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APOLLO PROGRAM

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THIRD QUARTER 1967
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APOLLO
RELIABILITY AND QUALITY ASSURANCE PROGRAM
QUARTERLY STATUS REPORT
THIRD QUARTER 1967

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PREFACE

The purpose of this quarterly report is to present in summary form the status of the Apollo Reliability and Quality Assurance (R&QA) Program in terms of significant trends. Selected R&QA aspects of missions of interest, the hardware program, and program management are contained in Sections 1, 2, and 3. A quick-look management summary identifying major significant items, as indicated by arrows (⇨) in the report follows the preface.

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George C. White, Jr.
Director
Apollo Reliability and Quality

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MANAGEMENT SUMMARY

APOLLO 4 (SA-501/CSM 017)

- SA-501 Launch Vehicle
  - Testing and modifications at KSC are continuing and have delayed the CDDT, the Flight Readiness Test, and cryogenic loading.
  - Significant open problems include:
    - ▽ S-II Stage
      - a. S-II Insulation — The adequacy of techniques developed by NAA for rebonding insulation, sealing tears and minor holes, and preventing the promulgation of blisters will be demonstrated in the CDDT. (Page 1-4.)
      - b. S-II Batteries — Terminal breakage has been encountered during vibration testing. A proven battery will not be available for flight. (Page 1-4.)
    - ▽ S-IVB Stage
      - a. S-IVB Stage Restart — Continual difficulties have been experienced with S-IVB stage "start" components. For example, the start discharge valve has exhibited leakage over the life of the program. There have also been problems with fuel and oxidizer turbine inlet temperatures — the high temperatures noted could be excessive for successful restart during flight. A valve redesign is underway. (Page 1-10.)
      - b. S-IVB Liquid Level Depletion Sensors — The LH_2 depletion sensors displayed erratic cycling during cryogenic loading operations at Sacramento. To correct this problem, a software arming time change is being incorporated into the KSC test procedures. More recently, S-IVB-503 LH_2 depletion sensors malfunctioned during cryogenic loading at Sacramento. The cause of this problem has not been established, nor has the impact on Apollo 4 been established. (Page 1-5.)
- Spacecraft
  - LTA-10R — Structural testing has uncovered LM structural weaknesses which may have an impact on the successful performance of LTA-10R. (Page 1-12.)
  - CSM 017 — A systems review was held at KSC during the week of 18 - 22 September 1967. Problems which are launch constraints for Apollo 4 include the following:
    - a. A transistor used in the glycol temperature controller failed on S/C 2TV-1 and a final decision regarding corrective action for CSM 017 is pending. (Page 1-2.)
    - b. Signal conditioner and transducer failures continue to exist in the temperature and measurement systems. (Page 1-6.)

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MANAGEMENT SUMMARY

- Launch Complex 39A
  - There is continued difficulty in maintaining trouble-free operation of the operational intercom system for the launch of Apollo 4. The problem is under investigation. (Page 1-14.)
  - A significant number of wires with exposed conductors havebeen found in the hypergolic service unit necessitating 100 percent inspection and appropriate rework. (Page 1-14.)

APOLLO 5 (SA-204/LM 1)

- SA-204 Launch Vehicle
  - Assessment of launch vehicle ground and flight test data and of corrective action effectiveness indicates that launch vehicle systems are sufficiently reliable to achieve launch vehicle objectives for this mission. Prolonged launch vehicle storage at KSC could be a source of potential reliability problems arising from exceeding the storage life of components and from wearout due to repetitive testing.
- LM 1 Spacecraft
  - There is some concern that the delays, incorporating modifications, and the amount of retesting required will lead to degradation in performance resulting from wear and tear on this spacecraft. In addition, the following specific problems are noted:

    a. The ascent stage engine injector instability and welding continued to be the pacing problems for the LM Program. The most promising configuration is the three- or five-legged baffle with a hub, causing only a minor injector redesign. Development of electron beam welding and electro discharge machining techniques is in process. Initial results are encouraging. (Page 1-16.)

    b. Repeated failures of the ascent stage Sterer helium regulators have been encountered and these have been replacedwith Fairchild-Hiller regulators with effectivity for LM 1 and subsequent spacecraft. Qualification testing is in progress at WSTF. (Page 2-6.)

    c. As a result of the LTA-5 descent stage heat exchanger rupture, the LM 1 heat exchanger has been replaced with the exchanger originally assigned to LM 4. For LM 2 and subsequent spacecraft, a design change is in progress to improve brazing and inspection. (Page 1-17.)

    d. Leaks have been discovered at many fuel and oxidizer flanges of the LM 1 ascent and descent stages. Maximum design operating pressure leak tests will be held up until reasonable assurance is evident that a good solution has been achieved. Several modifications have been attempted and GAEC is evaluating butyl, Gasko, Nitroso, and Rayco seals for use in a single-seal configuration. (Page 1-24.)

    e. Leakage and false indications exist with the RCS solenoid latching valve. Some design modifications appear necessary. (Page 1-21.)

MANAGEMENT SUMMARY

APOLLO 6 (SA-502/CSM 020)

- SA-502 Launch Vehicle
  - This launch vehicle appears to be in better condition, both with respect to problems and documentation, than was the SA-501 launch vehicle at this point in the checkout program.
- CSM 020
  - On 15 September 1967, during a factory test on CSM 020, the polarity was accidentally reversed on the external lead-oxide batteries used to replace the internal fuel cells. The resulting overload caused damage to signal conditioners, terminal boards, and mission events sequence controller relays. A special team from MSC has been appointed to investigate the situation. (Page 1-38.)

SA-205/CSM 101

- The mission reliability assessment, based on mature hardware, indicates a mission risk of 22 percent of not completing a ten-day mission as currently planned. For a five-day mission, the risk equals the goal of 15 percent. Crew safety assessment, based on mature hardware, is within the goal of 2 percent. (Page 1-41.)

MANNED LUNAR LANDING

The updated mission reliability assessment, based on mature hardware, indicates a mission risk of 40 percent and a crew risk of 3 percent which are in excess of goals. (Page 1-45.)

GENERAL

Failure Recurrence Control — Incomplete reporting of test time, inadequate demonstration of corrective action effectiveness, and numerous instances of failure recurrence during tests on space vehicle equipment remain significant program problems. These problems are under study by Apollo R&QA. (Page 3-0.)

Manned Space Flight Network — With currently available information, assurance cannot be provided that failures of critical MSFN hardware have been identified, verified, recorded, analyzed, compared with previous failures, and corrected on the item and/or subsequent items. Mission Operations is assisting APO/R&QA in obtaining the necessary MSFN reliability data. (Page 3-1.)

MANAGEMENT SUMMARY

Apollo R&Q Audits — APO Directive No. 32, Reliability and Quality Assurance Auditing, was issued 18 September 1967 to identify specific responsibilities for planning, conducting, and reporting on audits of reliability and quality program activities at all Apollo organization levels. A summary of planned and completed R&Q audits for 1967 appears on page 3-2. (Page 3-2.)

Apollo CSM and LM Electrical Inspection Criteria and Standards — This document, RA064-001-1A, has been approved for issuance and will be available for Centers and contractors during the Fourth Quarter 1967. (Page 3-1.)

Page

SECTION 1 — MISSIONS OF INTEREST

Chart 1-A. Overall Summary of Mission Risk Analysis 1-0
Chart 1-B. Summary of Missions 1-1

APOLLO 4 (SA-501/CSM 017)

Apollo 4 (SA-501/CSM 017) Critical Open Failures 1-2
Apollo 4 (SA-501/CSM 017) Significant Open Failures 1-3
Apollo 4 (SA-501/CSM 017) Technical Problem Areas 1-9

APOLLO 5 (SA-204/LM 1)

Apollo 5 (SA-204/LM 1) Critical Open Failures 1-16
Apollo 5 (SA-204/LM 1) Significant Open Failures 1-19

APOLLO 6 (SA-502/CSM 020)

Apollo 6 (SA-502/CSM 020) Critical Items List 1-28
Chart 1-C. Apollo 6 (SA-502/CSM 020) Critical Items List 1-29
Apollo 6 (SA-502/CSM 020) Critical Open Failures 1-35
Apollo 6 (SA-502/CSM 020) Significant Open Failures 1-36

SA-205/CSM 101

Chart 1-D. SA-205/CSM 101 Mission Risk Profile 1-40
SA-205/CSM 101 Mission Reliability Assessment 1-41

MANNED LUNAR LANDING (MLL)

Chart 1-E. Manned Lunar Landing Mission Risk Analysis 1-44
Manned Lunar Landing Mission Reliability Assessment 1-45
Manned Lunar Landing Mission — Flight Test Verification Analysis 1-46

SECTION 2 — HARDWARE PROGRAM

Hardware Problems 2-0
Chart 2-A. Failure Mode Effect and Criticality Analysis (FMECA/FMEA) Status 2-8
Comments on FMECA/FMEA Status 2-9

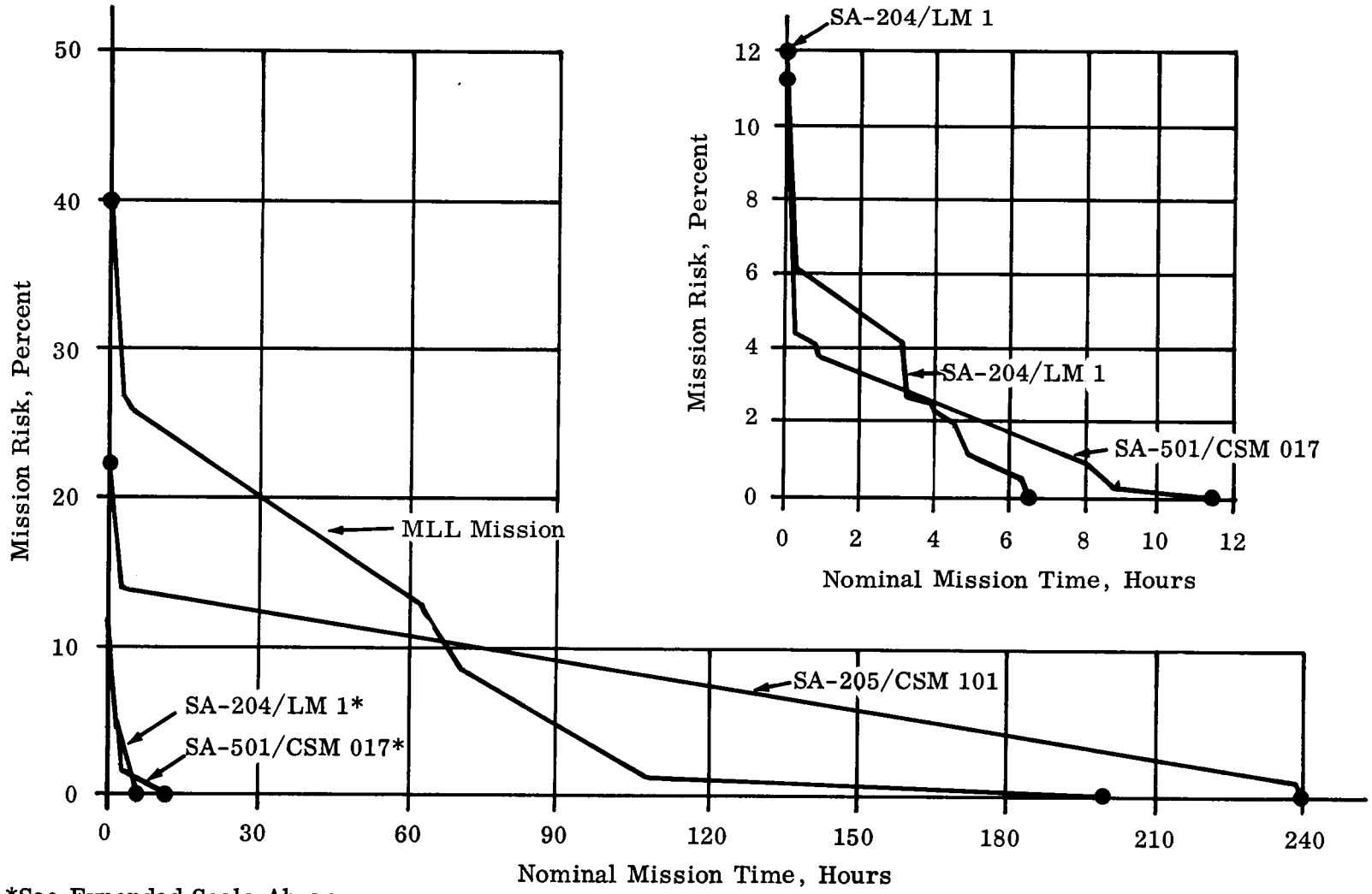
Chart 2-B. Qualification/Certification Test Status		2-10
Comments on Qualification/Certification Test Status		2-11
Chart 2-C-1. Failure Trends — Launch Vehicles		2-14
Launch Vehicle Failures by Responsibility and Cause		2-15
Chart 2-C-2. Failure Trends — Spacecraft		2-16
Spacecraft Failures by Responsibility and Cause		2-17
Chart 2-C-3. Failure Trends — KSC Ground Support Equipment — LC-37B/Uprated Saturn I		2-18
Analysis of KSC Ground Support Equipment Failures by Flight Mission/Subsystem/Component	LC-37/Uprated Saturn I	2-19
Chart 2-C-4. Failure Trends — KSC Ground Support Equipment — Saturn V		2-20
Analysis of KSC Ground Support Equipment Failures by Flight Mission/Subsystem/Component	LC-39A/Saturn V	2-21
Chart 2-C-5. Defect Trends — Launch Vehicles		2-22
Defects by Causes — Launch Vehicle		2-23
Chart 2-C-6. Defect Trends — KSC Ground Support Equipment		2-24
Defects by Causes — KSC Ground Support Equipment		2-25

SECTION 3 — PROGRAM MANAGEMENT

Apollo R&QA Program — Management Problem Areas	3-0
Chart 3-A. Summary of NASA-Apollo Reliability and Quality Audits	3-2
Chart 3-B. Apollo Program Office Directive No. 6 Key Checkpoints	3-3
Abbreviations	A-0

CHART 1-A. OVERALL SUMMARY OF MISSION RISK ANALYSIS

NOTE: Risk Estimates Based on Mature Hardware



*See Expanded Scale Above

CHART 1-B. SUMMARY OF MISSIONS

Mission Definition	Apollo 4 (SA-501/CSM 017) or * Apollo 6 (SA-502/CSM 020)	Apollo 5 (SA-204/LM 1)	(SA-205/CSM 101)	MLL
Configuration	Unmanned	Unmanned	Manned	Manned
Mission Duration (Approximate)	11.7 Hours	6.3 Hours	240 Hours	198 Hours
Trajectory	9885 NM Apogee Altitude Elliptical Orbit	85-200 NM Altitude Elliptical Orbit	85-130 NM Altitude Elliptical Orbit	Lunar
Mission Objectives				
Launch Vehicle Demonstration	X	S-IVB/IU Orbital Performance	S-IVB/IU Orbital Performance	Manned Lunar Landing and Return Capability
Spacecraft Subsystems Evaluation	X	LM Propulsion, Staging, and Structures	Spacecraft/Crew Operations	
Demonstration of Support Facilities and Mission Conduct	X	X	X	
Life Support Equipment Evaluation	X	Limited	X	
Heat Shield Evaluation	X	None	X	
Recovery Evaluation	X	None	X	

*Open-loop Emergency Detection System on Apollo 4.
Closed-loop Emergency Detection System on Apollo 6.

APOLLO 4 (SA-501/CSM 017) CRITICAL OPEN FAILURES

DEFINITION	
Critical Failure:	A failure at a single failure point that will definitely result in loss of primary mission objectives.

CSM SPS Gimbal Actuators

- **Problem** — A review of data obtained during frequency response tests at KSC revealed that output data from the rate feedback pot on the pitch and yaw actuators at maximum rate indicated a 17-cps nonlinear rate condition. Unstable operation of the actuators could cause loss of the spacecraft during an SPS burn.
- **Corrective Action** — NAA has been requested to determine the cause of this anomaly and provide an explanation at the FRR.

CSM ECS Glycol Temperature Controller (Item 2.40, P/N 820956-1)

- **Problem** — During acceptance testing of the glycol temperature controller for S/C 2TV-1 a transistor failed. This failure prevented the closure of the evaporator water control valve by the glycol temperature controller. Because the subject transistor is also used in the Block I controller, this failure must be considered applicable to CSM 017.
- **Corrective Action** — The Block II configuration of the temperature controller has been updated. A requirement for acceptance vibration testing has been established. NAA has been directed to replace the transistor with one of higher rating for all Block II vehicles. A final decision regarding corrective action for CSM 017 is pending.

CSM Instrumentation

- **Problem** — When power was applied to the signal conditioner unit excessive current caused the 28-volt DC power supply to overload.
- **Corrective Action** — This unit is being returned to the vendor for analysis. Malfunction of this power supply could result in loss of signal conditioner and approximately 114 measurements.

APOLLO 4 (SA-501/CSM 017) SIGNIFICANT OPEN FAILURES

DEFINITION	
Significant Failure:	A failure which is not at a single failure point but which could affect mission objectives and which should be closed out before launching.

S-IC Electrical Distributors

- **Problem** — On the S-IC-1 and S-IC-2 stages, the sequence and control distributors, thrust OK distributor, and timer distributor printed circuit boards have experienced buckling, raising, separation, and component damage due to expansion of foam potting.
- **Corrective Action** — All distributors on S-IC-1 and S-IC-2 will be replaced when replacements are available at KSC. Distributors foamed with new potting compound (Lockfoam) will be subject to qualification testing in accordance with ECP 0221. Recurrence control action will remain open until tests are completed and evaluated on S-IC-3 and subsequent.

S-II Static Inverter

- **Problem** — Erratic output of static inverter during static firing attempt. The problem was traced to defective output transistors.
- **Corrective Action** — To complete the test, this inverter and subsequently all of the inverters were replaced by redesigned units. This design incorporates higher power transistors in the output stages. The testing of the new inverters, however, is not complete.

APOLLO 4 (SA-501/CSM 017) SIGNIFICANT OPEN FAILURES (Cont.)

S-II Insulation

- Problem — The S-II stages, particularly S-II-1, have had numerous problems with the tank insulation. Most of the problems have been concerned with the outer skin; however, debonding of the insulation from the tank wall has also occurred. If a large portion of the sidewall insulation becomes unbonded, excessive boil-off of the propellants will occur and possible additional structural damage to the stage may be incurred.
- Corrective Action — Due to the frequency of occurrence, techniques have been developed by NAA for rebonding insulation, sealing tears and minor holes, and preventing the promulgation of blisters. The adequacy of these corrective actions on S-II-1 will be demonstrated in the CDDT. For future vehicles, a complete new system of spray-on foam insulation has been developed.

S-II Batteries

- Problem — During vibration testing of Electric Storage Battery Company's Type II batteries for the S-II stage, several terminals broke. These batteries were on test to evaluate changes made to correct a problem in voltage output under certain load conditions.
- Corrective Action — The terminal breakage has been attributed to poor control over the tightness of the cells in the cell jars. Four batteries have been procured from Electric Storage Battery Company with proper cell-pack tightness. These are at North American Aviation undergoing temperature/vibration testing (two under high temperature and two under low temperature). As backup, four batteries from Eagle Pitcher have also been procured and are undergoing similar testing at NAA. Modification kits for Eagle Pitcher batteries have been procured and qualified by analysis. Flight batteries have been procured from both Electric Storage Battery Company and Eagle Pitcher.

S-IVB LH_2 Vent and Relief Valve (Second Quarter 1967 Report)

- Problem — There have been failures of the LH_2 vent and relief valve during post-static checkout and launch checkout. The first was excessive leakage in the boost-closed position apparently caused by improper staking which allowed the piston rod to unscrew. The second failure was also leakage, but it was caused by improper torquing during assembly.
- Corrective Action — Valves have been replaced, and the operation has been satisfactory. The valve has been redesigned to reduce piston seal leakage, and a cotter pin has been added for piston rod retention. The redesigned valve, MN1A48257-511 has been approved for SA-501 and subsequent.

S-IVB Liquid Level Depletion Sensors (Second Quarter 1967 Report)

- Problem — The liquid level depletion sensors have been subject to erratic operation and have given erroneous depletion indications during the cryogenic loading cycle at the Sacramento Test Facility.
- Corrective Action — This problem is attributed to turbulence caused by the filling operation and the creation of a static charge. Upon discharge of the static charge, erratic operation of the measuring equipment occurs. This problem has not occurred at KSC; however, this has been attributed to the equipment at Sacramento being more sensitive than that at KSC. The contractor had promised to investigate the problem in a test program at Sacramento; however, it was determined that the restricted simulation possible at Sacramento would not result in meaningful results with respect to the effect of full-scale loading on the drop-outs of the sensors. The possibility of running the tests on the battleship is now being investigated. The flight sequencing has been changed so that arming of the depletion sensor circuit does not occur until 0.2 seconds after nominal velocity cutoff. This would prevent a premature cutoff by the depletion sensor.

