Armstrong

MAY 29 1968

Massachusetts Institute of Technology
Instrumentation Laboratory
Cambridge, Massachusetts

DANCE Memo #71

TO: Distribution

FROM: George W. Cherry

DATE: April 29, 1968

SUBJECT: Discrepancies reported by Astronauts Conrad and Schweickart at SUNDANCE FACI

1. Description: If R31, the Rendezvous Parameter Display Routine, is called prior to the selection of P20, the range rate display appears to be incorrect and is never corrected by the marks taken in P20.

   Explanation: It is true that the marks taken while R31 is running do not influence the display of range and range rate in N54 of R31. See attached PCN #129.2. When R31 is first selected the state vector is integrated to the present time to establish a base state vector. The displays are subsequently computed by conic extrapolations of the base state vector. The marks update the permanent state vector but not the R31 base state vector.

   Avoidance: Terminate and re-select R31.

   Disposition: Closed if NASA approves PCN #129.2.

2. Description: If the astronaut switches the Radar Mode Control switch from LGC to Manual, he observes multiple LGC re-starts.

   Disposition: This problem was due to a bug which was removed in a subsequent revision. The symptom was also observed here. Closed.

3. Description: The rendezvous radar range and range rate registers overflow during rendezvous radar operation in the LMS.

Explanation: The GAEC P&I Specification (LSP-370-3) and the GSOP section V (R-557) state that the radar sends the Range Low Scale discrete at 50.8 nautical miles. The P&I spec also states that the low range scale is 9.38 ft/bit. This is inconsistent and indeed the input counter would overflow at ranges greater than about 50.55 nautical miles with a bit weight of 9.38 ft/bit. Thus

$$50.8 \text{ n. miles} > \frac{(9.38 \text{ ft})(32,767)}{6076.115 \text{ ft/n.mile}}$$

where 32,767 is the maximum number of bits the 15 stage input counter can contain. Thus, if the Range Low Scale discrete did switch on at 50.8 n. miles, overflow would occur.

This appears to be only a documentation problem which has been perpetuated in the radar simulator at the LMS facility. GAEC should change the P&I spec and confirm 9.38 ft/bit. The radar hardware actually will not send more than 32,767 bits because it has an eighteen bit counter which does not send the Range Low Discrete until the three most significant bits are zero.

Disposition:

Action: GAEC to change P&I Spec to reflect when hardware actually changes Range Low Discrete.

Action: Put proper model in all simulators.

Also see PCN #141.1 which changes reference to 50.8 nautical miles in GSOP.

4. Description: In P35 it was noted that the first recycle response to FL V16N45 does not recompute TIG for the midcourse correction burn.

Explanation: The SUNDANCE program differs from the GSOP Section IV.

Disposition: MIT/IL recommends that the coding be corrected to comply with the GSOP. There is no impact for this change. See Anomaly Report attached (Originator Control No. Y3).

5. Description: The astronauts noted that if ENTER was keyed in between TIG-3.5 in response to FL V99N40 during an APS burn (P42), that the ullage jets came on anyway at TIG-3.5. The same symptom could occur if V34E (terminate) were keyed in during this window.

Explanation: A waitlist call is set up prior to TIG-5 to turn on the ullage translation jets at TIG-3.5. An ENTER or V34E keyed in between TIG-5 and TIG-3.5 should kill this waitlist task. The task kill is not provided for.

Disposition: It is recommended that the coding be changed to correct the situation. There is no impact. See attached Anomaly Report (Originator Control No. Y7).

6. Description: The astronauts noticed that the display of the orbital central angle of the passive vehicle during transfer from TIG(TPI) to the time of intercept changes between selections of the TPI program, P34. They wondered why the value they entered in R3 of N55 the first time they selected P34 was not maintained and displayed the next time they selected P34.

Explanation: The erasable for CENTANG is overlaid (time-shared) with erasables in other programs. CENTANG does not appear to deserve an inviolate erasable. However, CENTANG could always be loaded from fixed with the most probable value for that quantity. This would preclude the necessity of loading it most of the time.

Disposition: It is recommended that the program be modified to load the CENTANG erasable with the most probable value of this quantity (130°?) upon selection of P34. There is no schedule impact for this change. See attached Anomaly Report (Originator Control No. Y4).

