40, it would be necessary for the crew to reinsert the desired delta V's via the DSKY.

3. It was emphasized, however, that no harm is done by calling and recalling either P-30 or P-40; it is only when going back ~~from P-40~~ to P-30.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27

5010-107

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: FEB 6, 1968
68-PA-T-17A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Lunar Reentry Mission Techniques meeting

1. On February 1 we had another meeting on lunar reentry mission techniques. Almost all of our discussion dealt with the final midcourse maneuver prior to entry. As you know, midcourse maneuvers are currently planned to occur approximately 12 hours after TEI which is near the sphere of influence of the moon and about 15 hours prior to reaching the Entry Interface (400,000 feet altitude). Analyses have shown it is highly probable that these maneuvers will have to be made and propellant is budgeted for them. Planning has also included a third midcourse maneuver just prior to reentry, the need for which is nowhere near as certain. Of course, it must be included in the timeline regardless of that. It is this midcourse maneuver we discussed.

2. When should the maneuver be scheduled? Ron Berry stated that, according to their studies, the magnitude of dispersions at Entry Interface (EI) are relatively insensitive to the time at which the third midcourse maneuver is made as long as it is no earlier than about 5 hours before (EI). Therefore, this consideration puts an upper bound on the time at which this maneuver must be made. Paul Pixley states that for the cases they have examined it is always possible for the MSFN to obtain a good state vector for entry initialization provided the final midcourse maneuver occurs no later than 2 hours before EI. This MSFN tracking limitation establishes the lower bound. Selection of the actual time the maneuver should be made between these bounds is primarily based on operational considerations. That is, we would like to make sure the crew timeline following the maneuver is not unduly hurried and will be very much interested in the flight planning people's input on this (Tom Holloway please note). Until something comes along to change it, we propose for now to schedule the third midcourse maneuver 2 hours prior to 400,000 feet and all mission planning and analysis activity should be based on that.

3. We also established a criteria upon which it will be possible for the flight controllers to establish the need for this maneuver in real time. Based on the work of Claude Graves' group, it was stated that

a flight path angle dispersion at EI of .38° is considered acceptable. According to Paul Pixley, the MSFN is capable of determining that parameter to within 0.02°, given 30 minutes of tracking within 2 hours of EI. By subtracting this we established a flight path angle dispersion limit of .36° as the GO/NO GO criteria for whether or not to make the midcourse maneuver. That is, if the predicted flight path angle at EI differs from the desired value by more than .36°, the third midcourse maneuver will be executed. According to Pete Frank, this value is sufficiently large that the likelihood of the third midcourse maneuver is very low.

4. It was decided that the midcourse maneuver, if necessary, will be entirely in plane. This ground rule was established based on an understanding that very little lateral landing point adjustment is available without very large out-of-plane maneuvers. Nor is it needed since the lifting reentry footprint should provide more than enough lateral landing point control.

5. Another ground rule we established was that there would be no comparison of onboard navigation to MSFN navigation associated with the third midcourse maneuver. This is a necessary constraint since onboard navigation changes the CMC spacecraft state vector, which is an unacceptable thing to do just prior to entry. Furthermore, it is unnecessary anyway, since by that time in the mission we should have sufficient faith in the one which has been uplink from the ground without that coarse comparison.

6. This ruling poses the question as to how long before entry the ground determined state vectors propogated to EI are of equal accuracy to that determined onboard since, given communication loss, at some point the crew should abandon the MSFN state vector and start navigation and maneuver targeting onboard. The Mathematical Physics Branch and Orbital Mission Analysis Branch people were given the action item of determining this crossover point which is anticipated to be well before the second midcourse maneuver. In other words, I expect that once we have committed the spacecraft to executing the ground computed second midcourse maneuver utilizing a MSFN state vector update, there should be no further star landmark/star horizon exercises carried out onboard the spacecraft.

7. As a side issue, it may be desirable to include in the lunar mission plan some sort of "onboard Navigation and Return-to-Earth targeting" exercise as a systems test either on the translunar phase of the mission, or more reasonably, early in the transearth phase to evaluate that capability. But it is to be emphasized that it is a systems test only and that navigation and targeting of all these maneuvers should be based on ground computations given adequate communications.

8. Another question which must be answered dealt with how soon before EI it is reasonable for the CMC Average g program to start running. Of particular concern is the effect of approximations on the accuracy of the average g integrator when computing the influence of just the gravitation the spacecraft is experiencing. Guidance and Performance Branch is to answer that.

9. In the current flight plan we propose that platform alignments be carried out based on a ground computed REFSMMAT at 3 hours and 1 hour prior to EI. (We still haven't pinned down its specific orientation.) In addition to the ground transmission of this REFSMMAT, it is necessary to send up the spacecraft state vectors and External Delta V targeting parameters for the third midcourse maneuver if it is needed. Also the state vector for entry initialization must be sent sometime during the last hour before entry with its time tag close to the predicted EI time.

10. There was considerable discussion regarding the spacecraft computer entry programs. Several modifications have been proposed, but it was evident from our discussion that we didn't know enough about the current definition of these programs to do anything. We also inconclusively discussed initialization of the EMS again. Accordingly, it was decided that our next meeting should include participation by MIT and North American personnel.

Howard W. Tindall, Jr.

Enclosure
List of Attendees

Addressees:
(See attached list)

ATTENDEES

CB	M. Collins
CF	M. A. Rahman
FC	J. S. Lewellyn
FC	D. V. Massaro
FM	R. Perry
FM	M. P. Frank
FM	C. A. Graves
FM	J. C. Harpold
FM	P. T. Pixley
FM	J. C. Adams
FS	J. E. Williams
FA	H. W. Tindall, Jr.
TRW	R. Boudreau

Enclosure 1

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: FEB 5 1968
68-FM-T-25

FROM : FM/Deputy Chief

SUBJECT: Sundisk range rate computation is not real accurate.

1. As you know, one of the key parameters displayed during rendezvous is range rate based on the current state vectors in the computer. During our Sundisk Pre-CARR meeting at MIT on January 25, it was reported that due to approximations used in its computation, this parameter inherently has an error that can grow to as much as 5 fps. MIT has already reduced this error as much as they can by rectifying the solution every 100 seconds. Accordingly, it is my impression that the error grows over each 100 second interval up to as much as 5 fps, at which time it is reduced to zero again.

2. This deficiency, if I can call it that, seemed significant at first since the command module crew carries out their terminal braking schedule based on range and range rate. But considering the much larger errors we probably will encounter due to state vector inaccuracies, it will probably be lost in the noise which we had to be prepared for anyway. This note is just to make sure that everyone who is interested knows about this thing.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

TO : FM/Chief, Mathematical Physics

FROM : FM/Deputy Chief

SUBJECT: Landmarks must be referenced to Irene's earth.

We were informed at the Sundisk Pre-CARR meeting at MIT on January 25 that the CMC landmark tracking initialization data the crew is to use must be referenced to the Fischer ellipsoid. I'm talking about the numbers listed on their landmark photographs, etc., used during the navigation exercise. I could not remember what we were already using so I thought I would send you this note to make sure you do right.

Howard W. Tindall, Jr.

cc:
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/R. P. Parten
J. R. Gurley
E. D. Murrah
FM5/R. E. Ernull
FM7/R. O. Nobles
S. P. Mann
FM/Branch Chiefs

FM:HWTindall, Jr.:pj

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: FEB 7 1968
68-FM-T-23

FROM : FM/Deputy Chief

SUBJECT: Terminal phase transfer angle may be changed to 130°.

1. Extensive analyses were carried out in preparation for Gemini rendezvous which led to our selection of a 130° terminal phase transfer angle. Entirely independent analyses on Apollo apparently have led to selection of 140° for the rendezvous transfer angle. More recently, however, people in the Flight Crew Operations Directorate have been re-examining this and, according to Buzz Aldrin, may soon come to the conclusion that there is sufficient advantage to change to 130°. The primary reason is to minimize the line of sight rates during the terminal braking in an effort to reduce fuel used unnecessarily to eliminate perfectly nominal trajectory characteristics inherent in the present 140° transfer.

2. Since this proposal will influence the development flights as well as the lunar, it would be well to get it resolved ASAP. Accordingly, it will be discussed next Monday, February 12, at the "D" Mission Rendezvous Mission Techniques meeting to at least air the "pros" and "cons" and to see who is for and who is agin.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

UNITED STATES GOVERNMENT

Memorandum

TO : FC4/Chief, GNC Section

DATE: FEB 5 1968
68-PA-T-22A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Can we plan nominally to burn APS to fuel depletion?

1. During our Ascent Mission Techniques meeting on January 31, something rather significant came up. It was thought by several of the people there that it is now considered acceptable to burn the APS engine to fuel depletion. If this is the case, I am sure we would change the way we intend to perform the nominal lunar rendezvous mission. As you know, the present plan calls for making all maneuvers after insertion into orbit with RCS and, of course, since there is a chance of running out of APS fuel we would not open the interconnect.

2. On the other hand, if it is possible to run the APS to fuel depletion I am sure we would attempt to make the maneuvers using that engine, recognizing that if fuel depletion occurs during the maneuver we would have to finish it up with RCS. But, obviously whatever delta V we acquired with the APS gives that much saving from our critical RCS. Would you please have your people look into this and let me know if this is a reasonable way to operate the APS in a nominal mission. I think Jerry Elliott picked up this action item. I am writing this note just to make sure you hear about it.

3. Incidentally, it might also influence how we use the APS on the "D" and "E" missions, too. I'm not sure how.

Howard W. Tindall, Jr.

cc:
(See attached list)

UNITED STATES GOVERNMENT

Memorandum

NASA - Manned Spacecraft Center
Mission Planning & Analysis Division

TO : FM7/Chief, Guidance & Performance Branch

DATE: FEB 5 1968
68-FM-T-21

FROM : FM/Deputy Chief

SUBJECT: Average g

During a discussion about reentry at lunar return velocities the other day, the question came up as to when it was okay to turn on Average g. There was some reason for wanting to do this about one-half hour before arrival at 400,000 feet altitude. We all recognized the inaccuracy which results from accelerometer bias, but the thing we were uncertain about was the inaccuracy due to the approximations used in the average g processor itself. Could you guys determine the relative accuracy of the standard numerical integration program used onboard the spacecraft and Average g for a case like this? You probably already know the answer, having worked on 501 and 502.

Howard W. Tindall, Jr.

cc:
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/R. P. Parten
J. R. Gurley
E. D. Murrah
FM5/C. A. Graves
FM5/R. E. Ernull
FM7/S. P. Mann
R. O. Nobles
FM/Branch Chiefs

FM:HWTindall, Jr.:pj

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: FEB 5 1968
68-FM-T-20

FROM : FM/Deputy Chief

SUBJECT: Invitation to DPS throttling for DOI meeting

1. This memo is to notify you of a long overdue meeting. Even I have been aware for at least a year and a half of the lack of definition of the spacecraft computer program requirements associated with throttling the descent propulsion system (DPS). During that time we have gone through a whole series of program change proposals--- some of which have been implemented, some discarded. What we must do is to get all interested parties together to pin this business down once and for all in order to provide positive direction to MIT for the Luminary program. Unfortunately, we are probably already far late to avoid schedule impact.

2. Our primary problem deals with how we should use our guidance and propulsion systems to make the descent orbit insertion (DOI) maneuver on a lunar landing mission. Questions involve:

a) how long to remain at 10% thrust

b) what thrust level to proceed to for the latter part of the burn?

c) what sort of option should be provided the astronauts and/or the ground in the control of this maneuver?

d) what limitations the DPS imposes, such as helium pressure, freezing, etc.

e) what sort of limitations the guidance system imposes primarily involved in maneuver accuracy.

f) how the RTCC should do the targeting for those maneuvers

g) what guidance mode should be used (that is, Lambert or External Delta V

h) the value and desirability of providing a manual throttle test during the maneuver

i) And I am sure there are many others.

3. Accordingly, we have set up a meeting for February 14 starting at 9:00 a.m., and possibly lasting all day long, to attempt to resolve all this and to develop a precise definition of spacecraft and ground computer program requirements, and perhaps, some mission rules and procedures, etc. The meeting will be held in Building 30, Room 2032B. You and/or your representatives are urged to attend. In fact, I would appreciate it if you would review the distribution and see if I have overlooked anybody who should be there, and let them know.

Howard W. Tindall, Jr.

Addressees:
CB/E. Aldrin
C. Conrad
CF24/P. Kramer
EG/D. C. Cheatham
EG2/M. Kayton
C. T. Hackler
FC5/C. B. Parker
R. L. Carlton
FM13/A. Nathan
FM2/F. V. Bennett
FM7/R. O. Nobles
FS5/J. C. Stokes
T. F. Gibson
J. E. Williams

MIT/IL/D. Hoag

FM:HWTindall, Jr.:pj

UNITED STATES GOVERNMENT

Memorandum

NASA - Manned Spacecraft Center
Mission Planning & Analysis Division

DATE: FEB 5 1968
68-FM-T-19

TO : FM4/Chief, Mathematical Physics Branch

FROM : FM/Deputy Chief

SUBJECT: Sundisk W-matrix is a little weird.

During our Sundisk Pre-CARR meeting at MIT on January 25, Jerry Levine gave us a one hour briefing on some idiosyncrasies in the handling of the W-matrix during the navigation programs. Generally speaking, they involved the manner in which it is propogated with time. I do not think the way we have the mission set up they should bother us, but I urge that you have Bob Savely or someone become thoroughly familiar with this situation and make sure we are doing right. Incidentally, it is possible to change the initial values of the matrix since they are in erasable, in case you didn't know.

Howard W. Tindall, Jr.

cc:
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/R. P. Parten
J. R. Gurley
E. D. Murrah
A. Nathan
FM5/R. E. Ernull
FM7/S. P. Mann
R. O. Nobles
FM/Branch Chiefs

FM:HWTindall, Jr.:pj

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27

5010-107

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: JAN 29 1968
68-FM-T-18

FROM : FM/Deputy Chief

SUBJECT: LM-2 not expected to fly

George Low announced at his January 29 staff meeting that the LM-2 mission will not be flown unless something unexpected turns up in the postflight data analysis now underway. He termed this a "reversible decision" until the final review date, now set as March 6. As I understand it, they intend to continue development of the spacecraft just as though it would fly at least til that date; its disposition after that has not been established.

Howard W. Tindall, Jr.

Addressees:
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/J. P. Bryant
J. R. Gurley
E. D. Murrah
A. Nathan
FM14/R. P. Parten
FM5/R. E. Ernull
FM7/S. P. Mann
R. O. Nobles
FM/Branch Chiefs

FM:HWTindall, Jr.:pj

UNITED STATES GOVERNMENT

Memorandum

DATE: JAN 24 1968

TO : See list below

FA-JA-F-17A

FROM : FA/Chief, Apollo Data Priority Coordination

SUBJECT: Mission "D" Rendezvous Mission Techniques meeting

1. The second of the subject meeting was held on January 17. Some odds and ends were resolved, and one rather significant operational procedure was proposed dealing with CSM operations during [illegible] rendezvous.

2. G&C Division has indicated that it is necessary to execute some LM maneuvers using the AGS. The current "D" Mission Rendezvous exercise includes this mode for the first and/or second maneuver. Considering the status of the AGS and the critical nature of this flight, I took the action item of finding out if we would really use the AGS in this way since it has a heavy bearing on how we utilize the guidance systems. Intuitively, it sounds nuts.

3. We continued our discussion of the preferred platform alignment to be used during the rendezvous exercise. It has been universally agreed that the alignment should be in plane and that the ORDEAL will be used with one of the 8-balls. Choice of the inertial alignment has been hard to make since there seems to be no unique advantage to any particular orientation. Some members of the flight crew had discussed this and arrived at a tentative proposal requiring more discussion within their organization. Their suggestion is to align the platform in such a way that the white and black hemispheres of the 8-ball coincide with the sunlit and dark hemispheres of the earth. That is, as the inertially oriented 8-ball crosses from light to dark the spacecraft would be crossing the earth terminator from day to night.

4. Apparently, it is desired by the crew that both the command module and the LM will have the same 8-ball presentation when in a heads up attitude. Accordingly, the REFSMMAT for each of the two spacecraft will be 90° different from each other.

5. Since earlier in the mission it is planned to perform a docked DPS maneuver, it will be necessary to align the LM platform while in the docked configuration. These same procedures can obviously be [illegible]

preparation for the rendezvous sequence. As mentioned before, the procedures will probably include use of the CSM attitude control system to achieve the desired orientation for viewing the alignment stars in the LM AOT. However, the actual maintenance of this attitude during the alignment will probably be performed using the LM RCS.

6. Probably the most significant concept coming from this meeting dealt with the manner in which the command module should be operated during the LM active rendezvous. The importance of this is that it not only bears on the "D" mission but, if sound, would probably be used on all LM rendezvous including the lunar landing flight. The basic premise is that the most important thing we want to do is to maintain the optimum (nominal) rendezvous situation. That is, if it is impossible for some reason for the LM to execute its planned maneuvers [illegible] designed to continue the coelliptic rendezvous sequence with optimum lighting, approach angles, nominal line of sight rates during braking, nominal braking velocities, etc., as well as satisfying ground tracking constraints, then it is highly desirable that the command module execute a maneuver almost immediately to accomplish the same objective. Accordingly, the proposal under consideration is to target the command module to make a maneuver with a short time delay after the planned LM maneuver and then countdown both vehicles going through the prethrust and thrust programs such that if it is found the LM is unable to [illegible] maneuver, the command module would continue its countdown and maneuver. [illegible] Lineberry stated that their studies have shown that almost exactly the desired conditions are achieved by the command module performing the LM targeted maneuver backwards. And so, for operational simplicity, we would target both of these vehicles to execute essentially the same maneuver using the External Delta V coordinate system, the only difference being that the command module maneuver would be backwards, and the time of ignition somewhat [illegible]. The question of what delay magnitude resulted in two action items. First, the flight crew was to determine the time required following ignition failure of the LM engine to evaluate the situation and establish the need for the command module to burn. It is expected this time to be about one, and no more than, two minutes. The second task was for the Rendezvous Analysis Branch to perform a parametric study to show the degradation effect in terms of delta V costs, TPI time slippage, etc., resulting from various values of delay time for the command module to execute the maneuver. The basic point to be made is that we do not feel it desirable for the LM crew to spend very much time analyzing the situation, evaluating propulsion or guidance systems but rather in order to maintain a relatively nominal rendezvous situation [illegible] command module, thus making the "failure analysis" operation very much less time critical.

7. In conjunction with this operation, therefore, we would expect the LM [illegible] to relay to the command module pilot the maneuver he anticipates making in the External Delta V coordinate system. The command module pilot would use this targeting to prepare for the backup maneuver described above. In the event he is not called upon to make the maneuver, he utilizes that same information using the so-called Target Delta V routine (R-32) to update the LM state vector in the CMC.

8. One additional problem associated with this latter point deals with what to do if it is adjudged undesirable for the LM to trim velocity residuals in which case the maneuver passed to the CM for updating the state vectors is not accurate. There were three obvious courses of action as follows: (a) ignore the error and depend on sextant observations to eliminate it, (b) reorient the LM in such a way that they are able to read out the delta V residuals in the external delta V coordinate system to be relayed to the command module, and (c) utilize the ground network taking the LM state vector from telemetry and relaying it back to the command module with the obvious time delays associated with that. This matter was not resolved and requires further consideration.

9. In order to avoid midweek travel conflicts, we have found it necessary to abandon our plan to hold these meetings every other Wednesday. The next Mission "D" Rendezvous meeting is currently scheduled for Monday afternoon, January 29, at 1:00 p.m. in Building 30, Room 3080.

Howard W. Tindall, Jr.

Enclosure
List of Attendees

Addressees:
(See attached list)

ATTENDEES

J. A. McDivitt	CB
R. L. Schweickart	CB
D. R. Scott	CB
D. Blue	CF
M. Contella	CF
J. V. Rivers	CF
C. T. Hackler	FC
S. L. Davis	FC
W. E. Fenner	FC
L. Alexander	FM
C. R. Huss	FM
M. V. Jenkins	FM
E. C. Lineberry	FM
P. T. Pixley	FM
R. Boudreau	TRW
J. Scheppan	TRW

[illegible]
A[illegible] C. [illegible]
C[illegible] K. [illegible]
[illegible] A. [illegible]
J. A. McDivitt
N. Armstrong
F. Borman
M. Collins
C. Conra[illegible]
L. G. Cooper
C. Duke
R. Gordon
J. Lovell
R. L. Schweickart
D. R. Scott
T. P. Stafford
W. R. Pogue
W. M. Schirra
D. F. Eisele
CF/W. J. North
CF13/D. F. Grimm
CF2/J. Bilodeau
CF212/C. Jacobsen
CF[illegible]/C. C. Thomas
CF24/P. Kramer
M. C. Contella
D. K. Mosel
D. W. Lewis
CF3/C. H. Woodling
CF32/J. J. Van Bockel
CF33/C. Nelson
M. Brown
CF34/T. Guillory
T. W. Holloway
EA/M. A. Faget
EA1/J. Chamberlin
EA2/J. B. Lee
EA5/P. M. Deans
EB/P. Vavra
EE/R. Sawyer
I. Packham
EE1[illegible]/M. J. Kingsley
H. G. Irvin
EE3/E. L. Chicoine
EE6/G. B. Gibson
R. G. Fenner
EG/R. A. Gardiner
EG[illegible]/D. C. Cheatham
EG27/W. J. Klinar
H. E. Smith
[illegible]/J. Hanaway
EG[illegible]/B. Reina

[illegible]/J. H. [illegible]
[illegible]/C. W. Fr[illegible]
KA/R. F. Thompson
KA/G. M. Low
C. H. Bolender
K. S. Kleinknecht
PA2/M. S. Henderson
PD/O. E. Maynard
PD12/J. G. Zarcaro
R. J. Ward
R. W. Kubicki
M. H. von Ehrenfried
PD[illegible]/A. Cohen
PD[illegible]/H. [illegible]
PD[illegible]/W. R. Morrison
PD[illegible]/J. Loftus
PD[illegible]/D. [illegible] Lockard
PA/C. C. Kraft, Jr.
[illegible] A. Sjoberg
C. C. Critzos
R. G. Rose
FC/J. D. Hodge
E. G. Kranz
D. H. Owen
D. B. Pendley
M. P. Frank
FC2/J. W. Roach
FC[illegible]/A. D. Aldrich
G. E. Coen
B. N. Willoughby
G. I. Walsh
FC[illegible]/J. [illegible] Craven
[illegible] L. Carlton
J. C. Elliott
FC5/G. S. Lunney
J. S. Llewellyn
J. C. Bostick
D. Massaro
C. B. Parker
C. E. Charlesworth
G. F. [illegible]
[illegible] L. Davis
W. E. [illegible]
C. E. Dauler
W. S. Presley
H. D. [illegible]
P. C. Shaffer
J. H. Greene
K. W. [illegible]
[illegible] G. [illegible]
FL/J. B. Hammack
FD/L. C. Dunseith

FS[illegible]/J. C. Stokes
T. F. Gibson, Jr.
O. R. Sablonski
J. T. Williams
T. M. Conway
TH3/J. S. Dornbach
C. R. Hasser
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM12/R. R. Ritz
FM13/R. P. Parten
J. R. Gurley
[illegible]
[illegible] Nathan
FM[illegible]/M. Collins
FM4/P. T. Pixley
R. T. Savely
FM5/R. E. Ernull
FM6/R. R. [illegible]elbrugge
K. A. Young
IM7/S. [illegible]
R. O. Nobles
FM/Branch Chiefs

HE-03/H. E. Dornak
D. W. Hackbart
Bellcomm (Hqs.)/R. V. Sperry
G. Heffron
GAEC (Bethpage)/J. Marino
MAC (Houston)/W. Haufler
MIT/IL/R. R. Ragan
NR (Downey)/M. Vucelic
I. Zermuehlen
[illegible] Dimitruk, FB[illegible]O
TRW (Houston)/R. Boudreau
M. Fox
C. Pittman
W. R. Lee, Jr.
T. [illegible] Harvey
TRW (Redondo Beach)/R. Braslau
GSFC/F. O. Vonbun, 550
R. Kruger, 550
KSC/R. D. McCafferty (CFK)
P. Baker (CFK)
NASA (Hqs.) A. Merritt, MA[illegible]

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27
5010-107

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: MAY 1 0 1968

68-PA-T-99A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: "C" rendezvous open item clean up

1. Paul Kramer, Phil Shaffer, Due Morel, Ed Lineberry, and myself spent the morning of May 7 trying to close our major open items remaining on the "C" mission rendezvous. These items were:

a. How to handle an excessive slip in TPI time.

b. What kind of cross checking and backup modes should be used for the TPI maneuver.

This memorandum briefly summarizes the results of our discussion.

2. First of all, let me point out that without radar, it is important that the CSM does not approach the S-IVB while in darkness since range information is only obtained visually. Also, the sun must not be too near the line-of-sight - i.e., in back of the CSM - during braking for the same reason. These two constraints can be used to establish a "window" of acceptable TPI times to provide optimum lighting during the braking phase.

a. At this meeting we concluded that it is still best to locate TPI at the midpoint of darkness nominally.

b. In addition, we have specified that tolerable slip in TPI time is from 12 minutes early to 18 minutes late about that nominal time. That is, if the onboard solution for TPI time, based on the first sextant rendezvous tracking period following NSR falls within that period, no steps will be taken to change it. (It is currently estimated that the 3σ uncertainty of the onboard computation of TPI time at that point in the mission is 4 minutes. Exceeding the bounds listed above by 4 minutes is not unacceptable.)

c. On the other hand, if the predicted TPI time slips earlier than 12 minutes or later than 18 minutes, the TPI elevation angle will be adjusted as necessary to bring the TPI time back to the closest bound. This is done as follows. Let us assume that at the end of the first tracking period the TPI time is found to be more than 12 minutes early by having run through the TPI program (P34) using the "elevation angle option." P34 would be recalled using the "TPI time option" and the crew will input a TPI time exactly 12 minutes early in order to determine the elevation angle which will exist at that time. They will then recall P34 using the "elevation angle option" and will input that elevation angle. They will also relay this elevation angle to the ground in order that the MCC may determine a backup solution for TPI.

3. Associated with this, we have made a small change to the crew timeline. Based on latest trajectory information, it has been determined that the first sextant tracking period can be carried out about 16 minutes earlier than previously planned, even under the worst possible conditions. We are rescheduling it earlier in order to insure adequate time before the second sextant rendezvous tracking period to carry out the operation noted above if it is necessary. Specifically, the first tracking period will now begin 64 minutes before nominal TPI. This will occur no earlier than about eight minutes after local sunrise.

4. Deciding how to handle TPI comparison and backup solutions was a much more difficult task. The following is our proposal which we would be hard pressed to defend. Specifically, there are four parameters associated with TPI, any one of which could create problems if excessively in error. Therefore, it is our proposal that each of these parameters, as computed by the G&N, be compared with the best alternate source. If the difference does not exceed established limits on any of these parameters, the G&N will have passed the test and its maneuver will be executed. On the other hand, if any one of the four fails the test, a hybrid maneuver will be executed, each of its components being determined by the best alternate source. In that event, the average "G" program (P47) will be used to permit the G&N to navigate through the maneuver, and sextant tracking and G&N navigation would be continued after the burn in order to obtain as much data as possible for post-flight G&N performance analysis. However, if the failure exceeds twice the limit, we are arbitrarily recommending that the G&N be abandoned completely. That is, no more sextant observations would be taken if the indicated failure is that gross.

5. The four G&N evaluation parameters are TPI time, and the three components of delta V measured in "line-of-sight" coordinates, i.e., along the LOS and perpendicular to it both up (or down) and left (or right). The following table lists what we felt to be the best alternate source for each of these parameters and gives our current guess of the expected 3σ accuracies for both that system and the G&N.

PARAMETER	BEST ALTERNATE SOURCE (BAS)	3σ BAS	3σ G&N	TEST VALUE
Time of TPI	FDAI 8 Ball	2 min	$1\frac{1}{2}$ min	$3\frac{1}{2}$ min
LOS ΔV	MSFN	1 fps	4 fps	5 fps
Up/Down ΔV	Backup Chart	3 fps	4 fps	7 fps
Left/Right ΔV	Backup Chart	3 fps	4 fps	7 fps

Of course it is intended to replace the estimated 3σ values listed with those obtained by up-to-date analysis.

6. It is readily apparent that all we did was to add the largest anticipated G&N error to the largest anticipated error of the comparison source in order to obtain the test limit. This rather simple-minded approach should make abandoning the PGNCS quite unlikely. On the other hand, it is felt that maneuver errors of that magnitude are not intolerable for continuing the rendezvous exercise.

7. The procedures and techniques noted above will be incorporated in all official controlled documents, unless someone objects. Of course, they will then be subject to the same change control as everything else.

8. One other "C" rendezvous item worth noting is with regard to the NCC2 maneuver. Recent analysis has shown that it is not as likely to require an SPS burn as was previously thought. However, since RCS propellant is precious, I understand it is currently the flight controller's intention to reschedule it - delay it about two or three minutes - to force its growth to SPS size (15 fps) if it "naturally" falls in the region between 10 and 15 fps.

Howard W. Tindall, Jr.

Addressees:
(See list attached)

PA:HWTindall, Jr.:js

Addressees:

AA/R. R. Gilruth
AB/G. S. Trimble
CA/D. K. Slayton
CB/A. B. Shepard
J. A. McDivitt
N. Armstrong
F. Borman
M. Collins
C. Conrad
L. G. Cooper
C. Duke
R. Gordon
J. Lovell
R. L. Schweickart
D. R. Scot
T. P. Stafford
W. R. Pogue
W. M. Schirra
D. F. Eiselle
CF/W. J. North
CF13/D. F. Grimm
CF2/J. Bilodeau
CF212/C. Jacobsen
CF22/C. C. Thomas
CF24/P. Kramer
M. C. Contella
D. K. Mosel
D. W. Lewis
CF3/C. H. Woodling
CF32/J. J. Van Bockel
CF33/C. Nelson
M. Brown
CF34/T. Guillory
T. W. Holloway
EA/M. A. Faget
EA1/J. Chamberlin
EA2/J. B. Lee
EA5/P. M. Deans
EB/P. Vavra
EE/R. Sawyer
L. Packham
EE13/M. J. Kingsley
R. C. Irvin
EE3/E. L. Chicoine
EE6/G. B. Gibson
R. G. Fenner
EG/R. A. Gardiner
EG2/D. C. Cheatham
EG27/W. J. Klinar
H. E. Smith
EG41/J. Hannaway
EG42/B. Reina
EG43/J. M. Balfe
EG44/C. W. Frasier
KA/R. F. Thompson
PA/G. M. Low
C. H. Bolender
K. S. Kleinknecht
PA2/M. S. Henderson
PD/O. E. Maynard
PD12/J. G. Zarcaro
R. J. Ward
B. W. Kubicki
M. H. von Ehrenfried
PD4/A. Cohen
PD6/H. Byington
PD7/W. R. Morrison
PD8/J. Loftus
PE7/D. T. Lockard
FA/C. C. Kraft, Jr.
S. A. Sjoberg
C. C. Critzos
R. G. Rose
FC/J. D. Hodge
E. G. Kranz
D. H. Owen
D. B. Pendley
M. P. Frank
FC2/J. W. Roach
FC3/A. D. Aldrich
G. E. Coen
B. N. Willoughby
G. P. Walsh
FC4/J. B. Craven
R. L. Carlton
J. C. Elliott
FC5/G. S. Lunney
J. S. Llewellyn
J. C. Bostick
D. Massaro
C. B. Parker
C. E. Charlesworth
C. F. Deiterich
S. L. Davis
W. E. Fenner
G. E. Paules
W. S. Presley
H. D. Reed
P. C. Shaffer
J. H. Greene
K. W. Russell
S. G. Bales
FL/J. B. Hammack
FS/L. C. Dunseith
FS5/J. C. Stokes
T. F. Gibson, Jr.
G. R. Sabionski
J. E. Williams
T. M. Conway
UH3/J. E. Dornbach
J. H. Sasser
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM2/B. R. Ritz
FM13/P. F. Parten
J. R. Gurley
E. D. Murrah
A. Nathan
FM3/M. Collins
FM4/P. T. Pixley
R. T. Savely
FM5/R. E. Ernull
FM6/R. R. Regelbrugge
K. A. Young
FM7/S. P. Mann
R. O. Nobles
FM/Branch Chiefs

HE-03/H. E. Dornak
D. W. Hackbart
Tellcomm (Hqs.)/R. V. Sperry
G. Heffron
GAEC (Bethpage)/J. Marino
MAC (Houston)/W. Haufler
MIT/IL/R. R. Ragan
NR (Downey)/M. Vucelic
D. Zermuchlen
E. Dimitruk, FB30
TRW (Houston)/R. Boudreau
M. Fox
C. Pittman
W. R. Lee, Jr.
T. V. Harvey
TRW (Redondo Beach)/R. Braslou
GSFC/F. O. Vonbun, 550
B. Kruger, 550
KSC/R. D. McCafferty (CFK)
P. Baker (CFK)
NASA (Hqs.)/A. Merritt, MA3

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: MAY 6 1968
68-PM-T-97

FROM : FM/Deputy Chief

SUBJECT: LM3 AGS will use Kearfott accelerometers

Bob Gardiner announced at George Low's April 6 staff meeting that there are no Abort Sensor Assemblies available with Bell accelerometers. On the other hand, one is available with the Kearfott Group accelerometers - ahead of schedule. It is their intention to use this one on LM3.

Note to Guidance and Performance Branch - hopefully you people finally should be able to get some real performance information on the AGS.

Howard W. Tindall, Jr.

Addressees:
CB/J. A. McDivitt
C. Conrad
FA/C. C. Kraft, Jr.
S. A. Sjoberg
C. C. Critzos
FC4/R. L. Carlton
J. B. Craven
FC5/C. B. Parker
FS/L. C. Dunseith
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM12/R. R. Ritz
FM13/R. P. Parten
J. R. Gurley
E. D. Murrah
A. Nathan
FM3/M. Collins
FM4/P. T. Pixley
R. T. Savely
FM5/R. E. Ernull
FM6/R. R. Regelbrugge
K. A. Young
FM7/S. P. Mann
R. O. Nobles
Branch Chiefs

FM:HWTindall, Jr.:js

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27
5010-107

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: MAY 10 1968

68-PA-T-100A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: No special visual reference will be provided for the final transearth midcourse correction maneuver

1. On May 7 we reviewed the need for an RTCC program change to provide a special visual reference for the crew during the last transearth midcourse correction maneuver on a lunar mission. We concluded it is not needed and that no new programming or displays are required.

2. The final transearth midcourse correction maneuver has the following characteristics. It is scheduled to occur two hours before entry. At that time, the spacecraft is located approximately on the earth-moon line about 20,000 miles from the earth. The maneuver is essentially horizontal with respect to the earth - perpendicular to the earth-moon line.

3. The primary subject under consideration was the use of the earth or the moon as a visual reference. This is partly a carry-over from using the horizon as a reference during the retrofire maneuver on earth orbital missions since they are similiar maneuvers in a way - both set-up the reentry trajectory. Unfortunately located as they are with respect to a horizontal burn, the earth and moon are both located in the worst possible places for use as a burn attitude reference. Accordingly, we concluded that our best course of action is to use standard burn attitude checks such as comparison with a properly aligned SCS and stars if they are visable.

4. It should be pointed out that large orientation errors have relatively little effect on this unique maneuver since components of delta V perpendicular to the one we are trying to achieve don't do anything. Thus, misalignment merely reduces the effective magnitude of the maneuver by the cosine of the misalignment angle.

Howard W. Tindall, Jr.

Addressees:
(See list attached)

PA:HWTindall, Jr.:js

Addressees:
CB/J. A. McDivitt
CF/P. Kramer
T. W. Holloway
J. E. Hutchins
J. Owens
EG/C. T. Hackler
FC/G. S. Lunney
J. G. Renick
W. E. Fenner
K. W. Russell
H. L. Weyer
FM/ A. L. Accola
E. C. Lineberry
D. Reed, Jr.
A. Nathan
TRW (Houston)/R. Moran
R. J. Boudreau
D. L. Rue
J. E. Scheppan

ATTENDEES

H. W. Tindall, Jr.	PA
J. G. Renick	FC
W. E. Fenner	FC
K. W. Russell	FC
H. L. Weyer	FC
T. W. Holloway	CF
J. E. Hutchins	CF
J. Owens	CF
C. T. Hackler	EG
A. L. Accola	FM
E. C. Lineberry	FM
D. Reed, Jr.	FM
A. Nathan	FM
S. Paddock	MDC
R. Moran	TRW
R. J. Boudreau	TRW
D. L. Rue	TRW
J. E. Scheppan	TRW

Enclosure 1

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

UNITED STATES GOVERNMENT

Memorandum

TO : Guidance and Performance Branch
Attention: FM7/S. P. Mann

DATE: APR 30 1968

68-PA-T-91A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: PGNCS/AGS clock synchronization

During our "D/E" Rendezvous Data Priority meeting of April 29, Al Nathan reported that it is likely the PGNCS and AGS clocks may not be synchronized to better than 3/4 of a second - at least if we use the procedures currently planned. This is probably okay for rendezvous, but I wonder what it does to our ascent and descent monitoring.

I just wanted to alert you in case this is something your people should be looking into if you haven't already done so.

Bill

Howard W. Tindall, Jr.

cc:
FM6/F. V. Bennett

PA:HWTindall, Jr.:js

UNITED STATES GOVERNMENT

Memorandum

TO : Guidance and Performance Branch
Attention: FM7/S. P. Mann

DATE: APR 30 1968

68-PA-T-91A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: PGNCS/AGS clock synchronization

During our "D/E" Rendezvous Data Priority meeting of April 29, Al Nathan reported that it is likely the PGNCS and AGS clocks may not be synchronized to better than 3/4 of a second - at least if we use the procedures currently planned. This is probably okay for rendezvous, but I wonder what it does to our ascent and descent monitoring.

I just wanted to alert you in case this is something your people should be looking into if you haven't already done so.

Bill

Howard W. Tindall, Jr.

cc:
FM6/F. V. Bennett

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: APR 30 1968
68-PA-T-89

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: CSM should have good rendezvous navigation in the lunar mission

1. As you know, I have been pushing to get the capability back into the command module computer program to compute CSI and CDH rendezvous maneuver targeting. The reason I consider this valuable is that with both VHF ranging and sextant data, the command module potentially has a better rendezvous guidance system than the LM. Thus, with that capability, it could provide the comparison "yard stick" for evaluating the LM PGNCS determined maneuvers during a nominal flight and could provide targeting for its own maneuvers if a command module rescue situation arises.

2. I submitted a PCR for Colossus and MIT responded with a six week program delivery schedule slip which, of course, is unacceptable. Therefore, this PCR has been added to the list of changes to be considered for later versions of Colossus. During our discussion of this PCR, someone remarked that the VHF ranging device is limited to use for ranges less than 200 nautical miles, whereas the nominal range at insertion is about 270 nautical miles, and that lighting conditions for sextant observation were poor prior to the CSI and CDH maneuvers. If this were true, it would substantially reduce the benefit of this capability, and in fact, might make it impossible to use the command module as noted above. I have checked into the actual situation for lunar rendezvous and have found quite the opposite. The tracking conditions are really very good. Attached to this memorandum are figures which show this. They were lifted from an excellent memorandum (68-FM64-17) written by a couple of Ed Lineberry's people - James D. Alexander and Francisco J. T. Leon-Guerrero. You will observe (Figure 1) that approximately five minutes after insertion into orbit both spacecraft are in darkness which should make sextant tracking ideal and in fact at no time after that and prior to TPI is the angle between the LM and the sun as observed from the command module less than 70°. Furthermore, you will note (Figure 2) that, even if 200 nautical miles is a hard constraint on VHF ranging, it should be possible to get between 5 and 10 minutes worth of tracking before CSI, which should do quite a bit of good. And, of course, as Ed Lineberry says, there is nothing sacred about doing CSI that soon. That is, by delaying it 5 or 10 minutes, we could obtain an equal amount of extra VHF tracking. Of course, hopefully, VHF will work at ranges greater than 200 miles, particularly, if we are willing to restrict voice communications. (Figures 3 and 4 are attached to show an equally good situation will exist on the "F" mission.)

3. My basic purpose in sending around this memorandum is to clarify the situation by distributing this data, which I found very interesting, and to reemphasize the desirability of equipping and utilizing the CSM in this way.

Howard W. Tindall, Jr.

Enclosures 4

Addressees:
(See list attached)

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : PA/Chairman, Apollo Software Configuration Control Board

DATE: APR 26 1968

68-PA-T-86A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Results of "C" Mission Rendezvous Review meeting - April 2[illegible], 1968

1. At your request, I set up a meeting on our current "C" mission rendezvous problems with participation by all organizations interested in this activity. The attached attendee list will show you they were well represented. Our basic purpose was to determine current status of the situation and to recommend where to go from here with regard to the problems which have recently been coming to light (both real and imaginative) primarily as a result of the crew training exercises at KSC.

2. In summary:

a. It is the consensus that the Sundisk program is acceptable for flight - that is, program changes and new ropes need not be made.

b. Post release Sundisk program testing is underway to further verify its flight readiness. Results to date have been highly satisfactory and no new program bugs have been found. This testing is continuing, but confidence is high that it will be completed successfully.

c. A number of open items in the crew procedures were discussed and decisions were made which will permit consistent, unified work in the future with regard to development of the crew timeline, simulation activity, program verification testing, etc.

d. A number of desirable program changes were discussed which should be incorporated in the follow-on spacecraft computer programs.

Each of these items will be amplified below.

3. Post release verification testing of programs associated with the rendezvous exercise, currently underway, falls into three categories. They are as follows:

a. Testing of the sextant rendezvous navigation. Two runs have been laid out in detail covering the period from the NSR maneuver to the terminal phase midcourse maneuver [illegible] currently being run at MIT on their bit-by-bit simulator, their [illegible] simulator, and their digital engineering simulation program. Math Physics Branch (MPAD) is designing an additional run utilizing the final crew procedures, parts of which are defined in this memorandum. MIT will also make this run. According to Flight Software Branch, these three runs are being made a part of the formal post release verification and will be well documented.

b. Twelve rendezvous targeting and burn runs covering the period between NSR and docking have been defined by MPAD and Flight Crew. Four of these tests will be run on the MIT bit-by-bit simulator and also on the North American MK-101. All twelve of these runs are being processed through the MIT engineering simulation program, the equivalent MPAD programs, and the bit-by-bit simulation here at MSC. Many of these runs have already been made and their results have compared very favorably. In addition, the initial conditions and other data required to make these runs have been delivered to the AMF at KSC. The purpose of this is to provide test cases with which they may check out their simulator. It is not to test the Sundance program; as of this date, they don't intend to run these cases.

c. A completely independent test plan has been designed by TRW and reviewed by MSC defining a series of runs to be made on the local bit-by-bit simulator.

It was the consensus that successful completion of all this testing should provide adequate confidence in Sundance for its use in the "D" mission.

4. <u>Crew Procedures</u>

In order that everyone may carry on using the same approach, we discussed and chose the following crew procedures which should be considered official. That is, they should not be changed without future discussion and widespread dissemination since so many organizations are concerned.

a. The first and most important involved the workaround procedure for the terminal phase midcourse maneuver targeting program (P-35). It has been decided to handle this program deficiency by designating that the CSM state vector rather than the [illegible] state vector be updated based on sextant observations after TPI. Tests have shown that this technique works very well. In fact, it provides a theoretically perfect solution.

b. It was also decided that the crew would make a so-called "phony mark" after the TPI maneuver and prior to beginning navigation. This decision was made in spite of the fact that MPAD representatives did not feel this operation was necessary.

c. The consensus is that the "phony mark" is not necessary following the midcourse correction maneuver and so it will not be made at that time.

d. It was decided to set the Delta R and Delta V test parameters to zero so that after each sextant observation the crew will be forced to observe the effect of that observation on the state vector. It will also cause a program alarm to occur. The primary benefit to be gained from this procedure is that it will provide the crew with information regarding the trend of state vector changes which will be helpful in their editing process. It should be noted that this is the procedure currently in use on all simulators at MIT, KSC, MAC, etc. It was observed that after more simulator experience, it may be desirable to load values somewhat larger than zero to simplify the crew operation a little. This would be a minor modification to the procedure.

e. Based on the strong recommendation of MIT, it was decided to reinitialize the W-matrix during the second navigation period between NCR and TPI. This procedure was also adopted over the objection of MPAD personnel who intend to carry out future analysis to provide their contention that it is not necessary and perhaps that it is even damaging. There was also discussion of the value to be used for reinitialization of the W-matrix at this time. MIT currently proposes 1,000 feet and 1 fps, although it seems that values as much as three times larger may be recommended before the flight.

f. The flight crew has concern over allowing the average "G" program (P-47) to run continuously after the second midcourse correction. They are afraid that the accelerometer bias may introduce unacceptable error in the state vector. MPAD was given the action item of determining the effect of various levels of accelerometer bias acting over different periods of time on the range and range rate displays. This information should give some insight into how the system should be operated when someone establishes what accelerometer bias we should expect. As of now, they will continue to run P-47.

5. At least two program modifications should be considered for future spacecraft programs:

a. It has come to light that the Sundisk short burn SPS logic will cause a premature engine shut down amounting to about four fps as a result of some inaccurate spacecraft characteristics frozen in fixed computer memory. It is recommended that there parameters be located in erasible so that they may be loaded after true values are known.

b. There is an infuriating "Delta V residual bounce" following spacecraft maneuvers which preclude accurate maneuver execution. MIT is in the process of tracking down the cause of this. Hopefully it may be fixed in the later programs or at least maybe we will find out what it really is!

6. Finally, KSC simulator people were asked if any possible assistance not already available could be provided to help solve their problems. It was their opinion that at this time they have a number of known things that must be done which will substantially improve their facility and until these are completed, they feel no organized help from MSC or MIT would be particularly helpful.

Howard W. Tindall, Jr.

Enclosure
List of attendees

cc:
(See attached list)

PA:HWTindall, Jr.:js

ATTENDEES

PA	H. W. Tindall, Jr.
CB	D. F. Eicelle
CB	D. R. Scott
CB	J. W. Young
CF	D. W. Lewis
CF	A. H. Davidson
CF	J. N. Lee
CF	C. D. Nelson
CF	F. E. Hughes
CF	D. K. Mosel
CF	P. C. Kramer
EG	H. E. Smith
EG	J. H. Suddath
EG	E. M. Jones
ED	J. L. Raney
FT	D. W. Hackbart
FT	H. E. Dorunk
FD	R. C. Croston
FC	R. J. Williams
FC	J. T. Cox
FC	C. B. Baker
FC	G. S. Lunney
FC	R. J. Williams
FC	G. P. Walsh
FC	M. J. Neubauer
FC	F. C. Shaffer
FC	W. E. Presley
FC	J. C. Portick
FC	C. F. Deiterich
FS	G. R. Sablonski
FS	G. R. Kimball
FS	P. J. Pechek
FM	T. J. Blucker
FM	J. H. Shreffler
FM	J. B. Williamson
FM	R. O. Nobles
FM	S. P. Mann
FM	A. Nathan
FM	M. A. Collins
FM	R. L. Simms
FM	R. T. Savely
FM	P. T. Pixley
FM	E. R. Schiesser
FM	E. C. Lineberry
FM	R. G. Repellbrugge
MAC	J. C. Callihan
MAC	C. A. Jacobson
MAC	W. W. Haufler
MAC	F. M. Dugge
NASA Hqs.	A. C. Merritt
TRW	L. Knoedler
TRW	R. J. Boudreau
TRW	J. W. Wright
MIT	J. F. Vittek
MIT	B. J. McCoy
MIT	N. E. Sears
MIT	J. L. Nevins
MIT	R. E. Phillips
MIT	P. M. Kachmar
MIT	E. S. Muller
MIT	W. H. Templeman
MIT	L. S. Johnson

Enclosure 1

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: APR 26 1968

68-FM-T-87

FROM : FM/Deputy Chief

SUBJECT: Results of the Apollo Spacecraft Software Configuration Control Board meeting of April 23

This memorandum briefly summarizes the results of the meeting and primarily points out which PCR's were approved or disapproved.

1. SUNDISK

PCR 1[illegible] - GSOP Chapter [illegible] change to [illegible] and [illegible] was approved.

2. COLOSSUS

a. The following PCR's were approved:

(1) PCR 1[illegible] - to permit storing the present CSM [illegible] vector while doing cis-lunar navigation so that if it is subsequently needed, it is not destroyed.

(2) PCR 155 - will cause the spacecraft entry roll profile to be consistent with crew procedures - i.e., provide horizon reference to insure proper aerodynamic capture at entry. This was approved at the cost of one day.

(3) PCR 157 - will change the location of the Lambert targeting parameters to be in sequential order in erasable memory, consistent with the Universal Update Program format (V71).

b. The following PCR's were not approved:

(1) PCR 158 - to change the entry range prediction program - "Augekugel." Schedule cost of one day. This [illegible] to next meeting since the board could not clearly understand and make judgment. MPAD is to provide a formal presentation.

(2) PCR 101 - Adding CSI/CDH targeting into the rendezvous program would cost six weeks and may not fit in storage. This was disapproved and put into Colossus [illegible]

hopper to be reviewed at the next joint program development plan meeting at MIT in a couple of weeks.

(.) PCR 132 - to provide a DSKY light to indicate VHF data ... This was tabled until George Low's CCB presentation on the hardware.

3. COLOSSUS #2 (for mission "D" and/or "E")

The following PCR's were approved (I think):

a. PCR 134 - pulse torquing of the IMU to permit ... tion flexibility while avoiding gimbal lock.

b. PCR 156 - will provide an automatic "proceed" to change the display format when under peak reentry "G" ...

4. LUMINARY

PCR 139 - to get rendezvous radar data on the downlink while on the lunar surface. MIT evaluation is incomplete although apparently the impact is approximately two days. Tabled until detailed information is available.

5. PCN's by MIT (eight of them) are tentatively approved but will be formally reviewed at the next meeting. Most are GSOP and/or coding changes MIT feels are necessary to make the program work and meet specifications. There are several that MPAD people should investigate before then. Stan Mann is personally contacting those concerned to get their comments. If there is no objection, they will be approved.

Howard W. Tindall, Jr.

Addressees:
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/R. P. Parten
J. ... Garvey
... Morrow
A. ...
FM1.../...
FM6/... Pixley
R. T. Savely
FM5/R. E. Ernull
FM4/P. Pecker
FM7/S. P. Mann
R. O. Noble
FM/Branch Chiefs

FM:HWTindall,Jr.:...

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: APR 23 1968

68-PA-T-84A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Descent Orbit Insertion (DOI) monitoring and abort procedures are proposed

1. Something rather interesting came out of Floyd Bennett's April 16 Descent Mission Techniques meeting that I would like to push around. It has to do with monitoring the DOI maneuver.

2. Previously, in discussions with Ed Lineberry's mission planning people, it had been proposed that if an abort should be necessary within the first 10 minutes or so after DOI, the best technique was not to go through an entire coelliptic rendezvous sequence, but rather was to thrust back directly toward the CSM with sufficient delta V to insure closure and to go straight into the standard braking procedures. The delta V required to do this is in the order of 100 fps to be applied directly along the line-of-sight. At the time of our discussion on this, no one had thought of any reason for aborting in that short period and so I did not include this technique in my "Lunar Rendezvous Abort Summary" memorandum, which had already grown too long. However, when we considered monitoring DOI, such an abort situation became readily apparent. Specifically, we concluded if an LM PGNCS and/or DPS failure occurs during DOI - particularly if we have either overburn or underburn - we should use the abort procedures noted above. The alternate is to delay the abort action and accept a LM rendezvous from above with either the LM PGNCS or DPS not working properly.

3. The systems available for monitoring the PGNCS controlled DOI burn are obviously the AGS and the clock. The latter of course is very crude since it only takes an overburn of 13 fps on a nominal 70 fps DOI to result in lunar impact and this sort of dispersion would occur within two or three seconds at half thrust. If the AGS or the burn duration indicate PGNCS has commanded an erroneous burn magnitude, it is only necessary to pitch the LM to acquire rendezvous radar lock-on to find out what's up. Since the CSM is located directly ahead of the LM during this retrograde maneuver, the range-rate indication is all that is needed to determine if the proper delta V has been attained or not. We also considered use of the CSM VHF ranging device in this monitoring, but quickly concluded that since it does not directly range-rate, it would probably not be very useful. Of course, DOI occurs behind the moon so MSFN is out of the picture.

4. In the event of a DOI failure, the LM crew should align the X-axis along the CSM line-of-sight and thrust until a closing rate of about 6 fps is displayed on the rendezvous radar range-rate readout. It may be desirable to make this maneuver by staging and using four-jet RCS with the interconnect open.

5. Obviously, detailed procedures and systems utilization are only in the preliminary design phase on all this. On the other hand, the concept described here is better than anything else we could think of and is certainly feasible. I wanted to make you aware of it and solicit your thoughts.

Howard W. Tindall, Jr.

Addressees:
(See list attached)

PA:HWTindall, Jr.:js

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

Memorandum

TO : See list below

DATE: APR 17 1968
68-PA-T-83A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Status evaluation meeting - "C" Mission Rendezvous

1. As most of you are probably aware, we have a special "C" Mission Rendezvous meeting scheduled for April 22, starting at 9 a.m., in Room 966 of Building 2. This memorandum is to define its purpose, as I understand it. It is also to inform you that another somewhat related meeting which had been scheduled for April 25 regarding CSM Rendezvous Navigation is to be incorporated into this Monday's meeting.

2. Considerable trouble has been experienced by the flight crews during rendezvous simulations on the Cape AMS. Review of Sundisk test results has also uncovered some problems in that computer program. A series of new program tests have been designed and MIT, FOD, and others are in the process of carrying them out. Workaround procedures have been proposed for these known program deficiencies. At his April 9, Software Configuration Control Board meeting, Mr. Kraft requested that I set up a meeting to determine what the situation really is and where to go from here. It is to determine if new Sundisk ropes must be made. Which, if any, workaround procedures should be adopted; to review the test results and determine if additional testing should be carried out and where, etc. It is my hope we will settle on some positive recommendations at this meeting to propose to the Apollo Spacecraft Software Configuration Control Board on April 23. Anyone that has anything to contribute in this area is invited to attend and participate. It is very important that we get these things settled once and for all, if possible, since time is growing short.

3. The meeting previously scheduled for April 25 is somewhat related and certainly requires participation by many of the same people, particularly MIT. Accordingly, it seemed logical to reschedule that meeting immediately following the one discussed above. Its purpose is somewhat different. Specifically, it has become evident that the operational people, Crew and Flight Control, do not understand very well how the onboard rendezvous navigation works and how well. This meeting was set up in hopes that we could discuss this process in non-mathematical terms to give some intuitive insight into how it works. In addition, we wanted to review the results of the extensive analyses carried out by various organizations, specifically the extent of the trajectory dispersions and systems degradations which have been investigated and the results of how well it performs. The [illegible]

the better the operational people who will be involved in the actual flight understand the system, the better the chances are they will operate it correctly.

4. It is not clear how long it will take to go over all these things, so we are prepared to spend all of Monday plus Tuesday morning, if it turns out to be necessary. I hope you or your people will be able to join us.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: APR 16 1968

68-PA-T-81A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: "C" Rendezvous Mission Techniques Review

1. Attached is a preliminary version of the "C" Rendezvous Mission Techniques document. It is based on numerous meetings of a MSC working group involving Flight Operations Directorate, Flight Crew Directorate, and Engineering and Development Directorate people and their contractors. Although there are still known flaws and some open items, we have reached a point where wider participation is desirable in developing the techniques this document reflects. Accordingly, we are distributing it to you with the request that you and/or your people review it and then come to a coordination meeting prepared to comment, criticize, or what have you.

2. At this meeting, it is our intention to go through this data flow in detail to give a complete understanding of the proposed mission techniques and to review and incorporate whatever useful changes come up. This meeting is currently scheduled for Thursday, May 2, in Room 716 of Building 2.

3. Additional copies of this document may be obtained from Joanne Sanchez in Room 3068A of Building 30.

Howard W. Tindall, Jr.

Enclosure

Addressees:
(See attached list)

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: A[illegible] 6 1968

[illegible]-FM-[illegible]

FROM : FM/Deputy Chief

SUBJECT: Results of the Apollo Spacecraft Software Configuration Control Board meeting of April 9

This memorandum briefly summarizes the results of the subject meeting. For detail, I would su[illegible] you contact the [illegible] specific program change [illegible] m you are interes[illegible] You will note that PCR activity doesn't seem to be slacking off any.

A. SUNDANCE ITEMS

1. Several PCR's were approved to reflect changes already in [illegible] program - to wit.

   a. PCR's 1[illegible] and 1[illegible] affect the delta V monitor.

   b. PCR 1[illegible] applies to the rendezvous radar search routine. It eliminates the automatic attitude maneuver when the radar angle exceed [illegible]^{o} in order to avoid a DSKY display conflict.

2. There were two PCR's to make the LM software and hardware compatible.

   a. PCR 14[illegible] was approved to fix a GADC FDAI error and provide full scale deflection for 5^{o} attitude error.

   b. PCR 141 would have compensated for some GAEC hardware which doesn't meet specifications but was not approved due to excessive schedule slip. It involves the DPS trim gimbal alarm which has come on when it shouldn't. This is serious and may require a hardware fix. At least such a [illegible] is being taken to Low's CCB.

3. Finally, we intend to discuss the signif[illegible] of the "[illegible] Verify" [illegible] the FACI this week at MIT. [illegible] but could prevent either DPS or APS maneuver [illegible] wrong. It would be better to just cut an alarm and allow the crew to override if necessary.

B. LUMINARY ITEMS

1. The following PCR's were approved:

   a. PCR's 106 and 124 to delete the ascent lift off time computations P-10 and P-11.

   b. PCR 133 to provide an abort insertion orbit apogee of 30 n.m. prior to high gate and 30 n.m. after high gate (two days).

   c. PCR 140 - an improvement in the rate command attitude hold capability (two days).

   d. PCR 118 to simplify the proceed and inhibit logic in R1?.

   e. PCR 137 which permits use of landing radar data starting at 35,000 feet rather than 25,000 feet altitude.

   f. PCR 124 applies to the rendezvous radar search routine. It eliminates the automatic attitude maneuver when the radar angle exceeds 30° in order to avoid a DSKY display conflict.

   g. PCR 136 which adds what may be an outstanding capability deserving a memo of its own. It permits pulse torquing the IMU to a new orientation without making star observations. It is said to be accurate of 0.1 to 0.2% of the angle through which the IMU is torqued. Maximum torque rate is ?0/sec. This could be used for example to avoid gimbal lock. It only costs two days.

   h. PCR 143 reduces the DSKY update rate in an effort to avoid overtaxing the LGC during descent after high gate.

   i. PCR 144 is another adjustment in the delta V monitor already implemented.

2. PCR 141, the DPS trim gimbal alarm fix (see Sundance 26), was not accepted since the cost was seven days. A hardware fix is being taken to Low's CCB.

C. COLOSSUS ITEMS

Although rendezvous targeting for the CSI and CDH rendezvous maneuver are not needed in the earlier CSM flights, MIT was requested to determine the impact for adding the P-32, P-33, P-72, P-73 programs into Colossus.

2. The following changes were approved:

   a. PCR 128 to fix a programming error in the landmark navigation program P-22.

   b. PCR 140 to permit backward integration across the lunar sphere of influence.

   c. PCR 151 to restore the RCS deadband previously set by the crew when the computer exits the P-40 or P-41 thrusting programs.

3. The following were to be held:

   a. PCR 142 to provide a VHF ranging data good discrete light until the DSKY lights are available.

   b. PCR 134 to provide pulse torque reorientation of the IMU (see Luminary "1g") until Colossus #2. It would have cost seven days.

4. PCR 129 had the distinction of being the only one turned down! It was to avoid a display confusion in the return-to-earth program (P-37).

And that's it for this week.

Howard W. Tindall, Jr.

Addressees:
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/R. P. Parten
J. R. Gurley
E. D. Murrah
A. Nathan
FM4/P. T. Pixley
R. T. Savely
FM5/R. E. Ernull
R. Berry
FM6/R. Becker
FM7/S. P. Mann
R. O. Nobles
FM/Branch Chiefs

FM:HWTindall, Jr.:js

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: APR 2[illegible] 1968

68-PA-T-79A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Rendezvous maneuver targeting for guidance system backup

1. During the "D/E" Rendezvous Mission Technique meeting of April 15, we spent a lot of time discussing the data transmitted from the ground to the spacecraft involving the CSI and CDH maneuvers. This discussion, of course, centered on how the data should be used and led to a tentative conclusion regarding the backup of these LM maneuvers, which is somewhat different than we had previously reached. The purpose of this memorandum is to point out this difference.

2. We had previously concluded that the command module should be prepared to make "mirror image" rendezvous maneuvers in the event of LM problems. We had planned to target the CSM with data obtained by the LM crew from the PGNCS. The failure we had in mind was primarily propulsive. However, when you consider that the problem in the LM could also be in the guidance system, it seemed logical to modify the procedures slightly, since it is no better for the command module to make a bum maneuver than for the LM. Also, it did not seem that we were taking optimum advantage of the LM systems, particularly the AGS. Accordingly, we now propose the following:

Both the AGS and the CSM G&N will be targeting with ground computed CSI/CDH maneuvers passed to the spacecraft in External Delta V coordinates. If for some reason the LM PGNCS computed maneuver is not acceptable, we would class this as a PGNCS failure. Rather than carry out some real time systems analysis at this time critical period, they would switch to the AGS and make the ground relayed maneuver. If some further problem is encountered prior to the maneuver, the LM would go passive and the command module would continue its countdown and make the ground computed CSI/CDH burn. Following the burn the crew and ground would attempt to ascertain what the problem is in an attempt to get the LM systems ready for the rest of the rendezvous.

This procedure gives two levels of backup (AGS and CSM) to a PGNCS problem and helps keep the LM active. However, operating in this way would likely preclude either input of rendezvous radar data into the AGS or running through its CSI/CDH targeting computations in order to keep it in the best state of readiness to backup the PGNCS. There is still a period of persistence (FCSD) [illegible] the AGS in [illegible] which [illegible] some higher level direction necessary. I'll try to get a decision [illegible] away, one way or the other.

Howard W. Tindall, Jr.

[illegible]:
[illegible]

[illegible]

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: APR 17 1968
68-PA-T-78A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: April 9 Lunar Reentry Mission Techniques meeting

1. Almost the entire April 9 Lunar Reentry Mission Techniques meeting was spent in discussion of the second and third midcourse correction maneuvers made on the way back from the moon. Ron Berry presented some really interesting data which I think gives us an insight into the character of these maneuvers needed to assure the techniques we are developing will be effective.

2. It was noted that there are four modes for computing midcourse corrections in the Mission Control Center. All are designed to place the spacecraft on a trajectory which hits the center of the reentry corridor. They differ by the additional contracts they are designed to meet.

a. The first and most sophisticated determines the maneuver which will cause the spacecraft to land at a specified landing site (PLA).

b. The second relieves the constraint for latitude but will cause the spacecraft to land at a specified longitude (CLA).

c. The third mode does not constrain reentry to occur at any specific place but rather determines the minimum delta V maneuver required to assure a safe reentry.

d. The fourth mode does not aim for a specific landing site either, but determines the optimum maneuver based on delta V available to get the spacecraft back to earth in the least time.

Of these four modes, we are primarily concerned here with the first and the third. That is, we intend to use the PLA mode for determining the first and second midcourse corrections coming back from the moon (MCC 1 and MCC 2) provided the delta V cost is reasonable. The third midcourse correction (MCC 3) which occurs two hours before reentry will utilize the minimum delta V mode since effective landing point control is best achieved at that point with the guided lifting reentry and we want to make this maneuver as small as possible for safety reasons.

3. The MCC 7 will be computed utilizing the External Delta V spacecraft maneuver program. Right now FIDO has the maneuver scheduled at about 10 or 15 hours before entry, which is good for both trajectory and crew timeline reasons. According to Ron Berry the only component which has a significant effect on the trajectory is horizontal (i.e., perpendicular to the radius vector. A dispersion of 0.8 feet per second (fps) in the horizontal direction would cause the spacecraft to miss the entry corridor. That is, it will cause a .06 degree dispersion on flight path angle at the reentry interface. It is anticipated that MSFN accuracy will contribute approximately one-half of that dispersion leaving only 0.4 fps for maneuver targeting and execution error. This sort of dispersion is about what we would expect, which makes the likelihood of having to make MCC 7 much greater than we had been previously been led to believe.

4. Ron Berry reported that the MCC [illegible] also is most sensitive in a horizontal direction. Four fps dispersion in that direction will cause the flight path angle at the entry interface to change .06 degrees. After considerable discussion, the consensus was that we should modify the criteria we had previously established for determining whether or not to execute MCC 5. We had stated the maneuver would only be made if dispersion in flight path angle was anticipated to be in excess of .06 degrees which we now know to be equivalent to a 4 fps horizontal maneuver. There really seemed to be little reason for not reducing this limit. Accordingly, we have now modified the criteria such that whenever the maneuver required to bring the spacecraft trajectory back to the center of the entry corridor is greater than 2 fps it should be made. Making the decision based on delta V rather than flight path angle dispersion simplified the flight controller's job considerably since that parameter is readily available to him. One other thing that needs to be emphasized is that it is a "safe" burn to make in the sense that it is relatively insensitive to direction. That is, errors in the direction we apply the maneuver only tend to reduce its effectiveness and it is not until a 90 degree error is reached that any adverse effect would be felt. As a matter of fact, since only the horizontal component of the maneuver is effective in influencing the entry interface conditions, consideration is being given to orienting the maneuver such that a good visual reference is available when the maneuver is made. This would introduce delta V components lateral to the desired (horizontal) delta V, but that has no significant effect except to increase the magnitude of the burn.

5. Everyone was requested to see if there was any reason for not making this maneuver when it is not absolutely necessary. Otherwise, we will proceed as noted above, which I should think would make the probability of making this maneuver something like three out of four.

6. It is intended that at our next meeting, currently scheduled for Apr [illegible] 30, to review the mission technique [illegible]ow charts that TRW [illegible] preparing

based on our meeting up to this time.

Howard W. Tindall, Jr.

Enclosure
List of attendees

Addressees:
(See list attached)

ATTENDEES

H. W. Tindall, Jr.	FA
O. R. Sabionski	FB
C. A. Graves	FM
R. L. Berry	FM
J. D. Yencharis	FM
J. C. Harpold	FM
J. K. Burton	FM
H. O. Nobles	FM
J. S. Llewellyn	FC
D. W. Hackbart	PT
H. E. Dornak	PT
L. J. Riche	CF
C. H. Foulk	EG
D. R. Bergman	Boeing
C. Belton	TRW
J. E. Land	TRW
W. R. Lee, Jr.	TRW
T. V. Harvey	TRW

Enclosure 1

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: APR 16 1968

68-PA-T-77A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: List of "D/E" Rendezvous open items

1. On April 8, we had our first weekly "D/E" Rendezvous Mission Techniques meeting. We spent the whole time going through the data flow charts. This memorandum is not really minutes of the meeting, but rather a list of questions and action items. We are assuming that both the "D" and "E" missions will utilize the Colossus CSM computer program. If this turns out to be wrong for "D," we will have to go back and make some modifications on items which we are attempting to flag out now.

a. It is necessary to establish some sort of decision logic based on the trajectory situation and spacecraft systems status for use during the mission to give a go/no go for performing the rendezvous exercise.

b. Flight Dynamics controllers (FCD) are to check into the capability of the RTCC to compute a REFSMAT referenced to the local horizontal at some non-burn time. Previously, we have been told that they could do this, but the people at this meeting were not so sure.

c. I am to recheck and make sure the Sundisk, Luminary, and Colossus all have been modified to permit use of a ground computed REFSMAT. Sundisk, of course, requires an awkward manual setting of a flag bit.

d. We still have to establish what REFSMAT the CSM should use for the rendezvous exercise.

f. There was a lengthy discussion regarding which spacecraft computer program should be operating during the period from the undocking to the separation maneuver. Basically, it was a question of whether the "average G" program (P-47) should be running. If it were, the crew could utilize the PGNCS to monitor their small separation maneuver. However, there is concern the accelerometer bias could foul up the state vector. We must determine what the degradation would be over this period of time.

g. Trajectory design people were requested to bias the direction of the phasing maneuver in order to insure that a suitable elevation angle for TPI will be achieved in the event an abort in the football phase is necessary.

h. Ed Lineberry's people were also requested to determine the proper elevation angle to be used for TPI in this event. Actually, we must establish the entire technique to be used including such things as whether or not a delay should be planned between the LM and CSM TPI maneuvers.

i. Guidance and Control Division was requested to report on interference to be expected in the docked configuration of the command module in the field of view in the AOT. Docked alignments are planned in these missions and it is necessary to establish which detent position should be used.

j. Another lengthy discussion involved the procedure for accurately synchronizing the AGS "clock" to the PGNCS. It is still not clear how this should be done. Al Nathan (GAEC) noted that some work on this had been carried out in their simulator which he will report on next time. Although, it is anticipated that differences in the order of one second are probably acceptable for rendezvous, something much better than this may be necessary on a lunar landing mission for purposes of ascent and descent guidance systems monitoring. Accordingly, it may be desirable to get experience on clock alignments on these development flights compatible with the lunar landing mission.

k. FCSD will report next time on the manner in which the PGNCS and AGS will be used during the phasing burn. Primarily, questions dealt with what sort of attitude the AGS would provide prior to the burn (inertial hold or orbit rate torquing). We are also interested in how the PGNCS, operating in the P-30/P-40 programs can be faked out during the AGS burn so that it will navigate correctly to provide the capability of trimming delta V residuals.

