Eyles

Massachusetts Institute of Technology
Instrumentation Laboratory
Cambridge, Massachusetts

Apollo Project Memo # 1984

TO: Distribution

FROM: George W. Cherry

DATE: September 19, 1968

SUBJECT: Highlights of the 24th SCB Meeting Held at MSC on 17 September 1968

Approved LUMINARY PCR's and PCN's Requiring Programming Design, Coding and Re-testing.

PCN417.2 Deletion of ENDSAFE.

This was a PCN and it has already been coded. COLOSSUS had this change approved previously.

Action: Jim Kernan, please verify the change was properly made.

PCN490.2 New Noun for Option Code in Extended Verbs.

This PCN has the same status as PCN 417.2

Action: Jim, please check that this was properly done.
Walker Kupfer, GSOP changes please.

PCN507.2 Termination of Integration.

Same situation as above PCN's.

Action: Jim, please check that this was properly done.
Walker Kupfer, Bill Marscher, please provide GSOP changes.

PCR539 Provide option to disable the the pitch-roll RCS autopilot.

This PCR differs from the similar one in SUNDANCE because it allows the astronaut to disable pitch-roll jet firings during any DPS burn. This should be useful for monitoring trim gimbal operation during the first part of P63.

Programming Action: Jim Kernan or Craig Schulenberg, please provide the extended verb to set and re-set SNUFFBIT. Also, provide for the pitch-roll RCS jets to be extinguished in some fraction of the lunar landing Level III and Level IV tests. The RCS jets should be turned back on after about 300 or so seconds. Coordinate with Bill Widnall on this.

Programming Action: Bill Widnall, please provide a SNUFFBIT monitor in the DAP which extinguishes the pitch-roll jets during any DPS burn. This should provide an interesting demonstration of trim gimbal operation. Please provide a DAP edit to Jim Kernan which will show how the DAP works in the Level III's and Level IV's which have the pitch-roll jets off.

GSOP Changes: Section III - Bill Widnall
Section IV - Walker Kupfer

Information: Don Keene, Peter Weissman. Need date on Coding Change. The coding should be complete before all the new Level III and Level IV tests are started -- about 26 September 1968.

PCR 537 Substitute a Checklist Code Display for the Priority Alarm Display when the RR auto mode Discrete is not Present in P22.

Programming Action: Jim Kernan, Peter Volante

GSOP Action: Walker Kupfer, Bob White.

PCR 541 Decrease Frequency of Marks in P22.

This allows extended verb jobs a reasonable amount of execution time.

Programming Action: Jim Kernan/Peter Volante.

GSOP Action: Bob White, Walker Kupfer.

PCR 542 Assure Rate-Command/Attitude-Hold Mode During P66 & P67.

This should be implemented by knocking down the PULSES bit at ignition time in P63. Do not knock it down in P40 or P42.

Programming Action: Jim Kernan, Bill Widnall.

Information: Don Eyles, Bob Covelli.

done

GSOP Change: Section IV: W. Kupfer
Section III: W. Widnall

PCR 246 Implementation of One-Phase Descent Guidance Logic.

This was the big one considered at this SCB. I insisted on getting it approved. for a specific implementation. Please adhere strictly to this implementation (outlined below) because it has wide consent and agreement. It is particularly important to retain the two-phase landing as a possible logical mode of operation and demonstrate that we have done so. But there should be no more analysis or design time spent at MIT on the old concept. See the attached appendix A for the agreed-upon implementation and action items.

PCR 244 Delay use of LR Data for Four (4) Seconds after Detection of altitude and velocity Data Good Discretes.

Now is the time for all good programmers to come to the aid of their country. The landing radar sends the "data good" signal before the data is good. Fixing this in the hardware costs like millions and like months. I suggest the implementation in figure 1.

Programming Action: Jim Kernan, Bob Covelli.

GSOP Changes: Walker Kupfer, Bernie Kriegsman.

Simulator Changes (?) Alex Kosmala

Information: Craig Schulenberg, Don Eyles, L. B. Johnson.

