Aerospace Safety Advisory Panel
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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

OFFICE OF THE ADMINISTRATOR

April 5, 1972

Dr. James C. Fletcher
Administrator
National Aeronautics and Space Administration
Washington, D. C. 20546

Dear Dr. Fletcher:

The Aerospace Safety Advisory Panel is pleased to submit the enclosed annual report to the Administrator which summarizes the Panel's activities during the period from February 1971 to February 1972. This report is for your information and use and its distribution is at your discretion.

On July 10-11, 1972, the Panel will be meeting with the OMSF Skylab Program Office and the members hope during that period to have an opportunity of meeting with you.

Yours sincerely,

Charles D. Harrington

Charles D. Harrington
Chairman, Aerospace Safety Advisory Panel

CDH:dg

Enclosure

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

OFFICE OF THE ADMINISTRATOR

April 12, 1972

MEMORANDUM

TO: AD/Deputy Administrator

FROM: APA/Executive Secretary

SUBJECT: Third Annual Report.

Enclosed are copies of the report for you and Dr. Fletcher.

We are prepared to make further distribution at your direction. As a note, Panel members have urged that consideration be given to distributing a copy of this report to the contractors visited by the Panel.

With your comments and guidance we will be prepared to draft an initial letter of response for Dr. Fletcher which would serve to express appreciation of the Apollo 16 letter-report and acknowledge the Third Annual Report.

We are also prepared to coordinate the responses to the report from NASA offices and draft a further letter to the Panel, based on these reactions and your evaluation of them, which would reflect the Administrator's official response to the report.

Carl

Carl R. Praktish
Executive Secretary
Aerospace Safety Advisory Panel

THIRD REPORT

OF

AEROSPACE SAFETY ADVISORY PANEL

NASA HEADQUARTERS

(February 1971 - February 1972)

FOREWORD

The third Aerospace Safety Advisory Panel report to the Administrator of the National Aeronautics and Space Administration, presents the results of Panel activities during the period of February 1971 - February 1972. Material for this document was developed through the medium of scheduled Panel reviews, executive sessions, and attendant staff activities. Our principal tasks involved the Apollo and Skylab programs.

Since this report is for the Administrator, distribution should be at his specific authorization.

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ABBREVIATIONS

AM	Airlock Module
MDA	Multiple Docking Adapter
OWS	Orbital Workshop
CSM	Command and Service Module
EPS	Electrical Power System
ECS	Environmental Control System
TCS	Thermal Control System
HSS	Habitability Support System
CAS	Crew Accommodation System
MDAC-E	McDonnell-Douglas Corporation-East
MDAC-W	McDonnell-Douglas Corporation-West
MMC	Martin Marietta Corporation
NR	North American Rockwell Corporation
LM	Lunar Module
ECP	Engineering Change Proposal
EO	Engineering Order
SE&I	Systems Engineering and Integration
ICD	Inter-Center Documentation, Interface Control Document
EVA	Extra Vehicular Activity
SMEAT	Skylab Medical Experiment Altitude Test
FMEA	Failure Mode and Effects Analyses
EREP	Earth Resources Experiment Program
C&D Panel	Control and Display Panel
CARR	Contractor Acceptance Readiness Review
RID	Review Item Deficiency
PI	Principle Investigator
CFE	Customer Furnished Equipment
GSE	Ground Support Equipment

SUMMARY

At the request of the Administrator and Deputy Administrator the Aerospace Safety Advisory Panel undertook a review of the Apollo 15, Apollo 16 and Skylab programs centered on the ability of program management to anticipate and correct problems prior to their assuming deleterious proportions.

In the Apollo program with only two flights remaining two aspects are of significance: (1) correction of prior flight anomolies, and (2) management awareness including skill retention and motivation. In the case of the Apollo 15 an additional aspect was the change from an "H" to a "J" mission which meant major hardware differences. A report on the Apollo 15 was transmitted to the NASA Administrator and Deputy Administrator on May 10, 1971 and at their meeting July 13, 1971 the Panel presented a verbal summary briefing. The report provides an assessment of four areas to meet the above significant points: (1) planning and management as applied to design, development and qualification of new and modified elements of flight systems used in Apollo 15 mission; (2) the risk assessment system; (3) items that are worthwhile to include in the Administrator's "readiness review;" and, (4) items that should be reviewed on subsequent "J" missions for their significance at that time. Thus the Apollo 16 review was an increment to our extensive Apollo 15 effort. Our comment in the Apollo 15 report was that if

the system configuration remained stable and performance was as expected, the following were items that warranted continuing review: (a) changes in the management system, (b) the maintenance of personnel capability, and (c) possible age-life and storage problems.

The Skylab program review is divided into three phases: (1) contractor module development, (2) NASA overall program management, and (3) progress of test and checkout activities. Phase I is, at the date of this report, almost complete. To date the Panel has reviewed the OWS, AM, MDA, CSM and the Life Sciences-Skylab interface. Consequently, the Skylab is covered in this report on an interim or preliminary basis with a complete report to the Administrator to be transmitted in September 1972 at the completion of our reviews at Skylab contractors and NASA centers. Judgments based on the reviews to date are noted along with the criteria for assessment. The Panel concentrated on four module sub-systems (EPS, ECS, habitability, crew accommodations) associated with life support. Particular attention was given to configuration and interface management, vendor control, quality and workmanship, problem solving mechanisms, integrated test program, fire prevention and control, all of which include carry-over of Apollo experience. Phase II reviews will be conducted from March 1972 through July 1972.

In so far as possible the Panel's assessments defines a situation, how it is being handled and the degree of concern. These, of course, may change somewhat with the results of Phase II reviews. Phase III will provide for continuing reviews as required during the test and checkout phases at KSC.

INTRODUCTION

This past year the Panel undertook a review of the two major NASA manned spaceflight programs. Because the Apollo and Skylabs are in different phases of the program life-cycle, our criteria for review and evaluation were necessarily different.

APOLLO

A. Scope of Review and Criteria for Assessment.

Our prior reviews had surveyed the maturity of the technical management systems associated with effective risk assessment by management. This review focused on the maintenance of these systems and changes in the Apollo flight systems to support the new requirements of the "J" mission series. More specifically the scope of the review and the associated criteria were:

(1) Current management posture for maintenance of technical management systems associated with effective risk assessment and control by management and emphasis on sustaining a high level of personnel motivation and skill retention.

(2) Current inter-center relationships and hardware interface control.

(3) Safety activities for their adequacy commensurate with current program conditions.

(4) New and modified elements for proof of design maturity.

(5) Prior anomalies as they impact the next flight.

(6) Age-life and storage effects, if any, and their resolution.

The Panel visited with the three manned spacecraft centers (MSFC, MSC, KSC); the Lunar Roving Vehicle contractor at Kent, Washington; the Goddard Space Flight Center (GSFC); and, the Apollo Program Office, Washington, D.C. This review resulted in our Apollo 15 report which is attached. We planned an incremental review for Apollo 16. This would include discussions with the Apollo Program Director, the Acting Safety Director, and the contractor for the CSM and S-II stage. In this manner both an Apollo overview and a representative assay could be made.

B. Conclusions.

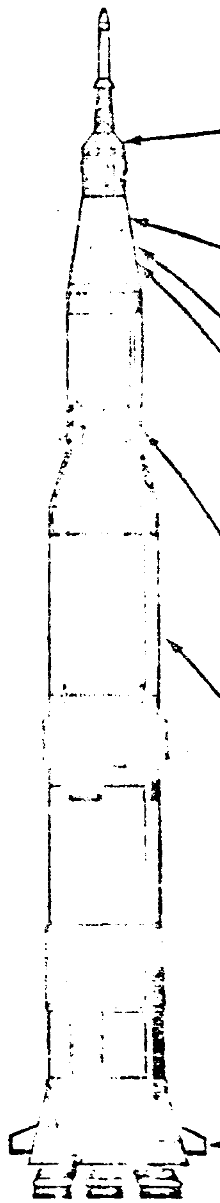
Specific conclusions are noted in the Apollo 15 report. In general the Panel concluded that those organizations involved in the review provided reasonable evidence that they have applied careful planning and responsible management to the design, development, and qualification of new and modified elements used in the Apollo 15 mission.

Management style and tools vary somewhat between those organizations reviewed by the Panel, with such differences resulting from the management and program environment and management philosophies. None the less they are successful and are within the scope of the basic management principles that NASA has developed over a long period of time. Management attached considerable importance to sustaining the dedication and abilities of program personnel at all levels and locations.

The system for the resolution of prior flight anomalies and current problems appears thorough and are being maintained at a level commensurate with the importance of the remaining Apollo missions. This provides confidence that the small number of configuration changes introduced with Apollo 16 do not introduce major new hazards. (See Figure 1)

We met with the only principal contractor where the technical management systems are still in essentially full operation due to a follow-on program (Skylab). They are still producing Apollo hardware or major modifications to it in the S-II launch vehicle stage and the CSM. This was accomplished in conjunction with our principal task on Skylab. Production of hardware for Skylab has reduced the problem of skill retention and personnel motivation during a "phase-down" period. The continuing program for evaluating age-life and storage issues on the launch vehicle stage gave us confidence in the contractor's ability to work such problems.

SIGNIFICANT CONFIGURATION DIFFERENCES
APOLLO 15 TO APOLLO 16



CM
- RCS CONTROL BOX - 61 SEC. TIMER
- STRENGTHEN METER GLASS
- PARACHUTE LINKS
- SINGLE POINT FAILURE SWITCH MODS

LM
- BATTERY MODIFICATIONS
- BATTERY COOLANT BYPASS
- STRENGTHEN METER GLASS

SLA
- CHANGED ORDNANCE ADHESIVE

LRV
- IMPROVED SEAT BELT

S-IVB
- TWO-PLY FUEL AND LOX FEEDLINE BELLOWS

S-II
- ELIMINATE CRITICAL SINGLE POINT FAILURES IN ENGINE START/ SHUTDOWN SEQUENCE
- MODIFIED STRUCTURE

S-IC
- ADD 4 RETROS (8 TOTAL)

FIGURE 1

As noted in previous reports the still present important variable, given mature management systems, appears to be the possibility for human error. This is particularly true where there is significant activity such as modification, test and checkout operations. In order to address this problem at its source requires management to insist on constant personal self-review and self-motivation at all levels. One approach in current use is the continued application of the Manned Flight Awareness Program to maintain the self-questioning attitude of all operational personnel.

SKYLAB

A. Scope of Review and Criteria for Assessment

The Skylab program review, which is still in process, is examining the program maturity as to its ability to state clearly requirements, allocate resources to meet these requirements and generate salient information to direct and control these resources.

These reviews are oriented toward specific sub-systems and management areas to meet the Panel objectives noted above. Thus the following efforts are being emphasized:

(1) Utilization of Apollo/Gemini design and hazard criteria as well as technical management experience. Emphasis on appropriate portions of the Environmental and Thermal Control Systems (ECS), Electrical Power Systems (EPS)

- particularly wiring, and Habitability and Crew Accommodation Systems.

(2) The technical management systems for design and fabrication of subsystems that are: an extension of the hardware/manufacturing state-of-the-art; new to the contractor's design and fabrication experience; new and/or changing integration and interface requirements.

(3) Program problem solving mechanisms and contingency planning. The interest here emphasizes the resolution of situations in a manner that does not compromise management control and knowledgeable risk assessment. This includes: mechanisms for program visibility; mechanisms for timely decision making; relationships with NASA centers, NASA resident offices, and other major contractors; auditing and surveillance programs.