CSM SPS Flight Combustion Stability Monitor

- Problem — During CSM 017 integrated tests on 19 July 1967 the flight combustion stability monitor (FCSM) light came on indicating that the FCSM sent a terminate thrust signal to the service propulsion system.
- Corrective Action — The FCSM will be closed-loop for CSM 017 with a ground backup. An engineering order has been issued to install a connector in the GSE line (which will be disconnected prior to launch) to prevent the line from acting as an antenna which might cause the false shut-down signal. The exact cause of the failure is still undetermined.

CSM SPS Propellant Retention Reservoir

- Problem — Cracks developed in the SPS propellant retention reservoir during Block II qualification test. This reservoir was redesigned following the flight of CSM 009.
- Corrective Action — The contractor is performing additional vibration tests, simulating launch and boost environments, that were scheduled for completion 22 September 1967. These tests should determine if the cracks developed as a result of shipping or the vibration test.

APOLLO 4 (SA-501/CSM 017) SIGNIFICANT OPEN FAILURES (Cont.)

CSM Temperature and Pressure Measurement Systems

- Problem: There are 23 open failures on the temperature and pressure measurement systems and their individual transducers and signal conditioners.
- Corrective Action: Past history shows the major cause of failure to be excessive moisture at the transducer end of the cable. Continued reduction of insulation resistance by increased moisture absorption could cause loss of several mandatory measurements. Most of the units are being returned to the vendor for analysis.

CSM Launch Escape Motor (P/N 588-09-0201 H)

- Problem: On 1 and 4 August launch escape motor cases from a follow-on production run ruptured during proof pressure acceptance testing at the manufacturer.
- Corrective Action: The case subcontractor sent material samples to US Steel and to an independent laboratory for analysis. The failure occurred in the heat-affected zone adjacent to the longitudinal weld.

CSM G&N Pulsed Integrating Pendulous Accelerometer (PIPA) (P/N 1000013)

- Problem: While running a pre-installation checkout of IMU S/N 11 an erratic Y-PIPA null was observed which became stable after about 3 hours.
- Corrective Action: The PIPA was degaussed and null instability was again noted. After the null value had become stable, the bias was adjusted to the nominal value. Subsequent testing shows the bias value is nominal and stable. The cause of failure has not been determined since the unit was not removed from the IMU.

CSM G&N Night Watchman Module (P/N 1005730)

- Problem: During performance testing of G&N System 122 in CSM 017, improper operation of the G&N FAIL light was observed.
- Corrective Action: This circuit is sensitive to noise on the input line which could delay transmission of a G&N FAIL indication to the MCP and transfer to the SCS mode. A review of the data indicates that this condition exists when DSKY entries are being made.

LC-39 Electrical Support Equipment (ESE) (Second Quarter 1967 Report)

- Problem — Recurring failure of Heinemann circuit breakers in the Saturn V ESE. The breakers are not considered launch critical; however, this type of failure could result in destruction of electronic equipment and cables. There are several hundred circuit breakers of this type in the ESE.
- Corrective Action — Failure analysis revealed that the probable cause of failure was presence of phenolic chips, which caused a short circuit that would not allow the circuit breaker to trip properly. Present indications are that the circuit breakers are to be "used as is" on SA-501 and SA-502; however, the Launch Vehicle Reliability Support Contractor has issued a report recommending replacement of the circuit breakers for these vehicles.

LC-39A LH_2 Lines (Second Quarter 1967 Report)

- Problem — Loss of vacuum in the vacuum jacketed LH_2 lines at Launch Complex 39 has been a continuous problem since the lines were originally installed. Predominant problems have been warped, damaged, or leaking bellows joints. This problem could delay a flight.
- Corrective Action — The Launch Vehicle Operations Reliability Support Contractor has submitted a list of recommendations for upgrading the reliability of the system. Investigation of recommendations is in progress.

LC-39A Automatic Positioning Device

- Problem — During operation of the automatic positioning device, which positions the white room at the end of Service Arm No. 9 with respect to the command module, a malfunction caused the arm to push and deflect the upper part of the space vehicle approximately six inches.
- Corrective Action — Investigation is still in progress.

LC-39A Propellant Lines

- Problem — Seventeen propellant lines on LC-39 Pad A, used for LO_2, LH_2, N_2O_4 and UDMH have been found to be coded with the wrong color paint. This is a hazardous situation.
- Corrective Action — A complete study of all propellant line color coding has been requested, per UCR 525188, and the correction of miscoded situations. This UCR is open and has been brought to the attention of KSC personnel for follow-up action.

APOLLO 4 (SA-501/CSM 017) SIGNIFICANT OPEN FAILURES (Cont.)

LC-39A Emergency Backup Power System

- Problem — The battery cells presently used in the emergency backup power system at Launch Complex 39A are continuing to experience a large number of failures.
- Corrective Action — Extensive investigations have been conducted by both MSFC and KSC. No solution, however, to the shorting problem has been obtained. Although numerous cells have been returned to the manufacturer for failure analysis, there has been no improvement in their performance, nor an explanation as to the cause of the shorting.

LC-39A Purge System

- Problem — Investigation has revealed hypergolic migration in the existing blanket purge system for fuel, oxidizer, and nontoxic fluid lines. A change request (CR 37-0338, 1 March 1967) was issued requesting individual gaseous helium and nitrogen lines in the pads to prevent failed check valves from allowing fuel and oxidizer from mixing and creating a hazardous condition and contaminating equipment.
- Corrective Action — The above change request CR 37-0338 and CR 37-0191 have resulted in disconnection of GN_2 from the system and the use of separate bottles for this part of the purge system. This has eliminated the possibility of fuel mixture for SA-501 fueling. However, this is only a temporary fix and this problem should be followed up to assure permanent correction.

LC-39A RCA 110A Computer (Second Quarter 1966 Report)

- Problem — There have been numerous and continuing failures in the nature of intermittent and open circuits on printed circuit modules of the RCA 110A computer.
- Corrective Action — Numerous fixes have been tried. Module boards in the ground computer are continuing to fail, and the significance of these failures will be demonstrated in the CDDT.

APOLLO 4 (SA-501/CSM 017) TECHNICAL PROBLEM AREAS

S-IC Stage

- ● Description — Exact status of configuration, its relation to static test configuration, and its relation to those items tested during the qualification program appears to be unknown to the Stage Office.
- ▽ Impact — Any malfunction would be difficult to analyze and corrective actions would be uncertain.
- ■ Action — Thorough discussion or review with MSFC is needed to determine the configuration status of the SA-501 launch vehicle.

S-IC Retrorockets

- ● Description — Ten of the S-IC retrorocket motors have been rejected for "thin-case walls".
- ▽ Impact — Probable damage to the S-IC stage during S-IC/S-II separation — vehicle loss could occur.
- ■ Action — Worst looking case (0.086-inch versus 0.098-inch wall) was selected for test. Specification requires 2800 psi, and case did not burst until 3060 psi.
- □ Status — The other nine cases were accepted by MRB.

S-IC GOX Flow-Control Valve (F-1 Engine)

- ● Description — The "O" ring material as used on the GOX flow-control valve has failed to pass the GOX/material compatibility test per MSFC-Spec-106. This valve is considered a flight-critical item and the danger is that the "O" ring may react with the hot GOX.
- ▽ Impact — Vehicle loss could result should this valve fail during the launch or boost phases due to a gummed-up "O" ring.
- ■ Action — Boeing and MSFC laboratories are analyzing the problem. A second source for the "O" ring is being sought. Probable switch to silicone material instead of the presently used Viton "A".
- □ Status — The "O" ring is well protected from local impact. Seals have been examined after hot firing with no indications of seal deterioration.

APOLLO 4 (SA-501/CSM 017) TECHNICAL PROBLEM AREAS (Cont.)

S-II Stage Traveled Work

- Description — Integrity of the S-II Stage. Over 30,000 man-hours of work were transferred to KSC from MTF. All of the UCR's, MCR's, contractors non-conformance (CNC), and deviations to COFW endorsements 1, 2, and 3 were analyzed and compared so that validation determination could be accomplished. The integrity of the static firing test would not be invalidated with all subsystems revalidated at KSC except for two possible exceptions:
  (1) MCR No. 3162 — The J-2 engine LOX turbines were inspected and turbines replaced. The replacement of these three turbopumps on the S-II-1 stage requires re-orificing and reverification of the engines as per Rocketdyne ground rules.
  (2) MCR No. 4083 — An in-flight helium injector system was added to the LOX recirculation system. It appears that this system can not be verified except by static firing.

▽ Impact — Mission degradation or mission loss.

■ Action — The S-II Stage Office was notified of the above MCR's by phone on 11 April 1967 and resolved the matter with KSC. The NAA contractor's non-conformance (CNC) states as a reason not to recalibrate: "Schedule does not permit".

S-IVB Engine Restart

- Description — The start-tank discharge valve has experienced continual leakage problems. Over 50 UCR's for gate seal leakage have been written. Propellant pump inlet and thrust chamber temperatures have exceeded the "red line" values. Engine restart test has been discontinued in acceptance testing for subsequent missions.

▽ Impact — If engine restart fails, the S-IVB can not provide thrust to insert the S-IVB/CSM into the 185-kilometer (100 nautical miles) parking orbit nor later into the highly elliptical orbit and therefore loss of mission will result.

■ Action — Discharge valve redesign has been completed. Cross-over ducts have been painted with high-emissivity paint. A compensating orifice was added to the main valve.

□ Status — Gaseous hydrogen purge of the cross-over duct has been provided as a backup solution. Qualification test report for the new valve, P/N 304386, has been approved by MSFC.

S-IVB Chilldown Inverter

- ● Description — The chilldown inverter converts DC power to AC power required by the chilldown auxiliary motor-driven pump. Approximately 10 percent of FARR's have been significant failures in the critical mode.
- ▽ Impact — Loss of the chilldown inverter results in failure of S-IVB engine to start, therefore, loss of mission. Turbopump cavitation could also cause engine structural failure.
- ■ Action — Four inverters have successfully completed the reliability verification test program.
- □ Status — A certificate of qualification for the inverter has been issued for the S-IVB-501.

IU ECS Water-Methanol Accumulator

- ● Description — Although the water-methanol accumulator has passed its qualification tests, the units demonstrate a design deficiency in the form of bladder extension or cold flow resulting in fluid leakage.
- ▽ Impact — Loss of fluid prevents proper pump inlet pressure and could lead to pump cavitation and eventual loss of the environmental control system.
- ■ Action — Available information indicates that a redesigned unit has been installed for the SA-501.
- □ Status — The unit on SA-502 is experiencing pH problems.

IU ECS Critical Life Components

- ● Description — It is reported that some critical life components have exceeded their design-critical life. The 501 measuring rod and the modulating flow-control valve are two such items.
- ▽ Impact — Mission loss.
- ■ Action — The modulating flow-control valve is considered critical inasmuch as it has experienced problems during KSC test.
- □ Status — Latest available information indicates it has been replaced three times and mod kits installed.

APOLLO 4 (SA-501/CSM 017) TECHNICAL PROBLEM AREAS (Cont.)

LTA-10R Instrumentation Single-Failure Points

- ● Description — The "D" transmitter and "D" modulator are identified single-failure points in the LTA-10R instrumentation system.
- ▽ Impact — Failure of either component would result in loss of all load, temperature, and acceleration measurements.
- ■ Action — The risk concerned with these single-failure points has apparently been accepted for this flight.
- □ Status — There is no information available concerning the test and failure history and qualification status of these components.

LTA-10R Structural Integrity

- ● Description — LTA-3 and LTA-3D/R structural testing has uncovered numerous LM structural weaknesses, some of which have an impact on LTA-10R. Although the descent stage top-deck weakness has been corrected on LTA-10R, the descent stage end-panel failure of LTA-3D/R is being rationalized for LTA-10R as no problem. Other LTA-3 test discrepancies have been difficult to refer to LTA-10R because of configuration differences.
- ▽ Impact — Possible structural failure during launch and boost phase of descent stage end panels.
- ■ Action — Some structural modifications are being made to future LM vehicles, but are not being incorporated in LTA-10R.
- □ Status — Current information indicates that GAEC rationalizes that the descent stage end panels of LTA-10R are "probably" acceptable because they were not subjected to anodizing and etching of their surfaces, a process which makes the panels thinner. This is a questionable rationalization.

CSM 017 Pressure Tanks

- ● Description — Stringers of alpha-phase metal have been discovered during routine testing of LM titanium tank forgings supplied by Ladish who also supplies forgings for the CSM tanks.
- ▽ Impact — Reduced structural strength due to possible inclusions of alpha-phase stringers opens the possibility of catastrophic failure of the CSM pressurized tanks.
- ■ Action — MSC is conducting an evaluation on Ladish test coupons. In addition, over-pressure tests were successfully conducted on the CSM 017 tanks.
- □ Status — The evaluation results from MSC are unknown but should be available at the FRR.

CSM 017 Data Storage Equipment

- ● Description — The data storage equipment (DSE) has had a long history of ground test failures. In the limited flight history of the DSE, satisfactory operation has been experienced.
- ▽ Impact — Failure of the DSE to operate properly can prevent acquisition of prime mission objective data. In addition, proposed relaxation of DSE functional requirements will eliminate the inherent redundancy in obtaining mission data once the playback capability is deleted.
- ■ Action — Fixes to problems have consisted primarily of relaxation and/or elimination of functional requirements.
- □ Status — Current plans will fly a DSE with greatly reduced capability.

LC-39A Service Arm No. 9 (Hydraulic Valve 75M08820)

- ● Description — This hydraulic valve, manufactured by Flodyne Controls Corp., failed in all 13 of the scheduled environmental tests. There is concern whether these unsatisfactory test results have been properly assessed by cognizant design personnel. The comments on test report TR-306D indicate generally poor quality and concern for the failure to meet pressure test requirements as failure in this mode could be critical.
- ▽ Impact — These valves are used in four priority II single-failure point applications and failure in a critical mode during Apollo 4 countdown would result in a launch scrub.
- ■ Action — The launch readiness assessment released 22 September 1967 indicates that these hydraulic valves are an acceptable risk for Apollo 4.
- □ Status — Recommended changes have been deferred until the Apollo 6 launch.

APOLLO 4 (SA-501/CSM 017) TECHNICAL PROBLEM AREAS (Cont.)

LC-39A Hypergolic Service Unit

- ● Description — An inspection of approximately 10 percent of the accessible wire bundles in the hypergolic service units have revealed numerous instances of damaged and/or deteriorated polyvinyl chloride (PVC) insulation. Exposed conductors were found in wires located in the interior and exterior of wire bundles inspected. Conclusive evidence of entirely unacceptable workmanship was found.
- ▽ Impact — Since this sample inspection has revealed serious inadequacies in the wiring of the hypergolic service units, it is highly probable that there are many other systems with damaged or deteriorated insulation. Any one of these discrepancies could cause mission scrub or vehicle loss.
- ■ Action — All hypergolic and cryogenic service units are being inspected 100 percent and rework as required is being performed. In some cases it has been necessary to replace 90 percent of the wiring.
- □ Status — It appears that problems in the wiring of the hypergolic and cryogenic service units are under control.

LC-39A Operational Intercommunications System (OIS)

- ● Description — Checkout operations for Saturn V systems are frequently hampered by network communications problems. These problems consist of noisy circuits, garbled sound transmission, and open lines.
- ▽ Impact — Inadequate communications during critical or hazardous operations could result in loss of life and flight equipment, or costly delays.
- ■ Action — Communication systems problems corrective actions are unknown.
- □ Status — Not reported in 22 September Launch Complex Assessment Report. A report is required before launch.

LC-39A Launch Umbilical Tower (Swing Arms 1 through 9)

- Description — The nine Launch Complex 39 service arm systems have a total of 49 priority I SFP's. These 49 SFP's are based on the possible failure of five types of solenoid valves, two pneumatic cylinders, one hydraulic cylinder, and one pressure regulator all of which are unique and unqualified. Solenoid valve P/N 75M08841 used in seven critical SFP applications is of particular concern. During component tests, 6 out of 12 tests scheduled were not satisfactorily completed.

▽ Impact — Failure in a critical mode of any of these components in any of the 49 SFP applications could cause vehicle loss.

■ Action — Launch Readiness Assessment, released 22 September 1967, indicates that these items are satisfactory to support the launch of Apollo 4. Thus no action is planned prior to the Apollo 4 launch.

□ Status — The Apollo 4 mission will be attempted using unqualified components in 49 critical applications in the launch umbilical tower.

APOLLO 5 (SA-204/LM 1) CRITICAL OPEN FAILURES

DEFINITION	
Critical Failure:	A failure at a single failure point that will definitely result in loss of primary mission objectives.

S-IB Gas Generator Control Valve

- Problem — The gas generator control valve was found to be leaking GN_2 during the functional and leakage test on H-1 engine No. 4. The cause of this failure was the accumulation of rust on the sealing surface of the poppet seat.
- Corrective Action — The control valve was returned to Rocketdyne for investigation. It was refurbished and returned to KSC and reinstalled. Subsequent checkout was satisfactory. The UCR has been held open pending establishment of a recurrence control action.

LM Ascent Engine (Fourth Quarter 1966 Report)

- Problem — Engine combustion instability at high frequency, ablative chamber gouging, and appearance of low-frequency instability (footballs) at high and low chamber pressure have occurred at Bell and WSTF with the E2B baffled injector.
- Corrective Action — An MSC/GAEC task force is working with Bell in determining corrective action for solving this problem. A new design injector with a three-legged baffle and ring has been tested indicating a stable burn. The production configuration for this injector has been initiated. Engine instability has been waived for LM 1 only. Rocketdyne has been selected as an alternate supplier for the injector. A rough-combustion shutoff monitor is being developed by MSC for use on LM 2 and LM 3 if a suitable injector is not available. This monitor will enable shutdown only to avoid catastrophic failure.

LM Ascent Engine (Second Quarter 1967 Report)

- Problem — A shift in the thrust vector point of intersection in the engine mounting plane was noted while the engines were test fired in the horizontal position. This condition caused a positive side force in the upward direction which causes RCS firing thus reducing fuel budget.

- Corrective Action: The engine will be test fired in a vertical attitude at altitude conditions and glass plugs inserted downstream of the engine throat. The thrust vector shift has been waived for LM 1 only.

LM Descent Propulsion Helium/Fuel Heat Exchanger (First Quarter 1967 Report)

- Problem: The helium/fuel heat exchanger on LTA-5 ruptured after completion of the LM 1 mission duty cycle firing. Subsequent testing with a clamping device added also failed. Heat exchanger freezeup occurred during cold flow testing at Bethpage.
- Corrective Action: A design change, that includes investigation of means to inspect the completed heat exchanger for braze integrity, the use of gold-alloy braze material (more ductile than a nickel braze), and fuel compatibility testing, with new materials, is in progress. GAEC is investigating the possibility of using Freon in place of water in cold flow test.

LM Descent Propulsion Helium Regulator LSC 270-827-1 (First Quarter 1967 Report)

- Problem: The descent regulator has had problems of: (a) excessive internal leakage following vibration testing, (b) high- and low-frequency oscillations, (c) out-of-tolerance regulation band due to thermal shift, and (d) high-regulation outlet pressures and high lockup during slam start.
- Corrective Action:
  (a) Inspection revealed a contaminant deposit probably due to an unrealistic compatibility test procedure. Subsequent testing reduced the leakage.
  (b) The size of the regulator sensing hole to the main actuator was reduced eliminating the oscillations.
  (c) True pressure shift is in question due to equipment accuracy and limited data. The vendor will run special tests to determine the actual shift at abnormal temperatures.
  (d) The problem is under investigation.

  The flight regulator has not been qualified. Due to the fire on LTA-5, the regulator will now be qualified on PD-2 starting 15 September.

LM Propulsion (First Quarter 1967 Report)

- Problem: Possible propellant freezeup after a short burn of ascent and descent stages.
- Corrective Action: MSC Propulsion Division is investigating the possibility of a freezeup after a short burn and its effect on LM 1. No results of this investigation are available to date.

APOLLO 5 (SA-204/LM 1) CRITICAL OPEN FAILURES (Cont.)

LM Reaction Control (First Quarter 1967 Report)

- Problem — The reaction control system explosions are the result of a combination of minimum impulse mode of operation, low temperature, and an "oxidizer lead" caused by a helium bubble in the propellant line.
- Corrective Action — The four heaters for the engine modules are being replaced by 32 individual flange heaters to maintain a minimum of 120°F on the engine. Heater performance is to be verified on LTA-8 and during LM 1 flight.

APOLLO 5 (SA-204/LM 1) SIGNIFICANT OPEN FAILURES

DEFINITION	
Significant Failure:	A failure which is not at a single failure point but which could affect mission objectives and which should be closed out before launching.

S-IB Fuel Tank Safety Valve

- Problem — Safety valve for fuel tank pressurization failed to completely close. The cause has been isolated to a decrease in lubricity at the sliding poppet seal.
- Corrective Action — Valve has been returned for failure analysis. A Teflon seal, which requires no lubricant, is being evaluated.

S-IVB LH_2 Vent and Relief Valve (IA48257-505) (Second Quarter 1967 Report)

- Problem
- Corrective Action

Same as for Apollo 4.

S-IVB Liquid Level Depletion Sensors

- Problem
- Corrective Action

Same as for Apollo 4.

IU Water-Methanol Accumulator (20Z42040) (Second Quarter 1967 Report)

- Problem
- Corrective Action

See Apollo 4 — Technical Problem Areas.

APOLLO 5 (SA-204/LM 1) SIGNIFICANT OPEN FAILURES (Cont.)