2. The next meeting is scheduled for Monday, April 15, at 9 a.m., Room 384 of Building 4, where we will continue the tedious process of going through the flow charts. We will start where we left off - on page [illegible].

Howard W. Tindall, Jr.

Enclosure
List of attendees

Addressees:
(See list attached)

ATTENDEES

H. W. Tindall, Jr.	PA
R. E. Simms	FM
E. C. Lineberry	FM
D. Reed, Jr.	FM
A. L. Accola	FM
A. Nathan	FM
D. D. De Atkine	FM
A. M. Larsen	FC
H. M. Draughon	FC
G. C. Guthrie	FC
M. G. Kennedy	FC
W. E. Fenner	FC
H. D. Reed	FC
T. R. Lindsey	CF
T. A. Guillory	CF
E. B. Pippert, Jr.	CF
T. W. Holloway	CF
J. E. Hutchins, Jr.	CF
D. K. Mosel	CF
M. Collins	CB
R. W. Simpson	EG
R. Boudreau	TRW
J. E. Scheppan	TRW
D. L. Rue	TRW
K. Baker	TRW
S. Paddock	MDC

Enclosure 1

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

Memorandum

TO : FA/C. C. Kraft, Jr.

DATE: APR 10 1968

68-PA-T-75A

FROM : PA/H. W. Tindall, Jr.

SUBJECT: "Any time" LM lift off is an unnecessary constraint

No big deal, but I'd just like to point out that I don't agree with something in the memorandum to TA/Director of Science and Applications, dated March 19, 1968, subject: Operational constraints for the fourth lunar landing mission, which you signed. It stated in part, "It is the opinion of the Flight Operations Directorate that the requirement to be able to rescue the LM from an "any time" launch phasing situation cannot be eliminated. However, the "any time" launch rescue capability must be available only for the first CSM orbit after LM landing. For all subsequent CSM orbits, only an "on time" launch LM rescue capability is required."

As laid out in the attached memorandum, I think we have established a good go/no go for lunar stay technique and I don't see why there should be a requirement for "any time" lift off after the LM has been on the lunar surface for about 12 to 14 minutes. After that, we should always constrain the launch to be on time - to coincide with the discrete time about once every two hours when the command module passes overhead. Of course, RTCC and onboard programs are available to permit launching quickly at other times and for determining the proper rendezvous maneuvers to be made. But the point is, I see no reason to provide allowance in the propellent budgets for the large maneuvers that would be necessary to handle the worst phasing case, nor is it necessary to keep the guidance system in the command module or the LM powered up to support "any time" launch. Also, I think very little emphasis should be given to planning or simulating launches at times other than those specified above, etc..

I would like to see the Apollo work proceed as we have laid out, until someone shows us what is wrong with it and would appreciate you letting me know if you don't think this is a reasonable way to go. Let's simplify the mission and put the burden on the "any time" lift off people, whoever they are, to explain why we need it.

Howard W. Tindall, Jr.

Enclosure

cc:
(See attached list)

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

UNITED STATES GOVERNMENT

Memorandum

Manned ... Center
Mission ... Division

TO : See list below

DATE: APR 5 1968

68-FM-T-

FROM : FM/Deputy Chief

SUBJECT: Flyby solutions in the RTCC Midcourse program will not be absolutely optimum

Bill - I don't know that I agree with this. We must need an RTACF program. Jim

P.S. Did you know that we are going to have a RTCC CCB pretty soon?

This memo is to inform you of a simplification in RTCC program requirements I recently approved. As noted below, the capability we are providing appears to be adequate and the cost of the optimization is incompatible with the benefit to be gained. The rest of this memo is lifted almost verbatim from one Bob Ernull wrote to me.

Quite a few months ago, it was agreed by MPAD, FCD, and FSD that a circumlunar (flyby) mode would be included in the RTCC midcourse program for alternate missions and circumlunar aborts. One problem we were particularly concerned about was the case where we have to get back home with the RCS only; this implies both a SPS failure and DPS failure, or failure to extract the LM after TLI. Because of the limited delta V available from the RCS, approximately 150 fps for translation, the guideline established was to develop a program logic which would provide the absolute minimum delta V solution to insure safe entry.

In trying to develop a program which would compute the "optimum" solution, we ran into many problems. We have reached a point now where even though program development is not complete, we probably know how to build the program required; however, the running time on the RTCC computers ranges from 20-40 minutes per solution. We have examined ways of reducing this time and do not see any possibilities which would effect any significant reduction. Although this might be acceptable during an operation, imagine the computer time and effort required to check it all out.

During the evaluation of computation techniques for the "optimum" solution it was found that a very near optimum solution could be found using a simple computation procedure based on a "return-to-nominal" concept. This concept simply takes advantage of the fact that the nominal pericynthion conditions which were optimized pre-flight, will still be very near optimum for any small midcourse maneuver. Since for the RCS problem we are by definition considering for the flyby solutions, get an answer which is near optimum and avoid the iterative search for optimized pericynthion conditions. This reduces the run time from 20-40 minutes for the "optimum" solution to 1-2 minutes for the "return-to-nominal" solution.

The next question is how much delta V penalty is incurred if we decide to implement the simple and faster computation technique in the RTCC. It can be shown that the "optimum" solution will cover S-IVB injection errors 50-100% larger than the return-to-nominal. However, these dispersions must be compared with the expected S-IVB 3σ dispersions to get a true picture of the situation. This comparison shows that with the return-to-nominal we can cover S-IVB injection errors twice as large as the 3σ errors. This is based on the assumption that up to 100 fps is available for the first maneuver, the additional 50 fps is reserved for subsequent corrections.

2×0=0

Summarizing, in order for the return-to-nominal solution to be inadequate we have to have an SPS failure, a failure of the DPS (or no extraction) and a S-IVB dispersion twice as large as the predicted 3σ dispersions.

On this basis, and considering the major impact of developing, checking out and verifying a program where each run takes 20 minutes or more, the decision was made to delete the requirement for computing an optimum flyby solution and use the return to nominal technique. I hope you agree.

Howard W. Tindall, Jr.

Attendees:
(See list attached)

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: APR 8 1969

69-PA-T-73A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Some lunar mission earth orbit phase ground rules

1. I would like to make sure everyone is aware of some important decisions which were made at Ron Berry's Midcourse Phase Mission Techniques meeting on April 3. They have to do with operations during the earth parking orbit phase prior to TLI on a lunar mission.

2. Current planning involves performing the TLI maneuver at the first opportunity. For Atlantic injection, this can occur approximately one and a half hours after launch. It is important that the efforts of all the organizations be in accordance with that. If it is determined that some activity precludes TLI this soon, the responsible organization should make this known immediately. As noted previously, it has been established that no spacecraft platform alignment is required prior to the first opportunity TLI, which helps the crew time line.

3. One component of the go/no go for the first TLI opportunity is validation of the S-IVB IU state vector. Since during the first revolution we are unable to generate an MSFN state vector superior to the anticipated IU's, the check can only be gross. The actual parameter to be tested will be magnitude of the anticipated midcourse correction. The criteria will be based on how well we will be able to determine right from wrong rather than on reasonable magnitude of the midcourse correction, we would be willing to accept operationally. It will be a function of MSFN tracking coverage available prior to the go/no go decision.

4. In order to avoid having to make unnecessary real-time decisions, in addition to all the associated pre-flight analysis and arguments to establish the decision logic, we have established the following ground rules:

a. We will never transmit a state vector update to the S-IVB IU for the first TLI opportunity.

b. We will always transmit a state vector update to the S-IVB IU for the second TLI opportunity.

c. We will always transmit a state vector update to the CSM G&N for the first TLI opportunity. The state vector to be sent to the CSM will be obtained via telemetry from the S-IVB IU.

The intention, of course, is to always use the best state vector. During the first revolution, the IU state vector should be superior to any other source and should be acceptable for use. Thus, there will be no reason to update the IU and no reason not to update the CMC. During the second revolution we can be certain the MSFN state vector will be adequate for guiding through the second TLI opportunity - at least as good as, or better than the S-IVB IU state vector - which means no harm is done by sending a state vector update, but it can improve the situation. There is reason to suspect that MSFC may not approve this ground rule (b) but it seems to me the burden of proving why we should do something else is on them.

[illegible]. All of this will be documented in detail in the minutes of the meeting. I hope the chairman will excuse my scooping him, but I felt it desirable to advertise and emphasize these things since they have a significant influence in the procedures we are implementing and you should all be aware of them.

Howard W. Tindall, Jr.

Addressees
(See list attached)

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: APR 8 1968
68-PA-T-72A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Sextant Rendezvous Navigation Review

1. As noted in the attached memorandum, I would like to request your active participation in a meeting on April 25 to review for "C" mission operational personnel the work your people have done on CSM sextant rendezvous navigation. I think, in order to insure proper use of the CSM G&N during the spacecraft 101 flight, it is important that they understand how it works and how accurate it should be. Accordingly, as I visualize it today, the agenda will consist of two parts. The first should be devoted to explaining in non-mathematical terms how it is possible to do rendezvous navigation with the sextant and the second part will be devoted to reviewing the results of the analysis which has been done by various organizations in an effort to establish anticipated performance.

2. We have reserved Room 716, Building 2, for this meeting which will begin at 9 a.m., on April 25.

Howard W. Tindall, Jr.

Enclosure

Addressees:
CF/P. Kramer
C. Jacobsen
FC/R. A. Gardiner
FS/L. C. Dunseith
FM/J. McPherson
MIT/IL/R. R. Ragan

FM:HWTindall, Jr.:js

UNITED STATES GOVERNMENT

Memorandum

TO : See list below DATE: APR 5 1968

68-PA-T-71A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Mission "E" Rendezvous Data Priority meetings

1. This memorandum is to report the meager accomplishments of the Second and Third "E" Rendezvous Mission Technique meetings of March 18 and April 1, 1968.

2. Much of the first meeting was devoted to trying to understand what the people responsible for AGS system testing were trying to accomplish in the mission, in order that the techniques developed would be compatible. Essentially, what came out of this lengthy quiz session is that they do not want the AGS reinitialized from the PNGCS, they want radar data input between the CSI and pseudo-TPI maneuver during the first half of the rendezvous exercise, and they want to execute the maneuvers as determined by the AGS provided they fall within acceptable bounds. There was a hopefully erroneous impression that a well thought-out systems test including post-flight analysis procedures does not exist which would be ludicrous to discover after the mission.

3. A substantial part of the latter meeting was devoted to the possibility that LM RCS propellent will not be adequate to support the currently planned rendezvous exercise. The mission plan is not our responsibility, of course, but significant changes to it could impact our works severely. It is anticipated that the FOD and ASPO mission design engineers will get this all straighten out soon. My impression was that if the LM can not fly the "D" rendezvous, it can not fly any rendezvous. In any case, at this meeting, we proceeded on the assumption that the trajectory, as it is currently planned for the "D" rendezvous, will be used for the "E" rendezvous as well. We spent some time bringing those people not familiar with "D" up to date. This included a description of the mirror image concept for targeting the command module to back up LM maneuver and the procedures which are beginning to take shape for aborts from the football trajectory in the beginning of the exercise and the pseudo-TPI half way through it. A lengthy inconclusive discussion on how to compare and use the various systems for the TPI maneuver ended the meeting.

4. A few things that have been definitely established are as follows:

a. It was stated that we want to make a PNGCS platform drift test before we embark on the rendezvous exercise. This means making two fine alignments spaced in time sufficiently to observe excessive drift. This is almost impossible to accomplish unless we make a fine alignment in the docked configuration. Therefore, that activity is being included in the operation.

b. We reviewed a previous decision and decided to always update targeting for the insertion maneuver. This maneuver, you recall, is the one that takes the LM out of the football trajectory. The primary reason for always updating is to eliminate need for developing the logic and criteria to make a real time decision of whether or not to update. The point in this exercise is busy enough already without adding an extra task and it would have to be included in the timeline anyway.

c. With regard to the mirror image CSM targeting, there seemed to be two alternatives which must be taken into account, some sort of system failure recognized well in advance of the maneuver and some sort of propulsion failure after ullage but before main engine ignition. Accordingly, this must be taking this into account in targeting the command module. Ed Lineberry was given the action item of establishing this technique to be incorporated in with maneuver biasing already being provided to compensate for the one minute delay in CSM ignition time.

Howard W. Tindall, Jr.

Enclosure
List of attendees

Addressees:
(See attached list)

ATTENDEES

H. W. Tindall, Jr.	PA
M. V. Jenkins	FM
E. C. Lineberry	FM
S. O. Mayfield	FM
A. J. Loyd	FM
E. N. McHenry	FM
D. Reed, Jr.	FM
A. Nathan	FM
G. R. Sabionski	FS
G. C. Guthrie	FC
M. G. Kennedy	FC
K. W. Russell	FC
A. M. Larsen, Jr.	FC
J. G. Zarcaro	FD
M. Collins	CB
E. E. Aldrin	CB
W. A. Anders	CB
F. Borman	CB
C. M. Neily	CF
E. B. Pippert, Jr.	CF
D. L. Rue	TRW
G. R. Shook	TRW
C. Summers	TRW

UNITED STATES GOVERNMENT

Memorandum

APR 4 1968

TO : See list below

DATE: 68-PA-T-71A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Mission techniques for the LM lunar stay go/no go

1. As a result of several meetings on the subject, I think we have finally pinned down how to handle the go/no go decision to be made immediately after LM landing on the lunar surface. This memorandum is to report the techniques and to solicit your comments.

2. LM systems people of the Flight Control Division have studied the problem of evaluating critical systems when the LM first lands on the lunar surface and feel certain they should be able to give a go/no go within two minutes for all systems with one exception. The one requiring a longer examination period is the APS propellent system. The problem with detecting leaks in this system is that during descent, differential temperatures build up on the structure which make it difficult to interpret the instrumentation readings after landing, until a period of about ten minutes has passed to permit them to stablize. They feel confident that they would be able to give a complete go/no go in about that time. Accordingly, the technique we evolved includes two go/no go's.

3. The procedures will be more or less as follows. Immediately upon landing, the crew cuts off the DPS manually, but retains the guidance system in the descent program while both they and the ground evaluate the LM systems. Although this task takes only about two minutes, it has been determined for rendezvous trajectory reasons to be preferrable to wait about four minutes after touchdown before launching if possible. (There is nothing to preclude going sooner, if that is found to be necessary for such things as the spacecraft tipping over or something else requiring immediate abort.) If at any time during this period through the go/no go decision, it is decided to abort, the crew would "abort stage," a technique which provides instantaneous launch with no external targeting required. If the decision is to not abort, the crew will proceed out of the descent program and call up the LM ascent powered flight program (P-12), input via the DSKY the desired lift-off time, and proceed through a standard countdown to launch. Again for rendezvous trajectory reasons, the lift-off will probably be delayed between 11 and 14 minutes after touchdown. Note that after proceeding out of the descent program, instantaneous lift-off is no longer possible; the crew must go through the regular procedures associated with P-12 although, of course, no platform alignment is required.

4. The flight controllers will continue to evaluate the APS propellant system during this time and will also determine if the PNGCS is functioning properly. If it is, the AGS will be reinitialized and realigned. Given a recommendation to abort, the crew will continue their countdown to ignition and perform a normal ascent. Otherwise, they will exit P-12 and remain on the lunar surface until the command module completes at least one revolution.

5. Given permission to stay, the LM crew will carry out many of the normal procedures required to launch when the command module goes overhead, almost two hours later, including reinitiating the ascent program and carrying out platform alignments using each of the different modes available. The purpose of this activity, of course, is to launch at the end of this two hour period if necessary, or in the normal case, to determine if there will be any problem in countdown required at the end of a normal lunar surface stay.

6. I would like to clarify the recommendations given above to delay lift-off a couple of minutes longer than it takes to make the first go/no go decision. According to the work of Ed Lineberry's people, primarily Jerry Bell, the time to rendezvous will be two revolutions, in any case; but selection of the optimum lift-off time makes the rendezvous sequence essentially nominal after the first revolution with regard to such things as maneuver scheduling and magnitude, slant range, differential altitude, etc. It also makes it possible to do a platform alignment after insertion into the orbit. The reduced slant range and accurately aligned platform should result in better onboard rendezvous radar navigation and maneuver targeting which should substantially improve the rendezvous operationally. The same sort of comments apply to the abort after the APS go/no go, except in that case, the rendezvous will require three revolutions. Ed Lineberry's people have the action item of establishing the specific preferred lift-off time of each of these go/no go situations. It should be noted that the times will probably be referred to initiation of powered descent (PDI) rather than time of touchdown in order to make them independent of hover time, a variable that significantly influences the phasing of the command module with respect to the LM.

7. This all turned out to be a pretty straight forward procedure. It seems to provide plenty of time to do what is necessary and does not involve any unique or special procedures. Unless someone can show us what is wrong with it, we will press on as noted.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27
5010-104

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: APR 4 1968

68-PA-T-70A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Lunar Reentry Mission Techniques meeting - March 21

1. On March 21 a small group of us went through the logical flow charts TRW prepared based on our last Lunar Reentry Mission Techniques meeting a couple of weeks ago. A couple of things came up that I should probably pass around.

2. First of all, there are three rather small changes which should be made in the spacecraft computer program, at least in that version of Colossus to be used for lunar reentry. The first and least important of those is to change the roll attitude commanded by the G&N during the time between spacecraft separation from the service module until 0.05 g's to a bank angle of zero degrees (lift vector up) instead of 15° bank angle. This is desirable in order to make the automatic system do the same thing the pilots will do if they control attitude manually. The reason we want a lift vector up orientation is to provide the best possible horizon attitude check to insure proper pitch trim angle during initial entry into the atmosphere. The program should also be changed to give a horizon reference until aerodynamic capture is assured as the spacecraft makes its second atmospheric entry after a skip. Since it is intended to fly in the automatic G&N mode in this region of the reentry, it is felt this program change is mandatory. The third change is to make the DSKY display change automatically from one set of parameters to another during the peak g period since it will be impossible for the crew to key the computer under those conditions. The specific change is in P-65 to make the display change to inertial velocity and altitude rate after a display of predicted exit conditions (DL and VL) for a fixed period of time, such as 20 or 30 seconds. Jon Harpold has the action for preparing and submitting these program changes.

3. We spent some time discussing the third midcourse correction (MCC3) which is scheduled to occur two hours before entry interface if it is needed at all. Ron Berry presented some information to show that this maneuver is likely to be very small. For example, it only takes 4 fps to change the flight path angle at the entry interface to 0.36° which is the maximum acceptable dispersion. This seems to imply that very small dispersions in the trajectory would cause us to miss the entry corridor without MCC3 which is contrary to what we have heard before. Accordingly, Ron has accepted the action item of determining the effect of delta V residuals in the second midcourse correction on the flight path angle at entry. He will also look into the effect of delta V residuals in MCC3. In addition, we requested that

he determine the anticipated direction this maneuver should be applied since it seems likely to be rather predictable as opposed to completely random. The reason we are interested in this, of course, is that if we could establish a preferred spacecraft attitude providing a good out-the-window reference we would all be a little more comfortable about executing this maneuver. And, if it is small enough we might be willing to accept the additional delta V costs of burning it off in control axis components rather than along one spacecraft axis. In general, what we have asked him to do is to get some data together which will give us a better insight on the characteristics of [illegible].

4. We got into a rather interesting discussion with regard to the EMS. It appears we are not using it in the best way with regard to ranging accuracy. Specifically, the EMS has its range-to-go counter initialized based on ground computed value of that parameter at a predicted time of reaching 0.05 g's. It seems as though we would be lot better off if we were to actually start the EMS running at the predicted time of 0.05 g's rather than when 0.05 g's is actually sensed. For example, typical time dispersions for 0.05 g's are as high as 20 seconds. And, since the spacecraft is traveling in the order of six miles per second range-to-go display would automatically be in error by about 120 miles. Accordingly, everyone was asked to look into the desirability of manually starting the EMS based on time as opposed to letting it be done automatically based on sensed acceleration.

5. Several potential checks have been identified to verify proper performance and develop in-flight confidence in EMS which I expect we will include in our flows somehow. For example:

a. It should be possible to compare the EMS displayed maximum g against the predicted value.

b. It should be possible to determine if the range-to-go display is behaving within limits of being right.

c. It is possible to see if the predicted velocity at the time of .2 g's as the spacecraft skips out agrees with the value predicted by the ground.

d. There should be a continuous comparison made of the g's acceleration as indicated by the EMS versus the value displayed by the g-meter.

6. Jon Harpold was given the action item of determining the pitch trim angle which should be experienced when making the horizon attitude check during second entry. It was noted that this quantity need not be obtained in real time but will be known well in advance of the flight.

7. We will probably set up another meeting within the next three or four weeks to go through the flow charts as modified today and to review the results of our action items.

Howard W. Tindall, Jr.

Enclosure
List of Attendees

Addressees:
(See attached list)

ATTENDEES

H. W. Tindall, Jr.	PM
J. C. Adams	PM
J. C. Harpold	PM
E. L. Pavelka	FC
D. V. Massaro	FC
R. F. Polmanteer	FC
C. H. Paulk	MC
M. Collins	CB
R. Boudreau	TRW
C. Belton	TRW
E. Howell	TRW

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: MAR 27 [illegible]

68-PA-T-69A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Eighth and Ninth "C" Mission Rendezvous Mission Techniques meetings

1. Most of the March 15 and 22 "C" Mission Rendezvous Mission Techniques meetings were devoted to discussion of onboard rendezvous navigation with the sextant. This was brought about by the rather bad experience suffered by the 101 flight crew and a number of the flight controllers on the Kennedy Space Center mission simulator earlier in the week. What apparently happened was that whenever sextant data was used in the rendezvous navigation, the resulting maneuver targeting was screwed up. In addition, the displays the crew used for working their onboard charts seemed to be erroneous too. As a result, they had all lost confidence in the capability of the sextant to do rendezvous navigation and felt that either much more reliance must be placed on ground targeting or else someone should explain why it was okay to keep on going like we are. After years of bad-mouthing the sextant, I find it difficult to suddenly start defending it. But an awful lot of analysis and simulation has been done showing the system to have some usefulness. However, it is obvious there is a serious problem somewhere, either in Sundisk, the cape simulators, the procedures, or something. Whatever it is, it has to be straightened out right away. In addition, it is evident that the operational people, Crew and Flight Control do not understand very well how the sextant navigation works and how well, so I volunteered to set up a special meeting to be devoted entirely to this subject to review the work of all organizations who have done work on this system - MIT, MPAD, GCD, MAC, FCSD, etc. I will try to get it organized for April 25, if that suits everyone - and will let you know.

2. One interesting thing that came out of our lengthy discussion was that the only real testing of the rendezvous navigation programs has been on the bit-by-bit simulators at MIT since they too have trouble with their optics in the hybrid simulator and are only able to test the program functionally. That is, they are only able to see that it runs but cannot confirm its accuracy in their hybrid. Furthermore, it also became apparent that the rendezvous navigation has never been tested under heavily dispersed initial conditions. Accordingly, at the March 15th meeting we requested FCSD and MAC to run a few rendezvous profiles on their procedures simulator starting after NSR with large errors in the spacecraft state vector.

3. On March 22 MAC/FCSD presented the results of these runs which they had already completed. What a great outfit those guys are! They had included "actual" sextant observations on our worst case and had also run the specific

case which gave trouble at the KSC - a 10 mile range error, which is really bad news. These results seemed to indicate that the sextant was capable of doing a pretty good job - much better than I expected was possible. The status now is that everyone is taking a hard look at the whole situation. Simulator runs and analysis continues. On April 25, we will get everyone together with all their data and review it thoroughly and decide where to go from there.

4. The only other item we devoted much time to was the "tweak" burn between NSR and TPI. This small maneuver (less than 3 fps) was proposed by Ed Lineberry to be made only if TPI had slipped in time so much that lighting conditions during braking would be unacceptable. Lighting at braking on the "C" mission is of much greater importance than on Gemini since we have no ranging device and the SIVB does not have running lights like the Agena did to give some measure of range. Tolerable TPI time slip is said by FCSD to be + 10 minutes which is just about what we could expect to happen due to anticipated ground control accuracy. Paul Kramer is not in favor of adding in this maneuver, primarily because it offers a chance to screw things up. It does not make the flight controller's job any easier either, although they can handle it. The flight crews, primarily Tom Stafford, are considering the pros and cons and we have agreed to go with their wishes. This is unique for the "C" mission incidentally. Ordinarily, there is insufficient time to do the burn, also this is the only CSM active rendezvous currently planned.

5. Finally, there is a procedure change that is probably worth reporting. The flight crew wants to use onboard computed REFSMAT for all platform alignments, except retrofire (which they can't do onboard). This is brought about by the way Sundisk is coded, forcing the crew to manually set a flag bit. This is forcing us to do the job on the ground differently than planned, although that is no big deal. Instead of computing and sending the REFSMAT, the MCC will now send a time within the present revolution, at which the "nominal alignment" as computed onboard will give the desired platform orientation for rendezvous. Incidentally, using the onboard computed values also forces the crew to make all SPS maneuvers heads up rather than heads down, as they prefer since the Sundisk alignment program assumes that attitude when it compensates for the SPS gimbal angle trim values. This heads up turns out to be fine for rendezvous. In fact, it is rather meaningless since all of the SPS burns are nearly radial anyway. It is just the change in the REFSMAT procedure that is a shame.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27

5010-104

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: APR 2 1969

68-PA-T-67A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Seventh "D" Mission Rendezvous Mission Techniques meeting

1. At the Seventh "D" Mission Rendezvous Mission Techniques meeting on March 25, we spent most of the time discussing activity in the football rendezvous, specifically, under what circumstances and how to abort. It turned out that the same ground rules and techniques probably apply equally well to the pseudo-TPI maneuver halfway through the rendezvous exercise. I think we've gone a long way getting these things pinned down.

2. In the first paragraph I would like to clean up a couple of old open items from some previous meetings.

a. FCD had been requested to look into the RTCC/MCC capability to be sure it was possible for the flight controllers to compute and relay to the crew the CSM gimbal angles to point the LM AOT toward a selected star in order to carry out a docked LM platform alignment. Bill Fenner reported that this capability does exist. Out of this discussion came the suggestion that we should probably prepare some sort of crew chart giving pseudo-sextant shaft and trunnion angles for the AOT as a function of the docking ring index reading in order that the crew could do this job themselves.

b. We spent a little time discussing the required accuracy of LM/CSM clock synchronization for the rendezvous exercise. It was concluded that misalignment of these two spacecraft clocks in excess of one second should not produce any significant problem in the rendezvous except as an operational annoyance. In conclusion, it seemed as though the current mission rule is fine. Specifically, either clock should be reset by the ground whenever it gets out of synchronization with the ground by more than one-half second. Thus, in the worst case, the LM and CSM clocks could conceivably be one second apart.

c. In order to avoid confusion of terminology, it was decided the maneuvers would be referred to as follows: the small one or two fps burn to separate the two spacecraft from one another initially, to avoid station keeping, shall be called the "separation" burn. The much larger maneuver, which starts the LM on the initial football rendezvous, will be called the "phasing" burn.

d. Regarding the phasing burn, it was restated that this maneuver may be executed with targeting established preflight, that is, it will not be updated in real time. It was noted that the AGS will be used for executing the burn and the PNGCS will be operated in a follow-up mode using P-30/P-40. It was emphasized that, because of the difference between AGS and PNGCS, the external delta V targeting parameters will be slightly different for each.

3. The rest of the meeting was devoted to the football rendezvous. We spent some time discussing the sort of trajectory-oriented system failures which would cause us to abort the rendezvous exercise and to return the LM to the CSM immediately. It was important to establish which of the systems may have failed because, obviously, the manner in which we would perform this rendezvous would be significantly influenced by the status of the spacecraft systems.

4. The following is a list of trajectory-oriented system failures which would force us to abandon the rest of the rendezvous exercise:

a. Rendezvous radar failure

b. LM PNGCS failure

c. CSM G&N failure

d. RCS jet failures

e. DPS failure to start when attempting to do the insertion burn

5. Based on those abort situations we arrived at the following general conclusions regarding how the rendezvous should actually be performed:

a. It was decided that whichever spacecraft was having the systems problem should be the passive vehicle for TPI and the subsequent midcourse corrections. It may or may not be desirable for that vehicle to perform the braking maneuver depending on the situation. It was noted that the systems problem referenced to is not necessarily one of those listed above, but could just as well be some other critical system such as, ECS, fuel cells, etc. The reason for this conclusion is:

(1) To relieve the crew with the problem spacecraft of rendezvous activity in order that they may devote full attention to the problem.

(2) To use the spacecraft which has all of its systems still working to do the rendezvous.

Of course, I am sure there will be some exceptions to this rule, although, I hope not too many. One probable exception would be a failure of the LM PNGCS, but with the rendezvous radar still working. Under this circumstance it would probably be preferable for the LM to be the active vehicle since it has superior observational data (the RR) and a guidance and control system (the AGS) adequate to carry out the maneuvers.

b. We had a lengthy discussion regarding whether the rendezvous should be carried out with the rendezvous transfer angle of 90° - 90° or to use the standard 130°. It was finally concluded that we should use the 130° transfer for the following reasons:

(1) The lighting conditions are superior. Specifically, the rendezvous would occur in darkness for the shorter transfer, unless the [illegible] and this is not an easy thing to achieve, retaining the proper lighting conditions for the rest of the rendezvous exercise.

(2) More time is available for obtaining rendezvous navigation observations after TPI.

(3) Use of 130° provides the standard rendezvous approach for which all training, crew backup charts, etc., have been prepared. It was noted that under some conditions it would be desirable to delay making the TPI maneuver for a revolution or two, depending on the spacecraft systems problem. That is, as long as the LM remains in the football orbit, conditions remain relatively constant for each successive revolution.

c. It was also concluded that ordinarily it would be preferable not to stage the DPS for the following reasons:

(1) Primarily it seems very desirable in an emergency situation to retain all possible consumables in the LM to avoid getting into a time critical situation. It is recognized that to perform an active rendezvous with the LM unstaged does present some problems and costs additional RCS, but in the general case, this is probably an acceptable penalty.

(2) A secondary consideration for not staging the DPS is that it will eliminate the concern of a possible recontact.

6. It was also concluded that a nominal mission planning change should be made to provide the best possible abort conditions and that the magnitude of the phasing maneuver should be increased about 50 percent in order to provide a reasonably large range rate at the braking maneuver. The current plan provides a closing velocity of about 13 fps, whereas it is generally agreed that it should be in excess of 20 fps. Morris Jenkins has the responsibility for getting the mission plans changed to increase the phasing maneuver from 40 fps to something in excess of 60 fps to provide this characteristic. Actually, since this will result in an almost delta h very near nominal, it was recommended that the magnitude of the phasing maneuver be chosen to make delta h exactly the same as that charted so that all nominal terminal phase work will be directly applicable.

7. Based on all of the above, we concluded that as a standard operating procedure during the football rendezvous the CSM should be targeted and prepared to execute the TPI if an abort is necessary.

8. As noted in the first paragraph, after looking over the results of our discussions of aborts from the football, there seems to be no reason the same conclusions do not apply equally well to aborts from the first half of the rendezvous exercise at the overhead TPI opportunity. At least we will proceed using these techniques for both cases for now. Furthermore, if the "E" mission rendezvous is made identical to the "D," as now appears probable - of course, all of this will apply to that flight too.

Howard W. Tindall, Jr.

Enclosure
List of attendees

Addressees:
See attached list

ATTENDEES

H. W. Tindall, Jr.	FA
D. Reed, Jr.	FM
C. W. Pace	FM
E. C. Lineberry	FM
L. D. Hartley	FM
J. H. Shaeffler	FM
A. L. Accola	FM
R. R. Regelbrugge	FM
A. Nathan	FM
M. V. Jenkins	FM
C. T. Hackler	EG
R. W. Simpson	EG
H. D. Reed	FC
W. E. Fenner	FC
M. C. Contella	CF
J. V. Rivers	CF
D. R. Scott	CB
C. Conrad	CB
R. Schweickart	CB
S. G. Paddock	MDC
G. R. Shook	TRW
D. L. Rue	TRW
J. E. Scheppan	TRW
R. Boudreau	TRW

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27
5010-107

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning ...

TO : See list below

DATE: APR 1 ...

69-FM-T-4?

FROM : FM/Deputy Chief

SUBJECT: Apollo Spacecraft Software Configuration Control Board notes for the March 19 meeting

1. We spent another couple of hours talking about the Delta V monitor programs. Two program change requests were considered for Sundance and Luminary. It was concluded that no change would be made to Sundance, but that both changes should be made to Luminary, although, I am not sure if one of them is not in there already. Specifically, PCR 121 provides a new engine fail monitor which does not turn off the engine in the event the Delta V is not detected, and PCR 122 reduces the ullage overlap such that is now stopped based on time, specifically, 1/2 second after time of ignition. This present logic stops ullage when the Delta V monitor detects engine ignition which could be as much as six to seven seconds later. It also was noted that the Delta V monitor threshold in Sundance must be made low enough to insure that the DPS engine will not be cut off on the early LM flights when that engine is used in either the docked or undocked configuration.

2. It was also decided to change the Colossus Delta V monitor/engine fail routine to make it the same as Luminary as far as crew procedures are concerned. This costs 14 days schedule slip.

3. The PCR's dealing with the new DSKY lights are being withdrawn and will be replaced by a more comprehensive one sometime in the future.

4. PCR No. 57, a DAP hand controller change, was disapproved.

5. PCR No. 70 provides a change in the Luminary abort programs P-70 and P-71 decreasing the early descent abort zone from 150 to 50 seconds and adds the jerk limit logic like the AGS. This PCR was approved at the cost of three days.

6. PCR No. 77, a modification to the LM DAP in Luminary, was also disapproved.

7. PCR No. 88 would move the rendezvous radar range and range rate variances into erasable memory to permit changing their relative weight in the rendezvous navigation, if the radar does not meet specification. This would have cost five days in the Sundance delivery, and it was disapproved.

As you recall, this same capability was approved at the last meeting for Luminary and Colossus.

8. PCR No. [illegible] was to put a valid data indicator on the landmark tracking downlist in Colossus. It was determined that control center work around procedures could be developed using the program as it is currently programmed, and so this PCR was disapproved.

9. PCR No. 94 would change the Luminary and Sundance programs to put a special identification on the erasible memory dump downlist such that the RTCC could distinguish this data as coming from the LM, as opposed to the command module; since this could be done with no impact, it was approved.

10. PCR No. 98 for Sundance and subsequent would have provided the capability of moving the rendezvous radar antenna out of the way of the AOT so that it would be possible to do a platform alignment when the rendezvous navigation program (P-20) was running. It would have cost 1[illegible] days, and since it would not seem to be particularly necessary, it was disapproved.

11. PCR No. [illegible] would have made the display of radar pointing angles more meaningful when operating in mode II. It was not needed on Sundance, so that was disapproved. MIT estimates a visibility impact of two days for Luminary and so they were requested to prepare a detailed schedule impact for Luminary. This would put the DSKY display of radar angles in the azimuth/elevation coordinate system consistent with the crew's orientation.

12. PCR No. 100, a program change requested by George Cherry (MIT), was approved. The change has already been made and so there is no impact. It is to eliminate a rate test from the thrust vector filter.

13. PCR No. 105 was to delete the LM/CSM separation program (P-46) from the Luminary program. This was approved and should advance program delivery five days.

14. PCR No. 106 was to eliminate the Direct Transfer Ascent Targeting program (P-11) from Luminary. I was given the action item of making sure that this deletion does not affect the stable orbit rendezvous capability. In addition, I was requested to look into deleting the coelliptic ascent targeting program (P-10) which provides an onboard capability, which is only needed if communications are not available with the ground.

15. PCR No. 1[illegible] was approved to delete a minimum deadband mode during minimum impulse burn in Sundance.

16. PCR's 11[illegible], 116, and 117 were minor changes to the way the LGC throttles the DPS. They would put throttle up time in a readily addressable address,

would delete the [illegible] second 10 percent thrust test, and would make it possible to automatically throttle to a value lower than maximum thrust. These changes were all disapproved for the first series of Luminary, but were put in the hopper for consideration for Luminary [illegible] and beyond.

17. The next meeting, as I understand it, will be on April [illegible], 1968.

Howard W. Tindall, Jr.

Addressees:
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/R. P. Parten
J. R. Gurley
E. D. Murrah
A. Nathan
FM4/P. T. Pixley
R. T. Savely
FM5/R. E. Ernull
R. Berry
FM6/B. Becker
FM7/S. P. Mann
R. O. Nobles
FM/Branch Chiefs

FM:HWTindall, Jr.:js

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: MAR 18 1968
68-PA-T-63A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Lunar rendezvous abort summary

1. A great deal of work has gone on over the years on the subject of lunar abort rendezvous, spearheaded by Morris Jenkins, Ed Lineberry, Buzz Aldrin and others. The results of some of this work have already been documented and more detailed reports are in the works. The primary reason I'm writing this note is to give you a layman's summary of the situation as I understand it. Basically, it is not as complicated a subject as you may have been led to believe. Also, I want to make you aware that current planning involves substantial use of the command module, more than you may have thought, since that's a rather important thing. And, finally, I'd like to point out several places where inflight abort preparations influence the nominal operations.

2. First of all, I'd like to emphasize one simple, very significant feature of these operations. All lunar rendezvous---nominal, contingency, abort---are essentially the same operation. The only two things that influence how it will be performed are:

(a) The phasing situation at the start; that is, which vehicle is ahead of the other and how far, and

(b) which spacecraft is to do the various maneuvers.

Perhaps they are so obvious and simple that they're not worth pointing out but it turns out everything we do is based on them. It is to be emphasized that current plans do not include exotic, special maneuver sequences, spacecraft or ground computer programs, operational techniques, etc. In fact, all lunar rendezvous---from (a) Hohmann descent following DOI, (b) powered descent and hover, (c) lunar surface, both nominal and abort, and (d) CSM rescue---are carried out using the standard four maneuver, rendezvous sequence---CSI/CDH/TPI/TPF. (For those who don't recall what that means, see footnote.) The variables to bring about rendezvous are the timing and magnitude of those four maneuvers, constrained to occur within a limited

---

[1] Coelliptic Sequence Initiation (CSI) is a maneuver which establishes the proper phasing and differential altitude conditions at the Constant Differential Altitude (CDH) maneuver point where the orbits are made coelliptic. Terminal Phase Initiation (TPI) establishes an intercepting trajectory of one spacecraft with the other, and the Terminal Phase Final (TPF) braking maneuver stops them from impacting each other.

number of revolutions (primarily due to LM systems constraints) and differential altitude constrained to be between 10 and 25 miles. Unfortunately, the final approach often ends up being above instead of below as we would prefer. This sequence is sometimes preceded by a CSM Hohmann transfer to a low orbit but only if the CSM is behind the LM at the time of abort and must assist in the rendezvous. Accordingly, standard maneuver logic is all that is needed in the RTCC/MCC and spacecraft computer programs.

3. Let's first discuss the situation after the LM has executed the Descent Orbit Insertion (DOI) maneuver and an abort is required. (Nominally the CSM is in a 60 nm circular orbit and the LM is in an 8.5/60 nm orbit.)

(a) During this mission phase and even to a point 30 minutes past nominal powered descent initiation (PDI), the LM can perform the rendezvous without CSM assistance within 2 revolutions. Since the LM quickly moves ahead of the CSM during this mission phase, it must transfer to a higher orbit than the CSM to get back. Accordingly, a LM active rendezvous will always be from above the CSM. Since the TPI times are solely dependent upon the CSM orbit to give optimum lighting conditions, it is possible and should be a standard procedure prior to DOI to relay to the LM crew these values for a 1 and 2 revolution rendezvous so that they are readily available for onboard targeting of the maneuver sequence, if needed. CSI is the LM's abort maneuver and it will always be posigrade and horizontal to raise the LM's orbit above the CSM's.

(b) If the LM is passive, the CSM must catch up by dropping to a lower orbit than the LM. Ed Lineberry's people have chosen a 20 nm circular orbit into which the CSM drops by making 2 canned Hohmann transfer burns of about 60 fps each. The first is executed one-half revolution after DOI and the second one-half revolution after that. (Incidentally, the rendezvous people are convinced that this CSM orbit and maneuver execution time is as good or better than any other, regardless of the time an abort situation is recognized in this mission phase.) The CSM then carries out the standard CSI/CDH/TPI rendezvous sequence finally arriving about 9¼ hours after DOI. One somewhat significant feature about all CSM active LM rescues is that since the LM has a perilune of only 8 or 10 miles, it is impossible to perform a coelliptic rendezvous from below. We can't fly the CSM lower than that in a coelliptic orbit. So all CSM active rendezvous are from above. In this particular abort case, it is necessary for the CSM to stay in the 20 nm catchup orbit long enough to actually pass the LM and set up proper phasing for a final approach from above. Accordingly, whenever possible the LM should at least do the braking——not only to save CSM RCS fuel but because of its more favorable approach conditions visually.

(c) If the LM's Descent Propulsion System (DPS) doesn't work when the abort is initiated, or abort is due to DPS failure to start at PDI, it is our proposal to make the CSM active as outlined in (b) in order to avoid staging the DPS with all its nice consumables. This would keep the whole process non-time critical. Of course, the LM should stage and become active at TPI or braking once everything is under control and rendezvous is assured.

Total CSM delta V required to do this does not exceed about 180 fps in the worst phasing case (all SPS, except ullage). This introduces an important concept. The nominal CSM timeline during LM descent should include targeting and preparing for the Hohmann transfer maneuver so it can do it if it needs to. It would countdown to go a little more than one hour after DOI.

4. Now let's discuss aborts from early Powered Descent (PD). During about the first 8 minutes of PD, or until about hi-gate, almost the same procedures would be followed as above, since the phasing at abort is the same---LM in front of the CSM. However, there are two significant differences:

(a) The LM using just the DPS is only able to achieve orbit for the first 5 minutes of PD. After that the LM must stage and use some APS fuel.

(b) The LM abort insertion orbit is currently targeted for only 10/30 nm whereas the post-DOI orbit is about 8.5/60 nm. This means the CSM cannot get into a smaller (shorter period) orbit to do a rescue. That is, if the CSM circularizes at 20 nm it will have the same period as the LM and will not catch up. This prompts a current program change request for the LM program (Luminary), namely, to change early abort targeting in the DPS abort (P-70) and APS Abort (P-71) programs to insert into a 10/60 nm orbit to permit CSM rescue if necessary. Without this we don't have a CSM rescue capability for this situation.

(c) If the LM does not have to stage to reach the 10/60 nm orbit, we again propose the CSM perform the rendezvous just as described in paragraph 3 in order to save LM consumables. Of course, if the LM must stage due to DPS failure or late abort (after 5 minutes into PD), it might as well go ahead and do the rendezvous, i.e., active LM and passive CSM.

5. During the rest of PD (approximately after hi-gate) through hover and even for the first few minutes on the lunar surface, the phasing has changed such that if the LM aborts it will be trailing the CSM when it gets into orbit again. That is, during PD the CSM overtakes the LM and proceeds ahead of it such that roughly after hi-gate, the LM should insert into the standard 10/30 orbit and, using the standard maneuver sequence, will rendezvous from below the CSM. CSI will occur 40 minutes after insertion just like a nominal rendezvous. Conversely, if after insertion (using the APS, of course), a CSM rescue of the LM is required, the phasing is right for the CSM to perform the standard maneuver sequence---essentially "mirror image" of the LM maneuvers---to reach the LM from above. In either case, the rendezvous can be accomplished within two revolutions.

6. Note then, that during the LM's Hohmann descent after DOI, the CSM trails the LM by an increasing amount making the phasing situation progressively worse. This trend reverses during PD until at some instant, shortly after hi-gate the phasing is perfectly nominal (when the LM achieves orbit following an abort). After that, the phasing degrades again but this time with the CSM leading the LM, such that the rendezvous by the LM is as we prefer---from below. The only thing is that the later we abort the longer it takes.

One thing is evident from this. From an abort trajectory standpoint there is a "preferred" period to abort. Therefore, if possible, we should attempt to select the "Go/No Go for landing" time (TD) within this period. Of course, many other considerations are involved in this choice, too.

7. Finally, I'd like to discuss aborts from the lunar surface. Much has been said about "anytime lift off" and a great deal of work has gone and is going into it. Personally, I feel it's time we knocked that off, and I'll explain why and what we should do instead. But, first I'd like to point out a remarkable similarity of the LM's lunar surface situation to any of our manned earth orbital missions. On the latter, immediately after insertion into earth orbit, critical parameters are checked and a Go/No Go for one revolution is given. And the spacecraft either aborts or goes one revolution. After that Go/No Go's for more interger revolutions are given at logical times---Go for six, Go for 16, etc. Reentry at these times is seriously prepared for and that's where the effort goes. Of course, some consideration is given to coming down in between these planned recovery areas due to critical systems failures but not much. It can be done but "anytime reentry" would be BAD NEWS! We have the same situation with the LM on the lunar surface. Immediately after the DPS is shut off after landing, the spacecraft should be maintained in the same state as during hover for about three more minutes. That is, the guidance system remains in the same program as used during terminal descent and everything remains prepared to "abort stage." During this three minutes (or whatever) the crew and the ground make a rapid check of all critical systems and spacecraft state (such as tilt, etc.). Then a "Go/No Go for two hours lunar stay" is given. If it's No Go--- "abort stage" into orbit and follow the standard rendezvous procedures noted above. If it's a Go for 2 hours lunar stay---stay and start preparing to lift off in 2 hours, if necessary. This includes platform alignments, guidance system targeting, etc., and all the rest of it. From here on is a series of Go/No Go's for more integer revolutions (CSM's) on some logical basis and serious preparations (targeting, etc.) should be carried out for them. That's where the effort should go. That is, if things go bad, launch when the CSM comes over again with nominal phasing. Special provisions should not be made to support a true "anytime launch" capability. That's BAD NEWS, too! Of course, MCC/RTCC programs and displays are available to handle the situation if it were to occur, but on a low probability contingency basis. Under some plausible situations, propellant requirement and spacecraft failures, etc., rendezvous would not result.

8. Furthermore, just like for reentry, I propose discrete lift off times for the nominal LM lift off. The countdown should include adequate time, built-in holds, etc., to insure being ready to go on time--once per CSM revolution. If that opportunity is missed wait two hours and get the problem that delayed lift off straightened out. What I'm saying is---all planning, procedures, ground rules, training and simulations, etc., should be oriented to those "probable" lift off times (i.e., 3 minutes after TD and on-time once per CSM revolution), just like we do for earth orbital reentry.

9. Well---that was a lot of reading. I hope it helped straighten out for you what lunar rendezvous aborts are all about. If you still don't understand it's not because it's complicated, but rather because I didn't explain it well enough. So give me a call. Or the people who are really doing the work.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27
5010-107

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: MAR 13 1968

68-PA-T-61A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Seventh "D" Mission Rendezvous Mission Techniques meeting

1. The "D" Rendezvous Mission Techniques meeting of March 10 was probably one of the least productive so far, and I sincerely apologize for it. I must have been tired or something. Even so, with all that talent present, there must be something worthwhile reporting.

2. At one of our earlier meetings we tentatively established that platform alignments would be performed by both vehicles during each period of darkness throughout the rendezvous exercise. Paul Pixley (MPAD) presented some data at this meeting which showed that, from a rendezvous navigation standpoint, loss of observational data---rendezvous radar in the LM and sextant in the CSM---during platform alignment hurts us more than a little platform drift. Accordingly, it is their proposal that platform alignments only be performed prior to the separation burn which initiates the football rendezvous in the beginning and in the darkness period shared by the psuedo-TPI when the LM is above the command module. This applies to both the LM and the CSM. Unless someone has reason for disagreeing with this, their recommendation is accepted and all further work should be based upon it.

3. In response to an action item from the very first meeting, the Orbital Mission Analysis Branch (formerly the Rendezvous Analysis Branch) reported their progress on developing techniques for insuring proper station coverage and lighting conditions during the rendezvous exercise in spite of trajectory perturbations earlier in the mission. The most significant of these perturbations, of course, is failure to launch on time. As a result of their work, it is anticipated they will recommend selection of an earlier nominal launch time and change in direction of the SPS engine tests early in the mission so that the spacecraft will nominally fly in a higher orbit, during the period between them. In addition, it will probably be recommended that these big SPS burns be separated in time by approximately a day instead of occurring within the same period of activity. If these things are done it will be possible to compensate for lift off time delays by decreasing the horizontal, in-plane component of these SPS burns in real time such that the spacecraft does not go to such a high altitude, thereby shortening the orbital period during that period. The implementation to carry out targeting of these maneuvers in real time may utilize the rendezvous mission planning tools in the RTCC that are already available. Their proposed approach would be to modify the SPS burns using the Gemini Agena maneuver logic to cause

[illegible] spacecraft to rendezvous with a phantom target. The phantom target [illegible] where the spacecraft would have been if it had been launched on time and had followed the nominal maneuver sequence. If this technique proves to be as reasonable as it seems to be now, changes to the nominal mission plan noted above will be processed through the FOP by Morris Jenkins.

4. I just reread that last paragraph and it sounds like I'm still asleep. Does it make sense to you?

Howard W. Tindall, Jr.

Enclosure
List of attendees

Addressees:
(See attached list)

ATTENDEES

E. E. Aldrin	CB
C. Conrad	CB
M. C. Contella	CF
S. H. Gardner	CF
J. E. Hutchins	CF
C. T. Hackler	EG
G. E. Paules	FC
H. D. Reed	FC
G. P. Walsh	FC
A. L. Accola	FM
H. L. Conway	FM
M. V. Jenkins	FM
E. C. Lineberry	FM
A. Nathan	FM
C. Pace	FM
P. T. Pixley	FM
D. Reed, Jr.	FM
R. R. Regelbrugge	FM
H. O. Spurlin	FM
J. L. Hall	FC
K. D. Leach	FS
H. W. Tindall, Jr.	PA
N. L. Bedford	TRW
R. Boudreau	TRW
D. L. Rue	TRW
J. E. Sheppan	TRW
C. E. Wilkins	TRW

Enclosure

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27

5010-107

UNITED STATES GOVERNMENT

Memorandum

TO : PD7/ASPO Contract Technical Representative

DATE: MAR 13 1968

In reply refer to: [illegible]

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: TRW performance evaluation for Task A-46

1. I don't know if other people have the same problem as I do--maybe Task A-46 is unique--but so help me God, I cannot think of anything productive to write in those blank spaces on the performance evaluation form month after month. So, I am sending this form back with a single, overall numerical rating and this cover memorandum as explanation.

2. The A-46 task calls for TRW personnel to support our Data Priority Mission Techniques meetings which occur at the rate of 4 or 5 each week. One or two of their people are highly qualified to participate in the discussions and they contribute substantially in the development of these techniques. Specifically, Dick Boudreau is an outstanding person in this respect. Most of the rest do not have operational experience preparing them to contribute in this way. But who does? And, it doesn't matter anyway. They are charged with recording and documenting the results of the discussions as logical flow charts and supporting literature describing the rationale of how the guidance systems will be used. To do that job in a professional way is all we ask of them, and I must say they have been extremely responsive in preparing and keeping these preliminary flow charts, which we change meeting after meeting, up to date. Furthermore, there is substantial evidence that these people are learning about the various systems and procedures very quickly along with the rest of us. Accordingly, I have every reason to believe that not only will the documentation they produce be accurate and complete but, as time goes on, they will become strong contributors to the development of the techniques themselves. They're enthusiastic and have plenty of initiative. In short, they're doing a swell job.

3. I hope this memo helps you to understand why I am not filling out the little blank spaces on the form, as well as give some basis for the numerical grade. Thank you for your patience.

Howard W. Tindall, Jr.

Enclosure

PA:HWTindall, Jr.:js

TASK PERFORMANCE EVALUATION

NAME OF CONTRACTOR: TRW [illegible]

TASK TITLE: [illegible] Control Data [illegible] and Data [illegible] Analysis

PERIOD: [illegible]

CONTRACTOR TASK MANAGER(S): Mary F[illegible]

MSC TASK MONITOR(S): Howard W. [illegible], Jr.

BRANCH: [illegible]

NUMERICAL RATING

1. QUALITY AND SIGNIFICANCE OF WORK

1 through 6 - See attached memorandum.

2. PROFESSIONAL RELATIONSHIPS

3. ECONOMICAL USE OF RESOURCES

4. COMMUNICATIONS

5. SCHEDULE/TIMELINESS

6. PRODUCTIVITY

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27
5010-107

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: MAR 13 1968
68-PA-T-60A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Lunar Reentry Mission Techniques meeting - March 7

1. On March 7 we had a Data Priority Mission Techniques meeting on lunar reentry. This was the first on this mission phase with contractor participation. Our objective was to understand the current status of the business and to begin pinning down the operational procedures to be used onboard the spacecraft and on the ground. We were particularly interested in data flow, decision points and logic, and the actual detailed techniques to be used during this phase of the mission. Although we intended for it to start just prior to the final (third) midcourse correction on the way back from the moon, it turned out the discussion unavoidably included activities earlier in the flight, starting with the Transearth Injection (TEI) maneuver itself. Generally speaking, I would say this mission phase is better understood and more completely developed than any other in the lunar mission. A reasonable set of mission techniques is more or less in hand right now. Of course, there is no question that significant changes will be made based on further analysis and actual flight experience.

------Paragraphs 2 through 5 deal with the midcourse correction maneuvers------

2. Jerry Yencharis (MPAD) briefly discussed the second midcourse correction maneuver (MCC2). It is a maneuver to be made entirely in-plane designed to achieve specific entry interface conditions consistent with a safe reentry and controlled landing point. Analysis summarized in Figure 1 has shown that this maneuver can be made efficiently anytime in the period between 15 and 25 hours before entry, and so it should probably be scheduled to fit the crew work/rest cycle. However, some consideration is being given to rescheduling it in real time based on its magnitude. Obviously, both the nominal time and real time decision logic must be worked out before that (i.e., now). One question to be resolved involves basic "small maneuver" philosophy. Specifically, should maneuvers of a magnitude less than the targeting uncertainty be made? We have generally said that they would be so that dispersions would be equally distributed plus and minus. This, however, is not the currently proposed technique for these midcourse corrections, and deserves further examination. It is clear that if this maneuver is made we'll use the External Delta V guidance mode with the SPS engine (if it is in excess of 8 fps). And it will be targeted from the ground. Platform orientation can be determined either onboard or on the ground; this appears to be pretty much a crew preference, and we'll be interested in their decision.

3. A third midcourse correction (MCC3) is scheduled in the timeline 2 hours prior to entry. The real time decision as to whether or not this maneuver need be made is carried out as follows: The desired flight path angle at the entry interface is compared to the predicted value assuming no MCC3. Only if the difference in these two exceeds .16° will the maneuver be executed. This limit has been selected to insure a safe reentry but is large enough to make the need for this maneuver extremely small. For example, a 300 sample Monte Carlo study was made, and in no case was the MCC3 required. In fact, the largest flight path angle difference was only about .25° (see Figure 1). It has been established that this maneuver will be entirely inplane, targeted from the ground to achieve the desired flight path angle and will utilize the External Delta V guidance mode. Of course, the inertial platform must be aligned prior to this maneuver. Its orientation will not be constrained to provide any particular pitch attitude display on the FDAI 8-ball during the burn. Of course, the ORDEAL could be used to give all zeros on the 8-ball. The actual REFSMMAT to be used during the MCC3 and reentry will be computed and relayed to the crew from the ground to provide 0, 0, 0 on the ball at 400,000 feet altitude when the spacecraft is in a heads down, in-plane, horizontal, wings level attitude, heat shield forward.

4. It has also been established that preparations for all maneuvers are begun 2 hours and 40 minutes before time of ignition to allow sufficient time to activate the systems from a standby state, to get all of the initialization data input into the system and to make all of the various checks to develop confidence that the burn will be made properly. It was also decided that the same timeline for bringing up the system, aligning the platform, etc., would be utilized regardless of whether the MCC3 maneuver is made or not. FCSD people involved in crew timeline development took the action item of making sure this is an acceptable approach.

5. Although major emphasis at this meeting was devoted to nominal reentry procedures with all systems working properly, we did depart long enough to discuss briefly current plans for handling communications failure occurring at about the time of the second midcourse correction or later. Specifically, it was stated that if the ground has transmitted to the spacecraft its MCC2 state vector and targeting command load prior to communications failure, there should be no attempt made onboard the spacecraft to perform onboard navigation using the sextant. The point is that onboard navigation can foul up the state vector and some of us intuitively feel it better to stick with the last set sent from the ground for entry if it is that current. Various people did not agree with this rule, of course, and so an action item was promptly levied upon them to determine a superior alternate approach in detail. In the meantime, we will continue on as described above.

------Paragraphs 6 through 12 deal with entry preparation------

6. At present the reentry guidance philosophy includes two planned landing areas (PLA) which are illustrated in Figure 2. (All figures attached are courtesy of MPAD's Lunar Mission Analysis Branch) PLA 1 is a thousand mile band including the primary landing point and giving the capability of bad weather avoidance. In the event of PNGCS failure a shorter range landing point, PLA 2, is designated consistent with a no skip, constant g reentry which is the planned backup reentry mode. Efforts are being made to determine if the PLA 1 range can be made to include PLA 2 with current PNGCS hardware and software implementation. If so, it is probable PLA 2 would be selected as the primary recovery area in order to make PNGCS, EMS and backup techniques all compatible.

7. With regard to the constant g reentry, the MPAD reentry people have the action item of preparing and delivering updated constant g reentry load factor profiles to FCOD for their evaluation and, hopefully, buy off. We anticipate no problem on this. Typically, they are a 4 g reentry with a 4 minute duration or a 3 g reentry with a 5 minute duration, sometimes preceded by a high acceleration, short duration spike (See Figure 3).

8. It was established that as long as communications exist with the ground, MSFN data will be used for EMS initialization. This activity will be scheduled at some convenient time, probably an hour or so before entry, since it is not time critical. Although the PNGCS computer is programmed to provide this data, there is no need to pay any attention to it unless communications prevent receipt of the ground update.

9. Command module/service module separation will be carried out using manual attitude control and will occur approximately 15 minutes before EI. It was stated that the Descent program (P-61) will be called up approximately [illegible] minutes prior to that event. This will enable the PNGCS to accept accelerometer inputs making it aware of any small spacecraft translations due to separation itself and/or due to subsequent attitude control. (Recall command module attitude control is not done with balanced couples.) Since accelerometer bias could accumulate over a period of time as a significant contributor to missing the landing point, we spent some time discussing the question of whether or not allowing the guidance system to accept accelerometer input for 20 or 30 minutes prior to entry interface is acceptable. According to recent analysis (summarized in Figure 4), down range miss distance due to a 3 sigma accelerometer bias (calibrated inflight) would be about 10 miles, and cross range would be about half that much, even if Average G is enabled by the Descent program (P-61) 30 minutes prior to entry. Some consideration is apparently being given to adding an accelerometer threshold limit into the computer program to avoid this small error. Since this worst case error is really quite acceptable, I would oppose any such program change which I assume would only be made after approval of a formal program change request.

10. Claude Graves' people presented some data to show the maximum landing point miss due to platform misalignment, the major contributor (see Figure 5). He showed that with 3 sigma gyros the miss distance was nearly linear at the rate of about .6 of a mile down range and [illegible] cross range for each hour spent between the last platform alignment and the entry interface. Since a 3 or 4 hour period of drift would only result in about 12 miles miss at the worst, we felt it unnecessary to make any further platform alignments after the third midcourse correction.

11. Some thought was given to making a spacecraft attitude check using the sextant prior to reentry; however, it was concluded that this really accomplishes very little. Confidence has been developed in the PNGCS prior to the MCC3 maneuver and so we would only be uncovering failure subsequent to that. Furthermore, there are a whole series of PNGCS performance evaluation tests associated with the reentry itself made before committing to the PNGCS and there is nothing that could be done to fix the system if it has failed in that short time. All of which says, the test is useless. Accordingly, although FCSD has not completed the detailed timeline yet, as of now there is no known reason for the crew to leave their couches after MCC3.

12. We had a lengthy discussion with regard to initialization and use of the EMS roll stability indicator (RSI), also known as the roll attitude indicator and lift vector indicator. Apparently, this device is merely a repeater from the FDAI roll bug driven by the GDC. It was originally included in the EMS when there was only one FDAI in the spacecraft. However, now that there are two FDAI's its purpose and value are rather nebulous. Actually, the discussion took a surprising turn. We started out trying to figure out how to initialize the damn thing and after much emotional, confused talk we seemed to arrive at the conclusion that it really has very little value. Mike Collins intends to obtain a crew position on this, and Clyde Paulk was requested to pulse G&C on the same subject. The thing that bugged several of us is that we shouldn't have something displaying wrong information in the cockpit, and so we should either cover it up with masking tape or else we should line it up properly, no matter how useless it is. The problem is that the way the PNGCS controls attitude is not consistent with the RSI alignment procedure. Therefore, it requires the crew to control spacecraft attitude manually until .05 g. Actually, I am not so sure if that ought not to be the procedure anyway, in order to utilize the horizon as an independent check that the spacecraft is in proper pitch trim attitude to insure aerodynamic capture of the spacecraft in the proper attitude. Left unresolved was whether we should submit a program change request to make the Colossus lunar return reentry program compatible with that procedure.

------Paragraphs 13 through 19 deal with------
entry proper

13. The remainder of this meeting dealt with reentry procedure based on Figures 6 and 7 which are attached to this memorandum. Generally speaking, these procedures for monitoring a nominal reentry and carrying out a backup reentry seem to be well thought out and complete. Obviously, there are still a number of relatively minor refinements or changes which have to be made. Some of these are the items reported in the following paragraphs.

14. Probably the most important decision to be made during reentry occurs when the reentry program changes from P-64 to P-65 which occurs just about at the time of peak g's. At this time, a display of predicted exit velocity and drag level (VL and DL) appears on the DSKY. The crew must determine if these values are within limits determined by the ground and relayed to the crew as part of the standard entry preparation procedure. If they are within bounds, the crew commits to the PNGCS. If they are outside, the PNGCS has failed and the crew takes over and flies constant g reentry to MLA. An important point to be made here is that the primary PNGCS Go/No Go check is based on a comparison with the ground and that this is considered absolute! Of course, the crew does monitor the EMS for scroll line violation which also could result in abandoning the PNGCS, but that is not a comparison of one system against the other for performance evaluation. The criteria on which this test is based is expected to be tied to the accuracy with which the ground is able to predict these parameters as opposed to being selected to establish such things as 3 sigma PNGCS performance, assurance of landing within some specified distance of the recovery force, or assuring reentry itself---although it better do at least that! Graves' people are in the process of determining values for these limits and then we will know what sort of reentry may be assured. They expect this work to be completed at least six months prior to the "E" mission.

15. It was noted in this discussion that a second set of DSKY display parameters are available in P-65 by a crew input of "proceed" to the computer. It is evident that the crew is not likely to perform that operation while experiencing 5 g's, so Graves was given the action item of determining whether these display parameters (inertial velocity and altitude rate) are of any real use to the crew. If they are, it will be necessary to submit a Colossus program change request to make their appearance automatic probably after display of VL and DL for a fixed length of time.

16. Another PCR Graves intends to submit for Colossus No. 2 would make PNGCS control of attitude be lift vector up until .2 g's during "second entry" following a skip. This is felt to be mandatory since a pitch trim attitude check on the horizon is critically needed at this time. At present the computer program will drive the spacecraft attitude to whatever bank angle is consistent with the reentry guidance objectives even though prior to .2 g's the aerodynamic forces contribute very little to landing point control.

17. Graves' people were requested to examine the EMS scroll lines to make sure no EMS line violation during the second entry would cause the crew to take over from a perfectly operating PNGCS. That is, we want to make certain that sufficient margin is provided to prevent this from happening.

18. Both MPAD and G&C were requested to develop some sort of tests to be included in the reentry procedure to determine if the EMS is performing properly. NR will probably do some work on this, too. The point is, it was apparent from our discussion that all performance evaluation was centered on examination of the PNGCS with switchover to the EMS in the event of its failure. What seemed to be missing was performance evaluation tests of some sort to make sure the EMS was working well enough to be used.

19. Based on this day's discussion TRW will prepare a mission techniques flow diagram to start the review cycle on this mission phase. After a couple of internal MSC meetings, I expect we will again call in MIT and NR and see if we can't put this business on ice.

Howard W. Tindall, Jr.

Enclosures 8

Addressees:
(See attached list)

TRANSEARTH DATA FOR 2 MIDCOURSES

• MCC1 AT TEI + 8 HOURS

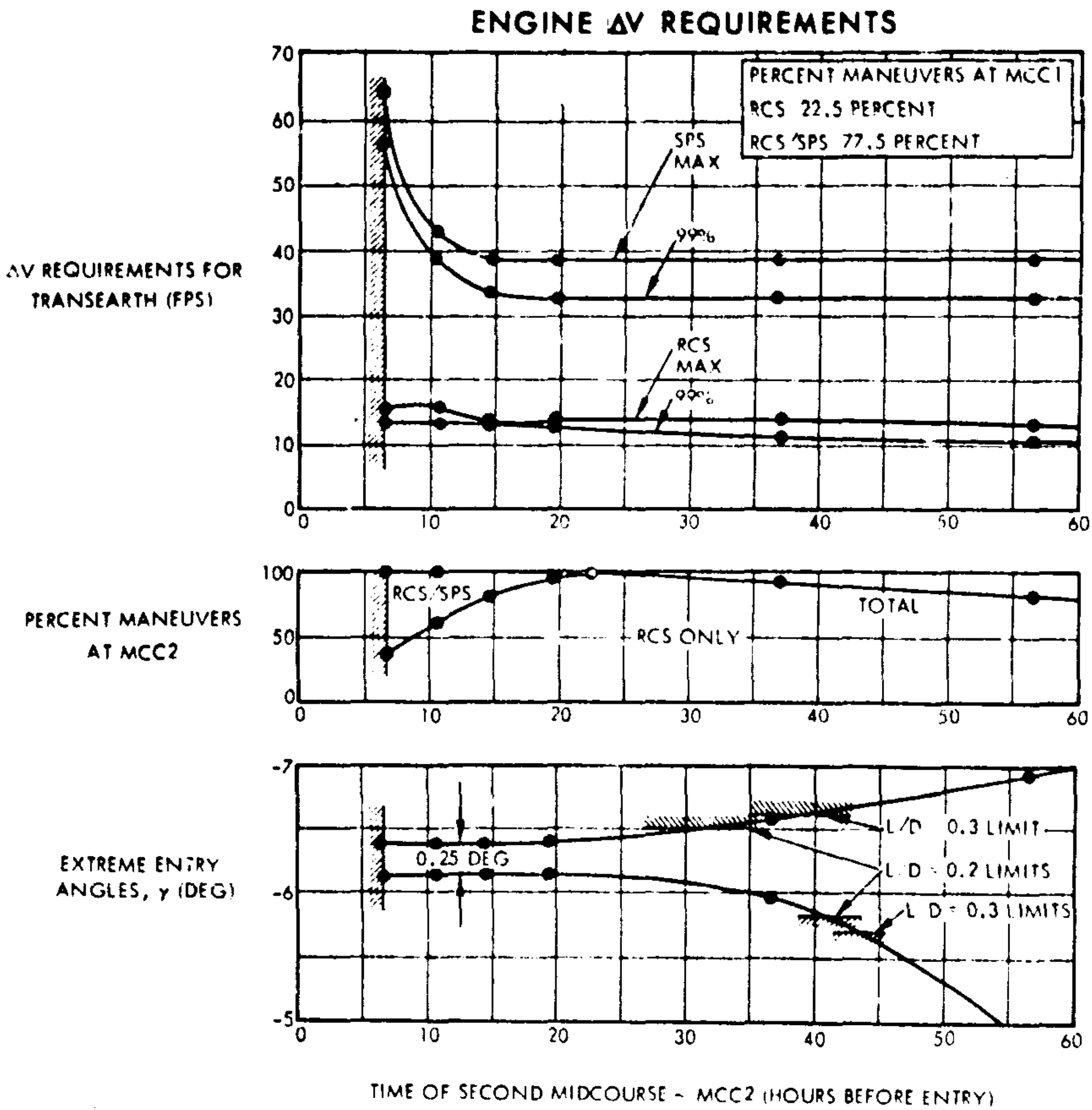


Figure 1

1968 TINDALLGRAMS

68-PA-T-2A (11 Jan.) First 2 hours on lunar surface will be devoted to spacecraft systems checks and launch preparations--simulation of final 2 hours before ascent and rendezvous: good practice, gives indication of any potential trouble spots, prepares LM for emergency situation.