(4) Sub-contractors and vendors - (a) an outline of the basic process for receiving, inspection and acceptance testing of the component, (b) any changes introduced in this process during the past six months, and (c) the nature of failures and their resolution.

(5) Consideration of the factors noted in the following documents:

- o Centaur Quality and Workmanship Review Board Report
- o Delta Launch Vehicle System Review Board Report

(6) The test program and specific plans for various levels of test, as well as the "open work" transfer posture.

(7) Flammable material, its use and control. On board equipment and crew procedures used to detect, contain and extinguish fires if one should start. Effects of toxic combustion products which might be generated during a fire, damage control, and the establishment of toxicity thresholds and capability of ECS to cope with it.

Currently the Skylab program review is in Phase II - having started in September 1971 with completion of this phase expected by July 1972. Consequently, only that material covering the first six meetings is within the scope of this report. A final Skylab program review report will be made available to the Administrator shortly after the July 1972 time period. The Panel emphasizes that the judgments provided here on the Skylab are of an interim nature and may be reconsidered in the light of future reviews at both NASA centers and the remaining contractors.

This report summarizes the Panel's efforts and previous discussions with the Administrator and Deputy Administrator.

B. Current Assessment

Based on our reviews to date the Panel can provide interim assessments that may be modified as the total Skylab review is concluded. None the less these are valid at this time. This is in addition to the comments to be found in the "Activities to Date

Section" which follows.

(1) Proper and Clear Policies. Contractors have, as a rule, formal and well thought-out policies concerning such areas as configuration management, design reviews, single point failure analyses, personnel motivation and skill retention, systems safety, test, vendor control, etc. These policies resulted from the contractor's prior Apollo/Gemini experience as well as guidance provided by NASA on a continuing basis. As an example, the test philosophy is to "optimize" (i.e. maximum use of analysis where applicable, large safety factors, over-design, use of proven hardware) and to determine degree of test vs analysis on a case-by-case basis for hardware that does not have a proven design, is non-critical, and does not have an adequate history. Another example is the policy to determine the adequacy of module design, manufacture, test and operations relative to potential hazards identified on prior space programs.

Policy with regard to principle investigators for experiments has been slower in definition than one would desire and in turn had created interface and test problems since such hardware is an integral part of the total cluster as well as individual modules. Intensive action by affected NASA centers appears to have set this area along the proper path. Contractor policies for joint operational activities, e.g., between MDA/AM (Martin Marietta and MDAC-E) indicates that this area required additional attention at the time of the Panel review.

(2) Planning. Each review gave a good deal of hard evidence that program planning at all levels has been thorough and knowledgeable. The utilization of personnel and material resources as well as standards of performance appear to be under constant management surveillance and have taken advantage of prior industry and government experience. They appear to have adequately met changing program requirements and funding availability over the past several years without measurable impact on current major schedule milestones. An example of this was the institution and accommodation of the EREP experiment hardware which occurred reasonably late in the program. Where necessary NASA has provided additional support through the use of MSFC/MSC personnel.

(3) Systematic Procedures. Disciplines applied by those organizations visited during this period which were of particular interest to the Panel included: program control, systems engineering, configuration management, interface control, reliability, quality and safety, and test integration. Inherent in these procedures was the

individual problem solving mechanisms, contingency planning, and mechanisms for timely decision-making. The level of effort exercised in these disciplines varied from contractor to contractor but appeared reasonably adequate in all. There were, however, some specific areas of concern which have been acted on or are in the process of being resolved. Examples of these are found in the basic Skylab discussion for each contractor review.

(4) Assignment of Responsibilities. The Skylab program has defined the roles and responsibilities for the many Skylab segments in a manner that is well defined and apparently has worked well over the past year or more. To assure the viability of such an arrangement, the management system utilized the services of personnel with continuity from Apollo and Gemini programs (spacecraft and launch vehicles) and where this was not available the services of competent personnel from related non-NASA programs. Because of the complex inter-center and inter-contractor relationships and evolving Skylab requirements and program concepts this required concentrated efforts to accomplish and maintain. Examples of this are: OWS solar array management changes were made to: (1) enhance handling of hardware, and (2) assign

additional personnel to monitor design and test progress. Another example is the utilization of "task teams" to meet test and manufacturing problems head-on as was done at MDAC-W to facilitate the OWS program. There will be, no doubt, minor areas of intercenter and intercontractor responsibility to be defined as the hardware progresses to KSC requiring continued attention of management to preclude their impacting on test and checkout in the 1972-1973 time frame.

(5) Monitoring and Auditing. The contractor's appeared well aware of their role in this area both in-house and with their suppliers. It was obvious that in-house monitoring and auditing to maintain a high level of quality and skill and to maximize safety was conducted on a regular basis. This included manufacturing processes, personnel training, and the like. Control of suppliers is a function of the individual's prior history and criticality of his hardware. For example, a resident representative is located at selected or critical suppliers with itinerant representatives applied to the others. All contractors indicated problems with one or more suppliers because of current aerospace business posture and the relatively small hardware quantities involved. Such problems are under constant surveillance and various means are be-

ing used to resolve these problem areas including more stringent acceptance requirements, and programs to motivate personnel through "manned flight awareness" programs.

(6) Communication System, Organizational Discipline, Motivation. Management systems now in use at those sites visited by the Panel indicated constant attention is being applied to these areas. On a program as geographically diverse and technically complex as Skylab necessary data flow between contractors and NASA centers requires careful regulation to preclude excess paper but not impede needed material. This is particularly so in the case of Interface Control Documents which number over a thousand and inherently acquire interface changes (IRN's) and often impact test and check-out procedures. These areas take on added significance as the Skylab plans for KSC and the cluster review take shape.

(7) General. As a result of the reviews conducted during this time period, the following items will be placed on the agendas for review at the NASA centers:

Pacing systems.

Inter-contractor operations.

Inter-center operations.

Skylab cluster review.

Launch vehicles.

Fire extinguishment and control of toxic contaminants.

Test results and their impact.

Systems safety posture.

Results and impact of SMEAT.

C. Activities to Date

Basic to the concept of obtaining a realistic and meaningful view of the Skylab program was the definition of a meeting schedule that: (1) showed the transition from the Apollo program management concept and approach to that applied to the Skylab program, (2) permitted the Panel to convene its reviews prior to the initiation or completion of key events, such as module systems' tests, so that Panel products could be factored into program on a timely basis, and (3) provided a logical view of the building blocks that constitute the total technical management and risk assessment structure - from modules to cluster to overall vehicle system and operations.

The schedule of Panel meetings (Table II) shows a progression at contractors and centers to Headquarters that attempts to meet the above criteria without unduly burdening the organizations involved. Those reviews completed are noted with an asterisk.

Between September 1971 and February 1972 the Panel covered the Skylab module contractor activities (orbital workshop, airlock, multiple docking adapter and CSM) including the SE&I contractor and the Life Sciences effort at Headquarters and MSC. This in effect has set a foundation for the Panel in its further review of the NASA's in-house activities as applied to the total management of this unique and geographically diverse program.

A word at this time on the Panel approach to the preparation of a Skylab meeting agenda may be helpful in viewing the results to date. The process involves: (1) an informal visit with the Panel chairman to the contractor to orient us to the specifics of contractor operations and to familiarize him with the Panel, (2) preparation of an agenda predicated on the criteria noted in the previous section and the Panel members' specific interests, (3) coordination with OMSF and Skylab program executives, (4) submittal to the Deputy Administrator for review and guidance, (5) further discussion with the contractor or center to aid him in understanding the Panel's requirements, and (6) the formalized agenda resulting from the above.

A brief analysis was made as background for the Skylab review of the impact of Apollo hardware anomalies and failures on the achievement of Apollo mission objectives and their application to the definition of possible Skylab review areas. The significance, it was found, of a given type of anomaly is not necessarily a function of the number of occurrences, e.g., the docking anomaly on Apollo 14 was a singular event but evoked great concern because of the lack of a definitive cause. On the other hand there have been numerous reaction control system and communication glitches

TABLE II

AEROSPACE SAFETY ADVISORY PANEL

Skylab Program Meetings

* September 14-15, 1971	Washington, D.C. (MD and Skylab Personnel)
* October 18-19, 1971	McDonnell Douglas, Huntington Beach, Calif.
* November 8-9, 1971	McDonnell Douglas, St. Louis, Mo.
* December 13-14, 1971	NASA Hdqrs., Washington, D.C. (Life Sciences, Apollo 16)
* January 10-11, 1972	Martin Marietta Corp., Denver, Colo.
* February 14-15, 1972	North American Rockwell, Downey, Calif.
March 13-14, 1972	Chrysler/Boeing/MSFC Launch Vehicle, Michoud, New Orleans
April 10-11, 1972	MSFC, Skylab Program Office, Huntsville, Ala.
May 8-9, 1972	MSC, Houston, Texas (Astronaut Group)
June 12-13, 1972	KSC, Cape Kennedy, Fla.
July 10-11, 1972	Skylab Program Office, NASA Hdqrs., Washington, D.C.
September 11-12, 1972	NASA Hdqrs., Washington, D.C.

* Reviews conducted to date of this revised schedule.

Revised 2/18/72

which turned out to be of much less concern because of the ability to quickly pinpoint and correct the problem. An examination of more than 200 anomalies covering Apollo missions 11 through 15 indicated six functional areas were subject to approximately one-half of the total:

(1) Propulsion systems

(2) Environmental control system

(3) Communications

(4) Cameras

(5) Electrical power system

(6) Extra-vehicular mobility unit

These indicators, combined with those Skylab functions which were new or an extension of the state-of-the-art provided the Panel with those specific areas to receive the bulk of the Panel's attention. Rather than spreading the effort "thin" it was felt that such concentration and continuity would, when applied to critical Skylab systems, provide a sounder basis for assessment. This does not mean that functions other than those covered in-force were neglected; they were simply examined to a lesser degree.

The systems receiving the major review thrust were (1) electrical power, (2) environmental control, (3) thermal control, (4) caution and warning, and (5) habitability and crew accommodations.

At this point in the Skylab review cycle, it is advantageous to first look at the results of the individual reviews and second to provide an interim assessment which includes direction for the remainder of the review cycle.

DATE: September 14-15, 1971
LOCATION: OMSF, NASA Headquarters, Washington, D.C.

This briefing was a natural starting point for the Skylab review in that it summarized the results of more than six months of in-house reviews conducted by the Mathews' team on the development and manufacture of hardware. This presentation provided the Panel an independent assessment of the design and associated hazards as well as the effectiveness of NASA's technical and risk management systems. Among the principle findings of the Mathews' team were: (a) that while the design reflected an evolution in mission requirements it promised mission success in terms of current requirements, (b) the NASA technical management systems and staffing patterns assured an application of Apollo experience to the unique requirements of Skylab. The major recommendation made by the team for implementation by the program offices dealt with: (1) hazard profile of the Skylab cluster, (2) integrated module/system test program and an integrated cluster review, (3) contamination control and design of the waste management system, (4) deployment mechanism on the workshop solar array, and (5) experiment development and integration.

It was apparent to the Panel that the Mathews' team had made a significant contribution to the overall maturation of the program. A further proof of this would only come then, from the Panel reviews at prime contractor's and NASA centers in the ensuing months.