LM Propulsion Solenoid Latching Valve LSC 270-713

- Problem: Internal leakage of the solenoid valves due to other internal leakage. The Nylon seals had been attacked by propellant vapor. Existing seal material has been shown to be inadequate.
- Corrective Action: Ascent Stage — Change is not required since the valves are normally open and cannot be operating during the LM 1 mission.

  Descent Stage — The Nylon seals have been replaced with Kynar seals which are compatible with propellant vapor.

LM Propulsion, Articulated Bellows Assembly

- Problem: Bellows leaked externally after vibration testing as a result of cracks on the outer crest of the convolutions.
- Corrective Action: To permit use on LM 1 (uncorrected) four units were subjected to penalty vibration tests. All units passed the tests successfully. For LM 2 and subsequent, clearance between the bellows slide and bellows has been increased to eliminate rubbing.

LM Descent Propulsion Shut-Off Valve

- Problem: Excessive leakage at the rotor seals.
- Corrective Action: Shut-off valves on LM 1 passed acceptance tests and pre-installation tests. New cleaning and flushing procedures have been incorporated.

LM Descent Propulsion Pressure Transducers

- Problem: Pressure spikes during start and shutdown are ruining the transducer calibration making them useless until recalibrated.
- Corrective Action: A shorter transducer line is being considered.

LM Descent Propulsion Flow Control Valve Elbows (Second Quarter 1967 Report)

- Problem: Cracks at the flange and base welds of the elbows have caused external leakage.

- Corrective Action — For LM 1 and subsequent the elbows have been redesigned incorporating the following changes:
  (1) Relocation of the weld area away from flange.
  (2) Orientation of the flange grain structure with blind flow.
  (3) New heat process.
  (4) Shot peening.

  Qualification testing is completed and data is under evaluation.

LM RCS Contamination

- Problem — Contamination in the RCS lines and hardware has resulted in failures of the valves to seat properly.
- Corrective Action — A program has been in progress to eliminate sources of contamination. Indications from the first meeting of a combined MSC/KSC/GAEC contamination committee are that GAEC has made a substantial improvement in contamination control operations at Bethpage.

LM RCS Solenoid Latching Valve

- Problem — The LM RCS solenoid latching valve (Parker) has had an extensive history of leakage and false indications (approximately 120 failures). The leakage has been the result of several factors the most prominent of which are; (1) lack of positive latching, and (2) valve seat susceptibility to contamination.
- Corrective Action — GAEC has generally ignored MSC recommendations on this valve and is attempting to prove its adequacy. General Electric has recommended the following changes: (1) positive latching, (2) positive valve position indication, and (3) a valve seat less susceptible to contamination (increased size). Parker has indicated that they could provide these changes and acknowledge their need, but will not proceed without direction from GAEC.

LM Gamah Fittings

- Problem — Several leaks have been reported in the swage area of Gamah fittings.
- Corrective Action — At present GAEC repair procedures specify the use of EPON 919 and EC 2216 as a sealant. NASA/MSC requested GAEC to provide assurance and test data indicating that this sealant has been qualified for LM use.

APOLLO 5 (SA-204/LM 1) SIGNIFICANT OPEN FAILURES (Cont.)

LM Absolute Pressure Transducer

- Problem — A number of failures have occurred during qualification testing of Pace-Wiancko and Micro-Systems absolute-pressure transducers. These failures have occurred at high and low temperatures and have resulted in calibration shift, excessive noise, and sensitivity shift.
- Corrective Action — Track the failure analysis and determine what temperature variation these transducers will experience on LM 1. The transducers now incorporated in LM 1 will probably remain unless the corrective action results in decreased confidence in these transducers.

LM FITH Pressure Transducers

- Problem — The pressure transducers have an inadequate range to fully measure the anticipated pressure spikes during fire in the hole. Also, the present telemetry channels assigned for these measurements have inadequate frequency responses to properly assess the pressure characteristics during FITH.
- Corrective Action — The frequency responses for the continous measurements will be increased to approximately 160 cps. This can be accomplished without hardware change or a schedule impact. The sampling rate for the commutated measurements will be increased from 40 to 80 samples per second, if this can be accomplished without schedule impact. New 0- to 4-psi transducers are being installed in LM 1.

LM Power Distribution Assembly (Second Quarter 1967 Report)

- Problem — The circuit breakers used in the LM mission programmer power distribution assembly have opened under vibration; the certification test endorsement (CTE) was disapproved.
- Corrective Action — Consideration is to be given to the possibility of slugging critical circuit breakers. For LM in general, a more thorough study is to be made by MSC/GAEC to develop recommendations for slugging other circuit breakers.

LM Bent Pins in Connectors

- Problem — There have been many instances of bent and broken pins in electrical connectors in LM 1.

- Corrective Action — Some pins have been straightened, some pins have been cut out if they were spares, and connectors were replaced where necessary. There is a need for an MSC specification relative to the straightening of bent pins, and there is a necessity for a compatible specification by GAEC. These specifications will be developed.

LM Wiring (First Quarter 1967 Report)

- Problem — There have been problems with solder and crimp splice, tensile strength test failures, breakage of number 26-gauge wire, "Red Plague", and "Green Corrosion". On several cables in LM 1, visible "Green Corrosion" was noted between shield braid and outer insulating jacket. Laboratory analysis has determined that these cables also contain "Red Plague". "Red Plague" is a condition which can cause the cable conductor to deteriorate to the point of failure.
- Corrective Action — LM 1 splices have been accepted "as is", based on repair of known defects and potting some connectors. However, a new CTR, LCQ-390-055, has been developed which will be applicable to LM 2 and subsequent. This new CTR will further provide more realistic testing of splices as integral part of harness assemblies. Number 26-gauge wire used in LM 1 panels and buses has been changed to number 22-gauge wire where determined necessary by GAEC. Also, special handling precautions have been initiated. It has not been established which LM will have all AWG 26 high tensile wire. (Reference: LVC 397-093-029A, dated 26 August 1966.) For LM 1 the pyro cables exhibiting the "Green Corrosion/ Red Plague" will be replaced. Inspection of other cables has been accomplished. For wires susceptible to contamination, it is planned to use Teflon tape to protect the wires at vulnerable points, however, it is quite difficult to identify all vulnerable points due to the actions of liquid flow.

LM Mission Programmer Digital Command Assembly AGC Shift

- Problem — A shift in the receiver sensitivity resulting from a shift in the AGC characteristics has been noted in at least two receivers.
- Corrective Action — GAEC is continuing additional testing in an effort to determine the cause of this AGC shift.

LM "Glitch" Detector

- Problem — There is the possibility of voltage "spikes" appearing at the input terminals of various "black boxes" resulting from failed suppression diodes, EMI, etc.
- Corrective Action — There has been direction that a "glitch" detector be designed and fabricated which will measure the amplitude of these undesirable inputs to the black boxes. The detector is not available at this time.

APOLLO 5 (SA-204/LM 1) SIGNIFICANT OPEN FAILURES (Cont.)

LM S-Band Power Amplifier

- Problem — Corona has been detected in the high voltage circuitry of the S-band power amplifier. Output power has been reduced during the presence of the corona and has not always recovered to the original value. It has been determined that pressure in the aft equipment bay may be sustained at a level at which the corona has been experienced. Also, corona has been experienced in the S-band transceiver. On subsequent vehicles, the radars and VHF communications equipment may have similar problems.

- Corrective Action — MSC will require GAEC to demonstrate that the S-band power amplifier can perform without degradation at pressures equivalent to 100,000 to 300,000 feet of altitude (10^{-2} to 10^{-3} Torr). Also, GAEC is to determine the frequency spectrum and amplitude of the radiation produced by the corona. During thermal vacuum testing of LTA-8 at MSC, the aft equipment bay pressure will be monitored carefully. The defective S-band power amplifier has been replaced with a "fixed" unit in LM 1.

LM Descent Stage Panels (First Quarter 1967 Report)

- Problem — Descent stage vertical end-panel failure occurred on LTA-3D/R during simulated low frequency launch and boost vibration testing. This failure is similar to earlier failures on top deck panels. Structural failures, cracks, etc., could result in the loss of primary mission objectives. Structural integrity must be verified on LM 1 to man-rate the vehicle for subsequent missions.

- Corrective Action — GAEC to check thickness and surface conditions of panels already installed. LTA-3D will be used as the reference vehicle for certification. Descent stage panel thicknesses as thick as those of LTA-3D are considered adequate. Panels thinner than LTA-3D will be tested at the component level for adequacy. The effect of surface conditions is being evaluated by GAEC at the component level. Aluminum tape has been applied to undersized LM 1 panels.

LM Descent Propellant Tank Feed Flanges

- Problem — The LM descent propellant tank feed flanges leak externally. Discrepancy reports from KSC and WSTF indicate that on LM 1 and LTA-5D it was necessary to retorque propellant tank flanges on several occasions to stop leaks prior to test firings.

- Corrective Action — Several modifications have been attempted such as the addition of chin straps, milled-flange surfaces, new oversized "O" ring seals, and increased torque on bolts, all of which have failed to stop the leaks. GAEC is evaluating butyl, Gasko, Nitroso, and Rayco seals for use in a single-seal configuration.

LC-37B Hypergolic Service Units

- Problem
- Corrective Action

See Apollo 4 — Technical Problem Areas.

LC-37B Emergency Backup Power System

- Problem — The battery cells presently used in the emergency backup power system at both Launch Complex 34 and Launch Complex 37B are continuing to experience a large number of failures. Since 1 June 1967, 57 cell failures have occurred on the Uprated Saturn I program. These failures are broken down as follows: 38 failed due to internal shorting, 12 failed to accept charge, 4 had hot spots on their plates, and 3 were rejected because of workmanship-type defects.
- Corrective Action — Extensive investigations have been conducted by both MSFC and KSC. No solution, however, to shorting problem has been obtained. Although numerous cells have been returned to the manufacturer for failure analysis, there has been no improvement in their performance, nor an explanation as to the cause of the shorting.

LC-37B LH_2 Facility Burn Pond (First Quarter 1967 Report)

- Problem — The aluminum vent lines in the LH_2 facility burn pond are pitted and corroded. Some of the pits are nearly through the 3/8-inch aluminum manifolds, and all surfaces of the aluminum lines are covered with aluminum oxide and salt. Water leakage into the headers would unbalance the system and result in accumulation of unburned hydrogen or excessive heat and flame in one area of the pond.
- Corrective Action — This condition was discovered in February 1967 and ECP's were submitted on two occasions to change the aluminum piping to stainless steel, but they were rejected. A safety restraint has been placed on operation of the pond, and on 24 August the LVO Reliability Support Contractor issued a report updating the problem and requesting immediate corrective action.

APOLLO 5 (SA-204/LM 1) SIGNIFICANT OPEN FAILURES (Cont.)

LC-37B LH_2 Vehicle Burn Pond

- Problem — The holddown brackets for the header line in the LH_2 vehicle burn pond at LC-37B are inadequate. Buoyancy of the header in the water of the burn pond causes these brackets to bend. Should the brackets bend further, and the bubble caps rise above water, an explosion might result. A similar condition existed at LC-34 until corrected by adding unistruts for additional strength.
- Corrective Action — On 3 May 1967 Pan American Pad Safety imposed a safety restraint on operation of the LH_2 vehicle burn pond at LC-37B. Hydrogen cannot be vented into the pond until the holddown brackets have been replaced with a stronger type. An EO has been approved to replace the holddown brackets and work is now in process.

LC-37B LH_2 Lines (Second Quarter 1967 Report)

- Problem — Loss of vacuum in the LH_2 vacuum jacketed lines has been a continuous problem since original installation. Predominant problems have been warped, damaged, or leaking bellows joints. The LC-34 and 37B LH_2 system mechanical specifications require these lines to maintain a "permanent vacuum for a period of at least two years". Loss of vacuum increases the vaporization of LH_2, since the heat transfer into the line rises sharply with a loss of vacuum. This could increase the time required to load the S-IVB stage, increase hydrogen vaporization, and decrease the hold time available for a launch.
- Corrective Action — The Launch Vehicle Operations Reliability Support Contractor has submitted a list of recommendations for upgrading the reliability of the system. Investigation of recommendations is in progress.

LC-37B Purge System

- Problem — Investigation has revealed hypergolic migration in the existing blanket purge system for fuel, oxidizer, and nontoxic fluid lines at LC-37B. A change request was issued requesting individual gaseous helium and nitrogen lines in the pads to prevent failed check valves from allowing fuel and oxidizer from mixing and creating a hazardous condition and contaminating equipment.
- Corrective Action — While a change request has been implemented to provide a temporary fix at LC-39A, the problem at LC-37B is believed to be unresolved.

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APOLLO 6 (SA-502/CSM 020) CRITICAL ITEMS LIST

The items listed in the following chart are all single failure points whose failure will definitely result in a loss of primary mission objectives. These are designated as Criticality Category II items and are divided into two groups:

II R — Reasonable probability of occurrence.

II L — Low probability of occurrence.

Since SA-502/CSM 020 is not a manned configuration, there are no single failure points listed in Criticality Category I.

General Rules for SFP Classification

1. Prelaunch phase up to initiation of automatic sequence, passive elements, emergency detection system, and crew operating errors not considered.
2. Criteria used in the identification of SFP items:
   - Launch Complex — Mission loss does not include scrub and therefore is limited to those items which will cause serious damage to the space vehicle.
   - Launch Vehicle — Loss of primary mission objectives as defined by MSFC.
   - Command Service Module — Loss of ability to obtain the intended heat shield data. Also assumed that receipt of heat shield data via telemetry will not be possible after blackout, necessitating recovery of a data recorder, and that post-flight analysis of the heat shield will not provide sufficient data.

CHART 1-C. APOLLO 6 (SA-502/CSM 020) CRITICAL ITEMS LIST

System	Item	SFP Criticality Category		No. of Critical Failures Total Program	SA-502 Critical Open Failure Details
		II R	II L		
S-IC					
F-1 Engine	Turbopump, Outboard, LOX	X		0	None
F-1 Engine	Turbine, Outboard	X		1	
F-1 Engine	Turbopump, Inboard, LOX	X		0	
F-1 Engine	Turbine, Inboard	X		1	
Electrical Power	Battery No. 1	X			
Fuel Delivery	Prevalve, Fuel, Outboard		X	0	
Fuel Delivery	Prevalve, Fuel, Inboard		X	0	
LOX Delivery	Pressure-Volume Compensating,Outboard,LOX,Duct		X	2	
LOX Delivery	Gimbal, Outboard, LOX		X	2	
LOX Delivery	Prevalve, Outboard, LOX (1, 3)	X		0	
LOX Delivery	Prevalve, Outboard, LOX (2, 4)	X		0	
LOX Delivery	Pressure-Volume Compensating, Inboard, LOX Duct		X	4	
LOX Delivery	Prevalve, Inboard, LOX	X		0	
LOX Delivery	Gimbal, Inboard, LOX		X	2	
Flight Termination	Exploding Bridge Wire Firing Unit		X	0	
Total for S-IC		8	7		
S-II					
Electrical Control	Electrical Sequence Controller	X		0	
Electrical Power	Inverter-Static and Connectors	X			
Electrical Power	Recirculation Battery No. 2 and Connectors	X		0	
Electrical Power	Recirculation Battery No. 1 and Connectors	X		0	
J-2 Engine	Turbopump Assembly Oxidizer	X		0	
J-2 Engine	Valve Assembly, GG Control	X		0	
J-2 Engine	Turbopump Assembly, Fuel	X		0	
J-2 Engine	Mainstage Control Valve, Solenoid Operated	X		0	

CHART 1-C. APOLLO 6 (SA-502/CSM 020) CRITICAL ITEMS LIST (Cont.)

System	Item	SFP Criticality Category		No. of Critical Failures Total Program	SA-502 Critical Open Failure Details
		II R	II-L		
S-II (Cont.)					
J-2 Engine	Valve Assembly, Main Oxidizer	X		0	None
J-2 Engine	Valve Assembly, Main Fuel	X		0	
J-2 Engine	Ignition Detector Assembly	X		0	
Separation	Separation Controller	X		0	
Separation	Ullage Motor	X		0	
Propellant Recirculation	Liquid Hydrogen Prevalve	X		2	
Propellant Recirculation	Liquid Hydrogen Recirculation Motor Pump Assembly	X		0	
Propellant Recirculation	LOX Prevalve	X		0	
Propellant Recirculation	Liquid Hydrogen Return Valve	X		0	
Propellant Pressurization	LOX Vent Valve	X		2	
Propellant Pressurization	Liquid Hydrogen Vent Valve	X		0	
Propellant Pressurization	Liquid Hydrogen Solenoid Valve (Actuation Pressure)	X		0	
Propellant Pressurization	LOX Solenoid Valve (Actuation Pressure)	X		0	
Propellant Pressurization	Liquid Hydrogen Tank Pressure Regulator	X		1	
Total for S-II		22			
S-IVB					
Electrical Control	Mounting Assembly Sequencer	X		0	
Electrical Control	Power Distribution Assembly, Aft 28 vdc	X		0	
Electrical Control	Battery, Wet, Silver Zinc, Forward and Aft No. 1 Bus	X		0	
Electrical Control	Switch Selector	X		0	
Flight Control	Bladder (Oxidizer Tank)	X		0	
Flight Control	Bladder (Fuel Tank)	X		0	
Flight Control	Valve, Servo (Yaw)	X		0	
Flight Control	Valve, Servo (Pitch)	X		0	

Flight Control	Engine (Pitch)	X		0	
Flight Control	Engine (Roll, Left)	X		0	
Flight Control	Engine (Roll, Right)	X		0	
Engine	Turbopump Assembly Oxidizer		X	0	
Engine	Valve Assembly GG Control		X	0	
Engine	Electrical Control Assembly	X		0	
Engine	Gas Generator Combustor Assembly		X	0	
Engine	Turbopump Assembly, Fuel		X	0	
Propellant PF & C	Valve, Propellant Tank Shutoff (APS-A)	X		0	
Propellant PF & C	Valve, Propellant Tank Shutoff (APS-B)	X		0	
Electrical	Mounting Assembly Power Distribution Forward	X		0	
Electrical	Battery, Wet, Primary Silver, Zinc, Forward and Aft No. 1 Bus	X		0	
Total for S-IVB		16	4		
IU					
Guidance and Control	ST-124M Platform	X		0	
Guidance and Control	Platform Electronics Assembly	X		0	
Guidance and Control	Platform ac Power Supply	X		1	
Guidance and Control	Accelerometer Signal Conditioner	X		0	
Guidance and Control	Launch Vehicle Digital Computer	X		1	
Guidance and Control	Launch Vehicle Data Adapter	X		0	
Flight Control	Flight Control Computer	X		2	
Flight Control	Control Signal Processor		X	0	
Electrical	Battery D-10		X	0	
Electrical	Battery D-20		X	0	
Electrical	Battery D-30		X	0	
Electrical	56-vdc Power Supply	X		0	
Electrical	Power Distributor		X	0	
Electrical	Auxiliary Power Distributor		X	0	
Electrical	Control Distributor	X		0	
Electrical	Emergency Detector System Distributor	X		0	

CHART 1-C. APOLLO 6 (SA-502/CSM 020) CRITICAL ITEMS LIST (Cont.)

System	Item	SFP Criticality Category		No. of Critical Failures Total Program	SA-502 Critical Open Failure Details
		II R	II L		
IU (Cont.)					
Electrical	Switch Selector Mod II	X		0	
Environmental Control	Pressure Regulator Thermal Conditioning System	X		0	
Environmental Control	Water Shutoff Valve		X	0	
Environmental Control	Modulating Flow Control Valve		X	0	
Environmental Control	Coolant Pump		X	0	
Environmental Control	Temperature Sensor		X	0	
Environmental Control	Quick Disconnect		X	0	
Environmental Control	Electronic Control Assembly	X		0	
Environmental Control	Pressure Regulator (Gas Bearing Supply)	X		0	
Total for IU		14	11		
CSM					
Service Propulsion	Nozzle Extension ME901-0192		X	0	
Service Propulsion	Injector Subassembly of ME901-0484		X	0	
Service Propulsion	Thrust Chamber Subassembly of ME901-0484		X	0	
Service Propulsion	Gimbal Actuator Subassembly of ME901-0484		X	3	
Environmental Control	Glycol Temperature Sensor 820980-4-1		X	0	
Environmental Control	Glycol Relief Valve 828450-3-1		X	0	
Environmental Control	Pressure Transducer 837008-2		X	0	
Environmental Control	Cabin Heat Exchanger 812100-4		X	0	
Environmental Control	Check Valves 827990-1		X	0	
Environmental Control	Cabin Temperature Control Valve 850028-2-2		X	0	
Environmental Control	Emergency Oxygen Inflow Valve 828510-3-1		X	0	
Environmental Control	Cabin Pressure Regulator 810200-2-1		X	0	
Environmental Control	Tank Pressure Regulator 810340-2-1		X	0	
Environmental Control	Oxygen Pressure Transducer 837016-1-1		X	0	

Environmental Control	Oxygen Flow Meter 836112-2-1		X	0	
Environmental Control	Surge Tank V16-613059-		X	0	
Environmental Control	Glycol Reservoir 812800-4-1		X	0	
Environmental Control	Glycol Evaporator 812500-2-1		X	0	
Environmental Control	Glycol Temperature Controller 820980-4-1		X	1	See (1) Below
Environmental Control	Back Pressure Control Valve 829100-1-2		X	0	
Environmental Control	Radiator Isolation Valve 821220-3-2		X	0	
Environmental Control	Glycol Temperature Sensor 820920-2-1		X	0	
Environmental Control	Water Check Valve B&C 828260-1-2		X	0	
Environmental Control	Backpack Oxygen Supply Shut-Off Valve Assembly 828290-2-1		X	0	
Environmental Control	3-Way Oxygen Valve 828860-2-1		X	0	
Environmental Control	Oxygen Pressure Regulator 827330-6-1		X	0	
Environmental Control	Waste Water Tank 812200-5-1		X	1	
Environmental Control	Check Valve 827360-2-1		X	0	
Environmental Control	Water Tank Pressure Relief Valve 828760-1-2		X	0	
Environmental Control	Water Inflow Valve 829130-1-1		X	0	
Environmental Control	Sensor Wick Temperature 820972-1-1		X	0	
Environmental Control	Glycol Pump 850024-6-1		X	0	
Environmental Control	Surge Tank Pressure Transducer ME449-0055-1043		X	0	
Guidance and Navigation	Inertial Measurement Unit 1001500-091		X	0	
Guidance and Navigation	Coupling Display Unit (5) 1015500		X	0	
Guidance and Navigation	Apollo Guidance Computer 1003700-051		X	0	
Guidance and Navigation	Power and Servo Assembly 1007570-021		X	0	
Guidance and Navigation	Display and Keyboard, Main Panel 1003563-051		X	0	
Stabilization and Control	Pitch Electronic Control Assembly ME901-0166		X	0	
Stabilization and Control	Yaw Electronic Control Assembly ME901-0168		X	0	
Stabilization and Control	Roll Electronic Control Assembly ME901-0167		X	1	
Stabilization and Control	Auxiliary Electronic Control Assembly ME901-0169		X	0	

CHART 1-C. APOLLO 6 (SA-502/CSM 020) CRITICAL ITEMS LIST (Cont.)