68-FM-T-12 (16 Jan.) Subject: "Automatic rendezvous boresight into Luminary." "The flight crew has bluntly announced that they intend to maintain boresight on the LM continuously, particularly after the CDH maneuver, and had requested that the computer program be modified to do this job automatically in order to relieve them for tasks only they can do." (RS: once again, I don't understand the technicalities, but thought you might be interested in anything the flight crew bluntly announces.)

68-AP-T-13A (17 Jan.) Subject: "No change needed in the landing site determination programs - CMC or RTCC." Data Priority meeting in late 1967 had resulted in program change request for the Colossus computer program, the program which is used for determining the location of the landing site. Unexpected result of 12 Jan. meeting on implementation of this change was that "the change was not needed at all and it was obvious that the CCB should be so advised." "It really is immaterial whether or not the spacecraft is able to compute the landing site location." "Some rather lousy operational procedures appear to be necessary during the lunar landing mission in order to do the job, but that is not as a result of any deficiency in this program."

68-AP-T-14A (17 Jan.) Subject: "Reentry from lunar missions." "On January 12 a group of Fligth Crew, Flight Control and Mission Planning guys got together to talk about the lunar reentry and some rather interesting things came out which I am recording here for my records and your amusement." Points considered: last mid-course correction before reentry, most desirable spacecraft attitude during service module separation; if and how the ORDEAL will be incorporated into this operation, "a lengthy and emotional discussion concerning the overall reentry trajectory philosophy," EMS initialization. "We'll work on all this some more and within two months we'll get together with NR and MIT too."

68-AP-T-15A (22 Jan.) Subject: "'Final' review of Spacecraft 101 (Mission "C") Retrofire and Reentry Mission Techniques." "Final" review held on 10 Jan. with crews for Missions "C", "D", and "E" in attendance. Probably most controversial item: manner in which the Entry Monitoring System is to be used: EMS is only being operated as a systems test and is not utilized in the actual control of the reentry. Some parties contested these decisions, in particular NA." Some things in regard to the EMS. "Once the comments noted have been incorporated, it is my intention to present this to the MSC management for their information, criticism and final approval."

68-PA-T-16A (24 Jan.) Subject: "Second Mission 'C' Rendezvous Mission Techniques meeting." Held 10 Jan. "Subsequent to this meeting I discussed our conclusions with Tom Stafford and Donn Eisele, who both concurred as of this time."

69-PA-T-42A (7 Mar.) Subject: "G lunar Surface stuff is still incomplete," re the use of the expression "go/no go" and the decision whether to stay or abort immediately after lunar landing: "Every time we talk about this activity we have to redefine which we mean by "go" and "no go." That is--confusion inevitably arises since "go" means to "stay" and "no go" means to "abort" or "go." Accordingly, we are suggesting that the terminology for this particular decision be changed from "go/no go" to "stay/no stay" or something like that. Just call me 'Aunt Emma.'" "Last summer GAEC honored us with their presence at one of our meetings and to celebrate the occasion we give them an action item. . . . We haven't heard from them since, on that or anything else.X . . ."

69-PA-T-44A (14 Mar.) Subject: "Happiness is having plenty of hydrogen."

69-PA-T-45A (12 Mar.) Subject: "Simplification to the pre-PDI abort procedure." discussion of the procedure as worked out by Tom Gibson and George Cherry; "Great work, Tom and George. Keep that up and I predict you'll go places."

69-PA-T-47A (20 Mar.) Subject: "F mission lunar orbit attitude sequence." "Who could suggest that the crew not look at the sunlit moon once they have gotten there, even if it costs some RCS."

69-PA-T-52A (1 Apr.) Subject: "PGNCS operations while on the lunar surface." "During our March 27 Lunar Surface Mission Techniques meeting I think we finally settled how we think the PGNCS should be operated. How many times have I said that before?"

69-PA-T-66A (30 Apr.) Subject "What's descent all about?" "As a result of some stirring around within NASA on how the various guidance and control systems are used during descent, George Cherry of MIT took it upon himself to write a complete description of the capabilities that exist and how they may be used. Without doubt, this is the finest, briefest, most readable description I have ever seen on the subject and for that reason I am forwarding a copy to you under this shining white piece of paper."

69-PA-T-70A (5 May) Subject: "Descent Monitoring Mission Techniques--a status report." "There is another thing about powered descent crew procedures that has really bugged me. Maybe I'm an "Aunt Emma"--certainly some ~~ma~~ smart people laugh at this concern, but I just feel that the crew should not be diddling with the DSKY during powered descent unless it is absolutely essential. They'll never hit the wrong button, of course, but if they do, the results can be rather lousy."

69-PA-T-73A (7 May) Subject: "Apollo Mission Techniques Documentation Schedule." Here is another Mission Techniques Doc. Sched., since the last one is three months old and barely reflects real life any more. The Lunar Orbit Activities Document will almost certainly have to be updated to reflect whatever we learn on the F mission. A June 30 release date for that update will be kinda late, of course, but that is a problem everyone has when the launch occurs seven weeks after the last splashdown."

68-FM-T-18 (29 Jan.) George Low announced at his 29 Jan. staff meeting that the LM-2 mission will not be flown unless something unexpected turns up. Final review date of this decision--6 March. Development of the craft to continue as if it were to fly until that date; disposition after that has not been established.

68-FM-T-19 (5 Feb.) Subject: "Sundisk W-matrix is a little wierd."

68-FM-T-20 (5 Feb.) Subject: "Invitation to DPS throttling for DOI meeting." Lack of definition of the spacecraft computer program requirements associated with the throttling of the DPS. "What we must do is to get all interested parties together to pin this business down once and for all in order to provide positive direction to MIT for the Luminary program. Unfortunately, we are probably already far late to avoid schedule impact."

68-FM-%-25 (5 Feb.) Subject: "Sundisk range rate computation is not real accurate." "This deficiency . . . seemed significant at first . . . But considering the much larger errors we probably will encounter . . . it will probably be lost in the noise which we had to be prepared for anyway. This note is just to make sure that everyone who is interested knows about this thing."

68-PA-%-26A (6 Feb.) "Something rather astounding happened at the Apollo Spacecraft Software CCB meeting on Tuesday, Jan. 30. It was so shocking the word spread like wildfire! But just in case you have not already heard, it looks like we are going to get rendezvous radar data on the downlink during the critical LM powered flight mission phases." ". . . it had been anticipated this program change request would not be approved. Their (MIT's) more detailed analyses, however, showed they could provide these capabilities with no impact at all, and so we're going to get it."

68-PA-T-26A (6 Feb.) Subject: "Lunar Reentry Mission Techniques meeting." "Almost all of our discussion dealt with the final midcourse maneuver (third) prior to entry. When scheduled: until something comes along to change it, we propose for now to schedule the third midcourse maneuver 2 hours prior to 400,000 feet. Meeting also established "a criteria upon which it will be possible for the flight controllers to establish the need for this maneuver." "If the predicted flight path angle at EI (Entry Interface) differs from the desired value by more than .36°, the third midcourse maneuver will be executed. According to Pete Frank, this value is sufficiently large that the liklihood of the third midcourse maneuver is very low." In regard to proposed modifications in spacecraft computer entry programs and initialization of the EMS, "it was decided that our next meeting should include participation by MIT and NA personnel."

68-PA-T-29A (7 Feb.) Subject: "Third Mission C' Rendezvous Mission Techniques meeting." "There is some concern about use of the SPS on this first manned mission, particularly these first maneuvers. For example, is there any problem in making three SPS burns within one revolution? And, can one of them be a minimum impulse burn? That is, is there a freezing problem or something? Any comments on this would be appreciated." "That is all I can remember that happened."

68-AP-T-30A (8 Feb.) Subject: "Third D Mission Rendezvous Mission Techniques meeting." "We had our third 'D' Mission Rendezvous Mission Techniques meeting on January 29. I am afraid it was a rather frustrating meeting for everyone. But on second thoucht--what's new?" End of memo: "If anyone comes, we'll get together again at 1:00 pm on February 12."

68-PA-T-24A (21 Feb.) Subject: "Landmarks for lunar tracking." On February 1 a bunch of us who had been working on operational procedures associated with lunar landmark tracking got together with some of the Lunar Mapping people who have the responsibility for selecting and precisely locating the lunar landmarks to be used. This was a rather refreshing get together since, as strange as it may seem, neither group knew much about what the other was doing in any detail."

68-FM-T-35 (20 Feb.) "Here is another request for information--this time dealing with landing radar reasonableness. The basic question is how well can the crew evaluate the quality of the landing radar data . . . is it possible for it to read out the wrong altitude but give every indication that it is performing in a perfectly normal manner?" "The point is it sure would be nice to be able to tell if the radar was wroking even in the face of a large altitude difference, since it is in that case we need the radar data the most."

68-PA-T-36A (20 Feb.) Subject: "Spacecraft computer programs controlling DPS throttling need some changes." "It turned out a number of program changes are highly desirable, if not mandatory, at least for the lunar landing mission."

68-PA-T-41A (21 Feb.) Subject: "Fourth Mission 'C' Rendezvous Mission Techniques meeting" Memo is general summation of meeting; ends: "Since everyone was having such a good time we decided not to wait two weeks for the next meeting."

68-PA-T-46A (1 Mar.) Memo about fifth "C" Mission Rendezvous Mission Techniques meeting. Ends with announcement of next meeting: "We'll probably start in the middle of the data flows this time to see if we can get to the end just once. Maybe there's something interesting in that part of it!"

68-AP-T-48A (4 Mar.) Subject: "Ascent Phase Mission Techniuqes meeting - Feb. 27, 1968." "In the absence of Charley Parker, our beloved leader, I inherited the job of chairing this meeting which probably accounts for why we didn't really get an awful lot done. However, there are a couple of things that are probably worth reporting." Systems check to be run immediately after lunar landing expected to last about 3 minutes. Until the GO/No GO we intend to remain in a state from which we can instantly "abort stage" and go. After that it will take much longer." Last point in memo: "I guess I am attacking the old "MIT me" in stating that we are seriously handicapped by having no reliable definition of the Luminary lunar surface and ascent programs. I understand review copies of these should be avai[illegible] within 3 to 6 weeks and I am sure nothing can be done to speed them up. [illegible] 'em raw when they get here!"

68-AP-T-49A (1 Mar.) Subject: "Fifth 'D' Mission Rendezvous Mission Techniques meeting--don't miss Paragraph 5: it's great." Para. 5: "The following is the most startling conclusion reached today! If the LM PNGCS is working but rendezvous radar has failed, we have a serious problem with the LM since no external data will be input to the spacecraft systems--PNGCS, AGS or charts. In this case, it is our recommendation that the command module execute the TPI and subsequent midcourse correction maneuvers and the LM do the braking maneuvers."

68-PA-T-54A (7 Mar.) Subject: "Sixth 'C' Mission Rendezvous Mission Techniques meeting." "This March 1 meeting conflicted with the President's speech but a few of us dedicated jokers pressed on as follows." Major items discussed in meeting are briefly outlined. Discussion of possibility of extending the launch window--launch earlier in the day. T. recommends against. "We would like to request that very serious attention be given to this matter prior to choosing a launch time earlier than currently planned."

68-AP-T-55A (7 Mar.) Subject: "First 'E' Mission Rendezvous Mission Techniques meeting - March 4." "devoted almost exclusively to understanding what the mission requirements and mission plans are for this phase of the flight." "One nice thing apparent was the substantial carryover from the "C" and "D" mission techniques meetings which should permit us to complete work on "E" in a considerably shorter period than would otherwise be the case." Next meeting: at 1:00 PM, March 18, in Building 4, Room e96. That's 1300 for you Frank." (Frank Who? Borman?)

68-PA-T-56A (7 Mar.) Subject: "Guidance system oriented ground rules for TLI Go/NoGo." (a) A TLI maneuver will not be attempted if there is any indication that the S-IVB IU guidance system is not working properly, (b) A properly operating CSM PNGCS is not mandatory for TLI. That is, it is acceptable to make a TLI maneuver with a failed CSM PNGCS if the subsequent alternate mission is considered more valuable than remaining in earth orbit."

Next mmeo (68-AP-T-57A, 12 Mar.) covers same ground as 56A with some amplifications. Ends: "Obviously, we have a lot to do. But if the ground rules are accepted it is mostly a matter of implementing a technique we understand. Believe it or not, I think we've got this TLI thing pretty nearly licked. I hope so!"

68-AP-T-59A (13 Mar.) Subject: "Seventh 'C' Mission Rendezvous Mission Techniques meeting." Devoted mostly to the terminal phase. "As you can see, we are really getting into the fine detail on the 'C' rendezvous and I predict that if we spend the next two or three sessions going through the mission techniques flow charts, we will be ready to call in the rest of the world and we could then ice this whole thing down within the next couple of months."

68-PA-T-60A (13 Mar.) Subject: "Lunar Reentry Mission Techniques meeting-March 7." "Generally speaking, I would say this mission phase is better understood and more completely developed than any other in the lunar mission."

68-PA-T-62A (13 Mr.) Subject: "TRW performance evaluation for Task A-46. "I don't know if other people have the same problem as I do--maybe Task A-46 is unique--but so help me God, I cannot think of anything productive to write in those blank spaces on the performance evaluation. . . The A-46 Tack calls for TRW personnel to support our Data Priority Mission Techniques meetings . . . They're enthusiastic and have plenty of initiative. In short, they're doing a swell job." High praise of this group, esp. Dick Boudreau.

68-PA-T-61A (13 Mar.) Subject: "Seventh 'D' Mission Rendezvous Mission Techniques meeting." "The 'D' Rendezvous Mission Techniques meeting of March 10 was probably one of the least productive so far, and I sincerely apologize for it. I must have been tired or something. Even so, with all that talent present, there must be something worthwhile reporting."

68-PA-T-63A (18 Mar.) Subject: "Lunar rendezvous abort summary." "One simple, very significant feature of these operations. All lunar rendezvous--nominal contingency, abort--are essentially the same operation. The only two things that influence how it will be performed are: (a) the phasing situation at the start; that is, which vehicle is ahead of the other and how far, and (b) which spacecraft is to do the various maneuvers." At end of 4-page memo: "Well--that was a lot of reading. I hope it helped straighten out for you what lunar rendezvous aborts are all about. If you still don't understand it's not because it's complicated, but rather because I didn't explain it well enough. So give me a call. Or the people who are really doing the work."

28-PA-%-69A (27 Mar.) Subject: "Eighth and Ninth 'C' Mission Rendezvous Mission Techniques meetings." Mostly a discussion of onboard rendezvous navigation with the sextant. "This was brought about by the rather bad experience suffered by the 101 flight crew and a number of the flight controllers on the Kennedy Space Center mission simulator earlier in the week." T. explains the trouble with the sextant at KSC in the next few sentences, then says, "After years of bad-mouthing the sextant, I find it difficult to suddenly start defending it. But an awful lot of analysis and simulation has been done showing the system to have some usefulness." Re MAC/FCSD (?): "What a great outfit those guys are."

68-PA-T-71A (4 Apr.) Subject: "Mission Techniques for the LM lunar stay go/no go." "I think we have finally pinned down how to handle the go/no go decision to be made immediately after LM landing on the lunar surface." LM systems people say it should be possible to give a go/no go within 2 minutes for all systems except the APS propellant system which will take 10 minutes; actually therefore there will be 2 go/ no go's. T. outlines procedure for making decision whether to stay or abort.

68-PA-T-75A (10 Apr.) Subject: "'Any time' LM life off is an unnecessary constraint." "I would like to see the Apollo work proceed as we have laid out, until someone shows us what is wrong with it and would appreciate you letting me know if you don't think this is a reasonable way to go. Let's simplify the mission and put the burden on the "any time" life off people, whoever they are, to explain why we need it." (at bottom of memo: "No argument." CCK)

68-PA-T-83A (17 Apr.) Subject: "Status evaluation meeting - "C" Mission Rendezvous." Mentions some problems in Sundisk computer program. Alos, "It has become evident that the operational people, Crew and Flight Control, do not understand very well how the sextant rendezvous navigation works and how well." (Quite a change from T's original impression of the sextant--see 67-FM1-12, 25 Jan. 1967 entitled: "Why does the AAP command module need a sextant?")

58-PA-T-101A (14 May) Subject: "Aborts from powered descent on the lunar landing mission." Day-long meeting on 8 May to discuss this subject. Begins by discussing several assumptions on which the abort procedure is based; T. indicates that he expects some of the assumptions to be challenged: "I'll bet I hear something about this!" and "Someone's not going to like this either." Memo discusses the abort procedure, which "is really very simple, at least if the above assumptions hold up. So simple, in fact, that I'm sure you'll wonder how we spent the day!"

68-PA-T-106A (24 May) Subject: "Spacecraft computer program newsletter." Discussed "apparent deficiency in Sundance." Also, "Our requirements for getting rendezvous radar (RR) data on the downlink while the LM is on the lunar surface was discussed again, and I am afraid I really blew it. MIT has resisted the program change we requested and I am beginning to think they may very well be right. T. outlines possible simple change; says at end "I would be surprised if it /the change/ is not acceptable to MSC even if it is not perfect--whatever perfect is."

68-PA-T-108A (29 May) Subject: "Spacecraft computer program--things dealing with lunar descent and aborts from it." "Interesting morning at MIT."

68-PA-T-110A (29 May) Subject: "Progress Report on Mission Techniques." "The mission phase giving me the greatest concern right now is the rendezvous on the "D" mission. . . The slip in the documentation since my March 1 estimate is shown by the distance between open and solid symbols /on the attached chart/. It looks awful and if I thought it was typical of the future I'd shoot myself right now. . . . The 'D' rendezvous really turned into a rather messy problem. When it comes to development of mission techniques, it is unquestionably the worse /sic/ mission phase to define in the entire Apollo program: (a) It is the most complex mission phase in any of the Apollo flights, (b) There are more guidance systems involved, none of which are really qualified before the flight, (c) It is potentially the most hazardous of any activity ever undertaken in the manned space program up to that point. I might also add that everyone has their own different opinion on how it should be done, making it that much more difficult."

68-PA-T-114A (3 June) Subject: "Lunar Rendezvous Mission Techniques." "On May 28 we finally kicked off the Lunar Rendezvous Mission Techniques business. Because of the imminence of missions 'D' and 'E', we started on those first some months ago. Now I wish we hadn't because they are so darned complicated. I have a feeling the lunar rendezvous can be finished up quicker than they can and, of course, some of the things we are planning to do in the lunar operation should influence how to go on the development flights."

68-PA-T-124A (12 June) Subject: 'D' mission launch window is nice." Launch window is about two and three-quarters hours long, opening at 10 am EST. "I checked with the mission plan guys and they know of no other activities more constrainint than the rendezvous on the launch window. Furthermore, they never heard of any five minute window. That must be a Washington rumor."

68-PA-T-130A (18 June) Subject: "Can some pre-DOI activity be moved to pre-LOI?" "As you are no doubt aware, the crew timeline just prior to Descent Orbit Insertion (DOI) is terrible. This period of activity has grown almost to the point of being unacceptable. This is due to the extensive LM checkout--particularly that requiring telemetry coverage--which unfortunately conflicts with other activities such as making landing site observations."

68-PA-T-182A (1 Aug) Subject: "North American Rockwell (NR) participation in Mission Techniques Activity." This memo really blasts NR! "This note is to let you know that NR participation in the Mission Techniques activity is almost negligible. (Except reentry - Bobby Johnson's team working on the EMS is outstanding.) . . . I'm not referring to /the small internal meetings/ but rather to the much less frequent big meetings, well attended by MIT and (recently) by GAEC. Frankly, I don't see how they /NR/ could possibly know what's going on!"

68-PA-T-183A (1 Aug.) Subject: "LM rendezvous radar is essential." A rather unbelievable proposal has been bouncing around lately. Because it is seriously ascribed to a high ranking official, MSC and GAEC are both on the verge of initiating activities--feasibility studies, procedures development, etc.--in accord with it. Since effort like that is at a premium, I thought I'd write this note in hopes you could proclaim it to be a false alarm or if not, to make it one. The matter to which I refer is the possibility of deleting the rendezvous radar from the LM."

68-PA-T-206A (25 Sept.) Subject: "C' Communication Loss." "A lot of work is going into the subject contingency - with respect to: (3 tiems) . . . all of which are solely for that failure. I won't comment on whether or not it's worthwhile. It's too emotional an issue to even consider eliminating it, regardless of how you feel. Therefore, by definition it's necessary to prepare for it. This memo is to report current status of this effort."

68-PA-T-208A (26 Sept.) Subject: "Unusual procedure required for LM Ascent from the moon." "Jack Craven surprised us with a little jewel the other day during the Lunar Surface Mission Techniques meeting. He says that in order to enable the APS engine-on and staging commands from the LGC, it is necessary for the crew to depress (now get this) the Abort-Stage button! That is, depressing this button must be part of the standard countdown procedure to LM liftoff."

68-PA-T-212A (2 Oct.) Subject: "Maybe lunar landing site observations are not needed to land. "For some reason only known to my subconscious, I had always assamed the CSM scanning telescope observations of the lunar landing site landmarks prior to LM descent were essential. As a result of your probing and similar comments by Jack Schmitt, I finally realized it was <u>only</u> an assumption and, much to my embarrassment, find that they are possibly not mandatory. . . This note is just to tell you we have our heads out of this sand pile in case you were concerned."

68-PA-T-257A (25 Nov.) Subject: LM DPS low level light fixing. "I think this will amuse you. It's something that came up the other day during a Descent Abort Mission Techniques meeting." The light indicating that there is about 2 minutes worth of propellant remaining in the DPS tanks during the lunar landing is attached to the master alarm. "In other words, just at the most critical time in the most critical operation of a perfectly nominal lunar landing mission, the master alarm with all its lights, bells, and whistles will go off. This sounds right lousy to me. In fact, Pete Conrad tells me he labeled it completely unacceptable four or five years ago, but he was probably just an Ensign at the time and apparently no one paid any attention. If this is not fixed, I predict the first words uttered by the first astronaut to land on the moon will be "Gee whiz, that master alarm certainly startled me."

[illegible]

[illegible] 1968)
([illegible])
4, 38, 39, 44, 47,
50, 52, 53, 58, 62, 64,
66, 68, 76, 82, 85, 86,
90, 98, 102, 105, 107,
108, 111, 113, 117, 118, 120,
122, 126, 128, 132, 135,
139, 141

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

Memorandum

TO : PD/Chairman, Data Requirements Control Panel

DATE: JUN 28 1968

68-PA-T-143A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Relative orientation of the LM and CSM navigation bases

Unless some unexpected problem arises, it is currently planned to align the LM platform on the "D" mission for the docked DPS burns without AOT star observations. The primary reason for this is to save LM RCS fuel, although it is anticipated that overall crew procedures may also be simplified. The proposed technique involves taking advantage of the known relative orientation of the CSM and LM navigation bases. The process involves reading out gimbal angles from the command module G&N and performing a simple mathematical transformation - including the docking index reading - to determine desired LM PGNCS gimbal angles for DSKY input. A piece of information sorely needed to evaluate the quality of this procedure is a knowledge of the accuracy to which we know the relative orientation of the two navigation bases, particularly if nothing special is done to determine these values. In other words, as the spacecraft is constructed, how accurately are the navigation bases located to the principal axes of the spacecraft. It is anticipated that fairly large attitude errors can be tolerated during the docked DPS burns, making it possible to accept misalignment of two or three degrees.

I am assuming that it is from your panel that this type information should be obtained. If this is not correct, would you please let me know as soon as possible.

Howard W. Tindall, Jr.

cc:
FM4/J. C. McPherson
FC5/H. D. Reed
C. B. Parker
CB/R. L. Schweickart

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : FM13/Chief, Mission Planning Support Office

DATE: JUN 28 1968

68-PA-T-142A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Need to know some transearth midcourse correction (MCC) ΔV costs

I think we have pretty well established the transearth MCC maneuver philosophy now. As you know, it involves making small corridor correction maneuvers as their need becomes apparent. Nominally they will be made with the RCS propulsion system utilizing the SCS control system. Very large attitude errors may be tolerated during the burn.

It is necessary to establish the threshold ΔV value below which it is better not to make a maneuver but rather to wait for the next opportunity some eight to twelve hours later. The threshold, of course, depends on the MSFN uncertainty as a function of time and the translation ΔV cost to achieve a particular objective as a function of time. These relations are already fairly well known, but that is not the total cost. I would appreciate it if you would initiate a task assignment - probably to the Guidance and Performance Branch - to define the non-translation RCS propellant costs associated with making a maneuver of the type noted above. These would involve, among other things, the propellant required to coarse align the SCS and to orient the spacecraft to burn attitude. I recently asked Charley Parker (FDB) to establish coarse SCS alignment procedures and I would suggest that whoever is given this task coordinate with him.

Bill T

Howard W. Tindall, Jr.

cc:
FC5/C. B. Parker

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE:

68-PA-T-140A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: DAP mass properties initialization and update requirements

This memorandum is to bring to your attention the recommendation of the Guidance and Control Division regarding DAP mass properties initialization and update requirements which are laid out in the attached memorandum.

They should be incorporated in our Mission Techniques products, unless you find something wrong with them, in which case we should probably contact Ken Cox and/or other responsible Guidance and Control Division personnel.

Howard W. Tindall, Jr.

Enclosure

Addressees:
FC5/C. R. Parker
TRW/R. J. Boudreau

cc:
EG23/K. J. Cox

PA:HWTindall, Jr.:jc

UNITED STATES GOVERNMENT

Memorandum

ACTION DUE [illegible]

Action Copy FM

JUN 19 7 35 AM '68

TO : PA/Chief, Apollo Data Priority Coordination DATE: JUN 17 1968

In reply refer to: EG23-125-68-678

FROM : EG/Chief, Guidance and Control Division

SUBJECT: Recommendations for DAP mass properties initialization and update requirements

This memorandum is written to present recommendations for simple mission rules for updating the Apollo DAP data load mass properties and engine trims. Both the Flight Control Division and Flight Crew Support Division have recently requested information in this general area.

Enclosures 1 and 2 list DAP mass properties update and initialization requirements, and indicate operational procedures for implementation of these requirements. The DAP update requirements, recommended in enclosure 1, are divided into two categories of "mandatory" and "[illegible]." These requirements are applicable to the SUNDISK, [illegible], and [illegible]/LUMINARY DAP's, and to all docked and undocked LM and CSM vehicle configurations. The DAP initialization requirements, recommended in enclosure 2, are intended to be general enough to cover the main line Apollo missions, yet specific enough to have concrete value for any given mission.

Detailed rules for initializing and updating the DAP data loads will vary from mission to mission, and the enclosed data load requirements are written with that fact in mind. The enclosed requirements are recommended as "rules of thumb" to be updated as additional analysis and flight test data becomes available.

Robert A. Gardiner

Enclosures [illegible]

[illegible]
([illegible])

PA MGR
PA-M,CSM
PA-M,LM
PA-AstMgr
PA-A,MgFLS
PA-YerAM
PAZ
PD
PE
PF
PP
PR
PY
FILCP

[illegible]/[illegible] R. [illegible]
[illegible]/[illegible] [illegible] [illegible]
[illegible]/[illegible] W. [illegible]
[illegible]/Branches & Project Offices
CA/D. K. Slayton
CB/F. Borman
J. A. McDivitt
W. M. Schirra
[illegible]/W. J. North
FA/C. C. Kraft, Jr.
FC/[illegible] F. [illegible]
[illegible] D. [illegible]
FM/J. P. Mayer
[illegible] Huss
[illegible]/[illegible] [illegible] [illegible]
[illegible]/[illegible] C. [illegible]
[illegible]/[illegible] [illegible] Williams
[illegible]/[illegible] H. [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible]/[illegible] [illegible] [illegible]
[illegible]/M. [illegible] von Ehrenfried
J. [illegible] [illegible]
[illegible]/[illegible] W. [illegible]

[illegible] 6-14-68

DAP Mass Properties Initialization Requirements

I. SUNDISK

A. Data Load - Pad load δ_{yp}, δ_{yy} (pitch and yaw trim angles) I_{xx}, $I_{AV} = (I_{yy} + I_{zz})/2$, and TL_x for the CSM configuration (in case of boost abort) via Routine 3. Ordinarily, the initial set of trim angles used in either the CSM or the CSM/LM configuration will be set to the expected center of gravity at the start of the first burn in that configuration.

B. Comment - The DAP inertia loads, I_{XX} and I_{AV}, permit the greatest RCS efficiency when they correspond to the actual CSM weights. These parameters may, however, be set prior to flight (for pilot convenience) to correspond to a single vehicle weight which does not seriously compromise RCS efficiency provided such a weight exists for a given mission. The values of the vehicle inertias noted are tracked by the SUNDISK Program during a DAP-controlled SPS burn, but are not retained by the program at the end of the burn. However, a second set of inertia values, input prior to the TVC burn, will be retained. Through this special feature of SUNDISK, end-of-burn inertias can be anticipated for post-burn DAP operation.

The values of the SPS trim angles, δ_{yp} and δ_{yy}, are also tracked by the SUNDISK Program during a DAP burn. They are, moreover, retained by the program at the end of the burn. These trim values will be on, or close to, the c.g., and should normally be taken as the trim setting for the next SPS burn if the vehicle configuration is not changed.

II. COLOSSUS

A. Data Load - Pad load the SPS trim angles, δ_{yp} and δ_{yy}, and the LM and CSM weights* via Routine 3. The initial trim angles are set for the CSM configuration in case of boost abort. Ordinarily, the initial trim angles used in either the CSM or the CSM/LM configuration are set to the expected center of gravity at the start of the first burn in that configuration.

B. Comment - The DAP mass parameters, I_{XX}, I_{AV}, and I_{AV}/TL_x are determined within the computer, from vehicle configuration weight inputs. These parameters and the SPS trim angles are tracked by the COLOSSUS Program during a DAP TVC burn**. Moreover, they are retained at the end of the burn for use in subsequent DAP RCS or TVC operation where the vehicle configuration is not changed. Also, the astronaut may use the final trim angles from the DAP for manual initialization of a subsequent SCS TVC burn. However, following an SCS TVC burn, the RCS DAP must be reinitialized with new weights, and the TVC DAP with both new weights and new trim angles, if DAP operation is to be resumed.

III. SUNDANCE/LUMINARY

A. Data load - Pad load the DPS pitch and roll trim angles, the LM and CSM weights*, by means of Routine 3. The DPS trim angles are set by Routine 3 after the operation of Routine 3 has been calibrated against telemetry read-outs of the GDA transducers. Ordinarily, the DPS trim angles will be set initially to the center of gravity of the vehicle configuration for which the first DPS burn is anticipated in a given mission.

B. Comment - In-flight checkout of the DPS gimbal drive actuators will drive the DPS away from any previously set position, e.g., a pad-set first-burn trim position. Following GDA checkout, the DPS is returned to its initial trim position or set to some new position by means of Routine 3. This position can be checked by ground-based telemetry prior to burn, if the vehicle is within MSFN line of sight prior to the first DPS burn. In such case, the telemetry monitor will know the position of the DPS with respect to the vehicle center of gravity better than the flight crew will know it, because (1) the GDA transducer outputs (which define the DPS position with respect to the LM X-axis) are observable by the telemetry monitor, whereas they are not displayed to the crew, (2) the mass history of the vehicle configuration is more closely accounted and tabulated on the ground than onboard.

The DAP mass parameters, I_{XX}, I_{YY}, I_{ZZ}, and L_X are determined within the computer from vehicle configuration weight inputs. These parameters are tracked by the SUNDANCE/LUMINARY DAP during a DPS or APS firing. During a DPS firing, the DPS trim angles are also tracked by the program, but, inasmuch as these angles are attained by a slow speed gimbal drive system, there is little assurance that the DPS gimbal angles existing at the end of a DPS firing are on, or close to, the vehicle c.g. The latter is especially true if maneuvers were made prior to cut off. Thus, the final DPS position following a burn would not necessarily be taken as trim position for the next DPS burn. (Good DPS trim at the initialization of a DPS burn is not ordinarily critical inasmuch as the engine is fired at low thrust before the throttle is advanced, allowing time for the DPS to be driven into or near trim.)

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: JUN 25 1968

68-PA-T-138A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: "C" Rendezvous W-Matrix

This memorandum is to inform everyone in writing that MIT has now agreed with MPAD that it is acceptable to use the same values of the W-Matrix when reinitializing (after three marks of the last batch of marks between NSR and TPI) as are used initially. That is, it is not necessary for the crew to punch new values into the DSKY - a clumsy procedure everyone wanted to delete if possible. I think Paul Pixley is to be commended for finally getting MIT's agreement to this crew procedure simplification.

The actual values to be used initially - that is, the pre-launch erasable load values - have not been finally agreed to yet, but that will not affect the crew procedures. Today's best guess is 1000 feet and 1 fps.

It is recommended that the flight crew and those responsible for documenting crew procedures, etc. adopt this mission techniques immediately. I have already told most of those concerned by the Don Ameche.

Howard W. Tindall, Jr.

Addressees:
(See list attached)

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: JUN 25 1968

68-PA-T-137A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: "D" Rendezvous Mission Techniques Ground Rules, Working Agreements, and other things

On June 14 we cranked up the "D" Rendezvous Mission Techniques activities again. It was a grueling profitable day. In fact, we had such a good time we've scheduled another one for July 12.

Prior to the meeting I distributed a list of working agreements I thought we had reached previously. The crew presented another list dealing primarily with the docked LM activation/mini-football period based on a lot of planning and simulations they have been doing lately. The major part of the meeting was spent going through these lists. I have since compiled a new set derived from those - including the changes, agreements, and comments the discussion brought about. This list is attached and we can review it July 12. The last section lists some major discussion items still open. A list of action items is also attached since they help to paint the picture of our current status, which I would describe as being typically frantic.

Howard W. Tindall, Jr.

Enclosures 3

Addressees:
(See list attached)

PA:HWTindall, Jr.:js

ATTENDEES

H. W. Tindall, Jr.	PA
J. A. McDivitt	CB
D. R. Scott	CB
A. L. Bean	CB
R. F. Gordon	CB
R. L. Schweickart	CB
E. E. Aldrin	CB
C. Conrad	CB
E. C. Lineberry	FM
C. W. Pace	FM
B. F. McCreary	FM
P. T. Pixley	FM
A. L. Accola	FM
L. D. Hartley	FM
A. Nathan	FM
J. B. Craven	FC
J. G. Renick	FC
W. E. Fenner	FC
H. D. Reed	FC
R. Holkan	FC
J. Neubaur	FC
E. E. Marzano	FC
J. Wegener	FC
H. K. Fanning	FC
C. T. Essmeier	FC
N. B. Hutchinson	FC
M. O. Kennedy	FC
M. C. Contella	CF
S. H. Gardner	CF
J. V. Rivers	CF
T. W. Holloway	CF
A. A. Jackson	CF
D. D. Traviss	CFK
D. K. Mosel	CF
S. Paddock	MDC
R. J. Boudreau	TRW
J. W. Wright	TRW
J. E. Scheppan	TRW
H. R. Klein	TRW
R. L. Baker	TRW
H. C. Woodring	NR
R. D. Lowenstein	Link/Sincom
J. L. Nevins	MIT/IL
P. M. Kachmar	MIT/IL
E. S. Muller	MIT/IL
R. A. Larson	MIT/IL

Enclosure 1

June 18, 1968

"D" MISSION RENDEZVOUS GROUND RULES WORKING AGREEMENTS AND THINGS LIKE THAT

1. General

a. The reference trajectory is that provided by MPAD dated June 7 1968.

b. Nomenclature for the burn sequence following undocking is:

(1) RCS Separation
(2) Phasing
(3) Insertion
(4) TPI_0 - If abort from football
(5) CSI_1
(6) CDH_1
(7) TPI_1 - If abort from 1st bubble
(8) CSI_2
(9) CDH_2
(10) TPI_2
(11) TPF

c. The rendezvous will be run throughout with the vehicle roll angles $\approx 0^\circ$. The only exception to this is the RCS Separation burn where the CSM roll is 180°. A 180° roll will be performed by the CSM immediately prior to or during the IMU alignment following the RCS Separation burn. (i.e., TPI from above will be initiated "heads down" and TPI from below will be initiated "heads up" for either vehicle.)

d. LM and CSM state vectors time tagged 12 minuted before RCS Separation are uplinked to the CMC and LGC prior to undocking. State vectors are not sent to either vehicle again until immediately after TPI_1, when the rendezvous navigation problem is reinitialized. At that time, state vectors are sent for both spacecraft and to both computers. IMU alignments will also be made at these points in the exercise and take precedence over the state vector updates if timeline conflicts develop.

e. On both spacecraft all rendezvous navigation will be carried out to update the LM state vector. That is, the LM radar data would be used to update the LM state vector in the LGC and the CSM sextant data would be used to update the LM state vector in the CMC.

f. The CMC's LM state vector will be updated after each LM maneuver with the R-32 Target ΔV routine using the preburn values as determined in the LM's pre-thrust program.

g. The AGS should be maintained in that state which makes it most useful to perform the rendezvous in the event of PGNCS failure. If, after having established the preferred techniques in accordance with that ground rule, it is possible to include some AGS systems tests without jeopardizing crew safety or other mission objectives, they would be considered.

h. The state vectors in the AGS will be updated each time PGNCS is confirmed to be acceptable. This will likely be at each time it is committed to make the next maneuver using the PGNCS except perhaps TPI.

i. AUC alignments will be made each time the PGNCS is realigned and each time the state vector in the AGS is updated from the PGNCS.

j. If PGNCS, RR, or G&N fails, the rendezvous is terminated at the next TPI opportunity.

k. The AGS is not mandatory for the rendezvous exercise. That is, if it fails prior to or during this mission phase, the exercise shall continue.

2. Prior to Undocking

a. The crew will synchronize the CMC clock as precisely as possible utilizing information voiced from the ground. The crew will provide initial synchronization of the LGC to the CMC clock. The ground will provide the necessary information by voice for fine synchronization of the LGC clock.

This supercedes the mission rule which specifies resynchronization of a spacecraft clock only whenever it disagrees with the ground reference by more than 0.5 seconds.

b. The LM Rendezvous REFSMMAT is that of a "nominal" alignment for T (align) = TIG (TPI_2). It will be uplinked from the ground.

c. The CSM Rendezvous REFSMMAT is defined by a stable member orientation where:

$\bar{X}$ CSM = $\bar{Z}$ LM

$\bar{Y}$ CSM = $\bar{Y}$ LM

Z CSM = $-\bar{X}$ LM

d. Prior to undocking, the CSM will maneuver the docked vehicles to an inertial attitude such that with no further attitude maneuvering the CSM will be oriented approximately 180, 0, 0 (roll, pitch, yaw) with respect to the local vertical frame at the time of the RCS Separation. The difference between the exact local vertical attitude and 180, 0, 0 is due to the regression of the line of nodes from TIG (RCS Separation) to TIG (TPI_2), and the fact that the CSM REFSMMAT is nominal at TPI_2.

e. Prior to undocking, but following the CSM attitude maneuver to RCS Separation attitude, the LM IMU will be aligned to the CM IMU using the docked alignment procedure which takes advantage of a known CSM inertial attitude and known CSM/LM geometry (with account of the docking ring angle $\Delta\phi$ being taken) to coarse align the LM IMU to the inertial frame. The CSM and LM gimbal angles are then compared directly (via V16N20) and coarse align and attitude dead banding errors are removed by direct torquing of the LM IMU gyros via the fine align routine (V41).

f. The formula used for docked alignment with identical REFSMMATS is:

$$OGA_{LM} = (300 - \Delta\phi) - OGA_{CM}$$
$$IGA_{LM} = IGA_{CM} + 180$$
$$MGA_{LM} = -MGA_{CM}$$

Where $\Delta\phi$ is the docking ring angle.

g. The formula used for docked alignment where the stable members are oriented:

$$X_{LM} = -Z_{CM}$$
$$Y_{LM} = Y_{CM}$$
$$Z_{LM} = X_{CM}$$

is:

$$OGA_{LM} = (300 - \Delta\phi) - OGA_{CM}$$
$$IGA_{LM} = IGA_{CM} + 90$$
$$MGA_{LM} = MGA_{CM} = 0$$

This is a special formula only valid where the CM MGA = 0. This set of equations will be used for the LM alignment prior to undocking.

3. <u>Undocking, station keeping and LM inspection</u>

a. Undocking will take place 15 minutes prior to the RCS Separation burn with the CSM oriented to the inertial attitude for that burn. Average G will not be on in either vehicle during the undocking or station keeping phase. This will preserve the relative state vectors until average G comes on in the CSM 30 seconds prior to RCS Separation.

b. Following undocking, the CSM will maintain attitude and will be responsible for station keeping. The LM will yaw right 120° and pitch up 90° placing the two spacecraft "nose-to-nose." (crewmen "nose-to-nose")

c. The LM will yaw through 360° (≈1°/sec) permitting the CSM to conduct a visual inspection of the landing gear and LM structure.

d. After completion of 3c, the LM assumes the station keeping task while the CSM prepares for RCS separation.

4. <u>RCS Separation and Mini-football</u>

a. The configuration of the spacecraft at the RCS Separation burn will be LM leading the CSM, both heads down facing each other with zero relative velocity. (Orbit rate FDAI's - LM: 0, 180, 0 - CSM: 180, 0, 0). (FDAI total attitude is read in the order roll, pitch, yaw; IMU gimbal angles are read in the order outer, inner, middle).

b. The CSM will execute a 1 FPS radial inward burn for the RCS Separation burn; i.e., the CSM will burn 1 FPS -Z (body). This burn will employ the P-30, P-41 sequence. LM uses R-32 to update CSM state vector in the LGC.

c. On entering darkness after the RCS Separation both spacecraft will perform REFSMMAT IMU alignments.

d. The LM COAS will be calibrated during the mini-football and will not be moved again after that.

5. <u>Phasing Maneuver</u>

a. Phasing targeting is established pre-flight.

b. The phasing burn will be executed under AGS control with PGNCS monitoring. The throttle will be set at 10% for 15 seconds at which time it will be advanced crisply to approximately 40% and left there til auto-cutoff. The PGNCS residual velocities will be burned to zero by use of programs 30 and 40.

c. The horizon is used as a burn attitude check prior to the phasing burn when AGS is under control. The ground supplies the LPD pitch angle for this check.

6. TPI$_0$

a. If PGNCS, rendezvous radar, or CSM G&N fails prior to insertion but after phasing, TPI$_0$ is performed. As a standard operating procedure during the football rendezvous, the LM and CSM should both be targeted and prepared to execute the TPI if an abort is necessary. If the failure is LM PGNCS, AGS is used for executing TPI. A 130° transfer angle shall be used for aborts from the football rendezvous. (See action item 5)

7. Insertion Maneuver

Preflight targeting will not be used for this maneuver. The ground procedures for determining the insertion maneuver are as follows: The MCC/RTCC will utilize the two-impulse logic (NCC/NSR combination) to achieve the proper differential altitude. The computed value of the NCC maneuver will be used as the insertion maneuver. The NSR will be forced to occur at apogee even if station coverage will not be available there for this (CDH$_1$) maneuver.

8. CSI$_{1,2}$ and CDH$_{1,2}$

a. As a nominal procedure, the command module will be targeted with "mirror image" maneuvers to be executed with a one minute time delay in the event the LM is unable to maneuver. Some biases will be added (See action item No. 4)

b. In the event the LM has performed an ullage maneuver prior to a main engine failure, the LM will remove that ΔV to maintain correct targeting of the CSM mirror image burn.

c. LM PGNCS ΔV solutions will be compared with the ground. If the solutions agree, the PGNCS solution will be burned. There will not be comparisons with AGS, charts, or CSM.

d. In the event the ground solution is to be used, it will be executed using the AGS which has been targeted with the MSFN solution as a standard procedure. The external ΔV mode is used.

e. No radar data shall be input into the AGS prior to CSI and CDH.

f. There will not be any backup charts used for $CSI_{1,2}$. The LM shall have backup charts for CDH and TPI. The command module pilot will be unable to compute onboard chart solutions for TPI due to the press of other activity and so they will not be available as a data source.

9. $\underline{TPI_{0,1,2}}$

a. If the LM PGNCS is working but rendezvous radar has failed, no external data will be input to the spacecraft systems----PGNCS, AGS or charts. In this case, the command module executes the TPI and subsequent midcourse correction maneuvers and the LM does the braking maneuver if visibility permits. However, the command module, of course, must compare the TPI solution with the MSFN and that comparison must be favorable. (If not, see 10b) The command module would voice relay to the LM the maneuvers it has executed in order that the LM crew could update the command module state vector in the LGC using the target ΔV program.

b. If the LM PGNCS has failed but the RR is working, compare the onboard chart solution for TPI with the MSFN. If the comparison is favorable, execute the chart solution and, if not, use the MSFN ΔV's executed at a time determined onboard the spacecraft. The maneuver would be made using the AGS external ΔV mode.

10. <u>For Discussion</u>

a. $\underline{CDH_{1,2}}$

If LM PGNCS/MSFN comparison shows disagreement, shall a LM chart/ MSFN comparison be made and used if favorable or shall the ground solution be burned regardless of the chart solutions?

b. If both RR and CSM G&N have failed, shall the LM perform TPI using chart solution or what?

c. G&CD has recommended in their memo, EG21-M-59-68-376, that the AGS be used in the following manner on the "D" Rendezvous:

(1) Align and initialize the AGS to the PGNCS after each PGNCS alignment.

(2) Perform AGS targeting for all real and pseudo-burns using the onboard solution. Execute the burns with PGNCS, unless PGNCS has failed.

(3) Perform an accelerometer calibration before each real and pseudo-burn.

(4) Perform gyro calibrations in sufficient number (at least four times over a two-hour period) to verify the technique.

(5) Perform at least one AOT or COAS alignment of the AGS, preferably AOT.

(6) Update the AGS with the RR near the second TPI burn.

(7) In the event of a PGNCS failure during the second rendezvous sequence, compare the AGS solutions with either charts or MSFN and execute the burns with the AGS if there is reasonable agreement. The AGS should be updated with the RR.

d. Review procedure and expected accuracy of the initial LM platform drift test made while docked to the CSM.

e. Review Mission Control Center/crew pad message formats.

June 18, 1968

"D" RENDEZVOUS MISSION TECHNIQUES
ACTION ITEM LIST
(To be discussed at next meeting)

1. FCSD and MPAD will provide for review an up-to-date rendezvous navigation tracking schedule for both the LM and CSM.

2. MPAD to present the pre-rendezvous maneuver ground rules and techniques to provide adequate lighting conditions and station coverage.

3. MPAD to report on analysis regarding modification of the RCS Separation burns to reduce probability of recontact due to small maneuver execution dispersions.

4. MPAD to report on which mirror image maneuvers need be biased as well as consequence of not doing so.

5. Crew will report results of simulator exercise regarding use of unstaged LM in terminal phase rendezvous.

6. FCD to report on techniques for checking the rendezvous radar during the mini-football and the football phase for purpose of go/no go.

7. MPAD to report consequences of using the MSFN uplinked PGNCS CSI/CDH targeting in the AGS for maneuver execution in the event of PGNCS failure. That is, are the errors thus incurred acceptable?

8. FCSD will define limits of acceptable TPI time slippage beyond which corrective action must be taken. Apparently, they will be based on CSM active rendezvous lighting constraints.

9. MPAD to establish acceptable difference limits for use in comparison of onboard vs MSFN rendezvous targeting (CSI, CDH, and TPI).

10. MIT to present recommended procedure for controlling the W-matrix by crew input to the LGC and CMC.

Enclosure 3

11. MPAD to report results of their survey into the onboard computation of CDH execution time which has been showing a tendency to be late. If this persists, it will result in TPI time slip, excess RCS ΔV costs, and difficulty in solution comparison.

12. FCD will report on acceptability of onboard PGNCS accelerometer bias determination while out of MSFN station coverage.

13. Rendezvous maneuver monitoring procedures will be reviewed for both critical and non-critical rendezvous phase burns. Attitude, attitude rate, and over and under speed limits will be established as well as the actions to be taken if they are exceeded. This, in effect, encompasses the procedures to be followed in the event of a partial burn.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS 77058

JUN 28 1968

68-PA-T-136A

THROUGH: NASA Resident Apollo Spacecraft Program Office
Massachusetts Institute of Technology
Instrumentation Laboratory
Cambridge, Massachusetts 02139

TO : Massachusetts Institute of Technology
Instrumentation Laboratory
Cambridge, Massachusetts 02139
Attn: D. G. Hoag, Director
Apollo Guidance & Navigation Program

FROM : Chief, Apollo Data Priority Coordination

At the June 14 "D" Rendezvous Mission Techniques meeting, I unofficially (I guess) assigned an action item to your people who were there. Specifically, we asked for MIT's recommended procedure for adjusting the W-matrix during rendezvous navigation in both the LGC and CMC. As a matter of fact, I understand that your people intend to discuss this with the "D" flight crew while they are there the week of June 17. However, I would appreciate it if you could write down the procedure you recommend in one of your informal MIT memos for discussion and incorporation into the mission techniques at our next meeting.

Incidentally, I think there was substantial benefit from having your people at our last meeting and hope they can come down for the next one, which is currently scheduled for July 12.

Howard W. Tindall, Jr.

Enclosure

"D" RENDEZVOUS MISSION TECHNIQUES
OPEN ITEM LIST

(To be discussed at next meeting)

1. G&CD has recommended in their memo, EG21-M-59-68-376, that the AGS be used in the following manner on the "D" Rendezvous:

   a. Align and initialize the AGS to the PGNCS after each PGNCS alignment.

   b. Perform AGS targeting for all real and pseudo-burns using the on-board solution. Execute the burns with PGNCS, unless PGNCS has failed.

   c. Perform an accelerometer calibration before each real and pseudo-burn.

   d. Perform gyro calibrations in sufficient n[illegible] (at least four times over a two-hour period) to verify th[illegible] technique.

   e. Perform at least one AOT or COAS alignment of the AGS, preferably AOT.

   f. Update the AGS with the RR near the second TPI burn.

   g. In the event of a PGNCS failure during the second rendezvous sequence, compare the AGS solutions with either charts or MSFN and execute the burns with the AGS if there is reasonable agreement. The AGS should be updated with the RR.

2. MPAD to present the pre-rendezvous ground rules and techniques to provide adequate lighting conditions and station coverage.

3. MPAD to report on analysis regarding modification to the RCS Separation burns to reduce probability of recontact due to small maneuver execution dispersions.

4. MPAD to report on which mirror image maneuvers need be biased as well as consequence of not doing so.

5. Crew will report results of simulator exercise regarding use of unstaged LM in terminal phase rendezvous.

Enclosure 1

6. FCD to report on techniques for checking the rendezvous radar during the mini-football and the football phase for purpose of go/no go.

7. MPAD to report consequences of using the MSFN uplinked PGNCS CSI/CDH targeting in the AGS for maneuver execution in the event of PGNCS failure. That is, are the errors thus incurred acceptable?

8. FCSD will define limits of acceptable TPI time slippage beyond which corrective action must be taken. Apparently, they will be based on CSM active rendezvous lighting constraints.

9. MPAD to establish acceptable difference limits for use in comparison of onboard vs MSFN rendezvous targeting (CSI, CDH, and TPI).

10. MIT to present recommended procedure for controlling the W-matrix by crew input to the LGC and CMC.

11. MPAD to report results of their survey into the onboard computation of CDH execution time which has been showing a tendency to be late. If this persists, it will result in TPI time slip, excess RCS ΔV costs, and difficulty in solution comparison.

12. FCD will report on acceptability of onboard PGNCS accelerometer bias determination while out of MSFN station coverage.

13. Rendezvous maneuver monitoring procedures will be reviewed for both critical and non-critical rendezvous phase burns. Attitude, attitude rate, and over and under speed limits will be established as well as the actions to be taken if they are exceeded. This, in effect, encompasses the procedures to be followed in the event of a partial burn.

14. Review procedure and expected accuracy of the initial LM platform drift test made while docked to the CSM.

15. FCSD and MPAD will provide for review an up-to-date rendezvous navigation tracking schedule for both the LM and CSM.

16. Review Mission Control Center/crew pad message format.

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: JUN 21 1968

68-PA-T-134A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Request to check some IMU alignment equations

The "D" mission flight crew has developed in detail the technique for aligning the LM platform while docked to the CSM which utilizes our knowledge of the relative alignment of the Nav bases on the CSM and LM. Part of the procedure is to establish the required LM IMU gimbal angles to be input into the LGC based on gimbal angles read-out of the CMC and the docking index reading. Rusty Schweickart derived the following equations for this purpose.

1. The formula used for docked alignment with identical REFSMMATS is:

$$OGA_{LM} = (300 - \Delta\phi) - OGA_{CM}$$
$$IGA_{LM} = IGA_{CM} + 180$$
$$MGA_{LM} = -MGA_{CM}$$

Where $\Delta\phi$ is the docking ring angle

2. The formula used for docked alignment where the stable members are oriented:

$$X_{LM} = -Z_{CM}$$
$$Y_{LM} = Y_{CM}$$
$$Z_{LM} = X_{CM}$$

is:

$$OGA_{LM} = (300 - \Delta\phi) - OGA_{CM}$$
$$IGA_{LM} = IGA_{CM} + 90$$
$$MGA_{LM} = MGA_{CM} = 0$$

This is a special case formula only valid where the CM MGA = 0. This set of equations will be used for the LM alignment prior to undocking.

We would very much appreciate it if you would have someone in your organization check these equations to assure they are correct and to report the results of their verification at our next "D" Rendezvous Mission Techniques meeting, currently scheduled for July 12 in Room 378 of Building 4.

Howard W. Tindall, Jr.

Addressees:
MIT/IL/Director, Apollo Guidance and Navigation Program
EG/Chief, Guidance and Control Division
FM4/Chief, Mathematical Physics Branch

cc:
FC/E. F. Kranz
CB/R. L. Schweickart

PA:HWTindall, Jr.:js

UNITED STATES GOVERNMENT

Memorandum

TO : FM13/Chief, Mission Planning Support Office

DATE: JUN 20 1968

68-PA-T-133A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: "D" Rendezvous Mission Techniques Task Assignments for MPAD

Attached is a list of action items associated with our work on "D" Rendezvous Mission Techniques. Would you please see that all these assigned to MPAD are covered by proper Task Assignments (I expect that most of them already are). Specifically, items 2, 3, 4, 7, 9, and 11 are probably OMAB's jobs and item 15 is probably MTB's. Some of the others may also benefit from MPAD attention. For example, item 13 may require some rendezvous trajectory considerations in establishing the limits. Please look it over. Chuck Pace was at our June 14 meeting and knows all about these. We'd like results for the next meeting - July 12 - if at all possible.

Howard W. Tindall, Jr.

Howard W. Tindall, Jr.

Enclosure

cc:
FM/J. P. Mayer
C. R. Huss
FM13/C. W. Pace
FM4/J. C. McPherson
FM6/E. C. Lineberry

PA:HWTindall, Jr.:js

"D" RENDEZVOUS MISSION TECHNIQUES
OPEN ITEM LIST

(To be discussed at next meeting)

1. G&CD has recommended in their memo, EG21-M-59-68-376, that the AGS be used in the following manner on the "D" Rendezvous:

   a. Align and initialize the AGS to the PGNCS after each PGNCS alignment.

   b. Perform AGS targeting for all real and pseudo-burns using the on-board solution. Execute the burns with PGNCS, unless PGNCS has failed.

   c. Perform an accelerometer calibration before each real and pseudo-burn.

   d. Perform gyro calibrations in sufficient number (at least four times over a two-hour period) to verify the technique.

   e. Perform at least one AOT or COAS alignment of the AGS, preferably AOT.

   f. Update the AGS with the RR near the second TPI burn.

   g. In the event of a PGNCS failure during the second rendezvous sequence, compare the AGS solutions with either charts or MSFN and execute the burns with the AGS if there is reasonable agreement. The AGS should be updated with the RR.

2. MPAD to present the pre-rendezvous ground rules and techniques to provide adequate lighting conditions and station coverage.

3. MPAD to report on analysis regarding modification to the RCS Separation burns to reduce probability of recontact due to small maneuver execution dispersions.

4. MPAD to report on which mirror image maneuvers need be biased as well as consequence of not doing so.

5. Crew will report results of simulator exercise regarding use of unstaged LM in terminal phase rendezvous.

Enclosure 1

6. FCD to report on techniques for checking the rendezvous radar during the mini-football and the football phase for purpose of go/no go.

7. MPAD to report consequences of using the MSFN uplinked PGNCS CSI/CDH targeting in the AGS for maneuver execution in the event of PGNCS failure. That is, are the errors thus incurred acceptable?

8. FCSD will define limits of acceptable TPI time slippage beyond which corrective action must be taken. Apparently, they will be based on CSM active rendezvous lighting constraints.

9. MPAD to establish acceptable difference limits for use in comparison of onboard vs MSFN rendezvous targeting (CSI, CDH, and TPI).

10. MIT to present recommended procedure for controlling the W-matrix by crew input to the LGC and CMC.

11. MPAD to report results of their survey into the onboard computation of CDH execution time which has been showing a tendency to be late. If this persists, it will result in TPI time slip, excess RCS ΔV costs, and difficulty in solution comparison.

12. FCD will report on acceptability of onboard PGNCS accelerometer bias determination while out of MSFN station coverage.

13. Rendezvous maneuver monitoring procedures will be reviewed for both critical and non-critical rendezvous phase burns. Attitude, attitude rate, and over and under speed limits will be established as well as the actions to be taken if they are exceeded. This, in effect, encompasses the procedures to be followed in the event of a partial burn.

14. Review procedure and expected accuracy of the initial LM platform drift test made while docked to the CSM.

15. FCSD and MPAD will provide for review an up-to-date rendezvous navigation tracking schedule for both the LM and CSM.

16. Review Mission Control Center/crew pad message format.

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: JUN 21 1968
68-PA-T-131A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Let's add a plane change into the lunar rendezvous timeline

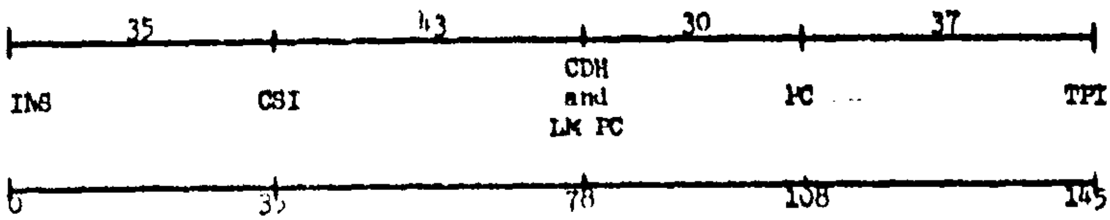
The June 13 Lunar Rendezvous Mission Techniques meeting was devoted to how to handle the plane change. As noted in my last bulletin, this problem had to be solved before we could do any meaningful work in the development of lunar rendezvous mission techniques. In my opinion a pretty good approach has been agreed to. It involves the addition of a new maneuver in the timeline, specifically, for cleaning up the out-of-plane situation. Although it is not certain, I expect this maneuver, which will occur at a fixed time - 30 minutes after CDH - will be performed by the CSM. It is almost mandatory to schedule this burn at a fixed time on such a short rendezvous as this in order to prevent it from interfering with the other maneuvers and the rendezvous navigation. However, as you know, unless it's controlled somehow, a plane change (i.e., the node) might naturally occur anywhere. Therefore, several other things also had to be settled to permit this particular approach. They are:

1. The LM shall burn whatever out-of-plane velocity is known to exist at the CDH time as part of the CDH maneuver. This will force a node 90° (i.e., about 30 minutes) later. Both the LM and the CSM have the onboard capability of computing this parameter using Routine 36, and the CM crew can input it into the CDH targeting. (The CSM will use the same routine to target its plane change 30 minutes later.)

2. In order to keep the out-of-plane component of the CDH maneuver within reasonable limits, it is necessary to set up a nominally in-plane situation at LM insertion. If this is done, the CDH out-of-plane will only be due to MSFN Ascent Targeting error and LM PGNCS dispersions during Ascent. These together are estimated to be no more than 35 fps which is approximately equal to the in-plane component. This means we shouldn't have a LM gimbal lock problem there.

3. There are two ways of doing this. Either the CSM must make a plane change prior to LM Ascent or if the required plane change is less than 50 fps, we can yaw steer the LM into the CSM plane during Ascent. That is, if the pre-Ascent plane change required is that small, we can probably simplify the operation by "dog legging" the LM Ascent and omitting the pre-Ascent CSM plane change.

4. TPI was scheduled to occur 20 minutes before darkness. However, in order to provide time for this extra maneuver, FCSD has agreed that TPI can be moved later. Their second preference is a good one - midpoint of darkness. This gives at least 67 minutes between CDH and TPI which makes the new plane change maneuver fit in nicely. The timeline looks like this now. (All the numbers are minutes.)



5. Note that we have moved CSI from 30 to 35 minutes after insertion and I've asked Ed Lineberry to see if we can move it even later. The pre-CSI timeline is quite crowded and if the LM has to do an IMU alignment after insertion, they will not get much rendezvous tracking in.

6. To do the plane change, the CSM (or LM) will have to reorient the IMU, probably by pulse torquing. In order to minimize the induced error which is proportional to the extent of the reorientation we should probably only move the platform the amount necessary to avoid gimbal lock - say 20 or 30 degrees. This would mean the crew will not have the FDAI ball at 0,0,0 for the burn.

7. If the CSM does the plane change, it may be preferable to omit all subsequent sextant tracking and to rely on VHF ranging only. With the new TPI time, there is likely to be some sun interference anyway and it sure simplifies the CSM pilot's task.

At the next meeting we'll pin down which vehicle should make the plane change, review the rendezvous navigation tracking schedule for both vehicles, and begin to fill in the details.

Howard W. Tindall, Jr.

Enclosure
List of Attendees

Addressees:
(See list attached)

PA:HWTindall, Jr.:js

ATTENDEES

Howard W. Tindall, Jr.	PA
E. C. Lineberry	FM
J. Shreffler	FM
R. T. Savely	FM
P. T. Pixley	FM
O. C. Guthrie	FC
W. G. Weppner	FC
L. J. Riche	CF
M. C. Contella	CF
K. Baker	TRW
J. W. Wright	TRW
H. Klein	TRW
J. E. Scheppan	TRW
W. O. Covington	Bellcomm
W. T. Misinl	McDonnell

Enclosure 1

UNITED STATES GOVERNMENT

Memorandum

TO : FC/Acting Chief, Flight Control Division

DATE: JUN 18 1968

68-PA-T-130A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Can some pre-DOI activity be moved to pre-LOI?

As you are no doubt aware, the crew timeline just prior to Descent Orbit Insertion (DOI) is terrible. This period of activity has grown almost to the point of being unacceptable. This is due to the extensive LM checkout - particularly that requiring telemetry coverage - which unfortunately conflicts with other activities such as making landing site observations.

Pete Conrad had a suggestion the other day which your people are probably in the best position to evaluate. It was his opinion that a lot of the LM checkout could be done prior to Lunar Orbit Insertion (LOI). One thing that makes this attractive is the continuous telemetry coverage we still have at that time. In any case, I would like to suggest that you have your people look into how much of the LM activation and checkout could be done at that time in order to relieve our serious pre-DOI situation.

Howard W. Tindall, Jr.

cc:
CB/C. Conrad
CF34/T. Guillory
PM4/A. Cohen
FA/C. C. Kraft, Jr.
FC4/J. E. Hannigan
FC4/R. L. Carlton
FC4/J. B. Craven
FM/C. R. Huss

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

NASA - Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: JUN 18 1968

68-FM-T-129

FROM : FM/Deputy Chief

SUBJECT: EMS will always be used on "C" if G&N fails

Mr. C. C. Kraft announced at his Monday morning meeting that the EMS will be used for controlling reentry on the "C" mission in the event of a G&N failure regardless of when that failure occurs. This was decided over his mild objection at George Low's CCB meeting last week.

Howard W. Tindall, Jr.

Addressees:
FM/J. P. Mayer
C. R. Huss
FM12/R. R. Ritz
FM13/R. P. Parten
J. R. Gurley
E. D. Murrah
A. Nathan
FM3/M. Collins
FM4/P. T. Pixley
R. T. Savely
FM5/R. E. Ernull
H. D. Beck
FM6/R. R. Regelbrugge
K. A. Young
FM7/S. P. Mann
R. O. Nobles
FM/Branch Chiefs

FM:HWTindall, Jr.:js

APOLLO DATA PRIORITY COORDINATION

MEETING SCHEDULE

AS OF June 18, 1968

68-PA-T-127A

	June										July									
SUBJECT OF MEETING	24	25	26	27	28	1	2	3	4	5	8	9	10	11	12	15	16	17	18	19
Descent Phase					█															
Midcourse Phase			▀	█									▀							
"D" Rendezvous															█					
Ascent Phase								▀						█				▀		
"G" Rendezvous			▄										▄							
101 Retrofire and Reentry																				
Lunar Reentry																				
"E" Rendezvous																				
Data Select							▀										▀			
SPECIAL MEETINGS																				
				*	*									*	*					

▀ Meeting begins at 9:00 a.m.

▄ Meeting begins at 1:00 p.m.

It is anticipated that a DRAFT of the Ascent Mission Mission Techniques Document will be ready for distribution by July 1. It will cover the period on the lunar surface from Touch down to liftoff. The big review is scheduled for July 11 as shown.

* Room 378, Building 4

Howard W. Tindall, Jr.

MSC FORM 1205 (FEB 68)

UNITED STATES GOVERNMENT

Memorandum

TO : PA/Manager, Apollo Spacecraft Program Office

DATE: JUN 14 1968

68-PA-T-125A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Apollo Crew Safety Review - Action Item No. 12

This memo is in reply to PA/GA-M172, dated May 13, 1968, in which you requested that I evaluate action item No. 12 and submit recommendations for review and implementation. Specifically, the item was:

> "An evaluation of the acceptability of pre-retro fire procedures considering eliminating any excess crew activity just prior to retro fire."

I have discussed this item with the Chairman of the Apollo Crew Safety Review Board, Mr. John D. Hodge, on several occasions and it is my understanding that they no longer consider this an area of concern. In fact, Mr. Hodge informs me that they deleted this action item prior to their presentation to General Phillips on May 28. The specific thing they were concerned about was that crew procedures required one of the crew to be in the lower equipment bay shortly before retrofire for final IMU alignment and spacecraft attitude checks. This activity is not mandatory and is left to the spacecraft Commander's discretion as to what will be done. It is anticipated that substantial experience will be available to the crew prior to the retrofire maneuver, which will permit them to determine time required for crew movement and task completion. If there is any question at all of running out of time, the activity will, of course, be deleted or terminated. This has been discussed with those responsible for developing crew procedures as well as the "C" mission flight controllers and I believe is understood by all.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27
5010-107

UNITED STATES GOVERNMENT

Memorandum

TO : PA/Manager, Apollo Spacecraft Program Office

DATE: JUN 1 2 1968

68-PA-T-124A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: "D" mission launch window is nice

This note is in follow-up to our "D" mission launch window discussion during our Tuesday morning meeting. Essentially, the situation is as I understood it to be at that time. Real time procedures can be and are being established to provide a launch window about two and three-quarters hours long by using the earlier propulsion and guidance systems tests to insure acceptable lighting and network coverage during the rendezvous. Incidentally, the launch window opens at 1500 GMT (10 a.m. EST). I checked with the mission plan guys and they know of no other activities more constraining than the rendezvous on the launch window. Furthermore, they never heard of any five minute window. That must be a Washington rumor.

I have attached a memo describing the technique in more detail, if you are interested. It should be simple to handle in real time and does not degrade the system tests. No special programs or displays are needed in the Mission Control Center to do this job. Over and out.

Howard W. Tindall, Jr.

Enclosures 2

PA:HWTindall, Jr.:js

NASA Manned Spacecraft Center
Houston, Texas
January 9, 19[illegible]

APOLLO PROGRAM

ABSTRACT OF MEETING

ON

RENDEZVOUS FOR MISSION "D"

DATA PRIORITY PANEL

January [illegible], 19[illegible], at Manned Spacecraft Center, Houston, Texas.

This abstract records what I think happened at our first Mission "D" Rendezvous Data Priority meeting. As I look over my notes I am impressed with how little we accomplished, but with how many questions we thought up requiring resolution.