This meeting also provided the Panel with the Skylab Program Director's assessment and a top level view of Skylab background, program approach and management responsibilities.

DATE:	October 18-19, 1971
LOCATION:	McDonnell Douglas Corporation Huntington Beach, California

It was the initial meeting with Skylab contractors and centered on the (a) orbital workshop module (OWS) and its electrical power, habitability support, crew accommodation and environmental control systems, (b) payload shroud, and (c) in-house operations, system safety, quality assurance and reliability.

Reaction of the Panel to this review was general satisfaction with the described systems for: (a) engineering and manufacturing control, (b) control of expedient practices during the current period of intensified activity, (c) the comprehensiveness of the quality assurance program, as compared with the program described in "Centaur Report," (d) initial assessment of supplier/vendor capability and controls; and, (e) use of Apollo design, reliability and hazard experience.

The Panel identified some areas in which members sought a fuller understanding than could be derived within the format of the meeting. These items and the contractor's response are shown in Attachment D.

In the McDonnell Douglas-West response the question of fire extinguishment and toxicity control is one that appeared to require further examination. This question was held open by the Panel and put to the Program Office and Life Sciences personnel during the December meeting in Washington, D.C. This is discussed under that review. The establishment of requirements for location, extinguisher quantities, usage procedures appear to be the responsibility of MSFC and MSC and will be covered during Panel reviews at those centers. The emphasis being placed on toxicity control by OWS contractor is indicated by the following examples taken from a recent systems safety report:

Hazard	Status
Toxicosis resulting from ingestion of critical dosage of toxic agents.	Investigation completed. Inhalation rather than ingestion of toxic materials is more critical.
Toxic particulate matter inhaled in critical dosage.	Investigation continuing and will continue through final design and production.
Toxic contaminates caused by locked rotor failure mode of ventilation control system fan.	Investigation completed. Tests conducted to determine maximum fan case temperature in this failure mode found to be $\approx$ 270° F. while this exceeds crew touch limits and requires special caution it does not approach temperature necessary to compromise the chemical stability of adjacent materials.
Toxic contaminants caused by poly-urethane foam considered for use as meteoroid penetration patching material.	Recommendations included out-gassing and toxicity testing of the foam to establish if any free isocyanate is released. The threshold limit value for isocyanate, absolute ceiling, is 0.14 MG/M^3 for continuous eight-hour exposure. Investigation

is temporarily terminated pending either material change or results of tests.

With respect to the flammable material question the Panel feels that consideration should be given to related activities conducted by independent organizations such as the NASA Safety Office and the Spacecraft Fire Hazard Steering Committee. Such a review might provide additional confidence in this area. The Panel recognizes that substantial effort has been made to identify and eliminate flammable materials; minimize the hazard involved where usage is considered necessary; and, isolate and contain ignition sources and propagation paths. The Panel's question was not based on a specific concern or issue but an awareness that significant flammable materials are in use and there is always the possibility of an incident despite everyone's best efforts. Thus their question was about the capability to cope with such incidents.

The Panel noted that the contractor and MSFC have instituted additional management efforts to support the OWS effort. These include:

(1) Assignment of an MSFC task force, headed by the MSFC-OWS project manager, to assist the contractor in his test program and timely handling of changes.

(2) Institution of special contractor management reviews:

- o Daily President's meeting
- o Daily MDAC/NASA action meeting

- o Other weekly reviews

(3) Tightening of suppliers quality control and motivational activities. This was necessary because of supplied items failing production acceptance tests prior to qual tests.

Several items brought out as a result of this meeting that will be covered during the latter stages of the review cycle with both the contractors and centers are:

(1) The ability of the crew to implement manual control procedures to cover the loss of critical automatic functions.

(2) The possible requirement to conduct EMI test on qual units because EMI tests might have been conducted on a development unit of a somewhat different configuration.

(3) Impact of launch pad winds on stability of folded OWS solar array system.

DATE: November 8-9, 1971
LOCATION: McDonnell Douglas Corporation
St. Louis, Missouri

Because the Airlock Module (AM) is essentially the cluster control center particular attention was given to defining the AM/MDA/OWS interfaces and their control, the application of MDAC-East management systems to the AM design, test and fabrication as related to electrical power conditioning and distribution, environmental and thermal control system, support system for EVA.

The Panel considered quality assurance and workmanship, including the findings and recommendations of the Centaur Board

Report. In both the description of the existing MDAC systems as well as illustrations of their operation, the Panel did not find any indicators to warrant concern. Of course, it should be noted that to verify that the system operates at the necessary level of detail would mean an on-site audit similar to the Centaur Board's activity. However, since much of the problem in Centaur developed because of lack of continuing management attention to the operation of their system, the Panel sought to reinforce Skylab managements continuing attention to operational functions.

As the "control center" for the cluster the AM team is involved with some 83 ICD's of which they are custodian for thirty-one and participate in fifty-two. This activity appears to be well in hand with at least sixty-eight or more contractually implemented.

Adverse weight trends on the AM were noted in mid-1971 and with this recognition the contractor instituted a more restrictive and visible weight control system to first bring the weight trends in line with design specifications and, secondly, to motivate personnel to the continuing weight control problem. At the time of the review the AM final weight (actual + calculated + estimated) was set at 16,420 pounds against a 16,650 pounds maximum design specification value. A continuation of strenuous weight control measures should assure meeting or beating the design values. Such attention is necessary because the impact of weight by any one module affects the cluster and total stack as to structural capacity, center of gravity, and moments of inertia (attitude control system).

Adequacy of the EPS and ECS design, installation, and test levels appeared acceptable based on the contractors recognition of the Apollo/Gemini experience and management's attention to the many details that can in one way or another lead to hazardous conditions. The following examples support the above contention:

- Redundant wiring and separate paths and accessibility for maintenance and inspection.
- Lay-in cables as opposed to feed-through to avoid captive wire harness and precludes wire damage and allowance for slack for equipment removal.
- Preclude adjacent connector interchangeability through: different shell size, angle potting, clamping, connector insert positioning, and identification marking.
- Adequate circuit protection.
- No unprotected wiring is routed inside the pressurized area.
- The AM coolant system is so designed that only those elements that must of necessity interface with the cabin atmosphere or the flight crew are located within the pressurized area. These include the condensing, cabin, and OWS heat exchanger modules that remove moisute from and cool the cabin atmosphere,

and the tape recorder module that must be accessible for tape recorder replacement in flight. Internal line lengths have been minimized by having no internal tubing runs between modules and by locating pressure wall penetrations as near each module as practical. Internal water loops for ATM Control and Display Panel and EVA suit cooling interface with the Coolanol system outside the pressurized area.

- In addition to the safety features that have been designed into the AM coolant system, tests have been conducted on all connectors and tube sizes used in the system to verify that minimum torque levels specified in assembly procedures are adequate.

In discussing the test programs it became apparent that validation of hardware by "similarity" had one area of concern - namely, hardware endurance to meet the Skylab eight-month mission time. The rationale in most cases is sufficient based on the function, usage and failure catagory, but in a system such as the EPS and EC where components are life tested separately there is always the question of what would be the effect on such life tests if components were "played" together during the same period. This question will be discussed with MSFC during the April 1972 review.

The materials program as described including those hardware items using thermal coatings to achieve specific α/e (absorptivity/emissivity) ratios did not indicate the utilization of data obtained from unmanned

unmanned vehicle programs in which long duration in a space environment is the norm, e.g. the results of the surveyor data obtained from the Apollo 12 mission. This is another point for discussion at later reviews.

In the area of vendor control the contractor showed full recognition of the problems and their resolution. No concerns appear here with respect to the contractor's mode of operation.

Electrical system change traffic reached major proportions in the first half of 1971 with 72 changes on major wire harness. Once alerted, the contractor's decision was to reduce work activity on such items and bring all the design and manufacturing documentation up to date to preclude a never ending modification routine with all of its attendant problems. Once the paper was up-dated and with additional change controls in this specific area the manufacturing was continued with little difficulty.

Management took charge of this problem and resolved it through the use of manufacturing composite work orders devised from a number of smaller individual changes and reduced the chance of error and/or damage.

As described to the Panel, the Acceptance Test and Launch Operations Division is the engineering test organization responsible for demonstrating by test that the vehicle performance meets the design specification. Gemini experience showed that such a test organization operating as a separate entity without ties to the other program elements (design engineering, shop, Q.C., etc.)

provided a system of checks and balances which resulted in a highly successful product. Mercury and Gemini experience has been drawn upon heavily in establishing the operations rationale and defining the test philosophy to be used. Detail test plans have been structured to progressively develop increasing confidence in the ability of the vehicle systems to perform properly together. The plan appears to provide a reasonable level of confidence of airlock module mission success at the time of launch.

DATE: December 13-14, 1972
LOCATION: NASA Headquarters, Washington, D.C.

This meeting was conducted in two parts - "Life Sciences and Bio-engineering and Apollo 16 Mission Posture." Apollo was covered in a previous section and will not be discussed here. The life science topic had three themes: (a) the objectives and supporting experiments of the inflight medical program as defined at this time, (b) the status of medical knowledge, either from prior flights or ground based studies, in support of the rationale for the flight medical program, and (c) the role of NASA life sciences in defining design and habitability requirements for Skylab flight systems and experiments.

In light of the Panel's interest in control of toxic products produced by fire, the Panel asked whether there were any materials (in sufficient quantity) aboard Skylab whose combustion products might poison or render unusuable elements of the ECS such as the molecular sieve. This discussion led the Program Office (Washington) to request the Centers to review the data produced by the MSC toxicology laboratory program and contractor data on the limitations of the MOL sieve. This review is now in progress.

Three systems were selected for detailed discussion to illustrate the Life Sciences participation in the medical requirements and development activities related to Skylab.

(1) The urine system as an example of the impact of the medical experiments on a Skylab operational system in the area of waste management. There has been almost constant Life Sciences participation in the selection, design and development of this system which will be decribed in detail.

(2) Carbon dioxide as an example of the Life Sciences requirements for control of the atmosphere and the concern for the impact of carbon dioxide levels on the medical experiments as the original system design for Skylab did not meet medical requirements.

(3) EVA (Extra Vehiclular Activities) preparation, in order to be fully understood and appropriately presented, reflects the Life Sciences original requirements for a two-gas system and the Life Science studies which were conducted to support the two-gas system recommendation. The subsequent studies, which were conducted in support

of the decision as to whether pre-breathing would or would not be required prior to EVA, was presented and the use of this information in the medical operational recommendations for Skylab EVA preparations.

Some items of interest included discussions on the possibility of arrangements to permit Skylab crew to have private conversations with ground personnel when such items as personal health or other intimate details are to be discussed. As of now, Dr. Berry notes, this is not the case, and Dr. Berry asked for Panel support in achieving this "private" communication posture. This is akin to the earthbound doctor-patient relationship and is under Panel consideration.

A problem with principle investigators for medical experiments was noted in that the P.I.'s are only "one deep" in many cases and may require qualified P.I. back-up. This area is being reviewed by MSC with final recommendations due in the near term.

Of special interest were the remarks on physiological aspects of long duration flight using people with "figher pilot" characteristics, and the possible problem with lack of qualified ground-based personnel to process data during the mission and provide necessary "go-no-go" decisions during actual crew orbital periods.

Dr. Berry noted that they are still working on the physiological problems but that no real definitive answers will be available because of the current and anticipated inability to understand human behavior to the necessary degree. This will come with actual flight experience. Dr. Berry also noted that he and his personnel will be hard pressed during the Skylab mission and that he is losing qualified ground personnel, but assured the Panel that in this area he is taking steps to mitigate such problems.

