Judie Pinson's thoughts

17.2 1

1967 TINDALLGRAMS

I'm impressed by the conversational, almost chatty tone of Tindall's messages. They are so unlike many standard governmentese memos. With great economy of words, Tindall manages to make his thoughts clear, easy to read, and memorable. He talks to his addressees as if it is understood that they are intelligent people, is often amusing as well as informative. He frequently ends a memo "at least this is the way I understand it" as if asking for corrections if anyone has any to offer; he also often comes right out and requests additional or differing information and opinions from his colleagues.

Some "Tindallisms" I found interesting or amusing, or thought you might be interested in knowing about:

67-FM1-5 (10 Jan.) Subject: "Significant modifications currently planned in the Apollo Spacecraft Computer Programs." End of memo mentions "Black Friday" review to be held at MIT tow days hence at which additional modifications were to be discussed. "It should be lots of fun. I'll let you know if anything interesting happens."

67-FM1-7 (18 Jan.) Subject: "Why is it everyone who likes radar wears a white hat?" ". . . it seems mandatory to me that some sort of range and range rate measuring system [in the Apollo command module] be provided. Of course, a complete radar would be even better . . . " "I'm sure there are many who would argue that the optical system is perfectly adequate, and they can back their arguments with all sorts of analyses. Personally, I don't believe any of that stuff, and I'm afraid waiting for the AS-256 experience will get us into the position where it is too late to fix up the command module for these AAP missions. Let's vote."

67-FM1-9 (23 Jan.) Subject: "Latest on the AS-206 spacecraft computer program." paragraph # 5 about trouble with Engineering and Development Directorate--"Response by that organization has been completely unacceptable," and T. goes on to any possible reason why ("rather informal manner in which this data was requested"). Solution: future requests to be "smothered in the usual stack of paperwork . . . " T. also says however, that "In spite of considerable difficulty in pulling this program together at MIT," he really expects it to "perform very well for us.... I don't know why I'm sticking my neck out on a prediction like that. Just living dangerously, I guess."

67-FM1-10 (23 Jan.) Subject: "AS-504 spacecraft computer program and storage status. Also a dash of AS-258." Memo about the MIT meeting which T. had been anticipating with some dread (see 67-FM1-5, above). Concensus was that MIT had put together an excellent presentation of current status and "a very reasonable proposal on which to base our future work." "This meeting had none of the fire and excitement of last May's Black Friday. In fact, this one is not worthy of that name." Memo includes 2 pages of elations and requirements for spacecraft computer program. End of Memo: "At least this is the way I think things stand. And now we'll start taking calls from the audience."

00000001

67-FM1-11 (25 Jan.) Subject: "More about computer self check" "If they ever have a contest to select the piece of Apollo with the funniest history, I would like to enter "computer self check." T. talks about the trouble with computer self check in AS-204: "Apparently if the system were left as it is now, it has the potential of bombing out the system irrevocably. I assume, or at least hope, that if it did that, it would light the little red light." (Ironic--two days later, the 204 fire occurred.)

67-FM1-12 (25 Jan.) Subject: "Why does the AAP command module need a sextant?" "Of course, I haven't thought much about it, but . . ."; in T's opinion, the sextant is not needed--eliminating might be a considerable saving of weight and make the spacecraft a "heck of a lot better for general purpose, earth orbital missions." (Interesting that he should say he hasn't thought much about it, and almost certainly not true. Right?)

67-FM1-17 (31 Jan.) Subject: "AS-206 Spacecraft Computer Program Newsletter" Report on another meeting at MIT; interesting paragraph on page 2 about MSC being "had" by "those slick New York Yankees"--Grumman.

Lapse of 26 days in Tindallgrams: #67-FM1-17, dated 31 Jan.; #67-FM1-18, dated 27 Feb. None during aftermath of 204 fire?

67-FM1-18 (27 Feb.) T. talks about need for new designation of boosters and missions, to replace numbers. "We will inform you of the new, more descriptive program names as soon as they have been selected." Re need for review of what is to be in the erasable memory of the AS0258 program: "That could be a fairly exciting get together since everyone wants their program in erasable. I wonder if there is a message in that observation." Re AS-206 computer program: "The MIT people have worked very hard on this program and deserve a lot of credit, both for their maintenance of extremely high standards and for their extra effort in trying to maintain a reasonable release sched."

67-FM1-19 (2 Mar.) "On February 17th we held a meeting in our continuing effort to reduce the program development demands on the Real Time Computer Complex." In summary paragraph at end, T. says "one of the best meetings yet."

67-FM1-24, (24 Mar.) Subject: "In which is described the Apollo spacecraft computer programs currently being developed."

67-FM1-25, (27 Mar.) Subject: "None." "This action item was given MIT by FCD. We stopped it. . . . But it needs to be done . . . Will you get someone to do it? GPB, I guess."

67-FM1-26 (28 Mar.) Subject: "Progress Report - RTCC program development - Review of AS-258(!) requirements." "My primary objective here is to summarize what we did and to document, for historical purposes, the rationale behind some of the decisions made." (6-page memo, initialed at top by C. Kraft with his comment: "Excellent--Pass on!")

67-FM1-32 (21 Apr.) Subject: "Descent engine gimbal polarity error!" "A serious misunderstanding between MIT and Grumman resulted in a situation which would have been catastrophic to the AS-206 mission if it had not been discovered." Tindall seems to be defending MIT.

67-FM1-33 (25 Apr) Subject: "MIT's digital computer facilities are still a problem."

67-FM1-36 (4 May) Subject: "Some things Ed Copps is worried about." "Ed Copps /MIT/ called the other day about some things that worry him. I figure if he's worried enough to call, it's probably worthwhile to dictate this note and send it to you. . ." About automatic gimbal lock avoidance capability having been removed from CALCMANU--the spacecraft computer processor which provides automatic attitude maneuvers. "This whole business apparently scares the hell out of Ed Copps, and I guess if I knew enough I would be frightened too." (RS: you will probably understand the technicalities of the problem; I just enjoyed the way in which T. presented it.)

67-FM1-37 (4 May) Subject: "Invitation to an AAP spacecraft computer program requirements shindig." (Tindall has a way of making it all sound like such fun!)

67-FM1-T-40 (19 May) Subject: "MIT can handle spacecraft computer program development for both Apollo and AAP to their mutual advantage" (3-page memo; many comments in praise of MIT.)

67-FM-T-41 (23 May) Subject: "Spacecraft computer program names!" Good, brief summary in lighthearted Tindall tone. Starts out: "I used to think MIT was a little odd when it came to selecting names for the spacecraft computer programs with all that weird preoccupation with the sun." (SOLRUM 55, BURST 116, SUNDISK, COLOSSUS--"Pretty good except, I miss the Sun"--and SUNDANCE.)

67-FM-T-43 (26 July) Subject: "LM is launched with air!" "I guess everybody already knows this, but I just learned that they intend to launch all LM's with air rather than oxygen in the cabin . . . to reduce the possibility of fire. (Next memo, 67-FM-T-44, mentions the use of panel coating "to provide fire protection or at least to prevent its spread.")

67-FM-T-45 (27 Jul.) Subject: "Spacecraft computer program flow chart status." "Just a note to you cats who are interested in flow charts . . ." Brief description of standards to be followed in the development of flow charts. "Naturally, we intend to execute any programmer whose flow charts contain a significant number of errors."

67-FM-T-55 (3 Aug.) To: FX/Acting Chief, Flight Support Div. From: FM/Deputy Chief. Subject: "Deep serious trouble." "I realize it's none of my business, and it's getting to be less all the time, but you are going to be in deep serious trouble when the MIT contract negotiations for Apollo and AAP hit the fan in the next couple of months unless you have somebody pretty sharp ready to take over for Larry Fry. Incidentally, did you or Pete Clements put Larry in for one of those awards they give outstanding Air Force officers assigned to NASA? He sure deserves it." (RS: Sounds like high praise--is L.F. anybody you're interested in?)

67-FM-T-63 (18 Aug.) Re LM-1: "I sure will be glad to see that bird fly before it drives us all over the brink."

67-FM-T-72 (29 Aug.) Subject: "Inflight loading of the spacecraft computer erasable memory." A 5-point memo whose last point, in entirety, is "Did I just hear the RTCC camel groan?" (Wonder what that means?)

67-FM-T-73 (29 Aug.) Memo pointing out to addressees that not even a 2-month delay is necessary between the launch of s/c 101 and s/c 103. "This note is to make sure you are aware of the situation so you won't get caught assuming a period of 3 months is necessary between the two missions. I must say this had not been clear to me before."

67-PA-T-79A (11 Sept.) Subject: "Data Priority Coordination - a plea for help." Handwritten note at bottom of first page "Bill T. A good review, pls. let me know if you need my help. G.M.L. 9-27"

67-FM-T-80 (11 Oct.) Apologetic note about necessity of using SUNDISK in Spacecraft 103 as well as 101. Ends: "I can't tell you how sorry . . . "

67-FM-T-83 (17 Oct.) Subject: "Spacecraft computer program status" - another of T's "irrgeular updates on what's going on in the business of spacecraft computer program development." Currently in process of determining an accurate program development sched. for programs and determining problem areas. "I don't want to minimize the seriousness of this situation. We are in deep, serious yogurt!"

67-PA-T-99A (30 Oct.) Subject: "Current status on the LM DPS engine gimbal caution light problem." Two paragraphs on current status, then two pages prefaced: "The rest of this memo just fills in some background and there is no need for you to read any further except for your own amusement."

67-FM-T-106 (14 Nov.) Subject: "EMS software verification doesn't exist." " . . . neither Gardiner nor Chilton conceal their distaste for the EMS (Entry Monitoring System). Both wish to see it torn by its roots from the spacecraft and flung out the window. So you can imagine the attention their people must give to it."

67-PA-T-113A (7 Dec.) Letter inviting R.V. Sperry of Bellcomm to 20 Dec. meeting at which Trajectory Control Data Priority flow charts (enclosed with the letter) for s/c 101 retrofire and reentry are to be discussed. "I hope you get a chance to review it and come down for the picnic. Please bring your own ants!"

67-AP-T-115A (15 Dec.) Subject: "Urgent recommendation that CMC [command module computer] steering of the S-IVB be deleted."

67-FM-T-124 (18 Dec.) Subject: "Spacecraft computer program newsletter." Sequel to memo of 23 May (67-FM-T-41).

00000004

UNITED STATES GOVERNMENT

Memorandum

FROM: PA/Chief, Apollo Data Priority Coordination

SUBJECT: Data Priority meetings schedule

1. In order to get a little bit more orderly in our conduct of the Trajectory Control Data Priority business, it's evident that we must schedule meetings on a pre-established, periodic basis. Accordingly, the Ascent and Descent meetings will take place on alternate Tuesday afternoons; Rendezvous meetings will be held on Wednesdays, one mission in the morning and another in the afternoon (right now they will be missions "C" and "D", respectively) in the same week as Ascent. The so-called Midcourse Phase, name to be changed I hope, will take place on Wednesday mornings in the same week as Descent. All of these meetings will be approximately ½ day long.

2. This sounds like a rather large time absorber because it is. However, there are a number of us who feel that the only way we can get this thing done at all - to say nothing of being on time - is to make a fairly intensive effort for a short time. For example, aside from the Rendezvous business, I anticipate the rest of the mission phases should be pretty well squared away within three or four months and after that they will require much less attention.

3. One more thing regarding the Midcourse Phase--it is proposed that this panel's work be enlarged to encompass all pre-launch targeting associated with the lunar landing mission, all activities in earth orbit, the TLI maneuver, the Midcourse maneuvers, the LOI maneuver and the TEI maneuver. It will not include launch and launch abort monitoring. The reason for this is that all those activities listed, aside from TEI, are aligned to the same end objective; that is, braking into a suitable lunar orbit.

Howard W. Tindall, Jr.

Addressees:
(Set attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: DEC 26 1967
67-PA-T-1259A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Rendezvous meeting reminder

This note is to remind you of our Rendezvous meetings on January 3, 1968. In the morning we hope to discuss Rendezvous on the "C" mission starting at 9:00 a.m.; and in the afternoon Rendezvous on the "D" mission starting about 1:00 p.m.

Howard W. Tindall, Jr.

Addressees:
CB/E. Aldrin, Jr.
C. Conrad
CF/N. R. Andersen
T. W. Holloway
P. Kramer
FC/A. D. Aldrich
R. L. Carlton
C. Parker
E. L. Pavelka
EG/C. T. Mackler
E. Smith
FM6/E. C. Lineberry

THW(Houston)/D. Boudreau

PA:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

TO: See list below

DATE: DEC 26 1967
67-PA-T-12MA

FROM: PA/Chief, Apollo Data Priority Coordination

SUBJECT: Lunar lift off shall be planned at discrete times only.

1. During our December 21 Ascent Phase Data Priority meeting we concluded that a continous launch window for lift off from the lunar surface is not a requirement. That is, all mission planning, procedures and program development associated with the nominal lunar landing mission should be based on the assumption that one or more discrete lift off times will be selected for each revolution of the command module and failure to lift off at one of those discrete times will result in a hold to the next discrete time. Each of these lift off times will be selected to produce the nominal differential altitude during the coelliptical rendezvous. If more than one discrete lift off opportunity is provided per command module revolution, it will be obtained by extending the rendezvous operation another revolution with orbital adjustment maneuvers provided to maintain the nominal differential altitude. (Personally, I feel one opportunity each CSM revolution is enough but that's just my opinion.) At this time, it appears that one additional revolution beyond the rendezvous scheme currently planned could produce two additional discrete windows after the nominal, one occurring 2½ minutes later and the other about 8 minutes after nominal.

2. If anyone can think of any reason why this constraint is unacceptable, they should let their concern be known immediately. We could not think of any reason except gross emergency which would produce the circumstance wherein having missed a discrete time we would want to go to the earliest possible time as opposed to waiting for the next preselected discrete time. Of course, "anytime" launch capability is being provided throughout the system but only for low probability contingency situations.

Howard W. Tindall, Jr.

Attachment
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: DEC 27 1967

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: LM rendezvous radar during Ascent is about to go over the brink.

1. It turns out providing justification for obtaining LM rendezvous radar data during Ascent from the lunar surface is an difficult an getting the data itself. This memorandum is to let you know that unless some sharp cookie comes along with sufficient justification we ain't gonna get it!

2. There have been numerous memoranda and discussions in which the requirement for use of the LM rendezvous radar during powered ascent was stated primarily as a data source to evaluate the performance of the AGS and the PNGCS both by the crew onboard the spacecraft and on the ground. In addition, intuition supported this idea and so a good deal of work has proceeded based on the assumption that the rendezvous radar data would be available. However, due to a series of circumstances still beyond my comprehension, the LM spacecraft computer program - Luminary - does not provide the capability for obtaining this data. In fact, as far as I can tell it is deficient in two respects. First, no automatic radar acquisition capability is provided during ascent which would be mandatory since radar lock can only be acquired after the big pitch maneuver at approximately lift off plus 10 seconds. And, second, once it's locked on no provision has been made for getting the radar data onto the telemetry downlink. Luminary change requests are in the mill to add these capabilities. However, it is anticipated that the schedule impact will be substantial, and since the current program delivery schedule is only marginally acceptable, modifications to it have to be in the mandatory category. In order to establish this justification we discussed this subject in detail during the December 21 Ascent Phase Data Priority meeting. Much to my amazement, mandatory justification does not appear to exist. The rationale for this statement is the subject of the following paragraph. The point to be made here is that unless a much stronger story can be put together, these proposed program changes will probably be rejected and rendezvous radar data will not be available either during powered ascent or immediately after insertion into lunar orbit.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000008

3. It had been proposed that rendezvous radar data was essential to permit the MCC to monitor ascent and advise the crew of the necessity to switch from the PNGCS to the AGS. How this would be done is thoroughly documented elsewhere but basically it was intended to determine the range rate of the LM with respect to the command module utilizing the PNGCS LM state vector and the AGS LM state vector separately, and then to compare these values with that actually measured utilizing the rendezvous radar. This information would be displayed on analog plots in the control center. The same comparison process would simultaneously be carried out with the range rate as computed and measured along the line of sight between the LM and an MSFN tracking station. In each case, the rendezvous radar and the MSFN provide an independent data source upon which to evaluate performance of the PNGCS and the AGS. Studies to date indicate that in most cases of guidance system malfunction, comparison against only the MSFN is adequate to identify the errant system.

4. The most significant exception is certain accelerometer scale factor or bias cases perpendicular to the line of sight between the LM and the MSFN station. That is, the MSFN comparison is always capable of determining unacceptable dispersions in flight path angle, but sometimes is not able to provide an independent measurement of the velocity magnitude particularly when inserting into lunar orbit from a centrally located landing site. The result is, if throughout ascent both the AGS and the PNGCS appear to be operating properly based on all data available but at insertion the PNGCS shuts down the APS engine producing conditions which the AGS indicates to be suborbital, it will be impossible to determine which guidance system is correct without rendezvous radar data. Accordingly, it would be necessary to reinitiate thrusting immediately probably using the RCS in order to provide safe orbital conditions based on the AGS readout. Subsequently, MSFN tracking and/or rendezvous radar measurements obtained as soon as possible will reveal whether it was the AGS or the PNGCS which was in error. If it truly was the PNGCS at fault creating an underburn at insertion the proper action will have been taken. On the other hand, if the AGS was in error the situation will be: the rendezvous catch up rate will have been decreased to a point where an extra revolution or so will probably be necessary, probably a lot of APS/RCS fuel will have been expended and, based on the (good) PNGCS and MSFN the situation will have to be sorted out and handled on a contingency basis. This particular set of circumstances is extremely unlikely. The action taken is undesirable but not catastrophic. It would probably require use of the command module to assist in the rendezvous but RCS is being provided for that specific situation. Rendezvous radar data during ascent and immediately following insertion would have prevented it from happening but it does not appear to be mandatory. So unless the analysis

00000009

now underway disproves the above rationale, someone else comes along with a good reason or if the Luminary program delivery impact turns out to be small, I expect these requested changes will not be made in the first version of Luminary, and maybe never. At this time I don't expect any of those things to turn out favorably. Furthermore, if we can't get this data we probably ought to simplify the RTCC programs and MCC displays to be compatible.

5. Finally, if we can't prove we need rendezvous radar data for Ascent, it's about certain we won't be able to for Descent either. But we do have to have it on T/M while the LM is on the lunar surface for "launch site" position determination and Ascent targeting. This data must be at a high update rate (10 to 30 samples per minute) and preferably without "improving" the spacecraft state vectors in the LM computer.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

00000010

UNITED STATES GOVERNMENT

Memorandum

TO : See list Below

DATE: DEC 18 1967
67-PA-T-126A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Third Trajectory Control Data Priority Meeting for Spacecraft 101

Reference memo 67-PA-T-110A dated December 4, 1967. The Trajectory Control Data Priority meeting which was scheduled for December 20, 1967, has been changed to January 10, 1968, at 9:00 a.m., Room 906, Building 2 of MSC.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000011

UNITED STATES GOVERNMENT

Memorandum

Mission Planning & Analysis Division

TO : FC5/Chief, Guidance Officer Section

DATE: DEC 18 1967
67-FM-T-125

FROM : FM/Deputy Chief

SUBJECT: Do you want a program to calibrate the COAS?

1. Charlie, I am afraid I goofed up when I sent the attached memo out open-loop. Most likely nothing is getting done. I am sending this over to you in case you would like to get one of your people to initiate the standard FCD procedure to have something implemented.

2. Incidentally, some people have apparently been discussing a procedure for doing this whole thing onboard. It involves boresighting the COAS on a known star and then calling the alignment routine which displays sextant shaft and trunion angles for that star. I gather it is not quite as straightforward as that. Since those values will be outside the mechanical limits of the sextant, it may be necessary to interrogate the memory and read out in octal. John Norton, for one, could give you more detail if you are interested.

Howard W. Tindall, Jr.

Enclosure

cc:
FM3/C. R. Hicks
T. F. Carter
FM5/R. E. Ernull

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: NOV 14 1967
67-FM-T-105

FROM : FM/Deputy Chief

SUBJECT: Inflight alignment of the COAS

1. As you know, the command module computer program---COLOSSUS---is being developed to permit use of the crew's reticle (COAS) as a backup reference source for aligning the IMU and for rendezvous navigation. This is to guard against some failure of the sextant and telescope as well as providing the capability to make line-of-sight measurements from the couch position as might be helpful in a one man rendezvous situation. Since precise COAS alignment cannot be established prior to launch, a provision has been made in the spacecraft program to accept and utilize its alignment as determined inflight and specified with reference to the sextant. However, it is necessary that the ground supply so-called "equivalent sextant" shaft and trunion angles. This note is to make sure that an RTCC and/or ACR computer program capability is provided or at least to make sure you know that it is expected to do that job.

2. The inflight procedure is as follows. The IMU is aligned using the sextant. The spacecraft is then maneuvered in attitude such that the COAS is centered precisely on a known star and the mark button is pushed to get the platform gimbal angles on telemetry to the ground. With this information, the ground is able to determine the "equivalent sextant" shaft and trunion angles. These are the angles which the sextant would have to assume to be centered on that star given that spacecraft orientation. Of course, it is impossible for the sextant to view the star with that spacecraft orientation since it would be located approximately on the spacecraft X-axis which is outside the field of view of the sextant. It is the "equivalent sextant" shaft and trunion angles which must be relayed by voice to the crew.

3. When the crew later specifies to the computer that they are using the COAS, it displays these parameters which, if not correct, must be input. It then uses the optical observation obtained with the COAS just as if it were a sextant mark obtained with those shaft and trunion angles. It should be noted that although these angles have sometimes

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

been referred to as COAS bias angles, they are really not biases as that term is ordinarily used and should have values substantially different than zero. At least that's the way I understand it.

Howard W. Tindall, Jr.

Addressees:
FC5/C. P. Parker
FM5/R. E. Ermill

cc:
(See attached list)

UNITED STATES GOVERNMENT

Memorandum

NASA-[illegible] Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: DEC 15 1967
CF-FM-T-1[illegible]

FROM : FM/Deputy Chief

SUBJECT: Spacecraft computer program newsletter

1. This memorandum is to make sure you are up to date on spacecraft computer programs. As you undoubtedly know, an Apollo Software Configuration Control Board, chaired by Chris Kraft, has been established. I am the MPAD representative and Stan Mann is the alternate. There have been three meetings so far in which we have discussed and taken action on quite a large number of proposed Program Change Requests (PCR) for all of the manned mission programs.

2. SUNDISK - Sundisk, the earth orbital command module program, has been completely finished and has gone through Level 5 testing. A tape has been delivered to Raytheon which they could use to manufacture the actual flight ropes. It is not our current intention, however, to make flight ropes from that tape since there are a number of changes that have been identified as necessary and some time is available to implement them. Following is a list of program changes that MIT has been directed to complete in time to send another tape to Raytheon on February 1.

a. PCR #3 - Flight Crew people stated that attitude error indication during the first 10 seconds of flight for use as an abort cue is mandatory for crew safety. Currently, the launch program does not start outputting attitude error signals until 10 seconds after lift off at which time a comparison is made with boost polynominals prepared preflight. This program change will provide a signal to the FDAI needles proportional to the difference between present attitude and that attitude which existed at receipt of the lift off signal by the computer.

b. PCR #24 - The orientation of the CSM rendezvous radar transponder has been modified on Spacecraft 103. This program change takes into account its new alignment in determining preferred attitude of the spacecraft during the rendezvous phase of the mission.

c. PCR #37 - An error was found in the formulation of the Lambert guidance which caused long duration burns such as TPI using the RCS propulsion system to be in error. This obvious deficiency is being corrected.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000015

4. SUNDANCE - Sundance, the earth orbital LM program, currently scheduled for delivery on March 15 had one PCR (#30) approved the other day. The time the DPS should operate at 10% thrust (currently fixed at 36 seconds) will be moved into erasable memory such that it can be modified if some other value is found to be more suitable. This change is part of an effort underway to reduce DPS constraints both from the standpoint of guidance system accuracy and buildup of helium tank pressure. Another change (PCR #32) which the crew is anxious to have implemented deals with providing an automatic attitude control of the spacecraft during the latter phases of rendezvous such that the spacecraft Z-axis would be maintained within 60 of boresight on the command module in addition to the 300 "dead band" currently implemented.

4. LUMINARY - The changes to the IMU alignment program for Luminary have been approved and MIT is implementing these simplifications to the crew procedures.

MIT has also been requested (PCR #4) to provide limited throttling of the DPS about the fixed high thrust throttle point during powered descent to compensate for thrust dispersions and, thus, permit a significant fuel saving. The impact for this change has been determined to be unacceptable for the first release of Luminary and MIT has been directed to implement it as soon as possible on some later version.

5. COLOSSUS - Schedule impact for the simplifications to platform alignment procedures requested by the crew for the command module (PCR #16) was determined to be unacceptable for the first release of Colossus. Accordingly, in this case too, MIT has been directed to implement them as soon as possible - probably to be included in the second release.

6. There are a small number of other piddling modifications that have been approved which I am not going to mention here. Also, I am not going to list those which have been disapproved or delayed and I recommend that if there are some program changes in which you have special interest you get in touch with proper personnel of the Flight Software Branch. The same advice goes for additional information on those I have noted here, since my understanding is often rather limited. But I did want to make you aware of the more significant items.

Howard W. Tindall, Jr.

Attachment:
(See attached list)

00000016

Addressees:
FM/J. P. Moyer
C. R. Hunn
M. V. Jenkins
FM13/J. P. Bryant
J. R. Gurley
E. D. Murrah
FM14/R. P. Parten
FM3/R. D. Weber
FM5/R. E. Ermull
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 : FM4/Chief, Mathematical Physics Branch

DATE: DEC 15 1967

67-FM-T-124

FROM : FM/Deputy Chief

SUBJECT: Can MSFN figure out where the LM is on the moon's surface?

Rod Rose sprung one on me the other day I would like to ask you about. He says that the MSFN should have a pretty good capability of determining the LM's position on the lunar surface given one day's worth of observation - such as during the lunar landing mission. And that this could be used to assist in targeting Ascent. I am a little surprised at that and would like for you to let me know if it is really true. If some sort of study should be initiated, please coordinate it with ATSO, et cetera.

Howard W. Tindall, Jr.

cc:
FM/J. P. Mayer
FM13/J. P. Bryant
FM6/F. V. Bennett

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000018

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : FM4/Chief, Mathematical Physics Branch

DATE: DEC 15 1967
67-FM-T-122

FROM : FM/Deputy Chief

SUBJECT: Some lunar landmark tracking questions

1. Associated with lunar landmark tracking with the command module optics, I have two comments and/or questions. First, I talked over our decision to delete this activity with Chris Kraft and he was relatively noncommittal. However, with regard to my comment that landmarks to the west of the landing site would be in darkness, thus invisible, he said he has looked at the moon a couple of times recently and said that with the naked eye, he could distinguish the characteristics from here on Mother Earth. The moon was one-quarter illuminated by the sun and the rest by earth shine, not dissimilar to a lunar landing situation. He was convinced that landmarks would be visible even in this kind of darkness. What do you think of that when you take into account the size and character of the landmarks we would have to use for navigation purposes?

2. The second item is with regard to the Lunar Orbiter photos on the back of the moon and those near the limb on the front side. Is it possible that landmarks useful for navigation may be located with sufficient accuracy from these photographs for use on navigation?

3. And one other thing that has been bugging me, that is, I realize that landmarks near the limb are hard to locate in longitude but I should think latitude accuracy would be as good as anywhere else and, for orientation of the orbital plane, latitude is the thing we need. I wonder if people took that into account when selecting them.

Howard W. Tindall, Jr.

cc:
FM/J. P. Mayer
FM13/J. P. Bryant
FM6/F. V. Bennett

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: DEC 15 1967
67-PA-T-121A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: It is proposed that we plan a two step LOI maneuver.

1. For the past several months there has been considerable discussion regarding the question of whether we should perform the lunar orbit insertion (LOI) maneuver as a single burn or if it should be made in two steps. This is an important matter to resolve since it has impact on RTCC program development, guidance systems targeting, crew monitoring procedures, mission timeline, the mission plan, the flight plan, and mission rules. Accordingly, the entire December 12 meeting of the Midcourse Phase Working Group of the Data Priority Coordination effort was devoted to this subject. Detailed minutes are being prepared for distribution by Mr. Ronald Berry, the chairman of that working group. However, the significance of the decisions reached were such that a more immediate, wider dissemination of them warranted writing this note. Specifically, it was concluded that we should utilize a two step LOI maneuver and that it should be performed utilizing the External Delta V guidance mode. The entire justification for this mission plan modification is based on the need to provide an adequate flight crew monitoring procedure, although it is anticipated that further advantage may be obtained by incorporating dispersion killing altitude and plane change adjustments in the second LOI burn which will provide a saving of both propellant and a reduction of timeline activity.

2. Considerable analyses, thought and discussion have been devoted to how the 3,200 fps, 380 sec. LOI maneuver should be monitored. That this maneuver is performed behind the moon and in its later stages has serious time critical, flight crew safety implications presents some special problems. The most serious consideration is the need to assure in the later stages of the LOI maneuver that the SPS engine is not shut down too late. For example, an overburn of approximately 8½ seconds would result in lunar surface impact. To avoid this with certainty the crew will be observing the duration of the maneuver (a clock) and the delta V counter and will be forced to manually shut down the engine when one or the other, or perhaps both, indicates a hazardous situation is imminent. Taking into account reasonable dispersions in those monitoring systems and the duration of overburn considered acceptable, it has been determined that the probability the crew would manually take over and shut down the engine before a satisfactorily operating primary guidance system gets the chance is more than 50%. This action, of course, creates a two stage LOI maneuver in

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

itself, but with a variable second stage magnitude. And the mission planner must provide for it in the lunar timeline. Since the probability of this occurring is so great, it was concluded the nominal mission plan should include a controlled, two step LOI.

3. Given this decision, it was determined that the first maneuver should be intentionally targeted to terminat early enough to insure that the primary guidance system has every opportunity to perform its function and to insure that the second phase of LOI is of sufficient duration to give good guidance system performance. A value of about 15 seconds was selected since it met both of these criteria and, therefore, it is proposed to target the initial LOI maneuver to provide a lunar orbit of 60 X 170 nautical miles. The second maneuver would occur approximately two revolutions later and would have a duration of approximately 15 seconds.

4. Another matter of significance was also resolved. Namely, it has been determined that there is very little to choose between use of Lambert steering or External Delta V steering modes with regard to delta V costs and guidance accuracy. On the other hand, the use of External Delta V does provide a real advantage for crew monitoring of spacecraft attitude during the burn which is also very important. Whereas, Lambert steering results in a continously varying attitude with a profile which cannot be established preflight, External Delta V provides a constant inertial attitude, substantially simplifying the procedures, the training and the operation. Therefore, pending confirmation by some simple, short studies it is proposed that we establish External Delta V as the guidance mode and concentrate all effort accordingly. For example, MTCC programs associated with Lambert targeting the LOI maneuver may be deleted.

5. In summary then, given CCB approval (if that's how this sort of thing is done!) I anticipate all future lunar mission work will be based on a two stage LOI maneuver performed utilizing External Delta V with the second maneuver being in the order of 15 seconds duration.

Howard W. Tindall, Jr.

Addressees:
(S e attached list)

00000021

Addressees:
CA/D. K. Slayton
CB/A. B. Shepard
J. A. McDivitt
E. Aldrin, Jr.
M. Collins
C. Conrad
T. P. Stafford
CF/W. J. North
CF13/D. F. Grimm
CF2/J. Bilodeau
CF22/C. C. Thomas
CF24/P. Kramer
CF3/C. H. Woodling
CF32/T. Guillory
EG/R. A. Gardiner
D. C. Cheatham
EG23/K. J. Cox
T. P. Lins
EG25/T. V. Chambers
EG26/P. E. Ebersole
EG27/D. W. Gilbert
EG42/B. Reina
EG43/M. Kayton
R. E. Lewis
C. F. Wasson
KA/R. F. Thompson
KF/T. R. Kloves
KM/W. H. Hamby
F. C. Littleton
B. D. Sturm
PA/G. M. Low
K. S. Kleinknecht
PA2/M. S. Henderson
PD/O. E. Maynard
PD13/M. G. VonEhrenfried
R. J. Ward
PD4/A. Cohen
PD7/W. R. Morrison
PE7/D. T. Lockard
PA/C. C. Kraft, Jr.
S. A. Sjoberg
C. C. Critzos
R. G. Rose
C. Kovitz
FC/J. D. Hodge
E. G. Kranz
D. H. Owen
D. B. Pendley
C. A. Beers

FC2/J. W. Roach
FC3/A. D. Aldrich
FC4/J. E. Hannigan
R. L. Carlton
FC5/G. S. Lunney
J. C. Bostick
J. S. Llewellyn
C. B. Parker
C. E. Charlesworth
M. D. Reed
P. C. Shaffer
FL/J. B. Hammack
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/J. P. Bryant
J. R. Gurley
E. D. Murrah
FM14/R. P. Parten
FM3/B. D. Weber
FM5/R. E. Ernull
FM7/S. P. Mann
R. C. Nobles
FM/Branch Chiefs

BELLCOM/R. V. Sperry
GAEC/A. Nathan (FM)
MAC/C. Jacobsen (CF)
MIT/IL/R. R. Ragan
TRW/M. Fox
NR(Downey)/M. Vucelic

PA:HWTindall, Jr.:pj

UNITED STATES GOVERNMENT

Memorandum

TO : EG/Chief, Guidance & Control Division

DATE: DEC 1 [illegible]

67-PA-T-120A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Mission C DAP initialization procedures

1. In a memo dated November 28, you recommend that "DAP initialization procedures for Mission C be established where either crew input requirements are eliminated entirely, or restricted at most to one inertia update following the largest SPS burn." I am writing you this note to let you know that what has been planned is entirely compatible I think.

2. As of now we do not plan to update the DAP initialization parameters at all during a nominal mission, since we all agree that it is probably unnecessary operationally. There is some concern that doing so, however, would make some of the burns more useful systems tests and we are interested in your Division's (and MIT's) opinion on this. The point is obviously we must establish some ground rules governing conditions under which we would update these parameters, and maybe they should be based on mission objectives rather than operational performance requirements.

3. As you probably know, the RTACF, our auxiliary computer support facility here in Building 30 which operates during the mission, has programs which will be used to continually maintain a best estimate of all the DAP initialization parameters and the capability exists to load them into the spacecraft computer via the universal uplink. If we do have to update them we will probably load them from the ground, rather than have the crew key them in.

Howard W. Tindall, Jr.

Enclosure

cc:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

TO : PA/Chief, Apollo Data Priority Coordination DATE: NOV 28 1967

In reply refer to: EG23-207-67-2C74

FROM : EG/Chief, Guidance and Control Division

SUBJECT: Digital autopilot initialization procedures - Mission C (S/C 101)

The Guidance and Control Division has been concerned with the amount of unnecessary initialization effort that may be required of the crew to operate the digital autopilots (DAP'S) for Block II missions. MIT has been directed to provide onboard software programs in both the CMC and LGC to update weight and inertia functions during main engine burns. At this time, the LM programs (SUNDANCE and LUMINARY) contain this self-contained update capability, but the first CSM manned program (SUNDISK) does not. MIT is incorporating the capability into COLOSSOUS although the routine has not been completely reviewed by MSC.

A study has been conducted to identify the DAP initialization procedures for Mission C and the results given in the enclosed memorandum. The objective was to develop procedures for reducing the crew input requirements for DAP initialization (SUNDISK Program).

Both CSM TVC DAP and the CSM RCS DAP were investigated to identify acceptable inertia variation bounds. The present TVC DAP has sufficient gain margin to perform satisfactorily for any value of SPS loading planned for Mission C. The RCS DAP, however, does degrade in propellant performance when the errors in inertia load exceed 20 percent. Since Mission C does not require a CSM/LM docked operation, and because the SPS is significantly off-loaded, crew input requirements are significantly decreased.

The Guidance and Control Division therefore recommends that DAP initialization procedures for Mission C be established where either crew

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

input requirements are eliminated entirely, or restricted at most to one inertia update following the largest RCS burn.

Robert A. Gardiner

Enclosure

cc:
CA/D. K. Slayton
EA/M. A. Faget
PA/C. C. Kraft, Jr.
R. G. Rose
FS/Lynwood Dunseith
PA/G. M. Low
PD/O. E. Maynard

EG23:KJCox:ddb 11-22-67

00000025

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : FM6/Chief, Rendezvous Analysis Branch

DATE: DEC 14 1967

67-FM-T-119

FROM : FM/Deputy Chief

SUBJECT: Extra cost of boresight TPI

You will be surprised to hear I actually read the Gemini Rendezvous Summary, except for the tables of course, and it looked like a real good piece of work to me. I do have one question, though, regarding the conclusions listed on Page 4-1. Are we going to recommend that the crew does not boresight the spacecraft toward the target during the TPI maneuver?

Howard W. Tindall, Jr.

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: DEC 18 1967

67-PA-T-118A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: No need to perform lunar landmark orbit determination

1. A number of Trajectory Control Data Priority meetings have been held on the Descent phase of the lunar landing mission. A basic question arose early in these meetings regarding lunar orbit landmark tracking with the command module sextant and/or telescope. It was necessary to decide whether or not such observations are required for use in improving our knowledge of the spacecraft orbital elements, otherwise determined using MSFN S-Band observations only. And, if so, at what time must they be obtained and how would they be used? Accordingly, a special meeting of all parties known to be interested in this subject was held on November 30 in order to answer these questions.

2. This memorandum is to report the results of that meeting, which I may briefly summarize at the onset by saying it was the consensus as of this time that performance of the MSFN orbit determination capability is expected to be adequate and landmark tracking for purposes of navigation does not appear to be required. Therefore, in order to make the overall operation itself and development of the systems to be used as simple and unsophisticated as possible, it is our recommendation that we should not include this activity in the mission at least until it is proven to be necessary. That is, in establishing the manner in which the various guidance systems are initialized, verified, monitored and used during the lunar landing mission, it is reasonable to assume that tracking of lunar landmarks will not be done. Furthermore, development of the crew timeline, RCS propellant budgets, mission plans, crew procedures, RTCC programs, etc., may also omit this activity. It is very important, however, to emphasize that spacecraft optical observations of the landing site are essential at various times in the lunar landing mission in order to establish its location with respect to the spacecraft orbital elements as determined by MSFN.

3. At our meeting, Math Physics Branch people described in some detail the current status of the MSFN lunar orbit determination capability. As you probably know, we have recently obtained a considerable amount of actual tracking data on Langley's Lunar Orbiter spacecraft which have revealed that the performance of MSFN is not quite as good as previous

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

preflight analysis had indicated it would be. Processing of all this data is far from complete, but there apparently is good reason to believe that the only significant error source associated with MSFN is a lack of precise knowledge of lunar potential. The effect of this on MSFN orbit determination accuracy shows up as an uncertainty in the orientation of the spacecraft orbital plane, the uncertainty being almost entirely a rotation of the orbital plane about the earth/moon line estimated to be in the order of $\frac{1}{2}^{\circ}$ in magnitude.

4. Associated with this, work is underway in two areas. The first is by Math Physics Branch people, both here and at JPL, attempting to define with more precision and confidence exactly what the characteristics of the orbit determination uncertainty really are. Results of this should be available within a couple of months for use in planning what to do if it doesn't get any better before we go to the moon. The other major effort is being carried out by the Langley Research Center with assistance from Boeing. These people are concentrating on improving our knowledge of the lunar gravitational potential which, if successful, should significantly improve MSFN accuracy. It is anticipated that results will be available in the March-April-May time period.

5. This discussion was followed by a brief definition of the current RTCC orbit determination capability. Specifically, at present there is no way we can directly utilize observational data in determination of spacecraft ephemerides other than S-Band data obtained from the earth tracking sites. Moreover, to add in the RTCC the capability of processing optical observations of lunar landmarks obtained onboard the spacecraft would have a significant impact on the development of RTCC programs. Therefore, we concluded we should not recommend doing so. It was noted, however, that both command module optical observations and LM-on-the-lunar-surface rendezvous radar observations can be processed to improve the RTCC's knowledge of the relative position of the landing/launch site based on the assumption that the MSFN ephemeris is perfect.

6. There was also some discussion about the onboard procedures and programs which, in general, sounded pretty good. There was one significant exception, however, dealing with the manner in which the spacecraft systems take into account the offset of the desired landing site location from the identifiable landmark associated with it. It is probable that a Colossus Program Change Request will be initiated from the Descent Phase Data Priority Panel to improve the manner in which this job is carried out.