PCR 248 LR Data Reasonableness Test Changes.

Clark Hackler of MSC's G & C division gave a fine clear presentation of this PCR. He explained that the Reasonableness check

PCR 248 (Cont.)

is only trying to repudiate LR data which comes to us during a side-lobe lock-on. He exhibited a view graph which showed the side-lobe lock-on errors as a function of V and H and illustrated that the following reasonableness checks rejected almost all of the sizes of errors which resulted from side-lobe lock-on without rejecting honest-to-goodness LGC-Good LR differences.

1. Change velocity reasonability test limits to $|7.5 + 0.125\ VT|$ where VT is total velocity relative to the moon. All velocities will use same test.

2. Remove altitude reasonability test above higate-below higate use $|50 + 0.125\ H|$ to test radar data.

Definition: I suggested that we define "hi-gate" as the time at which R12 begins to re-position the LR. This retains compatibility with the old two-phase concept of landing. The SCB accepted this definition.

Action items:

Coding: Jim Kernan/Bob Covelli
GSOP Changes: Bernie Kriegsman, Walker Kupfer
Information: L. B. Johnson, Craig Schulenberg.

LUMINARY PCR's Which Were Discussed But Neither Approved Nor Disapproved (Pending PCR's)

PCR 242 This is the PCR which, along with Mr. Kraft's direction at the last joint MIT/MSC development plan meeting, caused us to modify the DAP to fire -X jets preferentially during lunar landing. The DAP folks, especially Robert Stengel and Don Keene (aided by Bob Covelli), worked hard all last weekend to prepare a test tape for MSC and I hand carried it to Houston on Monday (9/16) night. Bill Widnall's DAP Group deserves real credit for the tape and some of the creative ideas Robert Stengel and Don Keene have put in it.

I am going to ask Tom Gibson to change the status of this PCR from pending to Provide Detailed Change Evaluation since so much work has been spent and is being spent on evaluating a software fix to bail out the hardware.

PCR 551 Rotational Hand Controller Scaling

I attach as Appendix B the excellent memo written by Robert Stengel suggesting a change in the ACA scaling. (Rob re-wrote his memo as a PCR because I wanted to expose these ideas to the SCB.) Bob points out that reducing the ACA maximum rate should both improve the handling qualities of the LM and reduce the jet plume impingement. The PCR was very well received. Warren North said that MIT deserved real credit for looking at the LLRF and LLRV data as we (Rob) did.

Chris asked Warren to evaluate Rob's proposal while he evaluated the uprated DAP manual mode and +X jet firing inhibition.

All the DAP manual mode problems and solutions are being evaluated at once now. I am very pleased that we are so well prepared to support the testing.

Bill Widnall deserves a great deal of credit for finding someone of Bob Stengel's caliber to work full time on the uprated manual mode DAP. Don Keene deserves equal credit for having first conceived the uprated manual mode ideas (he put them in SUNDISK) which Robert Stengel has extended in the LM DAP (under Don Keene's direct supervision).

PCR's Disapproved by the SCB

I'm simply going to list the disapproved PCR's since there is no MIT/IL action required. If anyone is curious about the reasons for disapproval please call me and I'll give you a run-down.

PCR 132
PCR 241
PCR 247

Action Items given to MIT/IL

It appears that the probability of LM tipping over can be reduced by firing 4 jet -X translation at touchdown (at the astronaut's command). The action item is for me to assess the schedule impact and design consequences of changing the DAP to fire 4 jets -X translation on command in, say, P67 and P66.

SUNDISK PCR's Approved at SCB !!!

There was a flurry of excitement among SCB members when a SUNDISK PCR was introduced. The excitement subsided when the members found out that only the GSOP was being changed.

PCR 533 Incorporate Anomalies 30, 31, 37 and 39 into GSOP Chapter 4.

Action: Joe Vittek has already directed that this be done.

PCR 553 Incorporate Anomaly SDK19A into GSOP Chapters 4 and 5.