Currently, the most important activity during the year 1972 is the "Skylab Medical Experiments Attitude Test" (SMEAT) whose primary objective is to obtain and evaluate baseline data for a typical Skylab mission for those medical experiments which may be altered by the Skylab environment; evaluation of selected experiments and ancillary equipments, mission data handling and reduction procedures, preflight, flight and post-flight operations' team training. This test will be conducted for 58 days during the mid-year period with an astronaut crew (not a Skylab crew). It is, by its very nature, a key test which may impact many aspects of delivered hardware dealing with experiments and crew accommodations.

A recommendation made by the Panel during this meeting concerned the use of Icons (stable isotopes of C, O, N & S) in the SMEAT in support of the metabolic objectives of the test. MSC personnel took this as an action item and after due consideration found that it was not feasible to introduce the use of Icons on the Skylab program, but would be considered in studies for future use. See Attachment F.

MSC provided data on their management tools used in the control and decision-making process applied to Skylab Life Sciences. This indicated a thorough closed-loop structure with reviews, configuration management activities, failure reporting, and verification program, etc.

Relevance of experience provided by Biosatellite II to manned missions indicated:

- No convincing experimental evidence of a radiation hazard to man in earth orbit during short duration missions.
- Restored confidence in the adequacy of the methodology of physical dose estimation for predicting radiation hazards to man.

Despite the abundance of radiological health research, major refinements in the available information are still needed. Currently, it appears that the absorbed radiation dose received by an astronaut can be predicted to only within a factor of two. For this reason it is logical to continue to study the biological effects and refined requirements for the high-energy radiations, particularly particles of high atomic number. Moreover, the effects of radiation have not been thoroughly distinguished from those of other flight conditions.

On the whole the Life Sciences appear to be receiving thorough and adequate coverage by both the Headquarters and MSC organizations, and their support activities.

DATE: January 10-11, 1972
LOCATION: Martin Marietta Corporation
Denver, Colorado

This review covered two major areas: (a) Martin Marietta's general role and specific tasks in systems engineering and integration; and (b) the management systems for the development of the multiple docking adapter and those systems associated with biomedical and EREP experiments.

The interest in system engineering and integration arises from the Panel's increasing sensitivity to the complexity of the module/system interfaces. Specifically in the work on such critical areas as the configuration management system; support for the evaluation of the electrical and life support systems at the cluster integration review scheduled for this spring (May 1972); and preparation of the unified test plan for the cluster.

The MDA segment of the review identified: (a) the pattern of problems encountered and the problem solving mechanisms that have evolved, (b) the mechanisms for senior management visibility of operations and their assessment of their operation in view of the Centaur Board Report, (c) the mechanisms for assimilation of manned spacecraft design, manufacturing and risk assessment experience, (d) the manufacturing difficulties in going from a "limited production line" to a "one of a kind" activity, and (e) programs for quality assurance, vendor and workmanship control.

Currently mission-level critical item status, a part of mission level FMEA effort, is such that some thirty-two items out of forty-nine submitted in 1971, are still under review. These critical items are both single failure points and critical redundant/backup components which must be eliminated or accepted with a known mission risk. To date some 2149 critical items have been baselined. All of those currently under review appear to be under a strict control and decision process including Level II CCB.

With respect to cluster systems development tests, certain of these are still in process and will in fact continue for at least another year. These are of two types: (a) breadboard for continuing Skylab system support, and (b) design development tests for verification of performance against specifications.

- Payload Assembly/Orbital Assembly Vibration/Acoustical Test

  Start August 1971

  Complete April 1972

- Electrical Power System Breadboard Test

  Start December 1971

  Complete March 1973

- Attitude and Pointing Control System Breadboard Test

  Start January 1971

  Complete January 1973

In view of the publication of Skylab systems safety checklists, the Panel was interested in the adequacy of implementation of such lists and the inclusion of available hazard and failure information. As a result of these discussions a request was made of the R, Q & S organization in Washington to provide data on their audits or reviews to assure: (a) the module contractors have satisfactorily reviewed their status in regards to these hazards and failures, and (b) reported the unresolved hazards to appropriate management for their decision. For instance, under "cabling and wiring" in the Flight Systems Design checklist (SA-003-002-2H, dated November 1971) we asked about references to shielding wiring from abrasion or other maltreatment. The response noted that protection of cabling and wiring is only partially covered in the checklist, but a specific call-out is missing. As a result, the next revision of the checklist will be upgraded to adequately cover this area. The module contractor responses to these safety checklists will be presented as a part of the Cluster Design Review.

The EREP program because of its history, initiation date and development requirements, has been of great concern to both NASA and its contractor. The Mathews' Skylab Subsystem Review Team Report indicated in September the following concerns evolved during their review and actions were taken to resolve them.

- Control of management interfaces.
- Control of technical parameters/interfaces.

- Grounding
- Thermal

o Criteria requirements, rational for qualification and acceptance testing.

Some of the EREP technical problems noted in the September Headquarters' review were still open items as of this January review - namely, for the multispectral scanner (S-192 experiment):

o Internal electronic circuit redesign by Honeywell Company to eliminate functional problems.

o C&D panel ready light "ON" when door switch closed and calibration sources 1, 2 and 3 operate incorrectly. Changes required to flight hardware.

o Noise on clock signal prevented proper operation of Miller encoders. Change to cabling shield grounding at C&D Panel reduced clock signal noise. Changes to hardware and revision to cabling ICD required.

The Martin Marietta approach to the EREP support has been to establish an MDA/EREP test team. This is indicative of the MMC approach to providing maximum effort to achieve flight hardware goals. They activated an EREP team to perform bench tests (includes technical representation from sensor contractors as required), which has moved to St. Louis where AM/MDA tests will be performed and most of team will in turn move to KSC with this hardware.

The MDA acceptance review summary indicated twenty-one RID's with all GSE items to be worked off by February 15, 1972, nine of sixteen flight hardware items to be completed by February 15, 1972 with the remainder due for resolution by June 1, 1972.

In the MDA instrumentation and communication systems, the following concerns were discussed: (a) power short to camera case could result in arcing problem, (b) incomplete history on many GFP items (RID Q-5 from CARR), (c) incomplete testing on CFE item, life testing (windows, hatch seal), and (d) amount of deferred work due to non-flight hardware tested in Denver. These are presently under study by both MSFC and MSC personnel with resolution in the near term.

As a result of the discussions conducted during this meeting special interest items were raised with the contractor and he provided written answers for the Panel's edification and clarification. See Attachment E.

DATE:	February 14-15, 1972
LOCATION:	North American Rockwell Corporation Space Division Downey, California

The previous reviews of the OWS, AM and MDA covered new Skylab hardware while the CSM is an adaptation from the Apollo program. In addition NR is the contractor for the S-II or second stage of the launch vehicle used for both Skylab and Apollo programs. Consequently, the Panel also discussed the status of the systems which produced the Apollo 16 modules.

Of particular interest were the following areas:

(1) Configuration differences resulting from the Skylab requirements.

(2) Changes, if any, in the management system and the implementation of such systems to meet Skylab needs.

(3) Impact of Skylab test results on Apollo program and vice-versa.

(4) The program to acquire and maintain technical knowledge of the subsystems as sub-contractors and vendors are phased out.

With respect to Apollo 16 the configuration changes were small in number and provided for elimination of single failure points and proper resolution of prior flight anomalies. Those changes required for the science requirements did not appear to impact previous risk assessments or hazard analyses. The prevention of human errors during test and checkout prior to launch received additional attention and was noted as a concern by the Panel. The procedures may be in place, but the implementation must be proven. The S-II stage appeared to be in a "ready" posture with few discernable problems.

The Skylab program consisting of CSM's 116-119 and S-II-13 and 15 are in a sense an extension of Apollo hardware and have benefited from this situation; a continuity in management and technical personnel, maintenance of necessary management systems and a carry-over of supplier controls and knowledge. The Panel was generally satisfied in each of the areas noted before. It is of interest to note that there is still a high change rate due to the continuing development of Skylab stowage requirements. Because of this NR has instituted stringent engineering and manufacturing controls to prevent problems from accruing from such stowage changes.

The ground support equipment changes are small and affect approximately ten percent of the hardware to be used. Such modifications appear to pose no new hazards or risks in the supporting of CSM and S-II Skylab equipments.

A further point made by NR in their brieing is the reduced chance of future CSM problems resulting from keeping CSM 116-119 as similar as possible. Noted exceptions are the use of experiments M-071, 072 in CSM 116 and the rescue mods for CSM 119.

Additional information concerning this aspect of the Skylab cluster will be discussed during the Panel's meeting at MSC in May 1972 since MSC has the responsibility for the conduct of this portion of the program.

FUTURE ACTIVITIES

Essentially the first half of the Skylab effort dealt with the prime module contractors and the later half with their NASA centers and Headquarters. Much of the material gathered to date will support and be background to the agendas at MSFC and MSC.

Of particular interest is the adequacy of center in-house efforts and their management of contractors:

(1) NASA visibility into the Skylab program and cross-feed of pertinent information (hardware, software, management).

(2) NASA systems' engineering and integration.

(3) Capacity to generate salient information to direct and control resources.

(4) Inter-contractor control and problem resolution.

(5) Cluster test requirements and implementation.

(6) Planning of modification, test and checkout work to be accomplished in conjunction with launch preparations.

CONCLUDING REMARKS

The Panel, during this past year, conducted reviews of the Apollo and Skylab programs from the point of view of technical management adequacy although in this process discreet hardware problems were surfaced. The major point was to examine the ability of the government and contractors to operate as a team in the total program process from design to operations. In other words, it was not the "problem" but the "problem solving" mechanism that was probed.

The major characteristics required of program management range from good leadership to clear delegation of authority and responsibility throughout every level of the government/industry structure. The success of the Apollo missions through Apollo 15 indicates that these elements do indeed exist. Further, as far as possible, this experience has been applied to the Skylab program with apparent rigor. We cannot at this time provide a total picture of the Skylab program but have indicated here the pertinent strengths and areas to be further strengthened. This is, of course, only an interim report on the Skylab program. The results of the next six months, coupled with the past contractor reviews, will provide the necessary material for a more conclusive report.

SUMMARY CALENDAR

This section of the report summarizes the Panel's agendas for the past year. As noted in prior sections the majority of effort was applied to Apollo 15 mission during the first half of this period and to the Skylab Program during the second half. Apollo 16 was reviewed only briefly due to the attention being given to Skylab.

The calendar of Panel agendas below indicates the depth of coverage.

Apollo 15 Mission

Activities conducted included an examination of:

(a) New and modified elements.

(b) Prevailing management structure.

(c) Current safety activities.

(d) Impact of Apollo 14 anomalies.

(e) Critical skill retention.

(f) Retest requirements.

(g) Landing site effects.

Apollo 16 Mission

Activities included here were:

(a) Major hardware differences between Apollo 15 and 16.

(b) Apollo 15 anomalies and their impact.

(c) Apollo 16 anomalies during launch preparation (February

1972 NR review).

(d) Maintenance of technical excellence.

(e) Landing site effects.

Skylab Program

After a brief orientation early in the year the major activities conducted here included:

(a) Program problem solving mechanisms.

(b) Utilization of Apollo/Gemini experience and hardware.

(c) Supplier control.