7. The discussions noted above were primarily to make sure everyone had an understanding of the expected capability of the systems we are dealing with. Following that we spent the rest of the time on how best they might be used and in determining if they were acceptable. These discussions

00000028

brought out that as long as accurate onboard optical observations of the landing site were made fairly soon before initiation of descent, the mission could be carried out with no apparent extra cost of propellant. This is because, like rendezvous, it is not necessary to have an understanding of the absolute, inertial position and velocity in space but only to have a precise knowledge of the target's relative position with respect to the current estimate of the ephemeris.

8. A much more difficult problem is involved in preparing for the Ascent phase. Again, it is almost certainly necessary that observations of one spacecraft with respect to the other must be made shortly before lift off. Furthermore, if a command module plane change is required to insure its being within the LM propulsion capability, it will be necessary to make observations of the LM/command module relative position prior to targeting that maneuver. There is a choice of using either the command module optical device and/or the LM rendezvous radar for this purpose. Since operating the LM radar will probably conflict with other lunar stay time activities when this timeline is eventually established, it is anticipated that the command module optical device will be prime for this purpose backed up by the LM radar. But only if it is impossible to obtain the optical observation for some reason. The PTCC has been programmed to accept both of these data sources for this purpose.

9. There is one feature of the Ascent phase which remains troublesome. Ascent, unlike Descent, demands that at the end of the burn the LM not only be in the right place (in the CSM orbital plane) but, in addition, must have its velocity vector in the right direction, namely in or parallel to the plane of orbit. Targeting for this additional constraint may be difficult to do unless MSFN performance is substantially improved and it is not entirely certain that adding more landmark tracking will help the situation very much.

10. Studies are continuing in this area to define exactly what our problem is. However, pending results of these analyses and those by the people attempting to improve the lunar potential model, there does not seem to be sufficient justification to make landmark tracking a requirement at this time, other than those of the landing/launch site. We do not propose to delete the currently planned capability anywhere and can add this activity back into the planning and procedures development later on if it proves to be worthwhile.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

00000029

UNITED STATES GOVERNMENT

Memorandum

TO : PA/Manager, Apollo Spacecraft Program DATE: DEC 11 1967

OT-PA-T-117A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Apollo 205/101 reentry procedures

1. ASPO's Systems Engineering Division wrote a memo outlining general procedures to be used by the Spacecraft 101 crew following a G&N controlled deorbit burn and also specifying that an automatic reentry would definitely not be performed. You forwarded that memo to me questioning whether our Data Priority Coordination group had looked into this subject and, if so, if we were consistent. I have attached a copy of our recently completed Trajectory Control logical flow charts for you to see. (Don't try to read it!) We expect to review them worldwide on December 20. After incorporating reasonable comments, we will review them in detail with you, Chris and Deke, at your convenience. As far as I can tell, they are completely consistent with the spirit of the FD12 memo and obviously go into far more detail.

2. With regard to the manner in which the reentry itself should be performed, we felt it unnecessary to specify that at this time since it is not particularly important from an operations standpoint. I'm sure the crew will do as well as the DAP, or vice versa, in closing the gap between computed guidance commands and spacecraft attitude control. It seems to me that the decision to which way it should be performed should be based on the objectives of the mission instead.

Howard W. Tindall, Jr.

Enclosure

PA:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: DEC 11 1967

ST-PA-T-11(A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Establishment of the Midcourse Phase Mission Techniques Working Group

1. This memo is in confirmation of telephone conversations requesting your participation in a continuing working group to discuss the Midcourse Phase of the lunar landing mission. This mission phase included the TLI, MCC, LOI and TEI maneuvers. The overall composition of this Midcourse Phase Mission Techniques Working Group is as follows:

FM	Ronald Berry, Chairman
CB	Mike Collins
CF	Ted Guillory
EG	Bi Smith
EG	Clarke Hackler
FC	Ed Pavelka
FC	Steve Bales
FC	Dave Masaro
FC	Gary Coen
FM	Stan Mann
FM	Tom Kyle
FM	Jerry Tencharis
PA	Bill Tindall
TRW	Bob Kidd
TRW	Dick Boudreau

2. The first meeting is scheduled for Tuesday, December 12, 1967, in Building 30, Room 3044, at 9:00 a.m. Its specific purpose is to establish targeting and monitoring procedures for the LOI maneuver to be included in the overall Apollo Mission Techniques document. It is desirable, I think, to keep this working group as small as possible, however, if you feel it desirable to bring additional people from your organization, be my guest.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

Dec 19 11 28 AM '67

TO : PA/Manager, Apollo Spacecraft Program

DATE: DEC 15 1967

67-PA-T-115A

FROM : PA/Chief, Apollo Data Priority Coordination ← SEE NOTE 12/21/67

SUBJECT: Urgent recommendation that CMC steering of the S-IVB be deleted

1. MSC and MSFC are currently operating in accordance with Headquarter's Apollo Program Directive No. 2A, dated September 1, 1966, which established the requirement for the command module computer (CMC) to be capable of guiding the S-IVB during the translunar insertion maneuver (TLI). The purpose of this memorandum is to recommend that action be taken to have this requirement deleted and to tell why we should do so. In summary, this recommendation is based on a conviction that the effort required to provide this capability is greatly out of proportion to the benefit to be gained by providing it. Its deletion would be just one more step in the current effort to simplify and clean up the overall Apollo program - eliminating niceties in order to concentrate our limited resources on those activities of greatest importance.

2. It is to be emphasized from the start that the CMC TLI steering can only back up a failure of the Saturn Launch Vehicle inertial platform occurring after insertion into earth orbit and prior to initiation of TLI. Reliability of this component of the IU has been estimated to be .996 at time of insertion into earth orbit. This is generally interpreted to mean that in four cases out of a thousand a platform failure will occur forcing deletion of the second S-IVB burn, resulting in a primary mission failure unless we provide this backup. The message here is that it is very unlikely we would ever use this capability even if it were provided. And perhaps of more importance, it is to be emphasized that crew safety is in no way involved.

3. It is generally agreed that this minute additional capability would be nice to have - provided the cost is not excessive. This is not the argument nor is it questioned here and now that sufficient confidence could be developed in the backup system to permit its use. The basic point to be made is that the NASA and its contractual support is now operating at a fixed or decreasing level of effort and that the energy required to do this job necessarily must be channeled from something else more important. Specifically, what are these various costs? It is the analysis and deliberations required of MIT people to determine the exact formulation

cc - info - Gilruth

12/20

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000032

of the CMC program. It is the actual programming and testing of that program integrated into the total flight software package. It is the analysis by MIT, MSFC and MSC to verify that the entire assembly - guidance and control system, propulsion system, structure, etc. - is dynamically qualified for flight. It is the planning, analysis and development of mission rules and procedures to carry out the real time systems evaluation and make the switchover decision in earth orbit. It is the development of crew procedures to initialize and monitor the back-up guidance mode during the TLI maneuver. It is the post-flight analysis to answer the question - how would it have worked if we had used it? It is the coordination of all this, and more, and endless explainations of how it all works. It is ten thousand meetings!

4. A rough estimate of the total cost of these things is given in the attached table. I am not listing them here because I am afraid that would divert your attention from the more important point. We have limited resources. The flight schedule is heavily upon us and there's an awful lot left to do for the nominal missions, the more likely contingencies and the situations involving crew safety. This low probability backup would demand attention of the same people who must do those jobs and we simply can't afford their involvement on it because its priority is too low in comparison. It's not just cost in terms of manhours and dollars but is something much more valuable - a drain on our straining resources.

5. The impetus for this campaign to delete CMC steering of the S-IVB came from discussions with some friends at MIT who expressed their concern regarding problems they still face in getting the program put together and flight qualified. They did not suggest that it be deleted, although they obviously concur with that idea. (It is to be emphasized that this program is not currently pacing delivery of the CMC lunar landing program [COLOSSUS] although there are some who expect it soon will. Nor is it absorbing an undue amount of computer storage.) I have recently polled a large number of other people and have found no champion for its retention, with one possible exception. That is, both systems and trajectory people of FCD, MPAD, G&C and ASPO and other interested parties, have all expressed a neutral position or, more often, concurrence that it should be deleted. Some members of the flight crew for the second and third manned missions still feel it would be nice to have, although it is my understanding there is no intention of using this capability in those missions. How could so many people be wrong?

00000033

6. In conclusion, I would just like to summarize by saying that the job of providing this backup can be done but the effort required is substantial, particularly if you weigh the fact that the particular talents involved are at a premium. The benefit to be gained is so small that to carry this job farther does not appear to be justified and it is strongly recommended that agreement be obtained at the earliest date for deletion of CMC guidance of the S-IVB during TLI, preferably before Christmas.?

Howard W. Tindall, Jr.

Enclosures 2

cc:
(See attached list)

Bill T. Believe several of our notes, phonecalls & memos have crossed on this subject. Here is my current understanding:

a) you will prepare memo (for Kraft's signature or mine?) to Phillips requesting deletion. The ground work for this has been laid.

b) In the meantime you will obtain Slayton's concurrence, or his specific objection so that we can take positive action w.r.t. his concern.

BML
12-27

00000034

Rough, incomplete estimate of remaining effort required to provide CSC capability to steer the S-IVB.

MIT

a) Program Formulation (CSOP)	Complete
b) Program Coding	1 manmonth
c) Level 3 and 4 Testing	3 1/2 manmonths
d) Level 5 Testing and Documentation	1 manmonth
e) Coordination MIT/MSFN/MSC	3/4 manmonth
f) Development of Simulation Programs	(MIT maintains they are not going to do these jobs. If directed to do so, the CSC programs will slip.)
g) Simulation and Analysis	

NASA

a) MPAD (See attachment 2)	6+ manmonths
b) CAD SIVB/PNGCS Dynamic Simulation	1+ manmonths
c) GCD, FCD, FCSD, FSD	(Not estimated, not insignificant) (GCD must do "g." above)

TRW

(See attachment 2)	34 manmonths

MSFC

a) Provide MIT with math models of slosh, bending, rigid body propellant utilization.	(Not estimated, not insignificant)
b) Specify MIT analytic runs to be made.	" "
c) Review results of MIT work for accuracy and performance	" "

Attachment 1

00000035

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : FM/Deputy Chief, Mission Planning and Analysis Division

DATE:

File No. 67-FM13-169

FROM : FM13/Chief, Apollo Trajectory Support Office

SUBJECT: Deletion of Spacecraft steered Translunar Injection requirement

As per your request, the following information has been collected to determine the impact on MPAD and contractor support manpower of eliminating the requirement for a takeover of the SIV-B guidance function by the Apollo spacecraft computer. These estimates have been established quickly but should provide a representative picture of the savings to be realized. One word of caution -- eliminating this specific requirement may actually allow more attention to be paid critical areas in the onboard software development and checkout, however, whatever replaces this logic in core will have to be given the same attention in verification and checkout that was expected to be shown the original program 15.

TRW Tasks

A-77 Empirical simulation of specific Apollo mission burn phases -- Approximately 3.5 manmonths of effort remains on this task. Eliminating the TLI switchover requirement would require redirection of this task with a potential savings of 2 manmonths.

A-143 Criteria for the TLI Guidance Switchover Decision -- This task has just recently been revised to cover the development of the limit lines and the associated criteria for switchover decision. A deletion of the guidance switchover requirement would require a reorientation of the task to cover only the SIV-B update and possible retargeting requirement. It is estimated that approximately 12 manmonths of the total 24 manmonths of effort associated with this task could be saved.

A-97 Independent Onboard Flight Software Validation -- A deletion of the guidance switchover requirement from this task would save an estimated 5 manmonths of engineering effort with approximately the same savings in the programmer support area.

A-103 Apollo Guidance Equations and Guidance Simulation Support -- Since the 6-Degree-of-Freedom portion of the SIV-B simulation program could be eliminated with the deletion of the guidance switchover requirement, a savings of 6 manmonths of engineering and 4 manmonths of programming effort could be realized.

Attachment 2

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

In addition to the TRW studies just mentioned, the MAB estimates a savings of approximately 6 manmonths of in-house engineering effort which would otherwise be required to assist MIT in checking out and running the 6 DOF simulation for S/C steered TLI, in assisting FSD/MIT/MSFC in defining software test plans and in supplying target parameters (guidance constants) for the test plan. Although no other MPAD branches indicated any impact on their in-house efforts, there is bound to be some. It is just difficult to estimate. The sum total of all of this discussion amounts to about 3½ manmonths of contractor support effort and 6 manmonths of in-house effort.

John P. Bryant

John P. Bryant

cc:
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
R. P. Parten
Branch Chiefs

FM13:JPBryant:lg

00000037

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS 77058

IN REPLY REFER TO: 67-PA-T-113A

DEC 7 1967

Bellcomm, Inc.
1100 Seventeenth Street, N. W.
Washington, D. C. 20036
Attention: R. V. Sperry

Roberto,

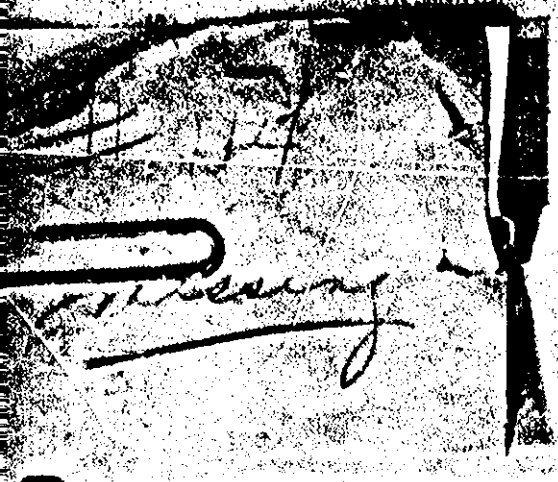
Attached is a copy of the Trajectory Control Data Priority flow charts we have prepared for Spacecraft 101 Retrofire and Reentry. This is the thing we are going to discuss at the December 20 meeting to which you were cordially invited.

I hope you get a chance to review it and come down for the picnic. Please bring your own ants!

Sincerely,

Howard W. Tindall, Jr.
Chief, Apollo Data Priority
Coordination

Enclosure



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS 77058

IN REPLY REFER TO: 67-PA-T-113A

DEC 7 1967

Massachusetts Institute of Technology
Instrumentation Laboratory
75 Cambridge Parkway
Cambridge, Massachusetts 02142
Attention: R. R. Ragan

Dear Ralph,

Here are several copies of the Trajectory Control Data Priority flow charts for the Spacecraft 101 Retrofire and Reentry. These are the latest version of the stuff we intend to review at the December 20 meeting to which your people were cordially invited. I have spoken to both Norm Sears and Jim Nevins about this and the invitation TWX went to Dave Hoag. Hope you find them amusing.

Sincerely,

Howard W. Tindall, Jr.
Chief, Apollo Data Priority
Coordination

Enclosure

00000039

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: DEC 7 1967
67-FM-T-111

FROM : FM/Deputy Chief

SUBJECT: Light weight LM attitude control is too sporty.

1. Pete Conrad expressed concern the other day about a problem he anticipates in attitude control of the LM. This has popped up on a number of occasions previously, but nothing much gets done about it. Specifically, as Pete says, the LM is too sporty when in a light weight configuration. Minimum impulse is expected to produce about 0.3°/sec. attitude rates which is said to be about 4 times too fast.

2. I am writing this note just to prompt some more thinking about this problem which may become quite serious. I certainly don't know what to do about it. Pete suggested that we should look into differential thruster firing. First reaction to that suggestion is that it would use too much RCS propellant. But if you consider how much will be spent limit cycling at 0.3°/sec., there is some reason to believe differential jet firing may be no worse. And, of course, they may be able to control the spacecraft which is highly desirable, if not mandatory. (Differential firing, of course, is the business of firing jets whose reactions oppose each other by controlling their difference to be the small, desired reaction in the right direction.)

3. Who has a better idea, or do you think the present design is okay?

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: DEC 4 1967
67-PA-T-110A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Third Trajectory Control Data Priority Meeting for Spacecraft 101

1. At 9:00 a.m. on December 20, 1967, in Room 966, Building 2, there will be a Trajectory Control Data Priority meeting to review the detailed logical flow charts prepared at MSC defining the retrofire and reentry phase of the S/C 101 mission. Appropriate comments shall be incorporated and they will be reissued as configuration controlled documents specifying the manner in which the various guidance and control systems will be verified, monitored and used during the flight. Copies of these flow charts may be obtained after December 6 from H. W. Tindall, Code PM, Ext. 4676.

2. You and/or your friends are cordially invited.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

PA:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: NOV 17 1967
67-FM-T-109

FROM : FM/Deputy Chief

SUBJECT: Spacecraft computer program orbital integration

1. This is just another little golden nugget for your files.

2. The spacecraft computer programs, of course, have orbital integration routines to support operations around the earth and moon, as well as in between. The gravitation of the earth, moon and sun are treated differently dependent on which of these regions you are operating in. On a number of occasions the question has arisen as to where the boundaries actually are governing this.

3. I have found out that MIT currently has written the command module program as follows. When operating within about 210 nautical miles of the moon's or earth's surface the orbital integration only takes into account the gravitational potential of that body including its oblateness effects. Beyond that altitude, and up to a radial distance of 42,000 nautical miles from the earth and 3,000 nautical miles from the moon, it adds to these the effect of the other two bodies (without their oblateness). Beyond that distance, the oblateness effects are dropped.

4. In order to save erasable memory in the LM computer, the LM program is somewhat different. No matter how much it is flying, it takes into account only that body around which it is operating including all its oblateness effects, but never takes into account perturbations caused by the gravitational potential of the other bodies.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

NASA - Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: NOV 16 1967
67-FM-T-108

FROM : FM/Deputy Chief

SUBJECT: 501/502 state vector update requirement

During the 501 operation apparently there was no question as to whether state vector updates would be sent. But I gather there may have been some question as to how important they are. This will probably just add to the confusion, but I thought I might redistribute the attached memos written last January which stated that the second update was mandatory and that the first update was only useful to assure that the spacecraft would at least reenter if, for some reason, the second update could not be made.

Howard W. Tindall, Jr.

Enclosures 2

Addressees:
FA/C. C. Kraft, Jr.
FC/J. D. Hodge
G. S. Lunney
C. Parker
FS/L. C. Dunseith
FM/J. P. Mayer
C. R. Huss
FM7/M. D. Cassetti

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

TO : FA/Director of Flight Operations

DATE: JAN

FROM : FM/Chief, Mission Planning and Analysis Division

SUBJECT: State Vector Update Criteria for AS-501

Because of the decision to utilize the AS-[illegible] Apollo guidance programs for the AS-501 mission, the mission was designed [illegible] on the premise that the state vector update would be made. [illegible] this, the situation exists that a perfect launch vehicle spacecraft combination without guidance or propulsion errors of any kind will [illegible] about 250 nautical miles from the planned target. This is caused by the inaccuracy of the spacecraft navigation equations used on the onboard computer (see attached memo by Marlowe Cassell). Another factor which affected the decision to base targeting on an updated vehicle was the inability to predict the time of the second S-IVB burn.

MPAD has been developing techniques and criteria to be used during the actual mission for making a decision on whether or not to make the update. The programs being developed to make this decision are monumental and time-consuming. I recommend, therefore, that we terminate this effort since the only possibility of not needing updates in the actual mission would be a chance combination of system errors in exactly the right combination to fall within the target tolerances.

If this decision is accepted, therefore, it means that it is mandatory to send updates during the AS-501 mission and that the complete ground complex utilized for updating must be thoroughly verified before committing the ground system for flight operations.

Another item to note in the attached memo is the revelation that IMU errors greater than approximately 3 sigma values may result in an unacceptable heating test.

John P. Mayer

Enclosure

cc:
(See attached list)

Enclosure 1

00000044

cc:
CA/ J. P. Finn
IM/ O. N. Maynard
IM2/C. R. Perrine
EC/ R. C. Duncan
FC/ J. D. Hodge
FC/ O. B. Lunney
FSO/Lynwood Dunwoody

[illegible]

FM/Chief, Mission Planning and Analysis Division

January 20, 1967

67-FM7-6

FM7/Acting Chief, Guidance and Performance Branch

State vector update situation for AS-501 and AS-502

1. The AS-501 and 502 missions have been designed to update the state vector (position and velocity) in the Apollo Guidance Computer (AGC) with a state vector from the Manned Spaceflight Tracking Network (MSFN) prior to the Saturn (S-IVB) out-of-orbit burn and again prior to the second Spacecraft Propulsion System (SPS) burn. If these updates are not transmitted from the ground the AGC will use position and velocity estimated from onboard navigation equations. Because of the inaccuracies of the navigation equations, even with perfect Inertial Measurement Unit (IMU) performance, a perfect vehicle will fly different trajectories depending on which combinations of updates are transmitted.

2. The attached table illustrates the deviations of four trajectory cases with various combinations of updates. Case #3 (no updates) has actual reentry conditions close to Case #1 (both updates) but the AGC navigated state vector is in error. Case #2 was propegated through the reentry phase and the Command Module could not achieve the desired landing point and the actual impact point (IP) was off from nominal by 225 nautical miles. At splash the AGC's estimate of the IP was in error by about 120 nautical miles (a similar run from MIT resulted in 90 nautical miles for this error).

3. Case #3 (first update only) indicated a large improvement over the no update case and Case #4 (second update only) brings condition back to the nominal (both updates) performance; however, in order to draw proper conclusions from these four cases, the performance of these cases with IMU errors must be examined.

4. The two update mission (Case #1) with the IMU performing at specification values has an entry flight-path angle error of $\pm .53^{\circ}$ (3σ), which produces a marginal first heat rate test. Case #2 with dispersions has a good probability that reentry will not be achieved. (That is, the minimum altitude is greater than 400,000 feet.) Case #3 will have about a thousand mile IP dispersion. Case #4 will have entry errors slightly larger than Case #1.

Enclosure 2

00000046

5. The second update is mandatory to insure a high probability of achieving the required 501 test objectives. The first update assures that the vehicle can be recovered in case the second update is not received as planned. In other words, you must send <u>both</u> updates.

Marlowe D. Cassetti

Enclosure

cc:
FM/H. W. Tindall, Jr.
C. R. Russ
M. V. Jenkins
J. F. Dalby
R. P. Parten
J. P. Bryant
MPAD Branch Chiefs

FM7:MDC:svp

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: NOV 27 1967

67-PA-T-107A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Some assumptions about Spacecraft 101 retrofire and reentry procedures

1. We have recently held several small Trajectory Control Data Priority Working Group meetings dealing with Spacecraft 101 retrofire and reentry. The results are being documented to show how the various guidance and navigation data sources will be compared to one another and used during the mission. During these discussions a couple of basic assumptions have been made which I thought might be advisable to disseminate.

2. MCC computer programming, procedures and mission rules are being established based on the assumption that if it is necessary to retrofire and reenter without the G&N either because that system has failed or because there is insufficient time to bring it on line, the retrofire shall be performed SCS auto mode and the reentry shall be ballistic. (It is assumed that at least two hours and forty minutes, including two periods of darkness, are required for retrofire preparation.) Accordingly, the retrofire time will be computed based on the reentry to be performed by either continuously rolling or by utilizing a 90° bank angle and a time to reverse it.

3. Associated and consistent with this basic assumption is the procedure that if a PNGCS failure is detected at the horizon alignment check performed at T_{Retro} minus 5 minutes and voice communications are available with the ground, a ballistic reentry will be utilized. The compatible retrofire time will have been determined previous to this event and relayed to the crew, the slip in time being approximately 2 minutes. The obvious objective of this procedure is to reduce landing point dispersion resulting from a lifting reentry without guidance, and it was felt that with solid ground assistance the delay in retrofire could be accomplished. Simulated exercises will prove or disprove this.

4. It is assumed that the role of the EMS is solely associated with monitoring and it will not be used directly in control of the spacecraft nor in evaluating performance of other spacecraft systems. There had been some question as to how its roll reference would be initially aligned. It is currently proposed that the nominal reentry bank angle of 55° will be loaded into the EMS and that the spacecraft will be oriented to that bank angle at the time of .05 g's when the pilot initializes the EMS. He will then roll to the post-retrofire backup reentry bank angle as determined by MCC and/or onboard charts.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

Mission Planning & Analysis Division

TO : FA/Director of Flight Operations

DATE: NOV 14 1967
87-FM-T-100

FROM : FM/Deputy Chief

SUBJECT: EMS software verification doesn't exist

1. I am pretty sure the verification of the Entry Monitoring System (EMS) scrolls is screwed up and I am sorry to say that, even though I suspected it for quite a while, I have not gotten around to doing much of anything. As soon as Bob Gardiner gets back from the Cape, Claude Graves and I will go talk to him. I'm pretty sure that no one besides NAA can generate the lines for the scroll nor can anyone but NAA figure out if the manufacturer put them in the right place on the scrolls. I've attached an NAA letter, which I'm sure they must have written tongue-in-cheek, that pretty well shows what I mean.

2. Claude Graves and his people can do some checking but only to the extent of plotting different reentry trajectories as they would appear on the EMS and looking for possible violations. But this could certainly not be considered verification of the "software," which, in effect, the EMS scroll lines are.

3. This note is just to alert you to the situation. I will let you know if I cannot get things straightened out. Personally, I think it would be desirable to have G&C report EMS status to your Software Change Control Board. One final remark, perhaps worth making, is that neither Gardiner nor Chilton conceal their distaste for the EMS. Both wish to see it torn by its roots from the spacecraft and flung out the window. So you can imagine the attention their people must give to it.

Howard W. Tindall, Jr.

Enclosure

cc:
FM5/C. A. Graves

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: NOV 14 1967
67-FM4-T-105

FROM : FM/Deputy Chief

SUBJECT: Inflight alignment of the COAS

1. As you know, the command module computer program---COLOSSUS---is being developed to permit use of the crew's reticle (COAS) as a backup reference source for aligning the IMU and for rendezvous navigation. This is to guard against some failure of the sextant and telescope as well as providing the capability to make line-of-sight measurements from the couch position as might be helpful in a one man rendezvous situation. Since precise COAS alignment cannot be established prior to launch, a provision has been made in the spacecraft program to accept and utilize its alignment as determined inflight and specified with reference to the sextant. However, it is necessary that the ground supply so-called "equivalent sextant" shaft and trunion angles. This note is to make sure that an RTCC and/or ACR computer program capability is provided or at least to make sure you know that it is expected to do that job.

2. The inflight procedure is as follows. The IMU is aligned using the sextant. The spacecraft is then maneuvered in attitude such that the COAS is centered precisely on a known star and the mark button is pushed to get the platform gimbal angles on telemetry to the ground. With this information, the ground is able to determine the "equivalent sextant" shaft and trunion angles. These are the angles which the sextant would have to assume to be centered on that star given that spacecraft orientation. Of course, it is impossible for the sextant to view the star with that spacecraft orientation since it would be located approximately on the spacecraft X-axis which is outside the field of view of the sextant. It is the "equivalent sextant" shaft and trunion angles which must be relayed by voice to the crew.

3. When the crew later specifies to the computer that they are using the COAS, it displays these paramters which, if not correct, must be input. It then uses the optical observation obtained with the COAS just as if it were a sextant mark obtained with those shaft and trunion angles. It should be noted that although these angles have sometimes

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

been referred to as COAS bias angles, they are really not biases as that term is ordinarily used and should have values substantially different than zero. At least that's the way I understand it.

Howard W. Tindall, Jr.

Addressees:
FC5/C. B. Parker
FM5/R. E. Ernull

cc:
(See attached list)

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: NOV 14 1967
67-FM4-T-104

FROM : FM/Deputy Chief

SUBJECT: Spacecraft computer program design to process VHF ranging for rendezvous navigation

1. On November 1, 1967, a team of MSC people were at MIT to discuss, among other things, use of the VHF ranging data in the spacecraft computer. Specifically, we reviewed the work MIT has done in this area since our "tiger team" meeting on October 5. Steve Copps is the guy at MIT responsible for incorporating this new requirement into Chapter 4 of the CSOP. He has nearly finished this but has not reviewed it in any detail with the programming people. He did make a point of emphasizing some assumptions he has made and I am writing this note to make sure you are aware.

2. The first matter deals with getting the data on the downlink. The only channel for sending VHF ranging data to the ground is through the spacecraft computer. However, Steve Copps is setting up the program such that, unlike the LM, there will be no special program in the computer solely for getting the ranging information from the VHF device and putting it on the downlink. It will only get on the downlink if the rendezvous navigation program is in operation. Doing it this way is said to be the easiest and least complex but means that VHF range data will not be transmitted directly to the ground when "average g" is running (during the final phase of the rendezvous and during burns) or when in the platform alignment programs.

3. The second point Steve emphasized was that precisely the same data acceptability test is used on all rendezvous navigation data sources--- sextant, telescope, reticle and VHF range. As you recall, each individual observation is processed and changes in the state vectors are computed. If this change is in excess of some test values (preset in erasable memory) the crew is given the option of rejecting that data. The test values are the same for all data sources.

4. Steve also noted that there is no VHF maximum range test governing the computer's use of the data. This function is left to the crew to make sure that the computer does not receive data in the second range interval, that is, beyond approximately 400 miles since it will be wrong by about that amount. Supposedly, the VHF is only designed to work to 200 miles anyway.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

5. Finally, MIT will attempt to display the number of sextant and VHF range observations separately as two digit integers in the same DSKY register separated by a zero or a blank. If anyone sees anything wrong with the above design assumptions, he better inform FSD personnel immediately as well as supplying justification for going in some other way. As of now, MIT has been told that these assumptions are acceptable to MSC.

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: NOV 13 1967

MSC-FM-T-103

FROM : FM/Deputy Chief

SUBJECT: MIT/MSC review of LUMINARY Descent Programs

1. On November 2, 1967, a team of Flight Crew, C&C and FOD people met with MIT to discuss the lunar landing descent programs. We have recently been reviewing these programs at MSC and it has become evident that many of the displays and associated computations which we had listed as requirements early in the year are not. That is, apparently insufficient thought was given at that time as to how the system would actually be used. We did not intend to insist upon changes that would make the MIT schedule situation more critical but rather to identify those things we were confident we would not need and would then leave it to MIT to decide whether to delete them from the first edition of the LUMINARY program or not. There was a strong impression that MIT would probably make most of the possible deletions, but we asked them to take as much time as necessary to review the situation and tell us what they intend to do, formally, in writing. I personally felt that the meeting was very worthwhile and should result in a much better program requiring considerably less MIT effort to complete.

2. Several items were discussed extensively which I thought might be worth recording for my own records and perhaps your information. The remainder of this memo will be devoted to them.

3. One of the items we spent the most time on had to do with crew procedures associated with the out-of-plane situation existing during descent. Proposals had been made to display quantities to the crew prior to initiation of braking which would enable him to plot the approach trajectory on a strip chart of the lunar surface, taking into account the existing out-of-plane situation. There was considerable skepticism during our discussion that visual monitoring of the lunar surface as it streaks by would be of much value in determining performance of the systems, need for abort, or for any other really useful function. The situation is somewhat equivalent to a low altitude pass over an unfamiliar desert at Mach-3 with lots of other interesting things going on inside the cockpit. Pete Conrad was going to review this whole business with FCSD people and the Astronaut Office to make sure that action we proposed at MIT was okay, namely make the display of delta R a requirement---to be computed exactly as now formulated in the MIT program. Specifically, delta R is the perpendicular distance of the landing site position vector from the LM orbital plane. This quantity is displayed in P-63, prior to DPS ignition, and may serve as an indicator to the crew of reduction in hover time they can expect due to use of propellant for plane change. And it may also be useful for some sort of lunar surface navig

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

chart initiation. It was noted that following Conrad's review we may recommend deletion of the entire 3-register display format containing delta R at MIT's option. We definitely don't want to change the definition of delta R from that given above.

4. In response to my question regarding the computer's test to determine whether or not to use landing radar data, MIT stated that it was made on the computed value of altitude based on the spacecraft navigation starting prior to DOI. Considering the flat approach trajectory and the possibility of relatively large error in computed altitude due to uncertainty in the lunar radius and degraded MSFN performance, it is possible that radar data may be accepted much earlier or later than it should be. This is just a remark about a situation which perhaps deserves some investigation. It is not a proposal to change anything at this time.

5. It is understood that the delta V monitor program in the LGC will only send an engine off command in one of the P-40 series thrust program. In the other thrust programs---ascent, descent and abort---it will only issue a program alarm since erroneous engine off commands in these time critical mission phases could be catastrophic.

6. The P-64 Spacecraft Computer Descent Program provides the capability for redesignating the landing site location with the hand controller. Pete Conrad was concerned that the stick could be deflected accidentally causing the targeted landing site position to be moved unintentionally. In order to avoid having a "hot stick" when it may not be needed at all, it was decided to slightly modify P-64. To be consistent with standard PNGCS operations, the P-64 display will be made a flashing display, thus, requiring the crew to hit Proceed if he wants to redesignate the landing site. It is only after this crew input that stick motion would be regarded as a legitimate request for landing site relocation. Following the input of Proceed the display stops flashing and the stick remains hot thereafter. The crew would only hit Proceed if he wants to redesignate, of course.

7. Another item on which we spent a considerable amount of time dealt with "Delta V Margin." MIT proposed to provide an on call display which was the LGC's prediction of delta V remaining at touchdown converted into hover time margin. Its primary use was to inform the crew of the fuel cost they have incurred by redesignating the landing site. The discussion brought out that this computation is really not particularly accurate. Furthermore, it was anticipated that allowable landing site redesignation would probably be governed by mission rules. However, this lengthy discussion revealed that it should be possible to make a fairly accurate prediction of how much fuel

is required from present time until touchdown including the effects of landing site redesignation. This display could be made to automatically appear after each LDP action. The crew could compare this with the fuel gauge, which is considered to be fairly accurate, giving him an indication of whether or not he had sufficient fuel to complete his landing as currently specified. It was agreed that this parameter should be added into the Pad program display format provided there was no schedule impact, excessive storage requirement or any program development trouble. At first incident of any of these it would be dropped. It will be displayed in units of "percent" fuel in order to be compatible with the fuel gauge and will take the place of Delta V Margin previously requested.

3. At one time it was proposed that when the crew detected there was no relative velocity of the spacecraft with the moon's surface, they would input this fact to the computer which would zero the velocity state vector. This was included in Chapter 5 of the LUNARY GSOP but not in Chapter 4. It was determined that this was not a computer program requirement and will be deleted from Chapter 5.

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: NOV 08 1967

FROM : FM/Deputy Chief

SUBJECT: Spacecraft computer program P05---on the way out

During a meeting of MSC people at MIT on November 2, it was brought up by MIT that some problems were being encountered in the development of P05, the program which assists the astronaut in turning on the primary guidance system. Although these problems are relatively minor, it was the opinion of MIT that this program contributes little, if anything, to the operation of the spacecraft and it was their suggestion that we delete it from COLOSSUS, LUMINARY and SUNDANCE. The consensus of MSC people present was that this was a good idea and it is probable that the Flight Support Division will so direct MIT unless someone comes along to protect it. I am writing this note primarily to give you that opportunity---if you like P05.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000057

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : FM3/Chief, Apollo Trajectory Support Office DATE: NOV 08 1967

67-FM-T-101

FROM : FM/Deputy Chief

SUBJECT: What is the effect of uncertainty in the lunar potential on spacecraft computer program performance?

1. Sig Sjoberg called after reading my memo (67-FM-T-98) regarding the impact of current MSFN performance on lunar operations. He wondered why I had not included in my list of studies the effect of lunar potential uncertainty on the spacecraft computer programs. I guess the reason I left it out was that it was somewhat different than those. Specifically, I suggested that we do the analyses listed utilizing current MSFN performance regardless of its cause. However, it would probably be useful to make some estimate of the uncertainty in the lunar potential based on our MSFN experience and use that in some additional studies.

2. Two studies that I can think of specifically are (a) the determination of the effect of uncertainty in lunar potential on the onboard computation of the landing site position, particularly its distance from the center of the moon, and (b) determination of the effect of uncertainty in lunar potential on the capability of the LGC to integrate the equations of motion from the time it is initialized prior to DOI until landing---with and without landing radar update. I assume both of these tasks should be assigned to the Math Physics Branch. Perhaps you could request them to expand on them and add others that haven't occurred to me.

Howard W. Tindall, Jr.

Enclosure

cc:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000058

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : MA3/Chief, Apollo Trajectory Support Office — DATE: OCT 27 1967
MPAD-67-T-70

FROM : FM/Deputy Chief

SUBJECT: Let's find out if the current MSFN performance is really not good enough for lunar operations.

1. On Monday, October 16, we had a briefing by the Math Physics Branch on the performance of MSFN tracking the lunar trailers. As you are undoubtedly aware, orbit determination of this vehicle, once it arrives in an Apollo type orbit, became a rather uncertain affair. They have not yet been able to determine what is causing the trouble. The result of the trouble is that the orbital elements produced for a given epoch are said to be substantially different depending on the amount of data processed in the orbit determination.

2. Steps are being taken by Jim McLaughlin to enlist the aid of the entire community in trying to resolve this problem. It appears they feel their most fruitful line of attack is improvement in the basis of the lunar potential. Anticipating that whatever is done will be entirely satisfactory or may turn out to be an explanation of gravity, effect and other traumas, we feel perhaps we can give some thought in another direction. Namely, what is the effect of the orbital element of uncertainty we are experiencing now with the MSFN on our ability to do lunar operations. For example, it is not clear to me that given significant onboard sensing and computation capability how much in terms of delta V, crew safety and whatever else you might think of is necessary. This can really only be determined by analysis or experimentation but it is for this reason that I am putting pen to paper on this occasion.

3. Specifically, I request that you initiate action [illegible] as follows:

a. MAB - Evaluate the effect of current degradation [illegible] of the MSFN orbit determination capability on lunar orbit [illegible] operations. Some parameters of interest are [illegible] V budget, resultant dispersions in the trajectory [illegible] ellipticity and [illegible] operation, increased dispersion in the maneuver to return [illegible] board the spacecraft, resultant shift in TEI and [illegible]

Enclosure

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000059

and the associated change in lighting conditions. And other parameters of that ilk which personnel of FAD themselves are in a much better position to specify.

b. RAB and/or MAR - Evaluate the effect of the degraded MSFN performance we are now experiencing in the determination of spacecraft state vectors on the targeting and execution of the Descent Orbit Insertion (DOI) maneuver. Then determine the impact of that on uncertainty in achieving the desired landing point and as well as increases in propellant usage which is likely to result from altitude dispersions encountered at initiation of descent braking.

c. RAB - Evaluate the effect of degraded MSFN performance we are now experiencing on ground targeting of the Transearth Insertion (TEI) maneuver. Probably the parameter of most interest will be the increase in delta V cost in the midcourse correction maneuver resulting from a dispersed TEI.

d. MPN and/or OPS - Evaluate the effect of degraded MSFN performance we are now experiencing on ground monitoring of the descent and ascent powered flight phases of the Lunar Landing mission for purposes of advising the crew of guidance system performance and need for switchover.

4. Perhaps you can think of some other things affected by this situation and would suggest additional studies. Also, I may have indicated the wrong launch and assume you will correct that. As for the completion dates are concerned, I don't think this is real urgent. However, perhaps some preliminary results could be made available sufficient to know if we really have a problem or not. I'm not so sure we do but there seems to be panic growing in some quarters.....Frankly, MSFN performance is turning out to be substantially better than I ever expected a couple of years ago when I was bad mouthing its use.

Howard W. Tindall, Jr.

ect
(See attached list)

00000060

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: OCT 30 1967
67-FM-T-100

FROM : FM/Deputy Chief

SUBJECT: Final word on the targeting of the externally targeted prethrust spacecraft computer programs

1. This note is to make sure that everyone who needs to know does know how we are actually implementing the general purpose prethrust (targeting) programs in the spacecraft computer program SUNDANCE, LUMINARY and COLOSSUS. I thought it would probably be worthwhile to pass the word since so many different proposals and tentative decisions have been made before, during and since the CSOF review for these programs.

2. There are two prethrust programs being provided, both of which require targeting from some source external to the spacecraft computer. One of these, P-30, is the External Delta V program which can be targeted either by crew input via the DSKY or from the ground through the uplink command program, P-27. The targeting consists of the following parameters: time-of-ignition and three components of delta V in a local horizontal spacecraft centered coordinate system.

3. The other program, P-31, may only be targeted from the ground. It is to provide the capability of inputting Lambert targets for a maneuver to be executed (steered) in that mode. There is no capability for the crew to input targeting to this program via the DSKY directly. Of course, it is possible for him to use the rather awkward procedure of going through P-27, if he chooses to do so. The target parameters consist of time-of-ignition, a position vector consisting of three quantities, in an earth or moon centered inertial coordinate system, and the duration of time which it is desired for the spacecraft to consume getting to that position. These are all double precision, octal quantities. Those responsible for MTCC program development please take note, since at one time it had been proposed that some sort of pseudo-External Delta V targeting be used for this program.

