

Eyles

Massachusetts Institute of Technology
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Cambridge, Massachusetts

Apollo Project Memo #1951

TO: Distribution
FROM: George W. Cherry
DATE: 10 July 1968
SUBJECT: Highlights of the 20th Software Configuration Control
Board Meeting

Before the meeting took up its agenda items Mr. Kraft asked me to give a report on SUNDANCE vis-a-vis the LMS reports of its deficiencies. I explained that we attempted to run the same mission profile, timeline, and initialization as an unsatisfactory LMS run and achieved tolerable (on our hybrid) to very satisfactory (on our all-digital) results. I stated that our all-digital results were infinitely better and our hybrid results very significantly better than the LMS results. My conclusion was that the LMS was deficient. I also announced that we had modified our all-digital simulation so that a digital astronaut option would be provided to perform Z-axis tracking and that we would modify our hybrid simulator so that cues would be provided (such as shaft and trunnion angles on the FDAI) to the operator to permit Z-axis tracking. This would permit our tests on SUNDANCE to be more operationally realistic. I explained that all subsequent testing on SUNDANCE would be mission oriented and use nominal crew rendezvous to the fullest extent possible. Mr. Kraft said that this was "outstanding."

There was quite a response from the LMS side of the house. The word has gone out that the program, not the LMS, was okay and they are digging into the LMS. Their diagnoses and trouble-shooting have turned up two new hypotheses for their troubles.

- 1) The LAMBDA-matrix which is used to communicate between their ISLGC and environment is defective. Thus, as I understand it, the state vectors and vehicle orientations get unintentionally different between the ISLGC and environment.
- 2) There is drag, perhaps more than reasonable drag, in the environment program. This explains the very large divergence between the ISLGC state vectors and environment when the rendezvous radar is off. It also explains why an old 258 trajectory (about 160 n. mile attitude) worked much better (the drag was less).

I gather from Warren North and Bill Goeckler that there has been intense debugging activity at the LMS since we have reported success with the same reset points and initialization with which they have experienced frustration. Their complaints led to our re-sealing of the measurement incorporation routine and the consequent improvement of P20. However, their own simulator problems appeared to mask completely the actual performance. The cross-talk has been mutually beneficial. I intend to keep it up by encouraging our team to visit the LMS periodically and keeping a finger on the pulse down there.

The second non-agenda item discussed was a request from G & C (Bob Gardiner) to modify the PCR form to state explicitly whether or not any ICD was affected by the proposed change. I was sympathetic to the idea and stated that PCR's which placed the software in violation of previously approved ICD's placed MIT in an awkward position. Two PCR's were cited, one which reduced the analog display routine frequency and the one which increased the number of DSKY lights and therefore used more than authorized power with all lights lit (such as when the DSKY test lights verb 35 is used). Mr. Kraft's response was to state that the SCB will not wait to make a change until a new ICD is negotiated but will write a letter broadcasting to the world that an ICD has been affected.

Myron Kayton stated that a new ICD taking care of the DSKY light change was being prepared and that tests and analyses at GAEC showed that there was no power problem.

Agenda Items: Apollo Spacecraft Software Configuration Control Board

Action Items Covered

Title: Determine APS Minimum Burn Times Required by Mission Plans.

Assigned to: H. Tindall, Jr.

Comments: Bill stated that the LUMINARY program, as amended by PCR 472, would accommodate all mission plans. Bill alluded to Apollo Project Memo 1933 and stated that difficulties could be averted by V37 selection of P71 for early aborts (in order to avoid engine ignition by Abort Stage and premature shut-down by P71).

Title: Determine the First APS on Time for Aborts Occurring Less than 50 Seconds into Powered Descent.

Assigned to: H. Byington

Comments: Our answer to the previous action item really avoids the necessity of short abort APS burns. Nevertheless, Byington gave some very interesting information which I would like to summarize.

The APS propulsion system chamber pressure must build up to 90% before the engine is turned off for an assured subsequent re-start. The problem is that the thrust chamber pressure build-up time depends on the ullage pressure in the tanks. If the ullage pressure is low, a four or five second burn may be necessary. The APS tank pressure should be above 120 p. s. i. Kraft said that there should probably be a mission rule which would abort the landing if the tank pressure dropped too low. Or, an APS pressure bottle should be opened. Neil Armstrong was very concerned

about pushing Abort Stage during hover and having to wait four or five seconds for APS thrust build-up. Mr. Kraft's suggestion of a mission rule regarding main APS tank pressure for proceeding with a landing seems to take care of this. Byington presented the following data. If there is a 3 second APS burn, a 30 minute coast may be necessary before re-ignition can be effected. A 30 second burn requires a 1 minute coast prior to re-start. The slow engine start-up can be avoided by maintaining a minimum APS tank pressure during landing. The short burn problem can be eliminated for early aborts by requiring the astronaut to select P71 via V37E 71E and then using RCS jets in P42 for very short burns or using the APS and waiting the required time to re-ignite. The keying in of V37E 71E and the consequent automatic selection of P42 is preferable to the abort stage selection of P71 for early aborts because the space craft is oriented to the posigrade orientation before the APS is lit. If the engine is ignited in the retrograde orientation the engine should be reignited as soon as possible in the posigrade attitude to raise the orbit. But the short retrograde burn would preclude a quick re-ignition for the posigrade burn.