(d) Management for interfaces and integration (design through checkout).

(e) Assessment against "Centaur" and "Delta" Board Reports.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

OFFICE OF THE ADMINISTRATOR

JAN 26 1971

TO: Mr. Dale D. Myers, Associate Administrator, Office of Manned Space Flight

FROM: Dr. George M. Low, Acting Administrator

Since we will soon begin the Apollo "J" missions, I have asked the Aerospace Safety Advisory Panel to review the changes introduced with Apollo 15 and the attendant system for risk assessment, including those technical management systems that impact it.

I have also asked the Panel to review the continuing evolution of the risk assessment system on the Skylab and Space Shuttle programs. This again would include those technical management systems that would impact risk assessment.

The review, as now planned, will take the Panel to the Manned Space Flight Centers and appropriate major contractors beginning in early February.

The Manned Space Flight organization's continuing support of the Panel activities is appreciated.

George M. Low
GEORGE M. LOW
Acting Administrator

Attachment A

A REPORT TO THE ADMINISTRATOR

BY

THE NASA AEROSPACE SAFETY ADVISORY PANEL

ON

A REVIEW OF THE CHANGES

INTRODUCED WITH APOLLO 15 AND

THE ATTENDANT RISK ASSESSMENT SYSTEM

JULY 1971

Attachment B

CONTENTS

FOREWORD

This is in response to the Administrator's request of January 1971 for the Panel to review the changes introduced with Apollo 15 and the attendant system for risk assessment, including those technical management systems that impact it. The Panel, as a result of these reviews, provides here a judgment on the impact of changes and the attendant system for risk assessment by management.

The conclusions are offered to the Administrator for consideration in his review of the Apollo 15 mission changes and their management.

CONCLUSIONS

This is a concise statement of the conclusions reached by the Aerospace Safety Advisory Panel based on material presented between February and July 1971 on the Apollo 15 mission. Details are in the body of the report.

(1) The Apollo Program Office, Manned Spaceflight Centers and Apollo contractors involved in our review provided reasonable evidence that they have applied careful planning and responsible management to the design, development and qualification of new and modified elements of flight systems to be used in the Apollo 15 mission.

(2) The management system for risk assessment appears thorough;and through it,senior program management has concluded that the changes made in the Apollo 15 flight system to meet the "J" mission requirements have not impaired the previously attained crew safety level.

(3) To assure that the Administrator is provided adequate background on the Apollo 15 mission,items such as the following should be included in the Apollo "readiness review:"

(a) Mission rules constraining EVA if the satellite cannot be jettisoned or SIM booms retracted.

(b) Mission rules and the flexibility permitted the astronauts in operation of the LRV and assessment of LRV limitations.

(c) Status of changes in the spacesuit involving new zippers, bootbladders and increased PLSS capability.

(d) The assessment of risks associated with the use of a teflon outer-suit covering backed by flame retardant beta cloth.

(e) The possibility of using the LCRU television system for diagnosis of LRV malfunctions.

(f) The system for evaluating the impact of lightning strikes on the vehicle. Note should be made of the evaluation possible after hypergolic loading, particularly in the area of spacecraft engine logic.

(g) The system for assessment of risks associated with the jettison of the Scientific Instrument Module (SIM) door.

(h) The operational status of the KSC Launch Control Center Alert System.

(i) The unresolved nature of the anomaly on the docking probe and the basis for probe redesign.

(3) If the system configuration remains stable, and performance on Apollo 15 is as expected, the following are items that should be reviewed by senior management on subsequent "J" missions for their current significance:

(a) Possible age-life and storage problems.

(b) Changes in personnel assignments, individual responsibilities and other personnel actions.

(c) Changes in management systems and possible relaxation of program discipline and controls.

SUBJECT

Review of changes introduced on the Apollo 15 and future "J" missions, as well as the applied risk management system. To accomplish this review, the Panel convened at NASA and contractor sites to examine the new and modified elements of the Apollo 15 mission, their requirements, and those aspects of technical management necessary to achieve "J" mission objectives.

PROLOGUE

With the successful completion of the Apollo 14 mission or last "H" mission, program efforts are focused on the "J" missions of which Apollo 15 is the first.

Significant changes introduced with the Apollo 15 mission, scheduled for launch no earlier than July 26, 1971, included: augmented LM capability; Lunar Roving Vehicle and associated LM stowage changes; CSM Scientific Instrument Module (SIM) requiring Extra-Vehicular Activities (EVA); modified Extra-Vehicular Mobility Unit (EMU); and, the attendant launch vehicle modifications for increased payload capability. The task directed to the Panel is defined in a letter, dated January 26, 1971, from the then Acting Administrator, Appendix A.

In accordance with this request, the Panel visited the three manned spacecraft centers (MSFC, MSC and KSC); the Lunar Roving Vehicle Contractor at Kent, Washington; the Goddard Space Flight Center (GSFC); and the Apollo Program Office, Washington, D.C. These reviews occurred during the February to June 1971 period.

This report presents the Panel's conclusions based on this series of Apollo 15 reviews. Such judgments are presented for the Administrator's use in his oversight of NASA operations.

SCOPE AND METHODOLOGY OF REVIEW

The Apollo space vehicle system is beyond the development phase and well into the operational phase. With this in mind, the reviews emphasized the "H" to "J" mission and hardware differences, indicators of hardware problems, including test failure and prior flight anomalies, and ascertaining whether the hardware is being used in the manner intended. In addition, the reviews involved examination of systems which define hazards and their control (e.g., safety, reliability, quality assurance, test, maintenance) and the logic leading to accepted risk assumptions.

Since the review effort was supported by subsystem managers and project managers this afforded the Panel an opportunity to examine to some depth the existing manpower support at the field centers.

Basically, then, the Panel looked at each of the following general areas with its associated criteria for judgment:

(a) New and modified elements of the Apollo 15 space system for proof of design maturity.

(b) Prevailing management structure and policies with emphasis on the risk management activities including hazard identification and control, risk assessment, and risk assumption.

(c) Formal safety activity, its utilization, and impact.

(d) Apollo 14 anomalies and failures - <u>their analyses and resolution with respect to Apollo 15</u>.

(e) <u>Retention of critical knowledge and skills</u> with diminishing contractor and vendor support.

(f) The current <u>relationship between centers in resolving inter-center hardware problems</u>.

Each review (location and general content) is described below to help place the Panel's summary and conclusions in the proper perspective.

LOCATION:	MSFC, Huntsville, Alabama
DATE:	February 8-9, 1971
MATERIAL COVERED:	See Appendix B

The purpose here was, first, to understand the results of Apollo 14 and their impact on the launch vehicle assigned to Apollo 15; second, to examine launch vehicle changes; and, third, understand the Lunar Roving Vehicle (LRV) which forms a vital part of the new "J" mission space systems for Apollo 15, 16 and 17. In the area of LRV, the Panel was exposed to a basic type review on management, technical change status, and schedules only since the LRV itself would be examined in detail at both the contractor's plant (Boeing Company) and MSC.

LOCATION:	Apollo Program Office, Washington, D.C., and Goddard Space Flight Center.
DATE:	March 8-9, 1971
MATERIAL COVERED:	See Appendix C

This meeting provided the Apollo Program Director's assessment and top level view of two major areas. These were: an Apollo 14 mission report which covered in detail the anomalies resulting from that mission along with their resolution (as known at that time), and the Apollo 15 mission differences in both hardware and operations. The Apollo Program Director indicated the areas of risk (e.g., first time use of the LRV and SIM) and the steps being taken to minimize them. Included in this review was the role of the Manned Space Flight Network based at Goddard Space Flight Center indicating their part in such things as contingency planning.

LOCATION: The Boeing Company, Kent, Washington

DATE: April 12-13, 1971

MATERIAL COVERED: See Appendix D

This review was a natural follow-up to the MSFC and Apollo Program Director's discussions concerning the Lunar Roving Vehicle and its place in the Apollo "J" missions. It was also an opportunity for Panel members to see the vehicle first-hand and to observe the fabrication and test operations in process. The availability of personnel directly responsible for design, test and checkout provided an opportunity for closer scrutiny by the Panel of the key personnel involved.

LOCATION: MSC, Houston, Texas

DATE: May 10-11, 1971

MATERIAL COVERED: See Appendix E

Because of the large part played by those operations and equipments under MSC cognizance, the Panel found the review here to be most important. The crew interface and spacecraft changes form the largest part of the expanded Apollo 15 capability and give rise to the greatest concerns as to hazard identification and control. This meeting was then the apex of this series of Apollo 15 assessment reviews.

LOCATION:	KSC, Cape Kennedy, Florida
DATE:	June 14, 1971
MATERIAL COVERED:	See Appendix F

This review provided the Panel with an insight into the Apollo 15 launch preparation and checkout operations and took into account the information derived from the previous reviews. Of particular interest was the system for hazard identification and control as applied at KSC. An interesting aspect of this meeting was the opportunity afforded the Panel to see the new "alert system: (caution and warning) in actual operation at the Launch Control Center during the Apollo 15 Flight Readiness Test (FRT).

LOCATION:	NASA Headquarters, Washington, D.C.
DATE:	July 12-13, 1971
MATERIAL COVERED:	See Appendix G

This meeting with the Apollo Program Director provided the Panel members an opportunity to explore the current status of the Apollo 15 hardware and technical management items of interest generated during the previous series of reviews. Included in the discussions were the results of the Flight Readiness Review. The meeting with the

NASA Administrator centered on the Panel's Apollo 15 activities and observations.

GENERAL ASSESSMENT

The results of these briefings, together with the data exchanged between Panel members, Panel staff, the Center and contractor personnel has been used as the basis for the conclusions contained herein.

Note that material presented at the Panel meetings is contained in its entirety in individual data packages maintained in the Panel files and is not appended to this report. Appendices B through G indicate the material covered by the Panel or background upon which this assessment is built. A side issue, but one of importance, was the degree to which applicable aspects of the Apollo 13 recommendations and ensuing NASA actions carried over to the Apollo 15 and subsequent missions.

APOLLO 14 LAUNCH VEHICLE FLIGHT EVALUATION

The MSFC presentation basically indicated three things:

(a) Launch vehicle performance was nominal.

(b) S-II Pogo effects had been corrected.

(c) Launch vehicle problems which did occur were minor.

These minor problems involved IU telemetry equipment failure re-

TABLE I

CSM APOLLO 14 PROBLEMS

APOLLO 14 PROBLEM	KNOWN STATUS
Docking Probe Latch, difficulty in Probe-to-Drogue latching	Actual cause unknown. Actions taken to alleviate possible problems.
High Gain Antenna, failure to lock-up in Narrow Beam Mode	Additional screening for defects. Cables, connectors and their assembly modified to correct fabrication problems. Retest completed.
Motor Switch for Battery Bus, failed to close	Verify transfer times for all (32) switches on spacecraft. If out of tolerance, replace switch. Work continues on identifying source and mechanism of contaminate build-up on commutators.
Circuit Breaker, Battery to Main Bus, intermittent operation	Non-critical, crew awareness for breaker reset.
VHF, Low Signal Strength	No modification, non-critical. Possible use of S-Band voice as back-up.

sulting in the loss of non-critical measurements. There is no anticipated impact on Apollo 15.