4. I would also like to emphasize that it is currently not our intention to eliminate either steering mode--External Delta V nor Lambert. As a matter of fact, it is my understanding that deletion of either one of these modes would save very few, say less than a hundred, words of storage.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

TO : PA/Manager for IM
Apollo Spacecraft Program

DATE: OCT 30 1967
67-PA-T-994

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Current status on the LM DPS engine gimbal caution light problem

1. This memorandum is to report the results of a very brief investigation into the adequacy of the LM Descent Propulsion System (DPS) engine gimbal caution light. Briefly, this light comes on if a difference between the gimbal drive signal and the gimbal response signal from the Y or Z axis trim malfunction logic is sensed. This signal is enabled only if the descent engine is armed. Once the gimbal caution light is on, the crew must determine if there is a display failure or a true gimbal failure. The basic question involved is whether or not practical procedures can be established utilizing only the existing spacecraft systems to make this decision during a lunar landing maneuver, or if some sort of modification is necessary in either the spacecraft hardware or computer program. The specific change most frequently suggested is the addition of gimbal angle position indicators on the cockpit instrument.

2. In summary, the MSC consensus is that probably crew and ground procedures can be developed and certainly insufficient justification exists right now to establish a mandatory requirement for any modification to spacecraft systems. Work is now being initiated to develop these procedures in detail.

3. The rest of this memo just fills in some background and there is no need for you to read any further except for your own amusement.

4. The Problem

For some time, a year or more, Flight Crew and Flight Control people have been concerned that the engine gimbal caution light provided a single cue for a mission abort situation. It was felt that the crew should be able to assess the situation and take proper action independently of MCC, where actual gimbal angle deflection information is available via telemetry. This assumption was made not so much to guard against communication failure as in recognition of the fact that the probable time lag between the event and receipt of MCC advice is between 10 and 15 seconds. At least one formal attempt to improve this onboard capability was made early this year during a LM-2 (manned) review at which it was requested that some means be provided for verifying descent gimbal drive electronic assembly (GDA) failure. It was noted that the present design could result in mission abort with no actual systems failure. This was turned down and G&C was given the action item of establishing some procedural substitute

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

by April 18, 1967, possibly with the help of MIT. MIT facilities were not available for this purpose and recently Ken Cox (G&C) has taken steps to obtain assistance at Grumman utilizing their hybrid simulation facility.

5. Possible Solutions Considered

On October 23 and 24, Flight Crew, Flight Control, MPAD and G&CD people reviewed the situation. In addition to defining some tentative ways of using the existing design (discussed in some detail later), possible changes to spacecraft systems were discussed which we ultimately eliminated as not presently justifiable. They included the addition of new LGC DSKY displays such as jet rate number (an indication of the extent of RCS jet activity) and/or the addition of direct readout of gimbal position in the cockpit. The latter would be provided through use of the existing gimbal angle sensing potentiometer or by a completely redundant system. There was also a question of whether new cockpit indicators would be needed or if existing indicators could be used such as the cross pointer which is already required for display of forward and lateral velocity in this phase of the mission or the FDAI needles which are also used to display attitude error and/or attitude rates.

6. Tentative Procedures with Existing Design

It is anticipated that the procedures are different depending on how far into the Descent braking phase of the mission we have gotten.

a. Early in descent, when the situation is relatively non-time critical, there are two schools of thought. One is, when the light comes on, the crew would do nothing immediately. If the engine gimbals are truly running away the turning moments would eventually exceed the capability of the RCS to maintain attitude and the spacecraft would begin to rotate. Given this "second cue," the crew would immediately switch to manual throttle control, dropping thrust to 10% which is within the capability of the RCS to maintain attitude, and would disable the gimbal drive motors. An abort would be necessary. If the gimbals are frozen or working correctly (false light indication) the mission phase would be continued. The alternate proposal is that the crew would immediately deactivate the gimbal drive motors when the light comes on and await advice from the ground as to the situation. It was felt that this might permit continuing on to the landing with either frozen or run away gimbals if sufficient RCS propellant was available to provide all necessary attitude and steering control with no further movement of the DPS engine gimbals. (Of course, this would necessitate a capability on the ground of predicting adequacy of the RCS propellant through the rest of the lunar operation.) If the ground determines that the failure was in the warning circuitry as opposed to the gimbals, they would advise re-activating them immediately.

00000063

b. During the latter stages of the Descent Braking maneuver, probably some time following high gate when the situation is time critical, the action would always be to deactivate the engine gimbal as soon as the light comes on. This is obviously necessary in order to prevent loss of spacecraft attitude control due to a runaway gimbal which could create a serious crew safety situation. Mission rules would govern whether to proceed on to landing or to abort dependent on the situation---time, position, velocity, gimbal misalignment, fuel remaining, etc. Thus, even runaway gimbals may not force an abort provided thrust is not aligned too far from the cg.

7. To complete the record, it should be noted that the LGC does receive an in-bit indicating the DPS gimbal failure at the same time the gimbal caution light is turned on, but it is currently programmed to ignore this signal and to continue sending steering commands to the DPS gimbal motors. If the crew disables the gimbal motors, a signal is also sent to the LGC which immediately stops sending commands to the DPS gimbal drive. (In fact, I might as well pass on something we learned, although it's not particularly pertinent to this matter, namely at any time the DPS is thrusting, provided the crew has not disabled the gimbal drive, the digital autopilot always attempts to keep the DPS thrust vector aligned through the spacecraft cg, even when the manual mode has been selected for attitude control.)

8. It is obvious we have not heard the end of this matter. At the least, detailed crew and ground procedures must be precisely defined. However, based on discussions we have had, I would be very surprised if the basic conclusion noted in paragraph 2 above turns out to be wrong.

Howard W. Tindall, Jr.

cc:
(See attached list)

00000064

MEMORANDUM

TO: MA/Chief, Apollo Program Support Office — DATE: OCT [illegible] 1967

FROM: FA/Deputy Chief

SUBJECT: Let's find out if the present MSFN performance is really not good enough for lunar operations.

1. On Monday, October 16, we had a briefing by the Math Physics Branch on the performance of MSFN tracking the Lunar Orbiter. As you are undoubtedly aware, orbit determination of that vehicle, once it was in an Apollo type orbit, became a rather unfortunate affair and we have not yet been able to determine what is causing the trouble. The symptom of the trouble is that the orbital elements produced for a given pass are said to be substantially different depending on the amount of data processed in the orbit determination.

2. Steps are being taken by Jim McPherson to enlist the aid of the scientific community in trying to resolve this problem. It appears that we feel their most fruitful line of attack is to carry out in the near future the lunar potential. Anticipating that [illegible] may not be entirely satisfactory or may turn out to be yet another [illegible] money, effort and other treasure, we had perhaps better [illegible] in another direction. Namely, what is the effect of the [illegible] of uncertainty we are experiencing now with the MSFN on our [illegible] lunar operations. For example, it is not clear to me that [illegible] cant onboard sensing and computation capability [illegible] delta V, crew safety and whatever else you might think [illegible] This can really only be determined by analytical [illegible] for this reason that I am putting pen to paper [illegible]

3. Specifically, I request that you initiate action [illegible] as follows:

a. FAD - Evaluate the effect of current [illegible] of the MSFN orbit determination capability on lunar [illegible] operations. Some parameters of interest are [illegible] V budget, resultant dispersions in the trajectory such [illegible] ellipticity and dispersed differential altitude [illegible] operation, increased dispersion in the [illegible] board the spacecraft, resultant shift in [illegible]

By [illegible]

00000065

and the associated change in lighting conditions. And other parameters of that ilk which personnel of RAB themselves are in a much better position to specify.

b. RAB and/or MAB - Evaluate the effect of the degraded MSFN performance we are now experiencing in the determination of spacecraft state vectors on the targeting and execution of the Descent Orbit Insertion (DOI) maneuver. Then determine the impact of that on uncertainty in obtaining the desired landing point and as well as increase in propellant usage which is likely to result from altitude dispersions encountered at initiation of descent braking.

c. MAB - Evaluate the effect of degraded MSFN performance we are now experiencing on ground targeting of the Transearth Insertion (TEI) maneuver. Probably the parameter of most interest will be the increase in delta V cost in the midcourse correction maneuvers resulting from a dispersed TEI.

d. MFB and/or GPB - Evaluate the effect of degraded MSFN performance we are now experiencing on ground monitoring of the descent and ascent powered flight phases of the lunar landing mission for purposes of advising the crew of guidance system performance and need for switchover.

4. Perhaps you can think of some other things effected by this situation and could suggest additional studies. Also, I may have indicated the wrong branch and assume you will correct that. As far as completion dates are concerned, I don't think this is real urgent. However, perhaps some preliminary results could be made available sufficient to know if we <u>really</u> have a problem or not. I'm not so sure we do but there seems to be panic growing in some quarters-----Frankly, MSFN performance is turning out to be substantially better than I ever expected a couple of years ago when I was bad mouthing its use.

Howard W. Tindall, Jr.

cc:
(See attached list)

00000066

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Divi...

TO : FB/Chief, Flight Support Division

DATE: OCT 26 1967
67-FM-T-47

FROM : FM/Deputy Chief

SUBJECT: Core rope simulator certification

As you know, Jack Williams is attempting to trace down and verify the validity of the logic which led to the decision to exclusively utilize core rope simulators for all spacecraft computer program verification. Since I anticipate we may never really reach a satisfactory conclusion to this investigation, it might be appropriate to have a document on the order of that attached signed by the appropriate representatives of the G&C Division and MIT, who should be responsible for certifying that the PAC is really okay. Perhaps representatives of other organizations such as Raytheon and AC Electronics should also be included.

Howard W. Tindall, Jr.

Enclosure

cc:
FA/C. C. Kraft, Jr.
FMT/S. P. Mann
FB5/J. E. Williams

FM:HWTindall, Jr.:pj

This would be good for 501
I should think - if you agree
you'd better hurry - ... BS

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000067

MEMORANDUM OF UNDERSTANDING

The undersigned representatives of the Guidance and Control Division of MSC and the Massachusetts Institute of Technology concur in certifying that sole use of a Program Analyzer Console (PAC), otherwise known as a core rope simulator, and Apollo spacecraft computer programs assembled on tape for input to these devices is adequate and sufficient for flight verification and validation of spacecraft computer programs in lieu of any use at all of the actual core rope memory modules to be used in flight.

This memorandum is for purposes of the Flight Readiness Review.

Ralph R. Ragan
Instrumentation Laboratory
Massachusetts Institute of Technology

Date

Robert A. Gardiner
Chief, Guidance and Control Division
MSC, NASA

Date

00000068

UNITED STATES GOVERNMENT

Memorandum

NASA - Manned Spacecraft Center
Mission Planning & Analysis Division

TO : PD12/Spacecraft 101 ASPO Mission Engineer

DATE: OCT 24 1967
87-FM-T-96

FROM : FM/Deputy Chief

SUBJECT: Immediate restart of the SPS engine under PGNCS control

1. This memo is in response to your question as to whether there was anything in the spacecraft computer that would prevent attempting to restart the SPS engine immediately if it shut down prematurely for some reason. I passed this question on to the Guidance and Performance Branch (MPAD). The following paragraphs are quoted almost verbatim from Rick Nobles' response.

2. During an SPS burn, if the delta V monitor program of the CMC detects that the accumulated velocity falls below 0.64 meters per second for at least two computer cycles (i.e., 2 to 4 seconds), it does the following:

a) terminates the Engine On command

b) maintains V_g computations

c) displays 59-59 on the DSKY (R1)

d) turns off the TVC DAP

e) turns on the RCS DAP

f) recycles to time-of-ignition minus 5 seconds (TFI=5) in the thrust program, and starts counting down

g) asks for Engine On enable which is given with an "enter"

h) commands the SPS on at TFI=0 (and no sooner!)

i) switches from RCS DAP to TVC DAP

At this point the delta V monitor checks acceleration again and if the thrust is on it will go right on through the program; if the thrust is still too low to pass the 0.64 meters per second test it recycles again as previously described.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

3. The program actually cycles back to TFI=5 in exactly the same program used for a nominal SPS burn. Accordingly, manual ullage must be provided if it is needed and the engine cannot be started earlier than stated above. This all means that the engine will be off for a minimum of 7 to 9 seconds in this guidance control mode.

Howard W. Tindall, Jr.

cc:
CF/P. Kramer
CF2/C. C. Thomas
FA/G. M. Low
K. S. Kleinknecht
FM4/A. Cohen
FM/O. E. Maynard
FA/C. C. Kraft, Jr.
S. A. Sjoberg
C. C. Critzos
R. G. Rose
FC/J. D. Hodge
E. G. Kranz
D. H. Owens
D. B. Pendley
FC2/J. W. Roach
FC3/A. D. Aldrich
FC5/C. B. Parker
J. S. Llewellyn
G. S. Lunney
C. E. Charlesworth
P. C. Shaffer
J. C. Bostick
H. D. Reed
FL/J. B. Hammack
FS/L. C. Dunneith
FS9/J. C. Stokes
T. F. Gibson, Jr.
L. A. Fry
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/J. P. Bryant
J. R. Gurley
E. D. Murrah

FM14/R. P. Parten
FM3/B. L. Wood
FM5/R. E. Ernull
FM7/S. P. Mann
R. O. Nobles
FM/Branch Chiefs

FM:HWTindall, Jr.:pj

00000070

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : FA/Director of Flight Operations

DATE: OCT 20 1967
67-FM-T-95

FROM : FM/Deputy Chief

SUBJECT: More about LM radar rendezvous data processing

1. This note is in answer to some questions you scribbled on the bottom of my LM radar observations memo (67-FM-T-81). You asked if there is any smoothing process on the LM radar data prior to its input to the spacecraft computer. My understanding is that there is not. That is, when the computer wants it, it reads the range/range rate register and the angle CDU's. In principle, this is the same as it was for Gemini, wasn't it? Of course, there is a check to confirm that there is tracker lock-on, the so-called "data good" signal from radar to computer.

2. Internal editing is considerably more complicated. First of all, a (side lobe) check is made to see that the radar angles measured are within 3^{o} of those expected by the computer based on the current state vector. If either of the angles fall outside this 3^{o} check, all of the data is rejected, however, the crew is informed of the situation and is given the opportunity to override and force acceptance of the data. Rejection or acceptance of the data involves all four pieces of information---range, range rate, and the two angles---simultaneously, that is, you cannot selectively use components of the total observation individually.

3. The next data check within the computer is based on the change in the state vectors resulting from the processing of these observations. This processing is done on each individual component of the observation-range, range rate and each of the two angles---and in each case a test is made to see if the change in either position or velocity is greater than some preset limit. If it exceeds this limit, the computer stops and presents the crew the option of overriding the computer and forcing acceptance of the new solution. He must make this decision based on rather limited information and, of course, will have nowhere near the skill of our highly specialized RTCC Data Select people with their magnificent computation and display capability. As the amount of radar data processed grows with time, the weight given new data is decreased substantially and I would be surprised if much data is rejected by this editing unless the radar goes ape.

4. As in so many other areas, it is surprising to discover how limited the analysis and justification is for the specific program formulation we have. However, when you consider the large number of different navigation processes in work I suppose we should not be surprised. An awful lot of the

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

effort lately has been spent on estimating quality and determining how to use sextant and reticle data for rendezvous navigation, how to use VHF data, how to use telescope data for earth landmark tracking--both around the earth and moon--and, of course, there is continuing MSFN orbit determination business. Each of these is a major effort and we have very few people capable of doing this work.

5. Of course, something else that increases the complexity of the LM rendezvous radar processing tremendously--and, unfortunately, in a very unresolved way right now--is the business of the rendezvous radar angle biases which apparently are an extremely complicated function of the orientation of the radar antenna off boresight. Attempts have been made to model the biases in the spacecraft computer program and estimate them in real time, along with determining state vectors. These models are almost certainly in error and actual radar performance data is very limited and of poor quality. My inclination over the past year and a half has been to eliminate this part of the processing which forces us to do a 9X9 solution as opposed to a 6X6. I'm afraid it may screw up the whole business. Unfortunately, I have not been able to prove this is a safe thing to do so far, especially from a standpoint of delta V costs.

Howard W. Tindall, Jr.

Enclosure

cc:
(See attached list)

00000072

UNITED STATES GOVERNMENT

Memorandum

Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: [illegible]
67-FM-T-81

FROM : FM/Deputy Chief

SUBJECT: About frequency of LM radar observations

1. I learned something the other day about how the LM computer uses rendezvous radar data that is different than I thought. It had been my understanding, and I think most other people's too, that rendezvous radar observations were obtained and processed by the computer every 60 seconds. In fact, there has been some concern that perhaps that is not frequent enough. Well, it turns out that the time between observations is probably more like 1½ minutes. What actually happens is the computer obtains an observation from the radar and processes it (i.e., redetermines the spacecraft state vector). This processing takes about 15 seconds. Once processing is completed, an internal timer is set in the computer to obtain the next observation one minute from that time. In some cases, it waits even longer if some other higher priority task is underway.

2. In addition to reducing the amount of radar data used during a mission, processing in this way prevents the crew from using the computer obtained radar observations in their backup computations as conveniently as they did on Gemini. On Gemini, you recall, observations were obtained and stored in computer memory exactly once per minute which allowed the crew to read them out at their convenience and be sure that they were obtained at precisely 60 second intervals - a convenient delta t to use in their backup computation.

3. This memo is just to pass on this discovery to you. It is not our current intention to change this program, although I suppose it would have been nice if we could.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000073

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS 77058

IN REPLY REFER TO: 67-PA-T-94A

OCT 19 1967

TO : North American Rockwell Corporation
Space Division
12214 Lakewood Boulevard
Downey, California 90241
Attention: M. M. Pucelik

FROM : Chief, Apollo Data Priority Coordination

SUBJECT: Descent phase to be added to your Apollo Mission Techniques Document

TRW recently completed the attached chapter to be added into the appropriate vacancy in the Apollo Mission Techniques document I sent you recently. As was the case for the other mission phases, this section on Descent was done essentially without participation by other than TRW personnel. Accordingly, I expect it will be modified substantially before it becomes a working, configuration controlled document.

I am sending it to you because I thought you might find it interesting in the meantime.

Howard W. Tindall, Jr.

Enclosure

Copy to NAA/Thomas
Robert Harmon 10/2.

00000074

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS 77058

IN REPLY REFER TO: 67-PA-T-93A

OCT 19 1967

TO : Joe Marino
Grumman Aircraft Engineering Corporation
Department 472, Plant 25
Bethpage, Long Island, New York 11714

FROM : Chief, Apollo Data Priority Coordination

SUBJECT: Descent phase to be added to your Apollo Mission Techniques Document

TRW recently completed the attached chapter to be added into the appropriate vacancy in the Apollo Mission Techniques document I sent you recently. As was the case for the other mission phases, this section on Descent was done essentially without participation by other than TRW personnel. Accordingly, I expect it will be modified substantially before it becomes a working, configuration controlled document.

I am sending it to you because I thought you might find it interesting in the meantime.

Edward G. Tindall, Jr.

Enclosure

00000075

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS 77058

IN REPLY REFER TO: 67-FA-T-928

OCT 19 1967

TO : Massachusetts Institute of Technology
Instrumentation Laboratory
75 Cambridge Parkway
Cambridge, Massachusetts. 02142
Attention: R. Ragan

FROM : Chief, Apollo Data Priority Coordination

SUBJECT: Descent phase to be added to your Apollo Mission Techniques Document

TRW recently completed the attached chapter to be added into the appropriate vacancy in the Apollo Mission Techniques document I sent you recently. As was the case for the other mission phases, this section on Descent was done essentially without participation by other than TRW personnel. Accordingly, I expect it will be modified substantially before it becomes a working, configuration controlled document.

I am sending it to you because I thought you might find it interesting in the meantime.

Howard W. Tindall, Jr.

Enclosure

00000076

UNITED STATES GOVERNMENT

Memorandum

TO : Systems Engineering Division
Attention: FD3/R. V. Battey

DATE: OCT 1 0 1967
67-FM-T-90A

FROM : FA/Chief, Apollo Data Priority Coordination

SUBJECT: Descent phase to be added to your Apollo Mission Techniques document

1. TRW recently completed the attached chapter to be added into the appropriate vacancy in the Apollo Mission Techniques document I sent you recently. As was the case for the other mission phases, this section on Descent was done essentially without participation by other than TRW personnel. Accordingly, I expect it will be modified substantially before it becomes a working, configuration controlled document.

2. I am sending it to you because I thought you might find it interesting in the meantime.

Howard W. Tindall, Jr.

Enclosure

FA:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

NASA - Manned Spacecraft Center
Mission Planning & Analysis Division

TO: FA/Director of Flight Operations

DATE: OCT 19 1967
87-FM4-E-89

FROM: FM/Deputy Chief

SUBJECT: K-start tape briefing

1. George Low had his monthly briefing by G&C yesterday, October 16, a part of which I attended. One subject reviewed for him was the development of K-start tapes for the spacecraft computers. They especially addressed the definition, scheduling, checking and actual manufacture of the K-start tapes required for guidance system testing at AC (for acceptance), North American and Grumman. Emphasis was on these K-start tapes since it is these the Guidance & Control Division is responsible for.

2. I should think he, and you too for that matter, might be interested in the same subject for the K-start tapes used to initialize computer memory for the mission itself. Here the prime responsibility is within FOD. In addition to the considerations noted above, such a briefing should include procedures for making changes within the last few days prior to launch.

Howard W. Tindall, Jr.

cc:
FM/J. P. Mayer
FM/S. P. Mann
FS/L. C. Dunseith

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000078

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: OCT 19 1967
67-PA-T-88A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: First meeting of the Descent Phase Mission Techniques Working Group

1. This memo is to request your participation in the detailed development of the Apollo Mission Techniques for the Descent phase of the lunar landing mission. We are setting up a small working group of the following composition to do this job:

MPAD	Floyd Bennett, Chairman
Flight Crew	Pete Conrad
FCSD	Paul Kramer
FCD	Phil Shaffer
FSD	Tom Gibson
G&C	Myron Kayton, Ed Smith
TRW	Bob Kidd
ASPO	Bill Tindall

2. The first meeting will be held on October 31, 1967, in my office (Building 30, Room 3068) at 9:00 a.m. The purpose of this meeting will be to review and propose modifications as necessary to the attached document prepared by TRW. It is anticipated that after several such meetings the overall operational logic will have been established and documented in sufficient detail and accuracy to permit wider distribution and comment. Right now, though, it seems desirable to keep the size of this working group as small as possible. However, if you want to bring additional people from your organization, feel free to do so.

Howard W. Tindall, Jr.

Enclosure

Addressees:
CB/P. Conrad
CF24/P. Kramer
EG/M. Kayton
E. Smith
FC/P. Shaffer
C. Parker
FM6/F. Bennett
FM7/M. Cassetti
FS5/T. Gibson
PA/G. M. Low (Info)
TRW/B. Kidd

PA:HWTindall, Jr.:pl

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000079

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: OCT 19 1967
67-PA-T-87A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: First meeting of the Ascent Phase Mission Techniques Working Group

1. This memo is in confirmation of our telephone conversation requesting your participation in a continuing working group to discuss the Ascent phase of the lunar landing mission. The overall composition of this Ascent Phase Mission Techniques Working Group is as follows:

FCD	Charlie Parker, Chairman
Flight Crew	Pete Conrad
FCSD	Paul Kramer
MPAD	Marlowe Cassetti
TRW	Dick Boudreau
ASPO	Bill Tindall

2. The first meeting is scheduled for Friday, October 27, 1967, in my office (Building 30, Room 3068) at 9:00 a.m. It's purpose is to go through the operational flow diagrams and associated analyses covered in the Ascent section of the TRW Apollo Mission Techniques document I sent you in September, and start the cyclic modification process needed to get it "right."

3. It is desirable, I think, to keep this working group as small as possible, however, if you feel it desirable to bring additional people from your organization, be my guest. Ultimately, once this document has been thoroughly reworked and substantial agreement has been obtained among the working group members on its content, it will be republished for final review with much wider participation.

Howard W. Tindall, Jr.

Addressees:
CB/P. Conrad
CF24/P. Kramer
FC/C. Parker
FM7/M. Cassetti
PA/G. Low (Info)
TRW/D. Boudreau

PA:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

NASA HISTORY OFFICE: REQUEST FOR INFORMATION

Source: _____ Inside NASA? Yes:___ No:___

Information Requested: _____

_____

Date of Request: _____ Date Filled: _____

Use of Information: _____

Time Spent on Filling Request: _____

Request Filled By: _____

UNITED STATES GOVERNMENT

Memorandum

NASA-[illegible] Spacecraft Center
[illegible] Analysis Division

TO : See list below

DATE: OCT 18 1967
67-FM-T-86

FROM : FM/Deputy Chief

SUBJECT: Some things about the Descent Propulsion System as controlled by the LOC

1. I guess I would have realized this if I had thought about it, but it was a surprise to me (and others) to learn that the Descent Propulsion System (DPS) engine in the LM is not aligned through the cg prior to ignition. I suppose I had assumed that it would be handled the same way as the SPS engine on the command module, but it is not for several reasons.

2. For one thing, it is possible for the cg to move substantially between one maneuver and the next since propellant transfer from one tank to another is not inhibited or controlled. Therefore, cg location is really not known prior to ignition. In addition, actual engine alignment is not known prior to ignition since there is no measurement and feedback of gimbal position. As I understand it, the way the DPS is aligned prior to the maneuver is as follows. The engine is moved to its maximum possible deflection with the drive motors running against the stops until it has surely gotten there. It is then driven back the length of time necessary to align it with the spacecraft X-axis based on an assumed engine drive rate. Of course, it is almost certain that thrust vector alignment obtained in this manner will not pass through the cg and will result in attitude disturbance torques. However, since the DPS is started at only 10% thrust, it is well within the capability of the RCS jets to hold attitude until the DPS has been realigned by the DAP through the cg.

3. Another thing I have learned about the DPS is that maneuvers which are shorter than 10 seconds never have closed loop steering other than attitude hold control. (This is equivalent to the 7 or 8 second SPS burn duration without steering.) Of course, there is no minimum impulse DPS programmed in the LGC but there is nothing in the spacecraft computer program to prevent calling for an extremely short burn. However, the shortest that could be achieved is in the order of 2 second duration at 10% thrust. This duration would occur even if a shorter burn, say ½ second duration, were requested.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000082

UNITED STATES GOVERNMENT

Memorandum

Mission Planning & Analysis Division

TO : See list below

DATE: OCT 19 1967

67-FM-T-85

FROM : FM/Deputy Chief

SUBJECT: Spacecraft computer program development improvements to be utilized by MIT

1. Just for the record, I would like to record a list of program development improvement ideas which MIT plans to incorporate. [illegible] list was gleaned from discussions by Ed Copps, Fred [illegible] and Alex Kosmala during the week of October 2, 1967.

a) Much more complete program structure [illegible] prior to program integration. This inclu[illegible] of the program module interfaces. And [illegible] like all[illegible] of computer memory.

[illegible] Control of program comments will [illegible] accuracy and to avoid duplication [illegible]

[illegible] In order to avoid the problem of [illegible] conflict[illegible] [illegible] established [illegible] the [illegible]

[illegible] proposes to [illegible] a series of [illegible] program [illegible] reviews.

e) Approved program [illegible] will be considered [illegible] they arrive from MSC but will [illegible] the flight [illegible] in blocks periodically as opposed to randomly as in the past.

f) Much tighter assembly control will be [illegible] all program modifications being monitored and reviewed by a higher level of MIT management. Only those [illegible] really necessary will be permitted. New assemblies will only [illegible] produced once a week as opposed to the much higher [illegible] otherwise.

g) Associated with [illegible] control, specific procedures will be "sealed" internally in [illegible] they [illegible] operational as opposed to the current practice of putting the entire program under configuration control when all components are working.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

i) It is my understanding that at present digital autopilots (DAP) are available for both the LM and command module. On the other hand, design improvements will probably be necessary on a fairly continuous basis. All modifications in the DAP's will be made and checked out in some program other than the current flight program assembly used by the rest of the program development personnel. Modified DAP's will only be added to this working assembly when they are running properly.

j) Much more coordination and communication between the various groups involved in software development is essential. It is Martin's intention to establish standing committees with periodic meetings for this purpose. These meetings will also be used for consideration and coordination of proposed changes.

j) Apparently, in the past development of program test plans has been carried out by a small group without much assistance, advice or coordination with other interested parties. Wider participation in this effort both at MIT and MSC is planned.

k) MIT has finally decided to utilize discrepancy reporting like we have requested for well over a year and which has recently proven to be of great value to them in the latter stages of the SUNDISK development. They intend to utilize this from the beginning on the remaining programs.

l) Associated with the discrepancy reporting, MIT will maintain an up-to-date operational constraint list. Obviously, one way in which discrepancies may be eliminated is by establishing work around procedures or operational constraints on program usage.

m) Steps are being taken to make sure that as problems are found and corrected in one major program these same flaws are corrected in the other programs (e.g., SUNDANCE and COLOSSUS).

n) Slow response in the exchange of data, particularly spacecraft characteristics, has delayed MIT previously. Steps are being taken at both MIT and MSC to provide faster response. When necessary, in lieu of answers from MSC, MIT proposes to state their assumptions and proceed ahead with program development to avoid delays of this type.

2. As you can see, nothing particularly startling here but I believe everyone would agree these are all good things to do, that is, they should improve the quality of the program itself and should certainly result in getting the job done faster. MIT has recently reorganized their personnel somewhat, hopefully in a way that will allow them to implement these ideas effectively.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

00000084

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: OCT 18 1968

FROM : PM/Deputy Chief

SUBJECT: There will be no manual input of range data capability in spacecraft rendezvous navigation

1. During the week of October 7 a group of MSC and MIT people completely defined the lunar landing command module and LM programs in "COLOSSUS Chapter 4" format including all the crew required rendezvous program modifications and MSCP review open items. This note is to inform you of one of the basic decisions reached during that effort, namely that the capability of manual input of range and/or range rate information will not be provided in either the command module or LM computer programs. Of course, LM radar data is automatically collected and processed in the LGC and data from the new VHF ranging device being added in the CSM will be automatically obtained and processed by the CMC. This decision certainly seemed logical to me based on the following rationale.

2. The command module only computes rendezvous maneuvers starting with TPI and has both a sextant and VHF ranging--two independent sensing devices--to utilize in these computations. It was not felt that backing this up by use of manual input of range and range rate information obtained by voice from the LM would be particularly valuable especially since the LM can utilize that data in its own computer and transmit all of the maneuvers including CSI and CDH that the command module must execute.

3. In the LM this mode was felt to be unnecessary since that vehicle is equipped with a complete backup system, the AGS, into which manual range data can be input. But probably the strongest argument against the need of manual input of range and range rate in the LM computer is that if the primary guidance system is working reasonably well the state vectors at LM insertion should be good enough even without radar data to permit targeting both the CSI and CDH maneuvers. Of course, conditions following CDH would not be ideal. That is, more than likely the orbits would not be precisely coelliptic and the TPI time would probably have shifted beyond the usual tolerances. However, a precise TPI maneuver based on updated rendezvous navigation will be available from both the AGS and from the command module based on sextant and VHF ranging. In addition to these, there are the backup techniques which utilize whatever useful observational data is available. And, of course, MSFN will provide assistance.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000085

4. Elimination of these rendezvous navigation modes substantially simplifies the spacecraft computer programs--as well as crew procedures and training, I suspect--and does not appear to significantly reduce overall onboard capability.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

00000086

UNITED STATES GOVERNMENT

Memorandum

NASA

TO : See list below

DATE: OCT 17
67-FN-T-83

FROM : FM/Deputy Chief

SUBJECT: Spacecraft computer program status

1. Here's another of my irregular updates on what's going on in the business of spacecraft computer program development.

2. SUNDISK, the earth orbital command module program, is essentially complete and, for all practical purposes, could be sent to Raytheon for rope manufacture whenever anyone wants to give the word. From all I have been able to determine, the quality of this program is very good and, perhaps, to balance some of the criticism of MIT, they should be commended for this. It provides the capability of doing all the things we specified over a year ago with numerous improvements added in along the way. (I am certain, however, changes will be made in it before flight for the same sort of reasons we have remade SUNBURST ropes twice.)

3. It is now evident that the lunar landing programs - COLOSSUS and LUMINARY - will not be completed for quite a long time---certainly not for LM-3 and command module 103 as we had planned. This has forced us into the position of having to use SUNDISK on Command Module 103 and has made it necessary to develop an interim earth orbital program (SUNDANCE) for use on LM-3 and LM-4.

4. At this time we are in the process of determining an accurate program development schedule for these three programs at MIT as well as trying to identify the major problem areas in order to attack them on at least two fronts, namely, implement improvements in the way the work is done and change the MIT organization to be compatible with them. I don't want to minimize the seriousness of this situation. We are in deep, serious yogurt!

5. One accomplishment of significance I would like to report is that we have recognized one way of substantially improving program delivery by making sure MIT has a precise, approved specification of the spacecraft computer programs required by MSC right now. Our recent SUNDANCE and COLOSSUS CSOP review and associated technical direction to MIT accomplished this to

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000087

a large degree. However, there was one large area lacking definition and MSC approval, namely the change in the structure of the rendezvous programs which Flight Crew felt to be mandatory to substantially improve their operational procedures. In order to complete this program definition phase as quickly as possible, a team of MSC and MIT people spent the week of October 2 at MIT formulating and documenting all unresolved items in CSOP Chapter 4 format. I think this was accomplished very well in terms of both quality and speed resulting in a rough draft of the CSOP with MSC approval upon which MIT may prepare the final CSOP and actually begin program design and coding immediately.

6. Thus, all three programs, SUNDANCE, LUMINARY, and COLOSSUS are now, in effect, covered by approved CSOP's and are under configuration control. That is, any changes must be handled through the standard change control procedures.

7. Unfortunately, it is highly probable that a similar exercise will eventually be necessary involving the Descent and possibly the Ascent portions of LUMINARY program once experience is obtained in their operation on the simulators at MIT and MSC. Mandatory changes to simplify crew procedures are likely to arise and the importance of crew evaluation of these processors at the earliest time can not be over emphasized. What ever can be done by the Flight Crew Operations Directorate to provide a meaningful evaluation facility and to utilize it for this purpose should be done for everybody's benefit.

Howard W. Tindall, Jr.

Addressees:
(see attached list)

UNITED STATES GOVERNMENT

Memorandum

TO: See list below

FROM: DD/Deputy Ch

SUBJECT: A ... aviation
exe

1. ...
a ...
It ...
sim...
time ...
... ,
essential
such as ...
etc.

2. I am ...
was rather ...
tion here ...
ment in ...

Enclosure

...
CF ...

...

...

FM ...

ATT/IL/...
...

FM/INT ... Jr

...support Division OCT 6 1967

...Software and Onboard Systems Memorandum 783

Proposed change to AOH/Vol II Operational Procedure (Change ... CR24-30)

References: (1) Memorandum CF221-78-3... from CF22/Chief, Spacecraft Systems Branch, "AOH/Vol II Proposed Spacecraft Operational ... Change number CR4-30," Sept. 27, 1967 and (2) MSC IN 66-FM-... "Study of Lunar Orbit Navigation and Landing Accuracy," November 16, ...

Reference 1) proposes that the ... shaft axis be aligned 10° ... of local vertical rather than the 0° position currently used in ... This division does not concur with the proposed change and also disagrees with the current S/C 101 landmark tracking procedure for the following reasons:

a. The apparent rate of motion across the optics field of view of a landmark 40° ahead of local vertical is only about half that ... apparent rate of a landmark located at local vertical. Thus, to ... crew tracking task, the landmark should be acquired as early as possible. Repositioning the shaft axis to 10° ahead of local vertical will ... the crew to acquire and track landmarks at a time when the apparent rate of motion is beginning to increase at a rapid rate.

b. The current S/C 101 procedure of tracking landmarks ... with the shaft axis local vertical mode is not the technique this division ... for lunar landmark tracking (ref 2). First, the optics field of view is partially occluded by the LM which decreases available tracking ... Second, the pitching technique is expensive in fuel in that the crew ... into must be set up about an axis having a high moment of inertia. Furthermore, because of the low pitch axis control power, the ... acquire a landmark that has passed through the optics field of view ... consuming process in addition to being costly in fuel usage.

... of the above reasons, this division recommends:

a. That operational ... proposed ... be implemented in S/C 101.

b. That pitch local vertical landmark tracking for S/C ... be ... roll-yaw local vertical operational procedure ... by this division and discussed in reference 2.

00000090

[illegible] at the start of [illegible] the roll [illegible] the crew to set up initial rates about the roll [illegible] yaw [illegible] mately [illegible] in roll and 2° [illegible] in yaw for [illegible] orbit. [illegible] the sighting and marking procedure is identical to the proce[illegible] the pitch local vertical mode. The initial alignment for [illegible] should be such that at the midpoint of the pass the spacecr[illegible] is normal to the orbital plane with the +X axis pitched dow[illegible] with respect to the local horizontal and the +Y axis in the orbit[illegible] rolled downward 20° with respect to the local horizontal pla[illegible] the IMU should be aligned out-of-plane to minimize the possibility o[illegible] look. With this alignment, the optics line-of-sight will [illegible] vertical by 20° throughout the pass (with correct initial r[illegible] tracking 60° ahead of and 20° behind local vertical. This [illegible] provide for early acquisition and also allow sighting and marking wh[illegible] apparent rate of motion of the landmark through the optic fi[illegible] view is at a relatively low value.

Original signed by
ROBERT A. GARDNER
Robert A. Gardner

CC:
EG2/D. C. Cheatham
EG26/P. E. Ebersole
EG43/M. Kayton
EG44/C. J. LeBlanc
CF22/R. A. Moses
FM/H. W. Tindall
PM/O. E. Maynard
PA/R. C. Rose

EG27:CTHackler:amp 9-27-67

[illegible]	EG/[illegible]	EG44/CJL	EG43/MK	EG2/[illegible]
		[illegible]	[illegible]	[illegible]
		[illegible]	4-28 [illegible]	

UNITED STATES GOVERNMENT

Memorandum

Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: OCT 1967
67-FM-T-81

FROM : FM/Deputy Chief

SUBJECT: About frequency of LM radar observations

1. I learned something the other day about how the LM computer uses rendezvous radar data that is different than I thought. It had been my understanding, and I think most other people's too, that rendezvous radar observations were obtained and processed by the computer every 60 seconds. In fact, there has been some concern that perhaps that is not frequent enough. Well, it turns out that the time between observations is probably more like 1¼ minutes. What actually happens is the computer obtains an observation from the radar and processes it (i.e., redetermines the spacecraft state vector). This processing takes about 15 seconds. Once processing is completed, an internal timer is set in the computer to obtain the next observation one minute from that time. In some cases, it waits even longer if some other higher priority task is underway.

2. In addition to reducing the amount of radar data used during a mission, processing in this way prevents the crew from using the computer obtained radar observations in their backup computations as conveniently as they did on Gemini. On Gemini, you recall, observations were obtained and stored in computer memory exactly once per minute which allowed the crew to read them out at their convenience and be sure that they were obtained at precisely 60 second intervals - a convenient delta t to use in their backup computation.

3. This memo is just to pass on this discovery to you. It is not our current intention to change this program, although I suppose it would have been nice if we could.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Bill
Is there any smoothing process or do you use the 3 pieces of data available at that instant? What is reasonable test? etc. Sounds lousy to me.

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: OCT 11 1967
67-FM-T-80

FROM : FM/Deputy Chief

SUBJECT: It's SUNDISK for Spacecraft 103

1. This memo is to make absolutely sure you are aware of the horrible decision we had to make, namely that we must use the SUNDISK spacecraft computer program for Command Module 103 as well as 101. Of course, I am bringing this to your special attention since it has obvious influence on how the Apollo Operations Handbook is developed by NAA.

2. It is our earnest desire that COLOSSUS be ready for the Spacecraft 104 flight and MIT has been so directed, but I should point out at this time we have no firm program development plan from MIT yet showing how they will accomplish this consistent with current spacecraft delivery and flight dates.

3. I can't tell you how sorry I

Howard W. Tindall, Jr.