System	Item	SFP Criticality Category		No. of Critical Failures Total Program	SA-502 Critical Open Failure Details
		II R	II L		
CSM (Cont.)					
Stabilization and Control	Circuit Breaker 45, Panel 25		X	Not Available	None
Stabilization and Control	Stabilization and Control System Power Switch No. 13 Panel 24		X	↓	
Stabilization and Control	Stabilization and Control System Channel Switch No. 12 Panel 8		X	↓	
Stabilization and Control	Channel Switch No. 13 Panel 8		X	↓	
Stabilization and Control	Stabilization and Control System Channel Switch No. 14 Panel 8		X	↓	
Total for CSM			47		

APOLLO 6 (SA-502/CSM 020) CRITICAL OPEN FAILURES

DEFINITION	
Critical Failure:	A failure at a single failure point that will definitely result in loss of primary mission objectives.

CSM Glycol Temperature Controller (Item 2.40, P/N 820956-1

1 ● Problem

■ Corrective Action

Same as for Apollo 4.

APOLLO 6 (SA-502/CSM 020) SIGNIFICANT OPEN FAILURES

DEFINITION	
Significant Failure:	A failure which is not at a single failure point but which could affect mission objectives and which should be closed out before launching.

S-IC Electrical Distributors

- Problem
- Corrective Action

Same as for Apollo 4.

S-IC Safe and Arm Device (Inert)

- Problem — The device locked in the armed position due to a burnt solenoid. This condition presents a risk of vehicle loss if a second failure occurs that could cause a launch delay and require the device to be returned to the disarm position. This multiple failure consideration presents a situation whereby the device must be mechanically or manually deactivated before work can proceed.
- Corrective Action — The failed device was replaced with a serviceable (inert) device which functioned satisfactorily. Live devices are now available for installation at KSC, but it has not been determined that they are flight worthy per ECP 0611. Actions have been taken to make design changes to the live device. Availability of redesigned hardware and requalification status has not been established.

S-II Static Inverter

- Problem
- Corrective Action

Same as for Apollo 4.

S-II LH_2 Prevalve

- Problem — During static firing countdown, the LH_2 prevalve, V7-480500-121, did not close. Subsequent analysis revealed water in the actuator assembly which was frozen under cryogenic conditions.
- Corrective Action — This problem is still open. An investigation is being made to determine the source of the moisture. A plan will be devised to eliminate the source of moisture.

S-II LOX Fill and Drain Line

- Problem — The LOX fill and drain line, ME271-0012-0004, was found to be leaking due to a rupture of the bellows during static firing countdown.
- Corrective Action — The line was replaced with a line from the S-II-3 stage in which the bellows had been redesigned. The new line with a three-ply bellows was successful during the firing.

S-II Batteries

- Problem
- Corrective Action

Same as for Apollo 4.

S-IVB Actuation Control Module GN_2

- Problem — Actuation control module GN_2 leakage at the control valve.
- Corrective Action — This failure occurred at post-static checkout in August 1966. The module was to be replaced by a new configuration, however, it failed qualification testing. A new design module is scheduled to replace the existing modules. The new design has completed qualification testing but has not received MSFC approval.

S-IVB Start Tank Discharge Valves

- Problem
- Corrective Action

See Apollo 4 — Technical Problem Areas.

APOLLO 6 (SA-502/CSM 020) SIGNIFICANT OPEN FAILURES (Cont.)

S-IVB Liquid Level Depletion Sensors

- Problem
- Corrective Action

Same as for Apollo 4.

S-IVB LH_2 Vent and Relief Valve

- Problem
- Corrective Action

Same as for Apollo 4.

CSM SPS Flight Combustion Stability Monitor

- Problem
- Corrective Action

Same as for Apollo 4.

CSM SPS Propellant Retention Reservoir

- Problem
- Corrective Action

Same as for Apollo 4.

CSM Electrical Power System

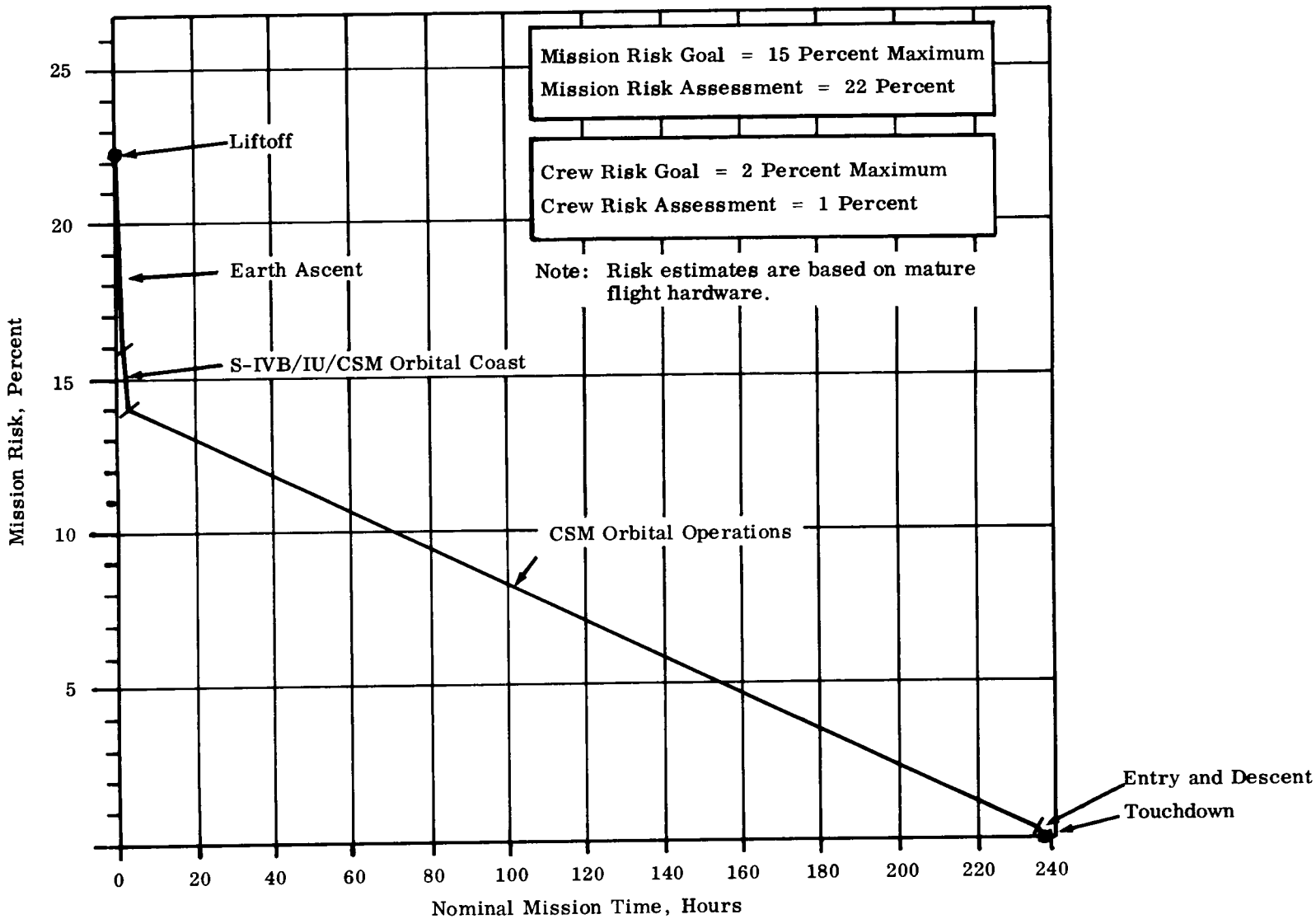
- Problem — On 15 September 1967 during a CSM 020 factory test a short developed as a result of reversed polarity on external batteries. There were five external lead oxide batteries used to replace the internal fuel cells. This failure caused damage to signal conditioners, terminal boards, and mission events sequence controller relays.
- Corrective Action — A special team from MSC has been appointed to investigate the situation. Some retesting may be required to determine the extent of the damage.

CSM Launch Escape Motor (P/N 588-09-0201 H)

- Problem
- Corrective Action

} Same as for Apollo 4.

CHART 1-D. SA-205/CSM 101 MISSION RISK PROFILE



SA-205/CSM 101 MISSION RELIABILITY ASSESSMENT

RISK ANALYSIS

Risk analysis (based on mature flight hardware since current operating time data on CSM equipments is not available) indicates that the risk of not completing a five-day flight equals the goal of 15 percent maximum risk for this mission. There is a 22 percent risk of not completing a ten-day mission as currently planned. Review of current CSM ground test records indicates that a number of CSM equipments have not approached desired maturity. The overall mission risk profile is shown in Chart 1-D.

The minimum crew risk is 1 percent for the ten-day mission and compares well with the goal of 2 percent maximum crew risk for this mission. The crew risk estimate reflects reliability data derived from a review of failures observed on 424 flights of liquid fueled launch vehicles. Assessments of failure reports and related documents on space vehicle systems are summarized below.

LAUNCH VEHICLE (SA-205)

Engineering analysis of ground and flight tests and corrective action program effectiveness indicate a launch vehicle reliability approaching the requirements for this mission.

Listed below are major areas of concern:

a. Test data is not available which demonstrates the readiness of the IU batteries for flight.

b. Contamination and leakage are recurring problems in the launch vehicle. Stringent recurrence control appears necessary to insure that vehicle reliability will not be degraded.

SPACECRAFT (CSM 101)

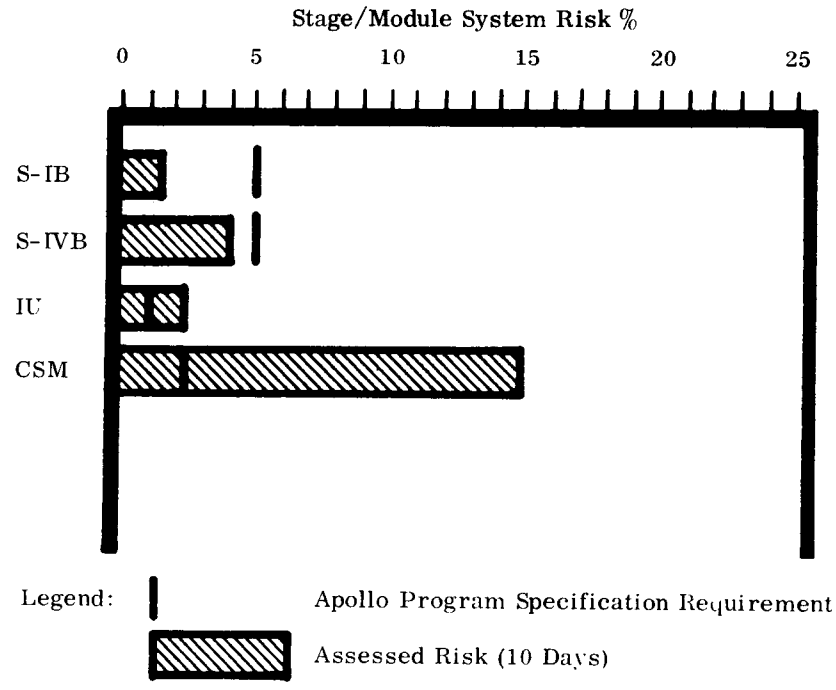
CSM 101 will be the first flight test of the Block II Command Service Module and will be manned. Preliminary results of current ground test program failures indicate:

a. Equipment failures are recurring after corrective action.

b. A large percentage of equipments are not qualified.

c. Equipments which are qualified have, in many instances, been qualified by "similarity" to Block I spacecraft hardware.

d. A number of items presently have insufficient failure-free test time.



SA-205/CSM 101 MISSION RELIABILITY ASSESSMENT (Cont.)

Block II spacecraft systems design changes are being implemented on CSM 101 and subsequent spacecraft. Major changes identified to date include the following:

Crew Protection

1. Nonflammable suit and duct connections.
2. Nonflammable material in cabin.
3. Breathing mask system with independent oxygen supply.

Structures

1. Installation of explosive hatch.
2. Redesign of crew hatch opening, heat shield, ablator, and areas for crew hatch mounting.

Environmental Control System

1. Replacement of aluminum lines with stainless steel and reinforcing of fittings.
2. Relocation and redesign of controls.
3. Rapid repressurization of command module.
4. Protective covering for plumbing lines.

Earth Landing System

1. Drogue chute diameter increase from 13.7 feet to 15.5 feet.
2. Dual main chute reefings to compensate for added weight.

Communications

Elimination of C-Band transponder and S-Band high gain antenna.

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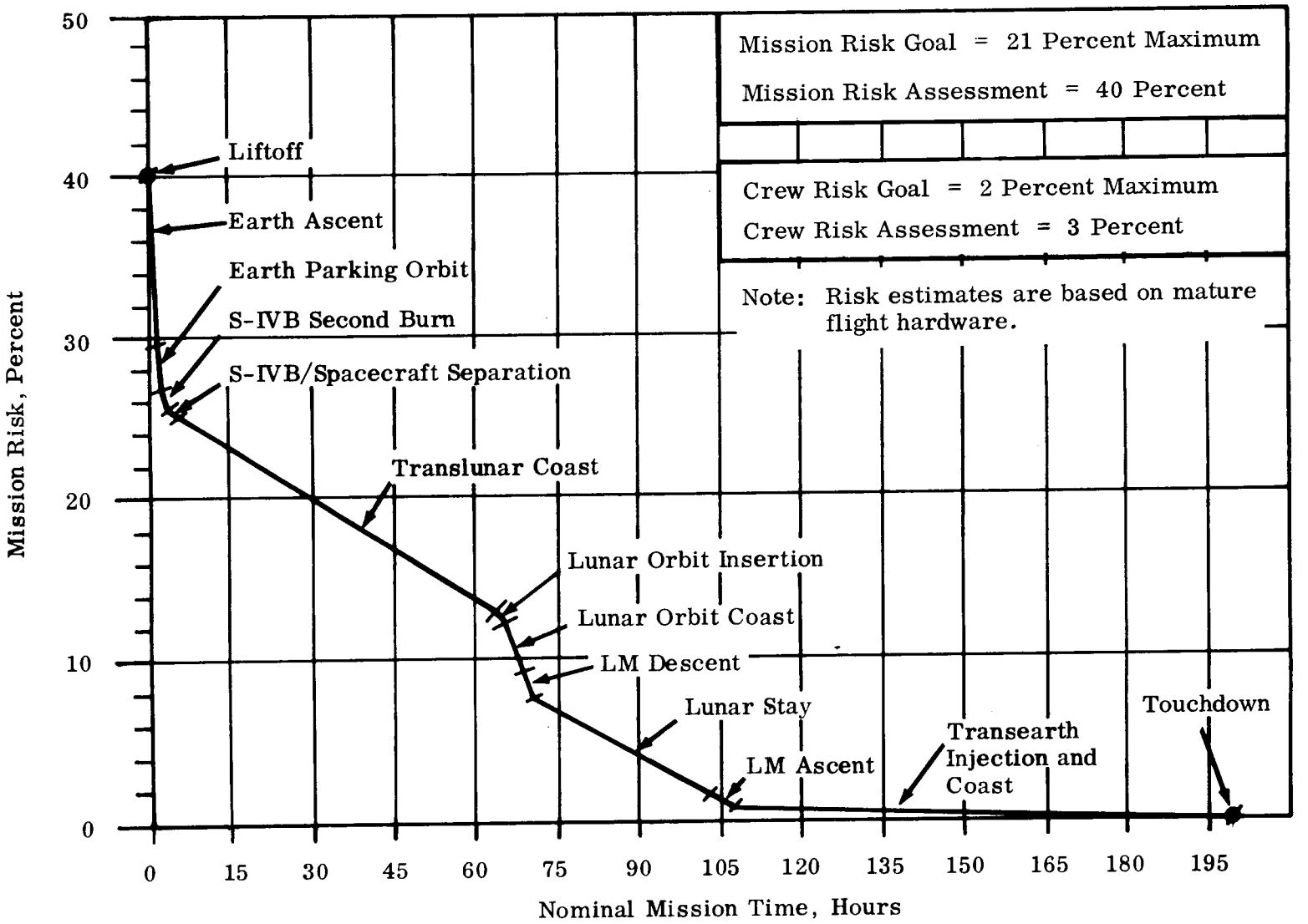
CHART 1-E. MANNED LUNAR LANDING MISSION RISK ANALYSIS



MANNED LUNAR LANDING MISSION RELIABILITY ASSESSMENT

RISK ANALYSIS

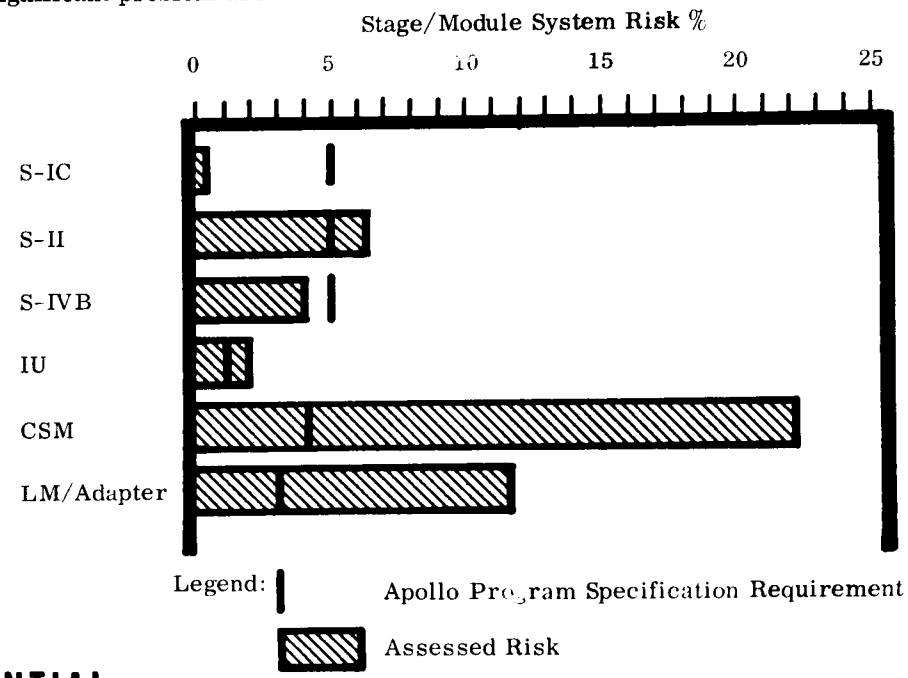
The overall mission and crew risk estimates for the MLL mission were updated to account for changes in Saturn V launch vehicle stages reliability estimates and for results of a review of failures with crew fatality potential observed on flights of liquid fueled launch vehicles. Based on mature spacecraft hardware, the updated mission risk is 40 percent and the crew risk estimate is 3 percent. These values exceed the respective program goal maximum risk values of 21 percent and 2 percent. The overall mission risk as a function of nominal flight mission time is shown on Chart 1-E. Assessments of failure reports and related documents on space vehicle systems are summarized below.

LAUNCH VEHICLE

- The structural integrity of the S-II stage is marginal, particularly for off-nominal flight conditions.
- Although recent simulated altitude tests have been successful, the J-2 engine of the S-IVB stage has yet to experience restart in space.
- The attitude control system of the S-IVB must perform intricate maneuvers in the repositioning of the LM. This system has yet to be tested under actual environmental conditions.
- Test data and open UCR's indicate that the IU batteries remain a significant problem area.