APOLLO 14 SPACECRAFT FLIGHT EVALUATION

CSM

Problems and status as known are shown in Table I. Of these the docking probe's inability to capture the drogue until the sixth attempt certainly warranted further investigation. This unit has been undergoing intensive study and to date no substantive cause can be assigned to this problem although there are several theories. As a result of thorough testing and analyses, the following corrective actions were indicated as under way:

(1) Establish tighter configuration management (drawing control) and inspection procedures; provide a removable probe head cover to reduce possible contamination; and, conduct of checkout tests as late as possible in launch preparation period (all of this without interfering with the basic mechanism).

(2) Lock-wire retention of shear-pin fragments and a design change to the cam assembly to eliminate obvious marginal design features. With "cause unknown," the making of such design changes, e.g., modifications to insure centering of the motor drive shaft, decreasing the sensitivity to side loads and reduction of friction, requires that extra caution be exercised to preclude the possible creation of other subtle problems.

An area not pursued in detail at the time of the review but worthy of consideration are possible drogue tolerance problems which might possibly cause latches to not engage. It is understood that substantial additional testing of the modified latch assembly has been successfully conducted at the factory and at KSC. This is mentioned as background for the Administrator's review.

The Apollo 14 O_2 system, modified after the Apollo 13 investigation, demonstrated its capability to meet special and emergency conditions for Apollo 15 and subsequent "J" missions. Further, it established the heat transfer characteristics of the O_2 tank (and its components) which provides further security in their "J" mission use.

LM

Problems and status as known are shown in Table II. None of these appear to pose a problem in either their resolution or impact on Apollo 15 mission. If, for example, the LM landing radar problem were to occur on Apollo 15 current knowledge indicates it would not be the problem for Apollo 15 that it was on Apollo 14. Greater knowledge provides insight into handling of such problems.

HYCON CAMERA FAILURE ON APOLLO 14

The unavailability of high resolution pictures of the Apollo 15 landing site requires real time, closed loop, mission control with experts on the ground observing the operation of the LRV and providing appropriate guidance to the crew.

THE APOLLO 15 MISSION ("J" Mission)

The important differences in Apollo 15 from Apollo 14 are re-

TABLE II

LM APOLLO 14 PROBLEMS

LM Problem	Status
Intermittent Steerable Antenna Operation	Cause unknown. Resolution still in progress.
Ascent Battery #5 - voltage slightly lower than expected (0.3 volts)	Improve quality control at vendor. Additional test to be conducted at KSC.
LM Landing Radar - switch from high to low scale at too high an altitude (71,000 ft.)	Wiring change to lock radar in high scale until 7,500 feet altitude.
Abort Guidance System - failed in standby mode - no warning or alarm given	No evidence of a design deficiency or generic problem. No corrective action.

TABLE III

INCREASED CAPABILITIES FOR APOLLO 15

Lunar surface scientific payload doubled

Scientific Instrument Module (Service Module)

Lunar surface stay-time doubled

CSM/EVA during trans-earth portion of mission

Increased lunar surface operational range

Earth launch azimuth 80° - 100° (previous 72° to 96°)

Apollo 15 launch vehicle payload capability - 108,730 pounds (+ 6,630 pounds) lated to trajectory profile, lunar landing attitude-range profile, increased lunar stay-time, CSM extra-vehicular activity, and increased science capability. The increased mission requirements, trajectory characteristics and launch vehicle changes are shown in Table III.

LAUNCH VEHICLE

The "J" mission changes to the Saturn launch vehicle were made to meet required payload commitment without degrading crew safety; to improve reliability and safety; and, correct anomalies.

The most significant changes are briefly commented on here as to their possible impact on mission success. Material presented by MSFC indicated the basic operational data for risk assessment to be sound and indicated a thorough understanding of each item presented. There was no reason to question the technical qualities of the decisions.

Payload increases related to optimizing around the accomplishment of Translunar Injection (TLI) at first opportunity rather than providing equal payload capability at either first or second opportunities has small impact on mission success confidence level (99.9% to 99.60%).

Launch vehicle hardware and operational changes to increase payload capability would appear to have little effect on safety and reliability. Much of this can be directly related to the maturity of these vehicles and the support equipment and personnel. For example, reorificing of the F-1 engines to achieve 1.5222 million thrust on S-IC stage follows similar efforts of the same nature which have previously shown no adverse effects. On the other hand, the replacing of S-II stage LOX and LH_2 tank pressurization regulators with orifices, thereby deleting the step-pressurization of the LOX tank, has in fact eliminated a single failure point and should aid system reliability.

In addition to obtaining greater payload other changes were made to the launch vehicle to enhance reliability and safety (Table IV). The Panel feels that these were minor software changes and appear to enhance mission success. In fact these changes might have been in the works for some time prior to Apollo 15. In one case, revision of the IU computer filters was done in order to maintain the previously set control stability margins with the newly increased payload requirement.

Subsequent to the Panel's visit to MSFC it was discovered that certain seals used on the launch vehicle could not be certified as compatible with LOX, GOX and other oxidizers as required by specification. This occurred because of confusion in actual materials employed in this proprietary seal. The Panel understands that actions taken have resolved this problem. It indicates the importance of management's continuing attention to the technical management systems in support of future missions.

LUNAR ROVING VEHICLE (LRV)

MSFC and Boeing personnel provided LRV management and hardware data to the Panel with crew and science interfaces provided

TABLE IV

SIGNIFICANT LAUNCH VEHICLE CHANGES TO IMPROVE RELIABILITY AND SAFETY

Modification of TILT arrest time for S-IC stage engine out.

Spacecraft computer-generated S-IV-B cutoff for TLI.

Revise the instrument unit flight control computer.

Modification of yaw maneuver for tower avoidance.

by MSC. The significance of the Rover in achieving Apollo 15 objectives cannot be overstated. Consequently, the Panel considered this a most vital area to be reviewed. The initial review at MSFC provided a broad insight of physical requirements and the details of program management, including center support functions while the Boeing Company and MSC coverage dealt primarily with the Rover hardware and operational details.

The LRV program provided for scheduled delivery of fully qualified flight hardware eighteen months from "go-ahead." This tight timing was compounded by the fact it was to be the first manned lunar surface transportation unit with stringent requirements for both complex scientific equipment, meticulous crew and LM interfaces, and rigid weight limitations.

Based on our discussions, it appeared that the efforts of both NASA and the prime contractor had now established a viable management system for this program. This included such things as designating key people at all levels by name to cope with various possible problem areas which might occur as a result of qualification testing at an accelerated pace. To maintain personnel motivation and capability, MSFC took such steps as making sure that the contractor had a place for LRV test engineers and technicians to do useful work when not needed on LRV.

Qual and acceptance tests indicate that the unanticipated problems from welding and soldering have been resolved.

Furthermore, in light of the Apollo 13 recommendations, a qualified team was designated to follow the LRV's from the factory through launch.

Continuing wheel/soil tests are contemplated to provide corrected speed and range data for traverse planning and we understand this will continue up to launch. This will no doubt be done with the idea that the first mission using the LRV must have adequate performance margins and operational flexibility.

The Panel understands that significant aspects of the LRV dynamic stability analyses have been incorporated into the LRV Operations Handbook with all known constraints identified. This provides the crew and support team with much needed vehicle limitations and capabilities. However, we further understand that no specific instructions have been formulated for such dynamic constraints at the time of our review. Since experience is lacking in LRV operations in the lunar environment, the Panel attaches great importance to the use of real-time closed-loop mission control with experts on the ground observing the operation and providing proper mission rules and guidance to the crew on the lunar surface. This has been mentioned as background for the Administrator's review.

Documentation, drawings, and test procedures appeared to be in good shape. Any future revisions, of course, must be scrupulously controlled by the appropriate level of management to preclude interference effects of any kind.

As explained to the Panel, the LRV crew training approach appears to be well-founded and implemented. As expected driving rules and techniques as developed during LRV trainer operation are structured to be effective for expected speed, slope, and obstacle conditions at the Apollo 15 site, but the Panel cautions that due to uncertainties, driving techniques must be tempered by rules which preclude the crew from approaching or entering a regime from which recovery techniques would be problematical. This is again mentioned as background for the Administrator's review.

The Panel requested prior to the reviews, that they be provided an LRV safety assessment covering three mission phases:

(a) Prelaunch through lunar landing.

(b) Deployment on lunar surface.

(c) Lunar surface operations.

Indications are that all foreseeable and identified hazards that have not been eliminated have been considered and decisions made as to their acceptability. This includes such hazards, and their resolution, as:

(a) When seated the astronaut slides down in his space suit to an extent that his field of view in front and down is somewhat limited. Because of this the added emphasis of suited one-G training is appropriate.

(b) The tires of the LRV are made of small diameter wire which when broken have a potential to puncture crew suits. Thus, if the crew is sufficiently aware of the potential danger inherent in wheel contact they can consciously avoid it. Under normal conditions this should pose no problem.

(c) The ability of the crew to return to the LM in the event of LRV breakdown has been covered in quite some detail as has the use of the Buddy-Portable Life Support System (PLSS) in case of PLSS problems. One particular case of double failure was noted and questioned by the Panel, i.e., possibility of LRV and PLSS failure at the same time. MSC indicated that the probability of such a double failure was extremely remote. Although structural failure of the LRV is considered a hazard, testing and analysis appears to have made this highly unlikely and consequently an acceptable risk. The NASA centers and contractor feel they have identified all single failure points and after analysis find them acceptable "as is," or where necessary, work arounds or contingency plans are available.

COMMAND AND SERVICE MODULES (CSM)

In reviewing this area the Panel felt that basic to minimizing the risks inherent in the Apollo 15 CSM (CSM 112), it would be necessary to assure:

(a) Minimum hardware and procedural change.

(b) Maximum utilization of qualified hardware.

(c) Validation of changes through a vigorous test and/or analysis program dependent on individual case.

(d) Proper application of the lessons learned from Apollo 13. Our review indicates that this in fact was done.

The third O_2 tank isolation valve has been relocated. The impact of SIM door ejection loads on the valve has been evaluated during risk assessment.

The Scientific Instrument Module (SIM) is a separate module and represents the major change to the CSM for Apollo 15 and future "J" missions. The Panel focused on areas such as identification and control of hazards, SIM bay lighting, temperature restraints, ordnance shock isolation, Reaction Control System (RCS) plume contamination, EVA hand-hold and foot-restraints, tether arrangements and so on. Applicable safety issues were reviewed with the understanding that the total safety assessment awaits the completion of hardware tests. Safety review work discussed included sharp edge hazards during EVA which had to be identified and corrected to assure they meet smoothness criteria set forth by MSC. In support of this work the crew is receiving training in visual inspection procedures as a part of their EVA training. Thermal hazards analysis indicates no areas accessable to the crewman in excess of 190° F which is well within the suit thermal tolerance.

Because of their mission significance the mission rules constraining EVA if the satellite cannot be jettisoned or SIM booms retracted should be considered for inclusion in the Administrator's review.

Within the CM itself the right hand outer window UV filter coating has been removed to accommodate on-board UV photography. The hazard here was the potential crew discomfort due to Ozone generation. Equipment and hardware were therefore changed and the MSC Safety Office now considers the hazard resolved.

The SIM door jettison situation appears to have been thoroughly investigated and tested. The Apollo Program Director indicated to the Panel that these tests have been successfully completed and that there is no hazard to the adjacent structure.

EXTRA-VEHICULAR MOBILITY UNIT (EMU)

The A7LB spacesuit, -7 PLSS/OPS, Buddy-PLSS operation portions of the EMU were of particular interest due to their differences from prior units and their expected extended use on Apollo 15.