Addressees:
CF/J. Bilodeau
M. E. Dement
PM6/C. R. Haines
J. P. Loftus

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

TH/D

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: SEP 11 1967
67-PA-T-79A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Data Priority Coordination - a plea for help

1. Over the past year considerable thought has been given to how to coordinate mission planning and procedures development involving use of the various guidance and control systems for the lunar landing mission. Initially, a four man panel (Cohen, Jenkins, Smith and Kramer) worked for a month or so and assembled a pretty good preliminary set of logic flow charts describing spacecraft and ground activity starting in the nominal mission with the LM on the lunar surface and ending with rendezvous. This work, you recall, ended with a recommendation to implement the orbit rate ball in the spacecraft and the panel was disbanded. Subsequently, a task was assigned TRW-Houston to carry on this work for the entire lunar landing mission, first under the direction of Dr. Shea and then Dick Carley. In my new assignment as Chief, Apollo Data Priority Coordination, I have inherited this imposing task. This memorandum is to request your assistance in two respects. The first is to solicit your opinion on a proposed approach to the overall coordination problem. The second is to request your review of the format and technical content of the attached Apollo Mission Techniques Document prepared by TRW, which, if proper, I would expect will become a prime component of whatever we do.

2. It has been proposed that the techniques to be used on Apollo missions should be thoroughly documented and maintained under configuration control. Among other things the intent is to make sure everyone working on Apollo who has interest in this business would know exactly what the officially approved scheme is for all phases of the mission under both nominal and degraded conditions in order that they can insure compatibility of the work they are doing. Of course, a process would have to be established for modifying these schemes as discrepancies or undesirable characteristics are uncovered. That is, some sort of change control is needed here as it is in so many other areas. Considerable work has progressed under Dick Carley's guidance to get this method of operation underway. For example, he fostered the attached TRW working paper which covers two of the major mission phases--Ascent and Rendezvous. It is their attempt at developing logic flow diagrams

Bill T. a good memo,
pls let me know if you
need any help GML 9-27

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

describing the normal G&C functions, identifying decision points in the mission, and establishing the procedures for monitoring the G&C systems required to assess systems performance and govern subsequent action. As far as I can determine, this document reflects the work of a few TRW people with some limited input informally obtained from individuals within MSC.

3. It is evident that in order to have a truly useful working document, close coordination and cooperation of all MSC elements and our contractors is required. What I would like to do, after allowing sufficient time for those of you interested in this work to review the attached material, is to have a meeting to discuss the manner in which we will carry out the coordination of this activity. Assuming documentation of the type attached is a necessary part of this activity, as I believe it probably is, we will also review the format and technical content of at least one of the mission phases documented here. Our primary purpose would be to make sure it does the job it needs to do in the best way. Right now I think it would be reasonable to aim for a meeting on the Ascent phase in late September for that dual purpose.

4. Based on the results of that meeting, I would propose to initiate a series of meetings early in the development of the documentation such as this for the rest of the mission phases during which the opinions and inputs of everyone concerned may be discussed and included from the beginning instead of after the work is carried as far as in the attached. The other mission phases are currently broken out as follows: (a) Earth Launch - beginning early in the countdown and ending after TLI, (b) Trajectory Maneuvers including MCC, LOI, TEI, (c) Lunar Descent, and (d) Reentry. As you can see this all applies directly to the lunar landing mission, but obviously it will also have considerable bearing on how we fly the earlier development flights.

I'll be in touch with you again.

Howard W. Tindall, Jr.

Enclosure

Addressees:
(See attached list)

00000095

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : FM6/Chief, Rendezvous Analysis Branch

DATE: SEP 11 1967
67-FM-T-78

FROM : FM/Deputy Chief

SUBJECT: Mission rule for TPI - ground or onboard

This is just a reminder of an action item you picked up at our August 31 panel meeting. As you recall, it is necessary that we establish the magnitude of the difference between the ground computed and onboard computed TPI maneuver which is used by the crew to decide which solution should be used. I suppose it will be based on the same sort of thing we used for Gemini. Please let me know what work is required to figure this out and how long you expect to take doing it. Also, could MAC be of assistance, I wonder?

Howard W. Tindall, Jr.

cc:
CF/P. Kramer
FA/C. C. Kraft, Jr.
FC5/C. Parker
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM3/J. P. Bryant
FM4/R. P. Parten
FM/Branch Chiefs

FM:HWTindall, Jr.:pj

Save U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

TO : FM4/Chief, Mathematical Physics Branch

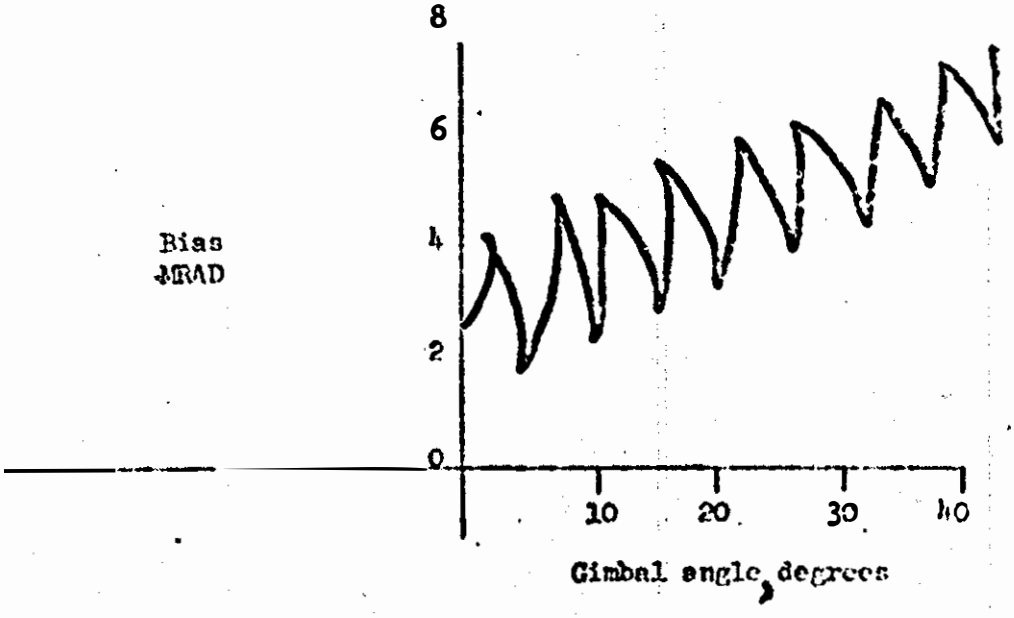
DATE: SEP 7 1967
67-FM-T-77

FROM : FM/Deputy Chief

SUBJECT: How do we get and use LM rendezvous radar observations?

1. There is a lot of concern at the present time regarding the manner in which the LM rendezvous radar data is to be processed onboard the spacecraft. I feel that you should devote as much attention to this as you possibly can since it influences both the formulation of the spacecraft computer program and, to a large extent, crew procedures. Of course, there are the usual problems associated with any system which must edit and weigh data automatically. All sorts of situations may be imagined in which such a system would fail, of course, and so our first impulse is to somehow get the man into the loop. When you consider how this is done in the RTCC with a great battery of specialists and multiple displays specifically designed for this purpose and compare that with the spacecraft's relatively untrained pilot with almost nothing to look at to assist his decision, the situation appears quite critical.

2. On top of this, the consequences of failure are probably much more serious. Myron Kayton showed me some test data of radar biases versus radar gimbal angle deflection from boresight. It looked something like this:



Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000097

3. According to several of the astronauts, attitude control of the LM ascent stage, particularly with empty tanks, is extremely sensitive. (Something like 5 times more reaction to a minimum impulse thruster firing than the Gemini spacecraft.) And unless we are willing to expend tremendous amounts of our RCS fuel, it is probable that relatively large attitude excursions must be permitted during the collection of rendezvous radar data. This consideration coupled with a so-called bias radar characteristics illustrated above suggests to me that the error on the data will most likely appear as random noise. If so, perhaps the proper way of handling that would be to take far more observations than one per minute and include only a constant bias term in the radar model determined preflight. This would permit us to drop the real time "improvement" of the radar bias terms in the onboard orbit determination process making it much less sophisticated---and more likely to work!

4. I suggest you get together with Kayton, if you have not already, and lay out a program of analyses to be carried out in parallel, complimentary to and independent of the MIT work. This work should be designed to ultimately select the best mathematical formulation of the onboard computer programs, the data rate, the computer program controls required by the crew, and the procedures they must follow with regard to spacecraft attitude control during procurement of observations, and manual data editing and display requirements, if any are required.

5. As usual, this must all be done as quickly as possible since program development and procedures are moving ahead. On the other hand, I am sure flight experience and analysis are going to force modifications in this program before we go to the moon and you should not sacrifice quality for speed.

Howard W. Tindall, Jr.

cc:
(See attached list)

00000098

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: SEP 7 1967
67-PA-T-76A

FROM : PA/Chief, Apollo Data Priority Coordination

SUBJECT: Another meeting about trajectory control on the first manned Apollo mission (S/C 101)

1. As you may have heard, we had the first of the Trajectory Control Data Priority Panel meetings last Thursday, August 31. My original intent was to go through the four major exercises on the Spacecraft 101 mission involving the Guidance & Propulsion Systems at that meeting but time did not permit discussion of more than the SPS maneuvers and rendezvous. As a result, I have set up a followup meeting on Thursday, September 14, in Room 660, Building 2, at 9:00 a.m. to finish that. The two mission exercises I expect we will spend most time on are: (a) retrofire and reentry and (b) earth landmark tracking and navigation. In addition, if the guidance systems performance data is available as requested last time, we will also go over that to evaluate its impact on selection of guidance modes and monitoring procedures for the SPS maneuvers.

2. I hope your organization can participate in this discussion, which I look upon as being for information exchange more than for decision making. Hopefully, we will all get a thorough understanding of how these various things are to be done and how the systems are to be utilized.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

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: SEP 6 1967
67-FM-T-75

FROM : FM/Deputy Chief

SUBJECT: LM spacecraft assignments

This is just to make sure you all get the word in case it influences your work in some way. As I understand it, Mr. Low has directed that LM-2 be configured for unmanned flight only. It has been established that the first manned LM will be the LM-3 spacecraft. If it's found unnecessary to fly a second unmanned vehicle, LM-2 will be reworked to be flown much later, perhaps on an AAP mission. One thing we must determine is whether another set of BURST ropes should be manufactured for the LM-2 spacecraft at this time, and if any modifications should be made in them.

Howard W. Tindall, Jr.

Addressees:
FS/L. C. Dunseith
FS5/J. C. Stokes
T. F. Gibson, Jr.
R. O. Nobles
L. A. Fry
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM3/J. P. Bryant
J. R. Gurley
G. L. Hunt
FM4/R. P. Parten
FM3/B. D. Weber
FM5/R. E. Ernull
FM7/S. F. Mann
FM/Branch Chiefs

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

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: AUG 29 1967
67-FM-T-74

FROM : FM/Deputy Chief

SUBJECT: Maneuver sensitivity coefficients

1. It's been almost a year since I went out a note on this subject, and since it keeps coming up I thought it might not hurt to remind you of the following sensitivity coefficients:

Maneuvers	Earth	Moon
Horizontal	.56 nm/fps	.72 nm/fps
Radial (Vertical)	.14 nm/fps	.18 nm/fps

These numbers describe the change in altitude (in nautical miles) as a result of making a horizontal or radial manguver (in feet per second). The change in altitude, of course, occurs 180° of orbital travel after a horizontal maneuver, and 90° after a radial maneuver. Incidentally, it is no coincidence that the values for the radial maneuver are exactly ¼ those for the horizontal. This is a true, mathematically defined relationship. I point that out because it might be easier to just remember values for horizontal maneuvers and the factor of 4 to get the others.

2. Aside from mission planning considerations such as football rendezvous, etc., the radial maneuver sensitivity is of interest from another standpoint. Specifically, now that we have guidance systems with rather poor pointing accuracy under certain conditions we are likely to pick up an unwanted velocity increment in an up or down direction, which change the orbit - perhaps dangerously, certainly undesirably. These coefficients will allow you to estimate the effect of these dispersions on the trajectory.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: AUG 29 1967
67-FM-T-73

FROM : FM/Deputy Chief

SUBJECT: Apparently, S/C 103 may fly one month after S/C 101

1. At his staff meeting on Monday, George Low made a strong point about uncoupling Spacecraft 101 and Spacecraft 103. Apparently, he feels it is likely that 103 will be launched on a Saturn 5 which implies no pad readiness schedule implications. The LM-2 will be available at the Cape early and, apparently, Spacecraft 103 is trailing 101 by about one month. He feels that, although the absolute schedules themselves may be mushy, the relative schedule between 101 and 103 will probably be maintained.

2. The point of all this is that there is no obvious reason for a delay of 3 months, or even 2 months, between the launch dates of those two spacecraft. In fact, he would like to see us retain the capability of flying one month apart. Apparently, crew training will not preclude this and I guess there is some sort of exercise going on in FOD to see if we can handle it. This note is to make sure you are aware of the situation so you won't get caught assuming a period of 3 months is necessary between the two missions. I must say this had not been clear to me before.

Howard W. Tindall, Jr.

Addressees:
FS5/T. F. Gibson
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/J. P. Bryant
FM14/R. P. Parten
FM/Branch Chiefs

FM:HWTindall, Jr:ipj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: AUG 29 1967
67-FM-T-72

FROM : FM/Deputy Chief

SUBJECT: Inflight loading of the spacecraft computer erasable memory

1. On August 25 we had a little meeting of Flight Control and Flight Software people to discuss adding a program in the RTCC to reload the spacecraft computer erasable memory in flight. This might be necessary to do when the LM computer is powered up for the first time in each manned flight or in the event of a fresh start occurring in either the LM or command module program anytime in flight.

2. Flight Control Division has provided the capability of checking the memory of the spacecraft computer against stored values to inform the flight controllers if any of the critical erasable parameters are in error. This is pretty much a manual operation using a 1218 computer in Building 12, or some place like that, involving hand carrying the data from one place to another and manually scanning an on-line printout. A response time of between 30 and 45 minutes has been quoted from the request to initiate the check until receipt of the data.

3. Having determined that reloading the erasable is required, the subsequent task becomes quite formidable at present. It is necessary for the computer controllers to type out the uplink command message word by word which takes quite a bit of time and has high risk of being in error. We concluded that an automatic RTCC program to do this job could be added fairly easily which would speed up the process a great deal while providing high confidence that the message would be formulated correctly. (It should be emphasized that neither the checking nor updating of the memory, even using an automatic RTCC program, is a fast response procedure.)

4. All together only a small part of the 2048 words of erasable memory is involved in this process - certainly less than 200 words and probably no more than about 100. Charley Parker (FCD) intends to identify the actual parameters in the near future and include this list in a request for development of the new computer program to the FSD. He will also specify that it must be possible to modify these critical parameters stored in the RTCC program since many of them change as the flight progresses (i.e., accelerometer biases, spacecraft inertias and weights, etc.). Since the S/C 101 flight does not even need a computer to perform

It takes 3 min/load when it's already on uplink list
Assuming 120 words ... there will be 100 loads ± 20
or 5 ± 1 hrs of 60 minutes

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

the mission or support crew safety, we certainly could not justify making this program a requirement for that mission. However, the second command module flight includes rendezvous where crew risk is involved as well as a powered LM in each, so this will be needed on that mission. In order to reduce the number of command loads as much as possible, Tommy Thorton will request MIT to locate the critical parameters sequentially in erasable memory as often as possible in order that the Verb 71 uplink command format can be used to the maximum extent. This format, you recall, makes it necessary to only identify the address of the first word and permits loading twice as many registers per command message.

5. Did I just hear the MCCC camel groan?

Edward W. Tindall, Jr.

Addressees:
(See attached list)

00000104

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : FM4/Chief, Mathematical Physics Branch

DATE: AUG 28 1967
67-FM-T-71

FROM : FM/Deputy Chief

SUBJECT: Analysis of LM rendezvous navigation is needed

This memorandum is just a reminder for a couple of action items I discussed with you coming from the lunar landing GSOP review August 17. I think it is very important that you really get on with analyzing the performance of the rendezvous navigation in the LM using the radar. Two items you should specifically address are the manner in which the radar biases are handled and the frequency at which the computer should request observations from the radar. Regarding the former, I am very much concerned that there might be situations in which this sophisticated radar bias estimation somehow fouls up the entire navigation process. With regard to the frequency of the observations, I expect we will ask MIT to change the rate from one per minutes to one every six to ten seconds, or something like that, on August 28 & 29. Of course, that is just a guess and we will all be interested in getting your final opinion after you look the whole business over.

Howard W. Tindall, Jr.

cc:
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM3/J. P. Bryant
FM4/R. P. Parten
FM/Branch Chiefs
FB5/T. F. Gibson

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

NASA - Manned Spacecraft Center
Mission Planning & Analysis Division

TO : FM6/Chief, Rendezvous Analysis Branch

DATE: AUG 28 1967
67-FM-T-70

FROM : FM/Deputy Chief

SUBJECT: Does the landing radar mess us up?

This memorandum is to request that you look further into the business of how the use of landing radar observations in the spacecraft computer during descent influences the onboard determination of the final landing point. Hopefully, the landing point is essentially fixed prior to processing of the landing radar data but that may not be the case. It might really foul it up quite a bit. Our problem, of course, is to select the best LM position for use in subsequent real time rendezvous mission planning, that is, lift-off time and plane change required.

Howard W. Tindall, Jr.

cc:
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/J. P. Bryant
FM14/R. P. Parten
FM/Branch Chiefs
FS5/T. F. Gibson

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : EG/Chief, Guidance and Control Division

DATE: AUG 23 1967
67-FM-T-69

FROM : FM/Deputy Chief

SUBJECT: Head up and locked DAP-wise

1. Bob, it looks like I've had my head up and locked for the last year or so along with a few of my cronies over here, because we sure did misunderstand the division of responsibilities. And I am sorry about that because I am sure it must have contributed substantially to our problems.

2. In any case, the division of responsibility you lay out in your August 22 memo to me, EG23-145-67-739, looks just fine and we will take immediate steps to start working that way. In fact, we were on the verge of proposing just such an arrangement to you based on our assumption that FOD had been told to keep their hands off of the Digital Autopilot in all respects. Obviously, the support you propose for us by your people will be badly needed, and I am sure based on various conversations we have all had we should have no problems working together this way.

3. Thanks for straightening us out!

Howard W. Tindall, Jr.

cc:
EA/M. A. Faget
EX12/D. C. Cheatham
EG/K. J. Cox
FA/C. C. Kraft, Jr.
FS/L. C. Dunseith
FS5/T. F. Gibson
R. Nobles
PA/G. M. Low
C. H. Bolender
K. S. Kleinknecht
PD/A. Cohen
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/J. P. Bryant
FM14/R. P. Parten
FM/Branch Chiefs

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

GENERAL SERVICES ADMINISTRATION
MAY 1962 EDITION
GSA FPMR 101 CFR 101-11.6

UNITED STATES GOVERNMENT

Memorandum

File

TO : FM/Deputy Chief, Mission Planning and Analysis Division

DATE: AUG 22 1967

In reply refer to: EG23-145-67-739

FROM : EG/Chief, Guidance and Control Division

SUBJECT: Spacecraft computer program status

Reference is made to MSC memorandum 67-FM-T-52, "Spacecraft computer program status - particularly Sundisk," dated August 1, 1967.

The referenced memorandum reviews the status of the Sundisk computer program, and includes comments that could be misleading to those addressees who do not have the developmental background of the digital autopilot (DAP).

This memorandum is written to review the present responsibility for DAP designs, and to present appropriate comments on present DAP status.

It is the understanding of the Guidance and Control Division that the management responsibilities for the DAP development, programming, verification, and spacecraft integration are as follows:

a. Development (including requirements definition and design verification) - Systems Analysis Branch (GCD)

b. Software programming (including documentation) - Flight Software Branch (FSD)

c. Software verification (including documentation) - Flight Software Branch (FSD)

d. Spacecraft integration - GCD Project Offices

In addition, the Systems Analysis Branch has the responsibility to provide technical support to FSD for items (b) and (c). Examples are (1) review and initiation of DAP test plans, (2) analysis of DAP test results, and (3) initiation of independent DAP verification (design and software) by other support contractors.

If, as possibly indicated in the reference, this division of responsibility is not presently in effect, there is a misunderstanding, and MPAD, FSD, and GCD must initiate action to clarify the responsibilities in the DAP area.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

Specifically, with regard to the present status of DAP programs, as mentioned in the reference, several comments are appropriate.

a. "Workable" DAP's for both CSM TVC and LM have been available approximately one year ago, and are documented in the 207/208 GSOP.

b. Following the flight schedule reshuffle, the decision was made to modify the LM DAP to reduce (1) computer memory requirements, (2) computer execution time (particularly in powered descent), and (3) control system sensitivity to knowledge of environmental conditions. It should be noted that a significant number of potential design deficiencies have been established by the detailed LM-1 verification studies, and appropriate modifications have been included into the simplified LM DAP.

c. TVC DAP performance has been sacrificed to accept a first structural bending mode frequency of 0.8 cps. This was considered a compromise in order to accomodate the significant uncertainties in the modal data. However, with the present low performance control gains, the CSM docked configuration is considered unacceptable from a crew display and monitoring viewpoint. MIT has been directed to investigate alternatives to correct this established design deficiency, and is actively pursuing this objective at this time.

d. Dr. Kenneth Cox attended the July 19, 1967, Software Development meeting at Cambridge, and stimulated a detailed discussion on general DAP development status. As a result, the management of MIT agreed to review the manpower requirements in the area of DAP development, and to initiate action to remedy the recognized DAP documentation deficiencies.

Since the management of the flight software programming task (which is a major portion of the present MIT contract) has been delegated to FOD, this responsibility should include the total product. It is our understanding that this applies to the DAP's as well as all other software programs. Configuration control of the DAP programs should be exercised in the same manner as in the case for other spacecraft computer programs. A single point management contact (Howard W. Tindall, Jr.) presently exists, and successful completion of the total DAP

00000109

designs is dependent upon close coordination between responsible elements of MPAD, FSD, and GCD.

Robert A. Gardiner 8/22/67

cc:
PA/C. H. Bolender
EG2/D. C. Cheatham
FS/Lynwood Dunseith
EA/M. A. Faget
PA/K. S. Kleinknecht
PA/G. M. Low
FM/J. P. Mayer

EG23:KJCox:dbb 8-22-67

UNITED STATES GOVERNMENT

Memorandum

NASA Manned Spacecraft Center
Mission Planning & Analysis Division

TO : FM5/Technical Assistant

DATE: AUG 28 1967
67-FM-T-68

FROM : FM/Deputy Chief

SUBJECT: Goodies affecting the RTCC gleaned from the 504 GSOP meeting

I am writing this memorandum to you in your position as RTCC program coordinator for MPAD. During the lunar landing GSOP review of August 16 and 17, I noted a number of items discussed which had some bearing on the RTCC program. I would sure appreciate it if you would look them over and see if the RTCC is able to do the jobs we assumed that it's being set up to do and/or is consistent with the spacecraft computer programs.

1. There is a routine which MIT proposed for the CMC called lunar landmark selection (R-35) which we intend to delete based on the assumption that the ground can perform this function better and easier. What it does is to recommend the best five landmarks stored in the CMC to be used in lunar navigation. They are presented to the crew in order of priority with the landing site as number 1. I assume the RTCC is already prepared to supply this information in the proper format.

2. It was decided that coordinates of earth landmarks used for navigation would be in coordinates of half latitude ($\phi/2$) and half longitude ($\lambda/2$) in order to obtain the necessary precision. These values are given to three decimal places. If it is intended to supply coordinates of landmarks from the ground, obviously they should be consistent with that unique system.

3. While in lunar orbit all altitude, apogee height, perigee height, etc., DSKY displays will be referenced to a spherical moon with radius equal to the current estimate of the landing site radius. (The only exception to this is the processing of landmarks which are referenced to a pre-established moon model.) The point here is that if sextant measurements are made onboard the CSM the estimate of the landing site radius will probably change and it will be desirable to make the RTCC consistent.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000111

4. The lunar orbit insertion (LOI) prethrust program, P-32, is another good candidate for deletion. In fact, based on our recent discussions it is probable we may not even want to target for a circular orbit, but rather cut off the engine somewhat early in order to make the powered flight monitoring safer. In any case, if we delete this program it will be necessary that the RTCC targeting be made consistent with the standard Lambert prethrust program, and it may also be desirable to change the RTCC program to target for non-circular orbit.

5. Another deletion candidate is the lunar orbit plane change and circularization prethrust program, P-33. I assume it should be no problem to depend on RTCC targeting for this maneuver, in fact, I think we always assumed the ground was prime.

Howard W. Tindall, Jr.

cc:
FC/P. C. Shaffer
FS/L. C. Dunseith
FS5/C. Parker
J. C. Stokes
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/J. P. Bryant
FM14/R. P. Parten
FM/Branch Chiefs

FM:HWTindall, Jr.:pj

UNITED STATES GOVERNMENT

Memorandum

NASA - Manned Spacecraft Center
Mission Planning & Analysis Division

TO : FM5/Chief, Reentry Studies Section

DATE: AUG 28 1967
67-FM-T-67

FROM : FM/Deputy Chief

SUBJECT: Is display of max g in P-61 any good?

During our lunar landing GSOP review someone commented that the display of max g in P-61 is of no use at all. It was said to be grossly in error for earth orbit reentry and of no value in determining appropriate action during entry from lunar return or following an abort when it is more accurate. It was noted that it would probably be desirable to replace that parameter with some other display and L/D currently loaded in the CMC was proposed as a candidate. As I recall, no action was taken at that meeting, but if you want to change this I think it would be a good idea for you to recommend something as soon as possible.

Howard W. Tindall, Jr.

cc:
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/J. P. Bryant
FM14/R. P. Parten
FM/Branch Chiefs
FS5/T. F. Gibson

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

NASA - Manned Spacecraft Center
Mission Planning & Analysis Division

TO : FM7/Chief, Guidance & Performance Branch

DATE: AUG 28 1967
67-FM-T-66

FROM : FM/Deputy Chief

SUBJECT: Prelaunch DAP initialization

During our review of the lunar landing GSOP's, the question of prelaunch DAP initialization was brought up. As far as I can see, there is no use for the DAP until after TLI, isn't that right? For example, the contingency orbit insertion maneuver does not use the DAP nor does CSM guidance of the S-IVB. Accordingly, I should think any initialization should be associated with the first midcourse maneuver while on the way to the moon. Isn't that right?

Howard W. Tindall, Jr.

cc:
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/J. P. Bryant
FM14/R. P. Parten
FB5/T. F. Gibson

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

NASA - Manned Spacecraft Center
Mission Planning & Analysis Division

TO : FM6/Floyd Bennett

DATE: AUG 28 1967
67-FM-T-65

FROM : FM/Deputy Chief

SUBJECT: Delete DOI thrust program, P-61

This is a reminder of the action item you picked up at the lunar landing GSOP review August 17. It was our desire, you recall, to delte the DOI prethrust/thrust program, P-61. It seemed at that time that it should be possible to make this small maneuver using the external ΔV targeting from the ground, particularly if a descent engine thrust of 30 or 40% could be used. You better assume it will be deleted unless we hear advice to the contrary from you.

Howard W. Tindall, Jr.

cc:
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/J. P. Bryant
FM14/R. P. Parten
FS5/T. F. Gibson
FM/Branch Chiefs

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000115

UNITED STATES GOVERNMENT

Memorandum

TO : FM/Director of Flight Operations

DATE: AUG 25 1967
67-FM-3-64

FROM : FM/Deputy Chief

SUBJECT: Reentry guidance is perfect for S/C 101 regardless of L/D

This memorandum is in response to your question regarding the reentry guidance with low L/D. It was erroneously reported to you in the August 3 MPAD Weekly Activity Report that, although the program could be modified easily to handle L/D as low as 0.2, it probably would not be implemented for Spacecraft 101. Actually, some consideration was given to not making any modification since without change the maximum miss distance was only 15 nm and that was only at the toe of the footprint. We felt that if changing the program would slip its delivery date it was not worth doing it. However, MIT was so anxious to make the change they finally agreed it could be done with no schedule impact and were directed to do so. Actually, the only change that was necessary was to make it possible essentially to input our best estimate of L/D prior to entry.

Howard W. Tindall, Jr.

cc:
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM3/J. P. Bryant
FM4/R. P. Parten
FM5/C. A. Graves
FM/Branch Chiefs

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000116

UNITED STATES GOVERNMENT

Memorandum

NASA, Manned Spacecraft Center, Houston, Texas

TO : See list below

DATE: AUG 24 1967

67-FM-T-63

FROM : FM/Deputy Chief

SUBJECT: Use of DPS for lunar mission aborts

1. The other day Carl Huss and some of the Flight Analysis Branch people gave an informal briefing on Apollo aborting procedures for the lunar landing mission starting with the translunar injection (TLI) maneuver. One thing that impressed me was the large number of situations in which dependence is given to using the Descent Propulsion System (DPS) to maneuver the combined LM/command module configuration. At that time, I remarked that some difficulty might be experienced in aligning the LM platform. This memorandum is to pass on what I have learned about that since then.

2. In the nominal lunar landing mission, the LM platform would be coarse aligned while the two spacecraft are still docked together by using a knowledge of the command module platform alignment and the relative orientation of the spacecraft navigation bases. This should be good to within something like 2° in all axes. The spacecraft would then be separated and the LM would carry out a fine alignment using its own optics. Obviously, this procedure cannot be used in an abort since it involves separation. As I understand it, it is possible to utilize some position of the LM AOT in the docked configuration to see stars for alignment, but this is not done since the LM RCS propellant costs would be too large. This is not necessarily the case with aborts since we may be quite willing to use the RCS.

3. A more serious problem, however, is the high probability that this cannot be done unless the vehicles are in darkness, since reflected light off various components of the spacecraft is likely to blot out the stars. It is noted that many of the abort situations requiring use of the DPS will have trajectories in which the spacecraft does not go into darkness. Furthermore, the proposed abort procedures often require that the DPS burn be made within 2 hours of the abort action which puts quite a tight constraint on getting the platform lined up. It certainly isn't a hopeless situation yet---for example, it may be that coarse alignment of the LM platform is adequate to carry out the maneuver,

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

although it must be emphasized that the command module platform must be operating to provide a reference to do the coarse alignment. Also, even though star patterns may not be visible in the AOT to give star identification, by using the star selection routine in the computer the coarse alignment may bring a selected bright star close enough to the center of the AOT that an assumption that it is the proper star may be acceptable. In addition, proposals are being made to shield the AOT for improved performance. Based on these things the proposed abort procedures may prove to be entirely acceptable.

Edward W. Tindall, Jr.

Addressees:
CA/D. K. Slayton
CB/A. B. Shepard
J. A. McDivitt
E. Aldrin, Jr.
CB1/T. P. Stafford
CF/W. J. North
C. H. Woodling
D. F. Grimm
P. Kramer (2)
CF22/C. C. Thomas
CF34/J. B. Jones
EG/R. A. Gardiner
D. C. Cheatham
EG23/K. J. Cox
T. P. Lins
EG25/T. V. Chambers
EG26/P. E. Ebersole
EG27/D. W. Gilbert
EG42/B. Reina
EG43/R. E. Lewis
C. F. Wasson
ET71/T. R. Kloves
EX/N. G. Foster
KA/R. F. Thompson
KM/W. H. Hamby
W. B. Evans
F. C. Littleton
B. L. Sturm
PA/G. M. Low
K. S. Kleinknecht
PA2/M. S. Henderson
PD4/A. Cohen
PM/O. E. Maynard
PM3/F. J. Ward

FK/D. T. Lockard
PA/C. C. Kraft, Jr.
S. A. Sjoberg
R. G. Rose
C. Kovits
FC/J. D. Hodge
E. G. Kranz
FC2/J. W. Roach
FC3/A. D. Aldrich
FC4/J. E. Hannigan
R. L. Carlton
FC5/C. B. Parker
J. S. Llewellyn
G. S. Lunney
C. E. Charlesworth
P. C. Shaffer
J. C. Bostick
H. D. Reed
FL/J. B. Hammack
FS3/L. C. Dunseith
FS5/J. C. Stokes
T. F. Gibson, Jr.
R. C. Nobles
L. A. Fry
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
M3/J. P. Bryant
J. P. Gurley
G. L. Hunt
R. P. Parten
Branch Chiefs
P. P. Mann
FM4/B. D. Weber
FM5/R. E. Ernull

JMiHwTindall, Jr.:pj

00000118

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: AUG 18 1967
67-FM-T-62

FROM : FM/Deputy Chief

SUBJECT: A new rope module for LM-1 computer

1. On August 16 General Bolender approved remanufacture of Module III of the LM-1 spacecraft computer program ropes. This was done based on the recommendation of both MIT and MSC technical personnel in order to correct two deficiencies.

2. The first, and most serious, is associated with the Descent Propulsion System (DPS) trim gimbal control by the Digital Autopilot which, under certain circumstances, could result in an attitude instability during the DPS burns. MIT has estimated that the probability of this instability occurring might be as high as 20 percent. If it happened the ground controllers would be forced to prematurely shut down the engine, seriously jeopardizing the remainder of the mission.

3. The second improvement was to provide restart protection for the fire-in-the-hole sequence. Without this change a computer restart occurring at a critical time would have resulted in staging without igniting the ascent engine, also demanding difficult ground controller action.

4. The current schedule calls for MIT to release the revised version of this program by August 31 to Raytheon for rope manufacture. The final decision as whether or not to use this flight rope module has not been made at this time, as I understand it, but will depend on such things as the results of a series of tests to which the system must be subjected, and the flight schedule itself. I sure will be glad to see that bird fly before it drives us all over the brink.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list below

DATE: AUG 14 1967
67-FM-T-61

FROM : FM/Deputy Chief

SUBJECT: New/old platform for AS-501

Cline Frasier told me today that the platform in Spacecraft 017 (that is, AS-501) has been replaced again by the one that was taken out several weeks ago. Apparently, there was an intermittent problem in one of the accelerometers. I believe Cline said they have replaced the Z-gyro. This change should be beneficial in terms of reducing dispersions at entry since the critical component, the Y-gyro, is supposed to be a real good one in the old, original platform.

Howard W. Tindall, Jr.

Addressees:
PA/G. M. Low
PD/A. Cohen
FA/C. C. Kraft, Jr.
S. A. Sjoberg
FC/J. D. Hodge
G. S. Lunney
FL/J. B. Hammack
FS/L. C. Dunseith
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
Branch Chiefs
EG/R. A. Gardiner

FM:HWTindall, Jr.:pj

bcc:
MIT/IL/R. Ragan

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

GPO GENERAL 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: AUG 14 1967
67-FM-T-60

FROM : FM/Deputy Chief

SUBJECT: Crew monitoring of the LOI maneuver

1. On August 3 we had an informal meeting to talk about crew monitoring of the Lunar Orbit Insertion (LOI) maneuver. The subject came up in connection with Jim McDivitt's preparation for the STAC presentation. I'm writing this note because we tentatively agreed on some fairly basic points with regard to how we might use the various systems. These preliminary conclusions, if they hold up, could have application on some of the other maneuvers, not just LOI.

2. I am sure you are all aware of the slow response of the thrust vector control digital autopilot (DAP) in the Command Module when docked with the LM. In order to avoid exciting the low structural frequency of this configuration (about 1 cps), it has been necessary to reduce the response of the DAP to a very large degree. As a result, if there is an offset in the alignment of the initial thrust vector from the spacecraft c.g., turning moments will exist at the beginning of the maneuver causing large spacecraft attitude excursions which take a couple of long period oscellations to damp out. Our current estimate of the maximum excursion for LOI is about 8° based on the assumption of fully loaded propellant tanks and initial thrust misalignment of 1°. The period of oscellation, as I recall, is in the order of 20 seconds for the half cycle in which the greatest excursion occurs and, unless the crew were prepared for it, it could create considerable concern on whether or not the guidance system was working properly. In the case of the LOI maneuver, which has a nominal duration of about 370 seconds. it is probable that the transverse velocity increments accumulated during this period should not jeopardize the crew. If this is true, the consensus is that the crew would be willing to passively ride out this perturbation.

3. Crew monitoring of the rest of the maneuver must be provided for two characteristics: duration of the burn itself and attitude error. With regard to the former, it was readily apparent that the only danger to the crew occurs from an overburn, that is, failure of the engine to shut down in time. There are three devices which

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000121

can be used to monitor and cross check against overburn: the PNGS, the ΔV counter on the EMS based on acceleration measured along the longitude spacecraft axis, and the clock which can be used to compare against the anticipated duration of the nominal burn. An overburn of about 110 fps would result in lunar impact. This is equivalent to about 10 seconds of extra burn duration out of a total 370 second maneuver. (Acceleration level at burnout is approximately 1/3 g.) A 3 σ low performance engine would extend the burn time just about 10 seconds which makes monitoring with the clock somewhat marginal. The EMS longitude accelerometer is said to have an accuracy of approximately 1.3 percent which is equivalent to about 40 fps for the LOI maneuver. It should provide a suitable cross check. In addition, lunar impact resulting from overburn, of course, occurs as much as 180° from LOI, thus, MSFN should have a good capability of predicting this event as soon as the spacecraft appears from behind the moon with sufficient time for the crew to respond following advice from the ground.

4. Monitoring attitude error is somewhat more difficult. It appears that a constant pitchdown error of less than 5° throughout the maneuver would result in a radial, ΔV downward causing lunar impact approximately 90° orbital travel following LOI, that is, at approximately first appearance of the spacecraft from behind the moon. It was proposed that the FDAI's be set up with one driven by the PNGS and the other by the SCS for attitude comparison purposes once the initial attitude transients noted above have ceased. In addition, it is necessary that the attitude time history compare favorably with a nominal determined preflight. The comparison against the preflight nominal is to protect against a degraded Z-axis accelerometer which could cause the guidance to deviate dangerously but would not be apparent from a comparison of the two FDAI's with each other. Differences in the FDAI's, of course, would indicate that one of the two systems was in error. Since there is no capability for vote breaking with a third source, there would be little option but to shut down when either of the two systems indicate a dangerous condition is impending. It should be noted, though, that attitude dispersions in only one direction, namely in the direction causing a radial velocity increment downward, creates a crew safety problem. In all other cases, it would not be necessary to shut down the engine. Critical downward incremental velocity is approximately 440 fps.

5. I guess to sum it up, even without ground monitoring and without very much onboard redundancy, it looks like given some ingenuity ways can be found to assure crew safety. However, they may require a

00000122

willingness to have "blind" faith for a considerable time in a system that might be malfunctioning and may require an action that could prevent mission success, that is, premature manual shutdown of a perfectly performing system. Probably most of this is old stuff, but I thought it might be worthwhile to write it down.

Howard W. Tindall, Jr.

Addressees:
CA/D. K. Slayton
CB/A. B. Shepard
J. A. McDivitt
E. Aldrin, Jr.
CB1/T. P. Stafford
CF/W. J. North
C. H. Woodling
D. F. Grimm
P. Kramer (2)
CF22/C. C. Thomas
CF34/J. B. Jones
EG/R. A. Gardiner
D. C. Cheatham
EG23/K. J. Cox
T. P. Lins
EG25/T. V. Chambers
EG26/P. E. Ebersole
EG27/D. W. Gilbert
EG43/R. E. Lewis
C. F. Wasson
EG42/B. Reina
ET71/T. R. Kloves
EX/N. G. Foster
KA/R. F. Thompson
KM/W. H. Hamby
W. B. Evans
F. C. Littleton
B. D. Sturm
PA/G. M. Low
K. S. Kleinknecht
PA2/M. S. Henderson
PD4/A. Cohen
PM/O. E. Maynard
PM3/R. J. Ward

PE7/D. T. Lockard
FA/C. C. Kraft, Jr.
S. A. Sjoberg
R. G. Rose
C. Kovitz
FC/J. D. Hodge
E. O. Kranz
FC2/J. W. Roach
FC3/A. D. Aldrich
FC4/J. E. Hannigan
R. L. Carlton
FC5/C. B. Parker
J. S. Llewellyn
G. S. Linney
C. E. Charlesworth
P. C. Shaffer
J. C. Bostick
H. D. Reed
FL/J. B. Hammack
FS/L. C. Dunseith
FS5/J. C. Stokes
T. F. Gibson, Jr.
R. O. Nobles
L. A. Fry
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
FM13/J. P. Bryant
J. R. Curley
G. L. Hunt
FM14/R. P. Parten
FM3/P. D. Weber
FM5/R. E. Ernull
FM7/S. P. Mann
FM/Branch Chiefs

FM:HWTindall, Jr.:pj

bcc: MIT/IL/R. Ragan

00000123

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 : FM/Chief

DATE: AUG 8 1967

67-FM-T-59

FROM : FM/Deputy Chief

SUBJECT: MPAD contractual effort provided FSD for software verification

1. As per your request, I have started to check into the MPAD contractual effort provided FSD for software verification. Jack Williams tells me that they do not have anything like 87 people, but more nearly 65. Furthermore, it is anticipated that this number will be reduced in the near future. At present, Lockheed has 43 people involved in developing the environmental programs for the MSC bit-by-bit simulations. The LM simulation is in operation now and the CSM simulation is scheduled for completion August 15. Following that delivery, the Lockheed effort could be cut back by at least 10 or 15 people with the remainder employed on program maintenance and documentation. As I understand it, a review of this task is scheduled for some time this month to establish FSD's requirements more precisely.