1. It was apparent that mission planning for the rendezvous exercise on the "D" mission has been carefully iterated such that the nominal plan satisfies all lighting constraints and provides station coverage for each of the major maneuvers. Both of these characteristics have been designated as mandatory for all practical purposes. The first question that arose was "What procedures and associated MCC systems implementation have been provided to assure having these characteristics during the actual operation? Remember, the rendezvous takes place in the fourth day of the flight during which it is almost certain dispersions will have caused conditions to have deviated substantially from nominal. It is also evident that delayed lift off can contribute substantial changes in the situation too. As of this time nothing had been done to handle this operational task, and Mr. Morris Jenkins and Mr. Ed Lineberry took the action item of establishing suitable procedures utilizing the spacecraft maneuvers during the earlier phases of the mission to insure that all mandatory characteristics would be provided during the rendezvous exercise. This will likely turn into a formidable job in real time. Also, it may impose a limit on the acceptable launch window.

2. The next question dealt with how the LM platform was to be aligned prior to this operation. Currently, it is assumed that it must be done during [illegible] and it is proposed that it be done while the LM is docked to the spacecraft with the command module controlling attitude in wide deadband. The MCC Guidance Officer took the action item of insuring that the MCC/RTCC is prepared to supply to the crew during the operation the required CSM attitude such that the AOT would be pointed toward the necessary alignment stars.

Enclosure 1

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

UNITED STATES GOVERNMENT

Memorandum

NASA - Manned Spacecraft Center
Mission Planning & Analysis Division

TO : Informal Distribution

DATE: MAY 27 1968

FROM : FM6/Orbital Mission Analysis Branch

68-FM64-171

SUBJECT: Extension of the Apollo Mission D (CSM-103/LM-3) launch window using the SPS/DPS ΔV capability

References

1. Conway, H. L.; Merriam, R. S.; Spurlin, H. O.; Calvin, C.: MSC Internal Note 68-FM-93 entitled, "Apollo Mission D (AS-503/CSM-103/LM-3) Spacecraft Reference Trajectory, Volume I - Nominal Trajectory", dated April 30, 1968.

2. Rose, R. G.: MSC memorandum entitled, "Ninth Mission D Flight Operations Plan (FOP) Meeting", dated April 18, 1968.

Summary

A study was conducted to determine the ΔV capability of the SPS/DPS to perform nodal shift and phasing maneuvers so that the launch window for Apollo Mission D could be extended. The results show that the launch window can be extended to approximately 2.75 hours provided the second SPS, third SPS, the docked DPS, and an additional 450 fps SPS burn are designed nominally to optimumly shift the line of nodes eastward. Following the nodal shifts, a series of phasing maneuvers (nominally zero for on-time launches) would be then required to complete the launch window extension. Operational considerations (such as non-optimum geographical burn locations to provide MSFN coverage) will prevent full realization of the nodal shift capability; and, as a result, the launch window of 2.75 hours theoretically possible may not be achieved. Redesign of the ΔV maneuvers from that of reference 1 will have no impact on test objectives. The data and analysis leading to these conclusions are discussed in this memorandum.

Discussion

To satisfy requests contained in reference 2, a study was conducted to determine the maximum launch window considering only the ΔV capability of the SPS/DPS to return a vehicle delayed at launch to the nominal lighting and MSFN coverage for the LM-active rendezvous (defined in reference 1). The launch window for the D Mission Reference Trajectory published in reference 1 is less than 1 hour.

Enclosure 2

The information in this paper is unedited and is not official FOD or MPAD information. It is released to provide rapid circulation and may later be incorporated in a formal paper.

There are basically two methods under consideration by which MSFN coverage and lighting requirements during the rendezvous may be satisfied in the event of a launch delay. The first method is to adjust the time from CDH to TPI by small changes in the differential heights during the concentric coasts of LM-active rendezvous. A study of this technique is currently underway. The second method, which is the subject of this memorandum, is to "rendezvous" the CSM/LM vehicle which may be lifting off late with an imaginary vehicle which lifts off at the nominal time and executes all nominal maneuvers. If the launch delay is long enough (over 15 minutes) then phasing maneuvers (apogee and/or perigee adjustments) alone may not reestablish nominal lighting and coverage since out-of-planeness arises due to earth rotation. A nodal shift is then also required, the magnitude of which is directly proportional to the rotation of the earth during the delay period.

Nodal Shift Requirements

The nodal shift required is due to the orbital plane of a vehicle launched on time becoming fixed at insertion (neglecting apsidal advancement and nodal regression) while the orbital plane of the delayed vehicle has an eastward shift in the line of nodes equal to the amount of earth's rotation during the delay period. The ΔV required for a nodal correction $\Delta\Omega$ is given in the following equation:

$$\Delta V = 2V_X \cos \gamma_X \sin \frac{\Delta\Omega}{2} \sin i$$

where V_X, is the inertial velocity at transfer, ft/sec

γ_X, is the flight path angle at transfer, degrees

$\Delta\Omega$, is the nodal shift required, degrees

i, is the orbital inclination, degrees

For example, from reference 1, if V_X = 25771 fps (130 n. mi. circular orbit), i = 30°, cos γ_X = 1, and if $\Delta\Omega$ = 1°, the ΔV required from equation 1 is 240 fps/deg. The total ΔV available in the D Mission which might practically be used for nodal shifts amounts to 5050 fps as shown in Tables 1 and 2. The 5050 fps represents the ΔV from the second SPS, third SPS, the docked DPS and a 450 fps SPS burn available from presently unused SPS propellant. If used optimumly it will provide a total of about 21.4 degrees of nodal shift.

In actual flight operations, consideration must be given to locating the SPS burns over MSFN stations (thus not necessarily at maximum Northerly or Southerly latitudes) and as a result the 21.4 degrees of nodal shift represents a theoretical value with 20.0 degrees being an operationally more realistic value. Thus, figure 1 shows that if the 5050 fps are nominally used to shift the line of nodes eastward then as the launch delay increases (the vehicle rests on the pad for an increasing period of time as the earth rotates at approximately 15 degrees/hour) the ΔV required to shift the plane of the delayed vehicle back to nominal decreases. At about 86 minutes of delay, no nodal shift would be required as shown in figure 1; in this case, the SPS burns required to reduce the CSM mass and accomplish the CSM autopilot test objectives, would be designed so as not to shift the line of node. Delays of over 86 minutes will require shifting the node westward. The magnitude of the shift westward increases until about 2 3/4 hours of delay when the available ΔV for nodal shifts is exceeded. Thus, the launch window for the Apollo Mission D would be 2 3/4 hours. Although such factors as lighting for end of mission and MODE IV aborts also influence the length of the launch window, preliminary studies indicate that the ΔV capability to adjust coverage and lighting for the rendezvous is the most constraining and the other launch window constraints serve only to establish a rather wide 6 hour period in which launch could occur.

Phasing Requirements

After correcting the nodal differences between the orbits of a "phantom" vehicle launched on time and a delayed vehicle, the two vehicles are basically in the same orbital plane although not in the same position in the orbit. To correct lighting and coverage, this position difference must be eliminated, and this is accomplished with a series of phasing maneuvers (apogee and/or perigee adjustments to change the orbital period).

Figure 2 illustrates a typical problem which might be encountered in a launch delay. Figure 2 deals with a phasing situation in which the launch delay is about 30 minutes and thus the on-time vehicle is about 120 degrees ahead of the delayed vehicle (the phase angle increasing at about 4 degrees per minute, for a orbital period of approximately 90 minutes).

Two choices are available to the maneuvering (delayed) vehicle once the nodal differential is corrected (Figure 1a and 1b). The first choice is to maneuver to a higher apogee orbit (greater period) and "dwell" for a sufficient time to allow the on-time vehicle to catch up 240°. The second choice is to reduce the apogee altitude and catch up 120° with the on-time vehicle. The problem is now reduced to simply making the proper choice based on minimizing the ΔV expended or the orbit change required.

Figure 3 shows the apogee (or perigee) adjustment (Δh) required for the maneuvering vehicle to catch up ("go below") or to dwell ("go above"). The magnitude of Δh is approximated by the following relation:

$$\Delta P = 1/50\ (\Delta h)\ (n)$$

where

ΔP is the delay time in minutes

Δh is the apogee or perigee adjustment required in n. mi.

n is the number of orbits over which the phasing interval is desired

In the D Mission, n is dictated by operational considerations and thus the Δh is determined as a function of n from figure 3. In the example,

Assuming n = 20 then Δh to go above is 150 n. mi. and the Δh to go below is 75 n. mi. The best choice of Δh in this case is Δh = 75 n. mi. provided low perigee problems do not exist (see figure 2c).

Revision of the D Mission

To extend the launch window the SPS/DPS burns in reference 1 must be redesigned in both orientation and duration and plans drawn up to accomodate launch delays up to 2.75 hours. Studies are now in progress to identify the operational problems associated with implementing the burn schedule, and reference 1 is currently being updated.

Conclusion

Using the SPS/DPS ΔV capability the D Mission launch window can be extended to nearly 2.75 hours. The extension can be accomplished by a series of nodal shifts and phasing burns which must be incorporated into the operational trajectory planning.

Harold O. Spurlin

Harold L. Conway

Enclosures 3

THE: 2L8

Distribution:
TJW/L. P. Johnson (3)
FM/J. P. Mayer
H. W. Tindall
C. R. Huss
R. P. Parten
R. R. Ritz
Branch Chiefs
C. Pace
HOS/HLC:bh

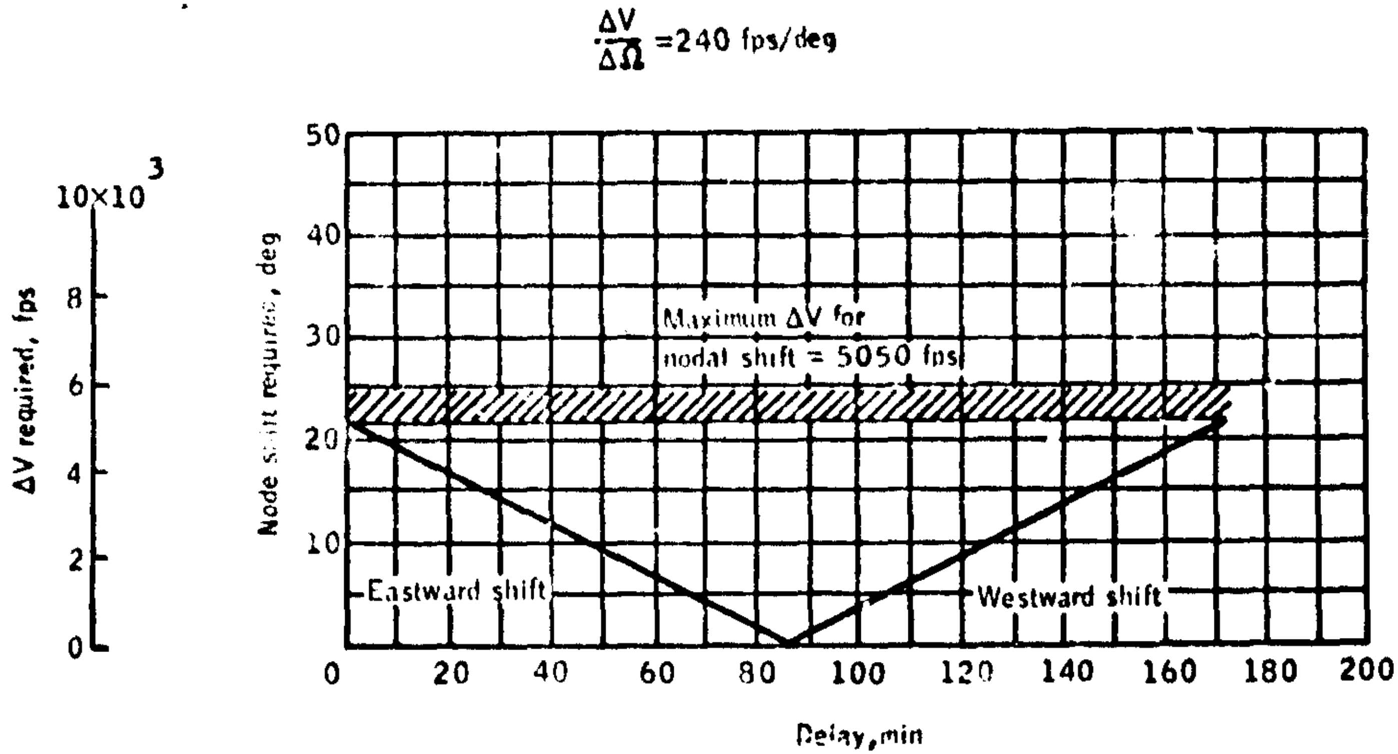
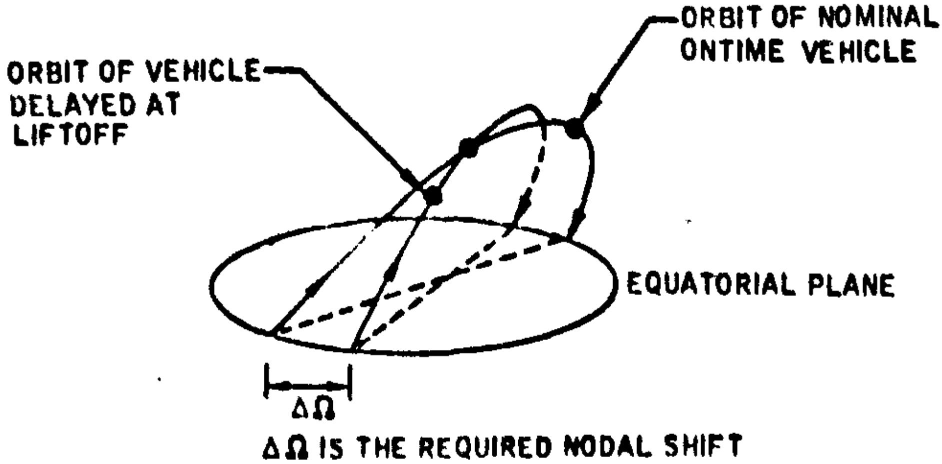
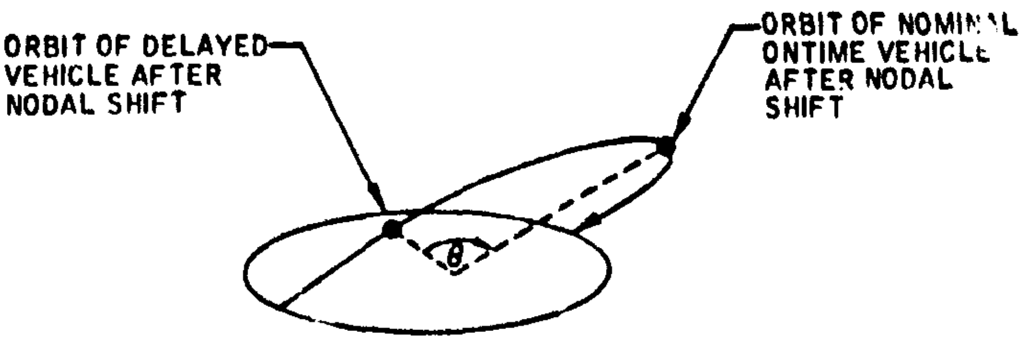


Figure 1.- Nodal shift ΔV requirements as a function of launch delay.



(a) NODAL (ΔΩ) AND PHASE DIFFERENTIAL AT DELAYED VEHICLE INSERTION.



(b) PHASE DIFFERENCE (θ) AFTER NODAL CORRECTION

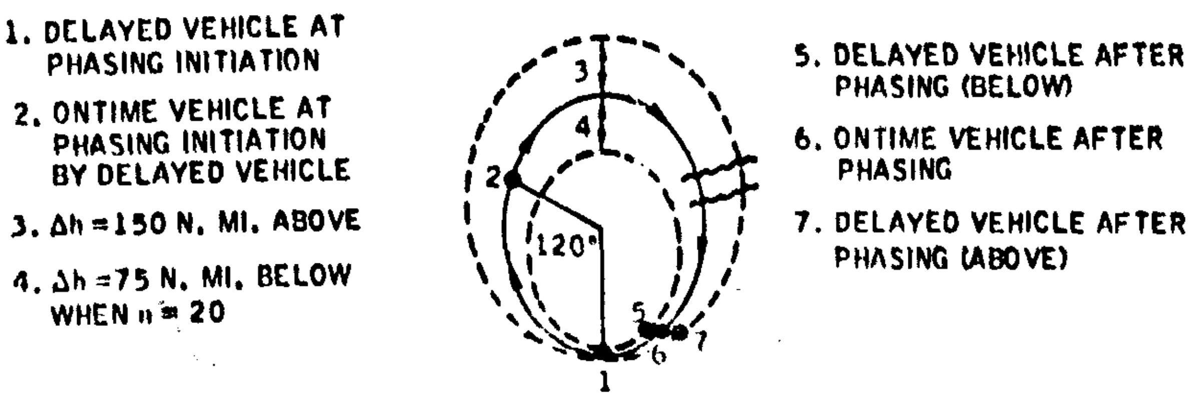


Figure 2. - Nodal and phasing maneuvers.

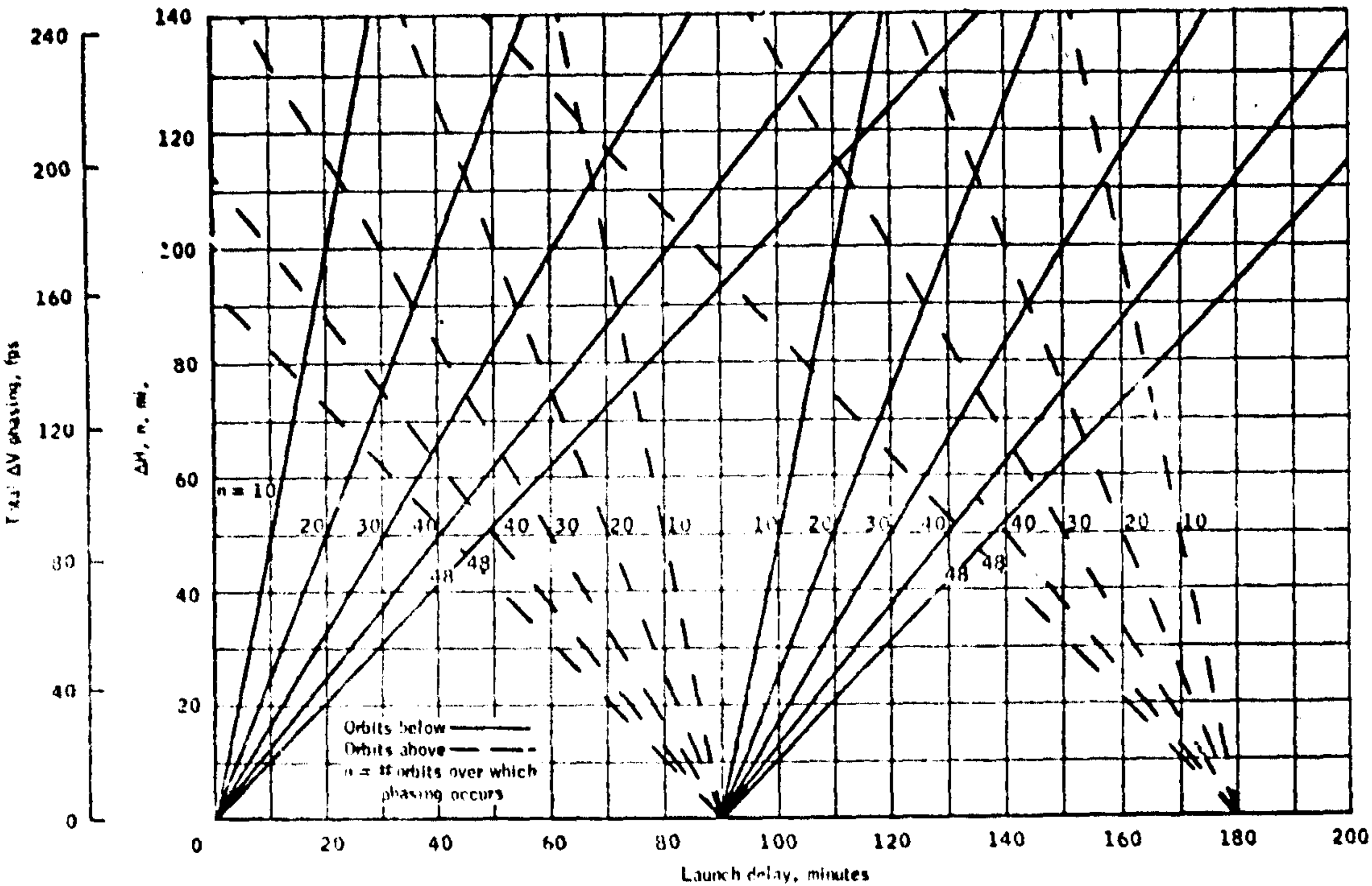


Figure 3.- Differential height required for phasing as a function of launch delay.

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27
5010-107

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: JUN 1 ^ 1968

68-FM-T-123

FROM : FM/Deputy Chief

SUBJECT: Results of the June 11 Apollo Software Configuration Control Board (ASCCB) meeting

1. Today's meeting was short and sweet - nothing particularly controversial. It started out with a discussion of the Stage Verify discrete. As noted in my last memo on this subject, program changes have been approved for Luminary such that the LGC completely ignores the Stage Verify discrete. Apparently we have generated enough concern that some wiring changes may be made in the LM's using Sundance to make the circuit interrupt redundant. This should help insure getting this discrete which is needed and used by Sundance.

2. Although Dave Hoag (MIT) could not present a particularly strong argument for approving PCN-173, it seemed easier to leave this capability in Luminary and Colossus than to delete it. The capability I am referring to is an extended Verb which permits DSKY display of RMS position and velocity error computed from the W-matrix. We are assured that it has been coded in such a way that it can be easily removed if we find we need the 90 words of memory it consumes.

3. GCD personnel expressed a concern regarding the stroking test program. Specifically, they feel it highly desirable to provide a Verb to terminate the excitation and also want to change the restart protection such that in the event of a restart, the stroking test is terminated. The only alternative to this would be procedural, namely to switch from G&N to SCS and then back again if troubles are encountered. Of course, you could always turn off the engine, but that is considered undesirable if it could be avoided.

4. FCSD submitted a new PCR (No. 205), duplicating one the board disapproved about three months ago which would have provided the DSKY display of raw rendezvous radar data. Of course, it's too late for Sundance, but MIT was requested to advise us of the Luminary impact if they implement this in the simpliest possible way. That is, eliminate from the basic request the radar angle display, the automatic update feature, reduce the number of programs that can be operating during this display, etc. If the impact is unacceptable, this change will be considered further for Luminary #2.

5. PCR 203 is also an FCSD request to provide Saturn takeover at max-Q. MIT's estimate of schedule impact is five days on Colossus. Since it is not a mandatory requirement, this program change is also going in the post Colossus hopper.

6. As you already know, a meeting is scheduled for Monday, June 24 to discuss follow-on spacecraft programs. This is an important one if you have changes you want made. The recommendations coming from that meeting will be carried to the next ASCCB meeting currently scheduled for June 25. The next Joint MSC/MIT Program Development Planning meeting has apparently now slipped to the second week of July, if you are interested.

Howard W. Tindall, Jr.

Addressees:
FM/J. P. Mayer
C. R. Huss
FM13/R. P. Parten
J. R. Gurley
E. D. Murrah
A. Nathan
FM2/M. Collins
FM4/P. T. Pixley
R. T. Savely
FM5/R. E. Ernull
H. D. Beck
FM6/R. R. Regelbrugge
K. A. Young
FM7/S. P. Mann
R. O. Nobles
FM/Branch Chiefs

FM:HWTindall, Jr.:js

APOLLO DATA PRIORITY COORDINATION

MEETING SCHEDULE

AS OF June 11, 1968

68-PA-T-121A

	June										July									
SUBJECT OF MEETING	17	18	19	20	21	24	25	26	27	28	1	2	[illegible]	4	5	8	9	10	11	12
Descent Phase										█										
Midcourse Phase								▀	█									▀		
"D" Rendezvous																				
Ascent Phase			▀										▀						█	
"G" Rendezvous								▄										▄		
101 Retrofire and Reentry																				
Lunar Reentry				▀																
"E" Rendezvous																				
Data Select		▀										▀								
SPECIAL MEETINGS																				

▀ Meeting begins at 9:00 a.m.

▄ Meeting begins at 1:00 p.m.

Note: The G Rendezvous meeting scheduled June 12 (pm) is being moved to June 13 (am). The Midcourse Phase meeting scheduled for June 12 (am) is being moved to June 13 (pm).

Howard W. Tindall, Jr.

MSC FORM 1705 (FEB 68)

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: JUN 7 1968

68-PA-T-119A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Some alternate ways of figuring out where the LM is on the moon will be available

For some months we have been concerned with the problem of determining the LM's location after its landing on the lunar surface. This information is essential in order to do a decent job of Ascent targeting and, in fact, a significant error can even influence crew safety. Primary modes already implemented in the Control Center/RTCC for determining LM location utilize observations of the LM with the CSM sextant and/or observation of the CSM with the LM rendezvous radar. In each case, these observations are combined with a knowledge of CSM location as determined by the MSFN to permit locating the LM. Another rather simple technique we have developed essentially uses procedures and computer programs already available to do the job in the same way a sailor at sea does. That is, we are able to determine the LM's location on the moon quite accurately by making an AOT platform alignment using the stars and by doing a gravity alignment which in effect establishes direction of local gravity and by then combining the information obtained. MPAD is in the process of formulating the equations to provide this capability in the RTCC and Charley Parker of the Flight Control Division will submit a request for the RTCC program change through the regular channels. We will also initiate a PCR to implement something similar in the Luminary computer program if it's as easy to do as we expect.

This not only gives a completely independent means (i.e., data source) for doing this job which is valuable for cross checking the prime techniques, but it also could become the prime mode under certain circumstances. For example, if it is necessary to abort one CSM revolution after landing, we would likely use this technique for determining LM location to target Ascent, since by that time neither sextant nor rendezvous radar data will be available to do the job.

Howard W. Tindall, Jr.

Addressees:
(See list attached)

PA:HWTindall, Jr.:js

UNITED STATES GOVERNMENT

Memorandum

TO : FM6/Chief, Rendezvous Analysis Branch

DATE: JUN 6 1968

68-PA-T-116A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: DPS Modeling

It might be worthwhile for you or your people to look into the DPS modeling in the RTCC. The "D" mission includes several maneuvers with manual throttling. Improper modeling of these burns may have some effect on the operation, although, offhand I would not think so.

Howard W. Tindall, Jr.

cc:
FC5/H. D. Reed
FM3/C. W. Pace
FM7/S. P. Mann

PA:HWTindall, Jr.:js

APOLLO DATA PRIORITY COORDINATION

MEETING SCHEDULE

AS OF June 4, 1968

68-PA-T-115A

SUBJECT OF MEETING	JUNE 10	11	12	13	14	17	18	19	20	21	24	25	26	27	28	JULY 1	2	3	4	5
Descent Phase															■					
Midcourse Phase			■										■	■						
"D" Rendezvous					■															
Ascent Phase								■										■		
"G" Rendezvous			■										■							
101 Retrofire and Reentry																				
Lunar Reentry									■											
"E" Rendezvous																				
Data Select							■										■			
SPECIAL MEETINGS																				

Meeting begins at 9:00 a.m.

Meeting begins at 1:00 p.m.

Howard W. Tindall, Jr.

MSC FORM 1209 (FEB 68)

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: JUN 3 1968

68-PA-T-11AA

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Lunar Rendezvous Mission Techniques

1. On May 28 we finally kicked off the Lunar Rendezvous Mission Techniques business.. Because of the imminence of missions "D" and "E", we started on those first some months ago. Now I wish we hadn't because they are so darned complicated. I have a feeling the lunar rendezvous can be finished up quicker than they can and, of course, some of the things we are planning to do in the lunar operation should influence how to go on the development flights.

2. This meeting was devoted to establishing some ground rules upon which we can base our work as well as making a cursory survey of anticipated problem areas requiring special attention. This memo will do little more than list these items. Some of the assumptions are debatable, of course, and if ultimately proven wrong, will require changing some things. However, we have got to get started somewhere.

3. The following is a list of the ground rules we established:

a. Assume Luminary (the LM spacecraft computer program) will remain as designed today for the lunar missions.

b. Assume Colossus (the command module spacecraft computer program) will be the same as designed today, plus the addition of the CSI and CDH rendezvous targeting programs and the addition of IMU pulse torquing.

c. Assume the VHF ranging device on the command module is operational.

d. Assume the "G" mission lunar rendezvous operation is as currently planned. That is, it should be completed within approximately one revolution. The coelliptic differential altitude is 15 n.m. and the terminal phase transfer angle is 130°.

e. Assume LM liftoff shall be on-time only. That is, there is no launch window.

f. Assume MSFN rendezvous assistance (that is, participation) is minimal as long as the situation remains essentially nominal.

g. Assume all in-orbit LM maneuvers will be made with the RCS propulsion system.

h. Assume both spacecraft will update the LM state vector based on their rendezvous navigation.

i. Assume that if an out-of-plane situation exists after LM ascent, all necessary maneuvers will be made prior to TPI to establish an in-plane rendezvous situation during terminal phase.

j. Assume all plane change maneuver targeting to be executed by either vehicle will be done by the CSM based on its sextant tracking.

4. The following is a list of problem areas, some large and some rather trivial for which we must seek answers:

a. By far the most significant is the problem of how to handle the out-of-plane situation. More on this later in the memo.

b. What is the source of the LM state vector in the command module computer after LM insertion?

c. Should frequent VHF range ambiguity tests be made by the crew as a standard procedure?

d. Should we include onboard determination of radar angle bias in the PGNCS?

e. Should rendezvous radar data be input to the AGS?

f. Should in-orbit platform alignments be performed by either spacecraft after LM insertion into orbit?

g. Should the CSM be targeted for a Holmann Transfer to protect against a low LM insertion orbit as a standard (that is, nominal) procedure?

5. I believe for the first time the question of how to handle the out-of-plane situation on the lunar rendezvous is being attacked. Primarily as a result of our beloved three gimbal platform (choke) any difference in the LM and CSM orbital planes becomes difficult to handle. Current estimates of MSFN targeting uncertainty for the LM ascent plus LM PGNCS errors during ascent assure us that an out-of-plane situation will exist. Therefore, a basic question to be resolved is - should we plan as a nominal procedure in the timeline to make a maneuver specifically for getting the two vehicles into the same plane. The alternate, of course, is somehow to pick up pieces of the out-of-plane by incorporating out-of-plane components into the CSI/CDH/TPI burns as much as we can and

then take care of the rest of it in the terminal phase midcourse maneuvers. Most of us are inclined to think we should provide a special maneuver probably using the command module. Of course, this idea immediately leads to another, namely why not eliminate the command module plane change prior to LM ascent and incorporate both that and the dispersions picked up during ascent into a single burn performed after sufficient in-orbit rendezvous navigation to determine the actual situation. There is a sort of philosophical question here since if everything worked perfectly, no post-ascent plane change would be required if we made the CSM maneuver before ascent. It was the opinion of the majority, I think, that we would be naive to think that everything will work perfectly. Some of the basic questions to be answered in order to make this important decision deal with its effect on rendezvous navigation and the impact of an extra maneuver on the timeline. For example:

a. How does this effect rendezvous radar navigation?

b. How does this effect VHF rendezvous navigation?

c. If we pulse torque the platforms, will that introduce unacceptable errors in the rendezvous?

d. What platform orientation should be used in the CSM before and after the plane change?

e. How does this effect the command module mirror image maneuver targeting?

f. What is the maximum plane change delta V which can be left until terminal phase? (This also has implications on RCS delta V residual trimming and possible use of SPS only.)

g. Should the out-of-plane maneuver be made at its natural node or should two burns be planned instead?

h. Should we plan any out-of-plane yaw steering during ascent?

i. One important matter which Ed Lineberry will discuss with Milton Contella (FCSD) prior to the next meeting regards selection of optimum TPI time, currently set at 20 minutes before darkness. The question is how undesirable from a lighting standpoint is it to move nominal TPI time later - perhaps even to midpoint of darkness - in order to give more time in the rendezvous sequence to perform the plane change maneuvers.

6. Well, there are a lot of questions and few answers. As I noted previously, its impact is so great on everything, we really must decide what to do about the plane change before we can get anywhere. So that's what we'll talk about at the next meeting - June 12th.

Howard W. Tindall, Jr.

Addressees:
(See list attached)

FA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: JUN 3 1968

68-PA-T-112A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: VHF range shouldn't be limited by software

Reference is made to the attached memorandum from Colonel Frank Borman. The 327 n.m. limit on the VHF ranging system appears to be a software constraint. I think it is due to the way they scale the range. Would you people please check and see if we would be better off to change the scaling so that the computer program will not limit the range at which we can use this instrument even though it may reduce the accuracy of the rendezvous navigation. Since program changes get harder and harder to make, you had better decide as quickly as possible.

Howard W. Tindall, Jr.

Enclosure

Addressees:
FM4/J. McPherson
FM6/E. C. Lineberry
MIT/IL/R. R. Ragan

PA:HWTindall, Jr.:js

UNITED STATES GOVERNMENT

Memorandum

cc: PA/G. M. Low
PA/R. Showers
PD/A. Cohen
PD/W. Sprier
PD/F. Harding
EG/R. Swifen
/Tindall
CB/F. Borman

TO : CA/Director of Flight Crew Operations

DATE: May 7, 1968

FROM : CB/Colonel Frank Borman

SUBJECT: Visit to RCA, Camden, New Jersey, May 3, 1968

I visited RCA, Camden, New Jersey on Friday, May 3 to review an engineering model demonstration of the VHF Ranging System. The test setup included the components for the Command Module (CM) and the Lunar Module (LM) located in two adjacent screen rooms. Signal strength between the two installations could be varied by changing a set of attenuators. The variation in signal strength was calibrated to provide a simulation of range. There was no provision to incorporate the delay times associated with actual variation in range. Therefore, the actual range capability was not completely verified. Neither the LM nor the CM audio center was used.

The following results were noted: The system locked on at an indicated 252 nautical miles. After initial activation, the signal was lost at a range of approximately 425 nautical miles. The voice quality was good and no appreciable effect on readability was noted when the VHF Ranging was in operation. The "jitter" in readout associated with voice transmission which was evident in the breadboard model has been eliminated. Accuracy is predicted to be ± 212 feet.

After the demonstration, the upcoming flight test program at White Sands was discussed. As a result of the discussion, it is suggested that a spacecraft audio center be employed on the ground so that a more realistic evaluation of voice quality can be made during the flight test. It is apparent that the only reliable and accurate demonstration and verification of the VHF Ranging System will occur during the flight test at White Sands.

One other item of interest is the fact that an ambiguity exists which will effectively limit the range readout of the system to around 327 nautical miles. Another area of some concern is the MIT software interface with the VHF Ranging System. It was noted, for instance, that the computer uses a 6000-ft nautical mile, while the VHF Ranging uses a 6080-ft nautical mile. MIT is aware of this, and I was told that the software program is proceeding without difficulty. Nevertheless, I do think it would be a good idea to hold direct discussions between MIT and RCA in the near future to make sure that there are no problems in integrating the system.

I checked on this: at 328 NM, the computer reads 1 NM, at 329-2 NM etc. The EMS Display however, reads correctly; @ 328=328, 329=329, etc. CB

Frank Borman
Frank Borman

cc:
CB/All Astronauts
PP?/Doug Broome

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

UNITED STATES GOVERNMENT

Memorandum

TO : PA/Manager, Apollo Spacecraft Program Office DATE: MAY 29 1968

68-PA-T-110A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Progress Report on Mission Techniques

1. Since we have not been able to get together this year, except for our short discussion prior to the George Mueller briefing, I thought it might be a good idea to send you a little informal Mission Techniques progress report. I guess our lack of contact is an implicit vote of confidence which I hope is justified. Overall I think we are in pretty good shape although things are not coming out as quickly as I had predicted in March.

2. The mission phase giving me the greatest concern right now is the rendezvous on the "D" mission. It has special problems requiring special action. I think it is under control again, now. The other matter concerning me, which I know is also on your mind, is the question of change control of our Mission Techniques documents. TRW is beefing up their group working with me to handle this activity and will soon give it a try on some "C" mission stuff. I may be naive but I really feel that by the time this business becomes most important - that is, for the lunar missions - both acceptance of the Mission Techniques documents and the procedures to keep them updated should be in good shape. As tentatively proposed in your directorate level meeting I feel the two months overlap period of configuration control should be between five and three months before launch. At least that is what I am aiming for. I really expect that experience on the earlier flights will finally dictate the best way of handling all this. With regard to schedule, I have attached a rough bar chart showing how I think things stand as of mid May. The slip in the documentation since my March 1 estimate is shown by the distance between open and solid symbols. It looks awful and if I thought it was typical of the future I'd shoot myself right now. However, I think we now have some experience that gives me confidence in the schedule shown. I would also like to point out - hopefully without sounding like an excuse - that the mission techniques documents are only one product from the effort and I would like to think considerable benefit is obtained much earlier than their release. Actually we are now experiencing a phaseover in the work. We are now at a point that it is necessary to bring substantial portions of it into final form and define the remaining areas on which we should concentrate our attention. We are doing this now by releasing several phases in June as you can see. But, I should point out that they are not complete which accounts for showing two release dates for the drafts. For instance, the Descent will not contain the ground monitoring, the Ascent book will only cover

the stay on the lunar surface, and Midcourse is only earth orbital through TLI.

3. The "D" rendezvous really turned into a rather messy problem. When it comes to development of mission techniques, it is unquestionably the worse mission phase to define in the entire Apollo program. This is brought about by at least three things:

a. It is the most complex mission phase in any of the Apollo flights.

b. There are more guidance systems involved, none of which are really qualified before the flight.

c. It is potentially the most hazardous of any activity ever undertaken in the manned space program up to that point.

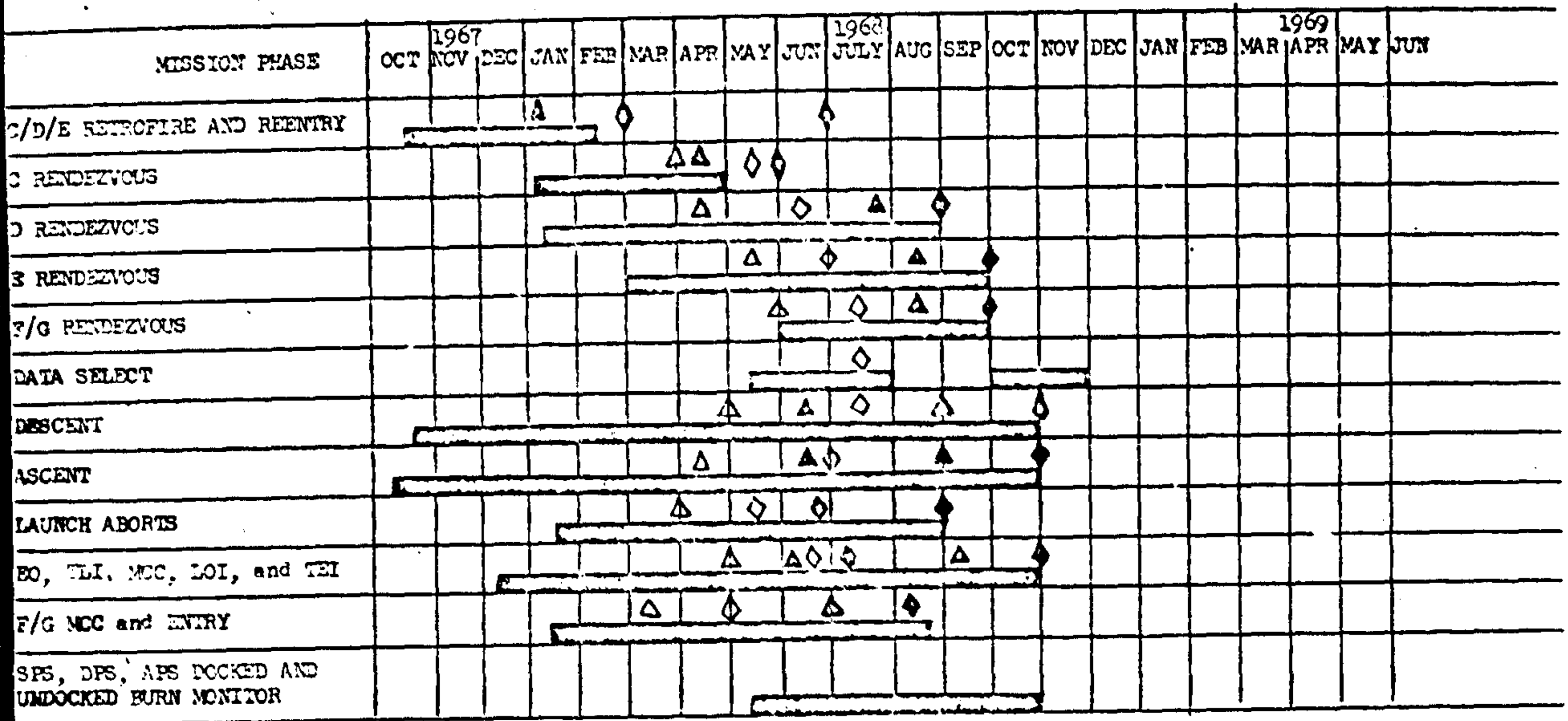
I might also add that everyone has their own different opinion on how it should be done, making it that much more difficult. All of these things have made it necessary to treat this mission phase somewhat differently than the others. However, I feel we now have a good plan for moving out on this and I have high hopes that we will be able to have our package put together by the end of July with substantial agreemen in everyone's part. I expect to enlist the direct participation of Gene Kranz and the Flight Crew, which will be extremely beneficial.

Howard W. Tindall, Jr.

Enclosure

PA:HWTindall, Jr.:js

DATA PRIORITY AND MISSION TECHNIQUES SCHEDULE AS OF MAY 14



Open symbols March 1 estimate

Solid symbols May 14 estimate

▲ Draft copies of Mission Technique Documents for review

◆ Final distribution of Mission Technique Documents

APOLLO DATA PRIORITY COORDINATION

MEETING SCHEDULE

AS OF May 29, 1968

68-PA-T-109A

SUBJECT OF MEETING	June 3	4	5	6	7	10	11	12	13	14	17	18	19	20	21	24	25	26	27	28
Descent Phase											*									▭
Midcourse Phase						*		▭										▭		
"J" Rendezvous										▭										
Ascent Phase			▭										▭							
"G" Rendezvous								▭										▭		
101 Retrofire and Reentry																				
Lunar Reentry				▭										▭						
"E" Rendezvous																				
Data Select		▭										▭								
SPECIAL MEETINGS																				

* It is anticipated that drafts of the Mission Techniques Documents will be ready for distribution on these dates. Reviews with NR, MIT, CAEC participation are scheduled as shown on June 27 and 28. Midcourse Phase will cover the Earth Orbit Phase through TLI. Descent Phase will cover from wake up through Touch Down.

▭ *Meeting begins at 9:00 a.m.*

▭ *Meeting begins at 1:00 p.m.*

Howard W. Tindall, Jr.

MSC FORM 1243 (FEB 68)

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list below DATE: MAY 29 1968

68-PA-T-108A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Spacecraft computer program - things dealing with lunar descent and aborts from it

1. I spent an interesting morning at MIT on May 16 with George Cherry, Don Lickly, Norm Sears, and Craig Shulenberg talking about Luminary - how it works and some things that really haven't been defined yet. It primarily dealt with lunar descent and aborts from lunar descent.

2. Powered Descent Braking Phase (P63)

There is a question in MIT's cumulative mind as to whether the x-axis override logic is consistant with the current landing radar utilization logic. Recently a PCR was approved to permit use of landing radar data earlier in powered descent but no changes were made in the x-axis override logic. MIT questioned if this is consistant. However, more basic than that, there is the question of whether or not any of these things should be keyed to navigated altitude as they currently are, rather than time of initiation from powered descent or simply crew choice. I believe we all are concerned that using navigated altitude as the system is currently designed may cause the system to be locked out from doing the right thing. Specifically, if the PGNCS has computed the wrong altitude for some reason, even though the crew may know they are getting true altitude from the landing radar, there is no way to get the PGNCS to accept it. Although this probably won't happen, the consequences are so serious that none of us could see any reason for designing the system in this inflexible way. The way the guidance system currently weighs the landing radar data precludes its use above 35,000 feet based on some sort of radar specifications. Even if the navigated altitude were correct, we may be making a mistake providing this data lockout in the computer program at this early point in program development.

3. MIT would like to make a design change in the Powered Descent Landing Phase programs P65/P66/P67. As currently designed, the crew exits these final descent programs by hitting "Proceed," which causes the LGC to do such things as storing gimbal angles and LM position, turning off average "g," turning off the DAP, turning off the abort monitor (which prevents PGNCS recognition of an Abort and Abort Stage discrete), sets the lunar surface flag, displays LM position to the crew, etc. This procedure is enabled when the computer thinks the spacecraft is within 50 feet of the

lunar surface. There are two potential problems here. First of all the crew is within one "Proceed" of catastrophy if he prematurely hits the button inadvertently. This is unlikely but is also unnecessary since there is no need to terminate that program by a single key stroke. Worse than that, if for some reason the PGNCS never realizes the altitude is less than 50 feet, there is no way for the crew to terminate the program in such a way that all those important functions are carried out. It is MIT's proposal to change the design by adding a new program (P68) which would be called in a standard way via Verb 37. This program would do all the things previously done following the "Proceed" in the final descent program and could be exited directly to any callable program crew procedures dictate such as Ascent (P12) or IMU Alignment (P57). I think it is a good idea that they do that. P68 would not be called til several minutes after the lunar landing, of course, in order to maintain the PGNCS in a state of readiness to Abort Stage from the lunar surface, if that unlikely event were necessary.

4. I learned some interesting things with regard to the APS Abort program (P71) - answers to questions noted in last week's bulletin on aborts from powered descent. Specifically, P71 does not have any so-called short burn logic. That is, if P71 is called when the duration of an APS burn required to fulfill the targeting requirements is less than four or five seconds, the PGNCS will not provide a well controlled cutoff. Actually, what it will do following Abort Stage is to turn off the APS as soon as it sees what is going on, which will be late. I asked MIT to look this over and tell us exactly what will happen in this unlikely event - for example, how big an overburn will we get? I'm sure this is an acceptable situation and the procedures we outlined in last week's memo are still okay. Of course, it may mean that RCS trimming is needed but at least the spacecraft would be in a safe orbit while it's doing it. (Incidentally, if the crew wants to do four jet RCS trimming following an abort, they will have to call up the DAP data load (R03) and reset it from the two jet logic used in preparation for powered descent.)

5. Finally, MIT people noted that there are two ways of calling up the abort programs (P70 and P71). The preferable way, of course, is through the use of the Abort and Abort Stage buttons. The alternate means is using Verb 37. They noted that program coding and testing could be carried out more efficiently if we were to delete the Verb 37 mode. None of us could think of an occassion for using Verb 37 as the primary technique. In fact, the only contingency conceivable would be to backup the abort discrete. At the time, I was inclined to think that this was unnecessary but after further reflection, I am now reluctant to see that discrete backup removed, particularly in the wake of our stage verify discussions.

6. I expect to see some PCR's or PCN's in the near future on some of the things noted above. Maybe this note will give you a little time to think about them.

Howard W. Tindall, Jr.

Addressees:
(See list attached)

PA:HWTindall, Jr.:js

Addressees:
AA/R. R. Gilruth
AB/G. S. Trimble
CA/D. K. Slayton
CB/A. B. Shepard
J. A. McDivitt
N. Armstrong
F. Borman
M. Collins
C. Conrad
L. G. Cooper
C. Duke
R. Gordon
J. Lovell
R. L. Schweickart
D. R. Scott
T. P. Stafford
W. R. Pogue
W. M. Schirra
D. F. Eiselle
A. L. Bean
CF/W. J. North
CF13/D. F. Grimm
CF2/J. Bilodeau
CF212/C. Jacobsen
CF22/C. C. Thomas
CF24/P. Kramer
M. C. Contella
D. K. Mosel
D. W. Lewis
CF3/C. H. Woodling
CF32/J. J. Van Bockel
CF33/C. Nelson
M. Brown
CF34/T. Guillory
T. W. Holloway
EA/M. A. Faget
EA1/J. Chamberlin
EA2/J. B. Lee
EA5/P. M. Deans
EB/P. Vavra
EE/R. Sawyer
L. Packham
EE13/M. J. Kingsley
R. G. Irvin
EE3/E. L. Chicoine
EE6/G. B. Gibson
R. G. Fenner
EG/R. A. Gardiner
D. C. Cheatham
EG2/M. Kayton
C. T. Hackler
EG23/K. J. Cox
E. E. Smith
EG25/T. V. Chambers
EG26/P. E. Ebersole
EG27/W. J. Klinar
H. E. Smith
EG41/J. Hanaway
EG42/B. Reina
EG43/J. M. Balfe
EG44/C. W. Frasier
KA/R. F. Thompson
PA/G. M. Low
C. H. Bolender
K. S. Kleinknecht
PA2/M. S. Henderson
PD/O. Maynard
PD12/J. G. Zarcaro
R. J. Ward
R. W. Kubicki
M. H. von Ehrenfried
PD4/A. Cohen
PD6/H. Byington
PD7/W. R. Morrison
PD8/J. Loftus
PE/D. T. Lockard
FA/C. C. Kraft, Jr.
S. A. Sjoberg
C. C. Critzos
R. G. Rose
FC/E. G. Kranz
D. H. Owen
D. B. Pendley
M. P. Frank
FC2/J. W. Roach
FC3/A. D. Aldrich
G. E. Coen
B. N. Willoughby
G. P. Walsh
FC4/J. B. Craven
R. L. Carlton
J. C. Elliott
FC5/G. S. Lunney
J. S. Llewellyn
J. C. Bostick
C. B. Parker
D. Massaro
C. E. Charlesworth
C. F. Deiterich
S. L. Davis
W. E. Fenner
G. R. Paules
W. S. Presley
H. D. Reed
P. C. Shaffer
J. H. Greene
FC5/K. W. Russell
S. G. Bales
FL/J. B. Hammack
FS/L. C. Dunseith
FS5/J. C. Stokes
T. F. Gibson, Jr.
G. R. Sabionski
J. E. Williams
T. M. Conway
TH3/J. E. Dornbach
J. H. Basser
FM/J. P. Mayer
C. R. Huss
FM12/R. R. Ritz
FM13/R. P. Parten
J. R. Gurley
E. D. Murrah
A. Nathan
FM3/M. Collins
FM4/P. T. Pixley
R. T. Savely
FM5/R. E. Ernull
FM6/R. R. Regelbrugge
K. A. Young
FM7/S. P. Mann
R. O. Nobles
FM/Branch Chiefs

HE-03/H. E. Dornak
D. W. Hackbart
Bellcomm (Hqs.)/R. V. Sperry
G. Heffron
GAEC (Bethpage)/J. Marino
MAC (Houston)/W. Haufler
MIT/IL/R. R. Ragan
NR (Downey)/M. Vucelic
D. Zermuehlen
E. Dimitruk, FB30
TRW (Houston)/R. Boudreau
M. Fox
B. J. Gordon
W. R. Lee, Jr.
T. V. Harvey
TRW (Redondo Beach)/R. Braslou
GSFC/F. O. Vonbun, 550
B. Kruger, 550
KSC/R. D. McCafferty (CFK)
P. Baker (CFK)
NASA (Hqs.)/A. Merritt, MAS

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: MAY 2 4 1968

68-PA-T-106A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Spacecraft computer program newsletter

1. I learned some things at MIT last week that seemed interesting enough to justify this note. Of course, it deals primarily with the spacecraft computer programs and their influence on the mission techniques we are developing.

2. Pete Conrad reported that during their KSC LM3 simulation, they have experienced an apparent deficiency in Sundance when making a docked DPS burn. He says that the DPS engine gimbal angles do not get changed at all during that low thrust period at the beginning of the burn which was provided specifically for trimming them. MIT looked into this problem and agreed that for some reason the program does appear to work - or not work - like Pete says. Their preliminary guess as to the course of this is that with low thrust and high inertial the gimbal trim estimator may be experiencing underflow. That is, the computer is simply not able to determine that a movement of the trim gimbal is necessary as it is currently coded. Of course, the RCS jets are very active both before and after throttle up.

3. Our requirements for getting rendezvous radar (RR) data on the downlink while the LM is on the lunar surface was discussed again, and I am afraid I really blew it. MIT has resisted the program change we requested and I am beginning to think they may very well be right. That is, I am not so darn sure any more that the program as currently designed and coded is not good enough. In any case, George Cherry now proposes to look into a very simple change which can be made in the lunar surface navigation program (P22), which would substantially increase the frequency of RR data on the downlink. All that it amounts to is to remove the delay after the previous computations before the computer collects another batch of RR data. Right now this delay is 15 seconds. If we eliminate this delay and operate P22 in the "no state vector update" mode, the computer should cycle very fast. George Cherry is going to make an estimate of what this RR downlink frequency would be as well as evaluating the schedule impact for this change. I would be surprised if it is not acceptable to MSC even if it is not perfect - whatever perfect is.

4. As Colossus is currently designed, the crew is required to press the "Proceed" button during the period of maximum reentry G's to obtain a DSKY display change. A PCR had been submitted to make this procedure

automatic. However, on future consideration, we are not so sure that it is a good thing to do. The initial display parameter in P65 are used in the primary go/no go logic employed by the crew in evaluating the G&N performance to decide whether to stay on it or to go with the EMS backup. It is essential that they see these parameters and an automatic "Proceed" could wipe them out before they have seen and digested them under certain circumstances. Accordingly, I suspect we should delete our request. The discussions have revealed, however, that some modification in the coding will probably be needed to make sure the system will work throughout the rest of the entry even if the crew does not provide the "Proceed" signal.

5. Here is one more note in the continuing "Stage Verify" story. According to John Norton the lunar ascent program (P12) no longer checks stage verify. That strikes me as a real improvement in the program but it mystifies me as how it got changed without a PCR or PCN, or even letting anyone know. Norton, of course, uncovered it by going meticulously through the program listing.

Howard W. Tindall, Jr.

Addressees:
(See list attached)

PA:HWTindall, Jr.:js

Addressees:
AA/R. R. Gilruth
AB/G. S. Trimble
CA/D. K. Slayton
CB/A. B. Shepard
J. A. McDivitt
N. Armstrong
F. Borman
M. Collins
C. Conrad
L. G. Cooper
C. Duke
R. Gordon
J. Lovell
R. L. Schweickart
D. R. Scott
T. P. Stafford
W. R. Pogue
W. M. Schirra
?. F. Eiselle
A. L. Bean
CF/W. J. North
CF13/D. F. Grimm
CF?/J. Bilodeau
CF 12/C. Jacobsen
CF22/C. C. Thomas
CF24/P. Kramer
M. C. Contella
D. K. Mosel
D. W. Lewis
CF3/C. H. Woodling
CF32/J. J. Van Bockel
CF33/C. Nelson
M. Brown
CF34/T. Guillory
T. W. Holloway
EA/M. A. Faget
EA1/J. Chamberlin
EA?/J. B. Lee
EA5/P. M. Deans
EB/P. Vavra
EE/R. Sawyer
L. Packham
EE13/M. J. Kingsley
R. G. Irvin
EE3/E. L. Chicoine
EE6/G. B. Gibson
R. G. Fenner
EG/R. A. Gardiner
D. C. Cheatham
EG?/M. Kayton
C. T. Hackler
EG?/K. J. Cox
EG25/T. V. Chambers
EG26/P. E. Ebersole
EG27/W. J. Klinar
H. E. Smith
EG41/J. Hanaway
EG42/B. Reina
EG43/J. M. Balfe
EG44/C. W. Frasier
KA/R. F. Thompson
PA/G. M. Low
C. H. Bolender
K. S. Kleinknecht
PA2/M. S. Henderson
PD/O. E. Maynard
PD12/J. G. Zarcaro
R. J. Ward
R. W. Kubicki
M. H. von Ehrenfried
PD4/A. Cohen
PD6/H. Byington
PD7/W. R. Morrison
PD8/J. Loftus
PE/D. T. Lockard
FA/C. C. Kraft, Jr.
S. A. Sjoberg
C. C. Critzos
R. G. Rose
FC/J. D. Hodge
E. G. Kranz
D. H. Owen
D. B. Pendley
M. P. Frank
FC2/J. W. Roach
FC3/A. D. Aldrich
G. E. Coen
B. N. Willoughby
G. P. Walsh
FC4/J. B. Craven
R. L. Carlton
J. C. Elliott
FC5/G. S. Lunney
J. S. Llewellyn
J. C. Bostick
C. B. Parker
D. Massaro
C. E. Charlesworth
C. F. Deiterich
S. L. Davis
W. E. Fenner
C. E. Paules
W. S. Presley
FC5/P. C. Shaffer
J. H. Greene
K. W. Russell
S. G. Bales
FL/J. B. Hammack
FS/L. C. Dunseith
FS5/J. C. Stokes
T. F. Gibson, Jr.
G. R. Sabionski
J. K. Williams
T. M. Conway
TH3/J. E. Dornbach
J. H. Sasser
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM12/R. R. Ritz
FM13/R. B Parten
J. R. Gurley
K. D. Murrah
A. Nathan
FM3/M. Collins
FM4/P. T. Pixley
R. T. Savely
FM5/R. E. Ernull
FM6/R. R. Regelbrugge
K. A. Young
FM7/S. P. Mann
R. O. Nobles
FM/Branch Chiefs

HE-03/H. E. Dornak
D. W. Hackbart
Bellcomm (Hqs.)/R. V. Sperry
G. Heffron
GAEC (Bethpage)/J. Marino
MAC (Houston)/W. Haufler
MIT/IL/R. R. Ragan
NR (Downey)/M. Vucelic
D. Zermuchlen
E. Dimitruk, FB30
TRW (Houston)/R. Boudreau
M. Fox
B. J. Gordon
W. R. Lee, Jr.
T. V. Harvey
TRW (Redondo Beach)/R. Braslou
GSFC/F. O. Vonbun, 550
B. Kruger, 550
KSC/R. D. McCafferty (CFK)
P. Baker (CFK)
NASA (Hq.)/A. Merritt, MAS

UNITED STATES GOVERNMENT

Memorandum

DATE: JAN 24 1968
68-PA-T-1A

TO : See list below

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Second Mission "C" Rendezvous Mission Techniques meeting

1. On January 17 we held our second Mission "C" Rendezvous Mission Techniques meeting. I feel we have this mission phase pretty well in hand conceptually. There are a number of numerical limits yet to be set.

2. It is evident that limits must be set regarding the magnitude of the delta V residuals following the NCC_1 maneuver which we would trim out with the RCS. That is, if they are small we will trim them. If they are large we will not trim them but will account for the dispersions they create with the NCC_2 maneuver. This limit must be established. It is expected to be in the order of 10 fps which is not an unlikely value using the present PNGCS design and thrust alignment uncertainties. Residuals at NCC_2 and NSR must be trimmed. If excessive, the alternative is to abandon the rendezvous, thus, the rendezvous RCS red line will probably fix the limit.

3. It had been established that the ground would update the state vectors of both the command module and the S-IVB at two times during the rendezvous exercise. The first is prior to the NCC_1 maneuver and the second is prior to the NCC_2 maneuver. We have now established the time tag for each of these state vectors as follows: the first command module state vector will be time tagged 6 minutes before the NCC_1 maneuver and the first S-IVB state vector will be time tagged 6 minutes after the NCC_1 maneuver. Time tags for the state vector update prior to NCC_2 for the command module will be 6 minutes before the NCC_2 maneuver and for the S-IVB will be 6 minutes after the NSR maneuver. External delta V targeting parameters will be relayed to the crew at the same time the state vector updates are made.

4. Two platform alignments will be made during this exercise, one in preparation for the NCC_1 maneuver and one in the time period between NCC_2 and NSR. Orientation of the platform for the entire rendezvous exercise shall be such that at the TPI time as predicted at the beginning of this mission phase the spacecraft FDAI 8-ball would read 0, 0, 0 when the spacecraft is in a horizontal, heads up, wings level, in plane attitude.

5. The [illegible] orbit rate torquing device (ORDEAL) will be used, of course. Although the primary mode is for the crew to determine initiation quantities onboard the spacecraft, it is also desirable that the ground have the same capability as a backup. Al Lineberry was given the action item of establishing precisely how the torquing rate parameter was to be computed on the ground. This will be specified in mathematical equation format probably as a function of spacecraft altitudes and optimal [illegible] for rendezvous.

6. The event timer will not be set up to run continuously throughout the mission phase but rather will be used to countdown to each of the burns. The only exception is that the crew will start it counting up at the TPI maneuver.

7. We had a lengthy discussion regarding the TPI maneuver. Specifically, there were two things which must be done. A decision must be made in real time as to whether to use the spacecraft computed TPI maneuver or the ground computed maneuver. Following this decision there is the task of executing one or the other. As a result, it was identified as necessary for the ground to transmit to the crew two sets of TPI maneuver targets—one for comparison with the PNGCS and one for execution if the PNGCS is declared NO GO. In order to make the comparison in the order of 9 to 12 minutes before TPI, the best PNGCS output for the crew to use in the TPI maneuver in the external delta V coordinate system from the P-41 RCS thrust program. Therefore, for compatibility the ground will transmit the same parameters for comparison purposes. If the crew determines the PNGCS is all right they will execute the onboard determined maneuver using P-41. The second set of targets transmitted from the ground will be used only if the PNGCS solution is declared unsatisfactory. These are the delta V's which the crew should use count up in the DSKY as they utilize P-47 to execute the maneuver manually with the spacecraft X-axis boresighted on the target and with wings level. The ground computation will assume that spacecraft attitude in addition to compensating for the $7\frac{1}{2}^{\circ}$ control axis rotation from the body axis. Burn duration of these delta V's will also be sent to permit execution with SCS if the PNGCS maneuver capability has failed.

8. It is our understanding that the navigation W-matrix which governs the weighting given the optical observations are automatically initialized in the spacecraft whenever new state vectors are transmitted from the ground via P-27, or when the crew manually requests re-initialization. It is our desire that the W-matrix be at its initialization values at the time the first sextant observations are obtained following NSR. Since state vectors were transmitted prior to NCC, with no subsequent sextant observations it is our understanding the W-matrix should still be at its initialization state at that time. If that is not the case, the crew must re-initialize them after NSR but only then. Specifically, it is judged undesirable to re-initialize following the TPI maneuver.

9. It is currently planned that the one and only midcourse correction will be set up to occur 30 minutes after TTI. We did not have time to discuss this maneuver or the terminal braking but will do so at the next meeting. Of particular interest is the desirability of braking and what to do next. Also, what is the state of the S-IVB at that time? In order to avoid conflict with [illegible] travel, the next meeting will be held starting at 9:00 a.m. on February 2—already breaking that nice schedule we set up!

10. Subsequent to this meeting I discussed our conclusions with [illegible] Stafford and Don Eisele, who both concurred as of this [illegible]

Howard W. Tindall, Jr.

Enclosure
List of Attendees

Addressees:
(See attached list)

ATTENDEES

J. A. McDivitt	CB
D. R. Scott	CB
D. W. Lewis	CF
M. Kayton	EG
J. Bostick	FC
S. L. Davis	FC
W. S. Presley	FC
F. Shaffer	FC
E. C. Lineberry	FM
P. T. Pixley	FM
J. Shreffler	FM
K. A. Young	FM
H. W. Tindall, Jr.	PA
D. Boudreau	TRW
R. L. Rue	TRW

Enclosure 1

UNITED STATES GOVERNMENT

Memorandum

DATE: JAN 22 1968

68-PA-T-15A

TO : See list below

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: "Final" review of Spacecraft 101 (Mission "C") Retrofire and Reentry Mission Techniques

1. On January 10 we had a "final" review of Spacecraft 101 (Mission "C") Retrofire and Reentry Mission Techniques as documented in the logical flow charts prepared by TRW based on a series of meetings we have had here at MSC. These flow charts, which show the operations starting several hours prior to the retrofire maneuver itself, had been distributed to all interested organizations, but this was the first time MIT, North American and others had an opportunity to thoroughly understand the rationale and to provide their comments. The charts are now being updated based on our new agreements and will be distributed within the next several weeks.

2. Although we were addressing ourselves specifically to the Spacecraft 101 flight, we are all in hopes that the techniques developed for that mission can be used on all subsequent earth orbital missions. Crews for Missions "C", "D", and "E" were in attendance and it looks like we may have accomplished that objective.

3. Probably the most controversial item of all dealt with the manner in which the Entry Monitoring System (EMS) is to be used. It was stated that if it is recognized that the primary guidance system (PNGCS) is not working for some reason in sufficient time prior to retrofire to respond, we would base our retrofire maneuver on a ballistic reentry and would not attempt to use closed loop reentry guidance for ranging control. It it is recognized that the PNGCS has failed in the last moments prior to retrofire, following retrofire or during reentry itself we are obviously committed to a lifting reentry if we hope to reach the desired landing point. It is our current plan to utilize the essentially open loop bank/reverse bank backup technique similar to that employed for Gemini. The point to be made is the in both cases the EMS is only being operated as a systems test and is not utilized in the actual control of the reentry. Some parties contested these decisions, in particular North American, and it is recognized that a number of things are going on at present which may make it desirable to reverse the second one regarding use of the EMS during a backup mode lifting reentry. Specifically, analyses are being carried out in a number of places to improve our knowledge of the EMS capability and to verify its readiness for flight. In addition, simulated reentries both with and without the flight crews themselves are scheduled and will have an influence on the way

we ultimately go. And finally, G&C Division had been requested to state positively their position with regard to flight readiness of the EMS. But as of now, we aren't using it! It should be emphasized, however, that our current plans for reentry at lunar reentry velocities definitely involve use of the EMS in a vital role and confidence must be developed in that system partially from these earth orbital development flights.

4. It had been stated that if the decision to retrofire is within 2 hours and 40 minutes of the time it is intended to do so we would not utilize the PNGCS. It is evident that there could be times wherein that system could be used in the unlikely event it was already in use and well aligned at the time of an immediate reentry decision. Accordingly, additional logic will be included in the flow to indicate the various conditions under which we would use the PNGCS, without a full 2 hours and 40 minutes for its preparation.

5. There are two ways of performing a ballistic reentry. One is to continuously roll a spacecraft as we did on Mercury. The other is to dissipate the lifting capability by banking the spacecraft 90° to one side and then 90° to the other causing the spacecraft to move in an out-of-plane direction. It was established that the primary mode for flying the ballistic reentry would be the latter based on a definite crew preference for that technique. The Control Center is prepared to handle either way including computation of the best bank angle to use taking into account cg offset in order to align the "lift" vector horizontally. Furthermore, if the recovery forces are known to be to the north or south of the ground track, the time at which the spacecraft reverses its roll attitude will be determined to minimize that miss distance.

6. It was determined that under no circumstances would we modify the retrofire maneuver targeting or state vectors in the spacecraft computer when the time to that maneuver is less than 30 minutes.

7. We decided to modify the final check on the PNGCS from that shown in the proposed flow. Specifically, it had been suggested that the spacecraft be pitched down from its inertial retrofire attitude 20° at 5 minutes before retrofire ignition time to verify that the horizon coincided with the window marking. If it did not, it was proposed to declare the PNGCS NO GO and use the SCS instead. In order to avoid the obvious undesirable change in spacecraft pitch attitude at this critical time, this was changed to utilize the COAS for the horizon check rather than the line on the spacecraft window. It was noted that with the spacecraft in retrofire attitude the horizon should pass through the middle of the COAS at approximately $7\frac{1}{4}$ minutes before retrofire providing just as accurate a check, earlier and without changing spacecraft attitude. It was established that the horizon check with the COAS should be to within 3° at the precise time the horizon should be centered in the COAS in order to commit the use of the PNGCS.

8. It was reported that during the retrofire maneuver 1 σ dispersions in the guidance and propulsion system result in 2° pitch and yaw excursions during the maneuver and Delta V residuals of 6 fps. Rather large.

9. In preparing this flow we had convinced ourselves that the orbit rate ball device (ORDEAL) should not be used. The crews feel differently and so we are in the process of including initialization functions etc., in accordance with its use.

10. At present it is planned that the reentry will be flown with the crew actually controlling the spacecraft attitude manually in accordance with the PNGCS recommended bank angle just as they did on most of the Gemini flights. Those responsible for the reentry Digital Autopilot (DAP) maintain that it will not be possible to evaluate the performance of the DAP if the spacecraft is flown in this way. Since this mode has been agreed to by the Program Manager, those organizations who are concerned (e.g., G&C, MIT, MPAD, etc.) were advised to prepare their case and submit it in writing to the Program Manager.