The A7LB suit required improved durability, improved mobility, a new closure, and changes for EVA by the CM pilot.

As a result of these requirements changes were made in the spacesuit involving new zippers, bootbladders, and increased PLSS capability. The final status of these changes should be indicated in the Administrator's review. Particular attention should be given to: (a) pressure sealing closure; (b) crotch cable assembly; (c) restraint zipper lock-tab; (d) shoulder convolute wear; (e) boot-bladder; (f) manufacturing controls on boots; (g) the oxygen purge system in the PLSS; and, (h) the reliability of the CO_2 sensor.

LUNAR COMMUNICATIONS RELAY UNIT/GROUND COMMANDED TELEVISION ASSEMBLY LCRU/GCTA

The possibility of using the TV equipment as a diagnostic tool during lunar surface operations was suggested by the Panel. MSC/MSFC were exploring the feasibility. Their conclusions should be considered for inclusion in the Administrator's review.

LUNAR MODULE (LM)

The review of the LM included the many configuration changes made to increase lunar surface stay time and landed payload capability. As back-up capability during the CSM experiments activity, the Panel reviewed a safety analysis for retaining the LM ascent stage for lunar orbit stay after redocking.

The Panel was interested in the extent of qualification of new and/or modified LM hardware. Of the many items examined, the thermal protection system, Lunar Roving Vehicle interface, descent propulsion system, consumables, and landing stability were considered in more detail because of their significance in meeting the Apollo 15 mission requirements. The briefings indicated both MSC and GAC conducted an extensive study of the need for qualification by test, analysis, and qualification through similarity to previously tested components, subsystems and systems.

THERMAL PROTECTION

Rearrangement of hardware (in each of the four quadrants), extended stay time, and propulsion changes all required thermal reconfiguration and system requalification. This was accomplished through thermal-vacuum tests, shock tunnel heating tests and analyses. As presented, the depth and scope of effort was convincing.

LUNAR ROVING VEHICLE (LRV)

This was discussed in the section on the LRV.

DESCENT PROPULSION SYSTEM (DPS)

This system was modified to provide the capability to land a heavier vehicle on the lunar surface. Changes include lengthened propellant tanks to increase capacity by 1150 pounds, a change from a low grade silica to high grade quartz fibers in the engine chamber to permit longer burn time, a ten-inch nozzle extension to increase ISP, and deletion of propellant tank balance lines. Extensive testing was accomplished on these changes, particularly on the engine modifications. Data presented indicated a thorough qualification program had been accomplished.

CONSUMABLES

A review of consumable margins for 67 hour Lunar stay showed that positive margins exist for all consumables after allowances for dispersions and contingencies. In the case of descent stage water, although the tank capacity is 666 pounds, the tanks are filled to cover mission plus contingency needs of 377 pounds. The basis for these analyses appear sound.

LANDING STABILITY

The LM-10 stability analysis presented, based on previous work which was proved-out on Apollo 11, 12 and 14, showed a greater margin for a stable landing with LM-10 than with prior vehicles. It is noted that GAC/MSC used a number of refinements in this program, reflecting flight experience and a better understanding of the inter-action of stability factors such as terrain slope, velocities, attitude rate, pilot reaction times, etc.

KSC LAUNCH PREPARATIONS

This visit afforded the Panel an opportunity to review the launch preparations for Apollo 15 at a time of increasing activity and to gain insight into those changes in hardware and procedures instituted as a result of their Apollo 13 efforts.

Many of the significant hardware changes reviewed by the Panel during the previous center and contractor visits were discussed with respect to their processing at KSC to assure proper operation and installation. In addition, the inter-center technical support and KSC safety activities were reviewed. The Panel expressed an interest in the availability of necessary documentation such as vendor drawings for use in troubleshooting in view of decreasing non-NASA support for remaining Apollo flights. The steps taken by the development centers to both augment the drawing files at KSC and to improve retrieval time from files at all locations appear to have born fruit. KSC states documentation is available in depth and in a form necessary to meet their requirements.

Status of the Apollo 15, at the time of the review, was indicated as being on schedule with no more problems than found on any prior launch even though Apollo 15 contained many new items due to "J" mission requirements. An interface problem surfaced during LM-10 descent engine gimbaling tests. During this test the extended nozzle scraped along the dome blanket of the S-IV-B tank indicating a lack of proper clearance. The proper change was made for AS-511 but not applied to AS-510 as required by the stack effectivity change. This evidences the need for continuing management attention to the application of the existing configuration management system to changes in the future.

KSC has carried out a structured program of mission and individual test simulations within the Launch Control Center, including failure simulations to maintain competence of their operational personnel. KSC indicated that their operational relationships with the Houston Mission Control Center are excellent and the team at MCC is activated at the time the vehicle moved to the launch pad and has aided considerably in the problem solving required during the critical launch checkout period.

Having reviewed the development, manufacture and planned use of the LRV and SIM at MSC, MSFC, and The Boeing Company, the Panel reviewed the test and checkout of these subsystems at the Cape. At the time of our review there were a significant number of tests still to be completed at KSC. We discussed this later with the Apollo Program Director and he indicated these were coming to a conclusion on schedule.

KSC appears to have conducted detailed and continuing liaison with the cognizant development centers in accomplishing their process work.

The Lightning Warning System, as described, indicated a growing knowledge in this area. Yet the methodology to date cannot have the precision that other launch operations have, and as expected it is still an art. The system for lightning protection and determination of impact of lightning strikes on hardware is one that is worthy of further study. NASA's advanced methods should be disseminated for use by other segments of the aerospace community.

During the conduct of the FRT (Flight Readiness Test), the

the Panel was to have had the opportunity to see the Apollo Alert System in partial operation. This system is an outgrowth of not only Apollo 13 recommendations, but of prior considerations climaxed by Apollo 13. The alert system, when fully operational, should reduce prelaunch and launch trouble-shooting problems. Given their significance, both these items are suggested for inclusion in the Administrator's review.

SUMMARY

The review emphasized the following areas:

(a) Management policies, systems, and their implementation as used to establish the design and safety maturity of Apollo 15 (and subsequent "J" missions) and its ability to meet mission requirements. This includes the qualification testing and analysis programs and their rationale, performance impacts, configuration management, and inter-center operations. This was specifically directed towards:

(1) Apollo 14 anomalies and their close-out.

(2) New and modified elements of Apollo 15 space system and mission.

(3) Launch preparation for Apollo 15.

(b) Risk management process:

(1) Identification of hazards associated with new and modified elements of Apollo 15 hardware and mission.

(2) Failure effect and acceptance or avoidance rationale.

(3) Safety assessment and hazard control

(c) Retention of critical knowledge and skills at proper locations and with dimishing contractor and vendor support.

Specific items are summarized below, based on the body of this report, and represent the Panel's conclusions:

(a) The response to the Panel's review requirements as set forth by the agendas was, on the whole, frank and informative.

(b) Two continuing characteristics of NASA's Apollo management philosophy that are important in meeting mission goals are detailed surveillance of contractor activities and the depth of NASA in-house reviews. These capabilities are perhaps most important in assuring the risk assessments and resulting risk assumptions are made with maximum knowledge in a time of continuing personnel reductions. The Panel was impressed with the current state of these capabilities and the importance of continuing management attention to the maintainance of them.

(c) The system for the resolution of the anomalies and failures found in the Apollo 14 appears satisfactory.

(d) Launch vehicle hardware and operational modifications to achieve greater payload capacity appear soundly based on individual stage maturity. Sustained successful launch and flight operations experience, coupled with a firmly established configuration, provide such maturity. The decision to include certain minor changes to enhance mission reliability and safety appears reasonable.

(e) Based on the results of the LRV review, the Panel notes a high degree of confidence among the OMSF Centers and vehicle contractor that the LRV maturity has been fully demonstrated by extensive tests and technical analyses. Because the LRV has not "flown" before the astronaut training, operational performance analysis, traverse planning and attendant mission rules take on added significance. The Panel feels that because experience is lacking in the lunar environment, it is most important to have real-time closed loop mission control with experts here on earth observing the operation and sending proper mission rules and guidance to the crew.

(f) The CSM modifications to support the extended mission and lunar orbit experiments were numerous. The rigorous test and analysis program, as described to the Panel, indicates a thoroughness of technical management necessary to minimize the risks associated with the "J" type mission.

(g) The improved A7L-B spacesuit and the -7PLSS for Apollo 15 have had their share of development problems not unlike those used on Apollo's 11 through 14. Based on data presented and successful completion of qual tests, it appears that the inherent risks here are no more or less than on previous flights. The use of teflon fabric has been extended and now covers the entire suit. The beta cloth base material is judged by MSC to satisfactorily constrain any fire propagation.

(h) The LM has been modified in many areas to meet Apollo 15 or "J" mission requirements. Here again rigorous testing and analysis, as described to the Panel, indicates an awareness of the hazards involved and an attempt, where possible, to alleviate or eliminate the associated risks.

(i) The risk management process continues to be an inherent part of the Apollo management system. It is supported by an extensive system of policies, procedures and actual implementation which identified hazards, evaluates and assesses the risks, and provides reasonable actions to eliminate or alleviate all those concerned with human safety and mission success.

The conclusions based on this summary are stated at the beginning of the report.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

OFFICE OF THE ADMINISTRATOR

JAN 26 1971

TO: Mr. Dale D. Myers, Associate Administrator, Office of Manned Space Flight

FROM: Dr. George M. Low, Acting Administrator

Since we will soon begin the Apollo "J" missions, I have asked the Aerospace Safety Advisory Panel to review the changes introduced with Apollo 15 and the attendant system for risk assessment, including those technical management systems that impact it.

I have also asked the Panel to review the continuing evolution of the risk assessment system on the Skylab and Space Shuttle programs. This again would include those technical management systems that would impact risk assessment.

The review, as now planned, will take the Panel to the Manned Space Flight Centers and appropriate major contractors beginning in early February.

The Manned Space Flight organization's continuing support of the Panel activities is appreciated.