SPACECRAFT

- The prime contributors to crew risk, as judged by the total number of reported Criticality I test failures, are the CSM service propulsion system, CSM environmental control system, CM/SM reaction control systems, and LM propulsion.
- The high numbers of reported Criticality I failures of CSM telecommunications and LM displays and controls are suspect and need further investigation.
- Lack of equipment test/operating time records prevents correlating equipment failure counts with test/operating time in many instances and limits the assessment of test-demonstrated effectiveness of corrective actions.



MANNED LUNAR LANDING MISSION – FLIGHT TEST VERIFICATION ANALYSIS

GENERAL

Completed and planned space flight missions have been examined to estimate the extent to which equipment performance requirements will have been verified for the Manned Lunar Landing mission by prior flights. Results of this verification analysis are based on Apollo program missions, Lunar Orbiter program missions and the Apollo Little Joe tests. The analysis covered space vehicle and ground operational support systems required for nominal mission conduct and space vehicle systems required for aborts during the launch phase starting with liftoff and ending with earth orbit insertion for the MLL mission. The results of this analysis complement the ground test verification result.

SPACE VEHICLE SYSTEMS

The following areas of concern were identified in the flight test verification analysis of the systems expected to be used on the Manned Lunar Landing (MLL) mission and its possible launch phase aborts:

1. Nominal MLL Mission

   a. Launch vehicle systems will be partially verified because of changes in S-IC, S-II, S-IVB, and IU subsystem hardware configuration which will not have been flight-tested on prior missions.

   b. The command and service modules will be fully verified based on two major assumptions:

      (1) The CSM hardware configuration is the same as that of Block II CSM 103 and 104.

      (2) The environmental effects on the CSM systems performance while operating in the area of the moon are different from those which will be encountered during the preceding two Apollo missions scheduled to be accomplished in cislunar space.

   c. The lunar module will be partially verified based on two major assumptions:

      (1) The LM hardware configuration is the same as that of LM 2 and LM 3.

      (2) The environmental effects on the LM systems performance while operating in the area of the moon and while on the lunar surface can be more severe than will be encountered during the preceding two Apollo missions scheduled to be accomplished in cislunar space.

2. Launch Phase Aborts

   a. The launch escape system (LES) for launch phase aborts is partially verified because of changes in ordnance and structural configuration implemented since completion of the Little Joe series abort tests.

b. The command module launch phase aborts will be unverified because:

(1) The sequential events control system and earth landing system configurations for the MLL mission differ from those used in the Little Joe tests of LES aborts.

(2) Some critical abort functions and conditions that are directly related to the Command Module are not planned for in-flight simulation due to high crew/equipment risk. (Examples are: manual abort initiation, high entry "g" loads of the Mode II abort, crew operations during launch aborts, and emergency RCS propellant jettison.)

MANNED SPACE FLIGHT NETWORK FUNCTIONS

The projected verification status of MSFN systems functions required for the nominal MLL mission is as follows:

1. Tracking — All MSFN C-band radars are fully verified. The unified S-band (USB) tracking function at all MSFN stations is at least partially verified. Other MSFN tracking systems such as ODOP and AZUSA/GLOTRAC are fully verified.
2. Telemetry — All ground-based MSFN S-band systems are fully verified. Five Apollo aircraft S-band systems are unverified. All ground-based MSFN VHF systems are fully verified. Three Apollo aircraft VHF systems are unverified. The USB telemetry function at all MSFN stations with the exception of two Apollo aircraft is at least partially verified.
3. Command Updata — All MSFN UHF updata-digital systems are fully verified. The USB command function at all MSFN stations is at least partially verified.
4. Spacecraft Voice Communication — All ground-based MSFN VHF voice systems are fully verified. VHF voice systems on four Apollo aircraft are unverified. The USB voice function at all ground MSFN stations is at least partially verified. USB voice function on two Apollo aircraft is unverified.
5. Television — The USB television function at all MSFN stations is partially verified.

HARDWARE PROBLEMS
(In Addition to Those Identified in Section 1)

Saturn V — All Stages

- Problem — The MSFC Quality Laboratory requested contractors to identify bolts used in launch vehicle stages in critical applications and to give a summary of controls applied. The S-IVB and S-II contractors supplied the following information:
  a. The S-IVB has four bolts in critical applications. Their controls vary depending on the source of manufacture. In one case, the material is accepted on the basis of physical and chemical test reports. In two cases, material is supplied by the vendor and is accepted on the basis of a "Supplier Certificate of Compliance". Future receipts will be subjected to analysis which includes chemical and physical tests on 1 bolt per 24 delivered.
  b. The list of critical items on the S-II stage contains thrust block bolts.

- Corrective Action — The following action has been taken by contractors (this problem is closed for Apollo 4):
  a. All existing mounting bolts on S-IVB-502 and subsequent will be replaced with bolts manufactured from traceable material. S-IVB-501 bolts are to be removed, hardness tested, and reinstalled, if satisfactory.
  b. S-II-1 has had all 32 thrust block bolts changed out. This will also be done on S-II-2.

S-IC Flexible Duct Assembly

- Problem — On 27 June 1967, at Michoud during an equipment quality analysis (part of the Boeing Inspection and Test Function), a visual and cleanliness inspection of the Resistoflex flexible duct assembly was made and a number of weld defects were found. Based on the inspection of the one assembly, 19 other assemblies were inspected indicating the same defects and all were rejected.

- Corrective Action — The defective flexible duct assembly was returned to the vendor for pressure testing. It successfully passed operating, proof pressure, and burst pressure tests. Duct assemblies on the S-IC-501 have been X-rayed and reviewed by MSFC. Based on the X-ray results and MSFC evaluation, the problem of ducts on S-IC-501 is considered cleared up; however, vendor investigation continues on the 20 assemblies rejected at Boeing Inspection and Test.

S-IC Solar Cells

- Problem — During pre-static firing checkout of the S-IC-T stage at MTF, the engine cut-off sensor failed to actuate. Also, during post-manufacturing checkout of the S-IC-4 stage, an erroneous LOX overfill signal was received from the LOX loading probe. It was determined that the failures were caused by separation of solder connections in solar cells used in both the cut-off sensor and LOX loading probe.

- Corrective Action — Preliminary qualification testing on a new solar cell design was completed on 15 July. The production items for qualification test were rejected due to poor soldering and were returned to the subcontractor. A new shipment has been received and has passed qualification test. It is anticipated that S-IC-2 and subsequent stages will be retrofitted with the new design. S-IC-1 will utilize solar cells of the old design which have been given extensive testing to provide reasonable assurance of flight worthiness and is considered closed for Apollo 4.

S-IC Shipping Cover

- Problem — A highly flammable nitrocellulose shipping cover has been used in the thrust section heat shield of the S-IC-1 and subsequent. This is a ground safety problem.

- Corrective Action — All launch vehicle contractors were contacted to re-evaluate the hazards from the use of flammable materials in any application, not just shipping and storage, and to take appropriate action.

S-II Flexible Ducts (Closed for Apollo 4)

- Problem — Problems have been encountered at Seal Beach in the interpretation of X-ray films of the weld area of the flexible ducts and in the omission of acceptance criteria for peaking in weld specifications. This first occurred in April 1967.

- Corrective Action — Representatives of MSFC and NAA have been working with the subcontractor to resolve the problems encountered in their welding operation and the radiographic inspection of welds. The following action has been taken to date:
  a. Weld characteristic sheets depicting acceptance criteria prepared for attachment to manufacturing traveler for use by inspection.
  b. A process bulletin outlining acceptance criteria for peaking has been prepared.
  c. Welding fixtures reworked to reduce misalignment, which was found to be a problem, and also contributed to peaking problem.
  d. New design initiated to reduce number of weld joints and to increase material thickness to reduce distortion.

HARDWARE PROBLEMS (Cont.)

S-II LH_2 and LOX Tanks (Second Quarter 1967 Report)

- Problem: Cracks were revealed by dye-penetrant examination of the circumferential welds of the LH_2 and LOX tank of the S-II-6 after pneumostat test at Seal Beach in May 1967
- Corrective Action: S-II-1 and S-II-2 were checked out at KSC and no significant weld defects found. These stages have been restacked. S-II-3 has now been inspected at Seal Beach. In the LH_2 tank, 37 defects were found; however, these were not all cracks. No rewelding or use of doublers was required to eliminate the problems in the LH_2 tank. No defects were found in the S-II-3 LOX tank.

S-IVB Aft Dome Welding (Saturn V)

- Problem: The joint weld on the aft dome for the S-IVB-509 was rejected for porosity after a complete reweld during July 1967 at Huntington Beach. The jamb was removed and a 1/4-inch larger diameter jamb was installed. During this weld, a $7 \times 10 \times 0.315$-inch "can" developed near the weld. The "can" could be pushed out but returned when the force was removed. Subsequently a similar problem developed in the S-IVB-510 aft dome.
- Corrective Action: A test is now being conducted to simulate the welding conditions in installing a second replacement jamb 1/4 inch larger than standard. X-rays are being made in the skin area within 24 inches of the can. Upon removal of the replacement jamb, the "can" disappeared. The last replacement jamb started at the same point as the original weld. This is believed to be a factor in the "canning". Procedures are being re-written to preclude starting and stopping jamb rewelds at the same point as the original weld.

IU Batteries (Uprated Saturn I and Saturn V) (Second Quarter 1967 Report)

- Problem: Battery cracking.
- Corrective Action: The batteries used in the IU were qualified on 19 May 1967 for SA-204, SA-501, and SA-502 only. Cracks were evident after qualification testing; however, the batteries did perform as required. Some questions have been raised about the monitoring and accuracy of the testing program thus limiting qualification as indicated above. These batteries are made of the new material, ABS Lustran, rather than of the original Bakelite material. MSFC had sent ECR-1066 to IBM for

a study of the impact of returning to the Bakelite material. The IBM reply is pending the results of ECP-920P now at MSFC for study and investigation of the cracks which occurred during qualification testing. ECP-1002 has been released which delineates storage, handling, and shipping procedures for the present battery design.

IU Solder Joints (Uprated Saturn I and Saturn V)

- Problem — PC boards used in the Instrument Units for the Uprated Saturn I and the Saturn V have experienced problems due to cracked solder joints.
- Corrective Action — This problem is attributed to thermal stressing created by materials of different coefficients of expansion. Necessary rework and/or repair for the Instrument Units on Apollo 4 and Apollo 5 has been accomplished. With regard to subsequent vehicles, the problem has been referred to the Solder Joint Committee (MSFC), with recommendations from the Q&RA Laboratory for resolution.

S-IB Hydraulic System (First Quarter 1967 Report)

- Problem — There was a continuing problem of contamination in the hydraulic system at Michoud. Included are:
  a. Servo Actuator Assembly — 60C-6000
  b. Outboard Hydraulic System — 60C-20840
  c. Auxiliary Hydraulic Pump — 20C-85064

  This problem has been attributed to the ground hydraulic service system rather than to the airborne package. It has been definitely concluded that the contamination is rust and the rust is directly proportional to the amount of atmospheric moisture contained in the system.
- Corrective Action — The following actions will be taken on the hydraulic service consoles at Michoud to correct this problem:
  a. All ferrous parts disassembled and cleaned of rust or replaced.
  b. Dessicant breathers installed in reservoir vents to prevent atmospheric moisture from entering the system.
  c. The console filters changed to 3-micron absolute filters (from 10-micron).
  d. Dehydrators installed in the consoles to keep moisture content within 100 ppm.
  e. EP-70679 issued to provide for a hydraulic oil with a rust inhibitor.
  f. A "standard patch" for maximum allowable discoloration has been established and furnished to responsible personnel.

  Similar corrective actions have been recommended for KSC.

HARDWARE PROBLEMS (Cont.)

S-IB Fuel Fill and Drain Valve

- Problem — In July 1967, a flow tube was found to be missing from a fuel fill and drain valve in the S-IB-9 at Michoud after the stage was returned from static firing.
- Corrective Action — Since it has been ascertained that the flow tube was installed in the valve, other considerations are:
  a. The flow tube may have gone downstream in the S-IB-9 fuel line although a check of filters and fuel lines showed no evidence of this.
  b. The flow tube may have gone into the fuel storage tanks.
  c. The flow tube may have pumped back into the S-IB-10.

  Investigation is underway to locate the missing flow tube. Chrysler is also trying to develop an X-ray technique to check stages for presence of the flow tube in the fuel and drain valves.

S-IVB Switch Selector (Uprated Saturn I) (Second Quarter 1967 Report)

- Problem — During the SA-204 switch selector functional test, the LOX chilldown inverter which supplies power for the chilldown pump, was powered "on". Immediately a 175-ampere spike was noted resulting in a 75-percent voltage reduction between phases A and C.
- Corrective Action — Since there have been no failures of this type during qualification testing, acceptance testing, and inflight operation, an investigation has been launched to determine if the cause of failure could be attributed to test equipment, procedures, or to a possible combination of these. This investigation is in progress.

S-IVB Electrical Connectors (Uprated Saturn I)

- Problem — Discovery of damaged insulation cups on Deutsch DTK connector pins on S-IVB-204 at KSC 12 June 1967 resulted in reinspection of all DTK connectors on that stage. Sixty-five pins in 15 connectors were found to be damaged. Damage is believed due to either the use of the wrong insertion tool or "probing" when the pins are not seated on the first attempt.

- Corrective Action: All DTK connectors on stage and in stock are being reinspected. The connector and all pins in the connector are replaced if damaged pins are found. Crews doing the work have been especially instructed on proper use of the correct tool and no "probing" is permitted. All technicians who install DTK connectors are being given refresher courses in proper technique. Cannon KTPM connectors were also inspected and no problems were noted.

LM Display and Keyboard (DSKY) (Second Quarter 1967 Report)

- Problem: Filtors relays have experienced nonrecurring open failures during vibration acceptance testing at Raytheon.
- Corrective Action: Problem is under investigation.

LM ECS Primary Water Boiler (Sublimator) (First Quarter 1967 Report)

- Problem: Sublimators have failed acceptance and/or qualification tests due to degradation in thermal performance.
- Corrective Action: Metallurgical analysis indicated that the brazing alloy used to fabricate the porous plate is "wicking" across the plates and partially blocking the pores. Additional contaminants and/or corrosion further compound the problem and thermal degradation occurs. Improved manufacturing techniques, including controlled porous plate orientation have been implemented. Since the failures occurred during endurance testing, beyond the 6-hour mission requirements for LM 1, GAEC believes the sublimator installed in LM 1 is suitable for use in this mission. LM 1 qualification tests are completed. LM 2 and subsequent qualification tests are scheduled to be completed on 17 November 1967.

LM Environmental Control Subsystem

- Problem: Contamination of the environmental control subsystem (a white substance was found on the seals in the waste management system), caused replacement of check valves.
- Corrective Action: A procedure for eliminating the contamination has been developed for LM 1. It consists of flushing the system with water, then phosphoric acid, followed by water again, then Alodine flush, and a final water flush. The deposit was analyzed and it was concluded that the contaminant was aluminum oxide. An investigation is currently in progress to determine the source of contamination and the significance of the contaminant in the water management.

HARDWARE PROBLEMS (Cont.)

LM Ascent Propulsion Helium Regulator (Fourth Quarter 1966 Report)

- Problem: Numerous failures have precluded flight qualification of the Sterer regulators which have since been replaced with Fairchild-Hiller regulators. The Fairchild-Hiller regulator has exhibited low-outlet pressure oscillations in ullage and outlet gas temperature out of specification, but within acceptable performance limits.

- Corrective Action: Additional testing is being performed at WSTF to evaluate the regulator performance. New hardware has been installed on LM 1. Problem is open for subsequent LM's.

CSM Communications System (Block II)

- Problem: Failures and defects have been experienced on the Block II high-gain antenna. These include:
  a. Mechanical binding.
  b. Electronic performance out of specification.
  c. Corrosion.
  d. Insufficient insulation.

  Twenty-four failure reports have been initiated. The first failure occurred at the subcontractor plant on 11 April 1967.

- Corrective Action:
  a. The design has been changed but not tested in some cases and is undergoing analysis in others.
  b. None reported.
  c. The corrosion will be removed from the affected wires and a conformal coating added. No analysis has been performed on the corroded box cover.
  d. Additional insulation was added and quality control techniques modified to eliminate the problem.

CSM Docking System (Block II)

- Problem: Sixteen failures (9 open, 7 closed and reopened) have been reported at the contractor and subcontractor's plants against the nitrogen pressure system of the docking probe assembly on the Block II spacecraft. All failures have been leaks, presumably resulting from (1) the use of a lubricant which solidifies at low temperature, and (2) low temperatures icing-in the system.

- Corrective Action — New lubricants are under evaluation. At present, GE G-300 Versilube looks the most promising.

LC-34 LH_2 Storage System

- Problem — An HCV-9 check valve used in a line from the primary vaporizer of the LH_2 storage system at LC-34 leaks during cold flow. This occurred in July 1967.
- Corrective Action — The LVO Reliability Support Contractor has issued a report recommending replacement of the stainless steel bolts in the valve with aluminum bolts, in order to stop excessive thermal expansion and contraction and to reduce corrosion.

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CHART 2-A. FAILURE MODE EFFECT AND CRITICALITY ANALYSIS (FMECA/FMEA) STATUS

Mission	Stage, Module, Launch Complex	Preliminary Issue	Final Update
		Scheduled	Scheduled
Apollo 4 (SA-501/ CSM 017)	S-IC	X	X
	S-II	X	X
	S-IVB	X	X
	IU	X	X
	LTA-10R	NP	NP
	CSM (Generic Block I)	X	X
	LC-39 (KSC Only)	X	1
Apollo 5 (SA-204/ LM 1)	S-IB	X	X
	S-IVB	X	X
	IU	NP	NP
	LM	X	X
	LC-37 (KSC Only)	X	1 October 1967
Apollo 6 (SA-502/ CSM 020)	S-IC	X	X
	S-II	X	X
	S-IVB	X	X
	IU	X	X
	LTA-2R	NP	NP
	CSM (Generic Block I)	X	X
	LC-39 (KSC Only)	X	2
MLL	S-IC	2 November 1967	29 February 1968
	S-II	2 November 1967	29 February 1968
	S-IVB	2 November 1967	29 February 1968
	IU	2 November 1967	29 February 1968
	LM	Planned	Planned
	CSM (Generic Block II)	X	X
	LC-39 (KSC Only)	X	2

X — Completed
NP — None Planned

1. FMEA's for 19 mechanical systems assigned to Boeing have been completed; however, formal document will not be issued for SA-501. General Electric has issued FMEA summary reports for 26 electrical systems. There is no known documentation which designates all launch critical KSC systems for which FMEA's are required.
2. Firm schedule not established.

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(This Page Unclassified)

COMMENTS ON FMECA/FMEA STATUS

CSM AND LM

MSC placed a requirement upon NAA and GAEC to provide FMEA's for each CSM and LM. As a result of the NAA response to this request, MSC has agreed to accept a single-failure point summary for each CSM, in lieu of a complete FMEA, if it contains the following minimum information:

- A spacecraft single-failure point mode (SFPM) summary of those items causing possible loss of vehicle or primary mission objectives. Details of the SFPM summary will include:
  - a. Component name.
  - b. Component identification.
  - c. Failure mode.
  - d. Failure effect.
  - e. Means of detection.
  - f. Status of redundancy (when and by what means last checked).
  - g. Statement of possible loss of mission objective.
  - h. Rationale for acceptance of SFPM.
- A safety evaluation of GSE.

The contractors have been requested to adhere to the following schedule for supplying this information:

NAA:	CSM 017 — 1 September 1967	GAEC:	LTA-8 — Preliminary complete
	CSM 020 — 11 September 1967		LM 1 — Preliminary complete
	CSM 101 — 4 weeks before CARR		LM 2 — 4 weeks before CARR

The spacecraft contractors have also been requested to provide an update of the FMEA's when design, configuration, or test changes take place.