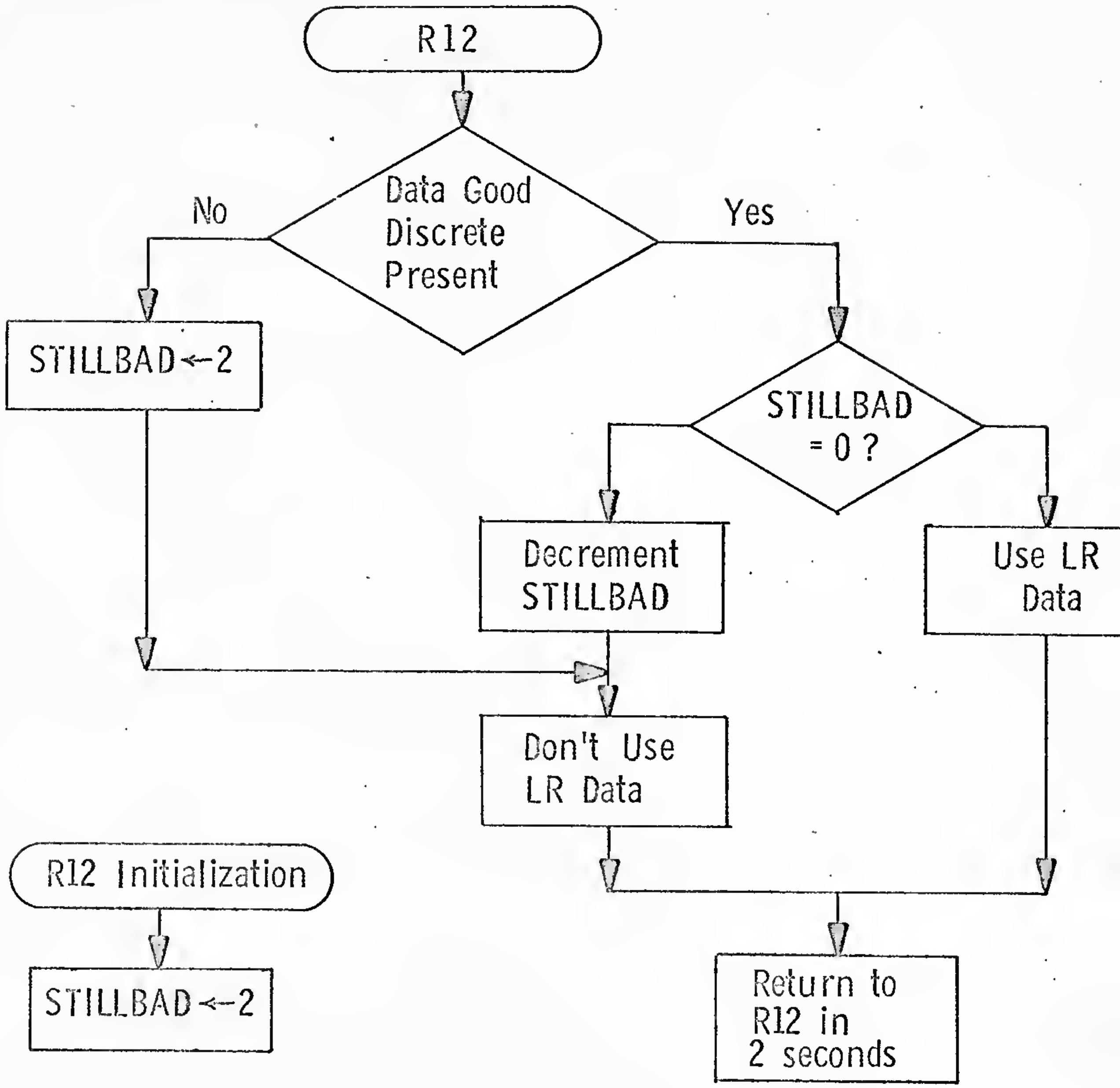
Action: Joe has already assigned this action.