As shown in the flow graph of P71 in my report of the 19th SCB meeting, when P71 is entered for TFI less than fifty seconds the LGC waits X.XX seconds and then removes the engine on bits. I have just stated also that for early aborts the astronaut should not use abort stage (which turns on the APS engine) because the APS engine would thrust in the retrograde orientation rather than thrust in the desired orientation and furthermore the LGC would command the engine off requiring a wait until the engine can be fired in the posigrade orientation. Thus, the desired operation is for the astronaut to select P71 via V37. Since we are hypothesizing an early abort, P71 will target P42 in the external Delta-V mode for the abort trajectory. The TIG P71 targets for it should be far enough in the future to allow the crew to go through a manual stage and separation sequence. The separation

could be taken care of automatically by the P42 automatic ullage. If the crew wants to separate manually they should wait until the LGC has turned on the powered flight navigation program, Average G, as indicated by the DSKY blanking at TIG-35. The SCB agreed to 3 seconds for the value of X.XX in the flow graph of P71.

MIT Action: Use 3 seconds for the delay before the engine is turned off in P71.

Program Action: Larry Berman

GSOP Action: Steve Copps

Title: Determine the Minimum Impulse Jet firing Time for CSM RCS

Assigned to: H. Byington

Comments: Fred Martin got this on this agenda because some chap at NAR told Don Keene that the jets would blow up if they are fired for short pulses of 14 milliseconds (the way the DAP is now) rather than 15 milliseconds. Byington said that 14 milliseconds was okay for the CSM and the LM. I pray that the guy from NAR didn't know what he was talking about. It does sound incredible. Neil Armstrong said "Just a silly little millisecond longer."

PCN's Approved by the SCB

The following PCN's were acted on by the SCB.

PCN 401.1 It was stipulated by the SCB that the IMU warm-up time assumption (change from 1 hour to 15 minutes) should be changed for P47 also.

Action: Steve Copps. Steve, have we changed this in all the GSOPs? It should be changed everywhere.

PCN 404 Approved.

PCN 414 Approved. But with the complaint that it was hard to tell from the PCN (the work order) what the new specification (the work) says. The SCB would like to see, therefore, the change pages themselves for a PCN when the PCN makes interpretation or detailed understanding very difficult or tedious.

Action: Fred Martin, George Cherry, Ken Greene. Forward change pages with the PCN when the PCN is inadequate for SCB members as a basis for understanding the change.

PCN 415. 1, 2 Approved.

PCN 423 Approved.

PCN 425 Approved.

PCN 435 Approved.

PCN 436 Approved.

PCN 442 Approval deferred because Stan Mann is still studying it.

PCN 449 Approved.

PCN 450 Approved.

PCN 451. 1, 2 Approved.

PCN 452. 1, 2 Approved.

PCN 453. 1, 2 Approved; but with the complaint again that the board members would have appreciated the change pages for study.

PCN 454 Approved.

PCN 455 Disapproved by the SCB because they did not understand and I could not remember the 3rd item in the description of the change which appeared to delete V91, the Show Bank Sum extended verb. The intention and implementation of the PCN was to eliminate the qualifying phrase about V91 - - not eliminate the verb. Thus item 3 on page 2 of the PCN

should have read:

V91 - Delete comment "(Temporary for Hybrid & System Group")

not

V91 - Delete (Temporary for Hybrid & System Test Group)

Action: K. Greene, please get the PCN changed and put it back on the next SCB agenda.

<u>PCN 456</u>	Approved.
<u>PCN 457.1, 2</u>	Approved.
<u>PCN 458</u>	Approved.
<u>PCN 459</u>	Approved.
<u>PCN 460</u>	Approved.
<u>PCN 461</u>	Approved.
<u>PCN 462</u>	Approved.
<u>PCN 463</u>	Approved.
<u>PCN 464</u>	Approved.
<u>PCN 467</u>	Approved.
<u>PCN 191.2</u>	Deferred while Stan Mann studies it!

The following SUNDANCE MIT-originated PCN's were walk-ons; i. e., I hand-carried 30 copies and submitted them to the board although they were not on the Agenda.