11. There was a question as to what should be done about starting the EMS if it does not start automatically as it is supposed to. There are some who say to manually start it at a computed time, and there are others who say not to do that. Dave Heath (MPAD) was given the action item of determining what the mission requirements imply and North American was requested to present their position on this matter.

12. Items recorded above are obviously just highlights of the meeting - that's primarily significant things which were changed in the flow as it was presented and those things on which controversy still exists. Some of the decisions may be changed, of course, but as of now I think everything is covered pretty well and everyone can understand exactly how we are going to do this mission phase unless changes are approved. Once the comments noted have been incorporated, it is my intention to present this to the MSC management for their information, criticism and final approval.

Howard W. Tindall, Jr.

Enclosure
List of Attendees

Addressees:
(See attached list)

ATTENDEES

MSC

CB/E. A. Cernan
M. Collins
J. Lovell
J. A. McDivitt
T. P. Stafford
D. R. Scott
CF/W. M. Anderson
W. W. Hinton
M. A. Rahman
C. P. Schaefer
EG/T. M. Lawton
C. H. Paulk
FC/W. J. Boone
S. L. Davis
C. F. Deiterich
J. S. Llewellyn
W. Presley
P. Shaffer
C. D. Griffin
FM/M. A. Collins
M. E. Donahoo
D. J. Griffith
J. R. Gurley
D. W. Heath
E. M. Henderson
O. Hill
C. T. Hyle
R. O. Nobles
J. L. Wells
PA/H. W. Tindall, Jr.
PD12/M. H. von Ehrenfried
PD8/C. R. Haines

Bellcomm

I. Bogner
R. V. Sperry

LEC

W. R. Worrenburg

MIT/IL

S. L. Copps
R. A. Larson
J. L. Nevins

NR

E. F. Knotts
D. O. Zermuchlen

TRW

R. Boudreau
C. Belton
J. M. Cencioso
T. V. Hamey

Enclosure 1

Notebook -

Bill T. — Let's not compromise the ... just because of ...

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: JAN 17 1968
68-PA-T-14A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Reentry from lunar missions

1. On January 12 a group of Flight Crew, Flight Control and Mission Planning guys got together to talk about the lunar reentry and some rather interesting things came out which I am recording here for my records and your amusement.

2. Apparently, the last midcourse correction before reentry on a lunar mission occurs about one hour prior to reaching 400,000 feet altitude. It is probable this maneuver will be made with RCS, although I suppose if it is big enough it may be necessary to use the SPS. It is currently planned to use the External Delta V guidance mode. If SPS is used it is expected that we will have to trim residuals with the RCS. There was a question, however, as to whether this last midcourse maneuver should include an out-of-plane component. Claude Graves seemed to think it worthwhile but was not sure; he took the action item of determining the advantages and disadvantages of this. Since the same platform orientation will probably be used for both the final midcourse correction and the reentry, it is anticipated that the most desirable REFSMMAT will be chosen based on reentry considerations making the position on the ball relatively random during the midcourse correction. John Llewellyn intends to propose what REFSMMAT to use. It may be necessary to add a capability for computing it in the RTCC if that does not already exist. It is expected that the platform alignment performed prior to the midcourse maneuver will be adequate for the reentry, that is, it will not be necessary to redo it.

3. We next dealt with the question of the most desirable spacecraft attitude during service module separation. As you know, the PNGCS automatically maneuvers the spacecraft to a preferred attitude which is stored in the Colossus reentry program (P-61). We were not sure how that value was selected and it is not certain it is the one we will ultimately want to use. We are not even sure we will want to use an automatic mode in the first place. One matter which it seems should be given consideration is use of an alignment providing an out-of-plane component while avoiding platform gimbal lock in the same way as will be done on earth orbital missions. I expect to request MPAD (Carl Huss) to resolve this overall preferred attitude question if it has not been done already. And we are reviewing the

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: JUL 2 1968
68-PA-T-140A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Throttle up time is fixed during the powered descent maneuver

1. We learned something interesting during our Descent Mission Techniques meeting June 28 from the MIT people there. It dealt with the way the DPS gimbal trim phase of the powered descent maneuver is programmed.

throttle recovery time

2. It is extremely important that the engine be at full throttle at the right place in the trajectory. (The figure given is that for each second of time delay in throttling up to the FTP, we lose 12 seconds of hover time.) Therefore, MIT has programmed the computer so that throttling up does not occur after a fixed duration DPS gimbal trim time, but rather at the "right time" regardless of how much trim gimbal there has been. For example, if the engine failed to start when it was suppose to and the crew chooses to recycle to TIG minus five seconds there can be as much as 13 seconds delay in engine ignition and the trim time woul' be reduced by that amount. This procedure is an argument for maintaining a 10% trim gimbal time of 26 seconds, making us somewhat tolerant of this sort of an event. We hadn't thought about this situation very much yet, but I think the consensus is that if the DPS fails to ignite under PGNCS control initially and again fails on a recycle, we should abort without attempting manual ignition since something serious is probably wrong.

3. This really looks like a good way to program it, but is different than documented in the GSOP. Accordingly, MIT will submit a PCN to correct the documentation.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27

5010-108

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: JAN 24 196[illegible]

68-PA&T-16A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Second Mission "C" Rendezvous Mission Techniques meeting

1. On January 17 we held our second Mission "C" Rendezvous Mission Techniques meeting. I feel we have this mission phase pretty well in hand conceptually. There are a number of numerical limits yet to be set.

2. It is evident that limits must be set regarding the magnitude of the delta V residuals following the NCC_1 maneuver which we would trim out with the RCS. That is, if they are small we will trim them. If they are large we will not trim them but will account for the dispersions they create with the NCC_2 maneuver. This limit must be established. It is expected to be in the order of 10 fps which is not an unlikely value using the present PNGCS design and thrust alignment uncertainties. Residuals at NCC_2 and NSR must be trimmed. If excessive, the alternative is to abandon the rendezvous, thus, the rendezvous RCS red line will probably fix the limit.

3. It had been established that the ground would update the state vectors of both the command module and the S-IVB at two times during the rendezvous exercise. The first is prior to the NCC_1 maneuver and the second is prior to the NCC_2 maneuver. We have now established the time tag for each of these state vectors as follows: the first command module state vector will be time tagged 6 minutes before the NCC_1 maneuver and the first S-IVB state vector will be time tagged 6 minutes after the NCC_1 maneuver. Time tags for the state vector update prior to NCC_2 for the command module will be 6 minutes before the NCC_2 maneuver and for the S-IVB will be 6 minutes after the NSR maneuver. External delta V targeting parameters will be relayed to the crew at the same time the state vector updates are made.

4. Two platform alignments will be made during this exercise, one in preparation for the NCC_1 maneuver and one in the time period between NCC_2 and NSR. Orientation of the platform for the entire rendezvous exercise shall be such that at the TPI time as predicted at the beginning of this mission phase the spacecraft FDAI 8-ball would read 0, 0, 0 when the spacecraft is in a horizontal, heads up, wings level, in plane attitude.

5. The [illegible] orbit rate torquing device (ORDEAL) will [illegible] course. Although the primary mode is for the crew to [illegible] [illegible] the spacecraft, it is also desirable that the ground have [illegible] capability as a backup. Ed Lineberry has given the action item of establishing precisely how the torquing rate [illegible] to be computed on the ground. This will be specified in mathematical equation format probably as a function of spacecraft altitude and [illegible] rendezvous.

6. The event timer will not be set up to run continuously throughout the mission phase but rather will be used to countdown to each of the burns. The only exception is that the crew will start it counting up at the TPI maneuver.

7. We had a lengthy discussion regarding the TPI maneuver. Specifically, there were two things which must be done. A decision must be made in real time as to whether to use the spacecraft computed TPI maneuver or the ground computed maneuver. Following this decision there is the task of executing one or the other. As a result it was identified as necessary for the ground to transmit to the crew two sets of TPI maneuver targets: one for comparison with the PNGCS and one for execution if the PNGCS is declared NO GO. In order to make the comparison in the order of 9 to 10 minutes before TPI, the best PNGCS output for the crew to use is the TPI maneuver in the external delta V coordinate system from the P-41 RCS thrust program. Therefore, for compatibility the ground will transmit the same parameters for comparison purposes. If the crew determines the PNGCS is all right they will execute the onboard determined maneuver using P-41. The second set of targets transmitted from the ground will be used only if the PNGCS solution is declared unsatisfactory. These are the delta V's which the crew should see count up in the DSKY as they utilize P-47 to execute the maneuver manually with the spacecraft X-axis boresighted on the target and with wings level. The ground computation will assume that spacecraft attitude in addition to compensating for the $7\frac{1}{2}^{0}$ control axis rotation [illegible] the body axis. Burn duration of these delta V's will also be sent to permit execution with SCS if the PNGCS maneuver capability has failed.

8. It is our understanding that the navigation W-matrix which governs the weighting given the optical observations are automatically [illegible] in the spacecraft whenever new state vectors are transmitted from the ground via P-27, or when the crew manually requests [illegible]. It is our desire that the W-matrix be at its initialization values at the time the first sextant observations are obtained following [illegible]. Since state vectors were transmitted prior to NCC, with no subsequent sextant observations it is our understanding the W-matrix should be at its initialization state at that time. If they [illegible] the crew must re-initialize them after NSR but only [illegible]. It is judged undesirable to re-initialize following the TPI maneuver.

It is currently planned that the one and only midcourse correction will be set up to occur 20 minutes after TPI. We did not have time to discuss this maneuver or the terminal braking but will do so at the next meeting. Of particular interest is the desirability of braking and what to do next. Also, what is the state of the S-IVB at that time? In order to avoid conflict with midweek travel, the next meeting will be held starting at 9:00 a.m. on February ... ready breaking that nice schedule I set up.

10. Subsequent to ... I discussed our conclusions with Tom Stafford and Gene Kranz, ... concurred as of this time.

Howard W. Tindall, Jr.

Enclosure
List of Attendees

Addressees:
(See attached list)

9. It [illegible] currently planned that the one and only midcourse correction will be set up to occur 30 min. [illegible] after TPI. We did not have time to discuss this maneuver or the terminal phasing but will do so at the next meeting. Of particular interest is the desirability of braking and [illegible] to do next. Also, what is the state of the S-IVB at that time? In order to avoid conflict with midweek travel, the next meeting will be held starting at 9:00 a.m. on February [illegible] breaking that nice schedule [illegible] set up!

10. [illegible] to [illegible] our conclusions with Tom Stafford and John Young [illegible] of this time.

Howard W. Tindall, Jr.

Enclosure
List of Attendees

Addressees:
(See attached list)

desirability of eliminating the auto altitude maneuver from the P-61 program since MIT says this would be a good time to do it if we're not going to use it.

4. If and how the ORDEAL will be incorporated into this operation must also be examined, as usual.

5. There was a lengthy and emotional discussion concerning the overall reentry trajectory philosophy. Within the past year the MPAD reentry people have developed what appears to be a rather good way to back up the PNGCS reentry guidance in the event it fails. Early in their investigation it was found that earth orbital backup techniques, that is, constant bank angle reentries, were completely unacceptable and they developed a technique involving use of a constant acceleration which is expected to be both safe and easily performed by the crew. Of course, simulations are necessary to verify that. Unfortunately, after about 2 minutes into the reentry phase, which starts at 400,000 feet, the backup technique is not compatible with the primary guidance resulting in a significant difference in where the spacecraft will land, depending on which is used. That is, during the first 2 minutes of reentry the automatic guidance system will control the spacecraft during which time the crew will evaluate its performance leading to a GO/NO GO decision on whether or not it should be used. If they stick with the PNGCS, and it works, they will land at the targeted landing point. If they declare it NO GO, they will take over manually, fly a constant acceleration profile and land at a substantially shorter range. The difference between these two landing points is currently about 800 miles, although it can probably be reduced somewhat without changing procedures very much.

6. There are two schools of thought though. John Llewellyn would prefer to make the closed loop guidance more compatible with this shorter range backup mode for obvious reasons. It is Claude Graves' argument that to do so will severely cut into the ranging control needed to avoid bad weather which has been stated as some sort of a requirement from the beginning of Apollo. The issues are not black and white and probably do not require resolution immediately. Several things are going on which will help to make this decision. For example, Claude Graves' people are looking into how much the difference in ranging with the primary and backup modes can be reduced while still retaining the weather avoidance capability and reasonable landing point accuracy. Mike Collins offered to look into the delay we are currently experiencing in FCOD's response to our query about preferable reentry g profiles. This is of interest since the backup mode results in some 250 seconds spent in excess of 3 or 4 g's while the primary mode gives two 50 second spikes up to 5 g's each separated by about 3½ minutes of low g's. Apparently, the onboard

programs as they are currently designed cannot be made completely compatible with a short range backup mode, although they will handle trajectories much closer to it than we are currently proposing. It was stated that complexity of procedures for each of the approaches are relatively equivalent.

7. An apparent discrepancy was uncovered regarding the EMS initialization. Specifically, prior to reaching 400,000 feet the primary guidance system will orient the spacecraft to one of four possible roll attitudes: 15°, 165°, 195° or 345°, that is, 15° to one side or the other of straight up or straight down. It cannot be predicted which of these will be commanded. Unfortunately, it is necessary that the EMS roll attitude indicator and the spacecraft attitude be the same when it is started, and as I understand it, this occurs substantially after PNGCS takes control. Actually, those of us present were not real sure how it all works, and Claude Graves took the action item of finding out what the score is.

8. We'll work on all this some more and within two months we'll get together with NR and MIT too.

Howard W. Tindall, Jr.

Enclosure
List of attendees

Addressees:
(See attached list)

ATTENDEES

M. Collins	CB
C. F. Deiterich	FC
J. S. Llewellyn	FC
J. C. Adams	FM
C. A. Graves	FM
J. C. Harpold	FM
M. Rahman	GP
H. W. Tindall, Jr.	PA

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: JAN 17 1968
68-PA-T-13A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: No change needed in the landing site determination programs - CMC or RTCC

1. During a Data Priority meeting a couple of months ago in which we discussed need for lunar landmark tracking, we uncovered what we felt to be a deficiency in the Colossus computer program. It was in the program which is used for determining the location of the landing site. Implicit in the program was the need for physically offsetting the optics from the associated known landmark to the center of the landing site itself. As a result, a program change request (PCR) was presented to the Apollo Spacecraft Software Configuration Control Board (CCB) on January 8 to correct this deficiency. It was felt to be a mandatory change based on the information available at that time although the precise derivation of it had not been established.

2. On January 12 a group of Flight Crew, Flight Software, Mission Planning and G&C people (see attached list) met to discuss implementation of this program change. Results of this meeting were certainly unexpected. Namely, it was concluded that the change was not needed at all and it was obvious that the CCB should be so advised. It is my understanding that MIT has not actually done any work yet and they have been notified of our conclusion. Some rather lousy operational procedures appear to be necessary during the lunar landing mission in order to do the job, but that is not as a result of any deficiency in this program. The remainder of this memo will be spent discussing those remarks.

3. [illegible] targeting of the descent can only be performed on the ground, the rationale having been that without communications there would be no descent and with communications the ground could supply all necessary information. Thus, the task to be performed is for the ground to be capable of determining the spacecraft state vector and the landing site position consistent with one another based upon which it can perform the necessary spacecraft guidance targeting computations. To do this it is necessary for the ground to obtain from the CSM optical observations of the landmark associated with the landing site. It really is immaterial whether or not the spacecraft is able to compute the landing site location; it is

desirable that the spacecraft can compute the location of the associated landmark to assist in auto optics positioning but even this is not essential. The point is, the capabilities that are required are available within the program as it is currently written although it is probable we will utilize this program in a different way than the people who developed it intended.

4. The operational problems came about from a variety of sources. First of all, when the spacecraft is in an attitude permitting optical observations of the landing site it is virtually certain the S-Band antenna cannot be directed toward the earth. This will probably cause concern for a number of reasons. The specific one which concerned us was that it would not be possible to obtain the optical observations on the downlink until the spacecraft had completed its pass and could be oriented to re-acquire S-Band antenna lock on. Even then it is only possible to get the observations on the downlink as the crew processes them one by one. Of course, this will also result in an onboard determination of the landmark position, if that is worth anything. The procedure is further complicated by the fact that these observations---up to five of them, each one of which consists of 2 optics angles, 3 IMU gimbal angles and a time---are stored in erasable memory and are subject to destruction if proper program sequencing is not observed. For example, it will probably be necessary for the crew to orient the spacecraft and re-acquire S-Band antenna lock on manually since the computer programs which do that job probably share erasable memory with the navigation program. There may also be problems associated with timeline conflicts. For example, the spacecraft goes into darkness almost immediately after making these observations and it is expected that a platform alignment will be required during the night time pass. Furthermore, for a westerly launch site, time between obtaining the observations and passing behind the moon is only about 15 minutes which will make it necessary to do these things very quickly. And to further complicate matters, it is probable that the LM has already been manned forcing one man to do it all by himself along with his many other duties.

5. I don't mean to be making a big deal of this, rather I am just trying to give some insight into the situation. In essence, programs as they are currently planned for both onboard and on the ground appear to be adequate. Fairly complicated crew procedures will be necessary and will be developed. Changes to the programs even if they were possible would probably not relieve the crew workload significantly.

Howard W. Tindall, Jr.

Enclosure

Addressees:
(See attach-

ATTENDEES

N. Armstrong	CB
C. Conrad	CB
D. C. Cheatham	EG
C. T. Hackler	EG
F. V. Bennett	FM
R. T. Savely	FM
T. M. Conway	FS
T. F. Gibson, Jr.	FS
G. Sabionski	FS
H. W. Tindall, Jr.	PA

Enclosure 1

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

DATE: JAN 16 1968
68-PM-T-12

TO : See list below

FROM : PM/Deputy Chief

SUBJECT: Automatic rendezvous boresight into Luminary

1. [illegible] to report an [illegible] item coming out of the [illegible] Configuration Control Board meeting of January [illegible].

2. A [illegible] LM [illegible] navigation the LGC program [illegible] with the radar boresighted [illegible] until the command module [illegible] would compute an automatic [illegible] to reach [illegible] and, given astronaut [illegible] execute it. The flight crew has bluntly [illegible] boresight on the LM con- [illegible] after the CSM maneuver, and had requested [illegible] be modified to do this job automatically [illegible] only they can do. This capability [illegible] to be particularly useful if attitude control in the [illegible] as difficult as [illegible] anticipated. In spite of [illegible] schedule impact on program delivery, [illegible] this change mandatory for Luminary.

3. [illegible] side light of this discussion was Jack Williams' [illegible] no longer considers it necessary to maintain an [illegible] a long period of time. As you recall, previously [illegible] in order to determine radar angle [illegible] more up-to-date analysis has shown this not to be [illegible]

Howard W. Tindall, Jr.

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27
5010-107

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: JAN 16 1968
68-PA-T-11A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: External Delta V for LOI

1. In a December 15 memo (67-PA-T-121A), I indicated that we were going to perform LOI using two maneuvers. I also stated that pending results of some studies then underway we expected to use the External Delta V guidance mode for these maneuvers rather than Lambert steering. The primary reason for doing this was to make the crew's monitoring easier since External Delta V provides a known constant attitude, whereas it was anticipated the Lambert steering would be neither constant attitude nor of a known profile until final targeting of the maneuver. However, the studies have now shown that the Lambert mode can also be targeted to give a constant attitude burn, and since it apparently has some other rather marginal benefits we have decided to select its use for the first stage of the LOI maneuver rather than External Delta V. (The second stage of the LOI will still be done using External Delta V.) The marginal benefits to which I refer are a) slightly lower sensitivity to dispersions in spacecraft weight, engine I_{sp}, and navigation state vector, and b) reduced time we will spend in arguing about and justifying use of External Delta V since there are a number of groups, both at MSC and MIT, who are convinced the Lambert mode is superior.

2. Bob Ernull, please take note. It seems perfectly reasonable to me that the RTCC LOI targeting program should be configured in accordance with the above. That is, if significant effort can be saved by not providing a choice of either Lambert or External Delta V in the programs. I would recommend you save that effort and design the system in accordance with our latest recent decision which I am now relatively confident is firm.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27

UNITED STATES GOVERNMENT

Memorandum

TO : PE/Chief, LM Project Engineering Division

DATE: JAN 16 1968
68-PA-T-10A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: LTA-8 lunar countdown tests not needed soon

1. This memo is to close the loop on an item brought up in a memo from Myron Kayton to me (FC21-M-51-67, dated December 29) regarding a lunar countdown timeline test on the LTA-8. You sent your copy to me stamped "action." I reviewed this business with Myron and some other people. The most important point to be made is that he did not intend to imply addition of these tests in the first series of LTA-8 runs. For one thing, it must be in a lunar landing configuration to be meaningful. Furthermore, we do not have a countdown in hand for the crew to use even if we wanted to do it. Once we are ready to conduct lunar ascent countdown tests, we will probably exercise them in the LMS since this provides the best simulation of the overall operation. As a supplement to that, it may be desirable to include one or two runs with actual equipment such as would be available on an LTA, but I would like to emphasize a simulation test program of this nature has not been laid out, by any means, or is its requirement clear.

2. None of those I spoke to know what is scheduled in your LTA test program. For example, we assume, but ask if it is true, that the LTA will be recycled through again, or is this a one shot affair. If it is going to be run again we would be interested in when you envision it being done in the lunar landing configuration, so that any proposals we might make are compatible.

Howard W. Tindall, Jr.

Enclosure

cc:
CF24/P. Kramer
FC2/M. Kayton
FC5/C. Parker
FD8/J. Loftus

PA:HWTindall, Jr.:pj

UNITED STATES GOVERNMENT

Memorandum

TO : PA/Chief, Apollo Data Priority Coordination

DATE: December 29, 1967

In reply refer to: EG21-M-51-67-

FROM : EG21/Manager, Mission Support Office

SUBJECT: Lunar Countdown Timeline Test on LTA-8

The width of the launch window from the lunar surface is decided by:

a. Delta-h limits in concentric orbit, to allow variable catch-up rate.

b. Maximum range during boost, if RR monitoring is needed.

c. Ability of the crew to successfully complete the countdown within the launch window.

If we are certain that the crew can complete the countdown on time, then a narrow window is suggested. If for some reason the countdown was not completed on time, the crew would wait for the next pass when the completion of the countdown would again be virtually assured.

However, if potential problems can arise during the countdown, we may wish to launch even if the countdown is completed late, since the next countdown might not finish on time either. Built-in hold capability would be needed under such circumstances.

We cannot make such a fundamental decision about the width of the launch window without factual data about the countdown. I suggest that a requirement be placed on LTA-8 for immediate lunar countdown simulations (perhaps five trials with each of ten pilots) in order to evaluate timeline and hardware problems and in order to ascertain the probability of on-time completion of a countdown. Simultaneously, I suggest LMS simulations to determine how built-in holds can be added to the countdown. The touchdown and lift-off tactics depend upon which launch-window strategy we choose to follow.

Myron Kayton

cc:
PD8/J. P. Loftus
CF24/P. Kramer
PE/O. Morris

EG21:MKayton:bjs 12-29-67

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: JAN 18 1968
68-PA-T-9A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Latest on TLI

1. It looks like all we need now is Headquarter's concurrence to eliminate command module steering of the S-IVB during the TLI maneuver. Unbeknownst to me, MIT was directed to stop work on this program (P-15) shortly before Christmas. They estimated that P-15 would become pacing if they did not start working again by January 15 and they have been told not to start. Work going on within MPAD and TRW associated with this spacecraft capability, is also being terminated and I recommend RTCC program and associated MCC display requirements be dropped immediately, too. (Of course, all effort required to make the TLI GO/NO GO decision must be continued.)

2. During the many recent discussions of TLI, crew monitoring when the S-IVB is guided by the Saturn system has repeatedly come up. It is our current intention to use the average g program (P-47) from which it will be possible to call up displays of velocity, attitude and attitude rate---the same parameters that are available during the launch phase. This will require a small program change which the Flight Software Branch is coordinating with MIT in preparation of the total FCR. I have been told there is no schedule impact.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: JAN 10 1968
68-PM-T-8

FROM : PM/Deputy Chief

SUBJECT: AGS accelerometers may not work.

1. Apparently, there is a basic problem in the LM Abort Guidance System (AGS). Although it is not widely known, there is a rumor the accelerometers do not work and it is highly likely G&C Division will elect to procure the AGS accelerometers from another source. Since it is too late to obtain and incorporate them into the system immediately, LM-3 and LM-4 will use the original accelerometers in the AGS. I believe it is their intention to select the best ones available in hopes of avoiding an unoperable system.

2. I am writing this note since, if the AGS is considered undependable on LM-3 and LM-4, this fact should be taken into account in mission planning and data priority decisions for those missions. For example, it seems highly undesirable to plan on utilizing the AGS for executing maneuvers in a nominal mission as is currently planned on Mission "D".

Howard W. Tindall, Jr.

Addressees:
(See attached list)

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: JAN 1[illegible] 1968
68-FM-T-7

FROM : FM/Deputy Chief

SUBJECT: Crew familiarization and training for TLI

1. During our many discussions on the need for command module steering of the S-IVB during TLI, a potential crew familiarization/training problem became apparent. Specifically, even if the P-15 CSM TLI steering is retained, it is not obvious that it will be possible to make the AMS faithfully reproduce the attitude excursions which may be encountered due to such things as propellant slosh, structural bending and, particularly, propellant utilization system oscillations. For example, the AS-501 mission oscillations around the expected attitude apparently are in excess of 10° with some rather high attitude rates.

2. I checked with Jim Miller with regard to fidelity of the modeling in the CSSC and he informed me that all of these characteristics have been included in their program, and it would be no problem for them to supply open loop trajectory tapes to the AMS and closed loop simulations when the AMS is tied into the MCC. I just wanted to make sure that all of you were aware this capability probably exists today. Jim told me he intends to run some AS-501 cases and compare the results with our actual experience to verify his system is right.

Howard W. Tindall, Jr.

Addressees:
CA/D. K. Slayton
CF/W. J. North
P. Kramer
C. D. Nelson
FA/C. C. Kraft, Jr.
FC/J. D. Hodge
C. Parker
H. G. Miller
G. L. Paules
FM/C. R. Huss
FS/L. C. Dunseith
J. Miller
PA/G. M. Low

FM:HWTindall, Jr.:pj

UNITED STATES GOVERNMENT

Memorandum

1-16-68

TO : FC?/Chairman, Ascent Phase Mission Techniques Working Group

DATE: JAN 15 1968
68-PA-T-6A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Some thoughts about Lunar Ascent procedures

1. Charley, please excuse this memo. It's to help me remember and let some others know what we're considering.

2. Now that we have almost certainly lost LM rendezvous radar as a tie breaker for AGS/PNGCS discrepancies in velocity magnitude during lunar ascent, we will have to pin down procedures that are consistent with what's left. I assume we will utilize the VHF ranging device if it turns out to be capable under ascent conditions (that is, multipath, range, etc.). Since it is not on the telemetry downlink, I suppose it requires voice relay from the command module to the LM for the LM crews use. In addition to that, it seems highly likely that velocity magnitude difference can be detected from the DSKY and DEDA during the final stages of ascent, both onboard the spacecraft and on the ground, which will enable us to determine that a PNGCS engine shutdown will be undesirable. I refer to the situation where the AGS shows a significantly smaller velocity magnitude than the PNGCS. Accordingly, specific procedures will have to be established for preventing the PNGCS from doing the job by manually inhibiting it and by taking over spacecraft control in some way. I think we all agree it would be undesirable to switchover to the AGS. I think we also agree that it would be undesirable to have the APS "prematurely" shutdown forcing immediate re-ignition to make up the AGS displayed delta V deficiency.

4. The question before us is how and when do we evaluate the delta V deficiency, what is the limiting value, how does the crew inhibit the shutdown signal and what sort of attitude control mode will be used? Following the maneuver, what will be the procedure to determine what the situation really is, that is, AGS right/PNGCS right, and how do we handle the situation subsequent to that?

5. It would be interesting to know maximum dispersion in Ascent burn time. It would be interesting to know how long it takes to re-ignite the APS once the PNGCS has shut it down. It would also be interesting to

know what sort of transient you could expect if you actually did switchover from the PNGCS to the AGS with only a velocity magnitude difference. I suppose that may not be a totally unacceptable procedure.

Howard W. Tindall, Jr.

cc:
CB/E. Aldrin, Jr.
C. Conrad
T. P. Stafford
CF24/P. Kramer
CF32/T. Guillory
EG43/M. Kayton
C. T. Hackler
PD4/A. Cohen
FA/C. C. Kraft, Jr.
FC/D. B. Pendley
FC3/A. D. Aldrich
FC4/R. L. Carlton
FC5/P. C. Shaffer
FS5/T. F. Gibson, Jr.
J. Williams
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/J. P. Bryant
J. R. Gurley
E. D. Murrah
A. Nathan
FM14/R. P. Parten
FM5/R. E. Ernull
FM7/S. P. Mann
R. O. Nobles
FM/Branch Chiefs

TRW (Houston)/R. Boudreau

PA:HWTindall, Jr.:pj

1-12/5

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : FA/Chairman, Apollo Spacecraft Software Configuration Control Board

DATE: JAN 11 1968
68-FM-T-5

Very good

FROM : FM/Deputy Chief

SUBJECT: AGS/PNGCS incompatibility review - Chapter One

1. At the January 8 meeting of your CCB I was given the action item of reviewing AGS SCP's Nos. 34 and 35. Specifically, I was to determine our position on the advisability of making these changes which you tentatively approved at that meeting, and, in particular, we are to satisfy ourselves that the AGS and PNGCS were sufficiently compatible. This memo is to report the results of that review.

2. AGS SCP No. 34 dealt with changing the limit on $\ddot{Y}_d$ as a function of vehicle configuration. This parameter, known as the "Jerk" (that is, rate of change of acceleration), influences attitude control of the spacecraft in the event of switching over to the AGS during a descent abort or during ascent. This change makes the AGS compatible with the PNGCS for monitoring purposes as well as minimizing attitude changes in the event of a switchover after 150 seconds into the powered descent maneuver. More important than that, it provides a safer insertion perilune if the AGS is utilized. Specifically, it would always aim for a value of 60,000 feet. This change does make the AGS somewhat incompatible with the PNGCS during the first 150 seconds of this maneuver which is a small disadvantage to the change. However, it was the consensus that the advantages far outweigh the disadvantages and we agree with your direction to TRW regardless of the outcome of the following proposal. An additional factor that came out during our meeting was that it is quite desirable to change the PNGCS to operate in the same way as the AGS and a PCR is being prepared by Floyd Bennett's people for the consideration of your panel. Although this certainly cannot be considered a mandatory PNGCS program modification, it provides three significant improvements. Specifically, it would make the AGS compatible with the PNGCS throughout the entire descent phase. More important, it would cause the PNGCS to target for a safer perilune. And most important of all, we would be able to move the mode change limit from 150 seconds into the powered descent to a much earlier time---probably to a value of 50 seconds or less; this reduces the probability of having to stop and restart the DPS by that amount. These final remarks are to make you aware of the status and are, by no means, meant to convince you of the desirability of this program change.

3. AGS SCP No. 35 is a small change to compensate for dispersions in cutoff altitude by adjusting the cutoff velocity. I believe the number proposed is 7 fps for each 10,000 feet altitude error. It was our opinion that it was a desirable change in the AGS since it will provide a somewhat better insertion orbit with no apparent disadvantage. The resulting incompatibility with the PNGCS is trivial with regard to guidance system monitoring and certainly does not necessitate a like change in the PNGCS. In fact, we do not propose that that even be considered.

4. The above discussion deals with our specific action item, but implicitly there was a much larger one, namely, review the overall AGS/PNGCS compatibility situation. Actually, Floyd Bennett had personnel of his branch already engaged in this activity and a memo outlining all of the identified differences is in final stages of preparation at this time. Both of the items discussed above, of course, were included on this list. Once they have satisfied themselves that the list is complete based on discussions with all interested parties, we will review them in detail and prepare a presentation for your panel describing the situation and recommending alternate courses of action for consideration.

Howard W. Tindall, Jr.

cc:
CB/E. Aldrin, Jr.
C. Conrad
T. P. Stafford
CF/W. J. North
CF24/P. Kramer
EG/R. A. Gardiner
EG43/M. Kayton
PD4/A. Cohen
FC/J. D. Hodge
FC4/J. E. Hannigan
R. L. Carlton
FC5/G. S. Lunney
C. B. Parker
P. C. Shaffer
FS/L. C. Dunseith
FS5/J. C. Stokes
T. F. Gibson, Jr.
J. Williams
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/A. Nathan
FM7/S. P. Mann
R. O. Nobles
FM/Branch Chiefs
FM2/J. D. Payne

Bellcomm (Hqs.)/R. V. Sperry
MIT/IL/R. R. Ragan
TRW (Houston)/R. Boudreau

FM:HWTindall, Jr.:pj

UNITED STATES GOVERNMENT

Memorandum

Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: JAN 11 1968
68-FM-T-3

FROM : FM/Deputy Chief

SUBJECT: Odds and ends about lunar landmark tracking

1. This memo is just to pass on some numbers which I found interesting when reviewing the lunar landmark orbit determination procedures. It is not intended as an argument "for" or "against" using landmark tracking by the command module for navigation.

2. It is Jonn Dorenbach's opinion that in order for a landmark to be visible by earthshine it must be in the order of 3,000 to 4,000 feet in diameter. It is his estimate that landmarks located by Lunar Orbiter photographs could be pinned down to within about 4 to 6 kilometers.

3. I would conclude from this that landmarks in earthshine and landmarks located by the Lunar Orbiter could be used for onboard orbit determination, but that the resulting ephemeris would be significantly more in error than published estimates of landmark tracking navigation accuracy using properly illuminated and located job-ee-dos, as Pete Conrad would say.

Howard W. Tindall, Jr.

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27
5010-107

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: JAN 11 1968
68-PA-T-2A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: First 2 hours on the moon is a countdown to launch - simulated or real thing.

1. Those who participated in the STAC presentation already know this, but perhaps some of you, like me, had not heard. It is currently proposed that on the lunar landing mission the first two hours on the lunar surface will be devoted to spacecraft systems checks and launch preparations which, for all practical purposes, simulates the final two hours before ascent and rendezvous. Going through an operation like this has a number of obvious benefits. It's a good pre-ascent "simulation" which lets you find out early if there are problems associated with that operation such as performing the necessary tasks within the time allotted. And, of course, it prepares the spacecraft for lift off at the end of the command module's first revolution if that action is required in response to some emergency situation. Also, it makes the countdown for that event the same as the countdown for the nominal ascent lunar stay---that is, standardizes procedures.

2. In preparing our mission techniques data flow we are assuming that the lunar operation will be conducted in this way. I assume those responsible for planning other facets of the lunar operation are doing the same.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: JAN 09 1968
68-FM-T-1

FROM : FM/Deputy Chief

SUBJECT: Lunar landing lighting constraint change

1. I have been delinquent and I apologize for not sending this note around sooner. About a month ago I learned in a discussion with Joe Loftus that it is his recommendation, apparently based on considerable analysis and review, that the acceptable sun-angle-at-lunar-landing boundaries should be revised. As I understand it, the old sun elevation angle at the landing point limits were between [illegible]° and 20° in order to reduce the possibility of light washout. He is recommending that this be changed to between [illegible] and [illegible]. I do not know the status of this, that is, whether action has been taken to make these values official or not.

2. If you are interested I recommend you get in touch with Joe Loftus. You have probably already heard this, but---just in case!

Howard W. Tindall, Jr.

Addressees:
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/J. P. Bryant
J. R. Gurley
E. D. Murrah
A. Nathan
FM14/R. P. Parten
FM[illegible]/B. D. Weber
FM[illegible]/R. E. Ernull
FM7/S. P. Mann
R. O. Nobles
FM/Branch Chiefs

FM:HWTindall, Jr.:jp

NASA0002

TINDALIGRAMS
JULY - DECEMBER 1968

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

UNITED STATES GOVERNMENT

Memorandum

TO : PD/Chief, Systems Operations Branch

DATE: December 13, 1968

68-PA-T-274A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: APS and DPS operational constraints clarification is needed

Procedures for descent abort (and nominal ascent, too) can be made significantly simpler if we assume it is possible to operate the DPS and APS engines to propellant depletion. You have indicated this is an acceptable way to operate the engines both verbally and in writing, and mission techniques have been developed based on that. This memo is to request that the official Operational Data Book be updated to reflect this constraint - or really lack-of-constraint.

Another characteristic of the DPS which should be clarified in the Data Book is the real throttle up constraint. Currently it shows a requirement for at least 15 seconds operation at 10 percent thrust prior to throttle up to provide sufficient time for trimming the gimbals. As I understand it, engine stability is the only real constraint and that takes much less than 15 seconds. This also has an influence on descent abort procedures since the LM spacecraft computer is now programmed to command full thrust immediately and we'd prefer to operate it that way if this 15 second constraint is not really valid. And we're currently assuming that it's not.

Please call if you have any question and let me know as soon as possible if our assumptions are wrong.

Howard W. Tindall, Jr.

cc:
FC/E. F. Kranz
FC4/J. B. Craven
FC?/C. T. Hackler
FM/D. H. Owen
FM2/F. V. Bennett
FM6/E. C. Lineberry
FM7/M. D. Cassetti
FM13/J. R. Gurley

PA:HWTindall, Jr.:js

Tindallgrams missing, July - December, 1968: 147, 149-150, 155, 156, 160, 164-166, 172-174, 177-181, 184, 186, 187, 195-204, 214, 216, 227, 231-233, 236, 335, 343-346, 350, 355-361, 362-365, 371, 373

Buy U.S. Savings Bonds

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: December 16, 1968
68-PA-T-272A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Revision to the C' Lunar Orbit Activities Document

Attached are the three change pages for the C' Lunar Orbit Activities Document. The changes are indicated by the black bar on the right-hand margin.

Howard W. Tindall, Jr.

Enclosures

PA:HWTindall, Jr.:jn

1. INTRODUCTION

This document discusses the activities scheduled to take place during the ten orbits of the nominal C-prime lunar mission. The major activities discussed are:

a) MSFN tracking coverage

b) Navigation sightings

c) IMU alignments

d) Uplinks, downlinks and voice (PAD) data

e) Contingency situations

f) Photographic

g) Television

The primary objectives of the lunar orbit are:

a) Obtain data for postflight analysis to evaluate the errors in MSFN orbit prediction solutions.

b) Obtain data to allow postflight evaluation of the errors in landing site determination.

c) Evaluate the procedures for lunar landmark tracking with respect to vehicle controlability and the ability to visually acquire and mark on landmarks with the SCT.

d) Obtain data for postflight evaluation of the spacecraft Orbit NAV Program (P22).

e) Determine the minimum sun angle at which lunar landmarks can be identified with the clarity required for tracking.

f) Obtain photographs to be used with simulators to provide crew training for subsequent missions.

g) Obtain photos of the lunar far side and eastern limb where previous photos were of poor quality.

5. UPLINKS, DOWNLINKS, AND VOICE (PAD) DATA

State vectors to provide the block data reference for TEI, in the event an abort is required, will be uplinked by MCC-H for every rev except after LOI-1 and LOI-2. For these two cases the CMC navigated state vector is assumed to be the best vector available at the time. (These CMC vectors will be evaluated by Data Select in real time as tracking data is obtained.) The uplinked state vectors will be based on tracking data obtained during the previous orbit and the vectors will be time tagged immediately prior to the next TEI opportunity approximately 1 hour later (1/2 rev). These vectors will be loaded in the CMC LM slots only rather than in both CSM and LM slots. The load is accomplished in less time with this procedure. (Three minutes are required to load a vector into either CMC slot.) If the uplinked vector is needed for an abort the crew will perform the 4 DSKY entries required to transfer the vector from the LM slots to the CMC slots (UNZAP). The P27 links will occur after passing the moring terminator but prior to the P52 alignments. Figure 2 shows the approximate location of the SC for the selection of these programs.

Associated with these state vectors is the block data sent up every rev to provide the TEI maneuver data. Tables 1 and 2 show the typical abort pad format and data transmitted each rev, respectively. The ground does not uplink abort maneuver data to the CMC for P30. Target ΔV data is loaded into the CMC only for planned maneuvers (LOI, TEI).

The state vectors for the planned maneuvers (LOI-1, LOI-2, and TEI) will be uplinked into both the CMC and LM slots. This is a safeguard in the event only the LM slot is loaded and the crew does not UNZAP the LM vector. After these planned maneuvers the integrated CSM vector will be transferred to the LM slots (ZAP).

To assist the crew with the landmark sightings, the estimated ground elapsed time of clos[illegible]st approach to the first identification point (IP) associated with th[illegible]rks will be sent by the ground. Ground elapsed time wi[illegible] be pr[illegible] for the closest approach to the unknown landmark [illegible]P's p[illegible]ior to the [illegible]irst time they are to be tracked and for the clos[illegible]st approach to the pseudo landing site landmark IP prior to each time it is to be tracked.

Table 2. Block Data Transmitted

Time Data Transmitted	Block Burn Data (TEI-x = TEI Performed at End of Revolution x)	Remarks
Pre-LOI-1	a) TEI-1	Assumes LOI-1 executed
	b) TEI-2	Assumes LOI-1 executed
	c) MCC 5	Assumes no LOI-1 executed, ΔV for return to CLA, perhaps fast return
Rev 1 (~LOI-1+1hour)	a) TEI-1	TEI-1 ΔV updated based on GNCS TM indication of LOI-1, ΔV
	b) TEI-2	Updated based on GNCS vector
Rev 2 (~LOI-1+3 hour)	a) TEI-3	Assumes LOI-2 accomplished
	b) TEI-3*	Assumes LOI-2 not performed
Rev 3 (~LOI-2+1 hour)	a) TEI-3	Updated based on GNCS vector
	b) TEI-4	Based on same GNCS vector
Revs 4 through 10	a) TEI-5 through TEI-10	One per rev based on MSFN vector

*Sent up in the event of total communications failure prior to LOI-2, in which case LOI-2 is not performed on the next rev.

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: December 9, 1968

68-PA-T-270A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: F Mission Techniques - LM Checkout

On December 6 we had our first F Mission Techniques meeting dealing with pre-DOI activity. It resulted in a lot of things I never expected, since I thought the timeline and procedures for LM checkout and CSM landing site tracking were pretty well organized and acceptable with just minor tune-up. At this meeting we really shook up the world and are now looking into substantial changes in overall concept as well as changes to the detailed techniques. The two most significant proposals under consideration now involve the following:

a. There are good reasons - and a strong desire on the part of the crew - for manning and checking out the LM prior to putting on their bunny suits (PGA's). The significance of this as I understand it is that the crew feels they can perform their tasks much easier without the suits on - including moving from one spacecraft to the other quickly and easily and then suiting up at some convenient time integrated in with the other activity just prior to DOI.

b. Everyone is now seriously looking into the benefits and disadvantages of scheduling a period of LM checkout prior to DOI Day. The idea is to see if it is possible to shorten DOI Day by manning, powering up and checking out many of the LM systems, and then powering it down again prior to LOI (actually before the last translunar midcourse correction) or immediately after LOI_2 before the rest period. Of course, it must be determined that checkout carried out at this time need not be repeated after powering down the LM and that the time and energy spent during this earlier period is not too expensive. It must be emphatically stated that our decisions must be based on G mission constraints since they may be tougher to meet than the F mission. The point is that we certainly do not want to set up a special technique just for F since one of our primary objectives is to use F as a dress rehearsal for G.

If we schedule a pre-LOI period for LM activation and checkout, the configuration on DOI Day will be:

a. LM will be pressurized

b. Drogue and probe will be stowed in the CSM (any structure or c.g. problem for LOI?)

and the following system checks will have been made:

a. S-Band steerable has been checked
b. VHF - B simplex checked
c. COAS and AOT lighting checked
d. LR checked
e. LM S-Band (PRN) ranging DTO accomplished
f. Cabin regulator checked
g. DPS throttle checked
h. Oxygen purge system checked
i. RCS cold firing (requires LGC and IMU powered up)
j. Gimbal drive test (requires LGC and IMU powered up)
k. PGNCS gyro drift checked
l. PIPA gyro drift checked
m. CES rate gyro checked
n. LGC E-memory dumped and checked - and reloaded if necessary

Again, the major reason for doing this is to reduce the pre-DOI timeline since on both F and G the DOI Day has grown excessively long. Specifically, the current timeline provides about 10 hours between wake-up and the DOI maneuver. More than one-half the day is gone before they even start doing anything.

So you see quite different than my naive pre-meeting impression, we have a lot of things to do to get this thing squared away, but before we can even do that we have to get some fairly significant decisions on the two items noted above. Of course, we must do enough work to supply the data required to get these decisions, unless someone wants to arbitrarily choose our course of action. We intend to get together again on Friday, December 13 to continue our deliberation. In the meantime, we are hoping to get some opinions from around the country whether this is an insane approach or not.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: December 6, 1968

68-PA-T-266A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: C' Abort Maneuver Overburn Monitoring

In response to a C' Mission Techniques action item, Rick Nobles informs me that they have established the burn monitoring procedure to guard against overburn during any non-nominal C' maneuver. As a standard procedure the crew should manually shut down the SPS as soon as the duration of the burn exceeds the nominal value by one percent and the EMS ΔV Counter indicates an overburn of one percent over its nominal reading. The nominal value of burn time and ΔV Counter reading are included in the PAD messages and block data relayed from the MCC-H for all abort maneuvers. (Current Mission Techniques Documentation reflects this procedure.) It is to be emphasized that this overburn monitoring procedure is only for the non-nominal maneuvers and does not apply to TLI, LOI, and TEI for which specific techniques have been developed.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

UNITED STATES GOVERNMENT

Memorandum

TO : EG/Chief, Guidance and Control Division

DATE: December 6, 1968

68-PA-T-265A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: GDC required for TLI

In reference to your November 18 memo to me in which you state that the Gyro Display Coupler (GDC) is required to be operable for commitment to TLI, I would like to assure you that current C' mission rules reflect this requirement. It is agreed by everyone I have talked to that redundant attitude reference systems are required prior to leaving earth parking orbit and, of course, without the GDC there is no backup to the GNCS.

Please excuse this late reply. I took action on receipt of your memo and then failed to inform you of it until I recovered it yesterday from the bottom of my "Immediate Action" basket.

Howard W. Tindall, Jr.

cc:
PA/G. M. Low
FC/C. E. Charlesworth
FC5/C. B. Parker
TRW/Houston/R. J. Boudreau

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: December 4, 1968
68-PA-T-264A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Some Mission D contingency plans

During a recent D mission rules review a couple of interesting things came up that I hadn't heard of before. You probably ought to know about:

a. The crew is considering making the docked DPS burn even if the PGNCS has failed. They would do this by turning off the gimbal trim motors - leaving the DPS in its pre-launch position, setting the AGS attitude control to pulse, and manually controlling attitude using the lateral translation RCS thrusters. They intend to check out this procedure in their crew trainer. And, this may be the only place it gets checked out before flight!

b. There was quite a discussion about what to do if they are unable to separate the LM and the S-IVB. The crew seems inclined to man the LM and power it up sufficiently to permit staging the DPS. That is, they would leave the DPS connected to the S-IVB and pull out only the Ascent stage. It is not clear what can be done with the LM in this configuration and so it is not clear what benefit is derived. Also it is not clear what risks are involved. Both of these are being evaluated in order to decide if this is worthwhile or not.

Howard W. Tindall, Jr.

Addressees:
FM/J. P. Mayer
C. R. Huss
D. H. Owen
FM12/R. P. Parten
FM/Branch Chiefs
MIT/IL/M. W. Johnston
NR/Downey/J. C. Johnson (4), AB46

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: December 2, 1968

68-PA-T-263A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Proposal to add something nice to the F mission

If it makes sense, I would like to start a campaign to add some actual powered descent into the F mission with an abort about 300 seconds after PDI or whenever it is that the DPS can return the LM to the desired orbit. Could you people please give me a list of the benefits we can obtain by doing this, such as:

a. Realistic full duration DPS test

b. Landing radar tests

c. Powered flight MSFN data to test the Lear processor

d. PGNCS guidance test

e. Shortening the rendezvous two hours

You might also identify hazards. If the results of this survey are positive, I will put together a proposal and try it out on our leaders.

Howard W. Tindall, Jr.

Addressees:
FC4/J. E. Hannigan
J. B. Craven
CF24/M. C. Contella
EG2/C. T. Hackler
FM/J. P. Mayer
C. R. Huss
D. H. Owen
FM12/R. P. Parten
FM/Branch Chiefs
MIT/IL/M. W. Johnston

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: November 29, 1968

68-PA-T-262A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: D Rendezvous Mission Techniques

This memo is to tell you about the results of the November 25 D Rendezvous Mission Techniques meeting. Except for a number of small clean up items, we spent most of our time talking about how to handle slippage of TPI time and incomplete Insertion and Phasing maneuvers. After an exhausting discussion, I think we have those items under pretty good control now.

1. There was a discussion of various techniques for aborting from the mini-football. The only procedure we will pursue is for the CSM to make a "tweak" maneuver at the horizontal crossing if necessary to return the two spacecraft to a nominal relative motion mini-football. This maneuver will be made only if it is known that an abort is required. It shall be based on a chart the command module pilot carrys.

2. It had previously been decided to stage the DPS if the LM must make the TPI_0 maneuver - abort from the football. Of the several techniques proposed, the one most favored now to preclude DPS recontact is to impart an out-of-plane ΔV to it as part of the TPI_0 maneuver. The crew is going to try out the following procedures in the simulator and if acceptable we will stick with them for flight.

a. Just prior to TPI TIG but after Average g comes on, the LM will thrust laterally using the y-axis RCS jets to build up approximately 5 fps out-of-plane.

b. At TIG they will start thrusting with the plus x-axis RCS jets and stage the DPS as soon as acceleration exists. The out-of-plane ΔV will be removed with the TPI thrusting with the x-axis jets by yawing the spacecraft (i.e., spacecraft roll). (We are told there is no problem in reinitializing the attitude control DAP for the staged configuration in SUNDANCE.) If the CSM is active for TPI_0, the LM shall not stage the DPS.

3. It had been recognized that when computing TPI in the football trajectory it is possible to get two different solutions since there are two times the relative angle between the spacecraft passes through 27.5 degrees. Both MPAD and MIT have run analysis to determine what happens and how to handle the situation. The following table summaries

the results:

Time From Phasing	PGNCS Operation
0 to 45 minutes	Alarm code (no solution)
45 to 85 minutes	Desired solution obtained (TPI = 70 minutes)
85 to 87 minutes	Wrong solution obtained (TPI = 87 minutes)
Greater than 87 minutes	Fails to converge

The nominal TPI$_0$ time we went to use is about 70 minutes after the Phasing burn and if the crew uses that value as an input to P34, there should be no trouble since it's well inside the boundaries which yield the desired solution.

4. Experience has shown that the crew simulators - LMS and CMS - do not accurately duplicate the true spacecraft guidance system with respect to the time the computers take to perform their operations. Specifically, the crew trainers run considerably faster than the actual flight computer and if not taken into account, this characteristic can badly mislead those responsible for setting up crew procedures. As a result, we levied an action on MIT to determine the actual, real-life computer time required to perform a list of specific operations. This list is included as an attachment to this memo. Based on this, I'm told the simulators can be fixed to be more realistic.

5. At this meeting we finally defined the acceptable TPI window and the procedures to be followed in the event TPI falls outside the window. MPAD reports that the current three sigma estimate of TPI time dispersion is ± 4 minutes. What I mean by this is that by using the LM radar navigation to perform the CSI and CDH targeting, errors can result causing the time at which the nominal TPI elevation angle actually occurs to be as much as four minutes from the time the targeting was aiming for. FCSD reports that the acceptable TPI window is 3.5 minutes which you recall, is centered about the nominal TPI time - 25.5 minutes before the CSM breaks into the sunlight. You can see from this that we have a very good chance of being within the acceptable window. However, obviously techniques must be developed to handle the case when we miss.

a. Our discussion revealed that it is unacceptable for TPI to slip earlier than the 3.5 minutes before nominal, since that would cause braking to occur in darkness. Accordingly, if that occurs the crew will recycle into the TPI targeting program (P34) using the Time Option with an input of the <u>nominal</u> TPI time.

b. Discussion also showed that, although undesirable, late TPI is not unacceptable and, in fact, it is preferable to continue to use the elevation angle option with a nominal 27.5 degree value regardless of how late TIG occurs. And, so this is what we shall do.

As you see then, we have a fairly simple logic to guide the crew in choosing their procedure. That is, the crew procedure is based on whether the TPI time as determined onboard the spacecraft occurs earlier than 3.5 minutes before nominal TPI. Since they only have to recycle the TPI computation switching to the Time Option if the TPI is too early by more than 3.5 minutes, they always have at least an additional 3.5 minutes to take action. This makes it possible for the crew to wait for the final computation of TPI after the last rendezvous navigation to make the decision of which way to go.

6. There is a problem brought about by this procedure with regard to what the MCC-H must do for the TPI PAD message. This data - relayed by voice to the crew - is normally used for two things. First to verify that the onboard guidance system is working acceptably and the second is to provide a backup maneuver to be executed in the event it is not. The procedure noted above presents an obvious problem if the crew has to go into the Time Option since there is no way for the ground to compute a compatible solution for comparison. Accordingly, the following procedures were developed, which are only used if the onboard solution of TPI time is more than 3.5 minutes early:

a. The MCC-H computes and relays only one maneuver PAD message - namely, a maneuver based on executing TPI with an elevation angle of 27.5 degrees, regardless of when TIG occurs.

b. Even though the LM crew determines that TPI time is too early, they will call for the 27.5 degree ΔV solution and compare it with the ground data to determine if their PGNCS is working. If it is acceptable, they will use the procedure noted in 5a above, calling for the Time Option with nominal TPI and continuing on without a ground backup maneuver.

c. If the LM comparison with the ground solution is not favorable, the CSM also compares its 27.5 degree TPI solution with the ground and if acceptable, will recycle into the Time Option of P34 using the nominal TPI time and will execute the resultant maneuver. In other words, if the LM PGNCS is broken and the CSM GNCS is working, the CSM should become active for TPI.

d. If the CSM solution is also found to be unacceptable, the LM crew should compare their chart solution with the ground and execute it if acceptable.

4

e. If all of these fail, we have a situation in which TPI has slipped too early, both spacecraft guidance systems have failed, as has the LM backup chart solution and there seems nothing to do but to perform the MCC-H solution. Boy!

7. A lengthy detailed discussion of what to do in the event of incomplete Phasing and Insertion maneuvers led to the following Mission Techniques:

a. Phasing

If the DPS does not light or if the DPS lights but shuts down prematurely, do not stage, null horizontal ΔV's and if possible, trim radial (x-body) $\overline{\Delta V}$ to within 2 fps of nominal. This places the LM in a football, its size dependent on the extent of the ΔV gained. Then it is necessary to choose one of the following courses of action in Real Time, dependent on what caused the premature shutdown.

(1) Execute TPI_0 from the present trajectory this rev or next.

(2) Complete the phasing one rev later (CSM shall be mirror image targeted for this maneuver) using DPS under PGNCS control, RCS (Staged), APS, or CSM (RCS or SPS) followed by TPI_0 at the next opportunity or insertion a quarter rev after that.

This is an appalling number of choices which must be substantially reduced before the flight based on systems considerations, mission objectives and extent of flexibility affected by the crew procedures. The latter is extremely important since the procedures are complex and completely time dependent; they are not easy to recycle into.

b. Insertion

(1) If DPS does not start, stay in football by nulling out ullage.

(2) If DPS does start, the primary goal is to complete the burn using RCS with APS interconnect. If the ΔV required is greater than about 8 fps, staging is required.

(3) In order to be prepared for some mysterious time critical problem discovered within one minute after TIG, the CSM will be targeted with the same burn as the LM to be executed with a one minute delay. This is not a mirror image burn. It nulls the LM burn.

8. MIT reported on an old action item that the CSM PIPA bias check cannot be conveniently reduced below 256 seconds duration.

9. In case everyone has not heard, the SUNDANCE program has been fixed so that the crew can use the rendezvous radar self-test program (R04) during terminal breaking with the Average g program (P47) running simultaneously. That is great!

10. Although not part of the D mission rendezvous, our final discussion of the day involved what the CSM should do during the docked DPS maneuver. Options for the CSM are to use the SPS thrust program (P40), the RCS thrust program (P41), or the Average g program (P47). Due to a limitation in the displays available in P47, which we know would work, the crew would prefer to use P40 or P41. We're not too sure how they will do so we asked MIT to look into how each of these programs would operate during the docked DPS burns such that we may make a final choice.

I don't expect to have any more full blown D rendezvous meetings until the final review of the Mission Techniques Document now scheduled for distribution about December 16. This review will probably be about January 10, 1969.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: November 25, 1968

68-PA-T-258A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Descent Aborts - Part III

We have had a couple more Descent Aborts Mission Techniques meetings resulting in substantial progress which I would like to tell you about in this memo, if you haven't already heard.

A basic ground rule we have established is that these abort procedures go into effect at the time powered descent initiation (PDI) is attempted (i.e., starting at the time of PDI TIG). The point is, if the descent burn is not attempted at all another procedure is used (TBD). But once descent is started and an abort is required, the crew will always go to P70 or P71, the DPS or APS abort programs.

As noted previously we have eliminated the special abort zone during the first 50 seconds of powered descent which used to require special procedures. A simple program change was made to LUMINARY to do this. In order to cause the system to work in an acceptable way, it is also necessary to increase the insertion apogee altitude in the PGNCS targeting. This is done by changing the value of an erasible memory constant in the LGC. (Insertion apogee altitude is now 100 n.m.; it was 60.) A preferable solution was considered for LUMINARY but must be delayed to LUMINARY II due to schedule impact. It is to have the PGNCS compute the optimum apogee insertion altitude in real time based on the phase angle between the LM and the CSM at the time of the abort. It is possible to do this such that the subsequent rendezvous sequence is almost identical to the nominal lunar landing mission rendezvous sequence - always providing a one rev rendezvous with a differential altitude of 15 n.m. This program change will likely be made in the AGS, too - perhaps even in time for the F mission since it is relatively simple. Assuming we are able to fix the PGNCS program for the lunar landing mission, it looks like we have a very good, straight forward, simple and standarized abort/rendezvous procedure.

One caution must be observed since the DPS abort program (P70) commands full throttle immediately. Therefore, if the crew decides to abort on the DPS immediately after PDI they must at least await engine stability before hitting the Abort button. I should also point out that aborts during the first 40 seconds of powered descent will currently result in a spacecraft pitch maneuver which will cause the MCC-H to lose all telemetry until the crew can realign the hi-gain antenna or switch to the omnis. A program change request for LUMINARY II has been submitted to fix this.

Another area in which we have been working is the procedure following a descent abort using the DPS engine immediately after the engine cutoff. Like any other maneuver, the standard procedure is for the crew to call up the ΔV residuals on the DSKY and check the horizontal ΔV still required. Then:

a. If the horizontal ΔV to be gained is less than 5 fps, which should be the usual case for aborts prior to about 300 seconds into powered descent, the crew will trim it with RCS without staging the DPS. Out-of-plane and radial ΔV components will be left untrimmed and their effects will be eliminated by the subsequent rendezvous maneuvers.

b. If the ΔV in the horizontal direction at the end of DPS burn is more than 5 fps but less than 30 fps, we want to stage the DPS off prior to burning into orbit with RCS since RCS plume impingement precludes dragging the DPS along. However, staging presents a problem since the PGNCS digital auto pilot (DAP) will not be aware it has happened. Since it would continue to assume the high inertia, unstaged spacecraft, it would command excessive RCS firing for attitude control. Like LM_1, it would really hose out the RCS fuel. The easiest way around this is to switch guidance control to "AGS" and attitude control to "AGS attitude hold" and then manually translate into orbit with RCS based on the PGNCS DSKY ΔV display. The procedure would be to manually stage immediately after initiation of the RCS trim burn. Again, there is no reason for trimming the out-of-plane and radial ΔV residuals.

c. If at DPS engine cutoff the ΔV residual in the horizontal direction exceeds 30 fps, the procedure is to simply hit "Abort Stage." This will automatically separate the DPS and utilize the APS to complete the maneuver required to achieve the desired orbit. The ΔV required depends on the abort time and can range from as little as 30 fps all the way to a full Ascent duration burn. The 30 fps boundary was chosen because attempts to use P71/APS for smaller maneuvers can result in very large ΔV errors, in fact as much as 60 fps. Again, only the horizontal in-plane component of ΔV need be trimmed after the main engine cutoff.

Of course, in case "a" noted above it will be necessary to separate from the DPS sometime. There was considerable discussion as to whether a special post-insertion maneuver should be made for this or if it was preferable to await the first of the scheduled rendezvous burns - CSI. We finally concluded that the most straight forward procedure was to separate the DPS at CSI in order to avoid the need for more complicated special procedures for this special situation. Separation at CSI rather than immediately at insertion also provides the peripheral advantage of an extra hour use of DPS consumables. But that is not our reason for recommending this procedure. Of course, it will be necessary for the crew to carry out certain DPS safing procedures. Specifically, they must vent the tanks just as they do after a nominal lunar landing. One open item in regard to this is the determination of how propulsive this venting is. If it turns out to be unacceptable we may be forced to provide some special procedure to stage the DPS at insertion. FCD has the action item of determining the magnitude of venting ΔV.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: November 25, 1968
68-PA-T-257A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: LM DPS low level light fixing

I think this will amuse you. It's something that came up the other day during a Descent Abort Mission Techniques meeting.

As you know, there is a light on the LM dashboard that comes on when there is about two minutes worth of propellant remaining in the DPS tanks with the engine operating at quarter thrust. This is to give the crew an indication of how much time they have left to perform the landing or to abort out of there. It compliments the propellent gauges. The present LM weight and descent trajectory is such that this light will always come on prior to touchdown. This signal, it turns out, is connected to the master alarm - how about that! In other words, just at the most critical time in the most critical operation of a perfectly nominal lunar landing mission, the master alarm with all its lights, bells, and whistles will go off. This sounds right lousy to me. In fact, Pete Conrad tells me he labeled it completely unacceptable four or five years ago, but he was probably just an Ensign at the time and apparently no one paid any attention. If this is not fixed, I predict the first words uttered by the first astronaut to land on the moon will be "Gee whiz, that master alarm certainly startled me."

As I understand it, cutting the wire to the master alarm eliminates the low level sensor light too. If nothing else can be done, this should be and we'll get along just using the propellent gauges without the light. If possible, a better fix would be to cut the wire on both sides of the master alarm and jumper the signal to the light only.

Incidentally, on the D mission the propellent levels will be low enough when we get to the DPS rendezvous maneuvers - Phasing and Insertion - that if this system is activated prior to ullage, the master alarm will likely go off. I guess it will be standard procedure to punch it off if that happens. But, where this is just an annoyance on D, it is dangerous on G.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: November 21, 1968

68-PA-T-256A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: C' entry initialization with no communication

Bob Weber, Jon Harpold, and some of their friends got together to work out the procedure for the crew to determine the landing point for targeting the GNCS entry program (P61) in the event of a no communication/return to earth. The procedure is essentially as we laid it out during one of our big meetings a couple of weeks ago with a few minor embellishments. The procedure is as follows:

1. The crew will use the Return-to-Earth program (P37) to obtain the predicted landing point longitude and inertial velocity at the entry interface.

2. Using a chart, they will determine a longitude bias based on the inertial velocity. For lunar return velocities this bias will be approximately three degrees. Since P37 always plans for an entry range which is too long - that is, too far to the east - this bias must be applied such as to result in a more westerly landing point. The resultant longitude is the one we're looking for.

3. Using the Ground Track Determination program (P21) the crew will iterate to determine the latitude of the point on the ground track which is compatable with the biased longitude. This is necessary in order to avoid having the GNCS attempt to reach a target point substantially off the ground track and perhaps even outside the available footprint.

4. The values of the latitude and longitude thus obtained are compared to the last Block data values received from the ground prior to communication loss. If the values of latitude and longitude in the Block data are both within one-half degree of those determined by the process outlined above, the Block data values will be used. If either differs by more than one-half degree the P37/P21 values will be used to target P61.

5. The Range-to-Go display obtained in P61 after input of this target point shall be checked to make sure the GNCS will be attempting to fly a reasonable trajectory. Specifically if the Range-to-Go display used for initialization of the EMS is less than 1350 n.m., the G&N shall be used. If the displayed value is larger than 1350 n.m., the crew should assume something is wrong with the G&N and should manually fly a constant 4 g entry.

Rationale in selecting the above procedure is primarily directed toward providing a safe entry by making all G&C systems available for the crew's use. That is, we want to use the G&N provided it can be initialized properly. Furthermore, we want it to be operated nominally such that the EMS monitoring techniques are standard. To accomplish this it was most important to select a landing point assuring a nominal entry range regardless of where the landing point turns out to be. Of course, if the crew navigation and maneuvers subsequent to communication loss are done properly, the landing point should be predicable and acceptable. Accordingly, the procedures were set up, not to land in any particular place, but rather to provide approximately a 1350 n.m. entry range. By attempting to make the chart as simple as possible consistant with that, we ended up with a linear longitude bias as a function of inertial velocity. Specifically, the chart is a straight line between zero bias at 34,000 fps to three degrees bias at 36,300 fps. It is recognized that we are not taking into account the affects of heading angle and latitude at entry, both of which can affect the entry range somewhat. However, it did not seem to us that the extra complexity in compensating for them was justified. This chart will be relayed to FCSD by Harpold via Mike Collins.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: November 20, 1968
68-PA-T-255A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Is MSFN ranging mandatory for C'?

During our C' Data Select Mission Techniques meeting a question came up which must be understood and answered prior to the flight. It involves the requirement for being able to obtain MSFN range information during the cis-lunar phase of the mission. It has been said unofficially that ranging is essential to do a decent job of orbit determination, although, I'm sure something can be done in its absence. The question is what confidence have we of being able to hit the entry corridor if ranging is not available. I have asked the Math Physics Branch to determine entry corridor targeting accuracy without ranging. If this turns out to be unacceptable, then a mission rule may be needed establishing that certain pieces of spacecraft equipment must be working prior to committing to TLI in support of this requirement. Further complicating the situation is our uncertainty as to just what the spacecraft equipment is - specifically, how redundant and how reliable.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: November 20, 1968
68-PA-T-254A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: C' Mission Techniques - mostly Entry

On Friday, November 15, we had the last C' Mission Techniques meeting I expect we will ever have. It was mostly devoted to entry although, of course, some other odds and ends were discussed.

Before getting into the results of the meeting I would like to report two minor adjustments we have made in maneuver monitoring. Specifically, we have changed the time limit the crew uses in protecting against overburn on TLI by manually shutting down the S-IVB from ten seconds to six seconds past nominal. We have changed the equivalent time on the TEI burn from three seconds to two seconds.

The MCC-H will uplink the entry REFSMMAT shortly after TEI. We intend to use the same REFSMMAT all the way back and no adjustments will normally be made to it prior to entry even though dispersions could cause it to deviate slightly from its nominal 0, 180, 0 values at entry interface.

In the event of communication loss, the crew will use the return-to-earth program (P37) for midcourse maneuver targeting and entry initialization. In a nominal mission this would not be necessary, of course, but the crew does intend to play games with it just to see how it works. It is to be emphasized that P37 must not be used after three and one-half hours before entry interfaces when the MCC 7 update is uplinked, because to do so will cause the External ΔV target load and the landing point location to be revised based on P37 computations and we don't want this to happen.

As noted previously, at EI-15 hours, the MCC-H will inform the crew that MSFN state vectors are adequate to complete the mission in the event of subsequent communication loss. It is to be emphasized that all other information required for carrying out the final midcourse correction and entry must also be supplied at the same time. This includes the complete entry PAD voice message and reentry reference time (RRT). The RRT value will not be changed after this voice message.

Flight Analysis Branch reports there is no recontact problem following CM/SM separation providing the ΔV is at least 3 fps. Of course, it should be substantially more than that.

In all cases, both with and without communication, the crew will hold lift vector up until .05 g's. This makes all the entry procedures standard, which considerably simplifies things.

Non-G&N constant g entries will all be flown with the lift vector toward the north in order to provide the best horizon view. With the EMS working, it was agreed that the crew will hold four g's until crossing the circular velocity line on the EMS. If the EMS is not working, they will maintain four g's as long as it is possible to do so. It is to be noted that it will not be possible to reach the 1350 n.m. target by following this procedure since by the time the crew starts ranging with the EMS they will probably not be able to fly more than 1200 n.m. with the remaining lift capability. Without EMS ranging at all, which is what they get by flying the g meter, a four g entry range is about 1100 n.m. It was decided after considerable discussion to use four g's since that is the center of the acceptable range (i.e., three to five g) and it is impossible to reach 1350 safely using the EMS alone. That would require flying a constant 1.5 g entry and this value is considered entirely too small to positively preclude skipping out. If Claude Graves' people are able to develop a chart for the MCC-H flight controllers to use in determining the time the spacecraft should achieve circular velocity, assuming a four g entry, they will do so and this quantity will be added to the entry PAD message. It will be used as part of the EMS performance evaluation and in the event of a g meter entry it will give the crew some idea when skip-out is no longer possible.