Distribution:

R. Ragan
R. Millard
N. Sears
J. Nevins
W. Widnall*
L. Berman
F. Martin
R. Tinkham
B. Kriegsman*
R. White*
D. Keene
A. Klumpp
M. Hamilton
L. Larson
K. Greene
A. Kosmala*
E. Copps
S. Copps
J. Saponaro
P. Philliou
C. Schulenberg*
R. Covelli*
P. Volante*
H. Chasan
L. B. Johnson
J. Vella
D. Hoag
R. Battin
W. Marscher
D. Lickly
R. Werner
D. Millard
B. Sokkappa
D. Eyles*
K. Glick
J. Kernan*
W. Kupfer*
J. Shillingford*
J. Vittek

G. Heffron (Bellcomm)
J. L. Norton (TRW)
N. A. Armstrong CB
R. A. Gardiner EG
T. J. Lawton EG/MIT
W. B. Goeckler PD
H. W. Byington PD6
C. C. Kraft FA
E. F. Kranz FC
H. W. Tindall FM
L. C. Dunseith FS
T. F. Gibson FS5
C. Hackler EG2
K. Cox EG23
F. Bennett FM6
D. Cheatham EG

* The starred individuals have action items. Their division managers and supervisors should review my assignments and confirm them or make re-assignments of the necessary work.



Note: Two Monitors and two "STILLBAD's" are required, one for velocity and one for range.

Fig. 1 Suggested Implementation for PCR 244.

Appendix A: Implementation of the MSC One-Phase Descent Guidance Logic PCR

1. Retain the hi- and lo- gate targets in separate eraseables. (It has previously been pointed out by MSC that the braking phase can be so targetted that the nominal lunar landing trajectory can look exactly like the current two-phase lunar landing trajectory without the guidance sensitivity to navigation just prior to high gate. This targetting selects for Phase 1 a desired state vector near the landing point - - but the desired state vector is so chosen that the nominal trajectory still flies through the old high-gate target. The neat trick here is that TGO does not become small prior to high-gate, and guidance sensitivity remains reasonable.) Implementing the PCR this way allows,
   (a) the current scheme to be used, i. e., the old two-phase trajectory
   (b) the MPAD proposal to be used
   (c) the previous "false hi-gate" proposal to be used

   Action:
   MSC and MIT/IL to specify target conditions for Phase 1 and Phase 2 so that MIT/IL can run mission - like Level IV tests before the FACI. Need date: 24 September 1968.

2. Provide radial acceleration allocation flexibility by a switch which tells the thrust vector orientation routine to allocate the full guidance commanded desired acceleration along the radius vector or, as presently coded, command the thrust vector along the desired total direction.

   Proposed Action:
   Allan Klumpp to provide the equations and Level I test data for implementing this change to 23B. Need date: 16 September 1968.
   Don Eyles to program and test change. Need date for Level II test results: 18 September 1968.
   Bernie Kriegsman to provide GSOP change pages. Need date: 20 September 1968.

3. Use the nominal engine thrust divided by LGC-computed mass for the thrust acceleration. (Thrust acceleration is required for 2. above)

   Proposed Action:
   MSC to confirm that this is satisfactory. (The alternative is to filter measured thrust acceleration as we do in ascent.)

4. Provide a switch to bypass linear guidance in P 63 during one piece landings.

   Proposed Action:
   Coding - Don Eyles
   GSOP - Bernie Kriegsman

5. P 64 is selected from P 63 by comparison of TGO with a number stored in the LGC. Move this comparison number into eraseable.