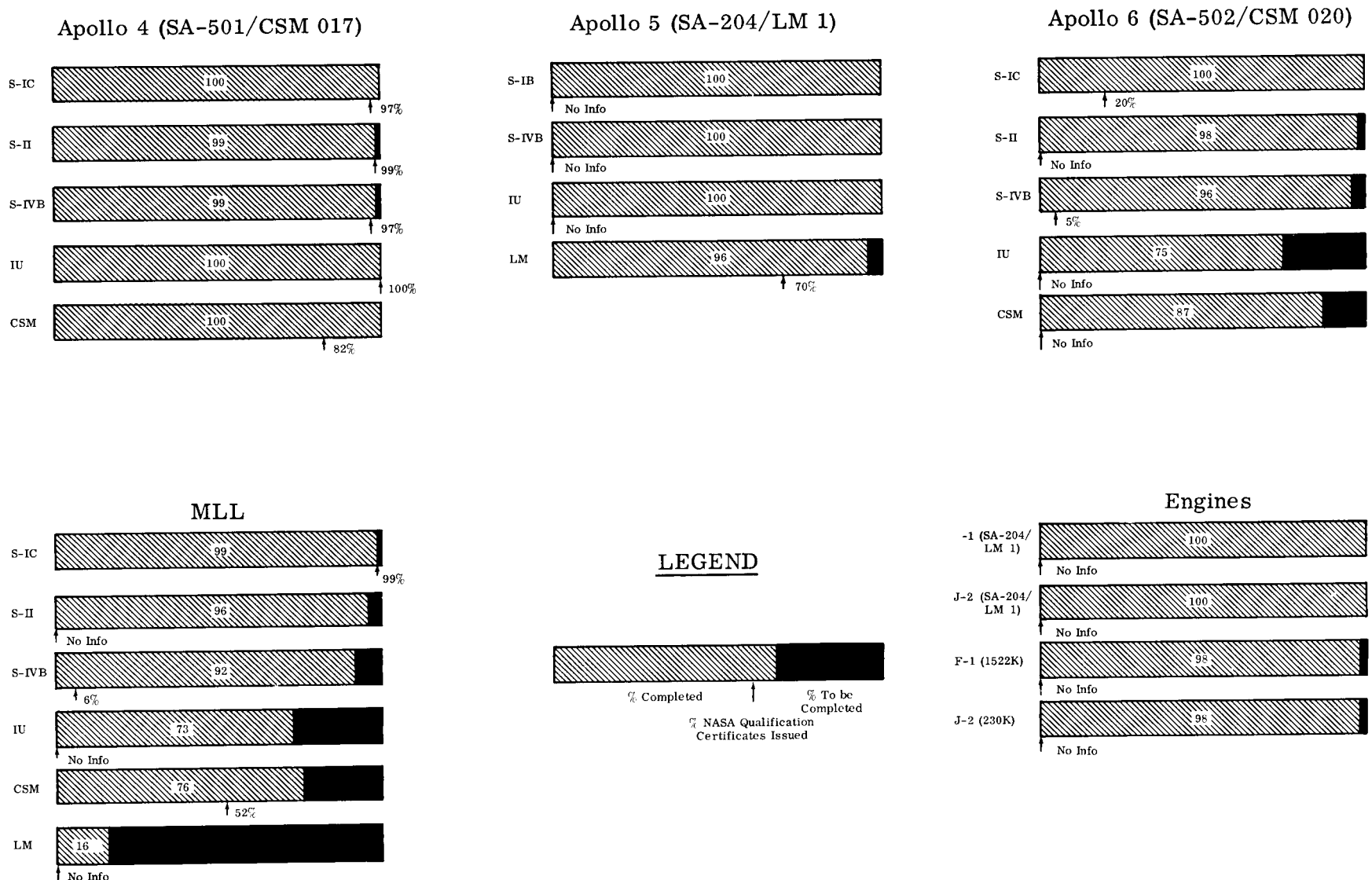
IU (SA-204)

An FMECA was released for S-IU-204 against the original SA-204 mission but no update is planned for the Apollo 5 (SA-204/LM 1) mission.

LAUNCH EQUIPMENT (SA-204)

Chrysler/Cape Kennedy is behind schedule in issuing the Apollo 5 (SA-204/LM 1) FMEA which is normally issued eight weeks before launch based upon a tentative launch date. Chrysler has verbally reported to date one "actual loss" exists in the LH_2 system FMEA — Check Valve A3376, D152103040003. There is a strong possibility that this will change to "possible loss" before official publication of the FMEA. In addition 52 other "possible losses" are recorded.

CHART 2-B. QUALIFICATION/CERTIFICATION TEST STATUS
(For Contractor Completed Tests – Not Necessarily Approved by NASA)



COMMENTS ON QUALIFICATION/CERTIFICATION TEST STATUS

APOLLO 4 (SA-501/CSM 017)

S-IC Stage

As of 1 September 1967 all components on S-IC-1 are considered as having completed qualification testing and are hereby qualified. Five components on S-IC-1 are awaiting certificates of qualification. These are:

- F-1 Center Engine Mounting Bolts (MS-20014-82)
- F-1 Outboard Engine Mounting Bolts (MS-20014-36)
- F-1 Outboard Engine Mounting Bolts (MS-20014-26)
- F-1 Outboard Engine Mounting Bolts (MS-20014-28)
- F-1 Outboard Engine Mounting Bolts (MS-20012-36)

It should be noted that there is one deviation request on the servo-accelerometer (60B72145-1B).

S-II Stage

As of 30 September 1967 all SA-501 components have successfully completed the scheduled tests with the exception of one engineering critical item, pressure regulator (ME284-0161-0008); due to redesigns and modifications, the qualification certification is not complete.

S-IVB Stage

As of 1 September 1967, in the S-IVB-501 components testing program there remains a single unqualified component. The continuous vent module (1B67193-503) is still in test. This is expected to be completed by the end of September.

CSM 017

As of 17 August 1967, the contractor has completed all of the 34 tests planned and NASA has approved 28 of these. Four tests have not been reviewed by NASA, and two tests have partial reports. Block I tests in support of CSM 017 total 445. Of these, 414 are approved, 4 conditionally approved, 20 are in review, 1 is disapproved, and 6 lack documentation as of 18 August 1967.

COMMENTS ON QUALIFICATION/CERTIFICATION TEST STATUS (Cont.)

APOLLO 5 (SA-204/LM 1)

LM

As of 30 September 1967 the following items have not completed initial qualification testing or require additional testing:

LM 1 Tests Not Completed

CTR No.	Item
LCQ 270-050	Descent Stage Helium Regulator
LCQ 320-012	Circuit Interrupter Cartridge
LCQ 320-013	Circuit Interrupter Air Cycling
LCQ 330-018	Cabin Pressure Valve
LCQ 390-009	Descent Stage Battery
LCQ 270-002	Ascent Engine Qualification
LCQ 270-047	Descent Engine Qualification

Propulsion subsystem components are the most critical items remaining to be tested in support of LM 1.

MANNED LUNAR LANDING (MLL) MISSION

S-IC

Two non-flight critical components remain open on qualification testing. These are: (1) DC-DC Converter (60B76123-003), and (2) Power Isolator (60B76503-003).

One hundred fourteen components identified as flight critical are awaiting certificates of qualification. (Certificates of qualification have been issued for 32 flight-critical items.)

CSM

As of 17 August 1967, 365 tests were planned: 279 Block II tests have been completed; 86 were incomplete. Of the completed tests, 144 have been approved, 15 were disapproved, 67 were in review, 39 had partial reports, and 14 had no reports. A Block II redefinition program is currently in progress, and additional certification tests will be required.

ENGINES

J-2 Engine Components

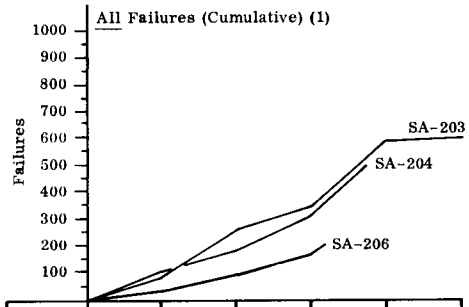
One component, the start tank discharge valve, remains to be approved. This valve configuration, which has been approved for SA-501 flight, failed in vibration test when the main shaft galled and developed wear. MSFC states the valve is qualified and that the vibration requirements were too severe.

F-1 Engine Components

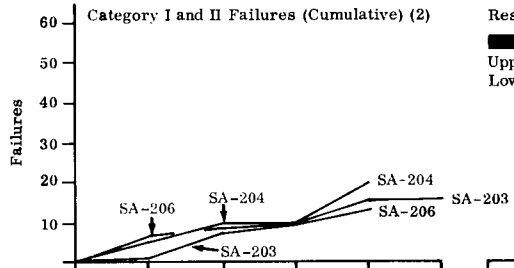
All component testing reports have been approved except those components related to the redundant shutdown system. Those components are now being tested. The redundant shutdown system has been kitted to S-IC-1 and all testing (laboratory and engine) which demonstrates reliability of the system has been completed.

CHART 2-C-1. FAILURE TRENDS – LAUNCH VEHICLES

UPRATED SATURN I



Checkout Phase	Post-Mfg C/O	Static Test	Post-Static C/O	Launch C/O	Post-Flight
SA-203	87/87	169/256	89/345	238/583	7/590
SA-204	102/102	85/187	117/304	188/492	
SA-206	36/36	48/84	74/158	43/201	(a)



Post-Mfg C/O	Static Test	Post-Static C/O	Launch C/O	Post-Flight
1/1	6/7	2/9	7/16	0/16
5/5	5/10	0/10	10/20	
6/6	3/9	1/10	2/12	(a)

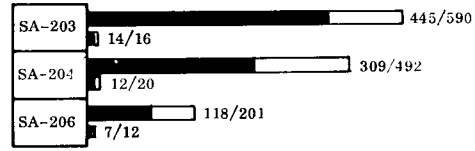
(a) SA-206 was destacked and removed from the Launch Complex.

Resolution Status*

Resolved/Total

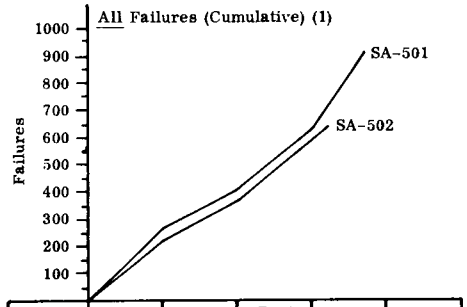
Upper Bar—All Categories

Lower Bar—Category I and II

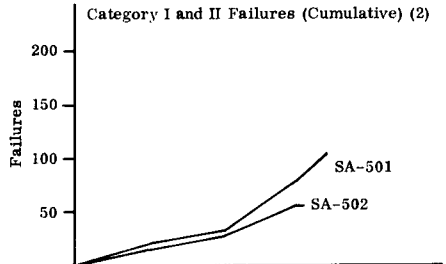


*Flight readiness action is taken to explain and give disposition on all failures prior to launch. Resolution Status relates to documented corrective action to prevent recurrence of the failure on similar hardware.

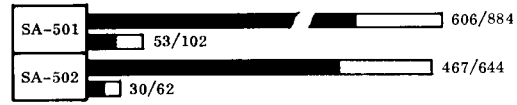
SATURN V



Checkout Phase	Post-Mfg C/O	Static Test	Post-Static C/O	Launch C/O	Post-Flight
SA-501	264/264	143/407	231/638	246/884	—
SA-502	220/220	145/365	211/576	68/644	—



Post-Mfg C/O	Static Test	Post-Static C/O	Launch C/O	Post-Flight
22/22	12/34	45/79	23/102	
17/17	11/28	30/58	4/62	



Phase Total

LAUNCH VEHICLE FAILURES BY RESPONSIBILITY AND CAUSE

The following table presents an analysis of the above Category I and II launch vehicle failures by responsibility.

Failures by Responsibility

Launch Vehicle	Percent of Total				Total Failures
	Design	Quality	Human	Other	
SA-204	57	5	28	10	20
SA-206	33	–	58	9	12
SA-501	55	14	29	2	102
SA-502	36	44	13	7	62

The following table shows the primary cause for the quality and human-induced failures described above.

Failure Causes — Quality and Human-Induced Type

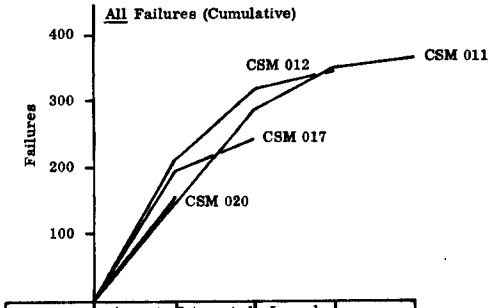
Launch Vehicle	Percent of Total			Total Failures
	Damaged Material	Assembly Errors	Contamination	
SA-204	29	57	14	7
SA-206	14	43	43	7
SA-501	14	33	51	43
SA-502	5	46	46	35

REFERENCE

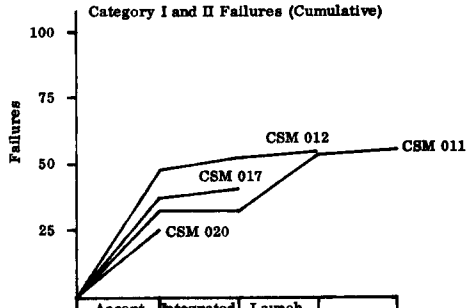
MSFC Significant Failure Evaluation Report, dated 31 July 1967.

CHART 2-C-2. FAILURE TRENDS – SPACECRAFT

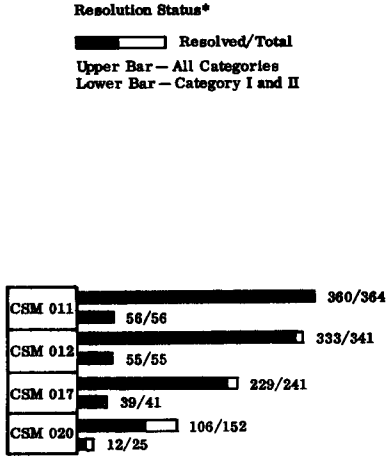
COMMAND/SERVICE MODULE



Checkout Phase	Acceptance Testing	Integrated System Testing	Launch Pad Operation	Post-Flight
CSM 011	148/148	135/283	67/350	14/364
CSM 012	210/210	113/323	18/341	–
CSM 017	197/197	44/241	–	–
CSM 020	152/152	–	–	–

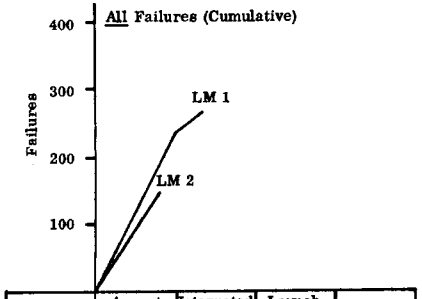


Acceptance Testing	Integrated System Testing	Launch Pad Operation	Post-Flight
34/34	0/34	19/53	3/56
45/45	9/54	1/55	–
37/37	4/41	–	–
25/25	–	–	–

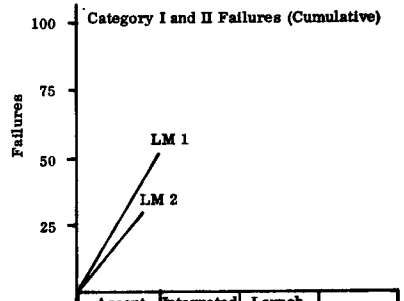


*Flight readiness action is taken to explain and give disposition on all failures prior to launch. Resolution Status relates to documented corrective action to prevent recurrence of the failure on similar hardware.

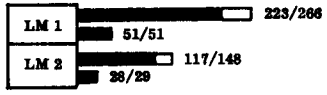
LUNAR MODULE



Checkout Phase	Acceptance Testing	Integrated System Testing	Launch Pad Operation	Post-Flight
LM 1	237/237	29/266	–	–
LM 2	148/148	–	–	–



Acceptance Testing	Integrated System Testing	Launch Pad Operation	Post-Flight
51/51	–	–	–
29/29	–	–	–



nn/oo — nn Phase Total; oo Cumulative Total

REFERENCE

MSC Failure Report Index: X10-05-511A, dated 7/14/67 (ACED); X10-05-211C, dated 7/28/67 (GAEC); X10-05-111C, dated 7/21/67 (NAA)

SPACECRAFT FAILURES BY RESPONSIBILITY AND CAUSE

The following table presents an analysis of all above spacecraft failures by responsibility.

All Failures by Responsibility

Spacecraft	Percent of Total				Total Failures
	Design	Quality	Human	Other	
CSM 017	15	26	26	33	241
CSM 020	23	12	21	44	152
LM 1	9	28	14	49	266
LM 2	9	33	12	46	148

The following table shows the primary causes for the quality and human-induced failures tabulated above.

Failure Causes — Quality and Human-Induced Type

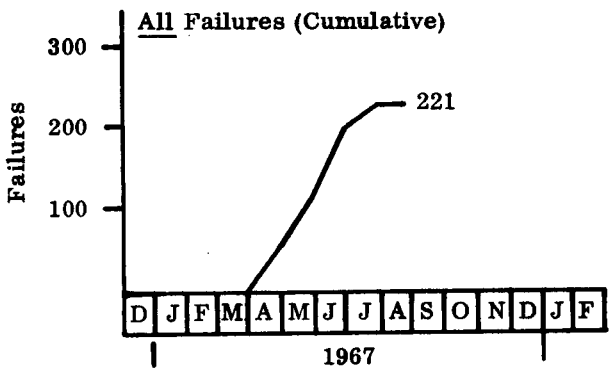
Spacecraft	Percent of Total					Total Failures
	Damaged Material	Dimensional Errors	Assembly Errors	Contam-ination	Procedural Errors	
CSM 017	27	5	26	6	36	124
CSM 020	18	0	43	12	27	49
LM 1	15	17	26	5	37	111
LM 2	10	35	17	12	26	66

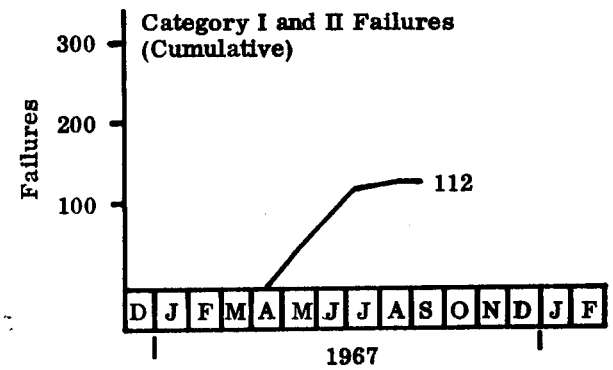
REFERENCE

Same as Chart 2-C-2 above.

CHART 2-C-3. FAILURE TRENDS – KSC GROUND SUPPORT EQUIPMENT – LC-37B/UPRATED SATURN I

KSC/GSE RELATED TO APOLLO 5 (SA-204/LM 1)

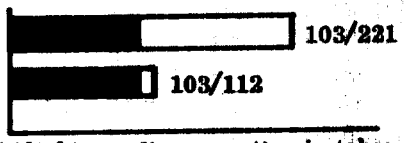




Resolution Status*

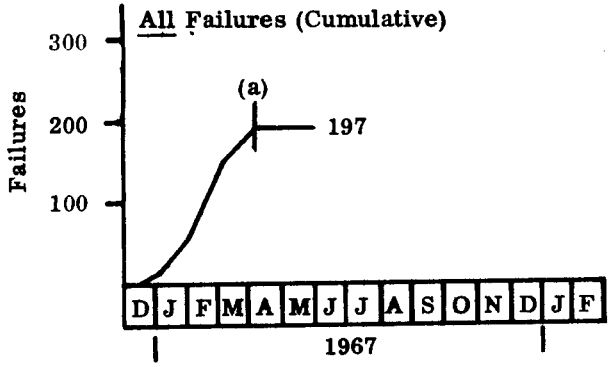
Resolved/Total

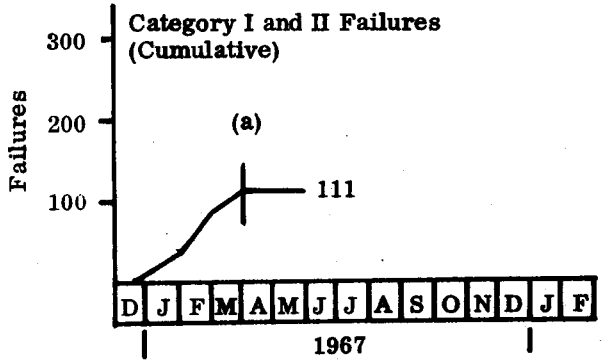
Upper Bar — All Categories
Lower Bar — Category I and II

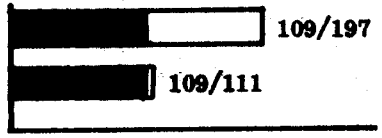


*Flight readiness action is taken to explain and give disposition on all failures prior to launch. Resolution Status relates to documented corrective action to prevent recurrence of the failure on similar hardware.