While reviewing the PAD messages, a number of minor adjustments were made. One item which should be reported is that the MCC-H will always include their best estimate of spacecraft weight on the maneuver PAD. The flight controllers recommend that the crew always load this value into the DAP data load routine (R03) regardless of how small the change from what is already presently in memory. You recall that COLOSSUS automatically updates weight during maneuvers. We expect that the crew will exercise some judgment when applying this procedure.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: November 15, 1968

68-PA-T-253A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: No real time landing site data processing is planned on C Prime

In a meeting with Flight Software Branch and Flight Control Division personnel, we concluded that we would not process landing site observations obtained in lunar orbit on the C' in real time in the RTCC unless directed otherwise.

During the C' mission, one of the primary objectives is for the crew to track a pseudo-landing site. This is to collect data to determine how well this can be done on the lunar landing mission in order to target LM descent. It has been proposed that we could actually carry out the same real time computing process in the MCC-H on the C' mission. The advantage of doing this in real time as opposed to post-flight is that we may uncover some subtle problem which post-flight processing would miss. It is to be noted, however, that a complete, high-fidelity rehearsal of this lunar landing mission activity is planned for the F mission which would do this job much better since the spacecraft configuration, crew operations, and MCC-H operations will all be identical to G. Problems encountered during landing site data processing on F could not jeopardize that mission in any way, of course. The disadvantage in attempting to do this is that in order to do it with confidence, RTCC computer time and personnel would be required to check it out and real time operations would have to be established and included in simulations prior to the C' flight. With the flight so imminent it does not seem logical to divert this kind of activity to a non-essential task. Therefore, it is our recommendation that we do not take this additional step on C'.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: November 15, 1968
68-PA-T-252A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: F Rendezvous Mission Techniques

We had our first F Rendezvous Mission Techniques meeting on November 12. We went through the whole thing rather smoothly with very few open items, probably due to all the past work on D and G. Obviously it is a much simplier exercise than the D rendezvous. This memo is to record a few of the significant agreements. Many more were reached but have been understood for some time and are not considered particularly controversial. Attached is a list of action items assigned to MIT.

1. The CSM Separation maneuver from the LM an hour before DOI shall be radially downward 2.5 fps.

2. We intend to use identical REFSMMAT in the CSM and LM. It will be computed by MCC-H at the beginning of the DOI period of activity and will not be changed throughout the entire rendezvous. In fact, it will probably be used for TEI as well. It is keyed to the pseudo-landing site and will not incorporate information obtained by later orbit determination or by optics observations of the pseudo-landing site - just like G.

3. Both the DOI and Phasing maneuvers shall be targeted from the MCC-H, of course. This will be done prior to DOI and relayed to the crew as a maneuver pair. We do not intend to update the spacecraft state vectors between DOI and Phasing from the MCC-H. However, a period of rendezvous tracking and navigation has been tentatively scheduled for about 30 minutes during that period.

4. The CSM will be targeted and counting down to make the first maneuver of a Hohmann transfer to a 20 n.m. circular orbit if the LM becomes inactive at phasing. The command module will also be prepared to execute a mirror image type maneuver when the LM executes the Insertion burn which starts its duplication of the lunar landing mission rendezvous.

5. Targeting for the Insertion maneuver will be updated in real time from the MCC-H, designed to achieve a 15 n.m. differential attitude during rendezvous. There is some question, however, if this targeting is to be based on MSFN tracking or on state vectors as determined onboard by rendezvous navigation during the phasing orbit.

6. We were not able to conclude much with regard to AGS operation since it is not clear what computer program will be available for the F mission. We hope to know what its capability will be about November 15. Of course, we are assuming that the primary guidance systems will be using COLOSSUS II and LUMINARY.

7. Just as is planned for the G mission, we intend for the MCC-H to relay the LM state vector obtained by telemetry following the Insertion maneuver back to the CSM. This will be followed by REFSMMAT alignments by both spacecraft.

8. The CSM will use its P30 series rendezvous targeting programs both for its own mirror image targeting and for relay to the LM. In order for the LM to compare solutions, it will be necessary to include certain bias on the maneuvers as determined pre-flight due to the errors induced by using P30's rather than the P70's and also because of the one minute time delay in TIG (for example, at 1.5 fps, bias is required on CSI). It is intended that the CSM backup CSI, CDH, and TPI using the SPS. Incidentally, it is intended to use LM +X RCS for CSI and +Z RCS for CDH and TPI.

9. As planned for G, we are labeling the CSM maneuver targeting as the "yard stick" for LM maneuver verification in real time. This is based on our belief that it is possible to independently verify GNCS performance in real time - something we can't do with the LM PGNCS.

10. We had our usual discussion regarding tolerable TPI time slip. It appears that with VHF ranging, the TPI window is quite large - perhaps ± 15 minutes or so. If this is the case, we should have very little problem. FCSD has accepted the task of determining just what the window is and of defining precisely the optimum location of TPI. MPAD will determine the anticipated three sigma TPI slip. The point that really counts though is that we should never have to abandon the TPI elevation angle option in favor of the time option and we are to carry out our planning based on that assumption. Incidentally, there is complete agreement that we must use two elevation angles for TPI. One for approach from above, the other from below just as was planned for G.

11. There may be some problem associated with recording LM low bit telemetry in the command module on the back side of the moon if someone really wanted to do that. It apparently conflicts with simultaneous VHF ranging which we consider mandatory. Whoever wants this data will have to look for some other substitute for a LM tape recorder, it seemed to us.

12. Our next meeting will be in a month or so. We'll firm up the tracking schedule and will list the equipment we feel required to continue

at each milestone in this exercise at that time. Something else we'll try to get squared away by then is all the "mickey mouse" required to get landing radar data at the same time we are doing the Phasing burn! And, we need to pin down the burn monitoring procedures to the Phasing and Insertion maneuvers.

Howard W. Tindall, Jr.

Enclosure

PA:HWTindall, Jr.:js

MIT ACTION ITEMS FOR F RENDEZVOUS

(November 12, 1968)

1. Is the Target ΔV going to be or has it been changed from a routine (R32) to a program (e.g., P76) in LUMINARY? If not, why not?

2. What program sequence choices have we for getting landing radar data on the downlink just before the Phasing burn?

3. What program sequence should be used for the APS Insertion burn preceeded by DPS staging to insure proper RCS attitude control by the DAP?

4. What is the cost of slipping TPI execution in COLOSSUS without updating TIG?

Enclosure 1

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: November 15, 1968

68-PA-T-251A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: C' Lunar Orbit - Navigation and Block Data

On Thursday, November 7, we gathered with the C' Flight Crew and everyone else who was interested in the lunar orbit operations on that flight. At this meeting we cleaned up a lot of loose ends primarily dealing with the lunar orbit navigation and with block data. This memo is to report the new things accomplished at that time.

Landing Site Lighting Evaluation

As you recall, one pass over the pseudo-landing site prior to marking with the optics will be made to permit the crew to evaluate lighting. The spacecraft will be oriented with a five degree pitch up attitude and will be torqued at orbit rate. The optics will be fixed at zero. The MCC-H will compute and inform the crew of the time at which the optics crosshairs will be viewing the lunar surface location experiencing a 10 degree sun elevation angle. The crew will use this time primarily as a check point to key in their verbal description of what they are actually looking at. Although, it had been proposed as an option that the crew would mark on the pseudo-landing site if it became visible, we dropped this option in favor of continuing the lighting evaluation beyond the terminator and into the region of earth lit lunar surface. It was emphasized that if any difficulty were experienced in finding the control points, forget'em and press on since a continuous evaluation of lighting conditions as the sun angle varies is the important thing on this pass.

Landmark Sightings

The only information the crew desired of MCC-H associated with the landmark sighting exercise is the GET of closest approach to the initial point (IP). This time will be relayed to the crew for every pass by the pseudo-landing site, but only for the first approach to the other three control landmarks on the back of the moon.

In order to avoid excessive shaft angle rates during the observational pass, the crew will roll the spacecraft to insure that the trunnion angle never gets less than 10 degrees. (This value is MIT's recommended minimum.)

The P22 initialization value of the W-matrix shall be 0, 0, 10,000 meters which will prevent the state vectors from being updated, but will permit onboard determination of the landmark location. It should be noted, however, that the updated location of the landmarks are not stored and each time the spacecraft comes over a landmark of interest it is necessary for the crew to key in the values of latitude, half-longitude, and altitude prior to the pass if auto optics are to be used. This obviously means that it is necessary for the crew to record these values following each pass.

Since the pseudo-landing site is being chosen specifically to provide the proper lighting conditions during the tracking exercise, it is necessary to have a bunch of pseudo-landing sites to cover the entire C' mission launch window. In fact, four have been selected for each lauñch day. The nominal is included in the pre-launch E-memory load. However, if the launch occurs at any other time, it will often be necessary for the MCC-H to uplink the proper pseudo-landing site at some convenient time during translunar coast. It was recommended to the crew that for the pseudo-landing site they do not use the onboard determined location on successive passes but rather always use the "01" option to operate with the old stored values.

In order to insure that all of the data is properly stored on the tape recorder, the crew has been requested to delay proceeding from the ΔR, ΔV display for at least one minute. This applies not only to back side observations but also to the pseudo-landing site where the data will be coming to the ground on low-bit rate via the omnis.

State Vector Updates

While in lunar orbit, state vectors will be transmitted once per revolution via the command program (P27) except no state vector updating will be done from the ground during the revolutions immediately following each of the two LOI burns. To be consistant with the rest of the mission, it was decided to update CSM state vectors only into the LM slots of computer memory. The only exception is immediately prior to a maneuver at which time both LM and CSM slots will be loaded - LM slots first.

Block Data

Attached to this memo is a list of the block data updates to be supplied associated with lunar orbit. As you will note, two maneuvers are supplied to get out of lunar orbit prior to LOI_1 and during each of the first three revolutions. Thereafter only one TEI maneuver per revolution is relayed to the spacecraft.

Regarding the TEI burns, which all take place with approximately the same earth-moon geometry and approximately the same targeting objective, the question arises as to how much the TEI ΔV components vary from one revolution to the next. Some of us simple-minded cats have a feeling that given a few TEI maneuvers you could probably extrapolate and get a pretty good maneuver to breakout of lunar orbit if it were necessary. We will get the answer to this question but it will only be for background knowledge, not to change the operational procedures we have established.

Howard W. Tindall, Jr.

Enclosure

PA:HWTindall, Jr.:js

TEI BLOCK DATA ASSOCIATED WITH LUNAR ORBIT

Pre-LOI_1

a. TEI_1 assuming LOI_1

b. TEI_2 assuming LOI_1

Rev 1

a. TEI_1 updated based on GNCS

b. TEI_2 updated based on GNCS

Rev 2

a. TEI_3 assuming LOI_2

b. TEI_3 assuming no LOI_2

Rev 3

a. TEI_3 updated based on GNCS

b. TEI_4 based on GNCS

Rev 4 → Rev 10

TEI_5 → TEI_{11}

Definition

TEI_2 "2" means end of Rev 2

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: November 14, 1968

68-PA-T-249A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: C' Mission Techniques clean up - Translunar and Transearth

On November 8 we went over the Translunar and Transearth phases of the C' Mission Techniques - pretty well cleaning all this up, I think. The following paragraphs describe the more significant decisions and agreements reached. They deal with block data, onboard navigation, and return-to-earth with no communications.

1. Block Data.

There had been considerable concern over the translunar block data targeting. As you recall, the maneuvers were designed to bring the spacecraft directly back to earth, often requring a very large SPS maneuver. Block data for this type of maneuver will still be transmitted to the crew. However, it will ordinarily be used as the secondary mode, to be executed only if a minimum time return is essential due to spacecraft systems problems. The primary mode during the period from MCC_1 plus three hours until LOI minus eight hours will be a lunar flyby. The flyby maneuver would always be executed at LOI minus eight hours (instead of the last translunar midcourse correction). It will be targeted to raise pericynthion to between 200 to 1500 n.m. and to result in a CLA landing. In summary, for each block data maneuver time, there will be two maneuvers transmitted to the crew- the old direct return and the new flyby mode.

There has been some confusion regarding the post-pericynthion block data maneuver transmitted for use after the LOI minus eight hour midcourse correction if something precludes going into lunar orbit. At this meeting we specified that this maneuver will be targeted for the fastest possible return-to-earth provided an SPS burn is required. However, if the present free return trajectory already provides a water landing or an RCS maneuver is adequate to do so, we do not recommend making an SPS burn just to get to a CLA using a block data maneuver.

2. Onboard Navigation

It appears there is no disadvantage to moving the first set of star/earth horizon observations earlier and to do so will significantly improve their quality. Accordingly, the flight plan guys of FCSD were requested to change the flight plan to include this activity immediately after the CSM/S-IVB separation burn - about two hours earlier than before.

As you recall, the first batch of sightings are used to determine the best value of horizon altitude as actually observed by the crew to be used in the CMC. This will be updated via the uplink program (P27), provided the update value differs from the pre-launch value by more than 4500 meters.

It is intended to update the onboard state vector utilizing the sextant observations. The CMP has been instructed to accept the update provided the ΔR does not exceed 50 n.m. and the ΔV does not exceed 50 fps during the first time a particular observation is processed. Exceeding either of these limits indicates that something may be wrong with the observation and serves as a warning that it should be carefully redone. The second time the same observation is obtained, it should be accepted regardless of the ΔR and ΔV based on the assumption that the CMP has certainly done right this time and the state vector is truly that much in error.

The spacecraft calibration limit has been changed from .006 to .003.

A momentous decision was finally reached, namely that the MSFN state vector shall be used for all maneuvers. Since it is uplinked into the LM slots in the CMC memory, it will be necessary for the crew to transfer it (UNZAP) into the CSM slots and after the maneuver to restore the updated CSM state vector into the LM slots (ZAP).

There shall be a new "go/no go" decision point regarding use of MSFN versus onboard navigation. It is currently estimated that at entry interface minus 15 hours, use of the MSFN state vector is preferable to onboard navigation for the final midcourse correction and entry initialization. Accordingly, at that time the MCC-H will update the CMC state vector and will provide an EI minus two hour midcourse maneuver targeting load. In addition, they will inform the crew that this data load is good enough to complete the mission without further onboard navigation and the crew should discontinue sextant observations. If this cannot be done by that time, the crew should obtain the following sets of data to maintain the onboard capability until the ground determined values are considered acceptable.

EI minus eight hours - six star/earth horizon observations

EI minus four hours - six star/earth horizon observations

EI minus two hours - four star/earth horizon observations (obtained immediately after the final midcourse correction).

3. Return-to-Earth - No Communication

It has been established, of course, that the crew will use the return-to-earth program (P37) to compute minimum ΔV midcourse correction maneuvers for corridor control only. Based on the output of this program, we are able to do two additional things. One is to determine the time the spacecraft will reach 400,000 feet which is required as an input to the IMU alignment program to get a "nominal" IMU orientation for entry. The other information from P37 is a precision prediction of the landing point. However, in order to target for a short range entry, it is necessary to bias the P37 values of predicted latitude and longitude prior to inputting them into the entry program (P61). These biases, which are a function of predicted inertial velocity at the entry interface, will be obtained by the crew from a chart. They will be chosen to provide an entry range of 1350 n.m.

In order to insure capture during the initial part of entry the spacecraft will be oriented lift vector down until 1.5 g has been achieved. (Note: This is exactly opposite to the normal technique with communication.) At that time, if the G&N has checked out, the crew will switch to auto CMC mode and continue a guided entry using their standard monitoring procedures.

In order to permit the crew to use the planets in place of stars during alignment of the IMU, it will be necessary to know their unit vectors. Accordingly, it is our intention to include this information as part of the crew data package specifically for each launch opportunity.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: November 12, 1968
68-PA-T-248A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: D Maneuver Monitoring Mission Techniques

On November 4 we had our first-and-last D Maneuver Monitoring Mission Techniques meeting. In addition to all interested MSC organizations, it was attended by MIT, NR, TRW, and GAEC. We spent the day going through all of the SPS maneuvers both docked and undocked, except for those associated with the rendezvous and the docked DPS burn, and discussing the pre-burn systems checks and the actual burn monitoring techniques. I believe we established procedures which should do the job and I feel they can be considered firm. The crew and the flight controllers intend to use these techniques in the forthcoming simulations and changes will only be considered to those which simulations show to be unacceptable.

Following is a list of final agreements which apply to <u>all SPS</u> maneuvers:

1. It is intended to use the onboard computed weight and SPS trim gimbal angles stored from the previous burn in the DAP, unless they differ from the MCC-H ground values by more than 10 percent and .5 degree respectively. If any of the three parameters exceed the limit, all three will be updated.

2. Except for retrofire, it is intended to use the onboard computed REFSMMAT for all maneuvers as determined by using the "preferred" alignment option. The MCC-H will compute and compare REFSMMAT with the onboard values primarily as a check for some procedures or communications error. This will be done by determining the angular difference between them, which should be zero. If it is in excess of .5 degree, the G&N should be considered no go.

3. It was concluded that the check of onboard computed apogee and perigee heights (ha and hp) is unnecessary and will be dropped from the procedures. In addition, these values will be dropped from the maneuver PAD message.

4. Prior to each maneuver, the crew shall make a maneuver attitude check using a sextant star. The shaft and trunnion angles of the star must agree with the PAD values to within five degrees or the burn is no go. If the crew is unable to see any stars, that check will be dropped for that burn.

5. In place of the previously proposed P40 VG test, we are substituting a check on the ΔV_R. This parameter must agree with the PAD value to within 10 fps.

6. Another CMC pre-burn check is through use of the Ground Track Determination program (P21). The crew will check latitude, longitude, and altitude against the PAD values to determine that they are within limits in order to give a G&N go. The limits are .02 degree and .2 n.m. respectively.

7. An attitude excursion limit of 10 degrees has been established for all SPS burns. Five degrees a second is the attitude rate limit. If the crew ascertains that either of these limits have been exceeded as indicated by two independent data sources (primarily the BMAGS and visible cues), they will takeover using SCS MTVC to damp rates and will shutdown the engine. An exception to this is that during the initial start transient, an attitude excursion beyond 10 degrees will be considered acceptable if, in the crew's judgment, it is truly due to the start transient and GNCS control of the spacecraft is still acceptable. (G&CD has the action item of approving this MTVC takeover procedures for safety when applied to docked burns. I have been told by Ken Cox that studies are underway, the results of which so far indicate this procedure is acceptable.)

8. The EMS ΔV counter will not be used as part of the crew monitoring procedure to avoid overburn. That is, for purposes of simplicity it was decided to backup the GNCS engine cutoff based on burn duration only. The procedure is for the crew to manually shutdown the engine if the GNCS has not done so within five seconds of the nominal burn time for docked SPS burns and within one second of the nominal burn time for undocked SPS burns. The nominal burn time is included on the maneuver PAD for each burn.

9. Although the EMS will not be used to monitor against an overburn, it will always be set up to provide an automatic cutoff if the crew switches to SCS. Accordingly, it is intended to slew into the ΔV counter that value (ΔVC) which would cause it to provide as accurate a cutoff as possible. In other words, tailoff and known accelerometer bias will be taken into account when computing the ΔVC included on the maneuver PAD.

10. Except for retrofire, the crew will not trim any ΔV residuals following any SPS maneuver.

11. Since the first SPS burn is made before adequate checks of the G&N can be carried out to insure proper GNCS operation, we propose to utilize some special techniques for that one burn. Essentially we intend to evaluate the GNCS performance during the launch phase on the D mission exactly as we do as part of our TLI go/no go procedure on the C' mission. The procedure involves comparing the performance of the spacecraft GNCS with the SIVB IU

during the launch phase. If the differences do not exceed certain pre-established limits (which incidentally are the same as · C') no further special checks are required to declare the GNCS go for SPS1. If the limits are exceeded, the crew will perform an additional platform alignment (REFSMMAT Option) to the pre-launch orientation just prior to the aligning to the burn REFSMMAT. If the gyro torquing angles indicate that the drift rate has been less than .6 degree/hour since the fine alignment while docked to the SIVB, the GNCS is declared go for the burn. Incidentally, the GDC is also checked during the same period. Its no go limit is 10 degrees/hour on all three axes.

Obviously, special procedures are required for the docked DPS burn. This maneuver is extremely unusual and provides the greatest chances of screwing up procedurally. Prior to the maneuver, the following steps are taken:

1. The LGC E-memory will be dumped to the ground and checked by MCC-H. If any of the critical E-memory values are in error, they must be updated prior to the burn.

2. MCC-H will compute and relay to both spacecraft that REFSMMAT which is consistant with the LM x-axis aligned along the velocity to be gained by the maneuver and the y-axis shall be horizontal. Both spacecraft will utilize the same REFSMMAT.

3. The MCC-H will update the state vectors for both vehicles. The same external ΔV targets will be uplinked to both vehicles. (There is some question as to how the CSM will monitor the maneuver. One proposal is to call up the SPS thrust program (P40), which would be operated just as though it was controlling the maneuver. However, we're not sure how it will perform when the ΔV targeted and achieved is in the negative x direction. MIT was asked to advise us on this matter.)

4. The CSM will maneuver the two spacecraft to near burn attitude using onboard computed gimbal angles. The LM completes this attitude maneuver using R60.

5. Both spacecraft will perform burn attitude checks, the command module using a sextant star and the LM using an AOT star while the LM controls attitude during the last darkness period prior to the burn. Five degrees has been established as the go/no go limit.

6. The DPS trim gimbals will be moved prior to the maneuver to verify they are operating properly and will be reset to align the thrust vector through the c.g. taking into account engine mount compliance at 40 percent thrust. Assistance by MCC-H is required since there is no onboard indication of engine gimbal angle. The technique will involve iterative attempts to align the engine which will be continued until they are within a 0.1 degree of the desired values.

7. The AGS will be initialized and used in the follow-up mode exactly as it is for the undocked DPS burns. Of course, there is no consideration given to taking over with the AGS.

8. We established an attitude limit of 10 degrees and an attitude rate limit of five degrees per second. However, this maneuver is likely to include some pretty wild attitude excursions, particularly as the thrust level is varied, which could easily exceed those limits. During these transient periods, it must be left to the crew's judgment whether a divergent situation is occurring or not. We did establish that a 45 degrees attitude excursion is an absolute limit. This should be coincident with the "VG increasing" alarm. If these occur, the DPS should be manually shutdown. The trim gimbal light is essentially ignored throughout the burn since it cannot really be trusted for anything.

9. Following manual shutdown, attitude control is turned over to the CSM. If a malfunction occurs requiring premature burn termination with excessive attitude rates, they will be damped using the LM y and z-axis RCS translation jets.

As noted previously, the above techniques do not necessarily apply to the maneuvers during the rendezvous or rendezvous abort situations. These techniques will be discussed at our next rendezvous meeting on November 18, at which time any special procedures for those maneuvers will be identified, agreed to, and documented.

Howard W. Tindall, Jr.

Enclosure
List of Attendees

PA:HWTindall, Jr.:js

ATTENDEE LIST

H. W. Tindall, Jr.	FM
T. H. Skopinski	FM
C. Pace	FM
S. P. Mann	FM
R. Nobles	FM
O. F. Graf	FM
C. Conrad, Jr.	CB
R. F. Gordon, Jr.	CB
J. A. McDivitt	CB
R. L. Schweickart	CB
D. R. Scott	CB
G. Renick	FC
J. E. I'Anson	FC
L. S. Cannin	FC
J. E. Roberts	FC/MR
J. B. Craven	FC
H. D. Reed	FC
J. E. Scheppan	TRW
H. R. Klein	TRW
P. Weissman	MIT/IL

Enclosure 1

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: November 7, 1968

68-PA-T-247A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: C Prime Maneuver Monitoring Mission Techniques into cement

On November 2 we went over the C' Maneuver Monitoring Mission Techniques for the last time - that is, we all hope and expect it's "final." Although, the detailed procedures will be documented elsewhere, I would like to describe the new things we established at this meeting. They deal primarily with overburn protection by manual takeover procedures although we did simplify the attitude monitoring a little too.

TLI

The crew will backup the SIVB IU engine cutoff signal based on burn time and GNCS DSKY readout only. The EMS is not involved. The procedure is for the crew to take no action until after the nominal burn time plus 10 seconds. At that time, they will shut down the SIVB as soon as the Inertial velocity (V_I) displayed on the DSKY reaches the nominal targetted value. This parameter is relayed to the crew while in earth parking orbit. (Although, the procedure has been fixed as described here, there is some consideration being given to reduce the burn time bias from 10 seconds to something as small as five seconds. We will change this number within a week if we are going to do it at all.)

This technique was chosen for simplicity and to give the greatest possible chance for the SIVB IU to do its job. Of course, it could result in an overburn of as much as 500 fps if everything were nominal except the IU cutoff signal failed. But, this in itself is not an unsafe condition.

LOI

The crew is to backup the GNCS cutoff signal by use of burn time only. For simplicity's sake we decided not to do "voting" with the EMS ΔV counter. The procedure will be for the crew to manually shutdown the SPS if it is still running six seconds after the nominal burn time, which is relayed to the crew as part of the maneuver pad. This procedure is also felt to be safest since that it will assuuredly preclude an overburn, which is the greatest hazard. With the two-stage LOI, premature manual shutdown of a good GNCS is extremely unlikely.

LOI_2 uses the same procedure except the crew backup occurs at the nominal burn time plus one second. Again the EMS is not in this decision logic.

It should be noted that on all SPS burns (not just LOI) the EMS is initialized to shutdown the SPS engine at the nominal cutoff velocity in the event of an SCS takeover. If the crew were to switch to the SCS during LOI1 burn, they will manually backup the ΔV counter automatic cutoff using the burn duration criteria exactly as noted here for the GNCS burn. If they switch to SCS on the LOI_2 burn, the burn will be terminated as soon as the attitude rates have been damped.

Incidentally, it was decided not to trim ΔV residuals of either LOI burn in the C' mission.

TEI

TEI and other large SPS burns such as return-to-earth maneuvers and aborts include the EMS in the manual cutoff monitoring. Specifically, for TEI the crew will manually shutdown the SPS if the EMS ΔV counter reads less than minus 40 fps and the burn time is greater than nominal plus three seconds. In this case, you can see we are looking for two cues before we manually shutdown the engine, since like TLI, our desire is to give the primary guidance system every opportunity to do its job.

EMS ΔV counter and burn time biases for the other SPS burns will have to be determined by MCC-H and voiced to the crew in real time as part of the maneuver pad data.

As usual, the EMS ΔV counter will be set to cutoff the SPS at the nominal cutoff velocity if the crew switches to the SCS.

There was a lenthy discussion about the pre-LOI_1 burn attitude check. It was concluded that a successful sextant-star burn attitude check is mandatory to start LOI. That is, if the star cannot be seen or if it is not within the established acceptable limits (0.9°) the burn is no go. The crew is also anxious to have a horizon burn attitude check similar to retrofire on an earth orbital flight and MPAD is looking into that. The MCC-H is able to compute the location of the horizon referenced to the window markings, provided it is visible to the crew. We established a tolerance of ± five degrees as the acceptable bound within which the horizon must be, if visible, in order for the LOI to be go.

Probably the longest and most emotional discussion of the day involved whether the LOI_1 burn should be continued or shutdown prematurely in the event of a spacecraft systems problem. As I understood it, we finally concluded that if the problem is guidance system oriented and the crew is able to take over on the SCS with good spacecraft control, they will continue the burn to completion. In the event of other spacecraft systems malfunctions such as the SPS - or something else I'm not qualified to talk about - the crew may choose to shutdown as soon as possible. In that horrible situation, it was agreed that the best course of action is to make an SPS abort maneuver fifteen minutes later using an onboard chart for maneuver targeting, but I suspect there are numerous circumstances when the crew would change the decision in real time and await renewal of communications and tracking by the earth to obtain advice and maneuver targeting from that source. This brief paragraph fails by far to give the rationale for this decision or to even define precisely what it is. I included it here primarily to call your attention to this matter so that you can check into it further if you are interested.

We reconfirmed the TLI attitude excursion limits to be 45 degrees, however, in order to ease the task of crew monitoring, we will probably modify this to be constant FDAI angles equivalent to the 45 degrees attitude excursion at the end of the burn. That is, make the limits constant throughout the burn rather than variable through the burn as a function of the attitude profile. MPAD is to make sure there is nothing wrong with that. The attitude excursion limit for all SPS maneuvers has been set to be 10 degrees throughout the burn. This is a slight change from the previous proposal which included a 15 degree limit during the first 100 seconds to be tolerant of initial attitude transients. We now propose substituting crew judgment. That is, the crew will not take over even though the attitude excursion exceeds 10 degrees, if it is clear that that excursion is due to a SPS start transient.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: November 5, 1968
68-PA-T-242A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: C' earth parking orbit duration is a variable

This note is just to make sure everyone is aware of the rather signi-ficant variation in the time between earth orbit insertion (EOI) and translunar injection (TLI) on the C' mission, depending on day and azimuth of launch. This came as a surprise to me and may have some impact on what you are doing. According to Ron Berry, the time from EOI to TLI ignition is 2 hours and 4[illegible] minutes at the start of the December 20 launch window and decreases to 2 hours and 28 minutes at the end. On the last day of the launch window, December 27, this time period starts at 2 hours and 22 minutes and shortens at the end of the window to 2 hours and 7 minutes. All these numbers, of course, are for the first TLI opportunity. It may be desirable to perform a simulation with the shorter duration earth parking orbit just to make sure everything goes together properly. The poorer ground coverage and shortened crew timeline may give some trouble if it hasn't been thought out in advance.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: November 4, 1968

68-PA-T-241A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: When is the rendezvous radar designate routine (R29) needed?

George Cherry (MIT) asked if it is possible to drop the rendezvous radar designate routine (R29) out of the descent abort programs (P70 and P71). He gave me the impression that to do so now would significantly reduce their work and permit concentration in testing in more profitable areas. I don't know when the next Software Board meeting is - soon I hope. Perhaps this would be a suitable subject to bring up at that time.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : TO WHOM IT MAY CONCERN

DATE: November 1, 1968
68-FM-T-240

FROM : FM/Deputy Chief, Mission Planning and Analysis Division

SUBJECT: ALEXANDER'S Rent-A-Car, Inc.

This is an unsolicited evaluation of ALEXANDER's rental car service at Boston. The service these people have provided has been so much better than that which we previously had that I'm prompted to write this note. The people are consistently friendly, helpful, and prompt about pick up and delivering to the terminals. And the cars have been just great - often brand new.

Howard W. Tindall, Jr.

FM:HWTindall, Jr.:js

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: October 25, 1968
68-PA-T-238A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Descent Aborts - Part II

This memo is to carry on from that three page snowflake I sent you the other day on the same subject. It turns out we have encountered one of those rare situations when in doing something to fix an undesireable situation we actually improve something else at the same time. Specifically, the rendezvous people want to target the LM to a substantially higher orbit following an early descent abort than they had previously proposed. This makes the horizontal posigrade burn following the descent abort larger, of course, and alleviates that crazy pitch profile problem which used to exist during an abort in the first 50 seconds of powered descent. The point is that by some fairly minor changes in the spacecraft computer program (LUMINARY), we can probably eliminate the special abort procedure we used to think was necessary early in descent. Changes to the DPS abort program (P70) are essentially just changes in some erasible constants. This does not impact coding but has a significant impact on testing. By that, I mean the program will work now. The APS program change noted in last week's memo is still required but is essentially achieved by a erasible constant change too. This will all be firmed up and brought to the Software Configuration Control Board in the near future for their approval or something.

Having the early abort situation under control, we pressed on to another phase of descent aborts requiring some attention - specifically, how to handle the situation when the DPS is not quite capable of getting the LM all the way back into the desired insertion orbit. In order to establish procedures, it was necessary to make some assumptions. They are:

1. We never want to "Abort Stage" and use the APS, if the DPS is still operational.

2. It is acceptable to operate the DPS to propellant depletion.*

3. We have no desire to use the APS engine again after achieving orbit (that is, during rendezvous). Of course, we intend to use the APS propellant through the RCS interconnect.

---

* This assumption must be verified by ASPO and then included in their data books.

4. The "Abort Monitor" in LUMINARY remains active following a DPS propellant depletion cutoff, which may result in a ΔV monitor alarm, even though the crew calls up the ΔV residuals.*

If we can make the above assumptions, the procedures become quite simple and standard. Namely, whenever aborting on DPS, the crew will permit that engine to operate at full thrust until either a guided cutoff is acheived or propellant depletion occurs. At that time, the crew will "proceed" to the DSKY display of ΔV residuals. If the ΔV remaining to be gained is less than 30 fps, the DPS will be manually staged and the crew will utilize the RCS to achieve the desired insertion condition by nulling the ΔV residuals. (It is probable that only the horizontal component need be trimmed if a convenient attitude reference is available. The FDAI eight ball should be good for this.) If the ΔV to be gained is in excess of 30 fps, the crew will hit "Abort Stage," automatically jettisoning the DPS and lighting off the APS to make up the ΔV deficiency. Again, only the horizontal ΔV residual need be trimmed.

It is to be noted that with the new, high apogee we will be targeting for, the RCS/APS switchover point is orbital by a substantial margin (apogee in excess of 75 miles) and so there is no problem in the use of an RCS burn whose duration is less than 30 seconds. It is also to be noted that if the ΔV required of the APS is less than 100 fps, the burn duration will be less than 10 seconds, which probably makes it unsafe to reignite the APS. There is so much mystery with what is and what is not acceptable with the APS we cannot really be sure about that. However, it does not matter since there is no problem anticipated in performing the rest of the maneuvers with RCS.

One final comment - it has been proposed that the DPS be operated at half thrust during aborts to prevent lofting when the APS is required to achieve orbit. Two miles perigee and four miles apogee are the maximum effects. Those do not significantly perturb the abort rendezvous and therefore the decision was to maintain full thrust.

* This assumption must be verified by me with MIT.

Howard W. Tindall, Jr.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: October 25, 1968

68-PA-T-237A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: X-axis or z-axis for LM TPI?

This memo is in response to a question that came up at the October 21 D Rendezvous Mission Techniques meeting. The question was: What is the additional LM RCS propellant cost if we use the z-axis RCS translation rather than the x-axis for TPI? Chuck Pace checked with the MPAD Consumable people who figured the x-axis would cost about 15 lbs. (taking into account the required attitude changes and use of the APS interconnect) and the z-axis will use at least 31 lbs. of RCS propellant (assuming the best CG location). These numbers are based on current spacecraft data book information. They intend to verify them through use of a 6D simulation program in the near future and will document the results.

In the meantime, we can probably use these estimates to decide which to use - x-axis which costs less RCS or z-axis which avoids breaking radar lock on.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: October 25, 1968
68-PA-T-236A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: CSI and CDH back into the AGS - maybe

Apparently the TRW AGS people have done a good job of putting the new rendezvous radar navigation filter into that dinky computer. In fact, they now estimate a surplus of some 80 words.

One of our brilliant ~~young~~ engineers here in MPAD - Ed Lineberry - has developed a simple technique for computing the CDI and CDH rendezvous maneuvers provided the CSM orbit is near circular as it should be on the G mission (reference MPAD memo, 68-FM61-318, dated October 15, 1968, subject: Linearized solution for CSI and CDH for a multiple-half-orbital-period transfer between maneuvers!). In fact, he expects that it could be fit into the aforementioned 80 words. He and Milt Contella have already discussed this with the TRW people who are looking it all over. If things go well, he expects they will come to the Software Configuration Control Board with the proposal to include it in some future AGS program and we can decided at that time if that is the best way to use our little 80 word Christmas present.

I wrote this because that idiot Ed Lineberry is too darn modest to tell anybody and I thought you might find it interesting.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

AA/R. R. Gilruth
AP/C. S. Trimble
CA/D. K. Slayton
CB/J. A. McDivitt
CB/A. B. Shepard
CB/N. Armstrong
CB/F. Borman
CB/M. Collins
CB/C. Conrad
CB/L. G. Cooper
CB/C. M. Duke
CB/R. F. Gordon
CB/J. Lovell
CB/R. L. Schweickart
CB/D. R. Scott
CB/T. P. Stafford
CB/E. E. Aldrin
CB/A. L. Bean
CB/H. H. Schmitt
CB/J. W. Young
CB/E. D. Mitchell
CB/E. A. Cernan
CL/J. A. Engle
CB/J. B. Irwin
CF/W. J. North
CF13/D. F. Grimm
CF212/C. Jacobsen
CF212/W. Haufler
CF212/R. P. Rudd
CF2/J. Bilodeau
CF22/C. C. Thomas
CF22/D. L. Bentley
CF22/R. L. Hahne
CF22/M. C. Gremillion
CF24/P. Kramer
CF24/M. C. Contella
CF24/D. W. Lewis
CF24/D. K. Mosel
CF3/C. H. Woodling
CF32/J. J. Van Bockel
CF32/M. F. Griffin
CF33/M. Brown
CF33/C. Nelson
CF34/F. H. Pippert
CF34/T. W. Holloway
CF34/J. V. Rivers
CF34/G. Colton
EA/M. A. Faget
EA2/J. B. Lee
EA4/J. Chamberlin
EA5/P. M. Deans
LB/P. Vavra
EE/L. Packham
EE/R. Sawyer
EE13/M. J. Kingsley
EE13/R. B. Irvin
EE?/R. L. Chicoine
EE?/G. B. Gibson
EE?/P. H. Fennel
EE?/J. R. McCown

EG/R. A. Gardiner
EG/D. C. Cheatham
EG2/M. Kayton
EG2/C. T. Hackler
EG23/K. J. Cox
EG2?/E. E. Smith
EG25/T. V. Chambers
EG26/P. E. Ebersole
EG27/W. J. Klinar
EG27/H. E. Smith
EG41/J. Hanaway
EG42/B. Reina
EG43/A. R. Turley
EG44/C. W. Frasier
EG/MIT/T. Lawton
KA/R. F. Thompson
PA/G. M. Low
PA/C. H. Bolender
PA/F. J. Kleinknecht
PA2/M. C. Henderson
PB/A. Hoboken
PC/W. H. Gray
PD/O. E. Maynard
PD/C. D. Perrine
PD/F. V. Battey
PD12/J. G. Zarcaro
PD12/R. J. Ward
PD12/R. W. Kubicki
PD12/M. H. von Ehrenfried
PD4/A. Cohen
PD6/H. Byington
PD7/W. R. Morrison
PD8/J. Loftus
PE/D. T. Lockard
TH3/J. E. Dornbach
TH3/J. H. Sasser
FA/C. C. Kraft, Jr.
FA/S. A. Sjoberg
FA/C. C. Critzos
FA/R. G. Rose
FC/E. F. Kranz
FC/M. P. Frank
FC/G. S. Lunney
FC/C. E. Charlesworth
FC2/J. W. Roach
FC2/H. M. Draughon
FC25/C. R. Lewis
FC27/W. E. Platt (3)
FC3/A. D. Aldrich
FC35/B. N. Willoughby (4)
FC4/J. E. Hannigan
FC44/R. L. Carlton (3)
FC5/J. C. Bostick
FC5/P. C. Shaffer
FC54/J. S. Llewellyn
FC54/D. M. Massaro
FC54/C. ?. Deitrich
FC54/J. ?. I'Anson
FC5?/R. L. ?lkn (5)
FC5?/C. R. Parker (3)
FC6/R. G. Miller (4)

FL/J. B. Hammack
FS/L. C. Dunseith
FS5/J. C. Stokes
FS5/T. F. Gibson, Jr.
FS5/J. R. Williams
FS5/T. M. Conway
FS5/R. Allen
FS5/G. R. Sabionski
FM/J. P. Mayer
FM/C. R. Huss
FM/D. H. Owen
FM13/R. P. Parten (9)
FM2/C. A. Graves
FM2/J. C. Harpold
FM3/C. T. Hyle
FM4/P. T. Pixley (2)
FM4/R. T. Savely
FM4/W. R. Wollenhaupt
FM5/R. E. Ernull
FM5/H. D. Beck
FM6/R. H. Regelbrugge
FM6/K. A. Young
FM6/R. W. Becker (3)
FM6/R. B. Merriam
FM7/S. P. Mann
FM7/R. O. Nobles
FM7/R. H. Brown
FM/Branch Chiefs

HA-58/R. L. Allen (Boeing)
HM-25/R. E. Dornak
HM-25/D. W. Hackbart
Bellcomm/Hqs./R. V. Sperry
Bellcomm/Hqs./G. Heffron
GAEC/Bethpage/M. Pollack
GAEC/Bethpage/J. Marino (3)
GAEC/Bethpage/R. Mangulis
GAEC/Bethpage/D. Shields
GAEC/Bethpage/R. Prusik
MIT/IL/R. R. Ragan (15)
MIT/IL/R. Copps
MIT/IL/M. W. Johnston
NR/Downey/M. Vucelic (3)
NR/Downey/D. Zermuehlen
NR/Downey/B. C. Johnson, AE75
NR/Downey/W. H. Marketing FB??
NR/Downey/E. Dimitruk, FB30
GSFC/550/F. O. Vonbun
GSFC/550/B. Kruger
KSC/CFK/R. D. McCafferty
KSC/CFK/P. Baker
NASA/Hqs./MAO/R. J. Sheridan
NASA/Hqs./MAOP/R. O. Aller (2)
TRW/Redondo Beach/R. Braslau
TRW/Houston/C. Pittman
TRW/Houston/W. J. Klenk
TRW/Houston/R. J. Nadreau
TRW/Houston/M. Fox
TRW/Houston/K. L. Baker

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: October 25, 1968
68-PA-T-235A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Some more C' Lunar Orbit Mission Techniques

At our October 14 C' Lunar Orbit Mission Techniques meeting we settled on a few things I would like to tell you about. Along with the TEI block data to be sent up each revolution in lunar orbit, we are also going to update the spacecraft state vector in the CMC every revolution. This will be done after tracking the pseudo-landing site and before the P52 fine alignment. Some consideration was also given to including a TEI external ΔV targeting load on the uplink each revolution but this will not be done since the block data should be adequate. Incidentally, the block data will be for a TEI maneuver for the revolution following the present one - that is, about three hours after its transmission.

We discussed the use of the tape recorder if the high-gain antenna does not work. In this event, you recall, it is not possible to dump the tape at lunar distances. The question to be answered is: What data should be recorded on the tape to be brought back by the spacecraft out of lunar orbit? Surely high-bit recording of the SPS burns - LOI and TEI - must be included and will use about half of the tape (15 minutes at high-bit rate). Recording of landmark tracking on the back side of the moon should have a high priority to be included and will take very little tape. The technique will be for the crew to obtain all of the sightings on a given landmark, which the CMC will temporarily store in memory. After completion of taking that set of observations the recorder is turned on for approximately 20 seconds at low-bit rate to collect and save that data. Since we are making eight sets of observations on the back of the moon, we are only using 160 seconds worth of tape, that is, about 2½ minutes out of the remaining one-half hour at low-bit rate.

What else should be recorded is an open question and people with requirements should come forward soon and identify themselves so the procedures can be worked out for the "no high-gain antenna" situation. Of course, if the high gain is working, continuous recording on the back side of the moon should be standard practice.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: October 25, 1968
68-PA-T-234A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: C' Contingency Review

We went through the draft of the C' Contingency Mission Techniques document on October 22, and I must say I was impressed with its quality. It seemed to me the Flight Analysis Branch, the Apollo Abort Working Group, and TRW had done a good job of putting this together. The final version will be distributed within the next week or so.

One item that came up needed resolution deals with the block data maneuvers - that is, those abort maneuvers which the MCC-H periodically sends to the spacecraft to be used in the event of a subsequent complete communication failure. It is necessary to agree on the targeting objectives of these maneuvers. First of all, let me emphasize that the free return trajectory that we adhere to on the way to the moon does not necessarily provide a water landing and almost assuredly does not provide a landing near the primary recovery forces. All it does it to make sure that the spacecraft can get back to earth with minimum ΔV in the event of an SPS failure. The question to be answered is: Should the block data maneuvers merely be designed to provide a water landing or should they also meet the additional constraint of landing in the planned recovery area - that is, targeted to the CLA? We had been assuming that they would aim for the CLA, although, this may require maneuvers of as much as 1200 fps. Some people were questioning whether it would be better to avoid making a maneuver any larger than is necessary to insure a water landing regardless of where it might occur. Basically, it is a tradeoff between a maneuver (of up to 1200 fps) to get where we really want to go versus a smaller maneuver (up to [illegible] fps) to provide a safe landing somewhere. Of course, there is also the question during the translunar coast of when to target the maneuver for a direct return which costs a lot of ΔV (up to 7,000 fps) as opposed to going around the moon, which is much cheaper. These things are really mission rules which must be established before the flight. They apparently aren't agreed to yet. At least I don't know the rule.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

APOLLO DATA PRIORITY COORDINATION
MEETING SCHEDULE

AS OF October 22, 1968

68-PA-T-230A

SUBJECT OF MEETING	Oct. 28	29	30	31	November 1	4	5	6	7	8	11	12	13	14	15	18	19	20	21	22
C' Mission Tech. Review										■				■						
C' Data Select		■					■					■								
D Maneuver Monitoring						■														
D Rendezvous																■				
G Descent Abort			■										■							
F/G Rendezvous								■										■		
SPECIAL MEETINGS																				

Meeting begins at 9:00 a.m.

Meeting begins at 1:00 p.m.

Howard W. Tindall, Jr.

MSC Form 1285 (Rev Sep 68)

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: October 22, 1968

68-PA-T-229A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: C' Spacecraft Navigation Mission Techniques

It appears we have completed basic development of C' Spacecraft Navigation Mission Techniques both for Cis-Lunar and Lunar Orbit. Documentation of these techniques will be distributed in the near future. No further meetings will be called specifically for these subjects. Whatever open items come up will be handled in our weekly C' Mission Techniques Reviews, along with the rest of the stuff we like to talk about. At the final meeting on October 17, we wrapped up the Translunar Spacecraft Navigation Mission Techniques by adopting the following:

a. The crew procedures and CMC update techniques should be essentially the same for translunar as for transearth. That is,

(1) A fine alignment for sextant calibration will be done prior to each navigation exercise period, which usually includes a midcourse correction maneuver.

(2) State vectors will be computed onboard and the W-matrix will be preserved.

(3) MSFN state vectors relayed to the CMC will be to the LM slots, etc.

b. It should be noted that the purpose of the Translunar Spacecraft Navigation is quite different than the Transearth Navigation. The latter is intended to provide an onboard capability to back up MSFN maneuver targeting and entry initialization in the event of communication loss; the former is to collect data to evaluate systems performance, primarily postflight, but to be partially done in real time in order to modify procedures or GNCS parameters if necessary prior to the transearth leg. It has been repeatedly emphasized that the translunar navigation schedule is not designed to provide valid comparison of onboard and ground determined state vectors and such comparison should not be made to evaluate performance. That is, trajectory control logic will not be influenced by the performance of the spacecraft navigation no matter how good or terrible it is. That is an important point and should be well understood.

c. If communications are lost on the way to the moon, our current plans rely on the use of block data to initiate return to earth. It is assumed that the accuracy of any block data maneuver based on the MSFN is adequate to assure missing the moon. (We have the action item of determining how big the uncertainty of missing the moon is for circumlunar aborts.) In this situation the procedure is for the crew to reinitialize the W-matrix prior to starting the transearth navigation. That is, sometime after passing the moon they should key in that verb which resets the W-matrix to the values loaded in E memory prior to lift off. Currently the values are 3,300 feet and 3.3 fps. It is to be emphasized that the only reason we are preserving the W-matrix during the translunar navigation is that we want to keep the procedures exactly the same as the transearth phase and W-matrix preservation is then apparently important.

d. The first two batches of spacecraft navigation observations are designed for special purposes. Those of the star/earth horizon at TLI + three hours are to be used to determine thelocation of the horizon above the Fischer Ellipsoid. This value will be determined in-flight by the MCC-H and will be related to the crew by voice or CMC uplink. (The mode has not been determined.) The second batch of observations are of star/earth landmarks (at TLI + six hours) and are included to determine how well observations of that type may be made in the event of a communication loss during the return to earth. It was established that if earth landmarks are not visible, the exercise will be deleted. That is, it will not be replaced by another type of observation. This situation, of course, is not unlikely considering the lighting conditions and cloud cover we can easily encounter. If these observations are not obtained on the translunar leg, they should not be used in the event of a communication loss on the transearth leg unless the crew has no confidence in the navigation using star/horizon observations to hit the entry corridor.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: October 18, 1968
68-PA-T-228A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: C' Contingency Procedures - Draft Review

A review of the C' Contingency Procedures Techniques Document is currently scheduled for October 22, 1968. Topics included are:

- TLI + 10 and TLI + 90 minute aborts
- Translunar Coast Aborts - Block data
- LOI and TEI Mode I and Mode II aborts

The burn monitor procedures are included in other techniques documents, but will be summarized in the contingency techniques to provide a comprehensive document.

Draft copies of the document will be provided at the review which starts at 9:00 a.m. in Room 396 of Building 4.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: October 17, 1968
68-PA-T-227A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: D Rendezvous Open Items, Action Items or whatever you call them

I've reviewed my notes of the D Rendezvous meetings over the last couple of months and have found the following open/action items. I guess most, if not all, are being worked on. But time grows short and so I'm sending this list around to make sure of it. If you know of others, please give me a call.

1. (TRW) What are the expected ΔV residuals at the conclusion of the AGS controlled, DPS phasing burn? We want to null the x-axis to within 2 fps but must avoid excessive RCS jet impingement.

2. (MPAD) Shall the DPS be staged for rendezvous at TPI? It has been decided that the greatly improved vehicle maneuverability and resultant saving in RCS fuel makes this desirable, provided no recontact with the staged DPS is positively assured. Ed Lineberry is developing a technique to do this.

3. (MIT) Braking procedures are placing heavy weight on the rendezvous radar range and range rate, of course. If the tape meter fails, it is hoped that the crew can get raw radar data displayed on the PGNCS DSKY by use of the V62 RR self test routine. MIT is requested to verify this technique works and inform us of any constraints or idiosyncrasies involved in this procedure.

4. (MPAD/ASPO) What is the accuracy of the PGNCS rendezvous navigation when using an IMU aligned with the COAS rather than the AOT? ASPO should define the accuracy of a COAS which has not been calibrated inflight.

5. (MPAD/MIT) When computing the TPI_0 solution using the PGNCS Elevation angle option, what solution will be obtained? Note that the spacecraft will pass through 27.5° two times in the football trajectory.

6. What other problems or special procedures are needed for the TPI_0 maneuver, if any? For example, can dispersions make it more desirable to use the time option. It is interesting to note that the TPI_0 maneuver is applied more-or-less away from rather than toward the target spacecraft! This certainly affects the backup techniques involving boresighting along the LOS developed for a "standard" rendezvous TPI.

7. (TRW/AGS) How is the CSM state vector in the AGS updated if the PGNCS has failed and the CSM makes a maneuver? Note the AGS has no program equivalent to the PGNCS "Target ΔV" (R32).

8. (FCD) Assuming the LGC is powered down after the docked DPS burn (is this true or is it set to standby?), an E memory check is probably needed to commit to rendezvous. If required it must be added to the timeline and positive procedures developed to do it.

9. (MIT) Can the time required to make a GNCS PIPA bias test be reduced to less than 256 seconds?

10. (MPAD) Determine expected (3 sigma) shift in TPI time from nominal during the rendezvous to assist in selecting the TPI situation to aim for.

11. (FCSD) Define TPI window of acceptable lighting conditions and degree of constraint "hardness."

12. (Data Priority) Based on 9 and 10 (above) establish the mission techniques regarding under what conditions, if any, the "Elevation Angle" option for TPI should be abandoned in favor of the "Time" option.

13. (GAEC/TRW/GCD) Shall an AGS gyro calibration be performed during the rendezvous period of activity? This depends on expected improvement in performance versus probability of screwing up the system.

14. How do we verify that the AGS is properly aligned from the PGNCS given the possibility of CDU transients?

15. Of course techniques for monitoring all of the main engine maneuvers are still undefined and must be developed.

Howard W. Tindall, Jr.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

APOLLO DATA PRIORITY COORDINATION

MEETING SCHEDULE

AS OF October 15, 1968

68-PA-T-227A

SUBJECT OF MEETING	Oct. 21	22	23	24	25	28	29	30	31	Nov. 1	4	5	6	7	8	11	12	13	14	15
C' Lunar Orbit				■										■						
C' Mission Techniques Review		■													■					
C' Contingency																				
C' Spacecraft Navigation				■					■											
C' Data Select							■					■					■			
D Rendezvous	■										■									
G Descent Abort			■										■							
G Rendezvous								■										■		
SPECIAL MEETINGS																				

Meeting begins at 9:00 a.m.

Meeting begins at 1:00 p.m.

Joanne Sanchez for Howard W. Tindall, Jr.

MSC Form 1285 (Rev Sep 68)

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: October 21, 1968

68-PA-T-226A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Descent Aborts

We have finally started mission techniques meetings on lunar landing descent aborts. At the risk of losing whatever confidence you might have in my judgment, I would like to describe a technique we are probably going to propose for aborts early in the descent phase. That is, within about 25 seconds of commanding the DPS to full thrust. It is a technique that Joe D. Payne and Floyd Bennett have been suggesting for quite a while, but which most of the rest of us had been unwilling to accept.

First of all, I don't think anyone will argue about what should be done between initialization of powered descent and DPS throttle up after the trim gimbal period (currently set for 26 seconds). The ΔV acquired during that period only drops the apogee down to about 40 miles so the best thing to do is probably just shut off the engine and sit tight. That is, no immediate abort maneuvers are required unless it is necessary to get away from a hazardous DPS stage.

After going to full throttle, though, there is a short period (roughly 25 seconds) during which aborts become a little difficult to handle. In this region the trajectory rapidly becomes suborbital, making an immediate abort maneuver necessary to achieve a safe orbit. The problem is that the spacecraft is oriented retrograde to perform the descent maneuver, which is exactly opposite to the direction required to get back into orbit. This causes the problem. Namely, if we want to abort on the DPS, you have a choice of:

a. Either turning off the engine, reorienting the spacecraft about 180°, and reigniting the DPS to make a posigrade burn into orbit - and no one wants to turn off the engine! or

b. Leave the DPS engine on as the spacecraft is being reoriented. Unfortunately, in order to avoid gimbal lock this attitude maneuver must be made in the pitch direction and leaving the engine on causes us to acquire a large radial velocity <u>during</u> the attitude maneuver which must be removed. To do this the spacecraft would go through a pretty wild pitch profile rotating almost a complete revolution from the time of abort to the time of engine shutdown. The reason for this is that attitude change is made at a rate of only 10 degrees a second, which means the engine would thrust with a component in the radial direction for a long time. As you can imagine, there are also considerable problems in the guidance equations, which would cause the engine to be shutdown prematurely under certain circumstances.

Abort Staging with the APS is not much better since it was felt necessary to provide an immediate separation maneuver (currently coded to be three seconds or 30 fps) to get away from the DPS before reorienting to posigrade attitude. And, you can't leave it running for the same reasons as the DPS. So you see, even for an APS abort, we end up turning the engine on, then off, and then back on, which we don't want to do.

Let me point out that after about 25 seconds at full throttle, the horizontal velocity required to get back into orbit when combined with the radial velocity picked up during the attitude change results in a guidance and attitude control situation considered acceptable. That is, it is not necessary to turn off the engine during the pitch over to posigrade attitude. So our only concern is with aborts during the first 25 seconds after throttle up, when it is neither acceptable to leave the engine on nor to turn it off for fear that it won't start again.

Standby for Payne's solution!

It is proposed that in the event of an abort recognized in that troublesome period to continue operating the DPS in the retrograde direction until we have reached the time it is possible to make the attitude change to the posigrade direction without turning off the engine! If the DPS is the system that isn't working and it is necessary to "Abort Stage" and use the APS, it is proposed to burn the APS in the retrograde direction as long as necessary to reach the point when we can pitch to the posigrade direction without turning off the APS.

This solution, you see, avoids the need for turning off an operating engine and makes the procedures for both DPS and APS about the same in this time period as they are after this period. The thing that takes awhile to get used to is burning in a retrograde direction lowering the orbit still farther after a need for an abort has been recognized. How do we rationalize doing a thing like that? We currently feel that the advantages of the simplified, standardized procedures and particularly of not shutting down a running engine sufficiently justify thrusting to a situation a little worse than that which existed at the time of abort recognition. And, of course, we do have a tremendous propellant surplus if we abort at this time. Furthermore, aside from some problem associated with throttle up, the probability of an abort being required in this 25 second period seems awfully remote making it very difficult to justify development of a unique set of abort procedures and training to use them. In effect, this proposal creates two rather than three abort zones. No abort maneuvers are required prior to DPS throttle up since the LM is still orbital. Procedures after throttle up are all the same. There is no discrete point in the descent required special techniques.

Formulation of the LUMINARY DPS abort program (P70) is completely compatible with this procedure. That is, for a DPS abort the crew would always delay taking abort action until 25 seconds after throttle up. A program change will be necessary to support this procedure in the APS abort program (P71) so that if the crew hits "Abort Stage," the APS will light off and separate, maintaining a retrograde attitude until 25 seconds after DPS throttle up time. Then it could go into the abort guidance as currently programmed. Specifically, the change is to have the spacecraft perform a continuous retrograde APS burn as opposed to a three second burn followed by an attitude change and reignition.

Mal Johnston of MIT was at our meeting and will discuss this with our friends in Boston. We'll talk about it some more next time after thinking it over a couple of weeks. I'd be interested in your comments.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: October 16, 1968

68-FM-T-225

FROM : FM/Deputy Chief

SUBJECT: Results of the October 8 Apollo Spacecraft Software Configuration Control Board (ASSCCB) meeting

In this memo I will briefly describe some of the highlights of the subject meeting:

1. There was a long discussion regarding the effects of CDU transients on AGS alignments while on the lunar surface. It appears there are some fairly simple procedures for making sure unacceptable errors are not introduced into the system. A matter that was not discussed was what sort of problems we can have in the AGS alignment while on coasting flight where spacecraft attitude changes make checking very difficult. We will have to pursue these matters in the mission techniques development.

2. There were four PCR's approved that I would like to call your attention to. They are:

a. PCR 546 (LUMINARY): Delete V50N25 display in P68. Crew must insure a stable LM before "proceed" response to V06N43. The V50N25 display is not necessary. Attitude storage can be done after crew response to previous V06N43.

b. PCR 547 (LUMINARY): Delete V37N57 display at end of P68 and add "Do final automatic request terminate routine (R00)." Chapter 4 incorrectly shows P68 terminating with V37N57.

c. PCR 551 (LUMINARY): Reduce normal maximum commanded rate from 20°/sec. to 14°/sec. since maximum commanded rate of ACA normal scaling is too high for manual lunar landing. Reduce normal and fine scaling by a factor of 7 for the CSM-docked case since normal and fine scaling of ACA are too high for manual lunar landing.

d. PCR 552 (COLOSSUS): Add P22 assumption to read as follows: The first mark obtained by this program cannot be the landing site. Coding in P22 cannot accept landing site as first mark.

3. Since all of DPS guided burns on the currently planned missions terminate at 40% thrust or less, it was decided to place the DPS tailoff for 40% in memory rather than full thrust.

4. MIT requested that we approve a change (PCR 494), which would put the LGC value of landing site location (RLS) on the ascent and descent downlink format. I am not sure why they want this unless it is for systems testing purposes. Note: We have no capability of reading it out in the control center in real time right now.

5. PCR 250 to put SPS mass flow rate (M DOT) into erasible memory of COLOSSUS 1A was approved.

6. PCR 245 to permit use of planets in P23 and R53 was approved for COLOSSUS II but will not be in COLOSSUS 1A.

7. Just so there is no misunderstanding on this, MIT has been directed to delete the rendezvous radar acquisition routine (R29) from the LGC descent program (P63) completely.

Howard W. Tindall, Jr.

FM:HWTindall, Jr.:js

Addressees:
FM/J. P. Mayer
FM/C. R. Huss
FM/D. H. Owen
FM13/R. P. Parten
FM13/J. R. Gurley
FM13/E. D. Murrah
FM13/M. Collins
FM4/P. T. Pixley
FM4/R. T. Savely
FM5/R. E. Ernull
FM5/H. D. Beck
FM6/R. R. Regelbrugge
FM6/K. A. Young
FM7/S. P. Mann
FM7/R. O. Nobles
FM/Branch Chiefs

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: October 16, 1968
68-PA-T-224A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: C' Earth Orbit and TLI Mission Techniques Open Items

It appears we have the Earth Orbit and TLI Mission Techniques for the C' pretty well under control. The only two significant open items that I know of deal with the optics check and the crew procedures for protecting against an SIVB engine cutoff failure during TLI.

The problem with the optics check is that no one has really established what they are trying to accomplish by doing it. My own personal opinion, of course, is that it is not really necessary. That is, we will be willing to do TLI with the optics busted, whatever that means, since we should be able to align the platform using the COAS good enough to perform the return to earth maneuver. Although, I guess, we really haven't proven that to everyone's satisfaction yet.

How the crew should backup the SIVB IU engine cutoff signal has been a sticky wicket (I believe that is the expression). I think we have now gotten through the emotional phase of this one and have zeroed in on two possible techniques, both of which seem pretty good. The one I personally favor was proposed by Charley Parker. Its merits are simplicity and the fact that it gives the IU the greatest chance to perform its job, if it is going to. Basically, no crew action would be taken until after an elapsed burn time is equal to that expected from a 3 sigma low performing engine. This would be like 10 seconds past the nominal burn duration. At that time, the crew would manually shut the engine down as soon as the GNCS indicated the targeted inertial velocity has been achieved as readout from their DSKY display. Of course, if we really have had an IU failure, the GNCS would indicate that we have already exceeded that velocity at that time and so the crew would take immediate action by turning the abort handle to shut down the engine and return it to its neutral position to avoid automatic separation of the spacecraft from the SIVB. (Note that the EMS ΔV counter plays no role in this procedure.) In the event the IU has truly failed to send the cutoff command when everything else is perfectly normal, this procedure would result in an overspeed of about 500 or 600 fps which would require a 2,000 to 3,000 fps return-to-nominal midcourse maneuver three hours after TLI. This does not preclude going into lunar orbit.

The alternate proposal is precisely the same as that, except than an additional period permitting manual crew engine cutoff is included - namely, that period containing all burn durations possible with a 3 sigma performing engine. This would be a 20 second period centered about the nominal cutoff time. During this period, the crew would send a manual engine off command if both the GNCS and the EMS ΔV counter indicated the desired cutoff velocity had been achieved.

Studies are continuing on both these techniques and a crew preference will also be obtained hopefully leading to resolution within the next couple of weeks. Since there is no crew simulation facility capable of faithfully simulating the TLI maneuver, it will not be possible to base the decision on experience gained in that way.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: October 16, 1968

68-PA-T-222A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: C' maneuvers - SPS versus RCS crossover

Neil Townsend (EP2) informed me by phone - and will supply written confirmation - that the minimum duration SPS burn for C' should be no less than 0.5 seconds. We had been assuming something smaller. According to MPAD (Otis Graf, FM7) this makes the crossover point between use of the RCS versus the SPS engine:

Translunar midcourse correction - 5 fps

Transearth midcourse correction - 12 fps

These values will be explained completely in an FM7 memo soon to be distributed. I just want everybody to be aware of the new values and to start using them in his planning.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: October 17, 1968

68-PA-T-220A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Transearth Spacecraft Navigation

During Jim McPherson's Transearth Spacecraft Navigation Mission Techniques meeting of October 8 and 15, a potpourri of ground rules, working agreements and constraints was established. I may be duplicating other reports with this memo but figure better too many reports than not enough. All of the following apply specifically to the first batch of sextant sightings - star/lunar horizon - after TEI on the way back to earth. Many may also apply to later navigation observations, but I won't attempt to identify them here.

a. Prior to initiation of transearth onboard spacecraft navigation, the pre-TEI MSFN state vector navigated through TEI will be stored in the CMC LM slots and will be used to initialize the navigation. That is, no new state vector will be uplinked.

b. Navigation using star/lunar horizon observations give approximately the same accuracy as star/lunar landmarks - at least as far as hitting the entry corridor is concerned. Accordingly for purposes of mission simplifications - both pre-flight preparation and real time operation - all star/lunar landmark observational exercises will be deleted from lunar missions starting with C'.

c. This exercise is to start at TEI + 1½ hours.

d. Altitude, which is not a constraint, should initially be about 6,000 nautical miles.

e. Stars of 2.3 magnitude or brighter are required for lunar observations.

f. Due to the required spacecraft attitude, the hi-gain antenna will probably be out-of-lock. Therefore, low bit rate telemetry will probably be used to transmit the data in real time. If so, marks must be made no more frequently than one for each 10 seconds - procedures are required to assure proper downlink antenna is selected.

g. After completion of this exercise, the crew will obtain sextant photographs of the lunar horizon - to see what the horizon looks like at altitudes of 10,000 to 20,000 nautical miles - not to determine its location.

h. The W-matrix will be initialized to 3,300 feet and 3.3 fps. If possible, they will be initialized at TEI and propogated from there. These are the same values to be used after TLI and included in the E memory load.

i. MPAD and MIT will establish the ΔR, ΔV threshold the crew should use for data selections - hopefully, it will be simple but perhaps must be a function of geometry and time in the mission. (The data is on the downlink regardless of whether the crew accepts the update or not.) It should be noted that no good simulation facility will ever be available to provide the crew any pre-flight judgment. Although the V83 rendezvous RR display gives relation of pre-navigation versus navigated state vectors, this kind of activity shall not be a part of the decision logic. If someone comes in with a good, useful proposal, this will be reconsidered.

j. A P52 align shall be performed immediately prior to this exercise.

k. The sextant calibration shall be repeated until agreement of at least two checks (not necessarily sequential ones) are within .006° before "preceeding."

l. Sextant calibrations will be performed every one-half hour.

m. The CMC clock shall be updated by the MCC-H whenever in "error" by more than .040 seconds.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO :See list attached

DATE: October 15, 1968

68-PA-T-219A

FROM :PA/Chief, Apollo Data Priority Coordination

SUBJECT: Lunar Rendezvous Mission Techniques

A number of people who know about the rendezvous radar (Myron Kayton, Richard Broderick, etc.) came to our little Lunar Rendezvous Mission Techniques meeting October 2 and assuaged our anxieties regarding the possibility of poor shaft angle measurements when the line-of-sight to the command module passes close to the lunar horizon. According to the data they presented, the error introduced by multi-path in the rendezvous radar data is essentially lost in the noise for elevation angles above 10° from the horizon. (During the nominal lunar rendezvous tracking begins at approximately 10° elevation and approaches 20° at CSI.)

Ed Lineberry's people have made sufficient runs to show that it is possible to use the same CSI targeting data computed in the CMC for LM maneuver solution comparison (properly biased) and for CSM mirror image maneuver targeting. We are currently recommending that the CMP use P32 rather than P72 since this would avoid the necessity of going through two pre-thrust programs.

One of the most significant things coming from the meeting, I think, was a report by the Math Physics Branch people to the effect that the rendezvous radar data is not expected to be of sufficient accuracy to target plane change maneuvers prior to terminal phase. The estimated errors are simply too great (e.g., 11 fps, one sigma). Accordingly, all plane change targeting prior to terminal phase must come from the CSM which can do an excellent job given as little as 10 minutes worth of sextant tracking (0.5 fps, one sigma). This does introduce sort of a problem since the technique for determining the magnitude of the plane change maneuver is to input the time of interest into the R36 routine. Unfortunately, if we put in the time of the LM maneuver, the solution would apply to the out-of-plane the command module should make at a substantially different place in orbit. For example, at CSI the command module is leading the LM by as much as 12°. Of course, the CMP could go through some "mickey mouse" to bias this time as a function of this phase angle based on some charts or something. However, he is already pretty well bogged down with other work and so we are going to put in a program change request for COLOSSUS II giving us a solution based on the LM state vectors rather than the CSM state vectors somewhat as the 70 series programs compliment the 30 series.

Jack Wright, TRW, had an interesting idea regarding the technique for checking the validity of the VHF range data. It is his impression that the rendezvous radar range and range rate measurements are essentially independent of one another, in effect providing two data sources for comparison with the VHF. Agreement of either of these with the VHF would provide confidence in its use. The crew display of raw VHF data is not really accessible to the CMP in the lower equipment bay and, of course, does not provide range rate at all. Therefore, the comparison must be against the DSKY display of range and range rate based on the navigated state vectors which include the sextant observations. It seems to us, in lieu of real data that this is probably a valid test of the VHF since it probably overwhelms the sextant data in the determination of navigated range and range rate. I would like to emphasize that this is a proposal requiring verification and may prove to be not useable. However, I thought it interesting enough to pass on to you.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: October 10, 1968
68-PA-T-218A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: D Rendezvous Mission Techniques

On October 4 we met to review a draft of the D Rendezvous Mission Techniques. Although we spent the entire day we didn't get past page 3 and so it is obvious we are going to have to beef up our effort in order to get all this cleaned up. In fact, I am going to schedule all day meetings every other Monday specifically for this purpose.