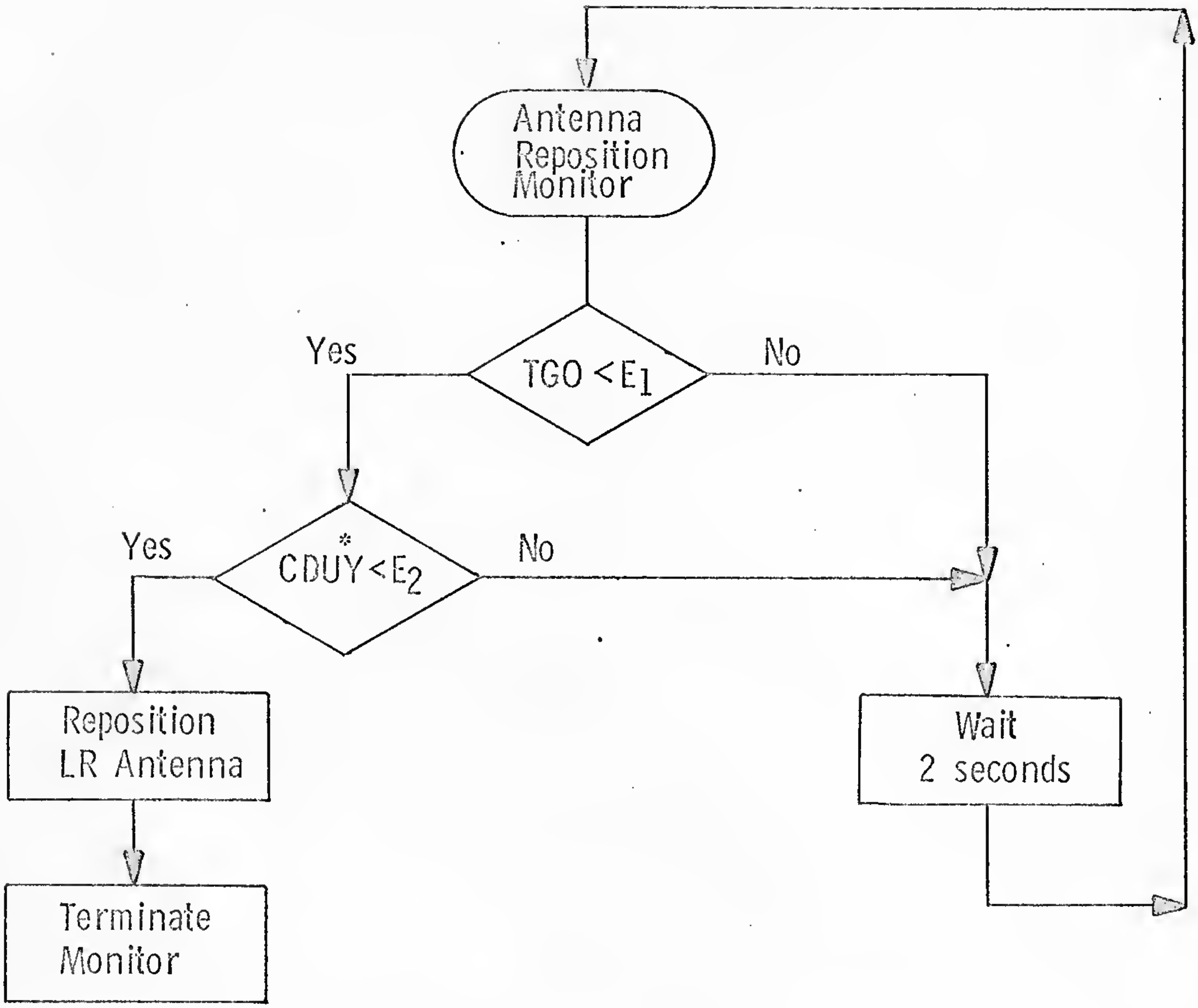
   Proposed Action:
   Coding - Craig Schulenberg or Don Eyles

6. Provide a new extended verb by means of which the astronaut can set the above comparison number to POSMAX causing P 64 and its associated displays and LPD capability to begin within two seconds after the astronaut's request.

   Proposed Action:
   GSOP change - Jack Shillingford
   Coding change - Craig Schulenberg or Don Eyles
   Need date: 18 September 1968

7. Re-position the LR antenna in accordance with the logic in Figure 2 of this appendix. This logic permits complete flexibility with respect to the criterion on which the antenna is re-positioned. If E_1 = POXMAX then CDUY controls antenna re-positioning. If E_2 = POSMAX then TGO controls antenna re-positioning. For 2 phase trajectories for example, E_2 = POSMAX and $E_1 \doteq 2$ seconds. For 1 phase trajectories E_1 could be set to a value which prevented very early re-positioning even if the CDUY E_2 criteria was satisfied.