7. Description: The astronauts noted that during a Lambert targetted RCS burn (P41) or during a Lambert targetted DPS (P40) or APS (P42) burn trim, that $\underline{V}_g$ changed rather erratically and unpredictably in the N85 display and that it was difficult to null its components.

Explanation: An investigation of this subject is presently being conducted at MIT/IL.

It is perhaps worth pointing out, even prior to the results of the investigation of the problem, that there is an intrinsic theoretical problem in nulling $\underline{V}_g$ in the program. A discussion of this phenomenon may give some insight into the problem and show why the astronauts should not try to make the components of $\underline{V}_g$ vanishingly small.

The velocity-to-be-gained, $\underline{V}_g$, at time t is defined as follows:

$$\underline{V}_g(t) = \underline{V}_r(t) - \underline{V}(t) \qquad (1)$$

where $\underline{V}_r(t)$ equals the Lambert velocity vector, the velocity required to coast from the present position at time t to the target position vector RTARG by T_{int}, the appointed time of intercept. The velocity required is a function of the present position vector as well as t and RTARG.

$$\underline{V}_r(t) = \underline{V}_r[\underline{R}(t), \underline{RTARG}, (T_{int} - t)] \qquad (2)$$

Note therefore that

$$\underline{V}_r(t) \neq \underline{V}_r(t + 2) \neq \underline{V}_r(t + 4)$$

because of the change in $\underline{R}(t)$ and $T_{int} - t$.

Once the spacecraft is on the coasting intercept trajectory, the rate-of-change of $\underline{V}_r(t)$ is equal to the gravitational acceleration, $\underline{g}$.

$$\dot{\underline{V}}_r(t) = \underline{g}(t) \tag{3}$$

But before the spacecraft achieves the required velocity the rate-of-change of the required velocity is not simply equal to the gravitational acceleration. Therefore

$$\dot{\underline{V}}_r(t) = \underline{g}(t) + \underline{\epsilon}(t) \tag{4}$$

when the spacecraft is not on the intercept trajectory.

The rate-of-change of the spacecraft velocity vector is simply

$$\dot{\underline{V}}(t) = \underline{g}(t) + \underline{a}_T(t) \tag{5}$$

where $\underline{a}_T(t)$ is the applied thrust acceleration.

Differentiating equation (1) yields

$$\dot{\underline{V}}_g(t) = \dot{\underline{V}}_r(t) - \dot{\underline{V}}(t) \tag{6}$$

Substituting equations (4) and (5) into equation (6) yields

$$\dot{\underline{V}}_g(t) = \epsilon(t) - \underline{a}_T(t) \qquad (7)$$

Equation (7) is the result I wanted to exhibit. This equation shows that $\underline{V}_g(t)$ changes not simply because of the RCS jet thrust acceleration which the astronaut commands but also because of the term $\epsilon(t)$. This term makes the nulling of $\underline{V}_g(t)$ theoretically more difficult for the crew than the nulling of a $\underline{V}_g(t)$ which obeys the simpler equation

$$\dot{\underline{V}}_g(t) = -\underline{a}_T(t) \qquad (8)$$

The behavior of the velocity-to-be-gained vector during an external DELTA V burn is described by the simpler equation (8).

Disposition: Open. The problem is under study at MIT/IL. The data from the bit by bit simulator is being carefully perused to establish with certainity what causes the erratic behavior of $\underline{V}_g(t)$. The data from an External Delta V Program butn is also being analyzed.

8. Description: The astronauts noted that the Rendezvous Radar Search Routine, R24, appeared to generate a pattern which is the mirror image of the one given in Fig. 2.4-4 in Section V of the GSOP.

Explanation: The GSOP illustrates how the pattern would look if viewed from a distant point in space, say the CSM; the astronauts, of course, view the pattern from the LM and it appears reversed.

Disposition: Closed.

9. Description: The astronauts complained that there was no MODE II attitude error display in SUNDANCE.

Explanation: An MDRB was written and approved to put MODE II attitude error displays into SUNDISK and subsequent CSM programs. (I believe that I recollect that it had a 28 day schedule impact.) A PCR was written and introduced in the first Software Control Board Meeting to put MODE II attitude error displays into SUNDANCE; it was never approved.