2. TRW has about 19 people, although 21 were requested, to actually carry out the program verification tasks. Their assignments have been recently augmented by request for runs for use in RTCC programs with the spacecraft programs. They have also recently been given additional tasks in independent testing of the DAP and the Abort Guidance System. As I understand it, this task is to be reviewed during the week of August 7. But Jack does not foresee a reduction possible here.

3. That apparently is the status as of now and I intend to take another look in a couple of weeks. Will let you know.

Howard W. Tindall, Jr.

cc:
FM/C. R. Huss
M. V. Jenkins
R. P. Parten
FM13/J. P. Bryant
FM/Branch Chiefs
FS/L. C. Dunseith
FS5/T. F. Gibson, Jr.
J. E. Williams

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

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: AUG 8 1967

67-FM-T-58

FROM : FM/Deputy Chief

SUBJECT: VHF ranging by CSM for ascent monitoring

1. Attention everyone!! As far as I can tell, everyone wants to get that VHF ranging device on the CM and there's a big effort going on right now to put together the proposal and justification for it. Most attention to date has been given to its use for rendezvous. It is obvious that it should be extremely valuable in saving RCS fuel and, doggone it, just helping the crew figure out what's going on during the braking maneuvers. The thing I want to make sure everyone knows is that this device also has the potential for getting us out of another problem that may be even more serious. And that is lunar ascent monitoring for switchover from PNGS to AGS.

2. Current planning calls for using the LM radar to obtain range rate (CM vs. CSM) data which, when combined with the MSFN, permits the ground to evaluate performance of the two systems. But the LM radar data is going to be hard to get. Reacquisition is almost certainly going to be required during powered flight and assistance from the LM computer is going to be tough to provide -- even if the crew has time to fool with it.

3. Transferring this task to the relatively inactive CM via the VHF ranging could really bail us out if it can do the job---and it provides further justification for the VHF ranging as if that were needed!!

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : CA/Director of Flight Crew Operations

DATE: AUG 8 1967

FM-T-57

FROM : FM/Deputy Chief

SUBJECT: Do y'all need the MIT hybrid facilities for crew training?

1. I have talked briefly with Pete Woodling about something I probably ought to bring to your attention, too. As you know, we currently have one hybrid simulator in operation at MIT with both a CM and LM cockpit available and we are on the verge of bringing a second facility on line.

2. This second facility was partially procured with funds from the Electronic Research Center (ERC) with the agreement that it would be turned over to them no later than about July 1968. We were getting it specifically for Apollo spacecraft computer program development which is supposed to be essentially completed by that time.

3. More recently, we have been looking to see if the follow-on work for AAP could provide sufficient justification to hold it beyond that date, but I really anticipate that such a justification will not materialize, at least for program development. On the other hand, I know there has been a recent investigation into the adequacy of the various crew training facilities for both Apollo and AAP.

4. My question is are you interested in trying to retain this second hybrid facility at MIT for that purpose. I might point out it could provide the capability of conducting joint LM/CSM exercises. If you are, please let me know as soon as possible so that we can start work on obtaining the necessary funds, as well as notifying ERC that they must get their hybrid some other way. As I understand it, Chuck Mathews has agreed to get up the dough if we can prove we really need it.

Howard W. Tindall, Jr.

cc:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See attached list

DATE: AUG 3 1967

67-FM-T-35

FROM : FM/Deputy Chief

SUBJECT: Inflight loading of the spacecraft computer erasable memory

1. Since we have gotten the uplink capability in the LM, some things have been done to make it possible to load the erasable memory in the spacecraft computer while in flight, but possibly not enough.

2. This note is just to let you know that we are looking into a requirement for a RTCC processor which would provide an uplink command format to restore all the critical parameters in the erasable memory. In effect, this would be the capability of loading the K-start tape while in flight. This may be necessary every time we power up the LM computer in space as well as being necessary in the event of a computer fresh start occurring in either the command module or the LM.

3. In regard to the former, I have had some indication from MIT hardware people that there's no assurance that the erasable memory remains unchanged once the computer power is turned completely off as it is prior to launch on all manned LM missions. We are taking steps to determine MIT's real opinion on this in writing. Computer fresh start is the situation wherein the computer is not able to restart itself for continued operation and goes into a standby mode where manual assistance is required. This might be as a result of some kind of electrical power transient or something like that.

4. As I understand it, Flight Control Division has established a requirement which is being implemented for examining the entire contents of the erasable memory, word by word, in a 1218 computer in the MCC. This computer would print out differences from those values which had been stored in it as being right. In the case of critical parameters (i.e., K-start type) deviations would be flagged out with particular emphasis. Of course, the real problem arises if critical differences are encountered since, at present, it is necessary for the flight controller to laboriously formulate a command load, perhaps during a time-critical mission phase. It is this deficiency Charlie Parker and I are attempting to remedy!

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000127

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 Div.

TO : FS/Acting Chief, Flight Support Division

DATE: AUG 3 1967
67-FM-T-53

FROM : FM/Deputy Chief

SUBJECT: Deep serious trouble

I realize it's none of my business, and it's getting to be less all the time, but you are going to be in deep serious trouble when the MIT contract negotiations for Apollo and AAP hit the fan in the next couple of months unless you have somebody pretty sharp ready to take over for Larry Fry. Incidentally, did you or Pete Clements put Larry in for one of those awards they give outstanding Air Force officers assigned to NASA? He sure deserves it.

Howard W. Tindall, Jr.

cc:
FA/C. C. Kraft, Jr.
FS5/T. F. Gibson, Jr.

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000128

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : FS5/Chief, Apollo Guidance Program Section

DATE: AUG 3 1967
87-FM-T-54

FROM : FM/Deputy Chief

SUBJECT: Verify Sundisk for CSM/LM missions

You know, it's becoming more and more likely that we will fly a combined command module-LM mission using the Sundisk program. It might be a good idea for you to review the testing that is being done on that program to make sure it can handle that kind of mission, if you have not already done so.

Howard W. Tindall, Jr.

cc:
FS/L. C. Dunseith
FS5/J. E. Williams
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
R. P. Parten
FM13/J. P. Bryant
FM/Branch Chiefs

FM:HWTindall, Jr.:rj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000129

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

UNITED STATES GOVERNMENT

Memorandum

TO : See attached list

DATE: JUL 31 1967

67-FM-T-53

FROM : FM/Deputy Chief

SUBJECT: Spacecraft computer storage requirement for restart protection

1. In response to a question by George Low the other day, I checked into the amount of computer memory used to provide restart protection. On Sunburst, the LM-1 program, almost 1200 words or 4 percent of the total will entirely fill memory, 4 percent would be about 1500 words. Incidentally, 225 words of that 1200 are erasable, the rest hardwired.

2. That was a good question. I never imagined it to be so much. Although I really do not know what we can do about it offhand, we certainly will look into it. Storage is in short supply and we will have to leave out desirable capabilities.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

NASA-Manned [illegible]
Missing Planning [illegible]

UNITED STATES GOVERNMENT

Memorandum

TO : See attached list

DATE: AUG 1 1967
87-FM-T-32

FROM : FM/Deputy Chief

SUBJECT: Spacecraft computer program status - particularly Sundisk

1. I have been putting off writing this note because it is rather painful. To put it bluntly, the release of Sundisk--the interim earth orbit command module spacecraft computer program--has slipped rather badly. What makes it painful is that it's not all together clear why it is slipping and we still haven't found a good way to monitor and predict these slippages further in advance of their occurring.

2. I am sure a substantial contributor was the digital computer facility saturation we experienced in January, February and March, when we were getting out Sunburst--the unmanned LM-1 program. The lack of computer time for Sundisk development during these critical months must have impacted us severely. Another cause was the delay in getting the hybrid facility converted to Block II as quickly as we hoped. It did not become operational until May. And it is my understanding that a backlog of hybrid testing in large measure is pacing program delivery even now. A third contributor was the substantial number of program changes. The [illegible] of these changes slipped the configuration control date from August 3 to August 28 where it stands today. Configuration control comes about a month prior to program release for rope manufacture which will be around October 1, I suppose. It takes about two months to make the ropes so they should be available well in advance of spacecraft delivery.

3. Of course, another consideration is to make sure we are not delaying flight crew training, but as far as I can determine, we are not. Substantial parts of the program are working and are now available for crew training. As I said, our problem is determining what is going on and what we can do about it.

4. Most troubles in the program now are in the Boost and Entry [illegible]. Actually, Boost does work in the bit-by-bit digital facility. The [illegible] is in the computer program simulating the Saturn in the hybrid facility. Entry apparently does still have some work required on it. The only major problem area that I know of is associated with the Thrust Vector Control (TVC) digital auto pilot. Apparently, even at this late date, configuration has not been entirely frozen - people are still diddling around with the design. I might also point out that we have decided to move some of the entry constraints defining L/D of the spacecraft from [illegible] to erasable memory so that we may respond as people play around with the

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000131

spacecraft ballast, etc. All testing, however, will be carried out assuming a L/D of .30. This verification testing, of course, is to prove that the program is bug free and runs. When the actual L/D is established, it may be desirable to run some more tests to determine the performance of the program under those conditions but not for verification purposes.

5. We have agreed with MIT on a delivery schedule for the final version of the CSOP. The blue cover of versions of Chapters 3, 4 and 5 will be available by September 30. It is our understanding that Chapter 5 (program formulation) is in the final stages of typing including all MDRB's; Chapter 4 (program sequencing) is kept up to date at all times and will be ready for release; and Chapter 3 which defines the digital auto pilot paces the whole works, but is supposed to be finished by that date. We are told that the entry DAP is in good shape, the RCS DAP requires some modification and the TVC DAP is being redesigned. No documentation of it exists anywhere. Deplorable situation.

6. It is pretty obvious to everyone that the delay we are experiencing in getting out Sundisk will reflect on our delivery of the subsequent programs - Colossus (CSM) and Sundance (LM). This, of course, results from not getting the full strength effort on these programs as soon as we had planned, but it is also evident from our experience that program development takes substantially longer than we had previously estimated. As of now Colossus and Sundance are scheduled for a release of February 1968, and that's a good target date to shoot for. I wouldn't be too surprised though if the actual release date of the first flight-worthy version of the entire lunar landing Sundance and Colossus programs was as late as June 1968. Rest assured both MIT management and we here will make every effort to minimize these slips and to at least get a system working so we'll know what's going on.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

UNITED STATES GOVERNMENT

Memorandum

TO : FA/Director of Flight Operations

DATE: JUL 31 1967

FROM : FM/Deputy Chief

67-FM-T-51

SUBJECT: We're gonna' find out if the PAC is a good substitute for the flight ropes

You re-opened an old concern of ours at the simulator meeting Tuesday and I just want to tell you we are going to take another good hard look at it. I am talking about how we can convince ourselves that the PAC performs in a manner truly equivalent to the flight ropes. As you quickly perceived, we really hang our hat on testing with the PAC. Actually, about the only experience we get with the flight ropes is Sim flight and that's a pretty limited test. Jack Williams is going to obtain and review the documentation of the analysis, engineering studies, actual test results, etc., which I suppose must have been available for somebody, whoever it was, to decide that use of the PAC was adequate for final systems verification. It certainly is a critical open area, at least in our minds, which we should have been readily prepared to discuss at any time. We better get ready now.

Howard W. Tindall, Jr.

cc:
FA/S. A. Sjoberg
FS/L. C. Dunseith
FS5/T. F. Gibson, Jr.
J. E. Williams
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
R. P. Parten
Branch Chiefs

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000133

UNITED STATES GOVERNMENT

Missions Planning & Analysis Division

Memorandum

TO : FM/Assistant Chief

DATE: JUL 27 1967
67-FM-T-50

FROM : FM/Deputy Chief

SUBJECT: Greater dispersion at entry on AS-501 with the new IMU

You have expressed concern about the somewhat poorer performance of the new platform in Spacecraft 017. While at MIT last week Dan Lickly and I spoke to John Miller about this. John says the component which contributes the most to dispersion in flight path angle at the entry interface is the Y gyro, as you know. The dispersion on this replacement gyro is almost exactly double that of the old one [3.0 MERU in place of 1.6 MERU, whatever that is]. According to a curve he had -- this alone will result in 0.6° flight path angle dispersion at entry (3σ) assuming a perfect nav. update prior to the second SPS maneuver.

Howard W. Tindall, Jr.

cc:
PA/G. M. Low
PD4/A. Cohen
PA/C. C. Kraft, Jr.
S. A. Sjoberg
FC/J. D. Hodge
G. S. Lunney
FL/J. B. Hammack
FS/L. C. Dunseith
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
Branch Chiefs
EG/R. A. Gardiner

FM:HWTindall, Jr.:pj

U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000134

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

DATE: JUL 27 1967

TO : See list below

FROM : FM/Deputy Chief

SUBJECT: There will be no S-IVB ephemeris in the RTCC after separation

We have had a couple of meetings of FCD, FSD, MTAD and IBM people to discuss some of the RTCC computer program requirements for the lunar landing missions. One item coming out of these discussions, which may interest you, is that there is currently no intention of carrying an ephemeris for the S-IVB after it separates from the Apollo spacecraft. As you know, there have been recurring discussions of the need for this in order to evaluate the possibility of recontract. I should point out that this was not really an area of disagreement among these people. I think it was fairly well agreed that the random venting of the tanks following loss of attitude control and ground tracking capabilities would make any such ephemeris meaningless.

Howard W. Tindall, Jr.

Addressees:
CA/D. K. Slayton
CB/A. B. Shepard
J. A. McDivitt
E. Aldrin, Jr.
CB1/T. P. Stafford
PD/A. Cohen
PM/O. E. Maynard
FA/C. C. Kraft, Jr.
S. A. Sjoberg
R. G. Rose
FC/J. D. Hodge
E. F. Kranz
FC2/J. W. Roach
FC3/A. D. Aldrich
FC4/M. F. Brooks
R. L. Carlton
FC5/C. B. Parker
J. S. Llewellyn

FC5/G. S. Lunney
C. E. Charlesworth
P. C. Shaffer
J. C. Bostick
FL/J. B. Hammack
FS/L. C. Dunseith
FS5/J. C. Stokes
FM/J. P. Mayer
C. R. Huss
M. V. Jenkins
Branch Chiefs
FM5/R. E. Ernull

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

NATIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR 101-11.6

NASA - Manned Spacecraft Center
Mission Planning & Analysis Division

UNITED STATES GOVERNMENT

Memorandum

TO : See attached list

DATE: JUL 27 1967
67-FM-T-48

FROM : FM/Deputy Chief

SUBJECT: Configuration control of the spacecraft computer programs for 504 is imminent

1. This note is to inform you of our current plans regarding final definition of the CSM and LM spacecraft computer programs for the lunar landing mission - Colossus and Sundance. It is anticipated that MIT will mail the complete Chapter 4 of the Guidance System Operation Plan (GSOP) on July 26. This is the chapter prepared by John Dahlen and Jim Nevens giving the sequence of operations. We will distribute copies of this as soon as they are received for review during the following two weeks. A gigantic Software Control Panel meeting will be scheduled for about August 15, 16, and 17, although hopefully it won't take that long, to go through the entire GSOP for both the command module and LM answering all questions and discussing all inputs, comments, requests for changes, etc., in short, to establish an MSC position on this documentation. MIT, North American and Grumman will be invited to participate. In the following week a (hopefully) smaller group will go to MIT for two or three days starting on August 22 to provide final technical direction to MIT which will put the GSOP's under configuration control. That is, after that time changes will have to be individually approved by the Software Control Panel. At the same time, we will hold our computer memory storage review and will trim the programs down to acceptable size if necessary. And it is almost certainly required in the LM.

2. As you know, it is our intention to fly all manned LM flights with Sundance---although some of the processors which are required only for the lunar landing missions may not be completely checked out in the ropes used on the earlier earth orbital missions. The point is the LM program used for the earth orbital missions will be defined and controlled by this GSOP.

Howard W. Tindall, Jr.

FM:HWTindall, Jr.:pj

00000136

GENERAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR 101 CFR 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : FS/Acting Chief, Flight Support Division

DATE: JUL 27 1967
67-FM-T-47

FROM : FM/Deputy Chief

SUBJECT: LMSS RTCC program test documentation needed

This may be a waste of time what with the LMSS on its way down the tubes, but during that review of the RTCC computer programs a few weeks ago it was obvious that the contractor has no intention of providing any test specification or test results documentation. In fact, I am pretty sure their need never occurred to them. You really did not have anyone at the meeting presenting your requirements and I doubt if they have responded to my meager comments. I suggest you look into this matter and make sure those people are doing what you want them to. You'll probably want some stuff to compare the IBM RTCC programs with.

Howard W. Tindall, Jr.

cc:
FA/C. C. Kraft, Jr.
FC4/M. F. Brooks
FM/J. P. Mayer
FM/C. R. Huss
FM/M. V. Jenkins
FM/R. P. Parten
FM13/J. P. Bryant
FM5/R. E. Ermull
FS5/J. C. Stokes, Jr.

FM:H.Tindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

TO : FM/Technical Assistant

DATE: JUL 27 1967

67-FM-246

FROM : FM/Deputy Chief

SUBJECT: Landing point dispersions given communication loss in lunar orbit

1. During Chris Kraft's staff meeting of July 17 there was a long discussion regarding the necessity of a beacon to help the recovery people find the spacecraft. It was pretty well concluded that it was not needed as long as we knew where the spacecraft landed to within several hundred miles. Of course, if the various guidance and tracking systems are in operation we should certainly know the landing point much better than that and so the beacon is coming off.

2. The reason I am writing this note to you is that it occurred to me that if we were to lose communication with the command module while in lunar orbit subsequent to separating from the LM, maneuvers would have to be computed and executed based on onboard information. [Of course, the TEI maneuver would be carried out using the block data transmitted prior to communication loss.] It is probable that the mid-course navigation would have to utilize star-horizon observations to obtain the state vector which would be used for mid-course correction maneuvers and for initializing the reentry guidance systems. I'll bet the landing dispersion under these conditions could be very large, although Pete Frank, who was sitting next to me, felt it would still be within several hundred miles. In any case, I asked him to look into this situation to make sure we have not overlooked something that might bear on the beacon decision. It is to be noted that this contingency situation is of a high enough possibility that we are providing several large computer programs onboard the spacecraft to handle it. Would you see that all the necessary task assignments, etc., are taken care of if you agree this job should be done.

Howard W. Tindall, Jr.

cc:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

UNITED STATES GOVERNMENT

Memorandum

TO : See attached list

DATE: JUL 27 1967

FROM : FM/Deputy Chief

SUBJECT: Spacecraft computer program flow chart status

1. Just a note to you cats who are interested in flow charts for the spacecraft computer programs. MIT has had a small group headed by John Venize who have done what appears to be an excellent job of establishing standards to be followed in the development of flow charts. A group of SDC people have been given the job of taking the program listings and rough flow charts from the programmers and turning those into the final product. We were given a schedule defining when various portions of the Sundisk earth orbital command module computer program will be completed. It should be finished no later than November 17. Substantial portions will be finished sooner than that, of course, available for distribution. It has been our goal to do those processors of most immediate interest first. Anyone interested in the actual schedule should get in touch with Jack Williams of the Flight Software Branch.

2. I really think we've got this thing moving well now (finally!) and will be interested in your comments. It was our intention to set up some system of discrepancy reporting in which we will encourage you to participate. The intent is to inform MIT people of differences between the program listing and the flow charts and the GSOP's such that they may be corrected. This should also provide an incentive for the programmers to thoroughly check the flow charts before release, since we are requiring that they sign off on them as being responsible for their accuracy. Naturally, we intend to execute any programmer whose flow charts contain a significant number of errors.

Howard W. Tindall, Jr.

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000139

UNITED STATES GOVERNMENT

Memorandum

TO : FA/Director of Flight Operations

DATE: JUL 26 1967

67-FM-T-44

FROM : FM/Deputy Chief

SUBJECT: Notes from ASPO Manager's staff meeting - July 24

1. I hope I didn't hurt your feelings by going to George Low's staff meeting instead of yours, but he specifically asked me to come and I felt you would agree that would be best. If not, please advise. I did pick up a few items that may be of interest to you which it is the purpose of this memo to relate.

2. According to ASPO's bar charts, the launch date for Spacecraft 017 is September 28. The shipping date for Spacecraft 101 is three weeks behind schedule, that is December 31. And LM-1 launch date is now about October 31. Of course, those dates are unofficial.

3. Apparently, there has been a problem with the LM-1 computer and they are sending it back to Raytheon. It does not work with the actual flight ropes, and they have replaced it with a new computer which does.

4. There was an extensive discussion about the overall spacecraft testing procedure, particularly at KSC. George is very concerned that every test anyone can think of is added, and was emphatic in directing that he wanted Apollo testing to be carried out in a manner much more like Gemini than it is at present. He wants to establish an MSC Test Requirements Document which defines when and where each test is to be run as well as spacecraft configuration. This is to be a configuration control document which can only be changed with high level concurrence. There was some speculation that this might lead to a fight with KSC.

5. It was reported that Buz Nello does not report to Dale Myers at North American which means they have two vice presidents to deal with now and they expect this will make things a little more difficult.

6. It seems the spacecraft problem currently requiring the most attention and effecting schedule most has to do with panel coating. Both the LM and CSM people describe the process as being quite difficult to control and not certain to work. Incidentally, the materials and process to be used on the command module are different than that used on the LM.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000140

However, in both systems a large number of coatings must be applied under strictly controlled conditions. This coating, of course, is to provide fire protection or at least to prevent its spread.

Howard W. Tindall, Jr.

cc:
FA/S. A. Sjoberg
FC/J. D. Hodge
FL/J. B. Hammack
FS/L. C. Dunseith
FM/J. P. Mayer
FM/C. R. Huss
FM/M. V. Jenkins
FM/R. P. Parten
FM/Branch Chiefs

FM:HWTindall, Jr.:pj

00000141

UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: JUL 21 1967

67-FM-T-43

FROM : FM/Deputy Chief

SUBJECT: LM is launched with air

I guess everybody already knows this, but I just learned that they intend to launch all LM's with air rather than oxygen in the cabin. As a result, the spacecraft never sees an oxygen environment with pressure greater than about 6 psi. Furthermore, no testing is done on any of the systems with pure oxygen at higher pressure than that. Of course, the purpose is to reduce the possibility of fire.

Howard W. Tindall, Jr.

Addressees:
FA/C. C. Kraft
S. A. Sjoberg
FC/J. D. Hodge
FL/J. B. Hammack
FM/J. P. Mayer
FS/L. C. Dunseith

FM:HWTindall, Jr.:pj

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

No.: 67-114

Date: August [illegible], 1967

File:

MANNED SPACECRAFT CENTER

ANNOUNCEMENT

CHIEF OF APOLLO DATA PRIORITY COORDINATION

APOLLO SPACECRAFT PROGRAM OFFICE

Mr. Howard W. Tindall, Jr., has been appointed Chief of Apollo Data Priority Coordination. In this assignment he will coordinate all MSC and contractor efforts in developing the techniques and procedures for the operational utilization of the trajectory control systems involved in manned Apollo missions. This effort has in the past been called "G&N Operations" or "Data Priority Specifications." Specifically, his job is to determine the operational rules and procedures for properly utilizing the Apollo systems, including primary and backup systems; to investigate the system capabilities and constraints and to evaluate their accuracies; to establish the criteria for system selection during various phases of the mission; and to establish the proper spacecraft and ground displays and use of these displays. His responsibility will include the utilization of the spacecraft propulsion, guidance and control systems, as well as the associated support from the MSFN and Mission Control Center.

Mr. Tindall will report directly to the Manager, Apollo Spacecraft Program and is, in effect, on loan from his present position as Deputy Chief of the Mission Planning and Analysis Division in the Flight Operations Directorate. A charter delineating his responsibilities and mode of operation will be distributed within the next several weeks. I request that you give Mr. Tindall the fullest cooperation in this important effort.

George M. Low
Manager
Apollo Spacecraft Program

DISTRIBUTION:
Y

00000143

UNITED STATES GOVERNMENT

Memorandum

TO : See list

DATE: MAY 15 1967

67-FM-T-41

FROM : FM/Deputy Chief

SUBJECT: Spacecraft computer program names

Good information

I used to think MIT was a little odd when it came to selecting names for the spacecraft computer programs with all that weird preoccupation with the sun. But now I see they were right all the time and the rest of the world is nuts - let's name the missions sequentially as they lift off the launch pad. Good grief, Charlie Brown! Having seen my error I'd like to apologize to our Bostonian friends for the abuse - and worse - I used to heap upon them and publicly announce the end of my campaign to change the program names. I think the old ones are just great and recommend you learn to recognize them if you're interested in this business.

There are only five names you need to remember; they are:

a. SOLRUM 55

This contraction of the more familiar "Revision 55 of Solarium" was adopted for the AS-501/AS-502 program when it was released to Raytheon for rope manufacture. (The numerical part of the name is the number of the program assembly on which the final flight verification testing was carried out. This is a characteristic of all program names).

b. BURST 116

Contracted from "Revision 116 of Sunburst", this is the name of the program for the unmanned LM mission we used to call AS-206.

c. SUNDISK

Sundisk is the interim Command Module program now scheduled for release in July which could be used for any earth orbital development flight. It probably won't ever be flown but it's availability will ensure that flight software does not pace the first manned mission. Dave Hoag suggested I could remember this name if I associated it with the shape of the command module - sort of a disk - and, by golly, it's worked for me.

d. COLOSSUS

This is the name of the command module program designed to support the lunar landing mission as well as all development flights anyone has

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

thought of, so far. According to Webster's New Collegiate Dictionary it also means (1) A statue of gigantic size; as, the Colossus of Rhodes; a statue of Apollo, about 120 feet high, made by Chares about 280 B.C. (2) Anything of gigantic size.

Pretty good except, I miss the Sun.

This program and Sundance (below) will undoubtedly be updated prior to rope manufacture for each mission, incorporating modifications and corrections as necessary. I expect these will be identified by different assembly numbers rather than completely new names.

e. SUNDANCE

You can remember the name of the LM program for all manned missions by associating dance with the LM's lovely legs - another of Dave's suggestions - and adding "Sun" as usual.

I'm serious, as usual.

Howard W. Tindall, Jr.

Addressees:
(see page attached)

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

UNITED STATES GOVERNMENT

Memorandum

TO : KA/Assistant Manager, Apollo Applications Program Office

DATE: MAY 1 8 67
67-FM-T-40

FROM : FM/Deputy Chief

MIT

SUBJECT: MIT can handle spacecraft computer program development for both Apollo and AAP to their mutual advantage

This memorandum is a compilation of my ideas and opinions in response to a request from your office regarding the questions of whether MIT should be chosen to perform spacecraft computer program development for AAP, and, if they were, would the impact on their Apollo work be acceptable. They are based on my observations and experiences over the past year while participating in MSC's technical direction and management of MIT work on the Apollo program for which I continue to have some responsibility.

For the past several years, MIT has been engaged in the development of the spacecraft primary guidance system computer programs to be used on the Apollo lunar landing mission and associated earth orbital development flights. It is estimated that approximately 80% of the AAP computer programs will consist of the specific processors MIT has developed for those Apollo missions. The schedules for main line Apollo and AAP missions overlap each other, which makes it certain that program development on both will also be a simultaneous and continuing effort. The advantage of having the same organization - in fact, the same people - do both of these tasks is obvious in terms of program quality, efficient use of this country's resources and, of course, cost. But of greater importance here is the effect on product delivery schedules. Whereas MIT is in a position to begin work and achieve a high level of productivity almost instantly, any other contractor would require a considerable period of time for personnel training and familiarization and for the procurement of program development facilities.

Special emphasis should be given to the problem of procuring the extremely complex digital computer and hybrid simulation facilities required to support program development, and, in particular the very large and sophisticated computer programs which make up an integral part of them. These facilities are absolutely mandatory to perform this job and would require another contractor about a year to duplicate.

Therefore, in answer to the first question - should MIT be chosen to do the AAP spacecraft computer programming - I must state that to choose any other contractor is implicit acceptance of a flight schedule slip. There is no choice.

If that is the case, what does this do to the effort on the main line Apollo

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

work at MIT? I am convinced that the effect will be more beneficial than detrimental. Although there will be occasions when Apollo will suffer to some extent, it will be an acceptable amount, and the advantages gained will more than compensate for it. Let us examine separately the two main commodities we are procuring from MIT, personnel and facilities.

a. Personnel

1. It is MIT's current intention to reduce their staff by about 40 people over a three-month period starting in June 1967. These are subcontract personnel chiefly in the AGC coding and testing business. This represents the first of the personnel cuts which would continue to take place throughout the rest of the Apollo program.

2. Based on the best manpower requirements estimate we can make today for the next year or so, it appears that the present MIT staff is within about 10% of that required to carry out both the Apollo and AAP work. In fact, I feel it is somewhat more probable that they will still have to reduce their staff in early 1968 rather than to increase it even with the AAP work to do.

3. Even if this estimate proves to be wrong due to unforeseen difficulties, it is important to note the rather outstanding capability MIT has demonstrated for quickly staffing up with competent personnel. In the period between June 1966 and March 1967 they increased their technical staff by 150 people. This was done at the same time that they were undergoing extensive reorganization and establishing substantially different working procedures, and producing the AS-204, AS-501, and AS-206 flight programs and the AS-278 Guidance System Operations Plans.

In summary, Apollo cannot employ the entire MIT staff today, and even AAP may not take up the slack. But if more people are required, MIT has shown they can get them and put them to work quickly.

b. Facilities

1. MIT is equipped with two Honeywell 1800 digital computers which our predictions show should be able to handle the entire Apollo and AAP program development task through calendar year 1968.

2. MIT is phasing in an IBM 360/75 digital computer which is expected to be completely operational this fall. It alone should have more than double the computing power of the two Honeywell 1800 computers.

3. It is MIT's intention to have the Honeywell computers taken out although I plan to resist this until the end of this year or until I develop some real confidence in the IBM 360/75. In any case, it is evident that, if necessary, it is possible to delay this computer phaseout for as long as we need to.

4. The vital digital simulation programs duplicating the spacecraft systems, the environment of space and earth, the Apollo Guidance Computer (AGC), etc.

00000147

are completely compatible to AAP and shall be maintained in a state of readiness for both types of computer.

5. The hybrid simulation facility consisting of spacecraft cockpit mockup, AGC and memory simulator, and sophisticated analog and digital computers and programs was found to be an invaluable program development tool on AS-204. This facility has been reworked for Block II and a second more-or-less duplicate facility is being brought on line now. It is ASPO's intention to turn this second facility over to NASA's Electronic Research Center in Boston next year. It will be necessary that this be retained via AAP funding for the mutual benefit of AAP and Apollo. But it is clear that these two simulators are adequate for both projects.

In summary, the capability of the program development facilities at MIT are still growing just as the Apollo program development effort is reaching its peak - soon to taper off. Current plans are to phase out about one-half of it within the next twelve to eighteen months. Even with AAP some of this phaseout should and would probably continue.

Therefore, I feel there is no other choice than to choose MIT for AAP spacecraft computer program development for schedule reasons alone although it is evident there are substantial advantages accrued in the areas of program quality and cost. Furthermore, it is probable that Apollo will also benefit from this arrangement in that it will be necessary to retain some excess capability at MIT to handle the peak load periods and emergencies which AAP will, in effect, be providing now at no cost to Apollo - I refer here to both personnel and facilities. And of course unique programs developed for AAP would be readily available to Apollo. As far as I can see, it is the only reasonable way to go.

Howard W. Tindall, Jr.

cc:
FA/C. C. Kraft
FA/S. A. Sjoberg
EG/R. A. Gardiner
FS5/T. F. Gibson, Jr.
FS5/L. A. Fry
FM/J. P. Mayer
FM14/R. P. Parten
FS/L. C. Dunseith

FM:HWT:dbp

00000148

NASA HISTORY OFFICE: REQUEST FOR INFORMATION

Source: _____ Inside NASA? Yes:___ No:___

Information Requested: _____

_____

Date of Request: _____ Date Filled: _____

Use of Information: _____

Time Spent on Filling Request: _____

Request Filled By: _____

UNITED STATES GOVERNMENT

Memorandum

TO : See list

DATE: MAY 17 1967
67-FM1-39

FROM : FM/Deputy Chief

SUBJECT: A new spacecraft computer program development working philosophy is taking shape

It's becoming evident that we are entering a new epoch regarding development of spacecraft computer programs, and I thought I'd try to put my impression relating to this into words and get them out in the open.

Until a few months ago, our most basic problem was getting the spacecraft computer programs - and ultimately the flight ropes - completed in time to support the official flight schedule. This presented such a challenge to the people involved that intense reluctance was created to making changes and, after a certain point, even correcting known deficiencies in the programs. Where necessary, work around procedures were invented as the only possible solution. Since the January accident the situation has changed considerably in two ways. First of all, the flight schedule has slipped to an extent that computer program development no longer paces the flights in any way (including crew training and system tests) and, secondly, the value of quality has become supreme. These things are most clearly evident right now on LM-1 where it's almost unthinkable to fly with any known deficiencies in the program - even those which would only affect very low probability contingency situations - in spite of the fact that the flight ropes have already been manufactured. I feel it's quite likely the decision will be made to rework the LM-1 program and remanufacture ropes regardless of impact on any of MIT's program development work, including delivery of the manned mission computer programs. In fact, we have asked MIT to determine the extent of this across-the-board impact assuming all of the known deficiencies in the LM-1 program are removed, no matter how minor. Much more significant, however, is that without doubt this situation is forcing us to adopt a new working philosophy which should be recognized and included in all of our planning - program development schedules, man loading, crew training, spacecraft systems tests, etc. It is clear that, as Ed Copps puts it, program "shelf life" is very short. That is, it is extremely unlikely we will ever fly with ropes manufactured substantially in advance of the mission; instead of releasing the flight program for rope manufacture at the earliest possible date we should release it at the latest possible date.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

The next question to be answered is - how far should the work on these assemblies proceed before being frozen (if you call slush "frozen") and put on the shelf until some key milestone associated with spacecraft flight readiness? Should complete flight qualification Level 5 testing be carried out with the realization that changes will come along forcing us to revise the program and thus to repeat substantial portions of the flight verification? Or should we merely carry the program development through Level 4 testing, resulting in an assembly on the shelf which is bug free as far as we know, but which has not been completely flight qualified? There are arguments for both positions. We have asked MIT to consider this subject - program development working philosophy - and to recommend their preference. We here at MSC will do the same and within a month will be prepared to adopt what appears to be the best over-all compromise. In any case, I'm sure it will force us to maintain a larger MIT staff and more program development facilities in order to be in a position to maintain and modify these programs until we finally release them. And we are less likely to have to throw sets of ropes in the garbage can so often.

I'm not trying to flag this all out as a big problem area. It should certainly be easier to handle than our previous "schedule is king - anything is better than nothing" type of problem. But I'm sure what we do will have some fairly significant implications on everyone involved in the business of program development as well as the various users of their product and I thought it worthwhile to bring it to your attention.

Howard W. Tindall, Jr.

Addressees:
(see page attached)

00000151

UNITED STATES GOVERNMENT

Memorandum

Notebook

TO : See list

DATE: MAY 1 7 1967
67-FM1-38

FROM : FM/Deputy Chief

SUBJECT: Reduced L/D presents a spacecraft computer program problem

This note is to help insure that the word gets around regarding reduced command module reentry L/D. MIT has heard rumors that the L/D may be reduced to a value of .25 and emphasized during our program development plan meeting that they are fairly certain the present spacecraft computer program formulation will not handle that. The current formulation is designed to handle a minimum L/D value of .30 and, although they do not know how far this limit can be extended, they feel certain major rework will be required for .25. This is not a new discovery. Our reentry experts in MPAD have been saying the same thing for some time.

Howard W. Tindall, Jr.

Addressees:
(see page attached)

Dear Bill,

It seems we might for using the
1/2 left techniques in the first place - If
you ask me you'd better get those astros
working on the right vectors ASAP.

CLS

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000152

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR 101-11.6

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list

DATE: MAY 4 1967

FROM : FM/Deputy Chief

67-FMD-37

SUBJECT: Invitation to an AAP spacecraft computer program requirements shindig

On April 20 we had our first meeting to establish spacecraft computer program requirements for the AAP missions. Sufficient time will soon have elapsed to permit substantial progress on the action items issued at that meeting making it worthwhile to gather again. Accordingly, you are invited to attend such a meeting at 9:00 a.m., May 18 in Room 3037 of Building 30. Based on these discussions, it is expected that the Flight Software Branch of the Flight Support Division will prepare a first draft of formal program requirements to be used by MIT and MSC in laying out the AAP program development work.

For some reason beyond my recall, we failed to discuss the AAP lunar mission involving the CSM/LMSS combination proposed to back up the first Apollo lunar landing mission. Therefore, I propose we remedy this oversight at this same meeting and suggest you come prepared for that, too.

Howard W. Tindall, Jr.

Addressees:
CA/D. K. Slayton
CB/A. B. Shepard
CF/W. J. North
CF/C. C. Thomas
EG/D. C. Cheatham
EG23/K. J. Cox
EG23/T. F. Lins
KA/R. F. Thompson
KM/W. B. Evans
KM/W. H. Hamby
KM/F. C. Littleton
KM/B. D. Sturm
FA/R. G. Rose
FA/C. Kovitz
FC/J. D. Hodge
FC/K. F. Kranz
FC5/G. S. Lunney
FS/L. C. Dunseith
FS5/T. F. Gibson, Jr.
FS5/R. O. Nobles
FM/J. P. Mayer
FM/C. R. Huss
FM4/R. P. Parten
FM/Branch Chiefs
FM3/B. D. Weber
FM5/R. M. Ernull
FM13/G. L. Hunt

FM:HWT:cm

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000153

UNITED STATES GOVERNMENT

NASA - Manned Spacecraft Center
Mission Planning & Analysis Division

Memorandum

TO : See List

DATE: MAY 4 1967

FROM : FM/Deputy Chief

67-FM1-36

SUBJECT: Some things Ed Coppa is worried about

Ed Coppa (MIT) called the other day about some things that worry him. I figure if he's worried enough to call, it's probably worthwhile to dictate this note and send it to you.

As you recall, to help relieve our computer storage problem, we removed the automatic gimbal lock avoidance capability from CAL/MANU - the spacecraft computer processor which provides automatic attitude maneuvers. MIT has recently conducted a study which revealed that about 20% of the automatic attitude change maneuvers in a typical mission would now violate that constraint. Ed Coppa has become rather concerned about this relatively high frequency. He feels that since the crew will be forced to override the computer so often they may lose confidence in CALCMANU altogether and will always choose to use the manual mode. Ed emphasized that if this were to happen, the RCS fuel requirements which their study showed to be relatively acceptable would rise drastically. Perhaps special emphasis will have to be given this matter in crew training.

One other thing that Ed was worried about at the same time was the spacecraft change to lower the docking collar latch preload from 4000 lbs. to 600 lbs. This modification probably would lower the frequency of first structural mode for the CSM/LM configuration below the current estimated value of about 1.0 cps. As has been reported elsewhere, this would probably require extensive redesign of the TVC Digital Autopilot filter, perhaps to the extent of requiring a completely "different control system design" approach. This whole business apparently scares the hell out of Ed Coppa, and I guess if I knew enough I would be frightened too.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000154

UNITED STATES GOVERNMENT

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

Memorandum

TO : See list

DATE: APR 28 1967

FROM : PM/Deputy Chief

67-PM1-35

SUBJECT: Notes from the MIT program development plan meeting of April 20

A few things came out of our program development plans meeting at MIT on April 20 that might be worth recording for my memory and your information.

1. We have decided not to produce a unique LM program for its first manned mission. What this basically amounts to is that MIT will continue with program development pretty much as they have been for AS-206, but instead of freezing the program at some point in time (probably in June) and flight qualifying it for rope manufacture, they would begin to add in the extra programs required to support the lunar landing mission. This would continue until the complete lunar landing program has been developed (probably in December 1967) or until it became apparent that the projected release date of the complete program was no longer consistent with the scheduled launch date. If the latter happened, we would freeze the program in its most suitable configuration, flight qualify it, and release it to Raytheon for rope manufacture. This procedure should provide the best, most complete program for the first manned LM and should also result in the least work required by MIT. In addition, recognizing that "shelf life" of a program is really quite short, we remain in the most favorable position to correct deficiencies as they are uncovered without having to perform extensive reverification or, even worse, having to remake rope modules.