Action Items:
Coding - Bob Covelli
GSOP Section IV - Jack Shillingford
GSOP Section V - Bernie Kriegsman
Coding Need Date: 23 September 1968



* Computed pitch angle or angle between Radar antenna axis and the local vertical could be used instead of this check.

Fig. 2 New Antenna Repositioning logic.

APPENDIX B

Rotational Hand-Controller Scaling

APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD
- PROGRAM CHANGE REQUEST -

No. 551
(Completed by FS

1.0 COMPLETED BY ORIGINATOR

1.1 ORIGINATOR: R. F. Stengel
DATE: 9/3/68

1.2 ORGANIZATION: MIT/IL
APPROVAL: [signature] DATE: 9-16

1.3 EFFECTIVITY: LUMINARY (NOT COLOSSUS)

1.4 TITLE OF CHANGE: Rotational Hand Controller Scali

1.5 REASON(S) FOR CHANGE:
a) Maximum commanded rate of ACA normal scaling is too high for manual lu landing.
b) Normal and fine scaling of ACA are too high for manual CSM-docked contro

1.6 DESCRIPTION OF CHANGE:
a) Reduce normal maximum commanded rate from 20°/sec to 14°/sec.
b) Reduce normal and fine scaling by a factor of 7 for the CSM-docked case.

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: George W. Cherry
DATE: 9/16/68

5.2 MIT EVALUATION:

6.0 SOFTWARE CONTROL BOARD DECISION ON MIT DETAILED PROGRAM CHANGE EVALUATION

6.1 ☐ START OR CONTINUE IMPLEMENTATION ☐ DISAPPROVED OR ST IMPLEMENTATION

6.2 REMARKS:

6.3 SOFTWARE CONTROL BOARD SIGN OFF:
DATE:

APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD

-DATA AMPLIFICATION SHEET -

PAGE ____ OF ____

PROGRAM CHANGE REQUEST NO. ________	PREPARED BY: ________ DATE: ________	ORGANIZATION:

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

The maximum commanded rates of the Lunar Module hand controller are presently scaled at 20°/sec (normal) and 4°/sec (fine). The commanded rate is quantized at $.476^{\circ}$/sec (normal) and $.0952^{\circ}$/sec (fine), as the Attitude Controller Assembly (ACA) output is incremented in 42 steps.

The results of flight evaluations with the Lunar Landing Research Vehicle (LLRV) and at the Lunar Landing Research Facility (LLRF), summarized in Reference 1, indicate that normal scaling of 14°/sec produces better handling qualities at the lunar landing control power of about $10\text{-}12^{\circ}/\text{sec}^2$. As shown in the accompanying figures from Reference 1, this combination lies further within the "Acceptable Contour" and provides greater contingency control in the event reaction jet or trim gimbal failure.

In Reference 2, attitude rocket propellant consumption of the LLRV is given as a function of stick scaling and rate deadband. In the figure from Reference 2, it can be seen that reduced stick scaling results in reduced propellant consumption. In view of current concern over control jet impingement, reduced stick scaling is again suggested by these data.

In the CSM-Docked case, automatic maneuver rates are limited to $.5^{\circ}$/sec or less. With fine scaling, this is 12.5 percent of full scale. When the quantization level of nearly $.1^{\circ}$/sec is also considered, it seems unlikely that precise manual control can be achieved with the present fine scaling.

REMARKS

APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD

-DATA AMPLIFICATION SHEET -

PAGE____OF____

PROGRAM CHANGE REQUEST NO. ______	PREPARED BY: ______ DATE: ______	ORGANIZATION:

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

It is suggested that 2 scaling changes be made in the uprated hand controlle now being developed. The first is that normal scaling be changed to 14°/sec., subject to further refinement after handling qualities simulation. This change can be made immediately with no additional LGC coding. It is also proposed that both scale factors be divided by 7 in the CSM-Docked manual control mode, giving maximum commanded rates of 2 and .57°/sec, granularity of .0476 and .0136°/sec. Additional coding amounting to approximately 6 instructions is required and can be accomplished immediately.

References

1. Hewes, D.E., Interim Report on Flight Evaluations of Lunar Landing Vehicle Attitude Control Systems, AIAA Flight Test, Simulation, and Support Conference, Cocoa Beach, Feb. 6-68, 1967.

2. Jarvis, C.R., Flight Test Evaluation of an On-Off Rate Command Attitude Control System of a Manned Lunar-Landing Research Vehicle, NASA TND-3903, Washington, April, 1967.

REMARKS

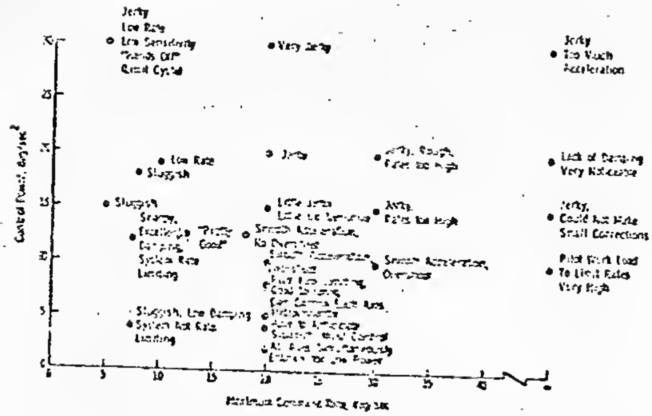


Figure 4.- Plot of pitch control system test points and pertinent comments for the LLRF Vehicle.

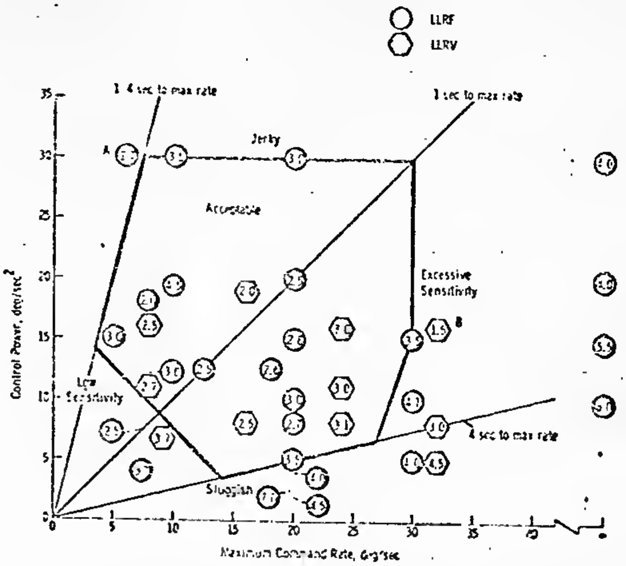


Figure 7.- Summary plot of LLRF and LLRV averaged pilot ratings for pitch control system showing tentative boundary for ratings of 3.5 and better.