<u>PCN 466</u>	Approved. This put the CSM-docked deadband into erasable storage. We did this because one all-digital simulation showed a bending instability. Apparently the problem was really caused by an incorrectly modelled jet plume impingement torque in the simulator and we will not have to use a deadband different from the one we have been using all along.
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PCN 480

Approved. This PCN moved the RR a priori measurement variances into erasable. This was consistent with our philosophy of putting critical parameters into erasable prior to release if there are any erasables left. (I believe the P&I Spec controls these RR performance values, incidentally.)

PCN 483

Approved. This provided the crew with two new extended verbs, V65 and V75, which can, respectively, disable or enable the pitch-roll RCS jet autopilot during a CSM-docked burn. V65 was provided to avoid CM CAPTAM scorching. I expressed the hope that GAEC would perform analyses and simulations to recommend exactly how V65 is to be used. The problem V65 was programmed to solve is not a PGNCs problem, i. e., we violate no ICD's, specifications, etc. However, GAEC and NAR do have a problem with respect to impingement (LM on CSM and LM on LM) and this PCR helps them. I volunteer no more unauthorized, zero schedule impact, work.

Action: Bill Widnall. Bill, I think we should supply enough consultation and cross-talk with GAEC to ensure that they do not compromise our DAP performance, but we should not undertake any considerable work on this essentially non-PGNCs problem without a PCR which could quote a LUMINARY impact.

PCR's Acted on by the Software Control Board

The following PCR's were acted on by the Software Control Board.

The COLOSSUS schedule was affected 2 days by the SCB's approval of PCR 220.

The LUMINARY schedule was affected as follows

- 1) 2 days by PCR 468.2 (Incidentally, MIT submitted this as 488 but the board changed it to 468.2 and changed the similar PCR on COLOSSUS from 468 to 468.1.)
- 2) 1 day by PCR 216.

PCR 215

Approved without MIT/IL impact evaluation. This PCR is, in effect, a review of our GSOP Section 6. It calls for us to provide the impact that incorporation of the new or changed data will have on the validity of SUNDANCE verification that is already completed. The data affects mass properties and some bending characteristics. Keith Glick has Herb Chasan looking at the data now to decide what has changed significantly enough to change the simulator. Bill Widnall has examined the data to determine what changes might affect the LM DAP.

Action: Phil Felleman, Keith Glick, Bill Widnall, would you please tell me by July 22, 1968 what your review of the data has shown? We must write a letter of response of some kind to state how we are dealing with the data. Keith said he will place all data in one of the following three categories:

- 1) The review must have misunderstood our GSOP.
- 2) The change called for by the review is too negligible to warrant changing the GSOP, the simulator or re-testing the program.
- 3) The change is significant enough to change the simulator and Section 6, and the program should be re-tested in selected areas.

PCR 216

Approved for 1 day. This PCR calls for R12 to command re-position of the LR to position #2 when $T_{go} = 0$ rather than when $T_{go} < 12$ in order to avoid losing approximately 20 sec of LR data. If we command re-position of the radar while the vehicle is pitching to the post-hi-gate position rather than 12 seconds before we will lose only about 8 seconds of data.

Action: program change - Bob Covelli; GSOP change: Forbes Little; Information: Bernie Kriegsmann.

PCR 217

Candidate for LUMINARY II. Turned down for LUMINARY at 3 days.

G&C is worried about the future of the drive motor or the position discretcs, causing an "unnecessary" abort of the landing. They want us to ignore the position discrete above hi-gate (because they are sure the antenna is in position #1 as the result of pre-launch positioning and CSM inspection of the LM) and to ignore the position discrete below hi-gate after 60 seconds have elapsed in so far as altitude readings and updates go. It turns out the altitude data works fairly well even if the antenna stayed in position #1, and if the velocity data was good above hi-gate, G&C (Kayton, Hackler), say you can land with only the compromised altitude data.

I have some more information about this. Anyone interested should contact me. The PCR was greeted with enthusiasm from most board members despite the fact that IESD claims the probability of a motor or discrete failure is very, very (they say that G&C should not worry about it) low probability. Bill Tindall thought we should have this "in the landing program," along with the succeeding LR PCR's.

Action: Bill Marscher, do you have any time in your division to do some analysis on landing with landing radar position errors?

Information: Bernie Krigsman, Allan Klumpp, Bob Covelli, L. B. Johnson.

PCR 218

Turned down for LUMINARY at 2 days. In LUMINARY hopper. Since GAEC rotated the LR antenna 6° about the LM -X axis the forward velocity of the LM has a large enough projection on the "cross-range" radar coordinate axis to saturate the lateral velocity cross-pointer when the LR data is displayed. This effect complicates guidance monitoring. G&C wants us to put in a six degree compensating yaw bias during P63 after inhibition of X-axis over-ride. This is basically a

hardware problem which we could help alleviate during P63 but which will still exist for P64 when our yaw attitude is constrained by LPD use. I and others pointed this out and a hardware fix will be examined but the outlook is pessimistic. The crew (Neil Armstrong said) is amazed this thing went so far and for so long without the display implication of the antenna rotation being advertised.

PCR 219

Disapproved for LUMINARY at 2 day impact prediction. In the LUMINARY II hopper. The PCR calls for R12 to read the lateral velocity from the LR and store it for the downlink when R12 begins to read the LR altitude data. Since the lateral velocity is derived from the two rearward velocity beams, the lateral velocity is good when the altitude data good is present. The ground needs this data, G&C says, for monitoring of the guidance system.

PCR 229

Walk-on PCR from G&C concerning the LR. G&C would like us to put R77, the landing radar spurious return test program into LUMINARY. I did not give a visibility impact at the time. I would now predict one day.

PCR 222

Disapproved for LUMINARY for 2 days. It was not officially put into LUMINARY II. This PCR would have changed P32 to improve its convergence characteristics for near circular orbits. I have seen 605 alarms often enough to want the CSI program improved. Tom Gibson pushed for this. But it got shot down, I think, because MPAD has stated that changing N (apsidal crossing for CDH) from 1 to 2 will cause convergence. Also, a simpler fix is going to be proposed, I think, which would merely change a constant in P32.

PCR 437

Approved for zero (0) impact. Initiated by MIT to put R41 into LUMINARY.

PCR 226

Approved (but without Mr. Kraft's signature since he left before the board acted), for zero impact on LUMINARY and zero impact on COLOSSUS. This PCR requests that we change the time a priority display is maintained without permitting an astronaut response from 5 seconds to 2 seconds. Action: Jim Kernan. Jim, would you please see that this gets done. Information: Margaret Hamilton, Craig Schulenberg, John Vella.

PCR 225

This PCR was approved (without Kraft's signature) for nominally zero slip; i. e., MIT will try to implement it for zero slip. The PCR requests that COLOSSUS be changed to permit the inhibit of R60 in P20 when the astronaut rather take another mark than maneuver or approve the maneuver to put the Z-axis along the LOS. The implementation Fred is providing is to light a DSKY light (when the stick flag is set) to notify the astronaut that R60 would like to be done. The astronaut can respond in three ways.

1. Key in V58E to let FLV50N18 come up.
2. Maneuver the spacecraft manually to position the Z-axis along the LOS. (The DSKY light will go out then.)
3. Ignore the light and take another sextant navigation mark. Something like this could be provided in LUMINARY also. The LM's mode control switch being in attitude hold is analogous to the stick flag's being set in COLOSSUS.

Action: George Cherry, Tom Price. Explore with the crew the desirability of analogous PCR for LUMINARY.

PCR 468.2

Approved for 2 days impact on LUMINARY. This changes R32 to P76 in order to re-start protect the CSM state vector when the LM is keeping track of a CSM Delta V maneuver. Previously approved for LUMINARY.

Action: Craig, is this in LUMINARY yet? Forbes Little, please update the LUMINARY GSOP.

PCR 439.2 Approved for zero impact on LUMINARY. This PCR makes it possible for the astronaut to select the preferred orientation alignment in P52 and P57 even though the preferred orientation flag is not set.

Action: Don Millard, would you please implement this.
 Forbes, please provide change in GSOP. Information:
 Bob White.

Capsule Summary of SCB Meeting

<u>PCR</u>	<u>Action</u>	<u>Predicted Slip</u>	<u>PCR</u>	<u>Action</u>	<u>Predicted Slip</u>
483	Approved	2 days	461	Approved	
220	Approved*	2 days	462	Approved	
191.2	Pending		463	Approved	
401.1	Approved		464	Approved	
404	Approved		466	Approved	
414	Approved		467	Approved	
415.1, 2	Approved		488(Changes to 468.2)	Approved	2 day
423	Approved		480	Approved	
425	Approved		215	Approved	
435	Approved		216	Approved	1 day
436	Approved		217	Disapproved	3 day
439.2	Approved		218	Disapproved	2 day
449	Approved		219	Disapproved	2 day
442	Pending		222	Disapproved	2 day
450	Approved		437	Approved	
451.1, 2	Approved		473	Approved	
452.1, 2	Approved		132	Pending	
453.1, 2	Approved		196.1	Pending	
454	Approved		205	Disapproved	
455	Disapproved		438	Disapproved	A - 7 day
456	Approved			"	B-10 day
457.1, 2	Approved			"	C - 14 day
458	Approved		226	Approved	
459	Approved		225	Approved	
460	Approved		224	Disapproved	
			223	Disapproved	

*Para. 5.7-15 and 5.7-18 Disapproved.

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(See following page.)

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