2. In line with that last remark, I would like to emphasize that no one involved in the development of programs as complex as these would ever be so naive as to claim a program was completely free of bugs. In fact I would like to emphasize just the opposite - that it is almost certain that deficiencies will exist in the program we ultimately fly. Of course, extensive effort will have been spent in checking the program to prove that it is safe and should perform adequately in the mission. It will always be our responsibility to describe accurately the quality of the flight programs to management, highlighting known deficiencies and describing, in whatever detail is required, the verification procedures which have been undergone in addition to stating some measure of our confidence in flight worthiness. We must not mislead management by overstating the quality of the flight program, since to do so is to implicitly take it upon ourselves to make the ultimate decision that a program is flight worthy - and that is not our job. This subject was discussed at MIT, and the reason that I mention it here is that I'm not sure this position is clearly understood by everyone.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000155

3. I had thought, and have told others, that Sundisk - the old AS-205 program - was a true subset of the AS-504 command module program. This turns out not to be the case in that not only must unique processors be added to Sundisk to support the lunar landing mission, but also some of the Sundisk processors themselves must be modified before they will be capable of supporting both earth orbital and lunar landing missions. Our current plans are not to make those modifications prior to the Sundisk release.

4. A number of modifications and additions are being made to the Sundisk AS-205 program in accordance with the wishes of various elements of MSC, such as use of the reticle for aligning the platform, providing the pilot the "mark" input capability from his couch position via the DSKY, and some others. There is at least one big one, however, which will not be added because its impact on release of the program is too great. This is the capability of performing rendezvous navigation (i.e., state vector updating) utilizing reticle observations.

5. We have requested MIT to provide us an MCRB for changing the program such that it will recognize depression of the Standby button as a signal both to "Standby" and "Proceed". We expect to make this program change regardless of whether or not the computer itself is modified, since that is immaterial to the program and the likelihood of its being implemented in the computer is quite great.

6. We had been asked to have MIT investigate and propose RCS jet select logic capable of handling individual jet failure as opposed to total quad failure. This would obviously require considerable amount of MIT effort and significant changes in the spacecraft computer program if it were to be implemented. As a result, we told MIT to do nothing on this until a much more precise requirement had been established by MSC.

7. We have recently had discussions with MSFC regarding the use of the LM spacecraft computer servicing their Apollo Telescope Mount (ATM). There was some concern expressed by MSC people that it might be necessary to provide coupling of the LM and command module guidance and propulsion systems, particularly to carry out the terminal rendezvous in the docked configuration. Without commenting on the advisability of this cross coupling for this purpose, I would like to remind everyone that according to MIT a data channel has been provided on these computers to handle that sort of an interconnection. I must confess that I didn't realize they existed.

Development of the spacecraft computer programs seems to have become routine enough that our program development plan meetings should occur no more frequently than once every three or four weeks, and it's our intention to schedule them that way. The next meeting is now set for May 10, in Beantown.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

00000156

UNITED STATES GOVERNMENT

Memorandum

TO : See list

FROM : PM/Deputy Chief

SUBJECT: Computer program requirements for AAP

On April 20 we had a meeting to assemble preliminary spacecraft computer program requirements for AAP missions 1 through 4. This is one step in the process of assembling a program requirements document needed to provide a basis for sensible contract negotiations with MIT and to provide a basis upon which MIT may proceed with preparation of the Guidance System Operations Plan [GSOP]. Personnel from AAPO, MPAD, FSD and CMC were represented. (I neglected to include Flight Crew people through some sort of stupid oversight, and I'm very sorry about that. But we will be getting together again, I'm sure.)

We did this job in two steps, first by identifying which of the individual processors in the AS-504 LM and CM and module programs were necessary and which ones could be deleted for the AAP missions. And then we went on to identify, as well as we could, all of the additional unique AAP requirements which must be added in. We attempted to list programs to support all of the proposed flight operations we have about based on the assumption it would be better to drop them from the list later than to risk overlooking them.

Following is a "required/deleted" list of the AS-504 CMC processors to support AAP 1 and AAP 3. [AAP 1 is a CSM LEM combination which will rendezvous with the AAP 2 S-IVB workshop, docking and multiple docking adapter. AAP 3 is a 56-day duration CSM which rendezvous with the AAP 4 LM/Apollo Telescope Mount (ATM) and the AAP 2 S-IVB workshop]. Of course, a number of non-mission programs [executive and service types] not listed here must also be carried over. Our preliminary estimate is that these deletions will free up about 5100 words of storage -- certainly not an excessive amount.

Required	Deleted
P00 CMC Idling	P07 [illegible]
P01 Prelaunch Initialization	P15 TLI Prethrust & Thrust
P02 Gyro Compass	[illegible]
P03 Optics Verification	P22 Lunar Orbit Navigation
P05 CMC Startup	P23 Cis-Lunar Navigation
P06 CMC Power Down	[illegible]
P11 ECT Monitor	P26 LOI Initialization
P20 Rendezvous Navigation	[illegible]
P21 Ground Track	[illegible]

[illegible]

00000157

CSC processors (cont'd)

Required	Deleted
P27 CSC Update	P37 Return to Earth Target (RTE)
P30 External ΔV	P65 Entry Up-Control
P31 Lambert Aim Point	P66 Entry Ballistic Phase
P34 Transfer Phase Initiation (TPI)	P70 Safe Perilune Target (PTS)
P35 Transfer Phase Mid. Corr (TPM)	P77 TPI Search
P40 DPS Thrust Maneuver	
P41 RCS Thrust Maneuvers	
P47 Thrust Monitor	
P51 IMU Alignment Determination	
P52 IMU Re-alignment (Sextant)	
P53 IMU Re-alignment (Backup using Telescope)	
P61 Entry Maneuver to Separate	
P62 Entry Sep. Maneuver	
P63 Entry Initialization	
P64 Entry Post .05 G Phase	
P67 Entry Final Phase	
P74 TPI (LM)	
P75 TPM (LM)	
R30 Orbit Parameter Display	
R31 Rendezvous Parameter Display	
R32 Target ΔV	

The following capabilities may be retained, modified or added to the CSC program processors listed above:

1. Digital Autopilots:

   a. A digital autopilot(s) is required to control RCS translation and attitude maneuvers for the following vehicle configurations:

      (1) CSM alone
      (2) CSM with LM/SS attached
      (3) CSM with LM/ATM attached
      (4) CSM with cluster(s)

   b. A digital autopilot(s) to provide thrust vector control (TVC) of the SPS engine is required for translational maneuvers of the following vehicle configurations:

      (1) CSM alone
      (2) CSM with LM/SS attached
      (3) CSM with LM/ATM attached

   c. A special digital autopilot may be required to control the integrated module RCS during the firing of the solid rocket, if they are provided for a backup aborts capability on the AAP 3 command module.

2. The following capabilities are required in support of the AAP 3 [illegible] operations:

00000158

a. Local vertical hold mode utilizing the IMU digital autopilot for the CSM with LESS attached.

b. The capability to compensate for the actual alignment of the LESS [and other components which make up the over-all cluster] with the command module "nav base" in order to provide attitude control of them.

c. A landmark sighting routine utilizing the sextant.

3. Additional requirements to support AAP 1:

a. As a result of the severe Return payload constraint, it may be necessary to provide guidance to the SPS engine serving as a third stage of the launch vehicle to get into orbit. If this does become a nominal part of the mission, as opposed to Contingency Orbit Insertion previously considered for main line Apollo, it will probably be necessary to also include some processing and displays to support crew backup procedures and abort procedures.

b. If a rendezvous radar is added to the command module, it will probably be desirable to utilize its observations in the rendezvous navigation processing. This could be in addition to or in lieu of sextant observations.

c. Special preferred alignment programs are almost certainly required in support of various experiments to provide unique attitude hold capabilities and/or attitude time history profiles.

d. Special solid retrorocket sequence to assist in attitude control during and after their firing may be necessary.

e. New telemetry downlists will be required.

f. Auto optics search and gimbal lock avoidance - programs deleted from the main line Apollo programs - may be restored to the program for AAP if storage permits.

g. Since the command module has been assigned the task of many complex operational rendezvous, it may be desirable to add the onboard capability of targeting the nominal rendezvous maneuvers [CSI and CDH] - programs we have deleted as unnecessary from the AAP 4 LM program. Storage probably will not permit this 1200 word addition which is certainly not mandatory.

h. Some inflight test programs may be desirable to check out the guidance system prior to its use following extended powered down periods.

i. Reconsideration is being given to including an automatic [rendezvous] braking capability.

Pertaining to a list of "required/deleted" AS-504 LM programs for use on [illegible]. Our probability estimate is that those deletions will [illegible] words of storage.

00000159

Required	Deleted
P00 LGC Idling	P07 System Test
P01 LGC Initialization	P10 Predicted Launch Time (CPF)
P02 AGS Initialization	P11 Predicted Launch Time (TPI)
P05 LGC Startup	P12 Powered Ascent Guidance
P06 LGC Power Down	P17 TPI Search
P20 Rendezvous Navigation	P22 MR-Lunar Surface Navigation
P21 Ground Track Determination	P32 CSI Prethrust
P25 Preferred Tracking Attitude	P33 CDH Prethrust
P27 LGC Update	P36 TPF Maneuver
P30 External ΔV Prethrust	P40 DPS Thrust Prog.
P31 General Lambert	P42 APS Thrust Prog.
P34 TPI Prethrust	P55 Lunar Surface Align (Normal)
P35 TPM Prethrust	P56 Lunar Surface Align (Backup)
P41 RCS Thrust Prog.	P57 Any Time Launch Align
P47 Thrust Monitor	P60 Predicted Lunar Land. Time
P51 IMU Orientation Determination	P61 DOI Maneuver
P52 IMU Realign	P63 Landing Braking
P53 LVD Realign (Backup using LPD reticle)	P64 Landing Approach
P74 TPI (CSM)	P65 Landing (Auto)
P75 TPM (CSM)	P66 Landing (ROD)
R30 Orbit Parameter Display	P67 Landing (Manual)
R31 Rendezvous Parameter Display	P70 DPS Abort
R32 Target ΔV	P71 APS Abort
	P72 CSI (CSM)
	P73 CDH (CSM)
	P76 Transearth Inject (TEI) Backup

Since the LM will be equipped with neither a Descent Propulsion System [DPS] nor an Ascent Propulsion System [APS], it is also possible to delete three AS-504 LM digital autopilots completely - namely, the APS, DPS and the command module-LM docked DPS [so-called SPS backup].

The following capabilities may be retained, modified or added to the LGC processors listed above:

1. RCS digital autopilots for control of translation and attitude maneuvers in the following vehicle configurations:
   a. LM/ATM, with solar arrays both extended and retracted
   b. LM descent stage only [if it is possible to jettison the ATM].
   c. LM/ATM with CSM attached, with solar arrays both extended and retracted.
   d. LM when docked to the cluster.
2. Other special LGC processor requirements follow. [illegible]

00000160

a. New telemetry downlists will be required.

b. Restoration of gimbal lock avoidance.

c. Some inflight test programs may be desirable to check out the guidance system prior to its use following extended powered down periods.

d. The MSFC is currently studying the desirability of utilizing the LGC to support their ATM and control moment gyro requirements as opposed to providing their own computer and/or special electronics. If they determine the LGC should be used they will document their requirements.

e. Reconsideration is being given to including an automatic rendezvous braking capability.

It is anticipated that within a month, a more formal spacecraft computer program requirements document will be distributed by the Flight Software Branch of the Flight Support Division. It will incorporate the results of action items assigned to various MSC elements at this meeting, such as:

1. The more precise definition of DAP requirements, which is the responsibility of GCD [Cox/Lins].

2. Definition of the special preferred attitude program requirements in support of experiments, assigned to MPAD [Hunt].

3. The detailed requirements for the LESS mission, assigned to AAPO and MPAD [Ernull].

4. Definition of the solid retro sequence requirements, assigned to MPAD [Weber].

5. The reconsideration of automatic braking, assigned to GCD [Klinar].

The purpose of distributing this memorandum is to inform you of what is going on in this area as well as to solicit your comments. We are particularly interested in being informed of omissions and would appreciate your assistance in providing more detail in the definition of the items above.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

00000161

[illegible] Kraft, Jr.

UNITED STATES GOVERNMENT

Memorandum

Bill — I guess we had better get George L & myself in on all the [illegible] this act [illegible] information that you don't have [illegible] this decision [illegible] [illegible]

TO : See list

DATE : [illegible]

FROM : FM/Deputy Chief

SUBJECT: MIT's digital computer facilities are still a problem

On April 12 at MIT we spent almost the whole morning discussing justification for and status of the IBM 360/75 computer installation they use for spacecraft computer program development. As of today, we haven't really resolved the issue of whether or not we should retain that computer at MIT. On the other hand, I think the exercise was fruitful in that we all - MIT and MSC - have a much better understanding of the situation.

Briefly, the situation is something like this. Back in November and December we were faced with the problem of producing command module and LM programs for the AS-258 mission to be flown in August 1966. This was going to put heavy demands on the MIT digital computer facility, which consists of two Honeywell 1800 computers. At the same time it was easy to see that during the first two or three months of 1967 that facility would be entirely saturated with work on the AS-206 unmanned LM mission which, flying sooner, necessarily had higher priority. At that time the only apparent thing we could do was to get their IBM 360/75 operational at the earliest possible date, which at that time appeared to be in February of 1967. As it turned out, in spite of our very best, intense efforts, the 360/75 has not become an operational facility even today, and our current estimate is that it probably will not be carrying any appreciable load until August or September. The programming work remaining to be done to make it operational is to finish development of the MAC compiler and to debug the IBM supplied programming systems. Although MIT does not admit it, I suspect that there are also significant hardware problems in the IBM installation which require fixing.

Now that all of the manned missions have slipped to a point where spacecraft computer programs are no longer pacing, there is no question in my mind that the two Honeywell 1800 computers at MIT can carry the entire load at MIT for the foreseeable future - say through calendar year 1968. In other words, we [illegible] no [illegible] need for the IBM 360/75 unless it offers us some significant [illegible]. It is MIT's position that the IBM 360/75 does not cost much more [illegible] the Honeywell 1800's over the period from now until the end of 1968 [illegible] does offer growth potential. Thus they feel that it is to [illegible] advantage that they retain the IBM 360/75 and phase out the Honey[illegible]'s as soon as that is practical. Their phaseout plan is optimistic, [illegible], since they propose to remove a Honeywell 1800 around the first of [illegible]st, which I feel is at least three or four months too soon. [illegible] it was

brought out in our discussion that the second Honeywell 1800 must be retained until postflight analysis of the AS-502 mission is completed. Therefore, the cost of phasing over to the IBM 360/75 is more expensive than getting rid of it, but something that must be considered is that the Honeywell 1800's must be phased out someday. Based on all this, and an MIT moral factor, CAD's Assistant Division Chief, Ralph Everett, recommended, and I agreed, that we should probably allow MIT to proceed on the course they have charted.

But this thing still bugs me, so I got ahold of the Honeywell representative to explain the over-all situation. He is now in the process of checking with his company to see if it is possible to obtain a significant cost reduction on the MIT Honeywell 1800 computers assuming that they would be retained until the second half of calendar year '68, operating on a three shift, seven day a week schedule. At that time, consideration would be given to phasing in one of their Honeywell 8200 computers, which by that time should have proven itself truly operational in the field. In addition to saving money, this approach permits us to take advantage of the compatibility of all the programs in use at MIT on the Honeywell 1800 plus avoiding having to debug the over-all system like we are going through now on the IBM facility. Part of this plan, of course, would be to remove the IBM 360/75 from MIT at the earliest possible date and to stop all effort on the programming for that facility which has forced MIT to divide its attention and efforts in order to have programs which will operate on both the Honeywell 1800's and the IBM 360/75. This division of effort is very distressing since very high level talent is required and work on the Honeywell 1800 programs will be going down the drain if we switch to the IBM 360/75. Going to a Honeywell 8200 means all effort could be concentrated on Honeywell 1800 programs which will be compatible with that machine.

Our next decision point is when the Honeywell representative reports back to Ralph Everett and me on the result of his Honeywell 1800 rental reduction mission. If those results are favorable, we will investigate with him the cost of a Honeywell 8200 computer in the configuration needed by MIT. If, as I hope, this is attractive in terms of both cost and growth potential, we will examine with MIT the advantages and disadvantages of their current approach versus the Honeywell approach.

/s/ Howard W. Tindall, Jr.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

00000163

UNITED STATES GOVERNMENT

Memorandum

NASA-Manned Spacecraft Center
Mission Planning & Analysis Division

TO : See list

DATE: APR 21 1967

FROM : FM/Deputy Chief

67-FM1-32

SUBJECT: Descent engine gimbal polarity error

A serious misunderstanding between MIT and Grumman resulted in a situation which would have been catastrophic to the AS-206 mission if it had not been discovered. Specifically, the direction the LM descent engine gimbals move when commanded by the spacecraft computer was opposite to the way they were supposed to. Upon discovery of this, Grumman immediately dispatched a TWX widely distributed through MSC, and perhaps elsewhere, placing the fault for this inconsistency on MIT. Since it was easier to make the necessary modification in the software than the hardware, we chose to do that - thus giving further weight to the idea that the MIT work was faulty, which I simply do not believe to be the case. I am distributing the attached letter from MIT which explains the situation in some detail in order to dispel the erroneous accusations you may have heard and believed.

Of course, finger pointing is not constructive, and I would like to emphasize that a number of positive steps have been taken. Their purpose is to improve the understanding of the various parties associated with these interfaces and improving coordination of their testing to make sure a vehicle is never flown with anything as fouled up as this. Also, it is worth noting that this discrepancy was detected well in advance of the mission and in time that something could be done about it fairly easily. Even if we had done nothing, I would expect on future spacecraft that this sort of thing would be found sooner as a result of much earlier delivery of spacecraft computer programs and earlier readiness of the test facilities to verify its interfaces with a flight hardware.

Howard W. Tindall, Jr.

Attachment

Addressees:
(See attached list)

Response to MIT's defense

9010-100

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS
INSTRUMENTATION LABORATORY
CAMBRIDGE, MASS. 02139

Tom Hall

NASA Manned Spacecraft Center
Houston, Texas 77058

Attention: Mr. W. R. Kelly, PP7

Through: NASA/RASPO at MIT/IL

Subject: Descent Engine Gimbal Polarity Error

References:
(a) LTX 500-52, Coursen to Young, 23 March 1967
(b) LM PGNCS Performance and Interface Specification, LSP-370-3, EDP Sheet #12, Paragraph 3.1.4.3(a), 18 March 1966
(c) Functional ICD LIS 540-10001
(d) LGC Electrical ICD LIS 370-10004 (Rev. B signed 25 May 1966), Sheet 39
(e) Memo, Stameris to Hoag, 23 March 1967
(f) Telephone call, Kayton and Hoag, 23 March 1967
(g) Report R-527, Rev. 1, Guidance System Operations Plan AS 206, Vol. 1, January 1967, pages 3-65 and 3-66
(h) Telephone call, Gibson to Miller, 23 March 1967
(i) Letter AG 144-67, Stameris to Smith, 27 March 1967

Gentlemen:

Ref. (a) TWX from GAEC states the AS 206 program, SUNBURST 113, which was delivered from MIT to the GAEC FCI 6 DOF simulation laboratory had a reversal of polarity in the DPS trim gimbal commands. This GAEC TWX further states ... "It was determined that this reversal was not caused by a wiring error in the laboratory but was due to a programming error."

MIT firmly disagrees with GAEC on this subject and herewith wishes to go on record that the polarity incompatability was not due to an error in the SUNBURST 113 AS 206 LGC program but was due to the FCI 6 DOF simulation at GAEC being wired backwards from that specified in controlling interface documentation. Apparently LM 1 is also wired incorrectly.

00000165

We believe the LM wiring mistake occurred due to confusion between the actual commanded motion of the gimbal from the subject signal and the eventual vehicle attitude response. If the command signal asks for a positive rotation of the descent engine trim gimbal with respect to the vehicle, the response of the vehicle with respect to space is negative angular acceleration - both variables defined in a right handed sense about the appropriate axis. The signal in question is that which commands a rotation rate of the trim gimbal. Its polarity definition should be and has been in terms of this variable and not in terms of the resulting spacecraft motion.

Pertinent controlling interface documentation to define the DPS trim gimbal drive signal polarities are the P&I spec (Ref. b), the Functional ICD (Ref. c), and the Electrical ICD (Ref. d) all of which have both GAEC and MIT signatures. In each of these documents the signals in question are identified as those which drive the descent engine trim gimbal. In each of these documents the signals are labeled in substance as "plus (or minus) pitch (or roll) trim gimbal signals." The LGC program was consistent with these definitions.

It has been stated (Ref. e and Ref. f) that the AS 206 GSOP, (Ref. g), which is written by MIT, supports the polarity convention with which GAEC wired the spacecraft. This is supposedly demonstrated by an equation on page 3-65 which relates positive vehicle angular acceleration to the positive variable "δ". This variable, however, is not the gimbal trim angle as argued, but instead is the angular difference of the vehicle CG to the thrust vector about the gimbal pivot. The gimbal trim angle command is variable "U" which is defined on page 3-66, a definition which is consistent with the interface documents. (An equation in the GSOP relating to this command signal is written with an error. Although this error was discovered and did not get propagated into the program for AS 206, the GSOP correction will not be made until the next revision of that document which is now in process.)

In order to fix the incompatability, MIT has been directed by MSC (Ref. h) to make changes in the SUNBURST program so as to send gimbal trim commands according to the polarity with which the spacecraft is wired. This change now exists in SUNBURST, Revision 116. Because this revision now is in violation to the ICD, MIT has initiated an interface change request authorization to GAEC (Ref. i) to issue an IRN making an appropriate ICD change.

Very truly yours,

D. G. Hoag

D. G. Hoag
Director
Apollo Guidance & Navigation

DGH:alr

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS 77053

APR 25 1967

IN REPLY REFER TO: 67-FM1-31

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
Attention: D. G. Hoag, Director, Apollo G&N Program

FROM: Project Officer Guidance and Navigation
Apollo Spacecraft Program Office

SUBJECT: Contract NAS 9-4065, Letter of Direction Concerning Program Development

This letter is to modify your contractual obligation to provide a unique spacecraft computer program for use on the first manned LM mission (formerly designated AS-208). This change in direction is brought about by the slip in the launch schedule for that mission, which makes it probable that sufficient time is available to complete the development of the LM lunar landing program (formerly AS-504 LM) in time to support the first manned LM mission. In confirmation of agreement reached between MIT and MSC representatives, it is understood that the development of the LM lunar landing program will proceed in such a way that no more than three months would be required between a decision to stop implementing additional capabilities into this program and the date of its release to Raytheon for rope manufacture. Our intention, of course, is to monitor the development of this program and the scheduled launch date such that if it becomes apparent the lunar landing program will not be available in time, it will still be possible to provide a flight qualified program for this development mission, which has a capability no less than had been planned for AS-208. Proceeding in this manner should assure provision of the highest quality flight program for that mission as well as resulting in a significant reduction in work. It also reduces the risk of having to make modifications in that program which might result if we were to have released it unrealistically early.

It may be necessary to give special consideration to the command and downlink formats to assure compatibility of the spacecraft computer program with their counterpart in the MCC-H to avoid unacceptably expensive effort. Items of this nature will be negotiated on an individual basis.

W. R. Kelly

00000167

bcc:
EG442/RASPO/MIT
EG443/RASPO/ACSP
NASA Hqs, Attn: MA
ASPO Files (2)
EG55/P. McCathy
EG/D. C. Cheatham
EG44/W. J. Rhine
PA/R. G. Rose
PS/L. C. Dunseith
PA141
PD4/A. Cohen
PF/R. W. Larzkron
PM2/R. Ward
PM2/C. Perrine
PM3/R. Battey
PPT

FM:HWTindall, Jr.:cm 4/21/67

UNITED STATES GOVERNMENT

Memorandum

TO : FS5/T. P. Gibson, Jr. DATE: APR 1 8 1967

FROM : FM/H. W. Tindall, Jr. 67-FMA-30

SUBJECT: Proceed button

Looks like we're approaching the final chapter in the proceed button story. As I understand it, all manned Apollo spacecraft will have computers wired such that the standby button serves the dual purpose of standby function, as before, and a proceed function duplicating Verb 33 Enter. At least, that is the current intention. Apparently there is some little uncertainty remaining on the first manned command module mission - Spacecraft 101 - in that Raytheon may not deliver the computer in time and an old, unmodified one might be used. However, as I understand it, there is no disadvantage in fixing the program such that it will respond to the standby button as noted above even though the computer has not been modified. If not, I see no reason for not going ahead with the change in the computer program immediately rather than waiting to see if Raytheon will deliver on time. MIT is checking this, aren't they? - and will follow up with the necessary MCRB.

Howard W. Tindall, Jr.

cc:
CB/T. P. Stafford
EG/R. A. Gardiner
FA/C. C. Kraft, Jr.

FM:HWT:cm

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

TO : See list DATE: APR 3 1967

FROM : FM/Deputy Chief, Mission Planning & Analysis Division 67-FMA-29

SUBJECT: Interim progress report - RTCC program development - AS-258(!) Ground Support Simulations Computer [GSSC] programs

I haven't gone very far into the AS-258(!) GSSC review yet. However, some things are beginning to crystallize. This memo is to list some of the conclusions I have tentatively reached. I would be very much interested in your comments the next time we get together.

1. As you know, four modes of operation were being provided in the GSSC, each of which requires a complex computer program. They are:

a) GSSC by itself, providing complete CSM and LM models

b) GSSC operating with the Apollo Mission Simulator [AMS], and providing the LM model

c) GSSC operating with the LM Mission Simulator [LMS], and providing the CSM model

d) GSSC operating with both the AMS and the LMS

It seems to me that modes (a) and (d) are needed for obvious reasons. However, if it saves effort, I would recommend deleting mode (c) and reducing mode (b) such that the GSSC can operate with the AMS only for mission phases without a free flying, powered up LM. That is, I see no occasion for simulating a LM active mission phase in conjunction with the AMS but without the LMS also operating.

2. For the mode in which the GSSC operates without either the AMS or the LMS, I would cut back modeling of the spacecraft Guidance, Navigation and Control Systems [GNC] in both the CSM and LM to provide only realistic launch and in-orbit maneuver capability. I would delete all parts strongly involving the astronaut, such as onboard rendezvous activity and reentry. This does not mean that realistic rendezvous and reentry simulations could not be carried on.

a) Rendezvous simulations would be performed assuming the ground [MCC-H] is the prime source of maneuver targeting which would be carried out by the spacecraft using the External ΔV guidance maneuver mode. That is, there would be no onboard processing of observations or state vectors to obtain maneuver requirements.

b) I would "shut off" the GSSC after the spacecraft reaches the entry interface, thereby eliminating the need for modeling any

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000170

spacecraft aerodynamics, command module RCS activity, GNC, etc., associated exclusively with entry. Incidentally, both the systems and trajectory flight controllers agree that this is not unreasonable.

The advantage of this is obvious. The GNC is the most complex system to model and the last to be defined (with the possible exception of spacecraft aerodynamics!). Deletions of this type substantially reduce the work and help avoid late checkout and delivery of the GSSC due to lack of definition. And I don't think it reduces quality of the training significantly. (I have documented my views in this area more completely and specifically in the attached appendix).

3. All simulation of AGS computer programs should be dropped with the possible exception of some of its telemetry downlink (that which is conveniently available already). That is, AGS controlled maneuvers can be simulated using the GSSC PNGS if necessary. There is no need to model that system, that I can see.

4. I see no need to simulate the launch phase of the (old) AS-208 Saturn with a powered down LM since there is no flight controller action required or systems evaluations to be gained during this phase. Deleting this would eliminate need to model the variable launch azimuth - a substantial effort, I am told.

Although the above recommendations are not final, they're probably not far from it. Along with finishing off those areas, I expect to start looking into the following next:

1. Simulation control display requirements.
2. Need for special programming and simulated displays for the insertion ship flight dynamics officer.
3. Need for modeling an EVA astronaut.
4. Review the SCS mode of thrusting.

Howard W. Tindall, Jr.

Attachment

Addressees:
(See attached list)

Addressees:
FA/C. C. Kraft, Jr.
FA/S. A. Sjoberg
FC/J. D. Hodge
FC3/A. D. Aldrich
FC5/G. S. Lunney
FC6/H. G. Miller
FC6/R. H. Koos
FS/L. C. Dunseith
FS2/J. A. Miller
FS2/P. Segota
FS5/R. O. Nobles

FM:HWTindall:cm

GSSC AS-258 Program Review Notes - Part 1 (GNC)

1. All simulation of AGS computer programs should be dropped with the possible exception of some of its telemetry downlink (that which is conveniently available already). That is, AGS controlled maneuvers can be simulated using the GSSC PNGS if necessary. There is no need to model that system that I can see.

2. All state vectors, REFSMMAT's and targeting for maneuvers must come from the MCC-H (Mission Program) either by uplink or voice. This data should all be input to the GSSC in the most convenient way with no attempt at simulating the prethrust programs.

3. Offhand, I see no need for simulating spacecraft attitude except during maneuvers (if even that is necessary). It seems to me attitude changes can be made (for maneuver initialization) instantaneously.

4. By the same token, platform realignment should be carried out instantaneously based on the ground supplied REFSMMAT.

5. GSSC simulation can be stopped following execution of the retrofire maneuver except to continue state vector updating for tracking and telemetry. Of course, if retrofire is unsuccessful the simulation should continue on in orbit. The point is, there is no need to simulate the separation maneuver and attitude changes (unless the AS-501 simulation is adequate for this). All reentry business should be deleted - digital autopilot, guidance, RCSSthruster, aerodynamics, spacecraft sequences, etc. (This also applies to launch aborts).

6. All rendezvous targeting should be deleted, trajectory and telemetry to be carried out in same way as all other maneuvers. The single exception to this is to supply LM rendezvous radar range and range rate on the LGC downlink (no angles, no optics).

7. No spacecraft state vector updating (i.e., navigation) will be carried out using optics, spacecraft radar, etc. This had not been planned anyway. Of course, Average g integration is needed during maneuvers which does update the state vector.

8. Launch monitoring should be modeled for the AGC downlink including DSKY displays (these to be restricted to the nominal, standard format - not the entire pilot choice). None of the computations associated with crew monitoring of the launch vehicle should be included, such as Saturn polynomials, etc. That is, downlink should be constrained to be only those quantities used for the insertion GO-NO GO decision and subsequent action.

9. Standard coast-phase downlink should be modeled - at least to the extent that the data is easily available and useful. Things like "CDU desired" could be omitted since spacecraft attitude means nothing.

10. I guess there's no way of avoiding relatively complete modeling of the propulsion systems and associated guidance for SPS, DPS, APS, RCS maneuvers including attitude control. This is needed for realistic telemetry when the maneuvers occur over ground stations and realistic trajectory data when the burns are very long and over a site. Furthermore, I suppose

modeling of these systems may be pretty complete already (carried over from AS-501 and 206). Care should be taken not to redo the DAP if the Block I does the control job.

11. Obviously, if other parts of the GNC modeling have been completed, consideration should be given to including them. But this should not be automatic approval since maintenance is required which must be traded off against value to the training.

AGC/LGC Program Modeling Requirements Summary

Program	LGC	CMC
P00	Model *	Model *
P01	Model *	Model *
P02	Delete	N/R
P03	-	N/R
P04	-	Delete
P05 & 06	N/R	Delete
P07	-	N/R
P11	-	Model
P20	Delete (except RR r*)	Delete
P21	N/R	N/R
P22	-	N/R
P23	-	N/R
P25	Delete	-
P26	-	N/R
P27	Model *	Model *
P30	Model *	Model *
P32	Delete	-
P33	Delete	-
P34	Delete	Delete
P35	Delete	Delete
P36	Delete	Delete
P40	Model	Model
P41	Model	Model
P42	Model	-
P47	N/R	Model (for SCS?)??
P51	Model *	Model *
P52	Delete	Delete
P61	-	Delete } Unless carried
P62	-	Delete } over intact
P63	-	Delete } from AS-501.
P64	-	Delete
P67	-	Delete

* MED and limited downlink only.

00000174

Following uplink command formats should be recognized by the LGC and CMC models:

	CMC	LGC
CSM state vector	x	x
LM state vector	x	x
External ΔV targeting	x	x
REFSMMAT	x	x
EMU A	x	x
EMU B	x	x
Retro External ΔV targeting	x	
Time increment	?	
Liftoff time	?	

FM:HWTindall:cm
April 3, 1967

TO : Bill Tindall

SUBJECT: LM S-band antenna boresight change

Regarding your memo on the same subject (67-FM1-28), I agree that there is no problem in changing the S-band antenna mount as far as the software is concerned. It only means substituting new equations in place of the old ones. However, I am not sure who is going to provide us the information concerning the transformation between the S-band gimbal system and the navigation base when and if this change is made. In other words, someone is going to have to pulse us in order that we can put the proper mathmatical equations in the LGC.

Ira Gibson

00000176

UNITED STATES GOVERNMENT

Memorandum

TO : FA/Technical Assistant for Apollo DATE: APR 3 1967

FROM : FM/Deputy Chief, Mission Planning & Analysis Division 67-FMA-28

SUBJECT: LM S-band antenna boresight change presents no LGC problem

This memo is in confirmation of our telephone conversation March 30, 1967 regarding LM S-band antenna acquisition. As you are aware, some months ago we reinstated to MIT the requirement for providing DSKY displays of pointing angles compatible with the astronaut's S-band antenna controls to assist him in acquiring the MSFN while in lunar orbit. (Actually, the pointing angles are those which, if utilized, cause the antenna to be pointed toward the center of the earth).

During our chat, I gave you assurance that the contemplated change in the alignment of the S-band antenna boresight would not seriously perturb the formulation of this LGC processor. Subsequent checking has reaffirmed that, so I say to you - "have at it".

Original Signed By:
Howard W. Tindall, Jr.

Howard W. Tindall, Jr.

cc:
FB5/T. F. Gibson, Jr.
FB5/P. J. Stull

FM:HWT:cm

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

TO : See list DATE: MAR 3 0 1967

FROM : FM/Deputy Chief, Mission Planning & Analysis Division 67-FM1-27

SUBJECT: Current plans for downlink of LM radar data

There have been so many questions asked about what rendezvous and landing radar data will be on the LGC downlink, I asked Paul Stull to fill out the attached table which, as you see, he has done. He has greatly emphasized that this whole business is still ill-defined and, therefore, the numbers given must be considered preliminary. In spite of that, I felt it desirable to circulate this around - if only to arouse interest and comments in hopes that it might speed up that definition. We will update and recirculate this thing whenever it seems appropriate.

The lists are for the lunar landing LM program (formerly designated AS-504 LM). This reflects our intention of only producing a single program for all manned LM flights, although I suppose it might be necessary to modify the downlist somewhat to satisfy special postflight analysis requirements on the early flights.

Howard W. Tindall, Jr.

Addressees:
EG/R. G. Chilton
EG/D. C. Cheatham
EG43/R. E. Lewis
EG43/M. Kayton
EG43/C. F. Wasson
PA/W. A. Lee
PD4/A. Cohen
FA/C. C. Kraft, Jr.
FA/S. A. Sjoberg
FA/R. G. Rose
FC/J. D. Hodge
FC2/E. F. Kranz
FC2/J. W. Roach
FC3/A. D. Aldrich
FC4/M. F. Brooks
FC4/J. E. Hannigan
FC5/G. S. Lunney
FC5/C. E. Charlesworth
FC5/P. C. Shaffer
FC5/C. B. Parker
FC5/J. S. Llewellyn
FS5/J. C. Stokes, Jr.
FS5/T. F. Gibson, Jr.
FS5/P. J. Stull
FM/J. P. Mayer
FM/C. R. Huss
FM/M. V. Jenkins
FM13/J. P. Bryant
FM/Branch Chiefs

FM:HWT:cm

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

RADAR DATA AVAILABLE ON DOWNLINK

Radar (~~Rendezvous~~ Landing) cross out one. Computer Program (~~Earth-Goddard~~, Lunar Landing) cross out one.
Values listed are the rate at which the radar data is updated in the downlist per minute.

PRELIMINARY

LOC PROGRAMS / MISSION PHASE	P00 LOC Idling	P01 LGC Initialization	P02 AGS Initialization	P03 LGC Startup	P04 LGC Power Down	P05 Self-Test	P10 Predicted Launch Time (CFP)	P11 Predicted Launch Time (TPI)	P12 Powered Ascent Guidance	P17 TPI Search	P20 Rendezvous Navigation	P21 Ground Track Determination	P22 MR Lunar Surface Navigation	P25 Preferred Tracking Attitude	P30 External ΔV Prethrust	P32 COI Prethrust	P33 CDH Prethrust	P34 TPI Prethrust	P35 TPM Prethrust	P40 TTV Maneuver	P41 DPS Thrust Prog.	P42 RCS Thrust Prog.	P47 APS Thrust Prog.	P51 IMU Orientation Determination	P52 LM/IMU Realign	P61 Lunar Surface Align (Normal)	P62 Lunar Surface Align (Backup)	P67 Any Time Launch Align	P63 Pred'ctd Lunar Landing Time	P64 LOI Maneuver	P66 Landing Braking	P64 Landing Approach	P65 Landing (Auto)	P66 Landing (ROD)	P67 Landing (Manual)	P70 DPS Abort	P71 APS Abort	P72 CSI (CSM)	P73 CDH (CSM)	P74 TPI (CSM)	P75 TPM (CSM)	P77 Transearth Inject (TEI) Backup	Orbit Parameter Display	Maneuver Parameter Display	P30 Target ΔV
1. Lunar Orbit (Pre DOI)	0	NA	0	0							0	0											0	0	0			0															
2. DOI & Descent Coast	0											0	0	0							0								0														
3. Powered Lunar Landing Maneuver			0																						0				30	30	30	30	30									
4. Lunar Surface Phase	0				0																																						
5. Lunar Prelaunch Phase			0	0			0	0																		0	0	0															
6. Powered Ascent Phase									NA																																		
7. Rendezvous (LM Active-Self Cont)			0							0	0	0		0		•	•	•	•	NA	•	0																					
8. Rendezvous (LM Active-Ext Calc)											0			0	•				•	NA	•	0																					
9. Rendezvous (CSM Act-LOC Passive)														0																													
10. Rendezvous (CSM Act-LOC Calc)											0	0		0																							0	0	0	0				
11. Transearth Inject (TEI) Backup		NA		0	0										0						0				0	0														0			
12. Dese Orbit Abort (PGNCS-Self Cont)										0						0	0	0	0	NA	0	0	NA																				
13. Dese Orbit Abort (PGNCS-Ext Calc)															0					NA	0	0	NA																				
14. Powered Landing Aborts																																			0	0							
15. AGS Aborts																							0																				
16. Aborts from Translunar (Prethrust & Maneuver)		NA		0	0										0						0																					

PGS:all/cm/ 3/24/67

* Unless the PGS MCRB routine gets in and stays in the LGC, this chart will be true.

** Altitude + 1 component of velocity every 2 seconds; 6 seconds for total update.

00000179

RADAR DATA AVAILABLE ON DOWNLINK

Radar (Rendezvous, ~~Landing~~) cross out one. Computer Program (~~Earth Orbital~~, Lunar Landing) cross out one.
Values listed are the rate at which the radar data is updated in the downlist per minute.