I feel we did accomplish some rather important things in this meeting. The most significant was identifying exactly what pieces of equipment must be working in both spacecraft at each of four go/no go points, namely:

a. Undocking

b. Separation into mini-football

c. Phasing into football

d. Insertion into CSI/CDH rendezvous

This is the first time we have made a coordinated attack on this subject and I feel we were probably 90% successful or better. I have attached a table summarizing the results which you may find interesting. The decision as to whether each piece of equipment was required or not in order to go on with the mission phase is based on a pretty detailed understanding of how we want to do the rendezvous exercise and how we want to get out of trouble if other pieces of equipment subsequently fail. We adopted, as a general philosophy, that the command module must be prepared to rescue the LM and so we insisted on having redundant CSM capability for all crucial operations. In the LM we were somewhat more liberal assuming that the CMC rescue capability provides an adequate backup for the next LM systems failure for all operations except braking. This philosophy seemed to us to provide the best tradeoff between crew safety and assurance of meeting mission objectives. One item I would particularly like to point out regards the AGS which we feel is not required for anything except Insertion into the CSI/CDH rendezvous. It may seem inconsistant that we are willing to make the phasing burn into the football rendezvous but then not go for the second bigger loop. The reason was that most objectives will have been achieved in the football and the additional experience gained in the CSI/CDH rendezvous does not appear to justify the risk of demanding CSM rescue for subsequent PGNCS failure. Incidentally, the thing we want the AGS for in this case is not rendezvous navigation or maneuver capability but as an attitude reference in the event we lose the PGNCS. This is considered important since without it, it may not be possible to keep the tracking light oriented toward the command module.

Some other items I would like to list briefly are:

a. Whereas previously we had stated the MSFN solution for CSI and CDH would be used to target the AGS, the crew has a strong preference for using the PGNCS solution once it has been tested and found satisfactory. They feel this gives a better burn monitoring. Our main reason for having suggested using the MSFN solution was to avoid unnecessary activity close to burn time. However, since the PGNCS solution is checked before the AGS targeting is loaded - that concern is not longer valid.

b. We had stated that no radar data would be input into the AGS prior to CSI and CDH. To this we are adding the football prior to TPI_o unless the PGNCS fails or it is known that TPI_o will be executed.

c. It has been established that the LGC rendezvous navigation W-matrix will be initially set to 1,000 feet and 1 fps. In addition, it is necessary to set initialization value for the radar angle biases. The value selected for this is .001 radians.

d. We have established a mission rule the flight controllers should utilize in targeting the maneuvers prior to the rendezvous exercise in order to meet satisfactory rendezvous lighting conditions and MSFN coverage. They may permit the Δh for TPI_o (that is, the football rendezvous) to vary $\pm$ 1 nautical mile. The Δh for TPI should be targeted to be 10 $\pm$ 0 nautical miles. Actually this tolerance variation in the football provides quite a bit of control for the real time mission planner and he should be able to do the CDH targeting to meet the TPI Δh constraint.

An open item still hanging around deals with whether or not an AGS gyro calibration should be performed during the rendezvous exercise. I believe both GAEC and GCD have stated it should not for fear of screwing up the AGS gyro calibration. TRW's AGS people, I believe, would like to have the calibration done since they feel it would greatly improve the accuracy of the system. Of course, everyone agrees with that providing the calibration works. We must vote everyone concerned with this again, I guess; right now the crew has included it in the timeline while docked to the CSM.

Howard W. Tindall, Jr.

Enclosures 2
List of Attendees
Table of LM systems and CSM systems

PA:HWTindall, Jr.:js

ATTENDEE LIST

H. W. Tindall, Jr.	FM
E. C. Lineberry	FM
R. R. Regelbrugge	FM
C. Pace	FM
J. H. Shreffler	FM
W. R. Lacy	FM
L. D. Hartley	FM
J. D. Alexander	FM
G. Michess	FM
K. Henley	FM
M. C. Contella	CF
D. W. Lewis	CF
J. V. Rivers	CF
R. L. Schweickart	CB
A. L. Bean	CB
D. R. Scott	CB
R. F. Gordon	CB
M. P. Frank	FC
H. D. Reed	FC
J. Saltz	FC
B. J. McCoy	EC
R. J. Boudreau	TRW
J. E. Scheppan	TRW
L. Diamiant	TRW
C. Summers	TRW
R. W. Puschinsky	MDC
W. Haufler	MDC
M. J. McRae	MDC
E. Lewandoski	GAEC

Enclosure 1

LM systems required to continue the exercise assuming that CSM rescue provides an adequate backup for failure (except Docking).

LM SYSTEMS	UNDOCKING	SEPARATION INTO MINI-FOOTBALL	PHASING INTO FOOTBALL	INSERTION, CSI/CDH
PGNCS LGC	R[1]	R	R	R
IMU	R[1]	r	R	R
AGS[3] AEA	NR	NR	NR	R[2]
ASA	NR	NR	NR	R[2]
CES	R[1]	R	R	R
DPS/DECA	NR	NR	R[4]	NR[5]
RR[6]	NR	R[7]	R	R
Tape Meter[8]	NR	NR	NR	NR
Event Timer	NR	NR	NR	NR
FDAI's[9]	NR	R	R	R
AOT or COAS[10]	NR	NR	R	R
Hand Controllers[11]	R	R	R	R
Cross Pointers	NR	NR	NR	NR
CSM Tracking Light	NR	NR	NR	NR

Redundant CSM Systems required to provide LM rescue capability without LM assistance.

GNCS CMC	NR	NR[9]	R	R
IMU	NR	NR[9]	R	R
Optics SXT	NR	NR	R	R
SCT	NR	NR	R	R
COAS	NR	NR	NR	NR
SCS BMAGS	NR	NR[9]	R[12]	R[12]
GDC	NR	NR	NR	R
FDAI's	NR	NR[9]	R	R
SPS	NR	NR	NR	R
DKSY[13]	NR	NR	R	R
Handcontrollers	R	R	R	R
EMS ΔV Counter	NR	NR	NR	R
Event Timer	NR	NR	NR	NR
LM Tracking Light	NR	NR[14]	R	R

1. Either PGNCS or CES required since "Direct" is assumed acceptable for docking.
2. Assuming additional experience gained in the CSI/CDH rendezvous does not justify the risk of demanding CSM rescue for subsequent PGNCS failure.
3. Includes DEDA.
4. Alternate mission may be possible.
5. Nominal trajectory possible with APS/RCS.
6. Includes transponder.
7. Separation acceptable if some important test objective can be accomplished.
8. Assuming RR self-test ([illegible]) [illegible] RR [illegible].
9. One or the other required - not both.
10. Assuming rendezvous navigation studies show uncalibrated COAS IMU alignment is adequate to make flight meaningful.
11. Translation and at least one RHC.
12. One/channel.
13. Crew to verify one CSM DSKY adequate to perform rescue for SPS burns and navigation.
14. Assuming running or cabin lights are visible at 2.5 NM.

APOLLO DATA PRIORITY COORDINATION

MEETING SCHEDULE

AS OF October 2, 1968

68-PA-T-211A

	OCTOBER																			
SUBJECT OF MEETING	7	8	9	10	11	14	15	16	17	18	21	22	23	24	25	28	29	30	31	1
C' EO, TLI				■																
C' MCC, LOI								■												
C' Lunar Orbit				■					■					■						
C' TEI, MCC, Entry			■																	
C' Spacecraft Navigation		■					■					■								
C' Data Select																	■			
D Retrofire & Reentry *	■																			
G Descent Abort			■										■							
G Rendezvous								■										■		
SPECIAL MEETINGS																				

Howard W. Tindall, Jr.

■ *Meeting begins at 9:00 a.m.*

■ *Meeting begins at 1:00 p.m.* * Starts at 9:30 am in Rm 378, Bldg. 4

MSC FORM 1265 (FEB 68)

UNITED STATES GOVERNMENT

Memorandum

TO : PA/Manager, Apollo Spacecraft Program

DATE: October 2, 1968
68-PA-T-210A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: C Mission Techniques - are they being used?

As you suggested, I checked with Phil Shaffer - Chief, Flight Dynamics Officer on the C mission - to determine if the flight crew and flight controllers are following the mission techniques we developed. He is completely satisfied that everything is being done properly - at least those things they are able to observe from the simulations. (There are some things the crew does that only a cockpit observer could check, of course.) For example, he says following each simulation there is a complete detailed discussion of such things as data source comparisons for rendezvous (TPI) and the crew is faithfully doing "right."

Some things have been changed since our document was updated the last time, but only after discussion with all interested parties to the same extent as during the original Techniques Development. The point is, "spur of the moment" changes are not being made nor are changes based on someone's whim. Examples of changes are:

a. Use of the G&N to make a retrofire burn which must be delayed at the last moment - by recycling through the pre-thrust program (P30) and changing TIG - rather than using the SCS. (See paragraph 2.6, page 13 and logic page 33 of S-PA-8T-011, our latest Mission C Retrofire and Reentry Document, dated September 6, 1968.) Actually, this is what we always wanted to do - the crew resisted it because they didn't think they had enough time. Now they agree it's best.

b. Trimming ΔV residuals after retrofire is now done since it avoids having to recompute the entry pad data - i.e., it keeps the burn nominal and the pre-burn entry data remains right. We previously felt trimming was unnecessary and crowded the timeline when they should be separating the CM from the SM. Simulations have shown the new technique to be superior. Everyone agrees.

Bill

Howard W. Tindall, Jr.

cc:
FC5/P. C. Shaffer

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: September 27, 1968
68-PA-T-209A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: C' Mission Techniques

Attached are a list of ground rules and working agreements I compiled from my notes taken at the September 13 and 14 Mission Techniques meetings and the September 20 Lunar Abort meeting, all on the C' mission. This list is far from complete. Basically, these items are only the changes and additions to the material in the existing Mission Techniques documents already published, which are generally accurate. I put this together to document what I thought was agreed to. We will get together on October 2, 1968, at 1:00 p.m. to review this whole thing. Probably going through this list will be the easiest way. Based on that, TRW will prepare Xerox review copies of the following Mission Techniques documents for review and publication on the following dates:

Subject	Review	Publication
Earth Orbit and TLI	October 10	October 21
Translunar MCC and LOI	October 16	October 28
TEI, Transearth MCC, and Entry	October 9	October 21

Also attached is a list of some of the action items coming out of these meetings.

Howard W. Tindall, Jr.

Howard W. Tindall, Jr.

Enclosures 2

PA:HWTindall, Jr.:js

September 27, 1968

C' LUNAR MISSION
GROUND RULES AND WORKING AGREEMENTS

General

1. It has been established that all earth orbit operations prior to TLI will utilize the pre-liftoff REFSMMAT. Furthermore, it has been established that all translunar MCC with the exception of the final MCC (at LOI -8 hours) will also utilize this same REFSMMAT. Of course, it is recognized that the direction of any MCC is completely random and it is possible that IMU gimbal lock could result if this were strictly adhered to. Accordingly, if it is determined that the middle gimbal angle during a MCC will be less than 45°, a new REFSMMAT will be relayed to the crew for that specific maneuver. In that event, a REFSMMAT yielding 0, 0, 0 on the FDAI when the spacecraft is in maneuver attitude will be utilized.

2. It is felt to be advantageous to utilize a single REFSMMAT for all lunar operations including the LOI maneuvers and TEI. Since the G&N is being activated for the lunar operations prior to the final MCC, it was decided to extend this procedure to include that maneuver. That is, the final MCC (at LOI -8) will also utilize the lunar orbit REFSMMAT. The lunar orbit REFSMMAT is defined as that platform orientation which will yield 0, 0, 0 on the FDAI 8-ball when the spacecraft is at a heads up, + X-axis forward, horizontal attitude at the time of LOI_2. This means that during the LOI_2 maneuver, which is performed retrograde and heads down, the FDAI display will be 0, 180, 0.

3. Pending agreement of MSFC, we have established a ground rule that if the COAS horizon check of TLI turn attitude has failed, the TLI burn will be inhibited (Berry, Paules, Huss).

Enclosure 1

4. It is possible for either the MCC-H or the crew to activate the CMC uplink program (P27) providing the crew has not inhibited it. The crew has a strong preference that they not be included in that activity. Therefore MCC-H shall do it whenever they send an update.

EARTH ORBIT

1. It has been determined that it is nominally not necessary to perform an IMU alignment while in earth parking orbit prior to TLI. The mission techniques which have been developed for a general lunar mission such as F and G have omitted the platform alignment as a part of the G&N systems evaluation, since it has been determined that other tests are adequate for that purpose without it. If these other tests reveal some problem or possible problems, a platform alignment is often required for resolution. Except for a late Pacific launch, this would ordinarily require utilization of the second TLI opportunity. On the C' mission there is time to perform a platform alignment and it is being included in the crew flight plan but it should be emphasized that it is optional and failure to perform it for some reason does not constitute sufficient reason for declaring the first TLI opportunity "no go". Furthermore, no special procedures are being developed to include information obtained from the platform alignment in the TLI go/no go logic.
2. The spacecraft state vector will always be updated by the MCC-H during earth parking orbit prior to TLI. Since it is anticipated that the state vector determined by MSFN tracking will be superior to that obtained via telemetry from the SIVB IU that one will be used unless there is some obvious fault with it; in that event, of course, the IU state vector will be used. A significant point to be made is that no procedures are being developed for determining which of these two data sources is superior in real time. That is, there is no comparison of state vectors to determine which is better. The MSFN is assumed to be better and will be used unless there is some reason to question its quality.
3. At present we are assuming that the EMS is not mandatory to fly the C' lunar

and the duration of the burn (a clock). It has been determined that burn duration for a booster operating within specifications can vary ± 14 seconds, which makes it essentially worthless as a data source for backing up cutoff. After lengthy discussions it was rather arbitrarily decided to establish a technique which puts maximum reliance on backing up the cutoff with the G&N and to use the EMS ΔV counter only as a last ditch device to use after it is obvious both the SIVB IU and the spacecraft G&N have failed. The technique selected requires the crew to monitor the G&N DSKY and to send manual engine shut down when the DSKY reaches an inertial velocity relayed by voice to the crew from the MCC-H while in earth parking orbit. This value of inertial velocity will be the anticipated nominal value biased to account for G&N systems dispersions, crew reaction time (including the DSKY display delay), and the SIVB delay in responding to the crew action. The EMS ΔV counter will be set prior to TLI with a MCC-H relayed velocity such that when it reaches zero, the crew should send the cutoff signal. This parameter shall also be biased. While of the same nature as the G&N this bias will be made substantially larger to assure that a premature shutdown, based on this cue, will not occur under any circumstance. A specific point to be made is that the manual backup signal will be sent if either the G&N or EMS reaches its limit. We are not waiting for both. The primary reason for this unusual procedure is that the G&N by itself, should provide the best possible backup as regards both accuracy and simplicity.

2. In addition to the parameters discussed in TLI paragraph 1b, the only other parameters to be included in the pre-TLI pad message are:

   a. The mission elapsed time of TB6

   b. The nominal burn duration

   c. The nominal inertial velocity the crew should observe on the DSKY at the end of the burn including tail off.

3. In the event of a catastrophic spacecraft failure during TLI requiring premature shut down of the SIVB, the crew will utilize the abort handle, which reinitializes the clock and will perform an abort maneuver 10 minutes later to return to earth. The maneuver will be performed using the horizon as an attitude reference and an onboard chart solution for burn magnitude based on the crew display of G&N inertial velocity (VI) and/or EMS ΔV, noted at SIVB shut down.

MCC

1. All translunar MCC will be performed utilizing the G&N. Based on that, the MCC's are scheduled to occur at the following times:
   a. TLI + 10 hours (if an emergency situation occurs requiring immediate return to earth, this maneuver may be scheduled as early as, but no earlier than TLI + 3 hours)
   b. TLI + 20 to 30 hours
   c. LOI - 20 to 30 hours
   d. LOI - 8 hours

   With regard to the final MCC, it has been determined that the minimum time required after the MCC to obtain adequate MSFN tracking and carry out targeting for the LOI is 4½ hours. In order to assure that adequate time will be available to compensate for unexpected occurrences and to avoid straining the MSFN targeting to its limit, it was decided to schedule the final MCC 8 hours before LOI. An additional benefit gained by this is that it provides the crew a final rest period prior to the especially taxing lunar orbital operations.
2. The MCC maneuvers have been scheduled to coincide with other crew activities such as the work/rest cycle. That is, they were not scheduled to optimize any trajectory considerations or anything like that.
3. MCC's prior to TLI + 30 hours will use the free return, best adaptive path (BAP) RTCC targeting mode. MCC's later than 30 hours after TLI require use of the Return-to-Nominal (X, Y, Z, T) mode, since the free return targeting mode does not work in this region. A test will be made

to assure that any MCC using the X, Y, Z, T mode does not depart too far from free return. Specifically the trajectory following the targeted MCC maneuver will be projected ahead to approximately the time the spacecraft exists the lunar sphere of influence and the magnitude required to hit the entry corridor will be determined. If this maneuver requirement is less than 45 fps, the MCC is considered to be within acceptable bounds. If greater than 45 fps, something serious must be wrong and the X, Y, Z, T mode must be abandoned in favor of a lunar flyby mode, which does provide a free return. This is an unlikely, badly perturbed situation and precludes going into the lunar orbit.

4. A lower threshold has been established below which an MCC will not be carried out. It is based on the anticipated accuracy of the MSFN and is currently set to be 1 fps. That is, if the MCC is computed to be less than 1 fps, it will not be executed; if greater, it will be executed. The only exception is the last MCC (at LOI - 8 hours) which will be performed regardless of magnitude.

5. Any MCC computed to be greater than 3 fps will utilize the SPS. RCS is used for maneuvers smaller than 3 fps.

6. Residuals - All ΔV residuals will be trimmed to within 1 fps (MSFN 3σ accuracy). The only exception is the final MCC which will be trimmed to zero - all components.

7. All transearth MCC, including the first, will be performed for corridor control only, unless it is determined in real time that the predicted landing point is unacceptable for some reason (e.g., unacceptable weather or land masses within the footprint or in the FLA 2, or excessive return

to base staging time). If a maneuver is required to relocate the landing point for reasons such as noted, above, the maneuver will be made large enough to provide acceptable landing conditions in the entire PLA I footprint and at PLA 2. Wherever possible, of course, the recovery ships will be removed to a new location consistant with a 1500 nautical mile entry range.

LOI

1. In the event of a G&N failure durir the LOI_1 burn, the crew will manually take over utilizing the SCS and will continue the burn to nominal completion. That is, the automatic EMS ΔV cutoff will be activated and used.

2. The attitude excursion limits for the LOI_1 burn are as follows:
   a. Not to exceed 15° during the first 100 seconds.
   b. Not to exceed 10° for the remainder of the maneuver.

   These limits apply to both pitch and yaw. Violation of these limits will be determined by observing both sets of BMAGS, one of which will be driving the attitude error needles; the other set will be driving the FDAI 8-ball. A violation must be apparent on both these indications prior to crew takeover.

3. Since both sets of BMAGS are required to monitor the LOI maneuver, they must be considered mandatory for initiating the LOI burn.

4. The crew should monitor and manually backup the automatic G&N engine cutoff signal through use of the EMS ΔV counter and the event timer. Limits have been established whereby it is considered safe for the crew to await violation of both of these systems before taking over from the G&N. (Reference MPAD memo, 68-FM-73-400, dated September 17, 1968, subject: Onboard monitoring of the LOI maneuver.)

5. LOI_2 will utilize the same attitude excursion limits as LOI_1. However, the engine cutoff backup will be performed based on the event timer only. That is, the EMS ΔV counter will not be utilized for this purpose. In the event it is necessary for the crew to take over from a malfunctioning G&N, they will complete the burn on the SCS utilizing the automatic EMS ΔV counter engine off command.

6. ΔV residuals of the LOI burns will not be trimmed except for the X-axis of LOI_2, which will be trimmed to zero.

TEI

1. TEI will be targeted to land at 165° W longitude on a specified day of landing using minimum ΔV. The latitude of landing will not be directly controlled. This is the so-called CLA mode in the RTCC.
2. Targeting for the TEI maneuver and all transearth MCC will be aimed at achieving the steep, contingency entry target line, which provides a -6.48° flight path angle nominally.
3. The TEI maneuver will be targeted to limit the return inclination to be less than 40°.
4. ΔV residuals of the TEI maneuver will not be trimmed except for x-axis which will only be trimmed to within 2 fps.
5. Monitoring of the TEI burn will utilize the same techniques and limits as the LOI_1 burn. That is, the attitude execution limits will be:

   a. Not to exceed 15° during the first 100 seconds.

   b. Not to exceed 10° for the remainder of maneuver.

   These limits apply to both pitch and yaw. Violation of these limits will be determined by observing both sets of BMAGS, one of which will be driving the attitude error needle, the other set will be driving the FDAI 8-ball. A violation must be apparent on both these indicators prior to crew take over.
6. TEI will be performed in a heads down attitude.
7. In the event of a G&N failure during the TEI burn, the crew will manually take over utilizing the SCS and will continue the burn to nominal completion. That is, the automatic EMS ΔV cutoff will be activated and used.

Entry

1. The EMS will be set up to start automatically when it senses .05 g's and will be backed up manually three seconds after the ground computed .05 g time.

2. An entry attitude check is made by comparing the position of the horizon with spacecraft window markings approximately 5 minutes before entry. It is mandatory that this check be passed successfully or the G&N will be declared unacceptable for entry guidance.

3. The entry will be flown utilizing the G&N in the automatic mode. That is, the DAP will be enabled in all three axes prior to .05 g's.

4. REFSMMAT for entry shall be that which provides an FDAI display of 0, 0, 0 when the spacecraft is oriented heads down, blunt end forward, x-axis horizontal at the entry interface.

5. On the C' mission a non-skip reentry will nominally be utilized. That is, the entry range shall be limited to from 1200 to 1800 nautical miles. (Based on these limits the GNCS should never enter reentry P66.)

6. The useful operational footprint nominally is 1200 to 1450 nautical miles. (Simulations currently underway are expected to permit extending this to 1550 or 1600 nautical miles.) The normal reentry range for targeting and ship location purposes (i.e., PLA I) shall be 1350 nautical miles (which, if flown would preclude use of P65).

7. PLA 2 is defined as a contingency area and will be located at a range of 1800 nautical miles. PLA 2 will never be used unless PLA 1 is unacceptable for some reason and the G&N is working. If during attempt to reach PLA 2 the G&N fails, the crew will fly a constant G reentry until aerodynamic

capture is assured and then will fly maximum range to get as close to PLA 2 as possible.

8. The SM/CM separation is to be combined with the pre-entry spacecraft attitude, horizon check. The separation pitch attitude has been defined as being the same as the horizon attitude check and yaw is 45° out-of-plane. Separation studies should be carried out, if they have not already been completed, to verify acceptability of this decision - not to optimize it.

C' ACTION ITEMS

1. Establish the TLI velocity cutoff bias values for the GNCS (V_I') and EMS (VC'). (MPAD)
2. Establish switchover point defining conditions under which the MCC-H will compute return-to-earth maneuvers to hit the "shallow" rather than the steep entry target line. (MPAD)
3. Determine what cues, if any, exist to give warning of impending GNCS failure. These are particularly needed to set the limit of the GNCS degradation we would accept and still initiate the TEI burn or the GNCS rather than SCS. (MIT)
4. Establish the spacecraft attitudes for the pre-entry horizon check. (FCD)
5. Establish tolerance on the horizon attitude check for GNCS go/ no go. (MPAD)
6. Confirm no SM/CM recontact problem (MPAD)
7. Establish GNCS entry monitoring procedures for the new short range entries. (MPAD)
8. Provide overall EMS check and burn procedure for RCS and SPS. (See page 50 of Entry) (NR)
9. Provide a P37 interation limit. (MIT)
10. Establish which is more important in targeting LOI_1
    a. Proper altitude (60 x 60) or
    b. Pass over the pseudo landing site (MPAD)

Enclosure 2

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

UNITED STATES GOVERNMENT

Memorandum

TO : PD/Chairman, Data Requirement Control Panel

DATE: September 27, 1968
68-PA-T-209A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Requirement for pre-PDI IMU alignment has been deleted

After extensive Mission Techniques Panel review, it has been established that a PGNCS IMU alignment immediately prior to Powered Descent is not required for any reason. It is, in fact, undesirable at this critical time in the mission when lighting conditions couldn't be worse (local high noon!).

I have attached an analysis THW performed to show that it is certainly not required to provide a safe AGS abort capability as has been suggested in the past.

I also refer you to the Apollo Mission Techniques Mission G Lunar Descent Document, dated August 23, 1968 (MSC IN S-PA-8N-021), which omits this procedure - intentionally.

In order to provide documentation compatibility and accuracy, may I request you revise the Spacecraft Operational Data Book, deleting the requirement for an LM IMU alignment immediately prior to Powered Descent Initiation (PDI). For your information an alignment is performed about one hour before PDI in our current timeline.

Howard W. Tindall, Jr.

Enclosure

PA:HWTindall, Jr.:js

TRW

TRW No. 68:7252.9-49
Re: Task ASPO 46B

10 July 1968

National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas 77058

Attention: Mr. H. W. Tindall, Jr. (FM)

Subject: PGNCS Alignment During Hohmann Transfer

Gentlemen:

The attached IOC presents an analysis which estimates the increase in the probability of an unsafe AGS abort if the PGNCS alignment during Hohmann transfer is not performed. The analysis shows that given that PGNCS fails, the probability of an unsafe AGS abort from hover is increased by less than 0.001 (one additional violation of the 30,000 feet minimum pericynthion constraint in 1000 cases). The increase in probability of an unsafe AGS abort over the range of times an abort is possible will be even less than the above value.

The small increase in the probability of an unsafe AGS abort should be worth the operational gains of eliminating the PGNCS alignment during the Hohmann transfer.

Very truly yours,

R. J. Boudreau, Task Manager
Task ASPO 46C

R. L. Robertson, Assistant Project Manager
Spacecraft Program Support
Apollo Planning and Operations Project

MF :RJB:db
Enclosure

Distribution:

Ralph Albon (PP7)
R. V. Battey (PD)
R. P. Parten (FM13)
Document Distribution (BF66)

TRW Distribution

T Bettwy
R Braslau
M Fox
T Haggenmaker
W Klenk
P Melancon

TRW SYSTEMS GROUP

DKP WJK

INTEROFFICE CORRESPONDENCE 68:7252.8-222

TO: R. Boudreau CC: Distribution DATE: 12 July 1968

SUBJECT: AGS Performance with no PGNCS Alignment During the Hohmann Transfer (Task 46)

FROM: R. Kidd RK BLDG H3 MAIL STA. 1023 EXT. 2047

References: 1. LM AGS Guidance Software Design Report No. 3, TRW 05952 TRW 05952-6079-T000, 30 November, 1966.

2. Master End Item Specification for Lunar Module PGNCS.

Introduction and Summary

There is some concern about the capability of the AGS to safely perform an abort from hover without a PGNCS alignment during the Hohmann transfer. This concern stems from the results of Monte Carlo analyses which indicate that the mean minus three sigma for perilune altitude of an AGS controlled abort from hover is less than 30,000 feet (the safe orbit limit), and from single error analyses which indicate that an initial misalignment slightly larger than three sigma results in an unsafe orbit. Obviously, the effect of eliminating the PGNCS alignment during the Hohmann transfer is to increase the probability of obtaining an unsafe abort orbit. However, the rough analysis presented herein indicates that the increase in probability is on the order of .001 times the probability of a PGNCS failure during the powered descent maneuver, and the decrease in the mean minus three sigma for the perilune altitude of a hover abort is about 3000 feet. Since the PGNCS alignment during the Hohmann transfer would require RCS propellant, time allocated for the correction of erroneous star sightings, and no insignificant amount of crew activity, the gain in safe orbit probability provided by the alignment does not appear to be worth the operational complexity of performing the alignment. However, the AGS performance specifications may need to be changed because the AGS performance capability will be degraded if the PGNCS alignment during the Hohmann transfer is eliminated.

Discussion

The probability that an unsuccessful abort results from a working AGS is given by:

$$P(\sigma_o) = \int_o^T f(t)\ P_1\ (t,\sigma_o)\ dt$$

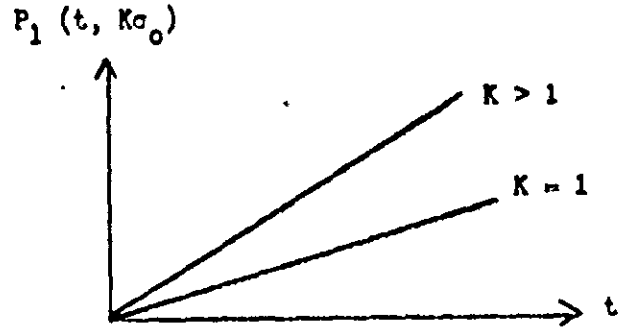
where

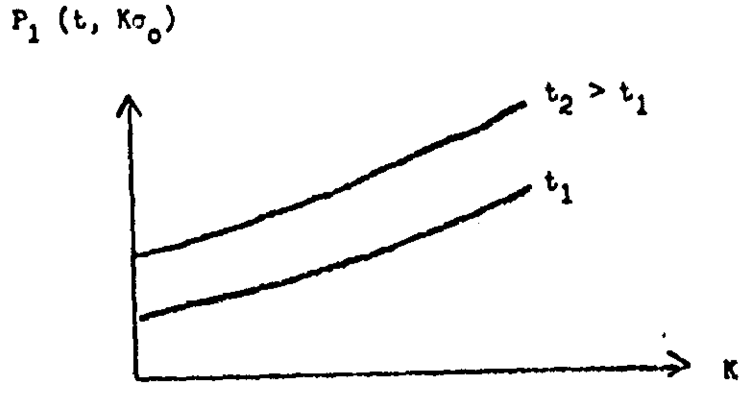
(o,T) is the time interval of powered descent,
σ_o is the standard deviation of the initial AGS alignment error,

$f(t)$ is the probability density function for the occurrence of an AGS controlled abort,

$P_1(t, \sigma_o)$ is the probability that an AGS controlled abort at time t will not be safe.

The general functional form of $P_1\ (t, \sigma)$ is shown below:





Since $P_1 (t, \sigma_o)$ is a positive, continuous, non-decreasing function of t,

$$P(\sigma_o) = P_1 (T, \sigma_o) \int_{\zeta}^{T} f(t)\,dt$$

$$= P_1 (T, \sigma_o)\, F(\zeta, T)$$

where

$P_1 (T, \sigma_o)$ is the probability that an AGS controlled abort at time T will not be safe.

$F(\zeta, T)$ is the probability that an AGS controlled abort will be required during the interval (ζ, T).

Generally, the following observations hold:

- An AGS controlled abort is required only for a PGNCS failure; and hence, $F(\zeta, T)$ is the probability of a PGNCS failure during the interval (ζ, T).
- The probability of an unsafe abort is less than or equal to the probability of an abort occurring - equality requires that $P_1 = 1$.
- The increase in the probability of an unsafe abort resulting from no alignment during the Hohmann transfer is less than the increase in $P_1 (T, \sigma_o)$ by the factor $F(\zeta, T)$.
- The probability, $P_1 (T, \sigma_o)$, is not a known analytical or tabular function; however, the random Monte Carlo samples which have been generated follow a normal distribution very closely (reference 1). Hence a normal distribution is a reasonable approximation for a qualitative assessment.

The functional form for the variation in perilune altitude is approximately (reference 1).

$$R_p = A\underline{e} + \underline{e}^T D\underline{e} + 60{,}000$$

Where,

> $\underline{e}$ is the vector of random errors such as misalignment, accelerometer bias, etc.
>
> A, D are matrices of first and second order coefficients, respectively.

For independent, normally distributed errors with zero mean and standard deviations σ_i, the mean and standard deviation for R_p are:

$$\mu = \Sigma\, d_i\, \sigma_i^2 + 60{,}000$$
$$\sigma^2 = \Sigma\, a_i^2\, \sigma_i^2 + 2\, \Sigma\, d_i^2\, \sigma_i^4$$

The effect of the initial AGS alignment accuracy on the mean and standard deviation of the perilune altitude for a hover abort was computed from the data available in the referenced document (inflight calibration error model). These results are shown on the attached figure. The initial AGS misalignment is the root sum square of the following:

- PGNCS alignment accuracy $1\sigma \approx 3.43$ $\widehat{\text{min}}$ (Reference 2)
- PGNCS gyro drift from previous alignment $1\sigma \approx .03$ deg/hr (Reference 2)
- AGS to PGNCS alignment transfer $1\sigma \approx 1.3$ $\widehat{\text{min}}$ (Reference 1)

The mean, standard deviation, and probability that the hover abort perilune altitude is less than 30,000 feet (unsafe) were obtained from the attached figure and standard statistics tables (assumed a normal distribution) for three alignment times of interest, and are tabulated below.

Statistics for Hover Abort Perilune

Total time for PGNCS Drift (Hrs)	AGS Align Accuracy σ_o ($\widehat{\text{min}}$)	Perilune Altitude Mean (ft)	Perilune Altitude Sigma (ft)	Probability that R_p $<30{,}000$	Mean Minus 3 Sigma (ft)
0.25	3.70	59,288.	7939.	.00011	35,471.
0.50	3.78	59,274.	8029.	.00013	35,187.
1.50	4.56	59,121.	8952.	.00079	32,265.

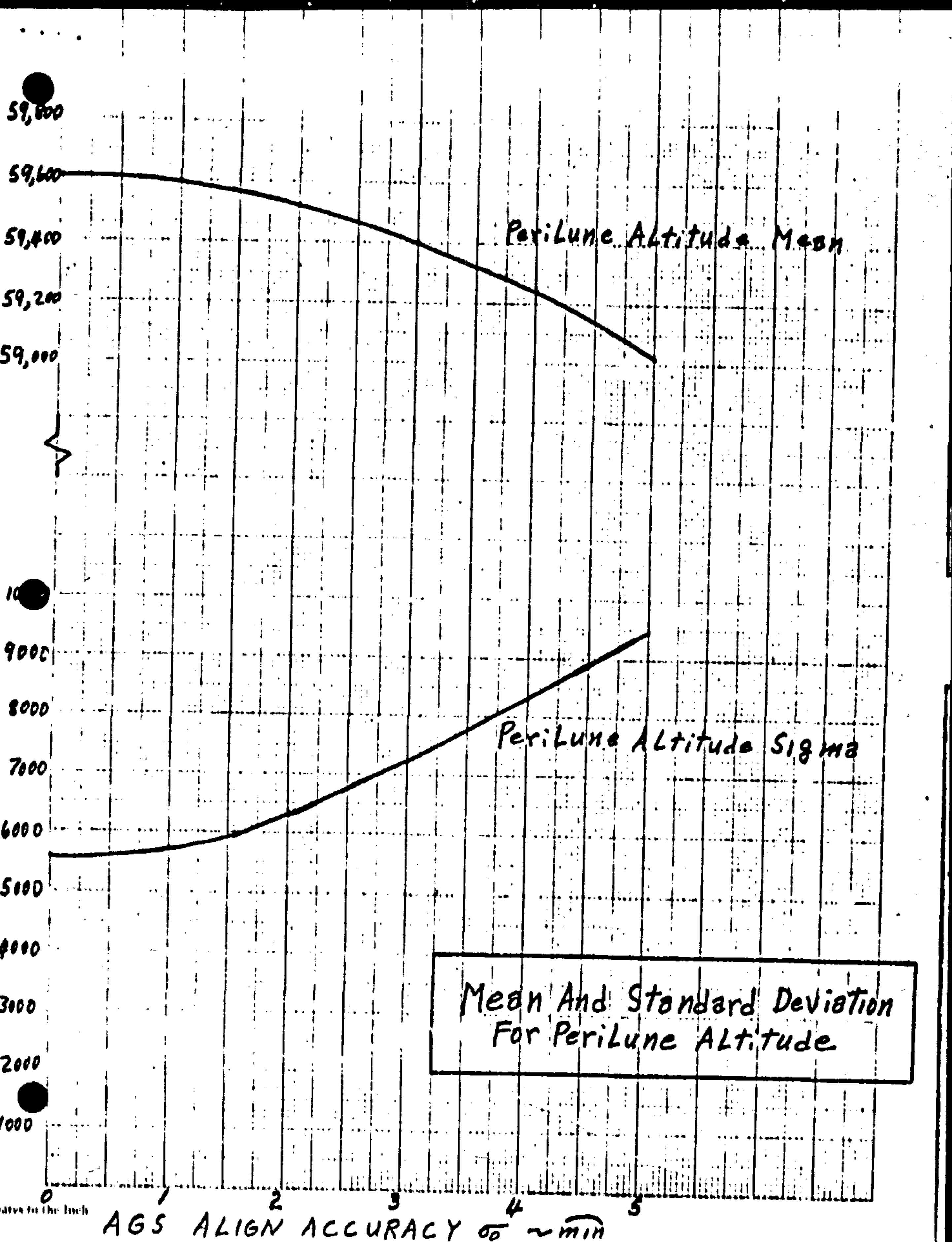
Conclusions

The statistics from the above table indicate that eliminating the PGNCS alignment during the Hohmann transfer increases the probability of obtaining an unsafe perilune by 6.8×10^{-4} times the probability of a PGNCS failure and decreases the mean minus three sigma for the hover abort perilune by 3206 feet. These changes are based upon the particular AGS error model available at the time the referenced analysis was performed. However, it appears reasonable to assume that the changes based upon the current error model would be of the same order of magnitude, i.e: 10^{-3} for the probability and 3000 feet for the perilune. This small loss in AGS performance should be worth the operational gains of eliminating the PGNCS alignment

RK:jr

Distribution

K. Baker
T. Barrie
T. Bettwy
R. Braslau
M. Fox
W. Klenk
P. Melancon
D. Phillips
G. Shook



59,800
59,600
59,400
59,200
59,000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1
2
3
4
5
Perilune Altitude Mean
Perilune Altitude Sigma
Mean And Standard Deviation For Perilune Altitude
AGS ALIGN ACCURACY σ_0 ~ min

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: September 26, 1968
68-PA-T-208A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Unusual procedure required for LM Ascent from the moon

Jack Craven surprised us with a little jewel the other day during the Lunar Surface Mission Techniques meeting. He says that in order to enable the APS engine-on and staging commands from the LGC, it is necessary for the crew to depress (now get this) the Abort-Stage button! That is, depressing this button must be part of the standard countdown procedure to LM liftoff.

Alternately the crew can manually arm the engine which permits them to send the engine-on command manually, but it does not enable the LGC signal. Furthermore, if they do this, it is necessary for the crew to also send the engine-cutoff signal manually since the signal from the LGC is inhibited.

Bill

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: September 25, 1968

68-PA-T-207A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Review of the Mission Techniques for Saturn V/Apollo Launch Phase Aborts

This memo is to backup our phone call notifying you of the review of the Saturn V/Apollo Launch Phase Abort Mission Techniques Document to be held Thursday, October 3, 1968, at 1:00 p.m. in Building 4, Room 383. At that meeting we will throughly discuss the attached draft of that document, as it applies to the C' and D missions. Please bring it with you or give it to your representative since we have only a limited number of copies.

Howard W. Tindall, Jr.

Enclosure

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: September 25, 1968

68-PA-T-206A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: C' Communication Loss

A lot of work is going into the subject contingency - with respect to:

a. Onboard cis-lunar navigation (P23)

b. Onboard return-to-earth targeting (P37)

c. Block data

all of which are solely for that failure. I won't comment on whether or not it's worthwhile. It's too emotional an issue to even consider eliminating it, regardless of how you feel. Therefore, by definition it's necessary to prepare for it. This memo is to report current status of this effort.

The spacecraft G&N is equipped to perform cis-lunar navigation. That is, determine its own position and velocity (state vectors) - primarily through use of star-horizon angle measurements. (Incidentally note that sextant trunion angle is the only observation used, an IMU is not required except to assist in acquisition of the targets.) We are told that at best the onboard navigation is marginal for providing a safe return to earth from cis-lunar space. Accordingly, if it is to be depended upon, it must be operated in the best way possible. For example, it cannot be simply cranked up and used at the time its need is recognized - half way back from the moon. Rather than that, as soon as the spacecraft starts back to earth, navigation must be initiated essentially as if a communication failure has already occurred. Specifically, observations and data processing must be carried out on a regularly scheduled basis through the transearth phase of the mission starting with star/lunar horizon observations within a couple of hours after TEI. This is necessary, we're told, to condition the observation weighting functions - the so-called W-matrix - so that subsequent observations are processed properly. In order to protect the W-matrix, it may be necessary to transmit the MCC-H/RTCC determined state vectors into the spacecraft computer memory locations assigned to the LM state vector which, of course, are unused on this flight. Or if uplinked into the CSM state vector slots, the crew will have to reset a flag bit to prevent reinitialization of the W-matrix during the next period of navigation. Associated with this, there must be a mission rule governing circumstances following communication loss in which the crew should utilize the onboard.

determined values rather than the old MSFN data transmitted before the failure. The point is, aside from obvious failure, there will be no way for the crew to determine in-flight which set of state vectors is the better. Jim McPherson's guys (MPAD) are determining this switchover point, which they expect to be about 20 hours out from the earth. Communication loss after this point would mean to use the last MSFN data uplinked - cause it'll be good enough. Before that though, the crew would essentially flush the MSFN and use their own navigation as a basis for maneuver targeting and entry guidance initialization. And - don't anyone kid himself. For the crew (and everyone else too) to learn how to operate that system is going to take a lot of time and effort.

Something else that's going to absorb attention is the return-to-earth targeting program. It doesn't necessarily come out with the answer you want automatically. Briefly, it has two options and will compute a maneuver to either get back-to-earth with the smallest possible maneuver (minimum ΔV mode) or as fast as possible using a crew specified ΔV (min. time mode). The landing point is not controlled in the computation and, if they want to return to some particular place - like the ships - the crew must manually iterate, noting the predicted IP and adjusting ΔV until they are satisfied. Use of the new, short range entry made the tables of predicted entry range in the spacecraft computer program wrong and so the crew will have to apply some biases in this process. (We're determining what they should be now.) Either that or use the minimum ΔV mode for corridor control only. This, of course, would usually be the preferred way to do it, I suspect.

Another action item Jim McPherson picked up is in regard to defining the minimum amount of time required to use the onboard navigation, starting from scratch. The problem here is in determining what "Block Data" maneuver should be sent up while in earth orbit for the TLI + 4 hour abort point. I think it is possible to provide a 17 hour return to the prime recovery area but if that is not sufficient time to navigate, target and execute an MCC onboard the spacecraft, it may be necessary to go an extra day - say a 41 hour return - to land there. That goes against the grain doesn't it, but that's where the no-communication logic led me!

Incidentally, all translunar navigation, as such, has been deleted from the flight plan. Essentially, all that is currently included are a series of observational periods to gather raw sextant star/horizon data for post flight analysis - particularly near the earth, which could not be obtained near the end of the transearth leg when we want to concentrate on entry preparations.

Obviously, we have a lot of thinking ahead of us. I just wanted to give a little status report and a chance for you to tell us how stupid we are, if you feel that way.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: September 24, 1968

68-PA-T-205A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Mission Techniques Documentation Schedule

Here's another guess at when the Mission Techniques Documents will be out. You'll notice eight are scheduled for October (what a lot of paper that is!), which means they are just about ready now.

This list reflects the change of emphasis to the lunar flight for C'. The two new areas we hadn't done much of anything about yet that are showing up now are C' Data Selection and G Descent aborts.

Howard W. Tindall, Jr.

Enclosure

PA:HWTindall, Jr.:js

MISSION TECHNIQUES DOCUMENTATION SCHEDULE
as of September 24, 1968

SUBJECT		JULY 24 EST.	CURRENT EST.	ACTUAL
C Retrofire and Reentry	Draft	-	-	Dec 6, 1967
	Final	-	-	Mar 6, 1968
	Update	Aug 23	-	Sept 6, 1968
C Rendezvous	Draft	-	-	Apr 16, 1968
	Final	-	-	May 29, 1968
	Update	Aug 12	-	Aug 12, 1968
C Data Select (MCC-H/RTCC)	Draft	July 29	-	July 25, 1968
	Final	Aug 12	-	Sept 16, 1968
C SIB Launch Aborts	Final	-	-	July 22, 1968
C'/G Earth Orbit & TLI	Draft	-	-	June 10, 1968
	Final	Aug 19	-	Sept 4, 1968
	Update	-	Oct 21	
C'/G MCC, LOI	Draft	Sept 16	Omit	
	Final	Nov 4	Oct 28	
C'/G TEI MCC & Entry	Draft	Aug 12	-	Aug 12, 1968
	Final	Sept 23	Oct 21	
C' Data Select (MCC-H/RTCC)	Final	Dec 2	Nov 20	
C' SV Launch Aborts	Final	-	Oct 14	
D Retrofire and Reentry	Final	Sept 23	Oct 28	
D Rendezvous	Draft	Aug 16	-	Aug 29, 1968
	Final	Sept 23	Oct 21	
G Descent (Wake up to touch-down	Draft	-	-	June 17, 1968
	Final	Aug 5	-	Aug 23, 1968
G MCC-H Powered Descent Monitoring	Draft	Sept 23	Note 1	
	Final	Oct 28	Note 1	
G Lunar Surface	Draft	-	-	July 22, 1968
	Final	Sept 16	Oct 7	
G Powered Ascent	Draft	Oct 7	Note 1	
	Final	Nov 18	Note 1	
G Rendezvous	Draft	Sept 23	Oct 28	
	Final	Oct 28	Dec 2	
G Descent Aborts	Draft	Oct 21	Nov 25	
	Final	Dec 2	Jan 13, 1969	

NOTE 1: Powered Descent and Ascent monitoring being implemented in the MCC-H/RTCC is limited to in-plane only. There is a proposal to modify this process extensively to overcome this deficiency but at substantial cost. The Mission Techniques, of course, are dependent on the outcome of "how-to-go" on this procedure. We should know within a month.

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: September 23, 1968

68-PA-T-203A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: D Rendezvous Ground Rules and Working Agreements update

Attached are the ground rules and working agreements updated based on our September 9 Mission Techniques meeting. They reflect the new, simplified D Rendezvous exercise - primarily changes in the football trajectory and the "insertion maneuver" plus a bunch of things we were able to delete. As noted in my last report of this subject, the most significant open item is the selection of the nominal TPI time and definition of the acceptable lighting conditions for it - i.e., its "window". Based on the studies underway, the procedures will have to be adjusted to assure meeting the constraints after they are defined and put in order of priority.

And - of course, we've gotta get that rendezvous radar thermal mickey mouse fixed! Other action items I failed to list previously are as follows:

a. The AGS people of TRW were asked to recommend the proper technique for managing the AGS in the event the PGNCS has failed and the CSM makes maneuvers since it has no program comparable to the PGNCS "Target ΔV" R32.

b. FCD was asked to determine the latest time the E memory could be dumped providing the MCC-H sufficient time to respond in its check-out and correction, if necessary.

c. GCD was asked to determine which CSM RCS thruster should be used for the RCS Sepration burn (i.e., -z or x) - or at least which would cost less RCS propellant, taking into account the altitude maneuvers and altitude hold required in each case.

d. MIT was asked to look into reducing the time required for observing the PIPA's in their bias test to less than the current 256 seconds.

I guess we'll get together again sometime. We haven't scheduled that meeting yet. We are planning to get a smaller group together to review the revised D Rendezvous Mission on October 4, 1968.

Howard W. Tindall, Jr.

Enclosure

PA:HWTindall, Jr.:js

September 12, 1968

"D" MISSION RENDEZVOUS GROUND RULES, WORKING AGREEMENTS AND THINGS LIKE THAT

1. General

a. The reference trajectory is that provided by MPAD, dated August 22, 1968, and as amplified in Appendix I.

b. Nomenclature for the burn sequence following undocking is:

(1) RCS Sepration
(2) Phasing
(3) TPI_0 - If abort from football
(4) Insertion
(5) CSI
(6) CDH
(7) TPI
(8) TPF

c. The rendezvous will be run throughout with the vehicle roll angles = 0°. The only exception to this is the RCS Separation burn where the CSM roll is 180°. A 180° roll will be performed by the CSM immediately prior to or during the IMU alignment following the RCS Separation burn. (i.e., TPI from above will be initiated "heads down" and TPI from below will be initiated "heads up" for either vehicle.)

d. LM and CSM state vectors time tagged 12 minutes before RCS Sepration are uplinked to the CMC and LGC prior to undocking. State vectors are not sent to either vehicle again during the rendezvous.

e. On both spacecraft all rendezvous navigation will be carried out to update the LM state vector. That is, the LM radar data would be used to update the LM state vector in the LGC and the CSM sextant data would be used to update the LM state vector in the CMC.

f. On both spacecraft the rendezvous navigation W-matrix will be set to 1000 feet and 1 fps initially and whenever it is reinitialized periodically during the rendezvous.

g. The CMC's LM state vector will be updated after each LM maneuver with the P-76 Target ΔV routine using the pre-burn values as determined in the LM's pre-thrust program

h. The AGS should be maintained in that state which makes it most useful to perform the rendezvous in the event of PGNCS failure. If, after having established the preferred techniques in accordance with that ground rule, it is possible to include some AGS systems tests without jeopardizing crew safety or other mission objectives, they would be considered.

i. The state vectors in the AGS will be updated each time PGNCS is confirmed to be acceptable. This will likely be at each time it is committed to make the next maneuver using the PGNCS except perhaps TPI.

j. AGC alignments will be made each time the PGNCS is realigned and each time the state vector in the AGS is updated from the PGNCS.

k. If PGNCS, RR, or G&N fails while in the football trajectory, the rendezvous exercise is terminated at the TPI_0 opportunity.

l. The AGS is not mandatory for the rendezvous exercise. That is, if it fails prior to or during this mission phase, the exercise shall continue.

m. As soon as possible after powering up the LGC, the E memory will be dumped via T/M so that the MCC-H may check its contents for completeness and accuracy. If necessary, the MCC-H will reload via uplink any important parameters found to be in error.

2. Prior to Unlocking

a. The crew will synchronize the CMC clock as precisely as possible utilizing information voiced from the ground. The crew will provide initial synchronization of the LGC to the CMC clock. The ground will provide the necessary information by voice for fine synchronization of the LGC clock. This supercedes the mission rule which specifies resynchronization of a spacecraft clock only whenever it disagrees with the ground reference by more than 0.5 seconds.

b. The LM Rendezvous REFSMMAT is that of a "nominal" alignment for T (align) = TIG (TPI). It will be uplinked from the ground.

c. The CSM Rendezvous REFSMMAT is defined by a stable member orientation where:

$\bar{X}$ CSM = $\bar{Z}$ LM

$\bar{Y}$ CSM = $\bar{Y}$ LM

$\bar{Z}$ CSM = $-\bar{X}$ LM

d. Prior to undocking, the CSM will maneuver the docked vehicles to an inertial attitude such that with no further attitude maneuvering the CSM will be oriented approximately 180, 0, 0, (roll, pitch, yaw) with respect to the local vertical frame at the time of the RCS Separation. The difference between the exact local vertical attitude and 180, 0, 0 is due to the regression of the line of nodes from TIG (RCS Separation) to TIG (TPI), and the fact that the CSM REFSMMAT is nominal at TPI.

e. The only in-flight adjustment of the LGC PIPA bias compensation parameters included in the nominal flight plan shall be done by the crew while docked to the CSM. The values will be updated regardless of how small the change. (i.e., there is no lower threshold) The crew will inform the MCC-H of the new values at the next MSFN station contact possible. The MCC-H will continually monitor the IMU performance and will advise and assist in additional updates if the compensation becomes in error by more than a specified threshold. Currently this threshold is set at .003 ft./sec.^{2}.

f. An AGS accelerometer calibration shall be performed while docked at about the same time as the PIPA compensation. This will be the only AGS accelerometer calibration in the nominal flight plan. AGS gyro calibration shall not be performed during the rendezvous exercise period of activity.

g. Prior to undocking, but following the CSM attitude maneuver to RCS Sepration attitude, the LM IMU will be aligned to the CSM IMU using the docked alignment procedure which takes advantage of a known CSM inertial attitude and known CSM/LM geometery (with account of the docking ring angle $\Delta\phi$ being taken) to coarse align the LM IMU to the inertial frame. The CSM and LM gimbal angles are then compared directly (via V16N20) and coarse align and attitude dead banding errors are removed by direct torquing of the LM IMU gyros via the fine align routine (V42). It is necessary for the MCC-H to compute and relay the gyro torquing angles to the crew in order to carry out this procedure.

h. The formula used for docked alignments with identical REFSMMATS is:

$$OGA_{LM} = (300 + \Delta\phi) - OGA_{CM}$$

$$IGA_{LM} = IGA_{CM} + 180$$

$$MGA_{LM} = -MGA_{CM}$$

Where $\Delta\phi$ is the docking ring angle.

i. The formula used for docked alignment where the stable members are oriented:

$$\bar{X}_{LM} = -\bar{Z}_{CM}$$

$$\bar{Y}_{LM} = \bar{Y}_{CM}$$

$$\bar{Z}_{LM} = \bar{X}_{CM}$$

is:

$$OGA_{LM} = (300 + \Delta\phi) - OGA_{CM}$$

$$IGA_{LM} = IGA_{CM} + 90$$

$$MGA_{LM} = MGA_{CM} = 0$$

This is a special formula only valid where the CM MGA = 0. This set of equations will be used for the LM alignment prior to undocking. (Equation verification is given in MIT/IL Apollo G&N System Test Group Memo No. 1224, dated August 2[illegible],1968. This reference notes there is a possible error in the sign of the $\Delta\phi$ term.)

3. Undocking, station keeping and LM inspection

a. Undocking will take place [illegible] minutes prior to the RCS Sepration burn with the CSM oriented to the inertial attitude for that burn. Average G will not be on in either vehicle during the undocking or station keeping phase. This will preserve the relative state vectors until Average G comes on in the CSM 30 seconds prior to RCS Sepration.

b. Following undocking, the CSM will maintain attitude and will be responsible for station keeping. The LM will yaw right 120° and pitch up 90° placing the two spacecraft "nose-to-nose." (crewmen "nose-to-nose")

c. The LM will yaw through 360° (1°/sec) permitting the CSM to conduct a visual inspection of the landing gear and LM structure.

d. After completion of 3c, the LM assumes the station keeping task while the CSM prepares for RCS Separation.

4. RCS Sepration and Mini-football

a. The configuration of the spacecraft at the RCS Separation burn will be LM leading the CSM, both heads down facing each other with zero relative velocity. (Orbit rate FDAI's - LM: 0, 180, 0 ; CSM: 180, 0, 0). (FDAI total attitude is read in the order roll, pitch, yaw; IMU gimbal angles are read in the order outer, inner, middle).

b. The CSM will execute a 5 fps radial inward burn for the RCS Separation burn; i.e., the CSM will 5 fps -Z (body). This burn will employ the P-30, P-41 sequence. LM uses R-32 to update CSM state vector in the LGC. The ΔV residuals will be trimmed to within 0.2 fps, all components.

c. On entering darkness after the RCS Sepration both spacecraft will perform REFSMMAT IMU alignments.

d. The CSM and LM COAS will be calibrated during the mini-football and will not be moved again after that. The LM utilizes the foward window.

5. Phasing Maneuver and Football

a. The magnitude of the phasing burn is always re-established inflight.

b. The phasing burn will be executed under AGS control with PGNCS monitoring by use of programs 30 and 40. The throttle will be set at 10% for 15 seconds at which time it will be advanced crisply to approximately 40% and left there until auto-cutoff.

c. The horizon is used as a burn attitude check prior to the phasing burn when AGS is under control. The crew determines the LPD pitch angle for this check.

d. Phasing burn monitoring

(1) Attitude and/or attitude rate limits are exceeded - terminate the burn.

(2) Overburn - Back up AGS engine off three (3) seconds after the PGNCS "engine off time" is indicated.

e. Upon completion of the burn, the LM shall be oriented with X-axis vertical and the y and z body axis ΔV residuals will be trimmed to zero.

The x body ΔV residual will be trimmed to within 2 fps to maintain Δh with 1/4 mile.

f. While in the football, both vehicles will exercise their complete rendezvous navigation systems and will update the LM state vectors in the LGC and CMC. The TPI targeting resulting will be used not only for maneuver execution if necessary, but also to evaluate the performance of the LM PGNCS and CSM G&N, providing confidence in proceeding with the Insertion maneuver. As noted previously, these onboard determined state vectors will not be updated from the MCC-H.

g. On entering the darkness period about a quarter of a revolution before the phasing burn, both spacecraft will perform REFSMMAT IMU alignments.

h. If it is found necessary to remain an extra revolution in the football prior to executing TPI_o or the Insertion burn, the same procedures will be followed as during the initial football revolution.

6. TPI_o

a. IF PGNCS, rendezvous radar, or CSM G&N fails prior to insertion but after phasing, TPI_o is performed. As a standard operating procedure during the football rendezvous, the LM and CSM should both be targeted and prepared to execute the TPI if an abort is necessary. If the failure is LM PGNCS, AGS is used for executing TPI. A 130° transfer angle shall be used for aborts from the football rendezvous. But staged or unstaged.

7. Insertion Maneuver

a. MCC-H will compute and target the LM PGNCS for the Insertion maneuver in real time. External ΔV targeting will be used, transmitted via the P27 uplink route if the timeline permits. Voice backup (pad data) will always be relayed.

b. The CSM will also be targeted to make a maneuver to guard against a partial LM DPS burn falling outside the capability of the LM RCS to correct.

This maneuver will probably be fixed preflight (for example - 20 fps, horizontal, posigrade) which would permit the LM to return to a football by RCS.

c. In the event the LM has performed a ullage maneuver prior to a DPS engine failure to start, the LM will remove that ΔV to stay in the football.

8. CSI and CDH

a. CSI and CDH maneuvers shall be targeted to cause TPI time to occur when the CSM is 25½ minutes before sunrise. TPI time is defined as the time at which the elevation angle of the CSM with respect to local horizontal as observed by the LM is 27.5° (see 9b).

b. The MCC-H will select and relay to the crew a single solution for each of the CSI and CDH rendezvous maneuvers which will be used by both spacecraft - for PGNCS comparison, AGS targeting, and CSM G&N mirror image targeting, etc. It shall be that solution which is most compatible with the PGNCS. Some biases will be necessary for use in the CSM G&N.

c. As a nominal procedure, the command module will be targeted with "mirror image" maneuvers to be executed with a one minute time delay in the event the LM is unable to maneuver. In order to maintain TPI time and differential altitude within acceptable bounds it is necessary to bias the radial ΔV component of the CDH maneuver relayed to the CSM from the MCC-H by an amount established pre-flight (probably 4.3 fps). No other ΔV component of either the CSI or CDH maneuvers need to be biased in the CMC.

d. In order to compensate for approximations in the onboard CSI targeting program (P32) resulting in a "nominal" TPI time shift, it is necessary to bias the TPI time the LM crew inputs to that program 120 seconds late. The crew shall bias CDH time 110 seconds later than determined by the PGNCS CSI targeting program (P32) when sequencing through the CDH targeting program (P33) to compensate for an approximation in P32 which would cause a large radial component if uncorrected.

e. An out-of-plane ΔV component will be computed by the LM PGNCS for CSI and CDH using R36. This maneuver ΔV shall be executed unless it is less than 2 fps. This ΔV component will be included in the LGC/MSFC solution comparison.

f. LM PGNCS ΔV solutions will be compared with the ground. If the solutions agree, the PGNCS solution will be burned. There will not be comparisons with AGS, charts, or CSM.

g. In the event the ground solution is to be used, it will be executed using the AGS which has been targeted with the MSFN solution as a standard procedure. The external ΔV mode is used. No ΔV components of either the CSI or CDH maneuvers need to be biased in the AGS.

h. No radar data shall be input into the AGS prior to CSI and CDH.

i. There will not be any backup charts used for CSI. The LM shall have backup charts for CDH and TPI. The CDH charts require a minimum of 29 minutes between CSI and CDH. The command module pilot will be unable to compute onboard chart solutions for TPI due to the press of other activity and so they will not be available as a data source.

j. In the event the LM has performed an ullage maneuver prior to a main engine failure, the LM will remove that ΔV to maintain correct targeting of the CSM mirror image burn.

9. TPI

[NOTE: Some of the following items (e.g., 9a and 9c) which involve lighting constraints have not been established as being right, since they are based on an assumption that lighting is not mandatory. In fact, the lighting is currently considered mandatory under certain circumstances. These items are included here to draw attention to this extremely important matter. It is all to be resolved as soon as results of analysis to determine firm lighting requirements and expected TPI time dispersions are available. Consideration is being given to shifting to the P34 TPI "time option" from the "elevation option" if necessary to force TPI to occur within the window. This business also has implications on 9d regarding the CSM procedures and the MCC-H solutions transmitted for comparison. These results of these studies may also cause a change in the nominal TPI time noted in 8a.]

a. Although studies have shown that if TPI time falls outside a window of approximately four minutes duration undesirable lighting conditions will result for one or both spacecraft, it has been established that it is more important to execute TPI at the proper elevation angle than to honor lighting constraints in terminal phase. That is, lighting constraints are desirable but not mandatory. Nominal TPI elevation angle is mandatory. (See note above)

b. The elevation angle to be used in the TPI targeting programs (P34) in both spacecraft shall be 27.5° for all rendezvous. A 130° transfer angle will be used for all rendezvous.

c. The LM shall always use the elevation angle option in P34 for TPI targeting. (See note above)

d. The CSM shall always use the elevation angle option in P34 for TPI targeting whenever it becomes the active vehicle. Therefore, the first time the CSM cycles through P34 it will use the elevation angle option; however, if the LM TPI solution is determined to be acceptable by comparison checks, the CSM will recycle through P34 using the LM TPI time as input to the "time option." (TPI maneuvers will not be biased.)

e. TPI shall be targeted onboard and at MCC-H to force a node at TPF (i. e., intercept). The MCC-H shall supply this maneuver via voice (pad message) in both External ΔV and line-of-sight components.

f. If the LM PGNCS is working but rendezvous radar has failed, no external data will be input to the spacecraft systems----PGNCS, AGS, or charts. In this case, the command module executes the TPI and subsequent midcourse correction maneuvers and the LM does the braking maneuver if visibility permits. However, the command module, of course, must compare its TPI solution with the MSFN and that comparison must be favorable. (If not, see 9h) The command module would voice relay to the LM the maneuvers it has executed in order that the LM crew could update the command module state vector in the LGC using the target ΔV program.

g. If the LM PGNCS has failed, but the RR is working, compare the onboard chart solution for TPI with the MSFN. If the comparison is favorable execute the chart solution and, if not, use the MSFN ΔV's executed at a time determined onboard the spacecraft. The maneuver would be made using the AGS external ΔV mode.

h. If both the RR and the CSM G&N have failed, use the LM PGNCS to execute the MSFN TPI solution given in LOS coordinates at the time at which the elevation angle is 27.5° as determined onboard the spacecraft.

i. If the CSM performs the TPI maneuver, RCS will be used rather than SPS as the propulsion system. This simplification significantly reduces the CSM crew loading and gives greater assurance he will be able to do all things required of him.

UNITED STATES GOVERNMENT

Memorandum

[illegible] Division

TO : PA/Chief, Apollo Data Priority Coordination

DATE: September 17, 1968

68-FM61-293

FROM : FM6/Chief, Orbital Mission Analysis Branch

SUBJECT: Reference trajectory usage for mission D rendezvous simulations and analyses

1. As a result of the recent change in the rendezvous profile for mission D, formal documentation does not currently exist which provides the trajectory information required for rendezvous-associated analyses. The OMAB was requested in the "D" Rendezvous Mission Techniques meeting of September 9 to define which, of the existing reference trajectories, should be utilized for interim analyses, software testing, and flight crew support prior to the publication of the operational trajectory (currently scheduled for publication November 15, 1968). The OMAB recommends that the document, "Revision 2 to the Apollo Mission D Spacecraft Reference Trajectory, Volume I - Nominal Trajectory," (MSC Internal Note No. 68-FM-210, dated August 22, 1968) be utilized for this purpose. The portion of the rendezvous profile from a ground elapsed time (g.e.t.) of 98:42:44.7 (Hr:Min:Sec) through TPF in this document is identical to the current profile following the insertion burn from a lighting and relative motion standpoint. That is, the relative position and velocity at 98:42:44.7 are identical to those in the current profile at the completion of the insertion burn. MSFN coverage can be obtained from the reference document by using the current g.e.t.'s for significant events. These are as follows:

Event	Current g.e.t.
Undocking	92:45:00
Mini-football separation	93:01:45
Phasing	93:46:07
Insertion	95:37:49
CSI	96:18:45
CDH	97:01:33
TPI	97:54:51
TPF	98:26:49

APPENDIX I

2. The flight crew is currently performing rendezvous simulations based upon the mission D reference trajectory (April 30, 1968). By starting simulations at the 9[illegible]:55:10 reset point, performing CSI at the time reflected in this document (98:52:14), and using as a nominal TPI time 100:29:00 (as opposed to the old value of 100:15:25) would afford almost the identical relative conditions as those in the current profile. That is, a ΔH of 10 n. mi. and a time between CDH and TPI of approximately 53 minutes would result. This procedure is recommended for future simulations until the rest points are updated to reflect the operational trajectory.

Edgar C. Lineberry, Chief
Orbital Mission Analysis Branch

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: September 23, 1968
68-PA-T-208A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: G Rendezvous Mission Techniques

If you can stand it, I would like to announce another change in the G mission lunar rendezvous timeline. In order to provide more tracking which will hopefully improve CSI targeting and to avoid bothersome real time variations of time between CSI and CDH which foul up the plane change scheduling, we propose:

a. Move CSI five minutes later - to 55 minutes after insertion which is nominal apogee. This is primarily to avoid a rather large radial ΔV at CDH.

b. Always schedule CDH one half a revolution (180°) after CSI.

c. Schedule plane changes 30 minutes prior to CDH and at CDH, as before. The LM should use the Z-axis RCS LM thrusts for the CDH maneuver (by yawing if necessary) to avoid losing RR acquisition.

d. The LM may include a plane change at CSI if the CSM has adequate sextant tracking for targeting it. Rendezvous radar only is not considered adequate.

The new timeline looks like this:

0	55	82	112	145
INS.	CSI	P.C.	CDH & P.C.	TPI

Intervals: 55 (INS. to CSI), 27 (CSI to P.C.), 30 (P.C. to CDH & P.C.), 33 (CDH & P.C. to TPI)

The only disadvantage we currently see is that it reduces the time between CDH and TPI to about 33 minutes. However, 33 minutes should be adequate even with dispersions and the advantages of a relatively fixed maneuver schedule and better navigation before CSI seem well worth it. It should be noted that a (hopefully small) change in the CSI targeting programs (P32 and P72) would be required to force the computer to use the 180° spacing between CSI and CDH. This can be done in either of two ways. Our preference would be to provide the crew control probably by modifying the second P32 DSKY display format to utilize the third register which is currently blank as option code. [The other two displays in this format are apsidal crossing (N) and TPI elevation angle (E).] The simplier but less flexible way of doing this job is to increase the magnitude of the parameter currently stored in fixed memory which is used in the CSI R test, which forces the logic to use a 180° transfer when the pre-CSI orbit is found to be essentially circular and apsidal crossings become ill-defined. Ed Lineberry will submit a PCR for this.

Several action items came out of our meeting as follows:

a. MPAD - It is necessary to develop a rule governing the use of the VHF data in the event no sextant data is being obtained. It is our understanding that VHF data by itself is not only inadequate, but could actually degrade the processing. If this is so, we need to establish procedures whereby the crew inhibits VHF into the CMC when sextant data is not available.

b. MPAD - It is our proposal that the CSM be the prime source of targeting the plane change maneuver regardless of which spacecraft executes it. This is because the sextant is potentially more accurate than the rendezvous radar for this particular purpose. Here again a rule is needed to define how much sextant data is needed to target the plane change maneuver as opposed to using the rendezvous radar solution.

c. MPAD - We came to the conclusion at the last meeting that it was not possible to use the same maneuver solution for CSM mirror image targeting as the LM uses for burn execution. This meant the crew would have to cycle through two programs rather than just one. On further thought, it seems as though we can avoid this extra complexity, which is really rather serious. I am sure we can for the CDH burn and it seems probable that something can be done for the CSI burn too, particularly since it's constrained to be horizontal. Accordingly, we have requested OMAB to re-examine this procedure to see if we can't clean it up. We must also determine whether one minute delay in the mirror image targeting is really a requirement since these are RCS burns and problems at TIG don't appear to be too likely.

d. ASPO - Milt Contella repeated a rumor that the rendezvous radar may have random error in the shaft angle measurement when the line-of-sight from LM to CSM is close to the lunar surface. We must find out what the true situation is as quickly as possible and start figuring out some workaround procedure to be added to all the other ones.