KSC/GSE RELATED TO SA-206







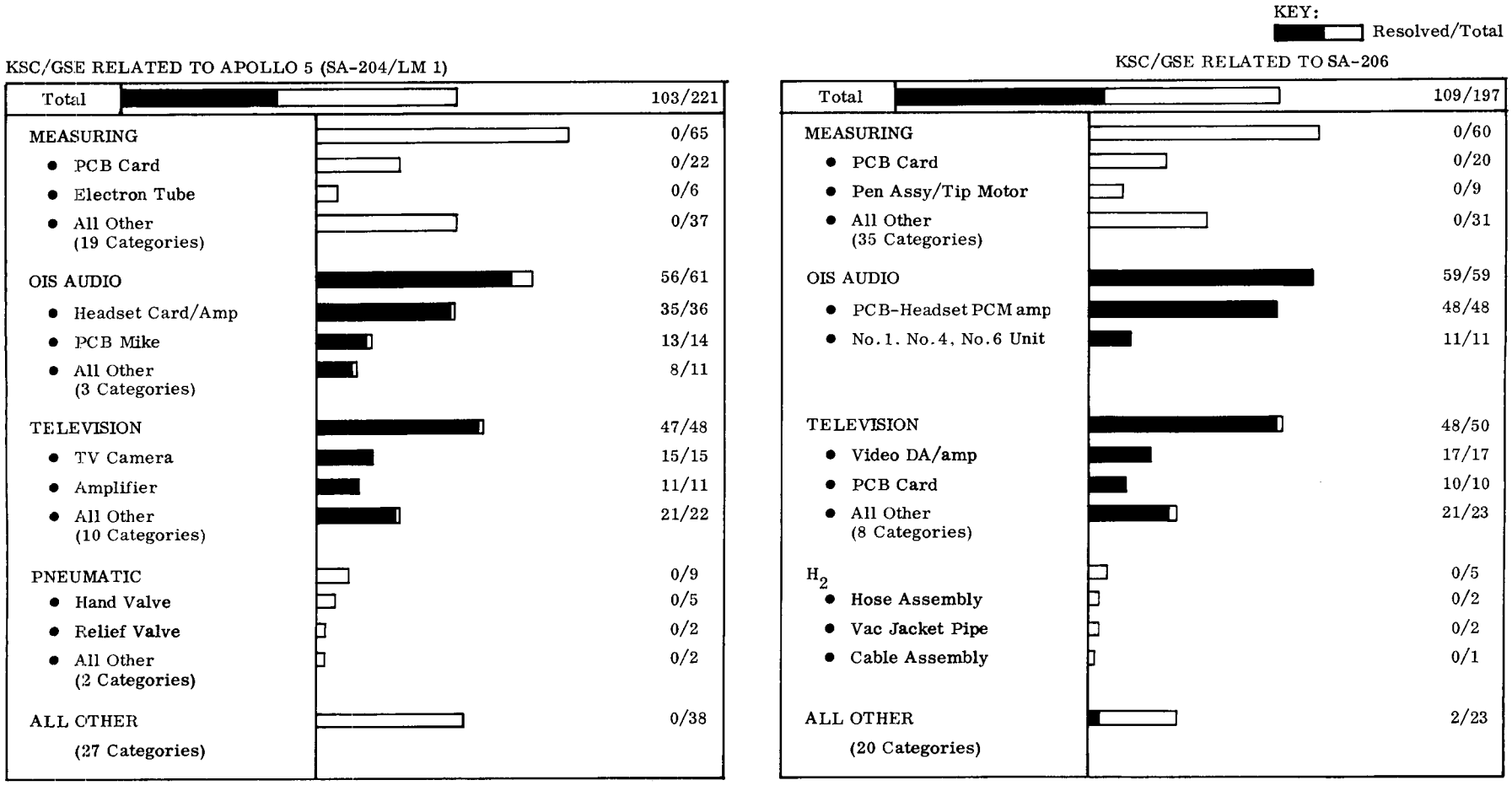
(a) SA-206 was destacked and removed from the Launch Complex.

REFERENCE

KSC Unsatisfactory Condition Report Printout, dated 4 August 1967.

[redacted]

ANALYSIS OF KSC GROUND SUPPORT EQUIPMENT FAILURES BY FLIGHT MISSION/SUBSYSTEM/COMPONENT LC-37B/UPRATED SATURN I



REFERENCE

KSC Unsatisfactory Condition Report, dated 4 August 1967.

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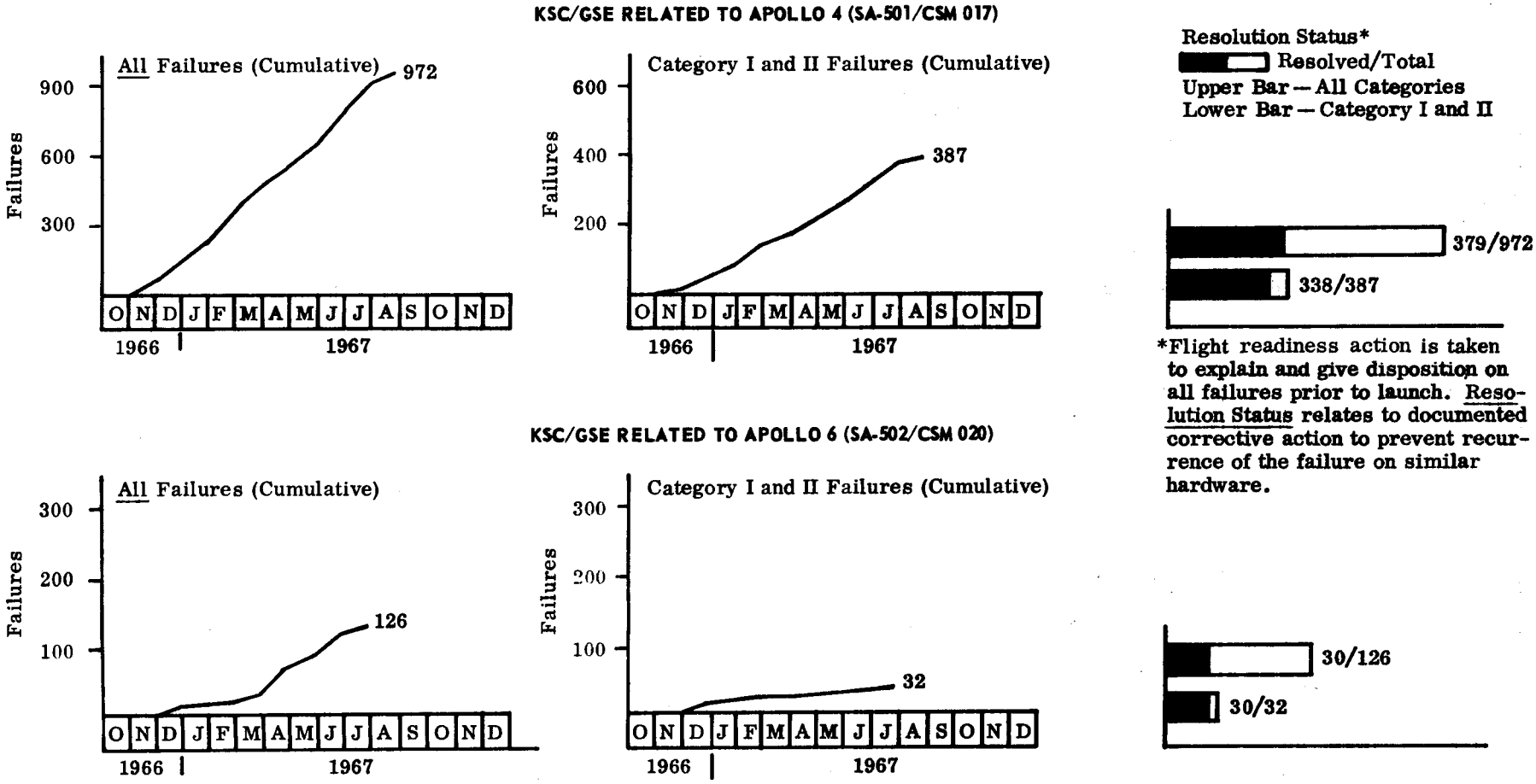
CHART 2-C-4. FAILURE TRENDS – KSC GROUND SUPPORT EQUIPMENT – SATURN V



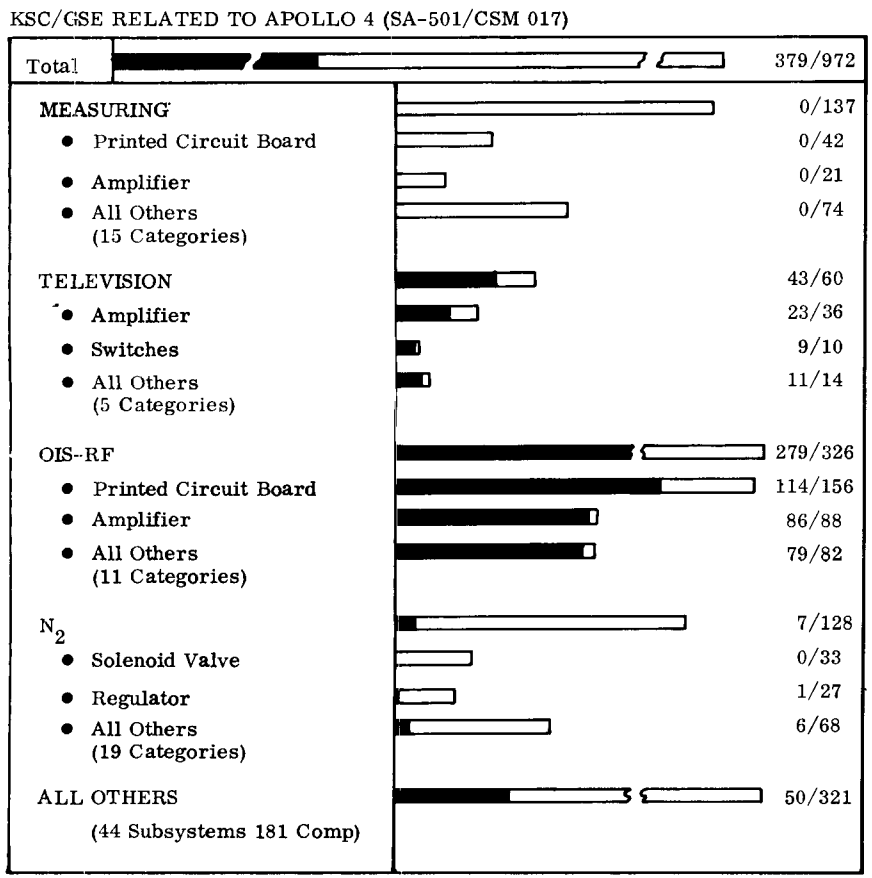
*Flight readiness action is taken to explain and give disposition on all failures prior to launch. Resolution Status relates to documented corrective action to prevent recurrence of the failure on similar hardware.

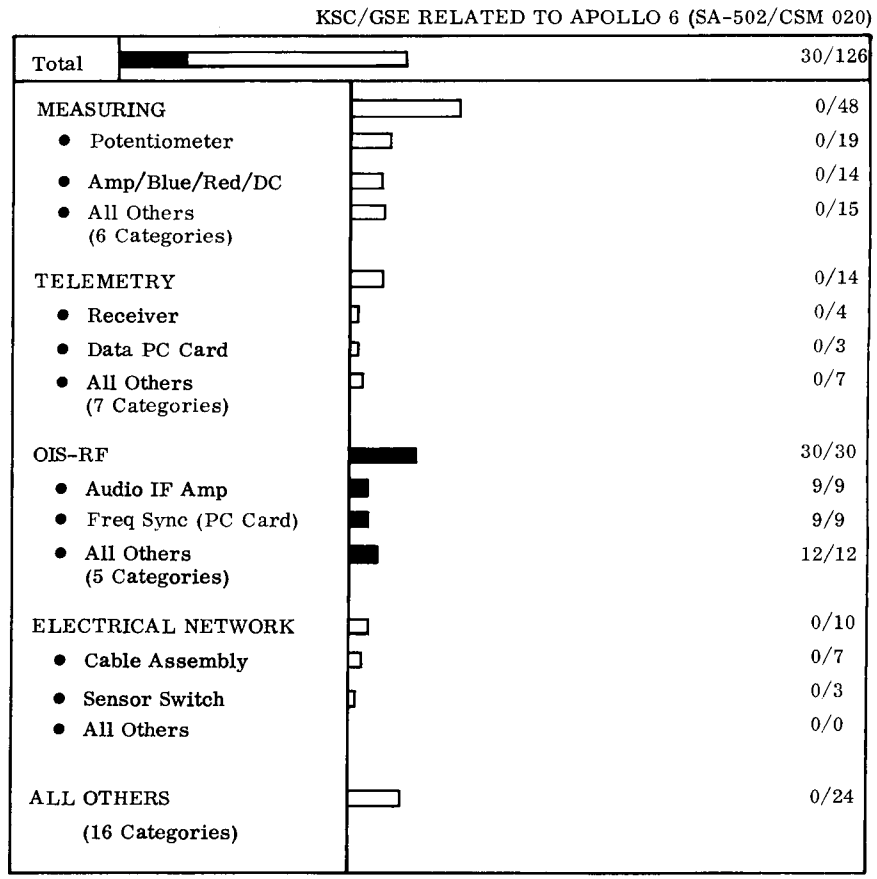
REFERENCE

KSC Unsatisfactory Condition Report Printout, dated 4 August 1967.

ANALYSIS OF KSC GROUND SUPPORT EQUIPMENT FAILURES BY FLIGHT MISSION/SUBSYSTEM/COMPONENT LC-39A/SATURN V

KEY: Resolved/Total



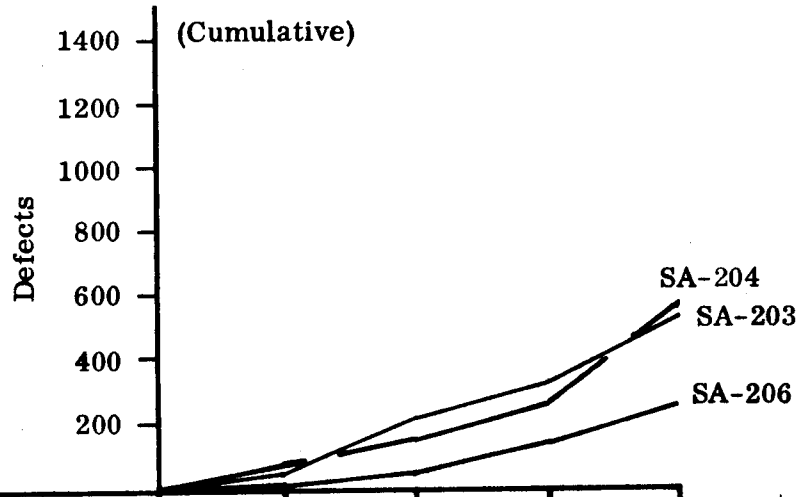


REFERENCE

KSC Unsatisfactory Condition Report, dated 4 August 1967.

CHART 2-C-5. DEFECT TRENDS – LAUNCH VEHICLES

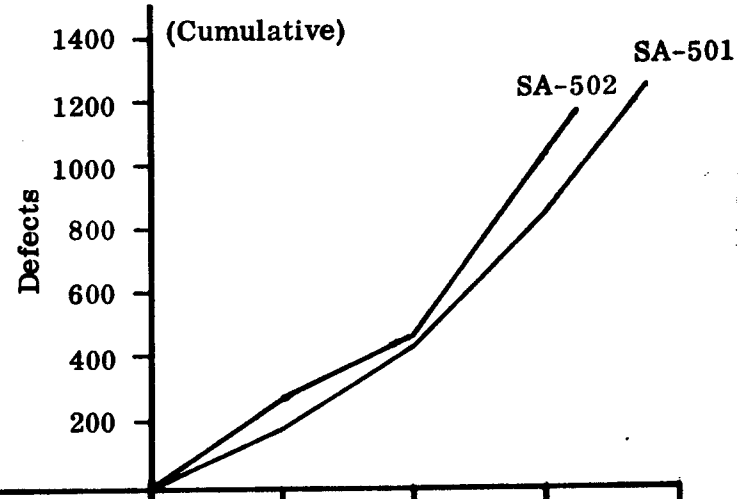
LAUNCH VEHICLE – UPRATED SATURN I



Checkout Phase	Post-Mfg C/O	Static Test	Post-Static C/O	Launch C/O
SA-203	49/49	160/209	106/315	198/513
SA-204	57/57	109/166	96/262	301/563
SA-206	17/17	48/65	103/168	89/257

nn/oo — nn Phase Total; oo Cumulative Total

LAUNCH VEHICLE – SATURN V

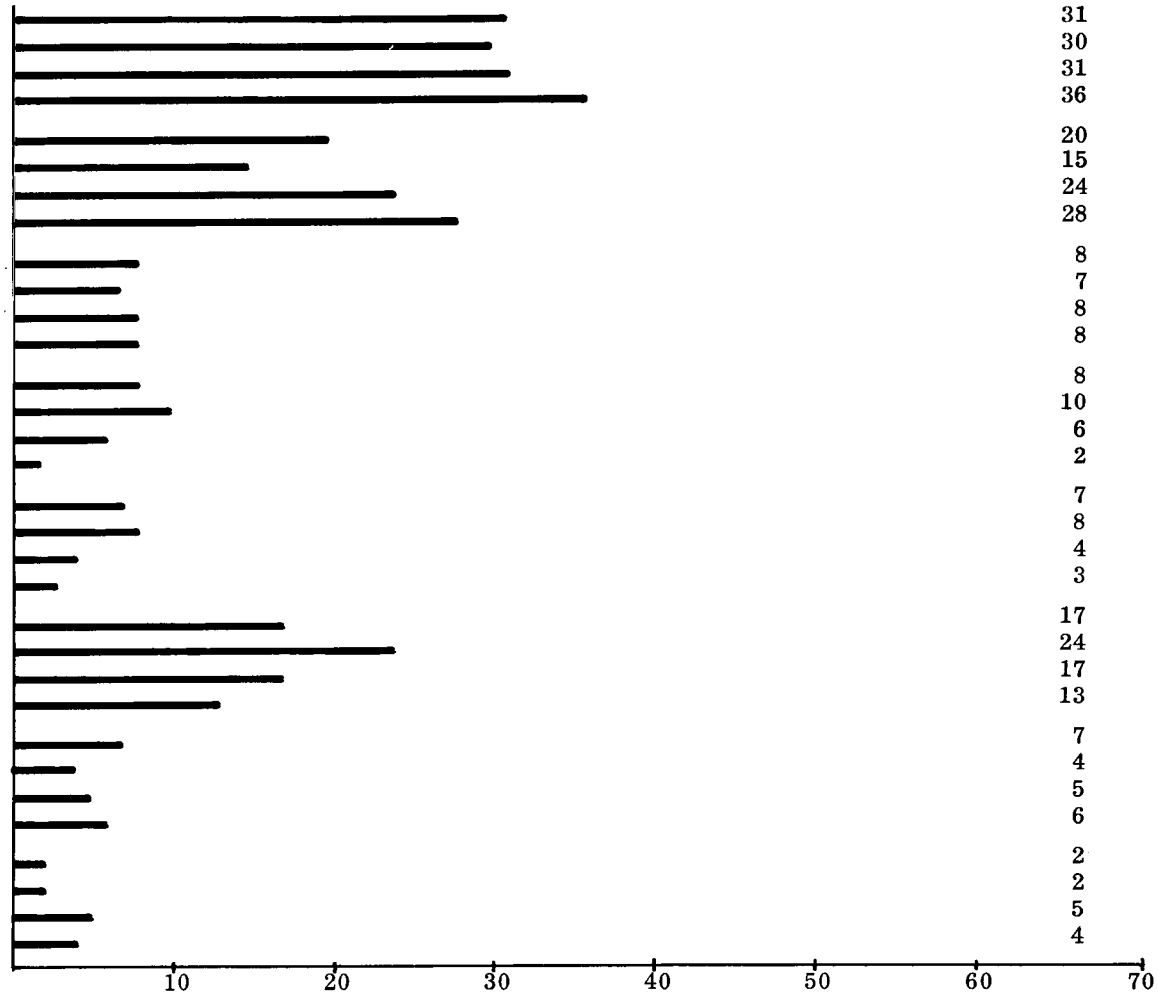


Checkout Phase	Post-Mfg C/O	Static Test	Post-Static C/O	Launch C/O
SA-501	191/191	233/424	415/839	423/1262
SA-502	275/275	172/447	589/1036	155/1191

REFERENCE

MSFC Unsatisfactory Condition Report Printout, dated 12 August 1967.