LGC PROGRAMS

PRELIMINARY

MISSION PHASE

Mission Phase	P00 LGC Idling	P?1 LGD Initialization	AGS Initialization	LGC Startup	LGC Power Down	P07 Systems Test	Predicted Launch Time (CSP)	Predicted Launch Time (TPI)	Powered Ascent Guidance	TPI Search	P20 Rendezvous Navigation	Track Determination	Lunar Surface Navigation	Preferred Tracking Attitude	ΔV Prethrust	CSI Prethrust	CDH Prethrust	TPI Prethrust	TPM Prethrust	TPF Maneuver	DPS Thrust Prog.	RCS Thrust Prog.	APS Thrust Prog.
1. Lunar Orbit (Pre DOI)	0	NA	0	0							1	0											
2. DOI & Descent Coast	0											0	NA	0							0		
3. Powered Lunar Landing Maneuver			0																				
4. Lunar Surface Phase	0				0																		
5. Lunar Prelaunch Phase			0	0			[illegible]	[illegible]															
6. Powered Ascent Phase									[illegible]														
7. Rendezvous (LM Active-Self Cont)			0							0	1	0		1		1	1	1	1	NA	0	0	
8. Rendezvous (LM Active-Gnd Calc)											1			1	1				1	NA	0	0	
9. Rendezvous (CSM Active-[illegible])														1									
10. Rendezvous (CSM Active-[illegible] Calc)											1	0		1									
11. Transearth Inject (TEI) Backup		NA		NA	NA										NA						NA		
12. Lunar Orbit Abort ([illegible]-Self Cont)										0						1	1	1	1	NA	0	0	0
13. Lunar Orbit Abort ([illegible]-Gnd Calc)															0					NA	0	0	0
14. Powered Landing Aborts																							
15. [illegible] Aborts																							
16. [illegible] ([illegible] Thrust & Maneuver)		NA		NA	NA										NA						NA		

Mission Phase	Thrust Monitor	IMU Orientation Determination	IMU/IMU Realign	Lunar Surface Align (Normal)	Lunar Surface Align (Backup)	Launch Align	Predicted Lunar Landing Time	1 ?O. Maneuver	Landing Braking	Landing Approach	Landing (Auto)	Landing (ROD)	Landing (Manual)	DPS Abort	APS Abort	[illegible] (CSM)	[illegible] (CSM)	[illegible]	[illegible] (CSM)	[illegible] Inject (TEI Backup)	[illegible]	[illegible] Display	Target ΔV
1. Lunar Orbit (Pre DOI)	0	0	0				NA																
2. DOI & Descent Coast								0															
3. Powered Lunar Landing Maneuver			0						0	0	0	0	0										
4. Lunar Surface Phase																							
5. Lunar Prelaunch Phase				0	0	0																	
6. Powered Ascent Phase																							
7. Rendezvous (LM Active-Self Cont)																							
8. Rendezvous (LM Active-Gnd Calc)																							
9. Rendezvous (CSM Active-[illegible])																						0	
10. Rendezvous (CSM Active-[illegible] Calc)																1	1	1	1				
11. Transearth Inject (TEI) Backup		NA	NA																	NA			
12. Lunar Orbit Abort ([illegible]-Self Cont)																							
13. Lunar Orbit Abort ([illegible]-Gnd Calc)																						0	
14. Powered Landing Aborts														0	0							0	
15. [illegible] Aborts	0																						
16. [illegible] ([illegible] Thrust & Maneuver)																							

[illegible]

* Preliminary Information.

** Requirement, not necessarily met.

*** Partial data.

00000180

UNITED STATES GOVERNMENT

Memorandum

TO : PA/Director of Flight Operations DATE: MAR 2 8 1967

FROM : PM/Deputy Chief, Mission Planning & Analysis Division 67-PMI-26

SUBJECT: Progress Report - RTCC program development - Review of AS-258(!) requirements

This lengthy memorandum deals with the recently completed review of AS-258(!) RTCC computer program requirements. I hasten to say, many other areas remain to be examined in our effort to bring the over-all job supported by the MCC-H to within acceptable bounds and to assure economical RTCC usage. Of course, specific actions resulting from our efforts are covered in detail by other memos and directives, primarily those issued by the Flight Support Division to IBM. In addition, several analyses have been initiated within MPAD. My primary objective here is to summarize what we did and to document, for historical purposes, the rationale behind some of the decisions made.

Before I do that though, there is something else I'd like to point out. It became apparent to me that our review meetings had significant benefit aside from the main purpose of making sure the requirements were all justified. It turned out that there were several areas in which misunderstandings existed about what the flight controllers wanted and what the Flight Support people were attempting to provide. Resolution of these differences should be beneficial by improving the program and, in some cases, by significantly reducing the effort required. Another benefit was the recognition that certain associated things were not being done and action was immediately initiated. Probably the most significant of these was the lack of definition of the AGC telemetry downlists by MIT which was severely impacting everyone's work - a problem we have taken steps to clear up. This also applies to renewed consideration of some displays provided to support certain flight controller functions but which are likely to be inadequate. Studies and analyses have been initiated to determine the inadequacy and, if necessary, to develop alternate proposals.

One other thing I probably should point out is that some of the processing and display capability which was identified as unnecessary in the AS-258 program obviously also applies to some of the earlier development flights. As a result, although we do not intend to go through a detailed review of AS-501 and AS-206 programs which have proceeded too far along to be fruitful, AS-258 deletions which also apply to those development flights are being made.

As usual, the material will be covered separated into three categories - trajectory, command and telemetry.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000181

Trajectory:

1. Spacecraft weights, c.g. location, moments of inertia and fuel remaining computations are being deleted from the RTCC program since these tasks are carried out in parallel by the GSC flight controllers and their staff support personnel, whose computations are trusted more than those in the RTCC.

2. Maneuver line monitor displays were deleted. These displays were a carryover from Gemini, although they were not found to be particularly useful on that project. In fact, they apparently were never used for anything.

3. Double integration is a complex processor which was deleted following rather lengthy discussions and without flight controller concurrence. This capability was provided primarily for use in determining whether or not an SIVB state vector update should be made prior to the simulated TLI maneuver on AS-503. This was one of those capabilities which had been included in hopes it might help to do this difficult job. Subsequently, investigation has shown that this special, complicated logic was unnecessary in the first place since the equivalent job can be done with the program as it remains defined today. Still, it is notclear that doing the job in the proposed way is adequate and continuing analysis is underway.

4. Special logic was being provided to specify use of the y and z RCS thrusters for orbital maneuvers. We deleted this capability for two reasons: one - there is no capability being provided onboard the spacecraft for making guided maneuvers with those thrusters and, two - the RTCC program as currently defined is already capable of supporting maneuvers of this type, although the procedures are somewhat inconvenient.

5. A composite display of all pertinent spacecraft REFSMMAT's has been deleted since that information is available on other displays.

6. The target closest approach display is a carryover from Gemini for use by the flight crew support people primarily to support their work on inflight experiments. This was another controversial deletion which was only made after our agreeing to re-evaluate their capability to get along using two new Apollo displays in the AS-258 system and reconsidering addition of this display if they encounter unacceptable difficulty. It is my impression the considerable new capability that the Experimental Acquisition Site display and the Star Sighting display have added should be adequate for handling their requirements, although perhaps not in quite such a convenient way.

7. It was agreed to delete the keyhole acquisition display provided the same information was incorporated in the Next Station Contacts display. It was our argument that this would not only simplify the program, but would actually present this information in a more convenient format for the flight controllers. For those of you unfamiliar with the expression "keyhole", as I understand it, this refers to the loss of telemetry and command from some S-band sites when the spacecraft trajectory is such that the pointing angles

fall within certain areas in which tracking is not possible. When it is determined by the RTCC that loss of contact will result, the Next Station Contact display will list that station as two or more separate contacts with all the associated information regarding duration of coverage, etc.

8. The H vs Tyy, H vs V and Vg displays were all dropped as being unnecessary for flight control.

9. Reentry footprint display was another controversial deletion which, incidentally, also applied to the AS-501 program. The Landing and Recovery Division people insist this display is used for making recovery force deployment decisions, but it appeared to me to be more of a "how goes it" display for impressing visiting dignitaries not directly involved in the operation. In its place we are slightly modifying the World Map display during the reentry phase to provide the same information. However, due to the reduced scale of the world map, this compromise does not completely satisfy those people most interested in retaining this display. Significant weight was given to the fact that projection plotboard displays of this type require by far the most extensive checkout and a significant reduction in effort would be achieved by this deletion.

10. Recovery Zone Summary plot was deleted since the information is readily available on other displays, such as the Recovery Zone Digital and Recovery Targeting Displays.

11. Revolution of the Ascending Node display is used by the flight crew support people and the recovery people for updating the crew and the recovery forces, respectively, with the information they need to lay out the ground tracks for the next six orbits. They had requested that the format of this display be changed somewhat, primarily to reduce the number of RTCC computer controller inputs required to support them. It was decided to put up with this not trivial inconvenience rather than to make this change now.

12. The General Purpose Maneuver programs and displays provide the flight dynamics people with a great deal of capability for determining maneuvers to satisfy a wide assortment of specific requirements. Although none of this processor will be eliminated, it is intended to restrict the flight verification testing to certain of the options based on a priority which has been established by the flight controllers.

13. The Launch Simulation Program was used to generate launch "nominals" on Gemini based on the desired insertion vector computed in the ACR. This Gemini carryover was included in the Apollo 258(!) program but was found to be unnecessary and was deleted.

14. The line of sight thrusting for orbital maneuvers processor was deleted. This was provided for such things as making adjustments in perigee by maneuvers at apogee with the spacecraft aligned toward the horizon.

15. Probably the most controversial deletion in the trajectory area was a cutback in the number of options available to the retrofire officer for

computing his maneuver. This subject is treated in detail in another memo. Briefly, it is intended to eliminate the capability of the RTCC to iterate for retrofire attitude in addition to retrofire time. This deletion was made based on my judgment that it was unnecessarily accurate and complex for the job that needed to be done.

Command:

Altogether, there are about 60 command formats which can be generated by the RTCC for the CMC, LGC and SLV for mission AS-258(!). We only deleted five and simplified one of the remaining, since all were either used frequently through out the mission or were required during time critical situations. Two of those deleted were digital autopilot initialization command formats: the one for the command module was deleted since it could be handled with relative ease using the universal uplink (i.e., erasable memory uplink); the one for the LM was deleted since the design of the spacecraft computer program was such that ever if sent the command would be ignored. Two special command formats had been requested for the retrofire external ΔV maneuver. One of these was deleted and the other was simplified by the elimination of the digital autopilot initialization parameters. Finally, it is my impression that two of the four SLV switch selector update formats are to be deleted.

Telemetry:

Most of the changes in the telemetry system are of two basic types - deletion of 104 discrete display formats (out of about 450 requested), and elimination of some of the redundancy in the data recall capability which was to be provided. In addition, there is one outstanding item initiated by our review which, if resolved favorably, will result in a substantial reduction of work to be done. This is the elimination of all teletype telemetry data. I understand there is a good chance this will happen.

Following is a summary of the changes brought about by our review:

1. High speed digital displays have been reduced from 94 to 62 formats!

2. High speed/low speed paging tabulation displays are one of the capabilities being provided for data recall. All together there were to have been 84 different parameter sets available in this display mode. This has been reduced to 75 sets which, at the rate of three display formats per set, eliminated 27 display formats.

Of equal or even greater significance than that is the reduction of the extent of data recall from 39 samples to a total of 15 samples. Based on the sample rate estimated by the flight controllers, this would have provided a data recall capability of about three revolutions rather than one. This extended recall capability required a large amount of extra computer

logic, the elimination of which considerably reduces the total effort necessary to get the system running. My recommendation for this deletion was based on a feeling that the extended capability for instant recall really didn't do much good. A total mission data recall capability is provided by the RTCC Report Processor which prints out precisely the same information offline in a much more readable format. Of course, this introduces a 20 to 30 minute delay in obtaining the data as opposed to instant recall, but that doesn't seem unreasonable considering the way it will be used. The point is, in actual practice, it seems to me it will be necessary to rely on the offline processing to carry out this function anyway. Obviously, if this turns out not to be the case, further consideration should be given to providing extended paging - probably for a longer term than two extra revolutions.

3. System plots have been reduced from 37 to 34 formats. These plots are set up to cover time spans of 200 seconds or 10 minutes. An effort was made to eliminate one or the other of these durations, but this was impossible due to their rather substantial justification.

4. Trend plots is a data recall capability which was carried over from the Gemini system, even though it was not found to be particularly useful to the "Systems" Flight Controllers. (It should be noted that some Flight Directors use them for banding over control from one shift to the next). Trend plots of all parameters stored within the RTCC were out of the question, and as a result only a limited number (37 formats in all) were to be provided. It has been decided to eliminate all of these with the understanding that this job will have to be performed by hand plotting if necessary. It was apparent that hand plotting of parameters requiring special attention would have been done anyway since the quality of the trend plots on the TV screen is not adequate for detailed analysis.

5. There is a catchall category termed "special displays" which we reduced from 14 to 9 formats.

6. Playback/dump displays. The capability to call up displays driven by real time data and playback data simultaneously was requested and is being provided. In some instances, the flight controllers have requested different display formats for the playback data as opposed to the real time data resulting in an over-all increase in the number of display formats required. Consideration was given to making them all the same, but this proved to be impractical at this late date.

7. Limit sensing has been provided on two levels, but on closer examination it was found that providing the secondary level was of little value since there were only a few instances in which it was to be used. As a result, this general flexibility is being deleted from the system and those special cases are being programmed individually.

00000185

Whew! That's about it! Long, but nothing particularly startling. Probably not as great a cut back as you hoped might be possible. I really don't think anyone lost anything needed very badly and would argue that most of the stuff we cut out should not have been there, even if we didn't have a computer time shortage. That is, the cleanup was probably worthwhile just for economical reasons.

Our next ventures are into the land of GESC simulation and a look at the additives going from this program to AS-503(?).

Howard W. Tindall, Jr.

cc:
CF32/J. B. Jones
FA/B. A. Sjoberg
FA/R. G. Rose
FC/J. D. Hodge
FC2/E. F. Kranz
FC3/A. D. Aldrich
FC4/M. P. Brooks
FC5/G. S. Lunney
FC6/H. G. Miller
FC7/R. A. Hoover
FL/J. B. Hammack
FL/W. E. Koons
FL/M. L. Windler
FL/H. E. Granger
FL/D. E. Stullken
FS/H. E. Clements
FS/L. C. Dunseith
FS2/J. M. Satterfield
FS2/J. A. Miller
FS3/H. E. Leech
FS4/J. A. Frere
FS5/J. C. Stokes
FM/J. P. Mayer
FM/C. R. Huss
FM13/J. P. Bryant
FM3/C. R. Hicks
FM4/J. C. McPherson
FM5/M. P. Frank
FM5/R. E. Ermull
FM6/E. C. Lineberry
FM7/M. D. Cassetti
FM8/J. Funk

FM:HWT:cm

00000186

UNITED STATES GOVERNMENT

Memorandum

TO : FM/Assistant Chief DATE: MAR 2 7 1967

FROM : FM/Deputy Chief 67-FM1-25

SUBJECT: None

This action item was given MIT by FCD. We stopped it.

> Provide criteria for checking the "usability of guidance equations and the navigation vector". If practical, it would be desirable to fly a "hands off" mission, but it was recognized that for degradations in the state vector (or trajectory) it would eventually become necessary to update the time of a burn, its targeting, or both (plus perhaps a state vector).

But it needs to be done... Will you get someone to do it? GFB, I guess -

cc:
FM13/J. P. Bryant

FM:NAT:cm

PCB

00000187

UNITED STATES GOVERNMENT

Memorandum

TO : See list

DATE: MAR 24 1967

FROM : FM/Deputy Chief, Mission Planning & Analysis Division 67-FMI-24

SUBJECT: In which is described the Apollo spacecraft computer programs currently being developed

It is possible to take advantage of the stretchout of the Apollo flight schedule in the manner in which we develop the spacecraft computer programs at MIT. Although the flight schedules have not been fixed, it is evident that certain things can be done which will not only improve the quality and capability of the flight programs but should reduce the intensity of effort required of MIT to get them ready on time. It is the purpose of this memorandum to describe what we are planning to do in this area.

Within the month, the unmanned earth orbital LM program [formerly known as AS-206] should be released by MIT. After that, all program development work will be directly applicable to the main line lunar landing mission programs. As has been noted previously, only two spacecraft computer programs are operationally needed - one designed to support the needs of the command module on the lunar landing mission [formerly known as AS-504] and the other for the LM on that same mission. [Recall, these programs can also support all earth orbital development flights]. Everyone wanted to fly all Block II manned missions with these two programs, but it was evident about a year ago that the program development schedule [November 1967 release] was not consistent with the flight schedule for the earlier earth orbital development flights. As a result, we initiated development of two additional programs - one for the LM and one for the command module - for missions flown before the AS-504(!) programs were ready. They were formerly known, respectively, as AS-208 and AS-207 [later AS-205] and were scheduled for release in June of this year.

It now appears evident that the lunar landing LM program can be made available in time to support the first manned earth orbital LM mission, and as a result it should not be necessary for us to release a flight qualified LM program exclusively for that purpose. It's conceivable that these same remarks apply to the command module. However, in order to avoid taking the chance of pacing the Apollo 2 flight, it is our current intention to continue development of the command module program almost as it had been defined for AS-207 [later AS-205]. Certain modifications are contemplated which will result in its release occurring somewhat later than originally planned.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

Thus, it is our current intention to release three flight qualified programs for rope manufacture - an earth orbital mission command module program, a lunar landing mission command module program and a lunar landing mission LM program. I would like to discuss each of these three individually in a little more depth.

Earth Orbital Mission Command Module Program:

Since this program will have the capability of supporting all earth orbital main line Apollo missions that have ever been discussed, its release, about the first of August, should effectively get the schedule completely off our backs for command module programs. Actually, I really don't expect that this program will be used for more than the first manned mission - Apollo 2 - since the lunar landing mission command module program will probably be available in time to support all of the rest of the flights. But, the point is, it could be used if necessary. Desirable modifications to the program, the implementation of which we were previously delaying until the lunar landing mission program, will probably be incorporated in this one. Final decision on these awaits MIT's evaluation of their impact. Since it will no longer be necessary to deliver a LM program in the same time frame as this command module program, MIT's overall task should be somewhat easier to accomplish and the command module program should be of a higher quality.

In addition to supporting the Apollo 2 mission and, if necessary, any other earth orbital missions, this program has two other major uses. It will serve as a high quality component in the flight crew training facilities prior to release of the entire lunar landing mission program. It will also serve as an ideal point of departure for the development of the lunar landing mission program and the earth orbital AAP mission programs. The point here is that this program is just about an ideal subset of both of those more complex but entirely different programs and, having been carried through complete flight verification testing, will serve as an excellent foundation on which to add the unique programs required for those more sophisticated missions.

Lunar Landing Mission Command Module Program:

This program, which has lowest priority of the three, will probably be released about the first of the year. Earlier delivery may be possible if we twist MIT's tail, but I really see no point in it. However, it should be used for mission support as soon as it can be conveniently phased in, taking into account flight crew training as well as flight schedule. This might even be Apollo 2, of course.

What it consists of should not be affected by the mission reshuffling now going on.

00000189

Lunar Landing Mission LM Program:

Definition of this program should also be unaffected by current events, nor should its release schedule be much different; i.e., it should still be possible to complete it some time in November or December if such an early release turns out to be necessary. Probably the most significant new factor influencing the development of this program is associated with flight crew training. Whereas a flight qualified LM program for earth orbital missions was scheduled for release in June which could have been used for extensive flight crew training. This is no longer planned, but the flight training requirement still exists. Accordingly, members of the Flight Software Branch are conferring with flight crew operations and program office personnel concerned with this activity in an effort to pin down flight crew training requirements. Specifically, we are trying to establish a schedule defining when certain components of the LM lunar landing program need to be operational. Based on this schedule, we shall negotiate an over-all development plan with MIT with emphasis placed on meeting this crew training schedule. Some slip in the final delivery date might be necessary for MIT to comply with this new program development constraint, provided that is acceptable from a flight schedule standpoint.

I guess I should point out that I really don't expect the development of these programs to be carried out much differently than had previously been planned. But slipping the flight schedule does provide some room to maneuver and has made it unnecessary to perform flight verification testing on a LM program exclusively for use on earth orbital missions.

To summarize the over-all situation regarding spacecraft computer program development, it is my feeling that no major problem exists any longer in this area. MIT has an organization and facilities geared up to handle the workload in an orderly, professional, unharried manner. High quality flight programs should be available well ahead of their need. Revised program development plans are being prepared to provide you definitive milestones which we'll pass on as soon as they are available.

Your comments shall be received with relish.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Addressees:
CA/D. K. Slayton
CB/A. B. Shepard
CB/W. M. Schirra
CB/J. A. McDivitt
CB/T. P. Stafford
CF/W. J. North
CF/C. H. Woodling
CF/D. F. Grimm
CF/P. Kramer (2)
CF/C. C. Thomas
CF/J. B. Jones
EG/R. G. Chilton
EG/D. C. Cheatham
EG23/K. J. Cox
EG25/T. V. Chambers
EG26/P. E. Eberspole
EG27/D. W. Gilbert
EG42/B. Reina
EG43/R. E. Lewis
EG43/M. Kayton
EG43/C. F. Wasson
ET71/T. R. Kloves
EX/N. G. Foster
KA/R. F. Thompson
KM/W. H. Hamby
PA/J. F. Shea
PA/W. A. Lee
PA/R. R. Carley
PD/R. W. Williams
PD4/A. Cohen
PM/O. E. Maynard
PM2/C. H. Perrine
PM2/P. J. Ward
PE7/D. T. Lockard
FA/C. C. Kraft, Jr.
FA/S. A. Sjoberg
FA/R. G. Rose
FC/J. D. Hodge
FC2/E. F. Kranz
FC2/J. W. Roach
FC3/A. D. Aldrich
FC4/M. F. Brooks
FC4/R. L. Carlton
FC5/G. S. Lunney
FC5/C. E. Charlesworth
FC5/P. C. Shaffer
FC5/J. C. Bostick
FC5/H. D. Reed
FC5/J. E. I'Anson
FL/J. B. Hammack
FS/L. C. Dunseith
FS5/J. C. Stokes, Jr.
FS5/T. F. Gibson, Jr.
FS5/R. O. Nobles
FS5/P. J. Stull
FS5/L. A. Fry
FM/J. P. Mayer
FM/C. R. Huss
FM/M. V. Jenkins
FM12/J. F. Dalby
FM13/J. P. Bryant
FM14/R. P. Parten
FM/Branch Chiefs
FM7/S. P. Mann
FM13/J. R. Gurley

FM:HWT:cm

00000191

UNITED STATES GOVERNMENT

Memorandum

TO : See list DATE: MAR 2 3 1967

FROM : FM/Deputy Chief, Mission Planning and Analysis Division 67-FM1-23

SUBJECT: Summary of what needs to be done to develop flight confidence in the spacecraft computer programs

There has been growing concern in many quarters regarding the adequacy and formality of the final verification testing of the Apollo spacecraft computer program and its interfaces with other spacecraft systems. This concern led to a meeting on March 21st to decide whether everything was really okay and whether something should be done about it. Attendees to this meeting were Don Cheatham, Aaron Cohen, Cline Frasier, Bob Gardiner, Tom Gibson, Myron Kayton, Stan Mann, Tom Price and Bill Tindall of MSC and John Norton and Mike Richter of TRW.

Our attention was primarily focused on the first LM program [formerly known as AS-206] although it was not restricted to that one. Indeed, this group felt that the situation was not satisfactory; that formal flight verification testing was not being carried out in the controlled, thorough manner necessary to develop flight confidence; that documentation of the test plans and test results was not even adequate to really understand what had been done.

One conclusion, obvious from the start, was that the AS-206 flight schedule, or whatever the first LM mission is to be called, does not permit delay of rope manufacture until that testing and documentation which would ordinarily be considered necessary prior to rope manufacture could be completed. In this instance, they must be carried out in parallel. If results of this effort are such that changes in the program are considered mandatory, ropes will have to be remanufactured and a slip in the flight schedule may occur. Alternately, flaws in the program revealed in this process could result in revision in the manner in which the mission will be flown; e.g., changes could be made in the erasable load, maneuver targeting, command update from the ground, mission rules, flight limits, etc.

Specific action items resulting from this rump session are as follows:

1. It was agreed that only MSC is in a position to integrate the over-all system. It is our proposal that this be carried out by the Guidance Software Control Panel [GSCP], and the Chairman of that panel accepted as an action item the task of developing plans and an organization to carry out the MSC integration function. It was emphasized that this is a systems

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

integration task not restricted to spacecraft computer programming but also covering all interfaces with that component. This task includes coordinating the activity of all associated organizations and making sure that nothing falls down a crack.

2. Each individual organization involved [i.e., MIT, GAEC, TRW, MSC, etc.] shall be called upon to document their understanding of the current situation regarding AS-206(1) flight verification for the GSCP. That is, in order to determine logically what must be done, it is necessary that the GSCP have a thorough and up-to-date knowledge of what has been done.

3. The Flight Software Branch shall direct MIT to deliver AS-206(1) test plans and test results, including analyses, of a quality at least as good as shall be available for AS-258, if you know what that means. This shall include complete documentation of the Level 4 and Level 5 tests and results already accomplished, as well as a complete verification plan on which acceptance of the final program assembly shall be based. In addition to this, MIT shall prepare a list of all program components which have not been unit tested [Level 2] and will make sure that unit testing which has been performed is completely documented.

4. Since it is anticipated that three of the six rope modules to be used on the AS-206(1) mission will have been manufactured from one program assembly and the other three from a later, different assembly, MIT shall be directed to prepare a verification plan documenting the manner in which they intend to verify compatibility of the various rope modules with each other.

5. It is intended that the so-called Bit-by-Bit simulation facility at MSC is to play a formal part in the program verifications process. Effort on readying that facility is currently divided between work on the programs required for the AS-206(1) program verification and on those for Apollo 2. Considering the flight schedule, as well as the fact that most of the former should apply to the latter, the Flight Software Branch will revise the priority to the Computation and Analysis Division and their Lockheed contractor such that the AS-206(1) work takes precedence in all respects.

6. Recognizing that certain aspects of the total systems verification task is beyond the capability of MIT to perform on their facilities, we have concluded that they must be augmented by including other organizations in this process. It is our proposal that ASPO direct GAEC to prepare a verification plan to check out all software/hardware interfaces to ensure compatibility. It is recognized that this task and the actual carrying out of the testing itself on the GAEC facilities is beyond their current contractual obligation, which will make changes in that necessary.

It is obvious that items 1 and 6, above, are new. However, the need seems equally obvious, and we feel that they should be adopted as a recognized way of doing business for all subsequent flights. Items 2, 4 and 5 are tasks unique for this particular mission in that we are attempting to correct a deficiency. Item 3 is also unique to AS-206(1) in that we must go back and do something which should have been done much sooner but had been rationalized away in the press of the flight schedule, as well as a general atmosphere which prevailed previously. Formal test planning and documentation for all program development following AS-206(1) is already well under control.

It is anticipated that slippage in hardware delivery and flight dates will make it possible to carry out this work within a time period that will be acceptable for the development of flight confidence. Although the diversion of MIT effort to carry all this out could and, in fact, will likely impact MIT's delivery of other flight programs, it is anticipated that this, too, will be considered satisfactory.

Howard W. Tindall, Jr.

Addressees:
TRW/J. L. Norton
TRW/M. Richter
EG/D. C. Cheatham
EG/R. A. Gardiner
EG43/M. Kayton
EG44/C. W. Frasier
PA/J. P. Chet
PA/W. A. Lee
PD/R. W. Williams
PD4/A. Cohen
FA/C. C. Kraft, Jr.
FA/S. A. Sjoberg
FS/M. E. Clements
FS/L. C. Dunseith
FS5/T. F. Gibson, Jr.
FS5/T. G. Price
FM/J. P. Mayer
FM/C. R. Huss
FM13/J. P. Bryant
FM7/S. P. Mann

FM:HWT:cm

00000194

UNITED STATES GOVERNMENT

Memorandum

FM [illegible] (Cys held in MWT - per SM's)

TO : FA/Director of Flight Operations DATE: MAR 2 0 1967

FROM : FM/Deputy Chief, Mission Planning and Analysis Division 67-FMA-22

SUBJECT: AS-258 RTCC Retrofire Time Computation

One step taken in an attempt to alleviate the RTCC program development problem has been to make major reductions in the area of retrofire time computations. Since these deletions have an impact on the Retrofire Controller's capability and mode of operation, I felt it desirable to report these things in a memorandum devoted solely to that subject.

Retrofire time computations to be used when the guidance system is up and operating are done with precision, as are those for non-G&N reentries wherein there is time to make proper adjustments in the inputs to the RTCC program. However, I would like to emphasize from the start that in certain contingency situations - namely those reentries which must be performed on an emergency basis and without the guidance system - the retrofire time computation may be in error as a result of our having eliminated one of the modes for computing retrofire time. Recognizing that almost all cuts in the RTCC programs involve a calculated risk, this one seemed to be as reasonable as any to me. I base this opinion on the knowledge that there are many other equally large error sources contributing to the landing point dispersion for non-G&N emergency reentries. Also, it must be recognized that an error in the retrofire time computation does not affect our knowledge of where the spacecraft will ultimately land.

In order to understand the reductions that have been made in the retrofire time computations, it is necessary to describe in some detail the options which originally were to be available. These options are made up of any combination of the following elements, which I will describe individually:

1. Type of reentry, with 4 options - no change.
2. Attitude hold mode during retrofire, with 2 options - reduced to 1.
3. Choice of propulsion system, with 4 options - no change.
4. Choice of retrofire attitude iteration, with 3 options - reduced to 1.
5. Orientation of the spacecraft, with 4 options - changed, but only in the manner in which it is specified.
6. Manner in which the maneuver magnitude is to be specified, with 2 options - no change.
7. Real time adjustment of a number of other parameters - probably increased by one.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

Type of Reentry:

There are four basic types of reentry for which we are able to compute the retrofire maneuver:

1. Retrofire only followed by guided reentry.
2. Retrofire preceded by a pre-retrofire maneuver and followed by a guided reentry.
3. Retrofire only followed by ballistic reentry.
4. Retrofire preceded by a pre-retrofire maneuver and followed by ballistic reentry.

Since there is a reasonably high probability of having to carry out any of these four basic types of retrofire maneuvers, we haven't attempted to decrease this capability.

Attitude Hold Mode:

When making a guided retrofire maneuver, it is intended to hold inertial attitude. This is also the case when using the SPS engines in conjunction with the SCS control system. However, if the SPS, G&N and SCS have all failed, the procedure is to maintain orbit rate torquing during a long RCS maneuver, and this option was available to provide a more precise retrofire time computation in that instance. Considering the low probability of making this sort of maneuver, along with the large probable error associated with one of that type, it would seem unnecessary to provide this extra precision in the computation of the retrofire time itself. Accordingly, all retrofire time computation will now only be based on the assumption that the attitude during the maneuver will be maintained inertially constant.

Choice of Propulsion Systems:

Retrofire time computations can be based on either using the SPS engines or the service module RCS. Two options are provided for the SPS mode, depending on whether 4-jet or 2-jet ullage is to be used. It is also possible to specify either 2-jet or 4-jet RCS retrofire, although it has been stated that a 2-jet RCS retrofire maneuver is not operationally feasible. If this option is considered unnecessary, some computer time could be saved by eliminating checkout of it.

It should be pointed out that retrofire time computations can also be carried out if the command module RCS propulsion system is to be used. However, this is done by manipulation of the input parameters and not through provision of special MTOC computer program logic.

Selection of Retrofire Attitude Iteration:

The original retrofire time program was designed to provide three basically different retrofire attitude options. In fact, it is the provision of these three options which contributed most to expanding this particular task out of reasonable bounds. It is the deletion of two of these which constitute the most substantial savings. The three options are as follows:

1. Retrofire attitude is selected external to the RTCC program and manually input to it. This was the mode used in Gemini where it was possible to change the retrofire attitude but the value was selected based on some logic external to the computer program, usually preflight. This retrofire attitude is referenced to the local spacecraft horizontal and the orbital plane at the time of retrofire initiation. The program then iterates for the retrofire time based on the assumption the retrofire maneuver will be executed in the attitude specified. It is this single option which we shall retain in the system, since it gives the greatest flexibility.

2. The second retrofire attitude iteration logic was introduced new for Apollo and, in fact, became the prime mode of operation. For some reason, it was felt necessary that the retrofire maneuver be made with a reference line on the spacecraft window aligned precisely with the earth's horizon at the time of retrofire initiation. Therefore, special computer logic was provided wherein the program would iterate not only for the retrofire time but also for the attitude to be used. As a result, it was not known what the spacecraft retrofire attitude would be until the final retrofire time computation was carried out.

It is understood that most non-CSM retrofire maneuvers will be carried out with the spacecraft orientation this option provides. However, considering the inaccuracies associated with a non-CSM retrofire and reentry, the small additional error incurred in the retrofire time computation itself seems acceptable. The error would result from using an attitude close to, but perhaps not precisely on, the visual horizon in the time-to-fire computation. Of course, the maneuver would most likely be performed at the horizon attitude to within the crew's ability to hold it. It must be emphasized again that deletion of this mode is implicit acceptance of a somewhat inaccurate retrofire time computation, but with the understanding that the knowledge of what the crew will do is not jeopardized in any way. Further, it should be pointed out it is not at all difficult to determine the retrofire attitude referenced to the horizontal which would provide the visual horizon reference within whatever precision is required. That is, the only time the error will result is non-CSM retrofires occurring on an emergency, immediate basis.

00000197

3. For some reason, it was concluded that the attitude to be used during an RCS retrofire must be aligned along the velocity vector rather than horizontal, and the third special mode had been provided to compute this attitude in real time. First of all, the difference between the velocity vector and horizontal seldom exceeds 2°, even for highly elliptic earth orbits. This is a rather trivial error even if it were not compensated for, as it could be quite easily. There was agreement that this mode could be deleted without hurting anybody.

Orientation of the Spacecraft:

Provision had been made for computing retrofire maneuvers in any combination of heads-up or heads-down and posigrade or retrograde [can you believe posigrade?]. We have not reduced this capability, but it is my understanding that, in order to provide consistency with inorbit maneuvers, the spacecraft orientation will be specified by pitch, roll and yaw as opposed to those quantities noted above.

Maneuver Magnitude Control:

The magnitude of the maneuver may be specified either in terms of ΔV or duration of burn.

Other Controls:

Just to be complete, I might list the other input parameters which control the retrofire time computation:

1. Revolution number, recovery area and landing point latitude and longitude.
2. Duration of the ullage burn.
3. Nominal reentry bank angle.
4. REFSMMAT is to be used to compute IMU gimbal angles.
5. g level at which rolling is to be initiated for ballistic reentries.
6. The bank angle it is intended to hold between retrofire and that g level.

In summary, it seems to me that the retrofire time processor still provides all the flexibility and accuracy required to carry out our missions. Several limitations have been made which should considerably reduce the systems test time. As you can guess from the length of the various discussions given above, the only real area of contention had to do with how reasonable it was to provide special retrofire iteration modes beyond that available on Gemini. Agreement by the Flight Controllers on this matter was only

possible assuming acceptability of somewhat erroneous retrofire time computations in the case of man-CSM rendezvous performed on an emergency basis.

Howard W. Tindall, Jr.

cc:
[redacted]
FA/S. A. Sjoberg
FC/J. D. Hodge
FC2/K. F. Kraus
FC5/G. S. Lunney
FC5/J. S. Llewellyn
FL/J. B. Hammack
FM/L. C. Dunseith
FM3/J. C. Stokes
FM5/R. O. Clayton
FN/J. P. Mayer
FN/C. R. Ross
FN3/C. R. Hicks
FN5/M. P. Frank

FH:EFT:cm

00000199

UNITED STATES GOVERNMENT

Memorandum

TO : FC/Chief, Flight Control Division DATE: 1 0

FROM : FM/Chief, Mission Planning and Analysis Division 87-FM1-:1

SUBJECT: Service Module RCS propellant remaining calculations in the CMC

In response to your memo dated January 13, same subject as above, we requested the Guidance and Control Division to carry out a study into the possibility of adding a CMC routine to compute RCS propellant consumed. The results of their study are detailed in the attached memo. As you can see, they have concluded that not only would such a computation be quite inaccurate but, "...the amount of data which would have to be handled is felt to be prohibitive". It is their recommendation that such a program not be considered for use in the CMC. On the other hand, if you still feel there is merit in this proposal, I suggest your people contact Guidance and Control Division personnel directly.

John P. Mayer

cc:
EG/R. G. Chilton
FA/C. C. Kraft, Jr.
FA/S. A. Sjoberg
FC35/G. D. Griffin
FS/H. E. Clements
FS5/T. F. Gibson, Jr.

FM:EWTindall, Jr.:cm

UNITED STATES GOVERNMENT

Memorandum

TO : See list

DATE: FEB 2 3 1967

FROM : MM/Deputy Chief, Mission Planning and Analysis Division

MM-MPA-20

SUBJECT: Star/landmark navigation exercise preflight planning

A call from Mr. C. C. Kraft the other day drew my attention again to the spacecraft guidance system navigation tests planned for the AS-503 mission. He had received indications that the planning for this exercise was rather haphazard. Specifically, he recommended that MIT be brought into the mission planning at this time in order to insure their satisfaction, since they are probably as much or more concerned than any other organization in evaluating performance.

This memo lists a number of jobs which need to be done. Perhaps they should be coordinated and formalized by ATSO. Specifically:

1. The Mathematical Physics Branch, working with MIT through the Flight Software Branch, should establish precisely the mission planning requirements for carrying out the star/landmark and star/horizon observations during high altitude orbits such as planned for AS-503. These requirements should include the identification of stars and landmarks to be used and the lighting conditions which are necessary. Since it is currently planned to fly the AS-503 mission with the AS-278 programs, you are reminded that actual update of the state vector onboard the spacecraft may not be possible. As a result, some thought must be given as to how the postflight data processing shall be carried out. It would be disastrous if, as a result of lack of foresight, insufficient data were collected during the exercise, making it useless. Since there is a good possibility of carrying out this type of exercise after the AS-503 program has been completed, some thought should also be given to what modifications to the exercise would be called for in that event.

2. Obviously, the Mission Analysis Branch must work closely with the people on the above task, giving proper emphasis in the mission design to the requirements for this exercise. They will certainly conflict with other mission constraints, and the compromises which will be necessary must ultimately be MAB's responsibility to identify and make.

3. I suppose it is up to the Mathematical Physics Branch to make sure that they and/or MIT have the proper programs prepared to carry out the postflight analysis. This preparation, of course, includes provision of the capability of accepting the data as it will be provided to them after the mission, as well as selection and formulation of program output formats

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000201

most suitable for analyzing the results. It is to be emphasized that we will be looking for answers relatively quickly, since I anticipate the missions will start to follow one another fairly rapidly by the time this exercise is carried out and little time will be available to modify the spacecraft computer programs if that is found to be necessary.

A task assignment, in the IRW format, should be prepared for transmittal to MIT for whatever work it is we feel they should do. For one thing, MIT should be requested to formally submit to us their post-flight data requirements.

It seems to me the most important thing right now is to insure that the mission planning is compatible with the needs of this exercise. Since the mission plans for the various Apollo missions are in such a state of flux, I would recommend that wherever possible the exercise be planned independent of the specific mission such that it could be inserted as a package into whatever mission it is ultimately felt it should be included.

Howard W. Tindall, Jr.

Addressees:
FC23/K. J. Cox
FA/C. C. Kraft, Jr.
FA/S. A. Sjoberg
FA/R. G. Rose
FC/C. B. Parker
FS/L. C. Dunneith
FS5/T. F. Gibson
FS5/R. O. Nobles
FM/J. P. Mayer
FM/M. V. Jenkins
FM12/J. F. Dalby
FM12/D. J. Incerto
FM4/J. C. McPherson
FM5/M. P. Frank

FM:HWT:jm

00000202

UNITED STATES GOVERNMENT

Memorandum

TO : FA/Director of Flight Operations DATE: MAR 8 1967

FROM : FM/Deputy Chief, Mission Planning and Analysis Division 67-FMA-19

SUBJECT: Progress Report - RTCC program development reduction - Review of requirements for the AS-502 mission

On February 17th we held a meeting in our continuing effort to reduce the program development demands on the Real Time Computer Complex. In this instance, a group of FCD, FSB and MPAD people reviewed requested modifications to the AS-501 RTCC program in preparation for the AS-502 mission. I could briefly summarize the results by saying eight of the changes requested were not considered mandatory and were deleted. There were three items which seemed so important that a concerted effort will be made to add them into the AS-501 program for use on that flight as well as AS-502. There will be four modifications required in the telemetry and command systems which were unavoidable due to changes in the space vehicles themselves between AS-501 and AS-502. In fact, it's quite likely that these four will be the only differences in the AS-501 and the AS-502 programs.

1. The following new requirements were deleted:

   a) (hp vs Vp) on X-Y plotboard. (Will be displayed elsewhere, if needed).

   b) (γ vs V) on projection plotboard. (Displayed elsewhere).

   c) Use AGC low speed telemetry vector in orbit phase for trajectory updates. (High speed vectors can be used and, if necessary, low speed can be used by a somewhat awkward procedure).

   d) Add Residual Summary Display II. (Not needed).

   e) Major modifications in the live plots of CSM SPS fuel and oxidizer remaining. (Not needed).

   f) Addition of two summation computations for radiation surface dose and depth dose. (Not needed for flight control).

   g) Display number of events from the AGC on TV rather than on lights. (Not necessary).

   h) RSDP GMTLO command update. (Not needed).