Odds and Ends

We are assuming that the CSM will backup the LM CSI and CDH maneuvers using the SPS; it is probable, however, as on the D mission, that it will backup TPI with RCS. We have also concluded that the CSM should not backup the plane change since that requires yawing out-of-plane and disrupts tracking between CSI and CDH. Of course, if it is known that the LM will not be able to perform the plane change maneuver, the CSM will do it at that time. If the LM and CSM both fail to perform the plane change 30 minutes before CDH, the CDH plane change will force the node near TPI and so in that event the plane change will be taken out during the TPI burn targeted with R-36 to force a new node 90° after TPI time. This, of course, is a departure from the nominal TPI plan which calls for forcing the node at intercept (TPF).

That's it!

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:jn

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: September 23, 1968

68-PM-T-201

FROM : PM/Deputy Chief

SUBJECT: Results of September 17 Apollo Spacecraft Software Configuration Control Board (ASSCCB) meeting

The first three hours of this marathon meeting were devoted to implementation of the descent program in LUMINARY. The currently approved plan is to implement the one-phase descent scheme proposed by Floyd Bennett and his merry crew. However, MIT has been directed to implement it in such a way that it would be possible to fly the old two-phase technique - if desired. Almost all effort is to be devoted to the one-phase technique with only one day's worth of testing included for the two-phase - and no design improvements are to be developed or included in the two-phase. What this really means is that at the cost of one day's worth of testing we have provided some cheap insurance for being able to change back later if we have to. If the decision were made to use the two-phase, a considerable amount of additional testing would be required and at that time, program deficiencies might be uncovered revealing that that capability does not really exist.

Several things that interested me about the new one-phase are:

1. The decision of which way to go - one or two-phase is made pre-flight and an option flag is set in erasible memory before launch.

2. The much smoother attitude time history of the one-phase scheme may very well permit the DPS trim gimbal to do all the steering, substantially reducing RCS usage.

3. MIT is providing a crew option via the DSKY for manually changing from P63 to P64 in the event they want to do that earlier than the automatic switch.

4. High-gate is now being defined as the time at which the landing radar position is changed.

MPAD has submitted a Program Change Request (PCR 949) to eliminate a lock-out of the landing radar data above 35,000 feet (estimated altitude). This was a two part change since it is necessary to fix a program to allow the data to be read and also necessary to change the weighting function such that data above 35,000 feet is not given a zero influence on the state vector. Since the proposed change was estimated to cost three days schedule impact, Floyd Bennett was requested to rewrite his PCR to simplify the requirement while achieving the same end results. Essentially, it amounted to replacing the 35,000 foot boundary with a 50,000 foot boundary. In addition, it is necessary that I verify that the rendezvous radar powered flight designate routine (R29) can be eliminated as a requirement and thus be made uncallable from the descent programs. Subsequent to the meeting I did that and have informed FSD.

Guidance and Control Division brought in two PCR's (Nos. 224 and 248) which influence the processing of the landing radar data. One changed the reasonability tests and the other provided a delay in utilizing landing radar data for four seconds after the LGC receives a "data good" discrete because it takes that long for the landing radar output to converge on the true value after lock-on. Both were approved at a cost of one day each.

MIT was requested to determine the impact of changing the descent program such that it would be possible for the crew to command all four RCS jets in the minus X direction immediately upon touchdown in order to smoosh the LM into the lunar surface and keep it from turning over while the DPS belches to a stop. Ain't that the damnest thing you ever heard?

Flight Crew Support Division presented a proposal to modify COLOSSUS II to permit the crew to manually steer the TLI burn in the event of a SIVB IU failure. No action will be taken on this until the technique is approved by Mr. Low's CCB.

A really ancient PCR, No. 132, submitted by the crew to provide a VHF ranging data good discrete light, was finally disapproved since the spacecraft will not be modified to provide the additional DSKY lights which would have been used for this.

Tom Gibson presented their proposal, which was approved, for the follow-on spacecraft programs. A so-called COLOSSUS I Mod A will be prepared, which is basically the COLOSSUS I program with all known anomalies corrected plus the following three simple program improvements:

1. IMU pulse torquing

2. Backup integration

3. An improvement on the mark incorporation

It is planned th t a tape release of this program will occur on December 1, at which time mission operations testing (Level 6) can be started along with rope manufacture. This program will be used for the D mission.

A COLOSSUS II program is also now being developed which starts from the COLOSSUS I Mod A baseline to which CSI/CDH will be added. I suppose it will also include anomalies uncovered too late for the Mod A version. MIT's estimate of tape release for this program is February 1, 1969. It is felt that this program can probably be made ready for Spacecraft 106 - that is, the flight after D, whatever that is. VHF ranging, incidentally, should also be available on spacecraft 106.

Howard W. Tindall, Jr.

Addressees:
FM/J. P. Mayer
C. R. Huss
D. H. Owen
FM13/R. P. Parten
J. R. Gurley
E. D. Murrah
M. Collins
FM4/P. T. Pixley
R. T. Savely
FM5/R. E. Ernull
FM5/H. D. Beck
FM6/R. R. Regelbrugge
K. A. Young
FM7/S. P. Mann
R. O. Nobles
FM/Branch Chiefs
TRW/Houston/R. J. Boudreau
MIT/IL/M. W. Johnston

FM:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: September 20, 1968
68-PA-T-200A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: C' Transearth Midcourse Correction (MCC) and Entry Mission Techniques

On September 13, we conducted a review of the Transearth MCC and Entry Mission Techniques for a lunar mission. Although, originally developed for an F or G type mission, the discussion was almost completely devoted to C'. Participation included all interested MSC organizations (including the C' flight crew) as well as representatives from North American, MIT, and Bellcomm. Some fairly significant decisions were made, which it is the purpose of this memo to report.

1. Previous to the meeting an agreement had been reached by Mr. C. C. Kraft and the flight crew that on the C' mission a non-skip reentry would nominally be utilized. It was noted, however, that in a contingency situation the full 2,500 mile reentry range might be needed for weather avoidance and, therefore, the capability was to be retained. At our meeting we determined that the full 2,500 mile range was really not a useful capability and are recommending:

a. All work should be oriented to provide capability of re-entering with ranges limited from 1200 to 1800 nautical miles. (Based on these limits the GNCS should never enter reentry P66.)

b. The useful operational footprint nominally is 1200 to 1450 nautical miles. (Simulations currently underway are expected to permit extending this to 1550 or 1600 nautical miles.) The normal reentry range for targeting and ship location purposes (i.e., PLA I) shall be 1350 nautical miles (which, if flown would preclude use of P65).

c. PLA 2 is defined as a contingency area and will be located at a range of 1800 nautical miles. PLA 2 will never be used unless PLA I is unacceptable for some reason and the G&N is working. If during attempt to reach PLA 2 the G&N fails, the crew will fly a constant G reentry until aerodynamic capture is assured and then will fly maximum range to get as close to PLA 2 as possible.

2. It seems logical that all systems tests, crew training, procedure development, etc. be limited to the above defined capability - that is, no effort should be devoted to preparing for entry ranges greater than 1800 nautical miles, at least for the C' mission.

3. Consistant with the short range reentry, it was decided at the meeting to eliminate the previously nominal, shallow entry target line. Subsequently it was decided to modify this decision to apply only to entries at velocity greater than some value to be established by C. Graves, J. Harpold, and Co. Essentially it applies to the nominal lunar flight and aborts performed some time after TLI. Henceforth, MCC-H maneuver targeting will be based on aiming for the steep target line, previously only utilized for contingencies which provide a -6.48° flight path angle at the entry interface. Use of this steep target line is considered to be compatible with a short range reentry and constraining targeting to it will substantially simplify flight controller and crew procedures.

4. The activity associated with SM/CM separation was throughly discussed and was finally combined with the pre-entry spacecraft attitude, horizon check. For the first time it appears we have an agreement on the timeline and crew procedures including management of the CMC for all this pre-entry activity. The separation pitch attitude has been defined as being the same as the horizon attitude check and yaw is 45° out-of-plane. Sepration studies should be carried out, if they have not already been completed, to verify acceptability of this decision - not to optimize it.

5. Previously it had been proposed that the EMS would be started manually at the MCC-H computed time of .05 g's because it was erroneously felt that the EMS Range-to-Go display could be made substantially more accurate by following this procedure. At this meeting the decision was reversed and it is now recommended that the EMS be started automatically with crew backup after a reasonable time delay, currently three seconds.

6. Two decisions were reached regarding the Transearth Injection (TEI) maneuver.

a. The criteria for switching over from GNCS to SCS will be based on providing a subsequent trajectory in which the MCC's do not exceed the remaining RCS capability.

b. The only ΔV residual requiring trimming at TEI cutoff is the x-axis and it should only be trimmed to within 2 fps.

7. It was agreed that all transearth MCC, including the first, would be performed for corridor control only, unless it is determined in real time that the predicted landing point is unacceptable for some reason (e.g., unacceptable weather or land masses within the footprint or in the PLA ?, or excessive return to base staging time). It was stated that if a maneuver is required to relocate the landing point for reasons such as noted above, the maneuver will be made large enough to provide acceptable

landing conditions in the entire FLA I footprint and at FLA 2. Wherever possible, of course, the recovery ships will be removed to a new location consistant with a 1350 nautical mile entry range.

9. Incidentally, it appears that it will be decided to fly the C' mission with the GNCS up and operating continuously, if power permits. I understand MIT will endorse this as being preferable from an overall reliability standpoint.

10. The C' Mission Techniques Document shall be updated to conform with these changes and decisions.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

APOLLO DATA PRIORITY COORDINATION

MEETING SCHEDULE

AS OF September 18, 1968

68-PA-T-199A

	September					October														
SUBJECT OF MEETING	23	24	25	26	27	30	1	2	3	4	7	8	9	10	11	14	15	16	17	18
Descent Phase			▀										▀							
C'Midcourse Phase								▀										▀		
"D" Rendezvous																				
Ascent Phase			▀										▀							
"C" Rendezvous																				
D **Retrofire and Reentry**										▀										
C' Lunar Orbit				▀					▀					▀					▀	
"G" **Rendezvous**								▄										▄		
C' Spacecraft Navigation		▀					▀					▀					▀			
SPECIAL MEETINGS																				
C' Data Select		▄					▄					▄					▄			

Joanne Sanchez
for Howard W. Tindall, Jr.

▀ *Meeting begins at 9:00 a.m.*

▄ *Meeting begins at 1:00 p.m.*

MSC FORM 1285 (FEB 68)

APOLLO DATA PRIORITY COORDINATION

MEETING SCHEDULE

AS OF August 20, 1968

68-PA-T-191A

SUBJECT OF MEETING	August 26	27	28	29	30	September 2	3	4	5	6	9	10	11	12	13	16	17	18	19	20
Descent Phase			▀										▀							
Midcourse Phase																				
"B" Rendezvous										█										
Ascent Phase			▄										▄							
"C" Rendezvous																				
101 Retrofire and Reentry																				
Lunar Reentry																				
"G" Rendezvous																		▄		
Data Select							▀					▀					▀			
SPECIAL MEETINGS																				
"F/G" Transearth MCC &									█											
Entry Document Review																				

for Joanne Sanchez
Howard W. Tindall, Jr.

▀ Meeting begins at 9:00 a.m.

▄ Meeting begins at 1:00 p.m.

MSC FORM 1285 (FEB 68)

APOLLO DATA PRIORITY COORDINATION
MEETING SCHEDULE

AS OF August 1?, 196?

[illegible]-IA-?-1? A

SUBJECT OF MEETING	August [illegible]	[illegible]	1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	September [illegible]	[illegible]	4	[illegible]	6	9	10	11	12	13
Descent Phase								■										■		
Midcourse Phase																				
"D" Rendezvous															■					
Ascent Phase								■										■		
"C" Rendezvous																				
101 Retrofire and Reentry																				
Lunar Reentry																				
"G" Rendezvous																				
Data Select			■										■					■		
SPECIAL MEETINGS																				
LM Descent Analyses			■																	
"F/G" Transearth MCC &															■					
Entry Document Review																				

The Descent data priority meeting for [illegible] is cancelled.

Joanne Sanchez

Howard W. [illegible]all, Jr.

■ (top half) Meeting begins at 9:00 a.m.

■ (bottom half) Meeting begins at 1:00 p.m.

MSC FORM 1?63 (FEB 6?)

UNITED STATES GOVERNMENT

Memorandum

TO : See list below DATE: SEP 4 1968

68-PA-T-189A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Should LM RCS jet #10 be disabled for the "D" mission docked DPS burn?

The following paragraph is extracted from MIT's Spacecraft Autopilot Development Memo #11-68, dated July 24, 1968, by William S. Widnall.

"In the docked configuration jet #10 produces such little torque, that it may be advantageous to disable this jet (with notice to the LGC). The DAP will perform better because the estimated acceleration will agree more closely with the actual acceleration. As a result there will be less bending exitation. Also, jet #10 would not be wasting RCS fuel and would not be heating the descent stage."

Is the recommendation being incorporated in the docked DPS burn procedure on the "D" mission, or shouldn't it be?

Howard W. Tindall, Jr.

Addressees:
CB/J. A. McDivitt
CF/W. J. North
CF24/P. Kramer
EG23/K. J. Cox
FC5/H. D. Reed
FS5/T. F. Gibson, Jr.
FM13/A. Nathan
FM7/S. P. Mann
MIT/N. W. Johnston

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: AUG 8 1968

68-PA-T-188A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Correction to memorandum

Please destroy the cover page of memorandum 68-PA-T-172A, dated July 26, 1968 and replace it with the attached corrected copy.

for Joanne Sanchez
Howard W. Tindall, Jr.

Enclosure

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: AUG 5 1968

68-PA-T-185A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Propulsion system to be used on the "D" Mission Rendezvous CSI Maneuver

One of the planned rendezvous maneuvers (CSI_1) on the "D" mission is nominally zero. Since it is intended to make this maneuver based on the real time situation, some logic must be established to govern when and how the maneuver would be made. This memo is to describe the proposed logic.

If the computed value of the CSI_1 maneuver is less than 1* fps, the maneuver will not be executed at all. If the maneuver is greater than 1 fps but less than 6* fps, the spacecraft will be oriented with the minus X-axis in the direction of the velocity vector and the maneuver will be carried out using four jet RCS. The reason for this orientation is to avoid losing rendezvous radar lock. This means, of course, that the maneuver may be executed in either $\pm$ X direction with equal probability.

The 6 fps upper limit is necessary in order to conserve RCS propellant as well as to remain within jet impingement constraints. If the CSI_1 is in excess of 6 fps, the DPS will be used at 10% thrust (even though rendezvous radar lock may be lost).

There was concern about using the DPS to carry out small maneuvers from the standpoint of how the PGNCS would work as well as whether a short burn for CSI would preclude use of the DPS for the 60 fps CDH maneuver approximately 30 minutes later. Harry Byington checked into this and has determined that the propulsion people intend to adopt the following DPS constraint for the "D" mission: the DPS may be used provided at least 30 minutes has elapsed since the previous burn, no matter how short it was. In other words, we have no problem there. It has also been determined that the PGNCS does not limit us either. Although the DPS thrust program (P40) does not have short burn logic like the SPS and APS programs have, including start up and tail off characteristics, it is capable of

---

* I selected these values to illustrate the point. They're probably not far off. MPAD is in the process of determining the proper values, OMAB - the first based on rendezvous considerations; G&PB - the second based on engine characteristics and consumables. (Task assignments are needed.)

handling the task. Just before igniting the engine, the PGNCS determines the duration of the burn required to achieve the desired ΔV, assuming the engine will operate at a constant 10% level for the entire period. (This, of course, is not an accurate assumption.) If the burn duration is less than six seconds, as it certainly would be for CSI_1, the PGNCS would command a timed burn. It will simply turn on the engine for the duration of time computed and then will turn it off regardless of the ΔV obtained. Orderinarly, this will result in an underburn since the slow thrust build up characteristics would not be compensated completely by the tail off. The difference should be well within trim capability, though.

Of course, if CSI_1 turns out to be as big as 6 fps it's bad news! Something is not working right, the implications of which may make all this unnecessary. However, it is interesting to know that there is a capability to make maneuvers of any size.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

4 . .

UNITED STATES GOVERNMENT

Memorandum

TO : PA/Manager, Apollo Spacecraft Program

DATE: AUG 1 1968
68-PA-T-183A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: LM rendezvous radar is essential

A rather unbelievable proposal has been bouncing around lately. Because it is seriously ascribed to a high ranking official, MSC and GAEC are both on the verge of initiating activities - feasibility studies, procedures development, etc. - in accord with it. Since effort like that is at a premium, I thought I'd write this note in hopes you could proclaim it to be a false alarm or if not, to make it one. The matter to which I refer is the possibility of deleting the rendezvous radar from the LM.

The first thing that comes to mind, although not perhaps the most important, is that the uproar from the astronaut office will be fantastic - and I'll join in with my small voice too, for the following reason. Without rendezvous radar there is absolutely no observational data going into the LM to support rendezvous maneuvers. This would be a serious situation both during the major rendezvous maneuvers (CSI, CDH, and TPI) and during terminal braking. Please let me discuss these separately.

First of all, let it be clearly understood the MSFN cannot support rendezvous maneuver targeting during lunar operations. That must be an entirely onboard operation due to limitations in MSFN navigation (i.e., orbit determination) using short arcs of data on a maneuvering spacecraft and because much of the rendezvous is conducted out-of-sight - and - voice of the earth. In other words, we couldn't tell them what to do if we knew!

Therefore, without the LM radar the only source of maneuver targeting is the CSM. Using what? A VHF ranging device to be flown for the first time on the lunar mission and a spacecraft computer program (Colossus), which does not have the CSI and CDH targeting programs in it. Thus, the CSM pilot would have to use charts! I'd like to emphasize the fact, though, that the CSM pilot is so busy making sextant observations (which are mandatory - VHF alone is not adequate) and performing mirror image targeting, etc. along with routine spacecraft management that it has been concluded he can not and will not perform onboard chart computations.

And - even if we were to think negative schedule-wise and assume we will get a flight qualified VHF ranging device and CSI/CDH targeting in Colossus, Jr. in time for the lunar mission, I can't believe we'd be willing to fly a rendezvous with no backup or alternate data source for comparison. The ΔV margins are too small and the consequence of failure is unacceptable!

Now, let me speak of terminal phase braking. Range and range rate information are essential for this operation. This can be obtained crudely by visual means and without radar that's the only source. (Lighting conditions must be satisfactory - although poor CSI/CDH targeting will cause TPI time slippage almost certain to mess it up.) The DSKY displays of range and range rate from the computers are based on the state vectors obtained by the rendezvous navigation and they degrade badly at close ranges. That is, their usefulness is highly questionable. (Unless lunar operations are better than "earthal," they are worthless; I'm not sure if lunar is better or not.) So its the eyeballs then and plenty of RCS.

If I sound like I'm on some higher energy level about this, it's cause I am. I'm sure most will agree that a rendezvous radar failure is the worst that can happen in the PGNCS (and AGS) during rendezvous since without it all data is lost. (For example, the current "D" rendezvous mission rule is that rendezvous radar failure dictates aborting the rendezvous exercise, the CSM goes active for TPI and midcourse corrections, using the sextant, and whoever can see best will give a try at braking.)

Please see if you can stop this if it's real and save both MSC and GAEC a lot of trouble.

Bill

Howard W. Tindall, Jr.

cc:
PA/C. H. Bolender
FA/C. C. Kraft, Jr.
CA/D. K. Slayton

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : PA/Manager, Apollo Spacecraft Program

DATE: AUG 1 1968
68-PA-T-182A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: North-American Rockwell (NR) participation in Mission Techniques Activity

This note is to let you know that NR participation in the Mission Techniques activity is almost negligible. (Except reentry - Bobby Johnson's team working on the EMS is outstanding.)

We have many internal meetings here at MSC; I'm not referring to these, but rather to the much less frequent big meetings, well attended by MIT and (recently) by GAEC. It is at these meetings that a great many details are resolved involving crew procedures and their interface with the ground, etc. Knowledge of much of this must be essential to prepare useful AOH's and to conduct meaningful simulations - and, NR input might be useful too!

I realize there is a budget squeeze damping travel, of course. I wanted to make sure you were aware of this situation so that proper priority could be assigned - if it isn't - to NR management. Frankly, I don't see how they could possibly know what's going on!

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

APOLLO DATA PRIORITY COORDINATION

MEETING SCHEDULE

AS OF July 30, 1968

68-PA-T-176A

SUBJECT OF MEETING	5	6	7	8	9	12	13	14	15	16	19	20	21	22	23	26	27	28	29	30
	August																			
Descent Phase								■										■		
Midcourse Phase																				
"D" Rendezvous																				
Ascent Phase								■										■		
"C" Rendezvous																				
101 Retrofire and Reentry																				
Lunar Reentry																				
"G" Rendezvous																				
Data Select		■										■					■			
SPECIAL MEETINGS																				

for Joanne Sanchez
Howard W. Tindall, Jr.

■ (top half filled) Meeting begins at 9:00 a.m.

■ (bottom half filled) Meeting begins at 1:00 p.m.

MSC FORM 1283 (FEB 68)

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

UNITED STATES GOVERNMENT

Memorandum

TO : PA/Manager, Apollo Spacecraft Program

DATE: JUL 31 1968

68-PA-T-175A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: LM propulsion of the LM/CSM configuration as an SPS backup technique

The capabilities described in the attached EA memo, same subject, were well coordinated throughout MSC leading to the present situation, which as far as I can determine is acceptable to everyone. No associated action is requested of you.

Howard W. Tindall, Jr.

Enclosure

PA:HWTindall, Jr.:js

UNITED STATES GOVERNMENT

Memorandum

BILL TINDALL - Any comment? Anything I should do about this? MAY 1 1968 GML

MAY 1 1 59 PM '68

TO : PA/Manager, Apollo Spacecraft Program

DATE: MAY 1

FROM : EA/Director of Engineering and Development

In reply refer to: EG23-88-68-486

SUBJECT: LM propulsion of the LM/CSM configuration as an SPS backup technique

Refer to #AAH-2-2-33

Response requested by:

Reference is made to the following documents:

1. MSC memorandum, "Mission Planning Systems Meeting No. 4," October 10, 1963.

2. MSC memorandum, "Use of the Apollo LM propulsion system as backup to the service propulsion system," November 10, 1963.

3. GAEC memorandum, LMO-500-112, "Dynamic and static stability analysis of a combined LM/CSM propelled by LM thrusting," May 28, 1964.

4. GAEC memorandum, LMO-50-192, "Stability of combined LM/CSM with LM thrusting including guidance loop," July 22, 1964.

5. Apollo Mission Planning Task Force (AMPTF) report, IED-540-8, July 27, 1964.

6. MSC memorandum, EG23, April 9, 1965, "Preliminary results of analog simulation of CSM/LM transearth injection using LM propulsion."

7. MSC Internal Note, EG-65-26, "Analog Simulation Study of LM Descent Engine Propulsion Backup to the SM Service Propulsion System," June 16, 1965.

8. MSC memorandum, 66-FM11-30, "DPS backup of SPS in the earth's sphere of influence," October 19, 1966.

9. MSC memorandum, "EG27-128-66-1178, "Manual mode DPS for SPS backup," November 16, 1966.

10. MSC Internal Note, 66-EG-48, "Limit cycle bounds for docked configuration," November 21, 1966.

11. MSC memorandum, FM2 to EG2, "Non-free return trajectories," October 5, 1967.

12. MSC memorandum, EG23-68-41, "Proposed extension of the LM DAP manual modes evaluation at GAEC," February 19, 1968.

PA-MGR
PA-M,CSM
PA-M,LM
PA-A,MGFLS
PA-Tech Asst
PA2
PD
PE
PF
PP
PT
FILES
RA
PP7

The question of using LM propulsion in a LM/CSM configuration has recently been the subject of detailed review. Control system studies, both inhouse and at GAEC, have contributed to that review. Because of the current interest in the LM propelled docked configuration and its guidance and control systems, a review of the studies performed in support of the system development effort has been made. The present memorandum is intended to summarize the results of those studies.

Use of the LM ascent and/or descent propulsion system to propel the LM/CSM configuration (as a backup to the SPS) was proposed by NR in late 1963 (reference 1). Shortly thereafter, a static feasibility study of such backup was made at MSC (reference 2). A dynamic stability analysis of the proposed backup control system was completed at GAEC in the Spring of 1964 (reference 3), and extended to include guidance loop dynamics two months later (reference 4). With the completion of single-axis static and dynamic guidance and control studies of the LM propelled configuration, a joint MSC/MIT/NAA/GAEC commission (the Apollo Mission Planning Task Force, AMPTF), recommended adoption of a LM DPS backup to the SPS (reference 5). Adoption of a control mode which would employ the LM APS to propel the LM/CSM docked configuration was not recommended because of the requirement to contain large APS/CG moment unbalances with the RCS.

The GAEC study described in reference 3 showed that adequate closed loop attitude control of the docked configuration during a DPS firing required a large gain increase (over the undocked LM configuration) in the pitch and yaw rate feedback channels of the LM analog attitude control system. This requirement was corroborated by a three-axis rotational and translational guidance and control evaluation of the docked configuration completed by the Guidance and Control Division early in 1965 (references 6 and 7). The effects of body bending and propellant sloshing were included in the evaluation, and the feasibility of both manual and automatic modes of control was demonstrated. The ASPO, in order to avoid the hardware change needed in the LM analog autopilot to accommodate both CSM on and CSM off configurations, decided to implement control of the DPS-propelled docked configuration in the LM digital autopilot only.

Attention was again called to the subject of LM DPS backup to the SPS in late 1966. The Mission Planning and Analysis Division pointed out that the LGC fixed memory requirements could be relieved by omitting a return-to-earth program in the LGC. Mission Planning and Analysis Division requested a [illegible] of the feasibility of a LM propelled fixed attitude burn for trans-earth injection of the docked configuration (reference 8). The Guidance and Control Division agreed that the proposed fixed attitude burn [illegible] feasible (reference 9) and determined the limit cycle bounds of the required attitude hold under the influence of LM/CSM bending (reference 10). These considerations strengthened the position of the Guidance Software Control Panel, which held that the LGC should not include a return-to-earth program, but should rely upon the CMC return-to-earth program and the MSFN.

In the fall of 1967, the question of LM propulsion of the LM/CSM docked configuration was raised in connection with non-free return trajectories (reference 11). The subject was reviewed by the Guidance and Control Division and the control status of the configuration presented to the Directorate. Most recently, the Astronauts expressed interest in the one time rejected APS-propelled LM/CSM. Control of this configuration (rotated at the docked interface to minimize APS/CG moment unbalance) was investigated at GAEC (reference 12). Inasmuch as the GAEC investigation did not include the dynamic effects of structural bending and propellant sloshing, it could not be considered conclusive. Nevertheless, there is indication that control of the described configuration may be feasible. Whether it is feasible to rotate the docking interface in the manner assumed is also a matter that needs verification.

According to present mission planning, there is only one control mode specifically intended for LM backup propulsion of the docked LM/CSM configuration. That mode employs LM DPS propulsion, DAP attitude control in "auto" mode, external delta V targeting, and cross product steering. The Guidance and Control Division does not plan to conduct further studies in the depth needed to verify the design of docked APS mode unless a mission requirement is established.

Maxime A. Faget

cc:
EG2/D. C. Cheatham
EG21/M. Kayton
EG/Branches and Project Offices
CA/D. K. Slayton
CH/R. L. Schweickart
CF/W. J. North
CF131/M. K. Lake
FA/C. C. Kraft
FM/J. P. Mayer
H. W. Tindall
FS/L. C. Dunseith
FS5/T. F. Gibson
PD12/R. W. Kubicki

EG23:TPLins:dub 4/23/68

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: JUL 26 1968

68-PA-T-171A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Mission Techniques Documentation Schedule

Some people have asked me for a schedule of when the various Mission Techniques books will be coming out. I can't remember who they all were so I'm sending it to everyone. I'll update it in a couple of months.

Howard W. Tindall, Jr.

Enclosure

PA:HWTindall, Jr.:js

MISSION TECHNIQUES DOCUMENTATION SCHEDULE
as of July 24, 1968

Subject		May 14 Est.	Current Est.	Actual
C Retrofire and Reentry	Draft	-	-	Dec. 6, 1967
	Final	-	-	Mar. 6, 1968
	Update	-	Aug 23	
C Rendezvous	Draft	-	-	Apr 16, 1968
	Final	-	-	May 29, 1968
	Update	-	Aug 12	
C Data Select (MCC-H/RTCC)	Draft	July 29	July 29	
	Final	-	Aug 12	
D Retrofire and Reentry	Final	-	Sept 23	
D Rendezvous	Draft	July 22	Aug 16	
	Final	Sept 3	Sept 23	
D SPS and DPS Docked Maneuvers	Final	-	-	
D Data Select (MCC-H/RTCC)	Final	-	Sept 30	
E Rendezvous	Draft	Aug 19	Sept 30	
	Final	Oct 7	Nov 18	
E S-IVB Burn		-	-	
arth Orbit & TLI	Draft	June 10	-	June 10, 1968
	Final	July 8	Aug 19	
G MCC, LOI, TEI	Draft	Sept 16	Sept 16	
	Final	Nov 4	Nov 4	
G Descent (Wake up to touchdown)	Draft	June 17	-	June 17, 1968
	Final	-	Aug 5	
G MCC-H Powered Descent Monitoring	Draft	Sept 5	Sept 23	
	Final	Oct 28	Oct 28	
G Lunar Surface	Draft	June 17	-	July 22, 1968
	Final	-	Sept 16	
G Ascent	Draft	Sept 5	Oct 7	
	Final	Oct 28	Nov 18	
G Rendezvous	Draft	Aug 19	Sept 23	
	Final	Oct 7	Oct 28	
G MCC & Entry	Draft	July 1	Aug 12	
	Final	Aug 12	Sept 23	
Lunar Data Select (MCC-H/RTCC)	Final	Dec 2	Dec 2	
G Descent Aborts	Draft	-	Oct 21	
	Final	-	Dec 2	
SIB Launch Aborts	Final	June 24	-	July 22, 1968
SV Launch Aborts	Final	Sept 9	-	

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
CA/... Armstrong
[illegible]
CB/M. Collins
CB/C. Conrad
CB/L. G. Cooper
CB/C. M. Duke
CB/R. F. Gordon
[illegible]/J. Lovell
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
CB/E. A. Aldrin
[illegible]
CF/W. J. North
CF[illegible]/[illegible] Grimm
CF[illegible]/J. Bilodeau
CF[illegible]/C. Jacobsen
CF[illegible]/W. Haufler
CF[illegible]/C. C. Thomas
[illegible]/P. Kramer
[illegible]/M. C. Contella
CF[illegible]/D. W. Lewis
CF[illegible]/D. K. Mosel
CF[illegible]/C. J. Woodling
CF[illegible]/C. J. Van Bockel
CF[illegible]/C. Nelson
CF[illegible]/M. Brown
CF[illegible]/[illegible] J. Riche
CF[illegible]/[illegible] W. Holloway
[illegible]
[illegible]aberlin
[illegible]
[illegible] Dunne
[illegible]
[illegible]
[illegible]
[illegible] Kingsley
[illegible] Irvin
[illegible] Ch corne
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]/W. J. Oliver
[illegible]/[illegible] Smith
[illegible]/[illegible]
[illegible]
[illegible]/J. M. [illegible]
[illegible]/C. W. Frazier
KA/R. F. Thompson
PA/G. M. Low
PA/C. H. Bolander
PA/K. S. Kleinknecht
PA2/M. S. Henderson
PD/O. E. Maynard
PD/C. D. Perrine
PD[illegible]/J. C. [illegible]
[illegible]
PD[illegible]/R. [illegible]
PD[illegible]/M. [illegible] von [illegible]
PD[illegible]/A. Cohen
PD6/H. Byington
PD7/W. R. Morrison
PD[illegible]/J. Loftus
PE/D. T. Lockard
FA/S. C. Kraft, Jr.
FA/S. A. Sjoberg
FA/C. C. Critzos
FA/R. G. Rose
FC/E. F. Kranz
FC/M. P. Frank
FC/G. S. Lunney
FC/C. E. Charlesworth
FC2/J. W. Roach
FC27/W. E. Platt (3)
FC3/A. D. Aldrich
FC35/B. N. Willoughby (4)
FC4/J. E. Hannigan
FC4/R. L. Carlton (3)
FC5/J. C. Bostick
FC5/P. C. Shaffer
FC54/J. S. Llewellyn
FC54/D. V. Maccaro
FC5A/C. F. Deitrich
FC55/E. L. Pavelka (5)
FC56/C. B. Parker(7)
FL/J. B. Hammack
FL/L. C. Dunseith
FS5/[illegible]C. Stokes
FS[illegible]/T. F. Gibson, Jr.
FS[illegible]/[illegible] Williams
FS5/[illegible] R. Sabionski
FS5/T. W. Conway
[illegible]/R. Allen
[illegible]
[illegible]
[illegible] Meyer
[illegible]
[illegible]
[illegible] (5)
FM5/C. T. Hyle
FM4/P. A. Pixley
FM[illegible]/R. T. Savely
FM5/W. R. Wollenhaupt
FM[illegible]/[illegible] E. Small
FM[illegible]/L. D. Beck
FM6/R. D. Duncan
FM6/R. R. Regelbrugge
FM6/K. A. Young
FM6/R. W. Becker (3)
FM6/S. A. Glantz
FM7/S. P. Mann
FM7/R. O. Nobles
FM[illegible]/R. H. Brown
FS/Branch Chiefs

HX-[illegible]/[illegible] Dorrah
HX-[illegible]/D. W. Sachtart
Bellcomm/Hqs./R. V. Sperry
Bellcomm/Hqs./G. Heffron
Bellcomm/Hqs./MA[illegible] Merritt
GAEC/Bethpage/J. [illegible]
GAEC/Bethpage/M. Pollack
GAEC/Bethpage/R. [illegible]
MAC/Houston/R. P. Rudd
MIT/IL/R. R. Ragan (2)
MIT/IL/E. Copps
MIT/IL/M. W. Johnston
NR/Downey/M. Vucelic
NR/Downey/D. Zermuehlen
NR/Downey/E. Dimitruk, [illegible]
TRW/Houston/R. J. Boudreau
TRW/Houston/M. Fox
TRW/Houston/R. L. Baker
TRW/Redondo Beach/[illegible]
GSFC/550/F. O. Vonbun
GSFC/550/B. Kruger
KSC/CFK/R. D. McCafferty
KSC/CFK/P. Baker

July 25, 1968

"D" RENDEZVOUS MISSION TECHNIQUE
OPEN ITEM LIST

(to be discussed at next meeting)

1. Rendezvous Navigation Mission Techniques Panel Report.

2. MPAD to determine expected trajectory dispersions at initiation of the rendezvous exercise.

3. MPAD to determine CSI/CDH out-of-plane ΔV lower threshold.

4. MPAD to determine CDH_2 time bias.

5. ASPO to determine expected LM IMU alignment accuracy when docked to the CSM.

6. Review of MCC-H/Crew Pad Message Format.

7. Crew to determine from simulator exercises the maneuverability of the LM in the docked configuration during terminal phase.

8. MPAD to establish acceptable difference limits for use in comparison of onboard vs MSFN rendezvous targeting (CSI, CDH, & TPI).

9. Review of rendezvous maneuver monitoring procedures.

10. TRW to present AGS align and initialization procedures.

Enclosure 3

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

UNITED STATES GOVERNMENT

Memorandum

Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: JUL 26 1968

68-FM-T-170

FROM : FM/Deputy Chief

SUBJECT: AGS program changes

On Thursday, July 25, Guidance and Control personnel met with Mr. C. C. Kraft, Chairman of the Apollo Spacecraft Software Configuration Control Board (ASSCCB), to discuss and obtain direction regarding what to do about the AGS computer programs starting with FP-6.

Since the cost is apparently negligible, it was concluded that they should go ahead with the changes described in AGS SCP nos. 42, 44, and 45, which were on the agenda of the July 23 ASSCCB meeting. They are primarily clean-up items that don't influence the AGS design capability.

In addition, it was decided to incorporate the new rendezvous radar filter which, of course, means that the CSI and CDH targeting programs must be eliminated. I think that everyone agrees that this was a very important thing to do, if it was possible, since without the new radar filter, the AGS performance can be unacceptably poor. FP-6 will be available to support an August 1969 launch date.

Incidentally, in case you weren't aware of it, FP-5 which supports the Mission "E" launch date has the altitude update at beginning of hover incorporated in it. This simple change greatly increases the probability of safe pericynthion in the event of a late descent abort.

I would recommend that Math Physics Branch review the new RR filter immediately if they haven't already, since it's being implemented now.

Howard W. Tindall, Jr.

Addressees:
FM/J. P. Mayer
C. R. Huss
D. H. Owen
FM13/R. P. Parten
J. R. Gurley
E. D. Murrah
A. Nathan
FM4/P. T. Pixley
R. T. Savely
FM5/R. E. Ernull
H. D. Beck
FM6/R. R. Regelbrugge
K. A. Young
FM7/S. P. Mann
R. O. Nobles
R. W. Brown
FM/Branch Chiefs
TRW/R. J. Boudreau

FM:HWTindall, Jr.:js

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

Memorandum

TO : See list attached

DATE: JUL 26 1968
68-PA-T-169A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: July 9 and July 24 "G" Rendezvous Mission Techniques meetings

1. During the July 9 and July 24 "G" Rendezvous Mission Techniques meetings we have developed preliminary intra-vehicular rendezvous navigation sighting schedules. Crew work load estimates currently in use for the "D" mission rendezvous are included. These tracking schedules are very important since they have a predominating influence on almost everything else. For example, from these it has been possible to develop a preliminary spacecraft attitude time history which shows some fairly large gaps are going to be present in the CSM MSFN telemetry coverage. This, of course, is due to the fact that the S-band antenna is on the same side of the spacecraft as the sextant, which must be pointed down in order to observe the LM. Of course, during maneuvers occuring within sight of the earth, the CSM can be yawed to a heads down attitude enabling S-band telemetry coverage. The rendezvous activities do not ordinarily interfere with LM telemetry coverage.

2. The Orbital Mission Analysis Branch (OMAB) of MPAD has distributed a memo (68-FM62-217, dated July 15, 1968) which presents the revised rendezvous profile including the relative motion plots and visibility and slant range time histories. Some of the most interesting features are:

a. Insertion occurs at approximately 340 n.m. slant range. By CSI this range will have decreased to approximately 170 n.m.

b. The LM will appear to the CSM to be less than 8° above the lunar horizon for the entire first two hours after insertion into orbit. After that, it will move below the lunar horizon.

c. There will be two points of sun interference for the sextant tracking of the LM. one immediately after insertion and another approximately two hours later, about 20 minutes before TPI.

3. OMAB presented the results of a study which shows that it is not possible to use the same maneuver solutions for LM maneuver targeting and CSM mirror image targeting on a lunar mission as is done on the "D" mission. Accordingly, if the CSM does not have CSI targeting capability in its computer, the LM crew will have to sequence through P72 to provide mirror image

maneuver targeting to the CSM and then P32 to target its own guidance systems. If the CSM does have the CSI targeting programs, the LM crew will be relieved of this job and will use P32 only. The CSM pilot will pick it up since the nominal procedure would call for his determination of the LM maneuver targets using P72, which he would relay to the LM for PGNCS solution comparison and AGS targeting. He would then use P32 to compute his own mirror image maneuver. It appears that the TPI time used in the P32 and P72 computations may have to be different regardless of which spacecraft does it. Since the mirror image maneuver is to be executed with a one minute time delay after planned LM ignition time, it may also be necessary to change CSI time. OMAB is looking already into this.

4. There was considerable discussion regarding initialization of the LM PGNCS and CSM G&N for rendezvous navigation. As reported previously, platform alignments by both vehicles right after insertion are now included in the timeline. Upon completion of the CSM platform alignments, the MCC-H will relay a new LM state vector into the CMC based on LGC telemetry after insertion. Even with this update, it is anticipated that the uncertainties in these state vectors will be quite large, making it necessary to use initial values in the W-matrix which will not be suitable for W-matrix reinitialization during the rendezvous sequence. The Math Physics Branch is looking into that. We ended the meeting by starting the development of some "G" mission rendezvous ground rules and working agreements similar to those developed for "D". Those we agreed to so far are attached.

5. The next meeting will be in September since many key people will be on leave during August.

Howard W. Tindall, Jr.

Enclosure

PA:HWTindall, Jr.:js

July 25, 1968

"G" MISSION RENDEZVOUS GROUND RULES WORKING AGREEMENTS AND THINGS LIKE THAT

1. General

a. The reference trajectory is that provided by MPAD, dated August 15, 1968.

b. Nomenclature for the burn sequence following insertion is:

(1) CSI
(2) CDH
(3) PCI
(4) TPI
(5) TPF

c. The rendezvous will be run throughout with the vehicle roll angles ≈ 0°. The only exception to this is when during maneuvers within sight of the earth the CSM roll is 180°. TPI from above will be initiated "heads down" and TPI from below will be initiated "heads up" for either vehicle.

d. A LM state vector time tagged 12 minutes after insertion will be uplinked to the CMC within five minutes after insertion. State vectors are not sent to either vehicle again during the rendezvous phase.

e. IMU alignments will be made starting five minutes after insertion by both spacecraft and take precedence over the state vector update if timeline and/or attitude conflicts develop.

f. On both spacecraft all rendezvous navigation will be carried out to update the LM state vector. That is, the LM radar data will be used to update the LM state vector in the LGC and the CSM sextant and VHF data will be used to update the LM state vector in the CMC.

g. The CMC's LM state vector will be updated after each LM maneuver with the P76 Target ΔV Program using the pre-burn values as determined in the LM's pre-thrust program.

h. The state vectors in the AGS will be updated each time PGNCS is confirmed to be acceptable. This will likely be at each time it is committed to make the next maneuver using the PGNCS except perhaps TPI.

i. AGC alignments will be made each time the PGNCS is realigned and each time the state vector in the AGS is updated from the PGNCS.

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: JUL 25 1968

68-PA-T-168A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: "D" Rendezvous

1. A great many things were discussed and resolved at the July 22 "D" Rendezvous Mission Techniques meeting. They will all be fully recorded in the minutes. There were three items, however, I would like to call particular attention to at this time by this memo.

2. In order to avoid any chance of recontact as a result of maneuver dispersions in the CSM RCS separation maneuver which starts off the "D" mission rendezvous, it was decided to increase its magnitude from 1.0 to 2.5 fps. It will still be performed in a radial direction. This was brought about when it was recognized that an error of about 0.4 fps in the horizontal retrograde direction would result in recontact after the big phasing burn. Dispersions of that magnitude could easily occur due to imperfect velocity nulling during station keeping, G&N maneuver dispersions, spacecraft venting, etc.

3. It has been established that the elevation angle to be used by both spacecraft in determining all TPI times - nominal and contingency - will be 27.5°.

4. The out-of-plane component of the TPI maneuvers shall be targeting to force a node at TPF rather than at the second midcourse correction maneuver. This will also apply to the lunar rendezvous mission, which the "D" was attempting to simulate in this respect. The change is being made to simplify the crew timeline and procedures; it is felt to be entirely adequate based on the recently adopted plans for handling out-of-plane on the lunar rendezvous.

5. The above decisions are considered firm and should be immediately incorporated in all aspects of the Apollo Program to which they apply. They will only be changed if there is a darned good reason - not just to make things a little better!

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: JUL 24 1968

68-PA-T-167A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: July 19 "C" Rendezvous Mission Techniques meeting

Although most of the things discussed in our Friday, July 19 "C" Rendezvous Mission Techniques meeting are not of general interest, there were a couple of things I would like to let you know about.

First of all, in an effort to reduce the probability of having to make the NCC2 maneuver, which would be an extra SPS burn, it has been decided to trim the NCC1 ΔV residuals if they are less than 10 fps. In addition, the time of the NSR maneuver will be adjusted in real time by as much as 30 seconds thereby changing the differential altitude. These two new things together should be adequate to maintain the nominal TPI time, which is the primary objective in targeting these maneuvers. The nominal differential altitude, you recall, is about 7.8 n.m. and it was finally agreed that acceptable targeting bounds are from 7 n.m. on the low side to 9 n.m. on the high side. These adjustment limits give us a capability of adjusting TPI time by about 20 minutes to account for dispersions. Using these procedures, it will only be necessary to make the NCC2 burn if we encounter dispersions far in excess of those expected.

Something else which has been changed is that the elevation angle at TPI is considered more sacred than any lighting limits at all and should be retained at the nominal value at all cost even though the so-called lighting limits are violated. Previously the elevation angle was to be changed if the lighting limits could not be met.

Another important mission rule adopted now is that the rendezvous exercise will be terminated if the C&N fails prior to NSR, and probably will be terminated any time the C&N fails. This is to conserve SM RCS and permit flying a full duration mission.

The changes to the mission techniques are relatively minor and it is probable that it will not be necessary to reissue the entire document. Rather than that, we will probably distribute change pages of some sort.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : CA/Chairman, Crew Procedures Control Board

DATE: JUL 23 1968

68-PA-T-163A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Guidance and control action limits

In the development of mission techniques, we are establishing quite a large number of parameter limits which are used to determine how the guidance and control systems will be used (for example, monitoring attitude during an SPS burn wherein if the attitude exceeds 10° or the attitude rate exceeds 5° per second, the crew would take over manual control from the G&N). These limits were already in the Mission Rules. However, they are not included in any of the Crew Procedures documents at this time. I would like to recommend that you give serious consideration to having them added to the Crew Check List as well as Crew Procedures, since it is anticipated that there will be too many of them for anyone to remember, and ground support is not always available. Perhaps, this can be discussed in one of your CCB meetings.

Howard W. Tindall, Jr.

cc:
CF/W. J. North
CF13/M. K. Lake

PA:HWTindall, Jr.:js

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: JUL 23 1968
68-PA-T-162A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: "C" Mission Retrofire and Reentry Mission Techniques meeting

On Friday morning, July 19, we had a "C" Mission Retrofire and Reentry Mission Techniques meeting to clean up some open items. It is evident that a distribution of correction pages to our previously distributed Mission Techniques document will be inadequate and it is our current plan to republish the whole book. Some of the most significant items resolved at this meeting are described in this memo.

1. It has been established that the G&N guidance system will be used in the event of a hybrid RCS deorbit. (A hybrid deorbit is one in which both the command module and service module RCS jets are used.) The retrofire will be targeted for a half-lift reentry.

2. It has been established that the G&N is mandatory for performing a hybrid deorbit; thus, if the G&N has failed and the service module RCS remaining has fallen below the return-line limits, the only remaining system for retrofire is SPS using SCS control. Accordingly, there is a mission rule that retrofire will be performed to land in the next best planned recovery area (PLA).

3. It has been established that if insufficient time is available for a fine alignment prior to retrofire, the G&N will be used with a coarse alignment if that can be done. Current estimate is that a coarse alignment will be to within 2° on all axis, which can result in as much as a 30 mile landing point miss.

4. In the absence of response to our request for better numbers, we have established the following limits beyond which the G&N will be declared No Go for reentry and the backup system will be used. The DSKY VG displays must be within 1 fps and the gimbal angles must be within 1°. Guidance and Control Division and MIT people please pay particular note.

5. Apparently the procedure has been established that command module separation from the service module will be performed following retrofire while still in the SPS thrust program (P40). This is to

keep Average G on during the separation maneuver without having to wait one minute as the entry programs are currently coded. The entry programs (P61, P62, etc.) will be sequenced after separation. Thus, these programs are being used in a completely different way than they were designed.

6. IMU PIPA and gyro drift compensation values are monitored continuously by MCC-H. It has been established that if the values currently loaded in the G&N are in error by more than .003 ft/sec^2 and .075 $^{\circ}$/hr, they will be updated in the CMC.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: JUL 1 8 1968

68-PA-T-161A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: LM Ascent lift-off time can be determined by the crew

Some months ago we submitted a PCR to remove the pre-Ascent targeting program (P10) from Luminary and this was done. This action was based on an assumption that a simple crew procedure could be developed for doing the same job, in the event of loss of communications, making the rather complicated computer program unnecessary. The Lunar Mission Analysis Branch of MPAD has concluded their development and analysis of this technique and is in the process of documenting it. It is only necessary for the ground to supply two parameters by voice to the crew prior to DOI which will allow them to independently determine lift-off time to within about six seconds. This dispersion takes into account current estimates of MSFN accuracies, etc. The effect on the rendezvous differential altitude due to this error is less than one mile, which is certainly far smaller than other dispersions which would occur in a non-communication situation. In other words, it is more than adequate.

Quite simply the procedure requires that the crew determine the time of closest approach of the CSM one pass before lift off by noting the time rendezvous radar range rate passes through zero on the tape meter. To that time, he must add the CSM orbital period and another ΔT to obtain lift-off time. These are the two parameters included in the pre-DOI pad message noted above which will be determined by MCC-H based on the actual CSM orbit.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: JUL 18 1968

68-PA-T-159A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: No 15 minute constraint for Lunar Ascent Guidance

The Luminary GSOP indicates that it is necessary for the astronaut to call up the Ascent Guidance Program (P12) at least 15 minutes prior to lift off. This, of course, is not consistant with our desire to be able to use P12 if we get a No Go for lunar stay approximately 10 minutes after landing. In that case, we intend to call up P12 with less than seven minutes to go before lift off. By checking with MIT, we have verified that the 15 minute limit is not a real constraint and that the only limit is the time required for the crew to go through the operations associated with P12, which is currently estimated to be less than five minutes. (Simulations will eventually refine this, probably to a smaller value.)

I have asked MIT to modify their GSOP (by PCN) to reflect this.

Bill T

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

APOLLO DATA PRIORITY COORDINATION

MEETING SCHEDULE

AS OF July 16, 1968

68-PA-T-158A

SUBJECT OF MEETING	July										August									
	22	23	24	25	26	29	30	31	1	2	5	6	7	8	9	12	13	14	15	16
Descent Phase							■											■		
Midcourse Phase			■										■							
"D" Rendezvous	■					■														
Ascent Phase								■										■		
"C" Rendezvous																				
[illegible] Retrofire and Reentry																				
Lunar Reentry									■											
"G" Rendezvous			■										■							
Data Select							■					■					■			
SPECIAL MEETINGS																				

Howard W. Tindall, Jr.

Meeting begins at 9:00 a.m.

Meeting begins at 1:00 p.m.

MSC FORM 1183 (FEB 58)

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: JUL 17 1968

68-FM-T-157

FROM : FM/Deputy Chief

SUBJECT: Results of the July 9 Apollo Spacecraft Configuration Control Board (ASCCB) meeting

This is my belated report on the July 9 ASCCB meeting. It was reported that Sundance Assembly 302 was delivered to Raytheon for rope manufacture on July 3.

1. There was another long discussion about the APS engine and how it works. Harry Byington reported that it takes about 700 milliseconds to reach 90% thrust. He also reported that following a three second burn, a 30 minute coast period is required before restart; following a 30 second burn, a one second coast is required. For longer burns, - duration of which he was unable to define, the coast period required can get as short as 30 seconds. This means that it will be unacceptable to "abort stage" during the first 50 seconds of powered descent. If we must use the APS, we will have to use the V37 entry into P71.

2. Bob Savely will be pleased to know that MIT submitted PCN 480, which indicates that the rendezvous radar variances are in Sundance erasable, even though our March PCR requesting that was disapproved.

3. PCN 483 was submitted by MIT regarding DPS docked burns, but my notes and memory fail me and I would suggest that those interested (Carl Huss, G&PB, etc.) look it up. It has to do with pitch-roll RCS jet selection for attitude control. It was noted that it will be necessary for the CSM to damp whatever residual rates exist at the end of a burn since the crew must turn off the PGNCS DAP to avoid excessive jet impingement.

4. PCR 488 (also PCR 468.2), changing the Target ΔV processor from a routine (R32) to a program (P76) in Luminary was approved to provide restart protection, the same as Colossus. Two days impact was quoted.

5. PCR 439.2 for Luminary was approved with no impact. It downgrades the "preferred attitude flag," the same as in Colossus.

6. Guidance and Control Division submitted a package of four PCR's dealing with the landing radar in the Luminary program. Only one of these (no. 216) was approved with a one day impact. It changes the

the time at which the landing radar antenna position is changed to coordinate it with the vehicle attitude change at hi-gate, in order to avoid loss of lock. Without this change it was almost certain the crew would have to reacquire with the velocity beams by manual switching to "Radar Test."

7. The other three PCR's were added to the Luminary Hopper.

a. PCR 217 was to change the way the antenna position discrete would have used. Specifically, it was requested that it be ignored (except to set an alarm) before hi-gate and if "wrong" after hi-gate to use landing radar data to update altitude only but not velocity. Three days impact was quoted.

b. PCR 218 was to compensate for the 6° landing radar antenna misalignment which screws up the crew's displays. The two day impact was unacceptable, although the crew considers this an important program change.

c. PCR 219, which cost two days impact, would have put the lateral velocity on the downlink at the same time the altitude data is - that is, at 35,000 feet rather than 22,000 feet. FCD wanted this one.

8. Guidance and Control Division informed the Board they intended to submit a PCR to add the Sundance Landing Radar Superious Return Test (R77) to Luminary for use on missions "E" and "F" (high speed lunar surface overpass).

9. PCR 222 was a change to the CSI targeting program in Luminary requested by MPAD to eliminate the lack of convergence on CDH time for near circular orbits. Two days impact was unacceptable and so it has been added to the Luminary Hopper. In the meantime, the LMAB was requested to look into selecting a better (higher) value for the altitude rate test which could be used in Luminary.

10. PCR 220, submitted by MPAD regarding a number of Colossus Entry modifications, was discussed amid great confusion at the end of the meeting. As I understand it, several modifications were approved but two (nos. 15 and 18) were left as open items pending coordination between MPAD and MIT. All together it was a two day impact.

That is all I can remember!

Howard W. Tindall, Jr.

Addressees:

FM/J. P. Mayer
C. R. Huss
D. H. Owen
FM13/R. P. Parten
J. R. Gurley
E. D. Murrah
A. Nathan

FM4/R. T. Savely
P. T. Pixley
FM5/R. E. Ernull
FM6/R. R. Regelbrugge
K. A. Young

FM7/S. P. Mann
R. O. Nobles
FM/Branch Chiefs
TRW/R. J. Boudreau

FM:HWTindall, Jr.:js

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: JUL 10 1968

68-PA-T-154A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: "C" Mission Clean Up

We'll try to clean up the rest of the "C" mission open items at a meeting on Friday, July 19, in Room 1032B of Building 30. Retrofire and Reentry will be discussed in the morning, starting at 9 a.m., and Rendezvous in the afternoon - or as soon as we finish the Retrofire session. Attached are open item lists for each session, kindly prepared by Stu Davis, FCD.

Howard W. Tindall, Jr.

Howard W. Tindall, Jr.

Enclosures 2

PA:HWTindall, Jr.:js

DEORBIT AND ENTRY DATA PRIORITY MEETING ITEMS

1. Is the entry following an RCS deorbit to be ballistic or guided?
2. Will the EMS be used for G&N failure occurring at any time?
3. Is closed loop G&N entry to be the nominal?
4. What are the thrust vector magnitudes and directions for SM - CM RCS deorbit ΔV's?
5. Is a fine align or coarse align sufficient for deorbit?
6. Are crew using ADPC procedures?
7. What are DCKY VG and gimbal angle limits in comparison with ground maneuver pad?
8. What are 3σ BMAG drifts?
9. What are PIPA bias and gyro drift limits and the compensation procedure?
10. Are the pads current?
11. What is the new REFSMMAT flag setting procedure?
12. Is the G&N needed for hybrid deorbit?

Enclosure 1

RENDEZVOUS DATA PRIORITY MEETING ITEMS

Open Items:

1.	Trim NCC1 to keep from doing NCC2.	Ken Young
2.	Rendezvous with SCS if G&N fails anywhere prior to to NSR.	Phil Shaffer
3.	Δh limits for terminal phase.	Ed Lineberry
4.	Lighting constraints for TPI hard or is elevation angle hard?	Flight Crew
5.	Is 27.45° the elevation angle for TPI?	Paul Kramer
6.	Are P-52 alignment completion necessary prior to NCC1?	FDB and FCSB
7.	Are the maneuver pads current?	Will Presley
8.	Limits on onboard TPI solution comparisons with ground TPI.	Ed Lineberry
9.	Discussion of backup TPI ΔT burn solutions (duty cycle problems).	Dick Moore
10.	Are crew using ADPC procedures?	Flight Crew
11.	Limit on DSKY VG's agreement with target load, and limit on gimbal angles comparision with maneuver pad.	MIT
12.	Residual reasonableness limit	G&PB
13.	What are allowable BMAG drift and gyro torquing angles.	Gary Coen
14.	What are crew time requirements for sextant star check, P-52, P-40?	Mosel
15.	What are PIPA bias and gyro drift limits and compensation procedures?	Gary Coen
16.	Should NC1 and NC2 be external ΔV or SCS targeted?	Stewart Davis
17.	What are 3σ BMAG DRIFTS?	NR
18.	What short burn logic will be programmed for RTCC?	Phil Shaffer
19.	Any corrections to Techniques Description document.	

Enclosure 2

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: JUL 9 1968

68-PA-T-153A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Good news on "C" mission SPS burns

The following is a verbatum copy of a note to me from Rick Nobles (MPAD). I thought it worth distributing.

"The cross axis velocity errors resulting from SPS mistrim (CSM alone) will be about one half of what was previously anticipated. The reduction in error is due to the new DAP filter constants that the G&CD is recommending for the "C" mission erasable load. The only adverse effect is the mission planning that has been done to date."

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

APOLLO DATA PRIORITY COORDINATION

MEETING SCHEDULE

AS OF July 9, 1968

68-FA-T-152A

SUBJECT OF MEETING	July 15	16	17	18	19	22	23	24	25	26	29	30	31	August 1	2	5	6	7	8	9
Descent Phase		■										■								
Midcourse Phase								■										■		
"B" Rendezvous						■					■									
Ascent Phase			■										■							
"C" Rendezvous					■															
101 Retrofire and Reentry					■															
Lunar Reentry			■											■						
"G" Rendezvous								■										■		
Data Select												■					■			
SPECIAL MEETINGS																				
						*														

*Notice that the "B" Rendezvous Meeting has been moved to July 22, 1968, Room 37? of Building 4.

■ Meeting begins at 9.00 a.m.

■ Meeting begins at 1:00 p.m.

Howard W. Tindall, Jr.

UNITED STATES GOVERNMENT

Memorandum

TO : See list attached

DATE: JUL 2 1968

68-PA-T-148A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Throttle up time is fixed during the powered descent maneuver

1. We learned something interesting during our Descent Mission Techniques meeting June 28 from the MIT people there. It dealt with the way the DPS gimbal trim phase of the powered descent maneuver is programmed.

2. It is extremely important that the engine be at full throttle at the right place in the trajectory. (The figure given is that for each second of time delay in throttling up to the FTP, we lose 12 seconds of hover time.) Therefore, MIT has programmed the computer so that throttling up does not occur after a fixed duration DPS gimbal trim time, but rather at the "right time" regardless of how much trim gimbal there has been. For example, if the engine failed to start when it was suppose to and the crew chooses to recycle to TIG minus five seconds there can be as much as 13 seconds delay in engine ignition and the trim time would be reduced by that amount. This procedure is an argument for maintaining a 10% trim gimbal time of 26 seconds, making us somewhat tolerant of this sort of an event. We hadn't thought about this situation very much yet, but I think the consensus is that if the DPS fails to ignite under PGNCS control initially and again fails on a recycle, we should abort without attempting manual ignition since something serious is probably wrong.

3. This really looks like a good way to program it, but is different than documented in the GSOP. Accordingly, MIT will submit a PCN to correct the documentation.

Howard W. Tindall, Jr.

PA:HWTindall, Jr.:js

APOLLO DATA PRIORITY COORDINATION

MEETING SCHEDULE

AS OF July 2, 1968

68-PA-T-146A

SUBJECT OF MEETING	July 8	9	10	11	12	15	16	17	18	19	22	23	24	25	26	29	30	31	Aug. 1	2
Descent Phase							■										■			
Midcourse Phase			■										■							
"D" Rendezvous						■														
Ascent Phase								■						■				■		
"C" Rendezvous		■											■							
101 Retrofire and Reentry										■										
Lunar Reentry								■												
"E" Rendezvous																				
Data Select							■										■			
SPECIAL MEETINGS																				
"C" Rendezvous*										■										

* Revive activities on "C" mission
Clean up a multitude of open items
Room ~~32B, Building 30

Meeting begins at 9:00 a.m.

Meeting begins at 1:00 p.m.

Note change in D Rendezvous from the 12th to the 15th

Howard W. Tindall, Jr.

Bill

MSC Form 1:09 (Feb 68)

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: JUL 1 1968
68-PA-T-145A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Checkout of CSM optics in earth orbit prior to TLI

The attached memorandum is of interest to you. Before we incorporate it into our Mission Techniques, I intend to check:

1. Why MSFN coverage is required.

2. If manual optics positioning is not adequate in lieu of CMC control for a TLI go.

Otherwise, I agree with it completely.

Howard W. Tindall, Jr.

Enclosure

Addressees:
FM/J. P. Mayer
C. R. Huss
FM13/R. P. Parten
FM5/R. L. Berry
FM7/R. O. Nobles
TRW/R. J. Boudreau
MIT/IL/D. G. Hoag
J. Nevins
N. Sears

PA:HWTindall, Jr.:js

UNITED STATES GOVERNMENT

Memorandum

[illegible]

[illegible] Division has [illegible] of the [illegible] prior to [illegible]

The [illegible] only of [illegible] of the optics to [illegible] (NTU) and proper [illegible] This should be accomplished [illegible] ground [illegible]. The procedure involved [illegible] drive the optics (OCT and DXT) for [illegible] The [illegible] will be jettisoned by the action [illegible] 20 degree rotation of the shaft axis will ensure an engagement of [illegible] which [illegible] the [illegible] retainer arms free of retaining clips on each [illegible]. [illegible] metal strips which are held in spring tension to impart a small [illegible] velocity to the [illegible]. Nonjettisoning of the [illegible] will be apparent if the [illegible] axis cannot be rotated beyond the approximate 20 degree rotation position.

A more extensive but not mandatory checkout is desirable and could be accomplished by performing an IMU alignment based upon star sighting [illegible] using the optics.

Robert [illegible]

cc: [illegible]
CF/[illegible]
[illegible]
PA/[illegible]
PD/[illegible]
[illegible]

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

UNITED STATES GOVERNMENT

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

Memorandum

[illegible]

SUBJECT: Results of the June [illegible] Apollo Spacecraft Configuration Control Board (ASCCB) meeting

This memo is to inform you of things that happened at the [illegible] ASCCB meeting. Some were quite significant.

1. There was a long discussion about minimum impulse APS burns and the associated propellant system freeze up problem. Actually, there is only one circumstance we know of that involves a short burn, namely after Abort Stage very early in powered descent. It is expected that workaround procedures may be developed to take care of this. Action has been given to the Mission Techniques Task Force to see that this is done.

2. It was reported that the VHF hardware and software have exactly the same range constraint - 327 nautical miles. I had been concerned that the hardware was capable of working at greater ranges and that the computer program would be limiting. This is not the case. I am still curious, however, as to whether or not the computer program should pay any attention to the "data good" discrete. Since both the astronaut and the rendezvous navigation program provide good data editing, I really don't see why we should fool with it. I would be interested in anyone's comments on this, how about you - Math Physics Branch?

3. PCR's 206 and 207 consist of 30 pages of GSOP, Chapter 4, changes and comments to make the document like the coding. They were both approved provided no coding changes were required as a result of that.

4. Two PCR's were submitted associated with the [illegible] tests. The first - PCR 208 to provide a [illegible] test terminate verb - was disapproved since the probable crew action, in the event of trouble, would be to turn off the engine. PCR 209 was approved to change the restart protection such that it would terminate the test rather than to recycle into it again.

5. PCR 210 changes the DPS throttle recovery limit in Luminary. This is a zero impact program change to put two parameters in erasable memory. It was approved.

6. PCR 211 is to provide the Colossus lift-off monitor routine with protection against an erroneous lift-off signal. It was added to the Colossus 2 requirements since it would have cost four days to provide in Colossus 1.

7. PCR 214 is a Luminary program change costing four days to take advantage of the recent DSKY light alterations for landing radar evaluation. It was, of course, approved.

8. PCR 438 was an MIT proposal to add a PIPA threshold to Colossus. MIT felt this was necessary to avoid unacceptable error during entry and to provide good range and range rate information during the final stages of the rendezvous. The errors MIT quoted for sustained operation of the Averge G far exceeded those we had estimated. Fred Martin was to verify their accuracy. In the meantime, I would suggest Claude Graves and Ed Linsberry each contact MIT to make sure they are familiar with the situation. My personal opinion is this program change is probably not needed. GPB's memo, 68-FM73-294, of June 26 seems to confirm this too.

9. PCR 439 is an MIT proposed simplification to Colossus deleting the "preferred attitude flag" in the alignment programs since they feel it is unnecessary. I must say they sound convincing to me and this PCR was approved for immediate implementation unless someone comes forward with a reason not to do it. Apparently, a similar Luminary PCR will soon be submitted.

10. An MIT proposal (PCR 441) to add a routine to permit the easy loading of a new lunar landing site location was disapproved, since it would cost two days and we could not figure out when it would be used.

11. PCR 468 to change the Target ΔV routine (R32) into a Colossus program (P76) was approved at the cost of two days impact. The reason for this was to avoid the danger of a restart clobbering the spacecraft state vector. You recall it is much easier to restart protect a program than it is an extended Verb. A similar change will be proposed for Luminary.

12. PCN 470 added a program (P68) to Luminary which will do the same sequence of operations which previously occurred when the crew hit "proceed" at the end of the landing phase descent program (P65, P66, or P67). This change would preclude an inadvertent engine shutdown before landing and would also insure that the crew would not be locked out from proceeding through the programs in an orderly way if the PGNCS navigated state vector had an erroneous altitude. The impact of two days was acceptable.

13. Another significant program change (PCR 477) makes the APS abort program (P71) almost exactly the same as the DPS abort program (P70). It also makes the Verb 37 entry into P71 effectively the same as the "Abort Stage" [illegible] other initialization [illegible] MIT and previously provided will [illegible] and readily approved.

14. PCR 478 improves the LM RCS thrusting-into-orbit processor by the addition of a gravity term. The improvement prevents insertion at too low an altitude. It was approved at the cost of one day impact.

15. PCR 475 would modify the Landing Analog Display Routine (R10) in Luminary such that the program will drive the tape meter and cross pointers while in Programs 12, 70, and 71. Approval was recommended for this additional capability at the cost of one day.

16. Myron Kayton (GCD) is submitting a Sundance PCR (No. 221) to change the rendezvous radar test routine such that the data will be collected at a higher frequency. This extremely late proposal was brought about by the realization that the time is extremely short during which the rendezvous radar test could be made as the "D" mission LM passes over the White Sands Missile Range - apparently less than half a minute. It is apparent that either a program change will be required, a location other than White Sands Missile Range must be used, or that the test objective must be modified. These alternate courses of action will be submitted to the Apollo Program Manager's Change Control Board once the Sundance impact has been terminated.

17. MIT officially informed us that the lunar landmarks selected by MSC are completely unsuitable and the lunar landmark selection routine (R35) has been rendered relatively useless as a result. MIT even proposes that R35 should be eliminated. We selected the landmarks as we did since it simplifies the currently planned mode of operation and we don't expect to use the lunar orbit navigation program for the purpose MIT designed it. Fred Martin suggested that possibly the CSM rendezvous navigation program (P20) could be used for observing the LM while on the lunar surface more conveniently than the orbit navigation program (P22). The primary advantage is that automatic spacecraft attitude control would be available. It is questionable, however, if the data which we require is stored for relay on the downlink in P20 as is necessary until S-band antenna reacquisition.

18. There was a lengthy discussion regarding the FCSD request for raw rendezvous radar data on the DSKY. FSD intends to coordinate this to make sure the simpliest possible program change may be defined based on the crew requirements and MIT's program constraints. (Incidentally, MIT apparently intends to propose an official PGNCS constraint limiting the use of P20 to ranges greater than five miles.)

That's it - at least the things I think would interest you most - It was quite a productive meeting wouldn't you say?

Howard W. Tindall, Jr.

Addressees:
(See list attached)

FM:HWTindall, Jr.:js