Incidentally, the same kind of situation could occur in LUMINARY. I still haven't seen a PCR to put MODE II attitude error displays into that program. Where is the eloquent advocator for this change before the SCB?

Disposition: Closed. Unless we receive a PCR.

10. Description: The astronauts stated that N78 does not contain the Rendezvous Radar range and range rate data when it is displayed during the operation of P20. The crew explained that they want this display for a back-up to the tape meters.

Explanation: The only program or routine which currently loads the erasables for N78 is R04, the Radar Self-Test Routine.

This probably should be construed as a discrepancy since the current GSOP section IV in the NOUNLIST, page 22, describes this noun as being callable in P00, P20, P3X, P7X. Indeed, it is only in P00 and then only if R04 is running that N78 contains the Rendezvous Radar range and range rate information.

It would be awkward to use this same noun for range and range rate during P20 because the erasables for N78 are time-shared. There would be less schedule impact if a new noun were defined for range and range rate during P20.

A very large schedule impact would be incurred if it were required that rendezvous radar information were required at a higher frequency and at times other than the P20 (R22) reading of the radar.

Consequently, it is desirable from a program schedule viewpoint that the radar ranging information be supplied only when P20 is running and at a frequency of about once per minute. Thus, P3X should not be expected to read the radar and provide display information about range and range rate when P20 is not operating in the background.

Disposition: I understand that NASA is writing a PCR to provide the display desired by the crew.

MIT/IL SOFTWARE ANOMALY REPORT

1.1 ORIGINATOR:	1.2 ORGANIZATION:	1.3 DATE:	1.4 ORIGINATOR CONTROL NO.	MIT REPORT NO.
P. Adler	MIT/IL	4/23/68	Y7	PROGRAM SUNDANCE PROGRAM REVISION 292

1.5 DESCRIPTION OF ANOMALY:

An enter or terminate response to FL V99N40 between TIG-5 and TIG-3.5 for an APS burn will not prevent ullage from coming on.

CONTINUED ON PAGE

1.6 DESCRIPTION OF RUN:

CONTINUED ON PAGE

- MIT ANALYSIS -

2.1 CAUSE:

Ullage off prior to ullage on doesn't stop ullage from coming on.

CONTINUED ON PAGE

2.2 RECOGNITION:

Effect after enter discovered by astronaut; similar problem after terminate found at MIT.

CONTINUED ON PAGE

2.3 MISSION EFFECT:

Ullage could be left on for an excessive length of time.

CONTINUED ON PAGE

2.4 AVOIDANCE PROCEDURE:

Do not respond to V99N40 until after TIG-3.5 sec. (for an APS burn)

CONTINUED ON PAGE

2.5 RECOVERY PROCEDURE:

Ullage will go off when new program selected.

CONTINUED ON PAGE

2.6 PROGRAM CORRECTION:

Delete ullage-on task following an ENTER or TERMINATE response to use (KILLTASK)

CONTINUED ON PAGE

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc):

Fix program

CONTINUED ON PAGE

2.8 RECOMMENDED RE-TESTING:

Level 5 and special hybrid test

CONTINUED ON PAGE

2.9 MIT/IL SIGNATURE:	2.10 DATE:
Gerry W Cherry	29 April '68

3.1 NASA DIRECTION:	4.1 CLOSING ACTION TAKEN:
CONTINUED ON PAGE	CONTINUED ON PAGE

3.2 NASA/MSC SIGNATURE:	3.3 ORGANIZATION	3.4 DATE:	4.2 SIGNATURE:	4.3 ORGANIZATION:	4.4 DATE:

MIT/IL SOFTWARE ANOMALY REPORT

MIT REPORT NO.

1.1 ORIGINATOR:	1.2 ORGANIZATION:	1.3 DATE:	1.4 ORIGINATOR CONTROL NO.	PROGRAM	PROGRAM REVISION
G. W. Cherry	MIT/IL	4/29/68	Y4	SUNDANCE	all revisions

1.5 DESCRIPTION OF ANOMALY:

CENTANG is loaded with garbage at the beginning of P34.

CONTINUED ON PAGE

1.6 DESCRIPTION OF RUN:

Observed by Astronaut Schweickart during every Rendezvous simulation.

CONTINUED ON PAGE

- MIT ANALYSIS -

2.1 CAUSE:

CENTANG is time-shared.