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

2. It is our intention to add the following three items in the AS-501 program for support of both missions, if possible. Jim Stokes, in conjunction with IBM, intends to determine their impact on the schedule for releasing the AS-501 program and, assuming it is no more than about two or three weeks, it will be our recommendation to make them. As I understand it, the likelihood of launch schedule slippage is great enough that this should be acceptable.

a) $(\phi$ vs $\lambda)_{EI}$ on projection plotboard. This capability is being added for a rather remote contingency situation which involves some chance of Flight Controller action causing the spacecraft to impact somewhere in the United States. The Flight Dynamics people had requested that the latitude and longitude at 400,000 feet (the so-called entry interface) be predicted and displayed during large maneuvers. As I understand it, the SIVB must have failed and the SIVB must not be under complete control for this display to be useful. However, the modifications requested were considerably simplified such that either the projection plotboard spotter or scriber would be used to display this predicted "impact" point on the standard 10 x 20 world map in place of present position. S nce $(\phi$ and $\lambda)_{EI}$ are already routinely computed, this capability should not be particularly difficult to provide. The request to scribe the nominal plot of these parameters was deleted.

b) The capability of initialising the MSCO program for the actual loaded propellant weights in the SIVB during the prelaunch countdown based on measurements made during the loading was added. Previously, the program assumed full tanks which introduced a considerable error of display of LOX and LH2 remaining.

c) The computation to compute Hs remaining in the SIVB is being completely redone. It will use a cryogenic type computation vis the old ambient temperature type computation which introduced a considerable error in the determination of this critical parameter which is used in conjunction with a mission rule for determining whether or not the SIVB may be reignited.

3. There are four changes in the telemetry and command syutems which do not apply to AS-501 but which are essential for AS-502 due to vehicle modifications.

a) The definit on of the IU coordinate system will be changed which must be reflected in the MSCO program.

b) The granularity and number of LVDC downlink parameters will be changed which influence the computations of GRR, TB4 start, orbital arms word, etc. The Guidance Officer considers this

00000204

change mandatory if he is to make a reasonable decision as to whether or not to send a navigation update to the SIVB. He maintains that without this improvement his computations would be sufficiently in error that he would have no choice but to send one every time.

c) The SLV time base update will be modified to make it a double precision output vis single precision.

d) A new command format, the SLV navigation update, will be added.

4. There is one orbital phase display requested by the Flight Dynamics people - namely, perigee height vs velocity - upon which we haven't made final resolution. The Flight Controllers maintain that the special character of the AS-502 maneuvers make the AS-501 displays inadequate. For example, a plot used to monitor one of the maneuvers goes completely off scale. On the other hand, if we're able to eliminate this request, the orbit phase could be made identical for the AS-501 and AS-502 missions. Our action on this item is for the Flight Controllers and MPAD people to determine if the other displays can support whatever job is to be done by the Flight Controllers adequately and also to determine if the requested display would be even adequate, since there is some question about that. Jim Stokes has assured us that if a decision is available by March 15th we should be able to add it without schedule impact.

I felt this was one of the best meetings yet. There was a true spirit of cooperation among all participants in trying to get the job done, and I felt that the compromises arrived at were really very good. The Flight Controllers freely abandoned their requirements where at all possible and the Flight Software people are making an extra effort to not only provide the capabilities identified as essential for AS-502, but where suitable will also make them available in the AS-501 system. The point is, I feel we have improved the product as well as significantly reducing the work which must be performed in getting it ready.

Howard W. Tindall, Jr.

cc:
(See list)

00000205

UNITED STATES GOVERNMENT

Memorandum

TO : Sec list DATE: FEB 8 1967

FROM : FM/Deputy Chief, Mission Planning and Analysis Division 67-FMA-18

SUBJECT: Spacecraft Computer Program Development Newsletter

We had a fruitful program development plan review meeting at MIT on February 15th. With one exception, everything seems to be moving along nicely now. In fact, much of our meeting was spent on non-technical matters - those associated with administrative management - not so time critical in so far as getting the programs out of MIT, but extremely important when it comes to determining where the money is all going.

We requested MIT to propose at our next meeting how they intend to provide cost accounting for their work in the software area, something which is sadly inadequate at this time. Specifically, we are interested in their reporting on a regular basis the man loading and computer usage - broken down by mission and task. In addition, we have requested that they provide a travel summary on a monthly basis.

MIT was requested to propose how they will comply with our requirements for providing complete flow diagrams of the AS-258 and AS-504 programs, to be updated once a month. This form of documentation has been sorely needed for a long time, and we are finally at a point where it should be possible to provide it without interfering with higher priority program development work. The fact is, a good deal of these programs are being flow charted already by MIT on an informal basis. Other flow charting has been done at MSC by Lockheed as part of their job on the Bit-by-Bit digital simulation here. MIT has been requested to determine the cost of this effort, which is unfortunately not covered by their current contract due to some horrible oversight on our part. It will likely be subcontracted but closely supervised by MIT personnel.

Another seemingly mundane topic of conversation regarded the need for naming the programs in some way other than with the number of the booster which might be used on the mission. It's getting impossible to converse clearly and the documentation is going to be hopeless if we continue to use such numbers as 205 and 504 to identify the spacecraft computer programs. And it would be naive to assume that this juggling of boosters and missions will not continue. We will inform you of the new, more descriptive program names as soon as they have been selected.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000206

It was reported that the Hybrid facilities are coming along nicely and on schedule. Modifications and uprating of the old facility is almost complete and should be in position to provide operational support to both command module and LM program development within a month. The second facility is still scheduled to be on the air about April Fools' Day.

The AS-278 programs (or whatever you call them) are reported to be on schedule, although Ed Coppa has found it necessary to beef up the manpower considerably to keep it that way. We discussed a number of relatively minor changes (MCR's) which interested parties are probably aware of. None have been approved having a significant impact on the delivery schedule as far as I know.

Incidentally, it's becoming more and more apparent that some sort of review will be needed regarding what is to be in the erasable memory of the AS-258 program. MIT will signify when it will be most profitable to do this, probably in about two months. That could be a fairly exciting get together since everyone wants their program in erasable. If wonder if there is a message in that observation.

Discussions on the AS-258 programs reopened the one remaining runny sore at MIT - namely, the inadequacy of the digital computer facility. This darn thing was flagged out for attention last spring, but in spite of all our best efforts we are still in a hole. The two 1800 computers are completely saturated as it was predicted they would be, and shall continue to be until the AS-206 program is released on about March 1st. [Alex Kosmala and Fred Martin report one to four-day turn around on their AS-258 program development computer runs (horrible)]. I expect that within six to eight weeks after that point they will probably be saturated again, and I'm completely frustrated as to what to do about it.

A handful of MIT people, such as Cliff Ide, have been working on this problem, and I must emphasize that these words are certainly not intended as any criticism of them. On the contrary, they have been doing an outstanding job. But the fact remains the IBM 360 computer is still not on the air and probably won't be for a long time. Although MIT reports otherwise, I suspect the MAC compiler, when it finally arrives, is not going to deliver us from our problems. Apparently the Fortran approach is not going to either, although MIT appears to have put as much effort and attention on it as you could expect from a group who basically didn't like the idea in the first place. They finally are also reporting IBM 360 equipment and programming systems problems like we have in the RTCC. I wondered when that would happen.

Jim Miller reported on the progress of the AS-206 program which was scheduled for release on February 2nd at that time. [A late breaking requirement for obtaining some special DAP data for postflight analysis during this mission has forced a program modification and a week's delay on us]. Jim's report was very encouraging - the program was in the final

00000207

stages of verification and apparently is behaving very well. I might also point out that MIT had used the delays required for getting some of the maneuver phases of the program working to add computer restart protection pretty much throughout the program. Although this had not been identified as a mandatory item by MSC, I think all of us involved were rather concerned at leaving it out (for schedule reasons). The MIT people have worked very hard on this program and deserve a lot of credit, both for their maintenance of extremely high standards and for their extra effort in trying to maintain a reasonable release schedule.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

00000208

UNITED STATES GOVERNMENT

Memorandum

TO : See list

DATE: JAN 31 1967

FROM : FM/Deputy Chief, Mission Planning and Analysis Division

67-FMP-17

SUBJECT: AS-206 Spacecraft Computer Program Newsletter

We had another long AS-206 program development discussion at MIT on January 26th, and some things came up you might find interesting.

First of all, there is only one mission phase that has not been successfully run at this time - namely, the second APS maneuver. There is some feeling that this may be due to improper targeting as opposed to problems in the actual program. Completion of a satisfactory test of this mission phase will signal configuration control of the assembly to be maintained until the final release of the program. It is planned that verification testing to assure flight readiness will be complete on February 15th, and we've set February 17th as the date for the formal MSC review of the AS-206 program verification results. Final acceptance of the program, prior to rope manufacture, is based on this MIT presentation which will be here in Houston.

Although MIT insists that the Digital Auto Pilots are adequate for the mission, there are several program modifications under consideration in this area. In fact, MDRB's have been requested from MIT which must be acted upon very promptly if they are to be included. Briefly, they are the following:

a) As I understand it, an instability, due to fuel slosh, has been discovered making it desirable to modify the Kalman filter gains in the DPS DAP. As presently designed, when the RCS tanks get fairly empty, fuel slosh causes control to oscillate back and forth between the DPS and RCS Digital Auto Pilots. This results in inefficient use of RCS fuel, although it does provide adequate control of the vehicle. Since AS-206 does not have an RCS propellant shortage, it is not mandatory to make the change until a later mission. The primary advantage of doing it now is to get a test of the "ultimate" system.

b) At some time during the DPS maneuver, it was intended to freeze the DPS engine position, i.e., no further steering commands would be given to the DPS and all control would be carried out with the RCS. This had been proposed as an interim fix of the instability problem noted in (a), but subsequent testing at Grumman of the DAP on their digital simulation has shown that misalignment of the thrust vector from the spacecraft cg actually results in a greater use of RCS fuel than is spent in

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000209

controlling the fuel slosh induced instability. We have requested an MDRB to fix the program so that it does not freeze the engine position. (Incidentally, there is concern that engine ball ablation or erosion may cause large thrust vector misalignment, and freezing the engine deflection during the maneuver could present a significant problem in that event).

c) MIT is very much concerned that insufficient data will be collected during the AS-206 flight for adequate analysis of the Digital Auto Pilots. It has been found that the PCM data will be saturated due to the unusual platform alignment which is required on this mission. Therefore, they are anxious to obtain another source of this data which they have identified as essential from the very beginning. One of their proposals is that the downlink be interrupted for four or five seconds during the DPS maneuver, substituting in it's place CDU data sampled every twenty milliseconds. Further, they feel it would be highly desirable to suppress the DAP during this period in order that the data be independent of control activity. Almost surely this type of program modification will cost a lot of time even if agreement could be reached by all parties that it was an acceptable change technically.

I predict we will not make change (a) but will make change (b) since it's so simple. I really am concerned about not getting the DAP data for postflight analysis since that is one of the primary reasons for flying the mission in the first place. Resolution of whether or not to make change (c) will probably bounce all of the way up to the Spacecraft Program Manager.

MIT reported that it looks like nothing can be done in either the hardware or software to fix the AS-206 downrupt problem. This, you recall, is the problem resulting from higher priority computer tasks preventing the computer from servicing the downlink needs ever so often during maneuvers. This causes that data frame to be garbled on the ground. As I understand it, it is possible to unscramble this data postflight, thus it is only a real time flight control problem which we have recognized and agreed to live with on this mission.

I hear that Grumman has not yet been able to use the tapes delivered to them due to problems with their own facility. I get the distinct impression that we have been "had" on this. Apparently Grumman knew their facility would not be ready on schedule, and in order to salvage their incentive points, got us (MSC) to give them a waiver based on our confession that the CFE computer program would not be available as promised. I guess we Texans are no match for those slick New York yankees.

That's about it. Obviously our toughest job is going to be wrenching this program out of MIT's grasp, since to them quality still comes before schedule. But that's just a little game we are playing, and I don't

consider it unhealthy. I'm really not near as worried about the quality of the AS-206 program as they are, but I am very anxious to get this bunch of experienced AS-206 guys off onto the AS-278 program as soon as possible.

Howard W. Tindall, Jr.

Addressees:
EG/D. C. Cheatham
EG23/K. J. Cox
EG25/T. V. Chambers
EG26/P. E. Ebercole
EG27/D. W. Gilbert
EG42/B. Reina
EG43/R. F. Lewis
EG43/M. Kayton
EG43/C. F. Wasson
KA/R. F. Thompson
KM/W. H. Hamby
PA/J. F. Shea
PA/W. A. Lee
PD/R. W. Williams
PD4/A. Cohen
PM/O. E. Maynard
PM2/C. H. Perrine
PM2/K. L. Turner
FA/C. C. Kraft, Jr.
FA/S. A. Sjoberg
FA/R. G. Rose
FC/J. D. Hodge
FC2/E. F. Kranz
FC3/A. D. Aldrich
FC4/M. F. Brooks
FC5/G. S. Lunney
FC5/H. D. Reed
FC5/J. E. D'Aneon
FS/L. C. Dunseith
FS5/E. F. Gibson, Jr.
FS5/R. O. Nobles
FS5/P. J. Stull
FS5/L. A. Fry

FM/J. P. Mayer
FM/C. R. Huss
FM/M. V. Jenkins
FM12/J. F. Dalby
FM13/J. P. Bryant
FM14/R. P. Parten
FM/Branch Chiefs

FM:HWTjcm

00000211

GOVERNMENT

Memorandum

TO : See list

DATE: JAN 8 0 1967

FROM : FM/Deputy Chief, Mission Planning and Analysis Division

67-FMI-16

SUBJECT: AAP platform should be torqued to local horizontal

In thinking about it a little more, I guess I should have pointed out in the last of these little notes that I'm assuming if we use horizon scanners, we will go ahead and torque the platform at orbit rate. This, of course, will require a certain amount of modification in some of the spacecraft computer programs but should not present an overwhelming problem. In fact, I have informally asked Norm Sears to look through his lists and let us know which ones would be affected. Once we have done that I suppose we will have eliminated the problem of the orbit rate ball, the value of which I don't believe anyone can argue about in these earth orbital missions.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000212

...GOVERNMENT

Memorandum

TO : See list

DATE: JAN 3 0 1967

FROM : MM/Deputy Chief, Mission Planning and Analysis Division

67-FMA-15

SUBJECT: Program interlocks - farewell

Ever since I've been involved with these spacecraft computer programs there has been an awful lot of flak regarding the program interlocks. Specifically, in the AS-204 program, there is a "Verb 37 Table" which prohibits the astronaut from calling up certain programs out of sequence. Constraints of this nature have been labeled intolerable, not only by the flight crew but by many other influential people. As a result of this, and partly due to the greatly increased complexity of the AS-258 programs, MIT has decided to include no interlocks whatsoever in them. Therefore, in the future it will be the crew's responsibility to see to it that they don't call programs in an improper sequence. The result of doing so may be as trivial as getting a bunch of garbage for answers, or in some cases could scramble the programs to the extent that it is necessary to initiate the sequence over again - perhaps at the cost of a considerable amount of time and effort. Apparently, there is no known circumstance whereby improper crew inputs could foul up the programs irrecoverably.

Since crew procedures will take the place of the "Verb 37 Table" in the AS-258 programs, MIT has prepared a preliminary program-matrix defining the sequences it is necessary to follow as the crew moves from one program to another. Copies of this preliminary matrix are available from Rick Nobles and Paul Stull for use in the development of crew procedures.

I am sure this will make all you interlock critics happy.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000213

TO : BG23/K. J. Cox

DATE: JAN 3 0 1967

FROM : FM/Deputy Chief, Mission Planning and Analysis Division

67-FM1-14

SUBJECT: Data for postflight analysis of the DAP

Ken, this is to remind you that you are carrying the ball for getting high rate CDU data on the downlink during DPS burns if you feel it is necessary for postflight analysis of the Digital Auto Pilot. MIT people, particularly George Cherry, are emphatic in stating this data is mandatory for DAP development and they claim you are in complete accord on this. I imagine it will be a tough battle for you, so I suggest you get it going as soon as possible. Our guys in the Flight Software Branch will assist you in any way you request, I'm sure.

Howard W. Tindall, Jr.

cc:
FD4/A. Cohen
FC/J. L. Tomberlin
FS5/T. F. Gibson, Jr.
FS5/R. O. Nobles
FS5/J. R. German
FS5/T. D. Keeton
FM/J. P. Mayer

FM:HWT:cm

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

UNITED STATES GOVERNMENT

Memorandum

TO : CA/Director for Flight Crew Operations DATE: JAN 2 5 1967

FROM : FM/Deputy Chief, Mission Planning and Analysis Division 67-FMI-13

SUBJECT: AGS Software Documentation

Reference: Memorandum from CA/Director for Flight Crew Operations to FM/Howard W. Tindall, Jr., "AGS Software Documentation", dated January 18, 1967.

The current status of Abort Guidance System (AGS) software documentation is given here in reply to the referenced memorandum concerning the same subject.

The LM AGS Software Development and Verification Plan, dated May 25, 1966, is currently being revised. Among other things, the content of the Operating Procedures Document contained in Design Report #3 for each mission will be redefined and the procedure by which MSC reviews and officially approves LM AGS Design Reports will be changed.

The Operating Procedures Document was not originally intended to be an all-inclusive document to be used by the flight crew for operational planning. However, since it could be used for that purpose if written with that objective in mind, we will take steps to incorporate your recommendations.

The Operating Procedures Document and Design Report #3 for the AS-258 mission will be released in a few days. This document will not contain the changes discussed by Cmdr. Mitchell with MPAD and TRW personnel on January 19, 1967. However, these changes and those listed in the referenced memorandum will be incorporated into the AS-503 Operating Procedures Document. Preliminary copies of this document will be available for your review by February 15, 1967. The final AS-503 document will be available by about March 1. It is expected that the AS-258 and AS-503 AGS program and procedures will not be different. Therefore, the final AS-503 documents may be used in your work in preparation for both the AS-258 and AS-503 flights. If this is not the case, differences will be clearly pointed out in the AS-503 documentation.

Howard W. Tindall, Jr.

cc:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

cc:
CB/J. A. McDivitt
CB/F. Borman
CB/N. A. Armstrong
CB/E. D. Mitchell
CF22/C. C. Thomas
EG/R. C. Duncan
PA/J. F. Shea
PM/O. E. Maynard
FA/C. C. Kraft, Jr.
FA/S. A. Sjoberg
FM/J. P. Mayer

FM:FJBuler:cm

GSA FPMR 101 CFR 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : See list

DATE: JAN 2 5 1967

FROM : FM/Deputy Chief, Mission Planning and Analysis Division

67-FM1-12

SUBJECT: Why does the AAP command module need a sextant?

Use of horizon scanners for AAP earth orbital missions would considerably reduce the crew's workload and would eliminate the operational constraint of only being able to align the platform when the spacecraft is in darkness. I realize the use of horizon scanners has already been suggested and is being investigated.

The reason for this note is to point out that if we put a radar on the AAP command module to take care of rendezvous and put horizon scanners on to line up the platform, I really can't think of any reason why we need that sextant any more. Of course, I haven't thought much about it, but it seems to me there might be a considerable saving of weight to go that way as well as making the spacecraft a heck of a lot better for general purpose, earth orbital missions.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000217

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

UNITED STATES GOVERNMENT

Memorandum

TO : See list

DATE: JAN 2 5 1967

FROM : FM/Deputy Chief, Mission Planning and Analysis Division

67-FM1-11

SUBJECT: More about computer self check

If they ever have a contest to select the piece of Apollo with the funniest history, I would like to enter "computer self check". It came up again at the MIT review on January 12 as a possible candidate for deletion. One of the MIT guys gave a long, convincing argument in its defence, and although MIT pointed out that approximately two-thirds of the program was not mandatory for flight, they certainly gave the impression it was highly desirable. It was only the next day we found out the actual MIT position was a recommendation to delete most of the self check program, and they were disappointed that we had not done so. Weird.

Something else just happened I think you will find amusing. You remember troubles were discovered in the AS-202 self check program and it was deactivated before the flight to prevent it from screwing up the system. Well, I hear the same thing has happened on the AS-204 program. I guess we should be happy they discover these problems before the flights instead of during them. Apparently if the system were left as it is now, it has the potential of bombing out the system irrecoverably. I assume, or at least hope, that if it did that, it would light the little red light.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000218

UNITED STATES GOVERNMENT

Memorandum

TO : See list DATE: JAN 2 8 1967

FROM : FM/Deputy Chief, Mission Planning and Analysis Division 67-FM1-10

SUBJECT: AS-504 spacecraft computer program and storage status. Also a dash of AS-258.

On January 12 a great herd of us went to MIT to review the AS-504 spacecraft computer program requirements, or at least the questionable items, to make sure we would not overflow the computer storage capability. The consensus of those present was that MIT had put together an excellent presentation defining, with considerable precision, the over-all computer storage situation as well as a very reasonable proposal on which to base our future work. This meeting had none of the fire and excitement of last May's Black Friday. In fact, this one is not worthy of that name.

In brief, MIT told us that presently defined programs exceed memory by about 2,000 words in both the CMC and LGC but that by the removal of certain pre-flight interface and system tests, along with a simple clean-up of the computer programming itself (such as removal of redundant subroutines and constants), we could provide a positive margin of about 1,500 words.

The rest of the day, and the following morning, was spent in discussion of programs identified by MSC and MIT as non-mandatory that are to be deleted either now or when more storage is needed. As a result of all that, we obtained potential pads of about 4,100 words in the LGC and 5,300 words in the CMC. These would result from making all thirteen deletions noted below in List 1. We also identified a number of potential changes and additions which are documented in the second list below with their presently agreed upon disposition. Obviously some of those absorb some of that precious pad, but I guess that's what it's for.

List 1 - Possible Deletions

Categories were:

A. Program to be removed immediately - no further effort to be expended.

B. Routine to remain in the program now but subject to later deletion - work to continue but on a low priority.

C. Routine to remain in the program now but subject to later deletion - no further effort required since the work is complete at this time.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

	AS-258		AS-504	
	LGC	CMC	LGC	CMC
6. CALCMAN maneuver to input gimbal angles	F	F	E	E
7. Transformation routine to align LM IMU docked	F	-	D	-
8. IMU align using reticle (to provide ISKY mark capability)	-	D	-	E
9. Rendezvous navigation using reticle	-	D	-	D
10. External targeting of Lambert steering	F	F	E	E
11. Erasable memory onto downlist	D	D	E	E
12. Trim option to P40 and R2	E	E	E	E
13. Perform desk calculator type function	F	F	F	F
14. S-band pointing angle display	-	-	E	D
15. Uplink	-	-	E	-
16. LR reasonableness check	-	-	E	-
17. Entry displays to be referenced to oblate earth	-	D	-	E

At least this is the way I think things stand. And now we'll start taking calls from the audience.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

UNITED STATES GOVERNMENT

Memorandum

TO : See list

DATE: JAN 23 1967

FROM : FM/Deputy Chief, Mission Planning and Analysis Division

67-FMA-9

SUBJECT: Latest on the AS-206 spacecraft computer program

During the January 17 program development plan meeting at MIT, a couple of things came up regarding the AS-206 program that are probably worth recording here.

The most significant one, affecting date of the program release, involves verification testing. MIT has laid out a complete test plan of about 46 runs. It was their strong recommendation that if time permits, i.e., if other factors are delaying the flight sufficiently, they should carry out the entire test plan. This would flight qualify the program not only for the nominal mission, contingency orbit insertion and launch aborts, but also would verify the system's capacity for tolerating spacecraft systems failures such as RCS jets or computer interrupts, etc. They felt they could do the whole business by February 15, going into configuration control about the 1st of February. Alternatively, MIT and MSC people have identified nine computer runs which the program must execute successfully before we would be willing to use it in flight. These mandatory tests could be carried out within the previously stated schedule with a release on about January 30. The Apollo Spacecraft Program Manager gave permission to slip release of the flight program to do the more complete job in accordance with our recommendation to do so on January 12.

You will recall our agreement with Grumman to release a program tape to them whenever they felt the program and their facility were ready. It is my understanding that we are making the first of these program releases on about January 18 along with sufficient typical test runs and verbal instructions to permit Grumman to make the most of it. Since early December, Grumman has assigned one of their better people, Clint Tillman, to duty at MIT for about two or three days each week. This arrangement seems to have worked out very well from everyone's viewpoint, I'm very pleased to report.

The AS-206 operational trajectory has just come out and apparently is based on four-second ullage. Since this indicated there is some confusion, Tommy Gibson and I thought it might be worthwhile to reiterate here that the spacecraft computer program is being designed with thirteen-second ullage as previously reported. This dictate was selected, you recall, to provide adequate ullage in the event only two jets are active. It was our way of protecting against RCS jet failures without providing logic for changing ullage time in that event.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000221

We have experienced considerable difficulty in obtaining from the Engineering and Development Directorate the necessary propulsion system data needed to complete the formulation of the spacecraft computer program. Response by that organization has been completely unacceptable. I suspect this is partially due to the rather informal manner in which this data was requested. It is obvious that we cannot continue to operate this way, and so in the future requests for this information will be made on a much more formal basis - smothered in the usual stack of paperwork, signed by the necessary managers around here. It is evident that if we fail to deliver this data on schedule to MIT, slips in the delivery of the flight programs will be charged to us - and with some justification.

You remember the business we went through some months ago regarding the attitude hold mode to be programmed in the LGC for use during separation of the LM from the SIVB. Without going through all that history, it is probably sufficient to report that MIT has finally concluded they can develop a better program providing inertial attitude hold rather than the attitude rate hold I previously reported would be programmed.

For whatever it's worth, I might summarize my impression of AS-206 program quality. In spite of considerable difficulty in pulling this program together at MIT, Jim Miller and Dan Lickly have done a commendable professional job, and I really expect this program to perform very well for us. Considerable credit is also due Tom Gibson, Carl Huss and a number of others in providing the necessary coordination and input from MSC. I don't know why I'm sticking my neck out on a prediction like that. Just living dangerously, I guess.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

00000222

UNITED STATES GOVERNMENT

Memorandum

TO : FC/Chief, Flight Support Division DATE: JAN 23 1967

FROM : FM/Deputy Chief, Mission Planning and Analysis Division 67-FMA-8

SUBJECT: Justification for SCAMA circuit to MIT/Boston

This memorandum is to provide justification for the addition of a SCAMA circuit between Houston and MIT/Boston and two additional telephones in Building 30, MSC.

The Flight Control Division has established a requirement that consultative services by knowledgeable MIT personnel be readily available during Apollo flight operations. Since the impact on future computer program development of extended tours of duty at Mission Control Center-Houston by key MIT personnel is unacceptable, an alternate approach has been proposed by MPAD and accepted by FCD. This approach is for Flight Software Branch personnel to provide this service in the Mission Control Center-Houston with immediate access by special communication circuits to the aforementioned MIT people at their disposal. Discussions with personnel of your Division have led to the conclusion that a special SCAMA circuit directly between MSC and MIT/Boston is most suitable and economical for this purpose. This circuit should be terminated at the MIT switchboard in Boston. Access to it must be available in the Flight Dynamics Staff Support Room of Building 30, MSC.

The need for rapid and convenient communications between those persons at MSC responsible for technical direction of MIT in the area of spacecraft computer programming has been long recognized. Present communications are of poor quality and often result in significant delays in the relay of important information. It is estimated that in the order of 200 telephone calls per month have been made over the last several months, and it is anticipated that the frequency is likely to increase. It is evident that addition of a SCAMA phone providing access to the mission support circuit requested above will not only improve communications but should result in a significant savings to the government by its absorption of telephone calls which are otherwise carried out on commercial and FTS circuits. This instrument should be located in the offices of the Flight Software Branch on the second floor of Building 30.

Since the AS-204 simulations and actual operation are imminent, and since the non-operational need is continuing, it is requested that these addi-

00000223

tional facilities be provided as soon as possible. If further assistance is required in establishing our needs in more detail, please contact either Stan Mann (Flight Software Branch) or myself.

Howard W. Tindall, Jr.

cc:
EG/R. C. Duncan
PD4/A. Cohen
FA/C. C. Kraft, Jr.
FA/S. A. Sjoberg
FC/J. D. Hodge
FS2/O. L. Jones
FS5/T. F. Gibson, Jr.
FM/J. P. Mayer
FM/C. R. Hinc
FM/M. V. Jenkins

FM:HWT:cm

UNITED STATES GOVERNMENT

Memorandum

TO : See list

DATE:

FROM : EW/Deputy Chief, Mission Planning and Analysis Division

67-FM1-7

SUBJECT: Why is it everyone who likes radar wears a white hat?

In one of these notes eight or ten months ago, I commented that it seemed to me the Apollo command module really does not have an operational rendezvous capability. In response to that, I was told to "think positive" and that's what I'm doing for main line Apollo. However, it would be unfortunate if we do not attempt to fix the AAP spacecraft. As I understand it, it is currently planned to carry out some rather advanced orbital missions involving multiple rendezvous in which the command module is not only nominally the active vehicle but is the only manned - quite a different situation than the lunar landing mission. Since mission success will depend completely upon the command module being able to carry out these various rendezvous within a reasonable fuel or propellant budget, it seems mandatory to me that some sort of range or range rate measuring system be provided. Of course, a complete radar would be even better. Failure to do this will mean the rendezvous operation must be carried out with that optical guidance system which is very heavily dependent upon a priori information. "A priori" is the mathematical way of saying that the ground control must be both timely and extremely precise in it's assistance. Such dependence is rather undesirable and constraining, of course. But I would like to point out what I expect one of the worst situations will occur during terminal phase rendezvous when ground assistance is almost worthless.

I would like to emphasize that all of this is just my opinion and is not necessarily the position of my division or directorate. I'm sure there are many who would argue that the optical system is perfectly adequate. They may even back their arguments with all sorts of analyses. However, I don't believe any of that stuff, and I'm afraid waiting for the real experience will get us into the position where it is too late to fix up the command module for these AAP missions. Let's vote.

Howard W. Tindall, Jr.

Attachment:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000225

UNITED STATES GOVERNMENT

Memorandum

Where was this? C. Kraft Gerst OK

TO : See list

DATE: JAN 18 1967

FROM : FM/Deputy Chief, Mission Planning and Analysis Division

67-FMP-6

SUBJECT: AS-504 Spacecraft Computer Programs will be able to support earth orbital and lunar missions

At one time I had sort of expected that we would have to maintain two basic programs for each of the Apollo spacecraft - one for earth orbital operations and one for lunar operations. The former would probably be a refinement of the AS-258 programs and the latter of the AS-504 programs. Further investigation, primarily by Norm Sears of MIT, has revealed that it should be possible to develop spacecraft programs for the lunar mission which will also handle earth orbital missions of at least the AS-258 complexity. Accordingly, it is our intention to develop the AS-504 programs in this way for use on all main line Apollo flights after AS-503. They will be designed to even permit execution of alternate mission plans as a result of contingency situations occurring during the operation. That is, the earth orbital versus lunar option can be exercised in-flight as well as pre-flight.

This new capability provides a considerable flexibility as well as allowing us to exercise the lunar mission programs in earth orbit. Since it is somewhat of a departure from our original plans, I thought it would be worthwhile to tell you about it.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000226

UNITED STATES GOVERNMENT

Memorandum

TO : See list

DATE: JAN 1 0 1967

FROM : FM/Deputy Chief, Mission Planning and Analysis Division

67-FMI-5

SUBJECT: Significant modifications currently planned in the Apollo Spacecraft Computer Programs

Quite a number of decisions have been obtained from the Apollo Program Manager affecting the development of the AS-258 and AS-504 spacecraft computer programs which I am recording here for my own later reference. As usual, I will send it along to you on the chance that you might be interested.

RCS translation maneuvers:

Although provision was being made in the AS-258 and AS-504 computer programs for G&N controlled RCS translation maneuvers, this capability is being deleted. As I understand it, the flight crew supported this decision which implies that all RCS translation maneuvers in both the command module and LM must be performed manually.

Auto proceed:

Auto proceed is the misleading term which has gained popular usage to define a capability requested by the crew for simplifying the procedure whereby the computer is commanded to progress on to it's next function with minimum input from the crew. At one time it was proposed that there be no input at all from the crew under certain circumstances. However, at this time the goal apparently is to provide the crew with the capability of making a "Proceed" command to the computer by a keyboard button assigned exclusively for that function in place of "Verb 33 Enter" - a 4-punch operation. No modification is currently planned associated with this in the AS-258 programs. However, Dr. Duncan has stated that it is his intention to provide this capability on the AS-504 and subsequent spacecraft through the redesignation of the "standby" button.

Direct intercept:

This program, which provides the capability for the crew to target a minimum ΔV, 2-impulse rendezvous sequence of maneuvers, was originally included to provide a flexibility it was felt might be required. Rendezvous mission planning, including aborts at the moon, has now progressed to the point where there is no recognized need for this processor, and as a result it is to be deleted from all Apollo spacecraft computer programs.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

00000227

LM S-band antenna steering:

Although it had been tentatively decided to drop this capability, more definitive mission planning has revealed that there are critical periods in the mission, particularly during descent, wherein crew activity demands computer assistance in steering the LM S-band antenna to acquisition with the ground. Accordingly this capability is to be provided in the AS-504 LM program.

LM platform alignment while docked:

The Program Manager feels some provision should be made for alignment of the LM platform while docked without attitude maneuvering of the craft. The procedure he proposes is for all necessary computations unique to this process to be carried out in the LGC utilizing data already available from the CMC programs. It is probably too late to provide this capability in the AS-208 program, but it should be available for AS-504.

DPS backup of SPS:

At one time there was some consideration given to deleting the DPS backup of the SPS. Since procedures must be developed making large DPS maneuvers docked on the development flights, this proposal has been dropped.

Descent guidance:

Another major program change which has been under consideration is to substitute for the current landing site targeting a fuel saving approach referred to as "range free". In view of recent developments associated with the LM spacecraft hardware, this proposal is not considered a requirement at this time, and so the descent guidance will proceed as it has without change. However, analysis will be carried out on the O&C proposed modification to the descent program which would permit a range free option if that should become necessary at some future time. This option will not be included in the AS-504 LM program unless time and storage permit. A decision on this matter probably need not be made for another four or five months.

Our long awaited "Black Friday" review at MIT is now scheduled for Thursday, January 12, 1967. At that time other modifications will probably be made for storage reasons based on priority and size of the various processors and their options. It should be lots of fun. I'll let you know if anything interesting happens.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

UNITED STATES GOVERNMENT

Memorandum

TO : See list

DATE: JAN 1 0 1967

FROM : FM/Deputy Chief, Mission Planning and Analysis Division

67-FM1-4

SUBJECT: No special spacecraft computer programs are to be developed for AS-208B and AS-503

The decision has been made by the Apollo Program Manager that unique computer programs need not be developed for missions AS-208B (LM) and AS-503 (CM). This decision was brought about due to concern that effort on these programs would affect development of the main line programs. It is certainly consistent with numerous other actions taken recently in support of this activity such as augmenting the MIT staff and providing additional facilities for this work.

AS-208B LM:

As you recall, MIT had been directed to develop a LM program in support of the AS-258B alternate mission to be flown if some failure on AS-206 precluded flying the AS-258 mission as planned. It was to provide the capability for the crew to initialize the system such that it could carry out an unmanned maneuver sequence basically equivalent to that planned for AS-206. The only addition to the AS-206 program for AS-208B was the capability of performing an inflight alignment of the platform by the crew. Although MIT has been directed to cease work on a unique AS-208B program, they have been requested to investigate the use of the AS-206 program without change for the AS-258B mission. I feel there is a good chance that by a combination of special crew procedures and assistance from the ground, techniques could be developed for carrying out this backup mission with that program.

AS-503 CM:

It had been felt desirable to add three capabilities listed below to the AS-205 CM program specifically for the AS-503 mission. Since the schedule impact was unacceptable for the AS-258 mission, direction had been given to MIT to develop a unique AS-503 command module program consisting of the basic AS-205 program with the following added: (a) astronaut steering of the booster into earth orbit, (b) star/landmark and star/horizon navigation, and (c) TLI steering of the SIVB. Now, based on a review by the Apollo Program Manager, it has been concluded that the over-all Apollo project will benefit more by using the AS-205 program as is. MIT has been directed in accordance with this decision.

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

For the sake of completeness, I might point out the rationale behind the decisions for these deletions.

a) It has been concluded that astronaut steering of the booster is not required for main line Apollo. At some later time, when schedule and storage permit, it may be desirable to reconsider this addition. Agreement has been reached by all responsible management personnel, both here at MSC and at Headquarters, on this subject.

b) It is felt that adequate experience and confidence may be obtained in the spacecraft navigation mode utilizing star/landmark and star/horizon observations on AS-503 by merely making the observations as previously planned, but not processing them onboard except to include them on the downlink for post-flight analysis.

c) Although some elements of MSC have been proposing that command module guidance steering of the SIVB would be prime for the trans-lunar injection (TLI) maneuver, the Program Manager emphasized that this is not MSC's position, and as a result the only purpose this program could provide on AS-503 is a backup in the event of a failure of the Saturn guidance prior to the maneuver. Adequate alternate procedures are available for post-flight analysis of the spacecraft guidance systems to determine if it could have handled this task properly in the absence of the actual TLI guidance program.

I should point out that it is currently planned to include the capabilities discussed in both (b) and (c) in the AS-504 command module program.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

00000230

UNITED STATES GOVERNMENT

Memorandum

TO : See list

DATE: JAN 9 1967

FROM : FM/Deputy Chief, Mission Planning and Analysis Division

67-FMA-3

SUBJECT: Rope manufacture for AS-502

This note is to inform everyone that the AS-502 spacecraft computer program ropes will be made precisely the same as those for AS-501. Specifically, it is MIT assembly Solarium 55. You recall Solarium 54 was our original AS-501 A-release, but it was necessary to make a modification in one of the rope modules to correct a scaling problem.

Cline Frasier was given the recommendation to direct Raytheon in accordance with this on January 5, and it is my understanding that he intended to have Raytheon begin rope manufacture for AS-502 immediately. He informed me that the manufacture of the AS-501 ropes will be completed by about January 12th.

Howard W. Tindall, Jr.

Addressees:
(See attached list)

Buy U.S. Savings Bonds Regularly or the Payroll Savings Plan

00000231

Memorandum

TO : FM2/Flight Software Branch
Attention: R. O. Nobles

DATE: JAN 9 1967

FROM : FM/Deputy Chief, Mission Planning and Analysis Division

67-FM1-2

SUBJECT: Procedures needed for the AS-503 TLI maneuver

This note is to back up our telephone conversation (1/5/67) in which I requested you to prepare your recommendation as to how the AGC should be used during the simulated translunar injection maneuver on AS-503. It's certain the crew will want to monitor the progress of this large SIVB maneuver, even though it's controlled by the Saturn guidance system. You were to find out what capabilities exist in the AS-205/503 program for use during this mission phase. For example, one possible solution is for the crew to observe a display of velocity, altitude and altitude rate if this launch phase processor is functional at that time.

Howard W. Tindall, Jr.

cc:
CB/F. Borman
CF/P. Kramer
CF/C. C. Thomas
CF/D. Grimm
CF/C. H. Woodling
EG/R. C. Duncan
EG/D. C. Cheatham
EG23/K. J. Cox
PA/J. F. Shea
PD4/A. Cohen
FC/C. B. Parker
FM/J. P. Mayer
FM/C. R. Huss
FM/M. V. Jenkins
FM12/J. F. Dalby
FM13/J. P. Bryant
FM14/R. P. Parten

FM/Branch Chiefs
FM2/T. F. Gibson, Jr.
FM2/P. J. Stull
FM2/L. A. Fry
FM13/J. R. Gurley

FM:HWT:cm

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

Memorandum

TO : FM2/Flight Software Branch

DATE: JAN 9 1967

FROM : FM/Deputy Chief, Mission Planning and Analysis Division

67-FM1-1

SUBJECT: Uplink will be on LM-4

A decision was made yesterday which I am sure will make a lot of people happy. ASPO has finally decided to equip the LM-4 with a digital uplink. Obviously, the associated computer programs must be added to the AS-504 LM program. I assume that these are the same as those developed for AS-208 and should present no significant problem.

Apparently it is too late to equip the AS-503 LM in this way, but since we are using the AS-208 program for that mission, that has no influence on our programming requirements. Please take whatever action is appropriate regarding technical direction to MIT.

Howard W. Tindall, Jr.

cc:
CF/C. C. Thomas
CF24/C. A. Jacobson
EG/R. C. Duncan
EG25/W. H. Hamby
EG 3/R. E. Lewis
PD4/A. Cohen
FC4/M. F. Brooks
FL/J. B. Hammack
FM/J. P. Mayer
FM4/C. R. Huss
FM/M. V. Jenkins
FM2/P. J. Stull

FM:HWT:cm

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan