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Aero-Astro 2
Apollo 8

NOV 5 1968

MEMORANDUM FOR A/Acting Administrator

Via: D/Associate Administrator for Organization and Management

From: M/Associate Administrator for Manned Space Flight

Subject: Request for Approval to Man the Apollo Saturn V Launch Vehicle

Reference: Administrator's Approval of Revised Apollo Flight Schedule Dated April 26, 1968

The purpose of this memorandum is to obtain your approval to fly manned missions on the Saturn V launch vehicle beginning with Apollo-Saturn vehicle #503 currently scheduled for launch in December 1968.

By reference, approval was given to proceed with planning, design, fabrication, development and proof testing necessary to lead to the possibility of a manned AS-503 mission. The contingent nature of this decision was based on the in-flight anomalies encountered in the AS-502 space vehicle during the Apollo 6 mission on April 4, 1968. The three principal problems identified in Apollo 6 were:

- longitudinal oscillations in the launch vehicle in the range of 5 c.p.s. which produced a "POGO" effect and unacceptable G-loadings on the spacecraft

- malfunction of the J-2 Engine Augmented Spark Igniter fueling lines resulting in early shutdown of one S-II J-2 Engine and failure of the J-2 to restart in the S-IVB

- a structural failure in the spacecraft LM adapter (SLA) at approximately T+133 seconds

In addition, other anomalies occurred on AS-502: early cutoff of a second J-2 Engine; failure of the S-IVB propellant utilization (PU) system; a Helium leak in the S-IVB.

It was established early that a decision to man the Saturn V vehicle must be predicated upon three accomplishments:

(1) The cause of these anomalies must be clearly identified;

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(2) The physics of the failures must be understood and duplicated in ground testing;

(3) The fixes for these anomalies must be demonstrated and qualified in analysis and testing.

The activities of the various program elements which addressed these anomalies have been subjected to continuous review by Apollo Program and Manned Space Flight Management. We are now unanimously agreed that these three objectives have been satisfied with respect to the anomalies encountered in Apollo 6.

Each of the problems, as reported to you at various intervals has received rigorous treatment. Satisfactory solutions have been implemented and proven in analysis and testing. The results of this effort are extensively documented including the basis of selection of fixes where alternate paths to solution were available. At the risk of understating the sizable magnitude of the technical and management effort involved in each case, I will briefly summarize each problem, our approach to a solution, the solution decided upon, and, evidence gained in analysis and testing that the solution is valid.

Launch Vehicle Longitudinal Oscillation (POGO)

On July 15 the POGO Solution was established. Testing and analysis had confirmed adequate stability margin at all structural modes by incorporating an accumulator in the S-IC stage LOX feedlines. This was accomplished by filling the existing prevalve cavity with helium. The fix was simple and failsafe, requiring a minimal addition of plumbing to provide helium to the prevalves from existing on-board helium supply. It only remained to qualify the hardware and verify its function in stage ground testing. The POGO fix was approved for hardware implementation and announced following this review. Subsequent testing and analysis has demonstrated at least 6 db stability margin at all structural modes. The hardware for the POGO fix has been installed on Apollo 8 (AS-503) and has been qualified in component testing and in S-IC stage static firings.

J-2 Engine Augmented Spark Igniter

At 260 and 318.9 seconds into the Apollo 6 mission during S-II stage powered flight, J-2 Engine #2 experienced unexplained performance shifts and premature shutdown occurred at 412.31 on this engine.

The cause of this anomaly has been conclusively demonstrated and the hardware fix was flown successfully in the S-IVB stage J-2 Engine on

Apollo 7. The cause, a failure in the fuel line feeding the J-2 Augmented Spark Igniter has been duplicated in engine testing and the specific cause for the failure identified as a flow induced vibration in the flexible bellows section of the line. This phenomenon had been masked in previous ground testing because of the vibration damping effects of liquid air on the exterior of the bellows. Vacuum tests have induced rapid failure in these bellows at peak flow rates. The ASI lines were redesigned to eliminate the bellows sections and a qualification test program verified the fix, including engine tests at AEDC at altitude conditions, and stage testing of both S-II and S-IVB. In addition, we have checked fluid lines throughout the space vehicle and are satisfied that similar problem inducing conditions do not exist elsewhere in the flight system.

Spacecraft-LM Adapter (SLA)

At 133 seconds into the Apollo 6 flight, mission photography visibly showed anomalous behavior in the SLA area. This correlated with abrupt reading changes in Spacecraft, IU and S-IVB instrumentation. The anomaly was identified as pieces of the SLA shell separating from the space vehicle. The SLA structure had suffered some local failure but had sustained flight loads for the remainder of the mission.

The SLA anomaly analysis determined that the local failure of the panel was most likely to have resulted from a localized area of debonding. Tests and analyses have established that earlier concerns of shell instability were not the cause of the anomaly. A rigorous program of ultrasonic inspection, tension/shear pull tests, and venting of the core through inner face sheet has been applied to all SLA's. In addition, to these actions which were applied to the recent successful Apollo 7 SLA, the 503 SLA has been insulated with cork to provide additional protection against heat. We are confident these measures will prevent re-occurrence of the Apollo 6 anomaly.

In addition to the three principal anomalies from the Apollo 6 flight described above, three other problems were identified and received similar treatment.

S-II J-2 #3 Premature Cutoff

At the time of cutoff of the S-II stage #2 engine from the failure of the ASI line, the #3 engine also cutoff and the stage continued to operate on three engines. The cutoff of the #3 engine was traced from flight data to the erroneous wiring of the #3 engine prevalve to the #2 engine cutoff circuit. Therefore, when the #2 engine cutoff, the signal to close the #2 engine prevalve went instead to the #3 engine prevalve, initiating cutoff of the #3 engine also. Review of engineering paper, modification history

and other stage configuration data revealed that the reference designators had been omitted from wiring connectors in the region where the circuits in question could be quite easily cross connected. Furthermore, modification of these wiring harnesses was made after the last scheduled single engine check of the circuits. Even though functional checks were made of the circuits, including prevalve operation, the checks were made only in five engine mode, and the erroneous crossed wiring was not discovered. Corrective action involved careful review of all stage hardware and wiring, correction of engineering to assure both foolproof referencing of connectors, and the inclusion of single engine testing at all sites including KSC, and a complete review of all modification/retest procedures and controls to eliminate any possibility of the same kind of problem in other systems.

Propellant Utilization (PU) System

During the S-IVB burn the Propellant Utilization (PU) sensor gave an incorrect indication that the LOX tank was full. This erroneous indication could have been caused by an open circuit in the cable shield or by a short between the inner and outer elements in the LOX PU probe. This failure would have caused LOX depletion prior to achieving velocity cutoff, if S-IVB second burn had occurred. Other instances of this type of PU failure have been noted in ground testing. Studies were undertaken aimed toward either providing a backup to the PU system in event of failure, or replacing the PU system with a less efficient, but failsafe propellant control. The studies have resulted in provisions to fly with a commanded time-shift propellant mixture ratio control. In this operation the PU systems on both S-II stage and S-IVB stage (essentially identical systems) will fly "open loop", i.e., mixture ratio will be preset and shifted by timer switch command from flight software. Some minor loss of payload margin accompanies this change, but the critical failure modes of the PU system are eliminated.

Helium Leak

A pressure decay was observed in the Apollo 6 S-IVB cold helium system, indicating leakage in either connections or valves. A severe leak could cause early shutdown or no restart of the S-IVB stage. A similar leak had been noted in the flight of Apollo 4 (AS-501). A complete reexamination of the helium system and all possible leak paths did not isolate the cause, but pointed up some precautionary steps that have been taken. Plumbing connectors (Conoseals) which are subject to loosening, have been replaced with teflon coated Conoseals, and procedures have been installed whereby all connectors will be retorqued after the S-IVB arrives at KSC and again following CDDT. These procedures were followed on Apollo 7 (AS-205) and no recurrence of the helium leak was observed.

These three less severe anomalies did not contribute in any way to the three principal Apollo 6 problems.

As shown on attachment, we have given identification and solution of the Apollo 6 problems top priority with the manned flight organization. General Phillips has kept this effort under continuing surveillance. Jointly we have conducted several major reviews as we progressed toward solutions.

On September 19, 1968, the OMSF Design Certification Review (DCR) Board reviewed the AS-503 launch vehicle and the results of corrective actions implemented to resolve the Apollo 6 anomalies. All subjects which affected the decision to man the AS-503 vehicle were examined. No constraining concerns were identified in this review. The DCR Board reaffirmed the intention to proceed with a manned launch pending completion of open work and the final results of the POGO assessment and space vehicle structural assessment which are scheduled for presentation to the Board on November 7, 1968. We do not expect any surprises or change in viewpoint to man AS-503.

Therefore, with the same proviso, that all open work is completed, and that final confirmation of man-rating is obtained in the POGO and space vehicle structural assessments on November 7, I request your decision now to proceed with manned missions on the Saturn V launch vehicle beginning with AS-503 in December 1968.

Original Signed By
CHARLES W. MATHEWS
for George E. Mueller

Attachment

MA/TEJenkins/avb/11-4-68
Ext. 37291

CONCURRENCES:

OFFICIAL FILE COPY

OFFICE CODE ▶	MA/Gen. Phillips	D/Mr. Ginger			
SIGNATURE ▶					
DATE ▶	11/4/68	11/4/68			

NASA Form 1267 (Nov. 65)

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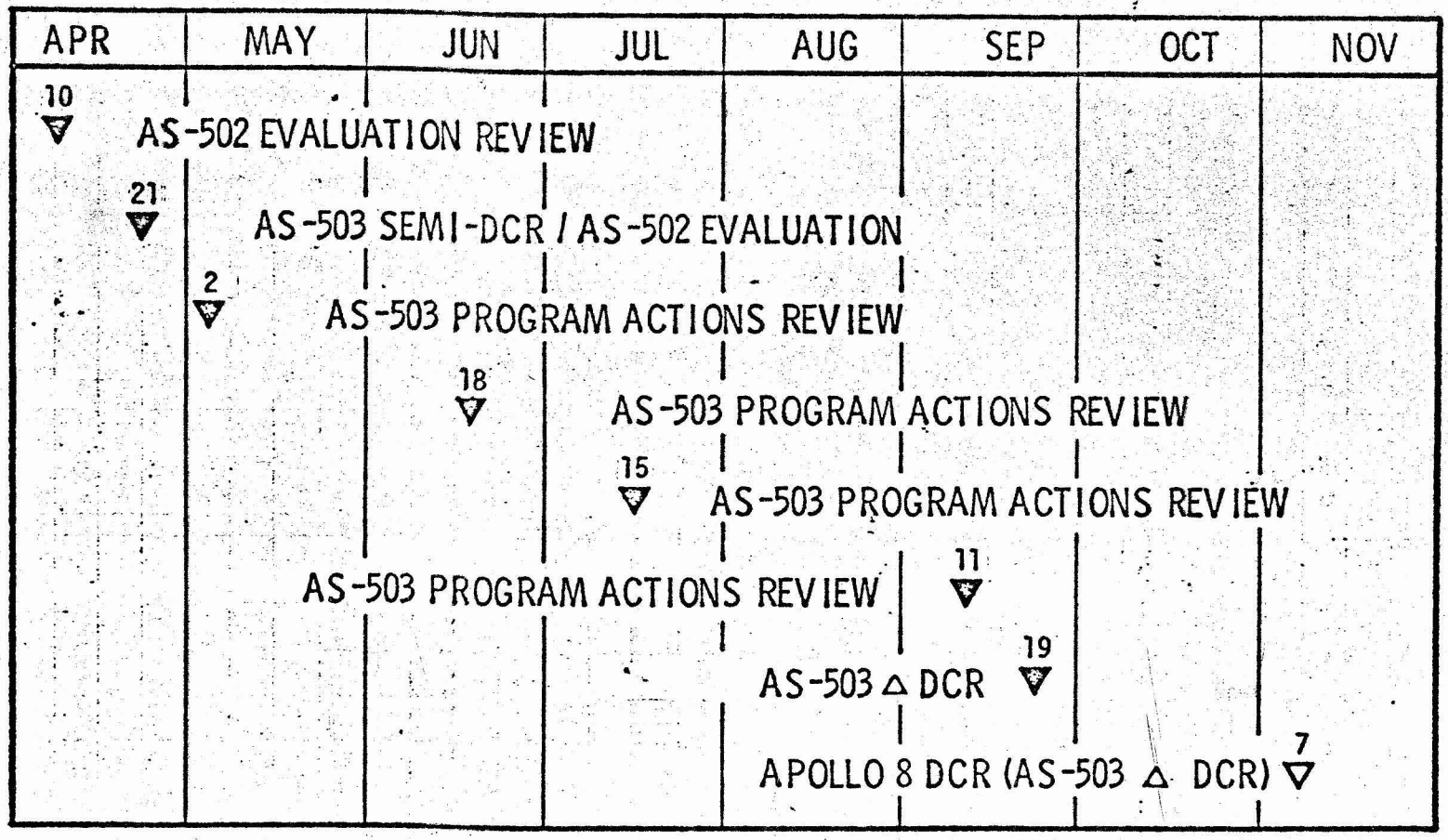
AS-503 DCR / PROGRAM ACTION REVIEWS



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