CONTINUED ON PAGE

2.2 RECOGNITION:

Sees garbage.

CONTINUED ON PAGE

2.3 MISSION EFFECT:

More time required to proceed through P34.

CONTINUED ON PAGE

2.4 AVOIDANCE PROCEDURE:

Load CENTANG every time.

CONTINUED ON PAGE

2.5 RECOVERY PROCEDURE:

N/A

CONTINUED ON PAGE

2.6 PROGRAM CORRECTION:

Load CENTANG from fixed at the beginning of P34 with 130°.

CONTINUED ON PAGE

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc):

Fix

CONTINUED ON PAGE

2.8 RECOMMENDED RE-TESTING:

Special hybrid test of P34.

CONTINUED ON PAGE

2.9 MIT/IL SIGNATURE:	2.10 DATE:
George W Cherry	

3.1 NASA DIRECTION:	4.1 CLOSING ACTION TAKEN:
CONTINUED ON PAGE	CONTINUED ON PAGE

3.2 NASA/MSC SIGNATURE:	3.3 ORGANIZATION	3.4 DATE:	4.2 SIGNATURE:	4.3 ORGANIZATION:	4.4 DATE:

MIT/IL SOFTWARE ANOMALY REPORT

MIT REPORT NO.

1.1 ORIGINATOR:	1.2 ORGANIZATION:	1.3 DATE:	1.4 ORIGINATOR CONTROL NO.	PROGRAM	PROGRAM REVISION
G. W. Cherry	MIT/IL	4/24/68	Y3	SUNDANCE	292

1.5 DESCRIPTION OF ANOMALY:

In P35 it was observed that the first recycle response to FL V16N45 does not compute TIG for the midcourse correction burn.

CONTINUED ON PAGE

1.6 DESCRIPTION OF RUN:

Observed by astronaut Schweickart during rendezvous sequence on LMS.

CONTINUED ON PAGE

- MIT ANALYSIS -

2.1 CAUSE:

Program differs from GSOP.

CONTINUED ON PAGE

2.2 RECOGNITION:

TIG not updated by recycle.

CONTINUED ON PAGE

2.3 MISSION EFFECT:

Too little time could be allowed to prepare for burn

CONTINUED ON PAGE

2.4 AVOIDANCE PROCEDURE:

Fix Program

CONTINUED ON PAGE

2.5 RECOVERY PROCEDURE:

NA

CONTINUED ON PAGE

2.6 PROGRAM CORRECTION:

Recompute TIG on recycle response to FL V16 N45

CONTINUED ON PAGE

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc):

Fix No impact to fix.

CONTINUED ON PAGE

2.8 RECOMMENDED RE-TESTING:

Re-test P35

CONTINUED ON PAGE

2.9 MIT/IL SIGNATURE:	2.10 DATE:
George W. Cherry	29 April '68

3.1 NASA DIRECTION:

CONTINUED ON PAGE

4.1 CLOSING ACTION TAKEN:

CONTINUED ON PAGE

3.2 NASA/MSC SIGNATURE:	3.3 ORGANIZATION	3.4 DATE:	4.2 SIGNATURE:	4.3 ORGANIZATION:	4.4 DATE:

MIT-141.1

APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD
- PROGRAM CHANGE REQUEST -

MIT-PCN

No. 191.1
(Completed by FSB)

1.0 COMPLETED BY ORIGINATOR

1.1 ORIGINATOR: G. W. Cherry
DATE: 4/29/68

1.2 ORGANIZATION: MIT/IL
APPROVAL: _____ DATE: _____

1.3 EFFECTIVITY: SUNDANCE

1.4 TITLE OF CHANGE: Correct GSOP Reference to Range Low Scale Discrete

1.5 REASON(S) FOR CHANGE:
GSOP reference is incorrect

1.6 DESCRIPTION OF CHANGE: Replace the sentence starting at the bottom of page 5.2-48 with "For ranges below 9.38 x 32,767 feet, the RR issues the Range Low Scale discrete indicating to the LGC that the low scale factor should be used."

2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT

2.1 ☐ APPROVED ☐ DISAPPROVED

2.2 REMARKS:

2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF: _____
DATE: _____

3.0 MIT VISIBILITY IMPACT EVALUATION:

3.1 SCHEDULE IMPACT:
0

3.2 IMPACT OF PROVIDING DETAILED EVALUATION:

3.3 STORAGE IMPACT:
0

3.4 REMARKS:
GSOP and simulator change only.

3.5 MIT COORDINATOR: George W. Cherry
DATE: 4/29/68

4.0 SOFTWARE CONTROL BOARD ACTION

4.1 IMPLEMENT AND PROVIDE ☐ DETAILED CHANGE EVAL. ☐ PROVIDE DETAILED CHANGE EVALUATION ☐ DISAPPROVED

4.2 REMARKS:

4.3 SOFTWARE CONTROL BOARD SIGN OFF: _____
DATE: _____

5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

5.1 MIT COORDINATOR: _____
DATE: _____

5.2 MIT EVALUATION:
GSOP action: Norm Sears
Simulator Action: Kosmala, Glick

APPROVED FOR IMPLEMENTATION
George W. Cherry

6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION

6.1 ☐ START OR CONTINUE IMPLEMENTATION ☐ DISAPPROVED OR STOP IMPLEMENTATION

6.2 REMARKS:

6.3 SOFTWARE CONTROL BOARD SIGN OFF: _____

MIT 129.2

APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD
- PROGRAM CHANGE REQUEST -

MIT-PCN

No. 190.2
(Completed by FSB)

1.0 COMPLETED BY ORIGINATOR

1.1 ORIGINATOR: G. Cherry DATE: 4/23/68

1.2 ORGANIZATION: MIT/II APPROVAL: _____ DATE: _____

1.3 EFFECTIVITY: SUNDANCE

1.4 TITLE OF CHANGE: Clarification of R 31's operation

1.5 REASON(S) FOR CHANGE: To clarify the operation of R31, the rendezvous parameter display routine.

1.6 DESCRIPTION OF CHANGE:

See amplification sheet

2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT

2.1 ☐ APPROVED ☐ DISAPPROVED

2.2 REMARKS:

2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF: _____

DATE: _____

3.0 MIT VISIBILITY IMPACT EVALUATION:

3.1 SCHEDULE IMPACT:

3.2 IMPACT OF PROVIDING DETAILED EVALUATION:

3.3 STORAGE IMPACT:

3.4 REMARKS:

3.5 MIT COORDINATOR: _____

DATE: _____

4.0 SOFTWARE CONTROL BOARD ACTION

4.1 IMPLEMENT AND PROVIDE ☐ DETAILED CHANGE EVAL. ☐ PROVIDE DETAILED CHANGE EVALUATION ☐ DISAPPROVED

4.2 REMARKS:

4.3 SOFTWARE CONTROL BOARD SIGN OFF: _____

DATE: _____

5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

5.1 MIT COORDINATOR: Gerry W Cherry
DATE: 4/29/68

5.2 MIT EVALUATION: 0 impact APPROVED FOR IMPLEMENTATION

This is a response to another anomaly discovered by the crew on the CMS
Action: BOB WERNER Gerry W. Cherry

6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION

6.1 ☐ START OR CONTINUE IMPLEMENTATION ☐ DISAPPROVED OR STOP IMPLEMENTATION

6.2 REMARKS:

6.3 SOFTWARE CONTROL BOARD SIGN OFF: _____

DATE: _____

APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD

-DATA AMPLIFICATION SHEET -

PROGRAM CHANGE REQUEST NO. 190.2	PREPARED BY: G. Cherry DATE: 4/23/68	ORGANIZATION: MIT/IL

CONTINUATION SECTION (REFER TO BLOCK NUMBER AND TITLE ON PROGRAM CHANGE REQUEST FORM)

Add the following assumptions to the list of assumptions

(3). If navigation marks are made after this routine is selected and running, the effect of the marks on the state vector will not be exhibited in the display of range and range rate. To see the effect of the navigation marks on the range and range rate in N 54, the astronaut must terminate this routine (PROCEED) and re-select it (V83E).

(4) If R31 is run for a long time in coasting flight the range and range rate information in N54 will begin to degenerate because of the conic extrapolations of the state vectors.

On line #20 show

Extrapolate LM and CSM state vectors to present time by precision integration (described in Section 5.6.7.1 of R 557) to establish a base state vector for the subsequent conic (Kepler subroutine) extrapolations.

REMARKS