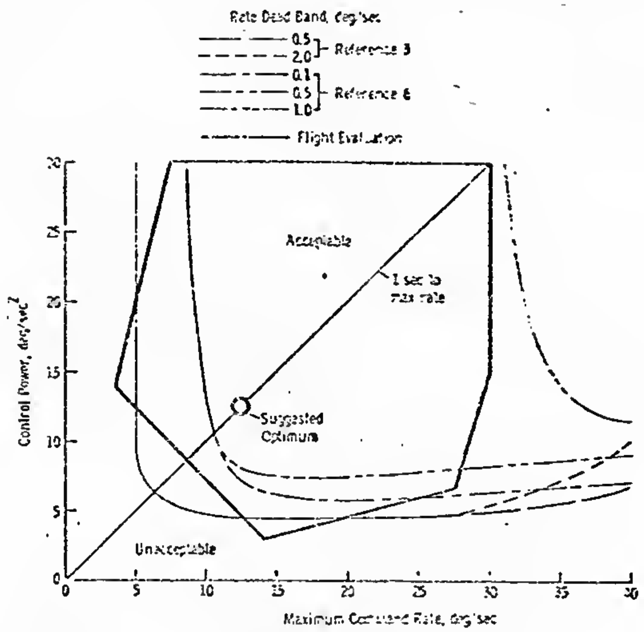
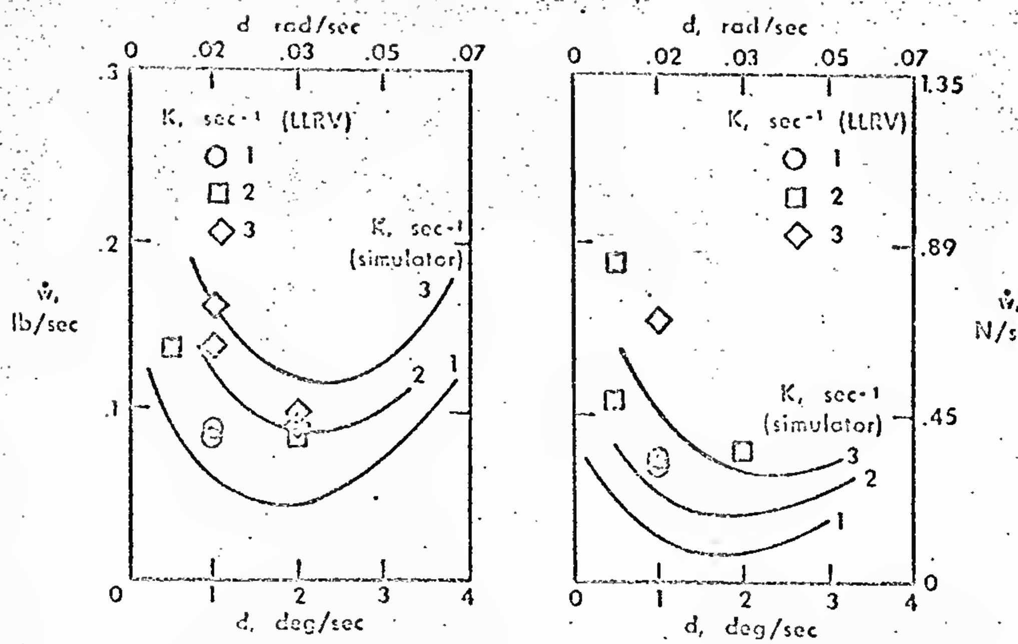


Figure 8.- Comparison of acceptable pilot rating boundaries established by use of the LLRF and the LLRV pitch control systems.

TABLE I.- COOPER PILOT-OPINION RATING SYSTEM

Operating conditions	Adjective rating	Numerical rating	Description	Primary mission accomplished	Can be landed
Normal operation	Satisfactory	1 2 3	Excellent, includes optimum Good, pleasant to fly Satisfactory, but with some mildly unpleasant characteristics	Yes Yes Yes	Yes Yes Yes
Emergency operation	Unsatisfactory	4 5 6	Acceptable, but with unpleasant characteristics Unacceptable for normal operation Acceptable for emergency condition only[1]	Yes Doubtful Doubtful	Yes Yes Yes
No operation	Unacceptable	7 8 9	Unacceptable even for emergency condition[1] Unacceptable - dangerous Unacceptable - uncontrollable	No No No	Doubtful No No
	Catastrophic	10	Motions possibly violent enough to prevent pilot escape	No	No



(a) Pitch.

(b) Roll.

Figure 22.— Comparison of LLRV lunar-simulation attitude-rocket propellant consumption from flight-test data with fixed-base simulator results. $\ddot{\theta} = 10$ deg/sec² (0.18 rad/sec²); $\ddot{\phi} = 14$ deg/sec² (0.24 rad/sec²).

K, sec⁻¹	Max Comm. Rate, °/sec
1	8
2	16
3	24