DEFECTS BY CAUSES – LAUNCH VEHICLE



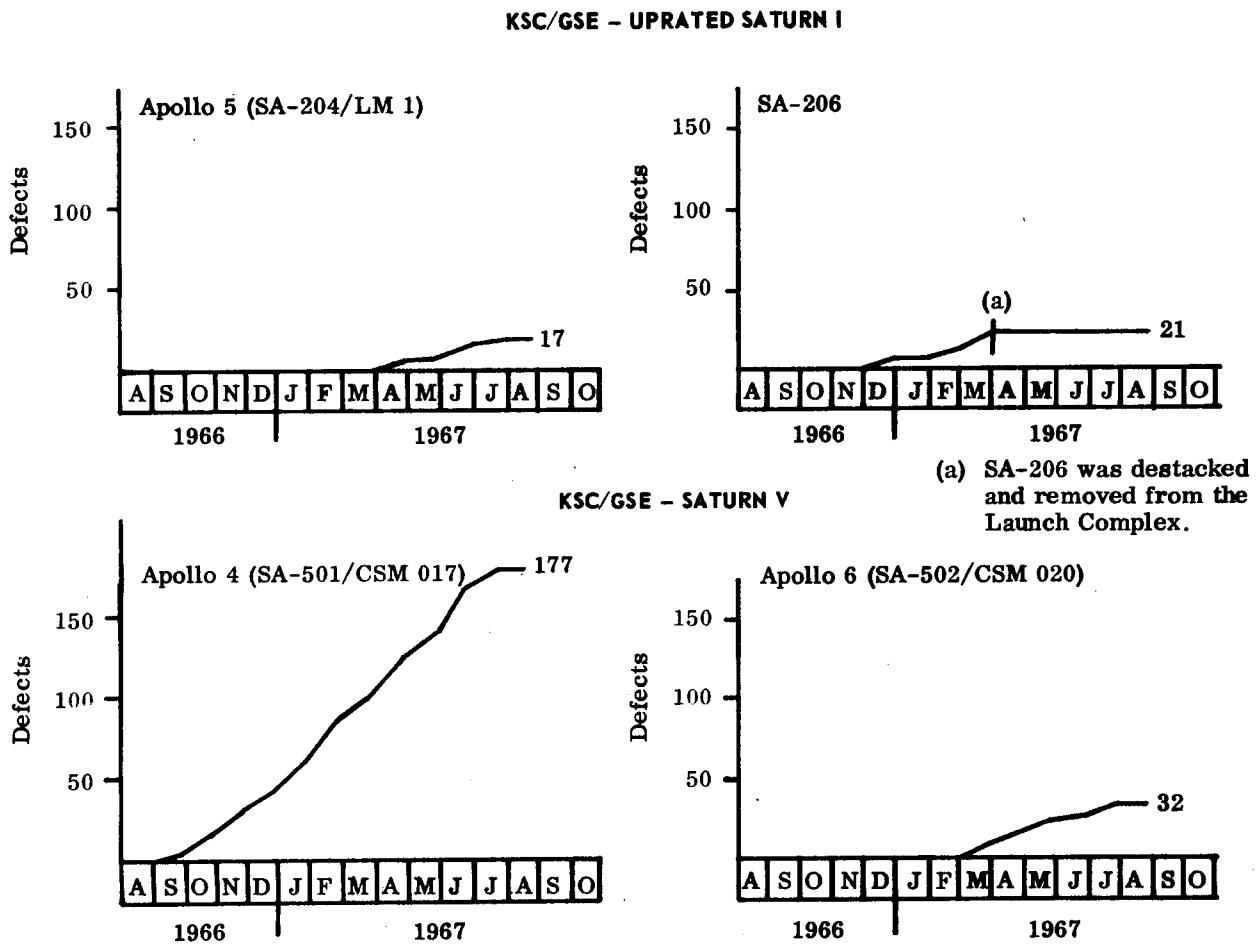
		PERCENT	NUMBER
DAMAGED MATERIAL	SA-204	31	177
	SA-206	30	77
	SA-501	31	394
	SA-502	36	431
ASSEMBLY	SA-204	20	113
	SA-206	15	40
	SA-501	24	299
	SA-502	28	331
CONTAMINATION	SA-204	8	43
	SA-206	7	17
	SA-501	8	100
	SA-502	8	92
DIMENSIONAL ERRORS	SA-204	8	43
	SA-206	10	26
	SA-501	6	77
	SA-502	2	22
BONDS (WELD & SOLDER)	SA-204	7	40
	SA-206	8	20
	SA-501	4	44
	SA-502	3	40
PROCEDURAL & OPERATIONAL	SA-204	17	94
	SA-206	24	62
	SA-501	17	217
	SA-502	13	153
PROTECTIVE FINISH	SA-204	7	40
	SA-206	4	11
	SA-501	5	66
	SA-502	6	66
MISCELLANEOUS	SA-204	2	13
	SA-206	2	4
	SA-501	5	65
	SA-502	4	56

PERCENT OF TOTAL DEFECTS

REFERENCE

MSFC Unsatisfactory Condition Report Printout, dated 12 August 1967.

CHART 2-C-6. DEFECT TRENDS – KSC GROUND SUPPORT EQUIPMENT



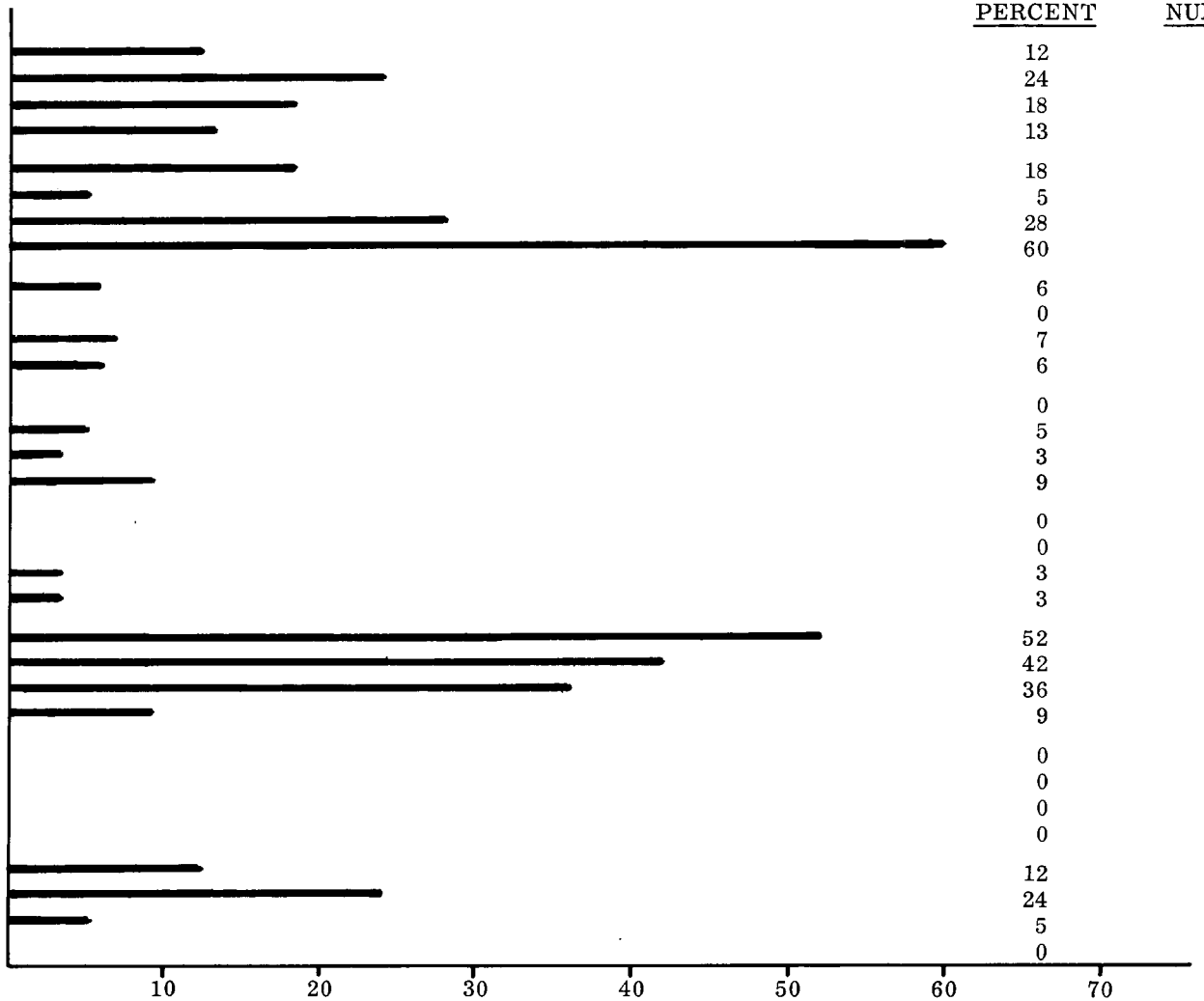
(a) SA-206 was destacked and removed from the Launch Complex.

NOTE: Curves do not include design errors.

REFERENCE

KSC Unsatisfactory Condition Report Printout, dated 4 August 1967.

DEFECTS BY CAUSES – KSC GROUND SUPPORT EQUIPMENT



		PERCENT	NUMBER
DAMAGED MATERIAL	SA-204	12	2
	SA-206	24	5
	SA-501	18	31
	SA-502	13	4
ASSEMBLY	SA-204	18	3
	SA-206	5	1
	SA-501	28	50
	SA-502	60	19
CONTAMINATION	SA-204	6	1
	SA-206	0	0
	SA-501	7	12
	SA-502	6	2
DIMENSIONAL ERRORS	SA-204	0	0
	SA-206	5	1
	SA-501	3	6
	SA-502	9	3
BONDS (WELD & SOLDER)	SA-204	0	0
	SA-206	0	0
	SA-501	3	6
	SA-502	3	1
PROCEDURAL & OPERATIONAL	SA-204	52	9
	SA-206	42	9
	SA-501	36	63
	SA-502	9	3
PROTECTIVE FINISH	SA-204	0	0
	SA-206	0	0
	SA-501	0	0
	SA-502	0	0
MISCELLANEOUS	SA-204	12	2
	SA-206	24	5
	SA-501	5	9
	SA-502	0	0

REFERENCE

KSC Unsatisfactory Condition Report, dated 4 August 1967.

APOLLO R&QA PROGRAM – MANAGEMENT PROBLEM AREAS

FAILURE RECURRENCE CONTROL

Incomplete reporting of test time, inadequate demonstration of corrective action effectiveness, and numerous instances of failure recurrence during tests on space vehicle equipment remain significant program problems. Causes of repetitive failures observed include mishandling, contamination, corrosion, welding, wiring, and inadequate inspection technique. These problems are under study by Apollo R&QA.

FITTING LEAKAGE

Numerous mechanical fitting leakage problems have been reported on both the launch vehicle and spacecraft. A preliminary review of practices and specifications related to flare fittings identified the following unexplained variations:

a. Crush Washers

- Boeing does not accept hardware with crush washers.
- Chrysler permits extensive use of crush washers.
- NAA uses crush washers as a standard repair for leaking spacecraft hardware which cannot be repaired by retorquing.
- NAA requires the use of crush washers on all aluminum flare fittings.

b. Threaded Fittings

- Although an MSC design standard recommends against the use of 303 stainless steel due to stress corrosion considerations, the IMU water-glycol fittings for gold plates are fabricated from this material.
- The Wiggins-type fittings used by NAA permit higher torque application than MC or AN fittings.
- Although MSC Design Standard DS-14 recommends against the use of 2024-T6 aluminum alloy, the Wiggins DL-100 connectors are fabricated from this material.
- GAEC uses Gamah fittings on which leaks cannot be corrected by retorquing.

Additional study of this problem by APO/R&QA is planned for the Fourth Quarter 1967.

WIRING DISCREPANCIES

Although wiring discrepancies are still being experienced at Downey, the CSM problem is considered temporarily closed since no problems have been encountered on CSM 017 during integrated system test.

Numerous LM wiring discrepancies have been reported which include: (1) solder and crimp splice tensile strength test failures, (2) excessive AWG No. 26 wire breakage at connector crimp contacts and solder terminals, and (3) reduction of dielectric strength due to fuel contaminants.

The GSE wiring problems cannot be considered directly related to flight hardware. They do, however, serve to illustrate the extent of the overall problem. Difficulties have been experienced at KSC with cable routing, wire dress, damage, deterioration, and termination.

A review of these problem areas indicates a need for Program-level documents providing specific direction on the selection, installation, test, and inspection of wiring. One such document, Apollo CSM and LM Electrical Inspection Criteria and Standards, RA064-001-1A, has been approved for issuance and will be available for Centers and contractors during the Fourth Quarter 1967. Similar documents for launch vehicles and GSE are needed.

LACK OF INFORMATION REGARDING MANNED SPACE FLIGHT NETWORK

A comprehensive list of critical MSFN hardware whose failure could lead to inability to perform essential mission operations is not available. Therefore, this impairs the effectiveness of the program for critical MSFN hardware problem identification, tracking, and assurance of follow-up corrective action. With currently available information, assurance cannot be provided that failures of critical MSFN hardware have been identified, verified, recorded, analyzed, compared with previous failures, and corrected on the item and/or subsequent items. In addition, a summary of MSFN hardware changes required by other programs which could affect the support capability for Apollo is not readily available. Mission Operations will assist APO/R&QA in obtaining the necessary MSFN reliability data.

APOLLO EMC ANOMALY ANALYSIS

As pointed out in the Second Quarter 1967 report, this area represents many open problems. APO Management has recognized this and has now recommended that OART be assigned the responsibility for the development and implementation of a NASA-wide program for EMI control.

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CHART 3-A. SUMMARY OF NASA–APOLLO RELIABILITY AND QUALITY AUDITS

Auditor	Audited Organization	Prev Completed	1967 Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
NASA Center Unless Otherwise Noted	ACED (G&N)	■2 4●	■					■a	□a o	□a o	□a ●i	□a □	□a □f	□a
	Bendix Corp (ST-124M)										■ ●			
	Boeing Co (S-IC)	■3 2●	■ a ●				■ c ●				■		□	□
	Chrysler Corp (S-IB)	■2 2●						■d	■	●a		□a	□ o	
	Douglas Aircraft Co (S-IVB)	■3 1●				■		■					□a □	o
	General Electric Co (ACE) (ESE)							■a					o	□a o
	Grumman Aircraft (LM)	■1 2●		■		■ b ●	X h	■a	■a ●	■a ●b	■a ■b		□a	□a
	IBM (IU)	■1 1●	■ a ●					X h						
	NAA (CSM)	■1 3●	■		X h	■ ●		■a	■a	■a	■a		□a □	□a o a f b
	NAA (S-II)	■2 1●					■						□ X h	
	Rocketdyne (NAA) (F-1, J-2, H-1)	■4		■	■								□	
NASA Headquarters Unless Otherwise Noted	NASA — KSC				■		■ g ●	■ g ●	■ g ●	■ g ●		□ g o		□ g o
	NASA — MSC						■ ●							
	NASA — MSFC											□ o		
	NASA — MTF											□ h o		
	NASA — Michoud											□ h o		

o Reliability Audit Scheduled
● Reliability Audit Completed
□ Quality Audit Scheduled
■ Quality Audit Completed
X Special Audit

a. At KSC
b. At MSC/WSTF
c. At MTF
d. At KSC and/or Huntsville, Ala
e. At KSC and Bethpage, NY
f. At Downey
g. At KSC, Director QA
h. By MAR
i. At Milwaukee, Wis

APOLLO PROGRAM DIRECTIVE NO. 32

APO Directive No. 32, Reliability and Quality Assurance Auditing, was issued 18 September 1967 to specifically identify responsibilities for planing, conducting, and reporting on audits of reliability and quality program activities at all Apollo organization levels.

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CHART 3-B. APOLLO PROGRAM OFFICE DIRECTIVE NO. 6 KEY CHECKPOINTS

Mission	Stage Module LC	PDR Completed or Scheduled	CDR Completed or Scheduled	FACI Completed or Scheduled	COFW Completed or Scheduled	Date DCR Initiated	FRR Date
Apollo 4 (SA-501/ CSM 017)	S-IC	Note 2	Note 2	Note 2	Note 6	NA	Not Established
	S-II	X	X	X	Note 6		
	S-IVB	X	X	NA	Note 6		
	IU	Note 3	X	NA	Note 6		
	CSM	X	X	NA	9-67		
	LTA	NA	NA	NA	NA		
	39A	Note 4	Note 4	Note 5	NA		
Apollo 5 (SA-204/ LM 1)	S-IB	X	X	X	X	Note 7	Not Established
	S-IVB	X	X	X	X		
	IU	NA	X	X	X		
	LM	X	X	X	10-67		
	37B	Note 1	Note 1	Note 5	NA		

Blank Space—No Information NA—Not Applicable X—Completed

Note 1—Accomplished on previous missions.
Note 2—MSFC responsibility—there is no requirement for CDR, PDR, and FACI
Note 3—The intent of NPC-500-1 met through working groups and other reviews.
Note 4—PDR's and CDR's for LC and associated GSE equipment cannot be treated the same as for flight hardware. In many respects, the 500F tests served as a design review for many of the LC systems.
Note 5—Current information not available at this time.
Note 6—COFW Indorsement No. 4 has been accomplished. The final indorsement (No. 5) will take place after CDDT (probably October 1967).
Note 7—A DCR was held on the SA-204 launch vehicle during the third quarter of 1966.

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ABBREVIATIONS

3M	Minnesota Mining and Manufacturing Co.
ac	Alternating Current
ACE	Acceptance Checkout Equipment
ACED	AC Electronics Division
AFETR	Air Force Eastern Test Range
AGCS	Automatic Ground Control System
amp	Amplifier
APO	Apollo Program Office
APS	Apollo Problem Summary Ascent Propulsion System
AS	Apollo Saturn
ASI	Augmented Spark Igniter
ASPO	Apollo Spacecraft Program Office
CAR	Contractual Action Report
CARR	Customer Acceptance Readiness Review
CB	Circuit Breaker
cc	Cubic Centimeter
CCSD	Chrysler Corporation Space Division
CDDT	Count Down Demonstration Test
CDR	Critical Design Review
CM	Command Module
CNC	Contractor Non-Conformance
C/O	Checkout
COFW	Certification of Flight Worthiness
COMM	Communications
cps	Cycles per Second
CSM	Command and Service Module
CTR	Certification Test Requirement
dc	Direct Current
DAC	Douglas Aircraft Corporation
DCR	Design Certification Review
DPS	Descent Propulsion System
DR	Discrepancy Record
DRS	Discrepancy Record (Squawk)
DSE	Data Storage Equipment
DSKY	Display and Keyboard
ECP	Engineering Change Proposal
ECR	Engineering Change Request
ECS	Environmental Control System
ECU	Environmental Control Unit
EDB	Engineering Data Bank
EDS	Emergency Detection System
ELS	Earth Landing System
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EN	Engineering Notice
EO	Engineering Order
EPS	Electrical Power System
ESE	Electrical Support Equipment
ETV	Environmental Test Vehicle
FACI	First Article Configuration Inspection
FARR	Failure and Rejection Report
FCSM	Flight Combustion Stability Monitor
FIAR	Failure Investigation Action Report
FITH	Fire in the Hole
FMEA	Failure Mode Effect Analysis
FMECA	Failure Mode Effect and Criticality Analysis
FRR	Flight Readiness Review
FRT	Flight Readiness Test
GA	Government Agency
GAEC	Grumman Aircraft Engineering Corporation
GE	General Electric Company
GN_2	Gaseous Nitrogen
G&N	Guidance and Navigation
GN&C	Guidance, Navigation, and Control
GOX	Gaseous Oxygen
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
IBM	International Business Machines Corp
IMU	Inertial Measurement Unit
ITI	Inspection Test Instruction
IU	Instrument Unit
JPL	Jet Propulsion Laboratory
K or k	Thousand
KSC	Kennedy Space Center
LC	Launch Complex
LES	Launch Escape System
LET	Launch Escape Tower
LH_2	Liquid Hydrogen
LM	Lunar Module
LMP	LM Mission Programmer
LOX	Liquid Oxygen
LTA	LM Test Article
LUT	Launch Umbilical Tower
LV	Launch Vehicle
LVO	Launch Vehicle Operations (KSC)
MCP	Mission Control Programmer
Mfg	Manufacturing
MGSE	Mechanical Ground Support Equipment
MLL	Manned Lunar Landing

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(This Page Unclassified)

mod kit	Modification Kit
MRB	Material Review Board
MS	Military Specification
MSC	Manned Spacecraft Center
MSFC	Marshall Space Flight Center
MSFN	Manned Space Flight Network
MSOB	Manned Spacecraft Operations Building
MTF	Mississippi Test Facility
NA or N/A	Not Applicable
NAA	North American Aviation
NASA	National Aeronautics and Space Administration
N_2O_4	Nitrogen Tetroxide
NM	Nautical Mile
OART	Office of Advanced Research and Technology
OCP	Operational Checkout Procedure
ODOP	Offset Doppler Tracking System
OIS	Operational Intercommunication System
OMSF	Office of Manned Space Flight
PAR	Problem Action Record
PC	Printed Circuit
PCB	Printed Circuit Board
PDR	Preliminary Design Review
PIPA	Pulsed Integrating Pendulus Accelerometer
PIRR	Problem Investigation Repair Record
P&WA	Pratt and Whitney Aircraft Division
PMPFR	Program Manager's Pre-Flight Review
PMRR	Pre-Mate Readiness Review
PN, P/N	Part Number
pp.	Pages
psi	Pounds per Square Inch
psig	Pounds per Square Inch Gage
PVC	Polyvinyl Chloride
Q&RA	Quality and Reliability Assurance
RCA	Radio Corporation of America
RCS	Reaction Control System
RECP	Request for Engineering Change Proposals
RF	Radio Frequency
R&D	Research and Development
R&Q	Reliability and Quality
R&QA	Reliability and Quality Assurance
SA	Saturn Launch Vehicle
scc	Standard Cubic Centimeters
SCS	Stabilization and Control System
SCO	Spacecraft Operations (KSC)
SFP	Single-Failure Point
SFPM	Single-Failure Point Mode
S&ID	Space and Information Division (NAA)
SLA	Spacecraft LM Adapter
SM	Service Module
S/N	Serial Number
SPS	Service Propulsion System
STDV	Start Tank Discharge Valve
SWAT	Stress Wave Analysis Technique
TRW	(Thompson Ramo Wooldridge, Inc.)
TV	Television
UCR	Unsatisfactory Condition Report
UHF	Ultrahigh Frequency
UDMH	Unsymmetrical Dimethyl Hydrazine
UR	Unsatisfactory Report
USB	Unified S-band
VAB	Vehicle Assembly Building
VHF	Very High Frequency
VO	Vehicle Operations
WSTF	White Sands Test Facility

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DOCUMENTS ISSUED BY APO

1. Flight Test Verification Analysis, Volume I, Space Vehicle Systems, Draft; OMSF; RA-014-002-1A; August 1967.
2. Flight Test Verification Analysis, Volume II, Aborts, Draft; OMSF; RA-014-006-1A; August 1967.
3. Flight Test Verification Analysis, Volume III, GOSS, Draft; OMSF; RA-014-004-1A; August 1967.