George M Low
GEORGE M. LOW
Acting Administrator

AGENDA FOR MEETING OF

AEROSPACE SAFETY ADVISORY PANEL

AT

MARSHALL SPACE FLIGHT CENTER

FEBRUARY 1971

Apollo 14 Launch Vehicle - significant events

Apollo 14 vs Apollo 15 (Launch Vehicle)

- Mission/Operational Differences
- Launch Vehicle/Software Differences

Lunar Roving Vehicle

- Introduction and Background
- End Item Description
- Requirements
- Crew Integration
- Reliability and Safety Activities
- Testing
- Quality Assurance
- Management Systems
- Schedules

Skylab Program

- Introduction, Organization and Responsibilities
- Systems Description
- Inspect ATM Assembly Area

Appendix B

Inspect Skylab Mock-up Hardware Area

Materials Compatibility

Caution, Warning and Emergency Systems

AGENDA FOR MEETING OF
AEROSPACE SAFETY ADVISORY PANEL
AT
WASHINGTON, D.C.
(APOLLO PROGRAM OFFICE)
MARCH 1971

APOLLO 14 MISSION REPORT

- CSM Problems
- LM Problems
- O_2 System Flight Test Results
- Mission Events
- Mission Results

APOLLO 15 MISSION REPORT

- Detailed Objectives
- Increased Capabilities
- Launch Vehicle Performance
- Spacecraft Weight
- Changes and Modifications
- LRV
- Operational Aspects

MANNED SPACEFLIGHT NETWORK (Goddard Space Flight Center)

AGENDA FOR MEETING OF

AEROSPACE SAFETY ADVISORY PANEL

AT

THE BOEING COMPANY, KENT, WASHINGTON

APRIL 1971

INTRODUCTION

- Design Familiarization
- Program Description
- Schedule

PROGRAM MANAGEMENT CONTROLS

- Organization
- Suppliers
- Schedules
- Program Control and Reporting
- Configuration Management

LRV OPERATIONS

- Material Procurement
- Manufacturing Control
- Quality Assurance
- Industrial Safety

HARDWARE/FACILITY TOUR

DESIGN CERTIFICATION

- Requirements
- Performance
- Design
  - Design Criteria
  - Subsystem Assessments
    - Chassis
    - Mobility
    - Electrical
    - Navigation
    - Crew Station
    - Thermal Control

Appendix D

AGENDA FOR MEETING OF

AEROSPACE SAFETY ADVISORY PANEL

AT

MANNED SPACEFLIGHT CENTER, HOUSTON, TEXAS

MAY 1971

OBJECTIVE OF REVIEW

APOLLO 14 PROBLEM UPDATE

- CSM
- LM
- GFE
- ALSEP
- "J" MISSION DIFFERENCES - LM
  - LM-8 and LM-10 Major Configuration Differences for Payload and Hover Time
  - Weight and Performance
  - Consumables Margin
  - Landing Stability
  - CTR/CTE Status
  - Current Problems
- LUNAR SURFACE OPERATIONS
- "J" MISSION DIFFERENCES - CSM
  - New Requirements
  - Ground Rules
  - Design Approach
  - Modifications
  - SIM Checkout
  - Crew Station Details, Including EVA
  - Certification Status
  - Current Open Problems
- "J" MISSION DIFFERENCES -GFE
  - Introduction
    - Major Subsystems of the EMU
    - "J" Mission Performance Requirements
  - Pressure Garment Assembly
  - Portable Life Support System
  - GCTA
  - LCRU
  - Safety Assessment

AGENDA FOR MEETING OF

AEROSPACE SAFETY ADVISORY PANEL

AT

KENNEDY SPACEFLIGHT CENTER, COCOA BEACH, FLORIDA

JUNE 1971

Introduction and General Discussion

Apollo 15 Launch Processing and Test Status

Apollo 15 Safety Activities

Inter-Center Technical Support on Significant Problems and Management Posture During Launch Related Operations

Operation of Lightning Warning System

Off-Line Flight Support During Mission

ASC Alert System

Review of Alert System in Firing Room

Appendix F

AGENDA

AEROSPACE SAFETY ADVISORY PANEL MEETING

JULY 12-13, 1971

JULY 12

Review of Status of Apollo 15 - Dr. Rocco Petrone, Apollo Program Director.

Panel Discussion of Apollo 15 Report

Dr. Low's Office - Presentation of NASA Public Service Award to Dr. Reining

Benefits vs Risk Management for NASA - Dr. Raymond Wilmotte, NASA Consultant

JULY 13

Dr. James C. Fletcher, NASA Administrator

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO
ATTN OF:

OFFICE OF THE ADMINISTRATOR

September 30, 1971

MEMORANDUM

TO: OSP/Executive Secretary
Aerospace Safety Advisory Panel

FROM: AD/Deputy Administrator

SUBJECT: Aerospace Safety Advisory Panel Activities

Thank you for your memorandum dated September 28, 1971, on the same subject. I very much appreciate your summarizing for me the Panel's recent activities.

The agenda for the Panel's visit to Huntington Beach appears to be sound and well thought out.

I recently received a copy of the final report to the Lewis Research Center of the Centaur Quality and Workmanship Review Board, dated August 1971. You might want to make copies of this report available to Panel members, not for the purpose of reviewing the Centaur Program, but for additional background in their review of the Apollo and Skylab programs.

George M. Low

George M. Low

Attachment C

NASA

AEROSPACE SAFETY ADVISORY PANEL

SPECIAL OWS INTEREST ITEM NO. 1

The Panel was quite concerned with the quantity of flammable material which is incorporated in the OWS. We appreciated the reasons given for the necessity of using this material. Since possible fire aboard the vehicle must be considered we would appreicate receiving a fuller description of the on-board equipment and crew procedures which will be used to detect, contain, and extinguish fires if one should start. In this regard we would also like information on studies of the possible effects of toxic materials which might be generated during a fire, damage control, and the establishment of limits of contamination as applied to atmosphere composition.

Attachment D

OWS Flammability Control

The safety provisions of manned spacecraft must always consider the question of a potential fire. All aspects of such a hazard must be evaluated in order to minimize possible ignition and effect. This includes probability of ignition, flame propagation paths, containment if a fire occurs, and toxicity effects on the crew from combustion products.

Since the beginning of the design phase, it has been NASA/MSFC's and MDAC's philosophy that the key to crew safety is fire prevention. MDAC has implemented this policy by communicating to the designer that special design precautions are mandatory when using known flammable materials. This emphasis on the design techniques for fire prevention has promoted a concept for fire containment and the elimination of flame propagation paths, if a fire did occur. The use of any flammable material is contingent upon isolation of such material or materials in the composite configuration. Flame-containment design techniques include isolating each flammable material from other materials by enclosement, by encapsulation, or by use of a barrier between the material and the operating atmosphere. Each of the design applications has been reviewed by MDAC and NASA/MSFC to determine adequacy of the precaution to insure that safety provisions are satisfied.

The following discussion presents a general overview relative to fire detection, containment, and extinguishment provisions, and toxicity control within the OWS. It should again be emphasized that the basic ground rule applied to the OWS design is fire prevention. Use of all flammable material is reviewed and documented as follows:

(a) All flammable materials are identified and reported on Materials Usage Forms. These forms include area, volume, weight, and location information for each flammable material usage. In addition, this form also includes offgassing data (carbon monoxide and total organic offgassing rates) for each material.

(b) All forms are approved by the OWS Program Manager and are submitted to MSFC for review and approval.

(2)

OWS Flammability Control (Continued)

(c) Flammable material is used only when no adequate non-flammable substitute is available. Detailed rationale and tradeoffs are included with each material submittal.

(d) Each submittal item is also included as a part of the Materials Usage Map (MDAC drawing No. 1B77015). This drawing depicts the location of each item and aids in determining the distribution of material throughout the OWS and its proximity to other items.

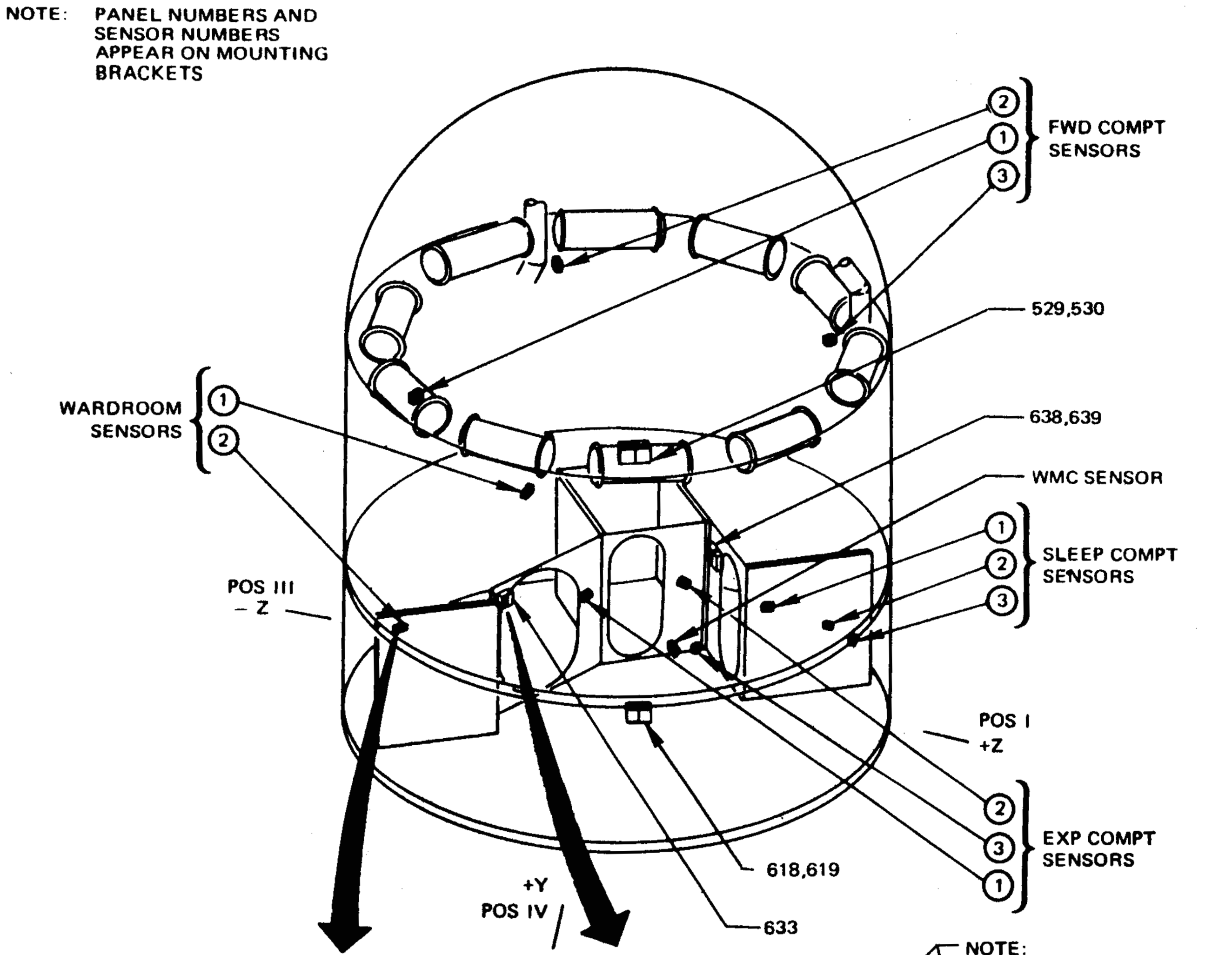
Fire Detection

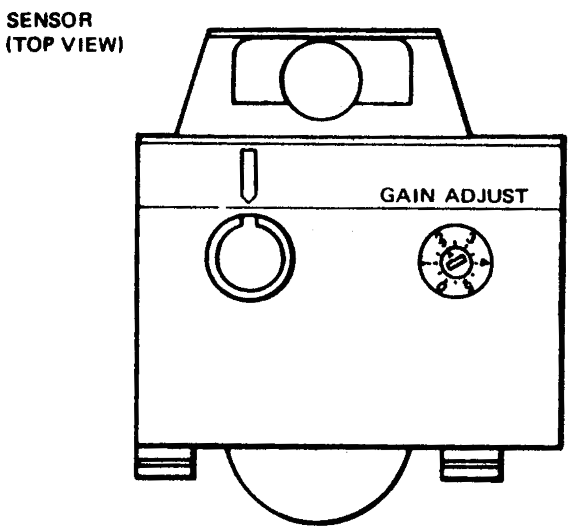
A fire detection system study was conducted and the results reported in MDC G0095-P, dated 8-20-70. The results of the study indicated that an adequate fire detection system could be achieved by incorporation of an area-type surveillance technique using single coverage ultraviolet detectors.

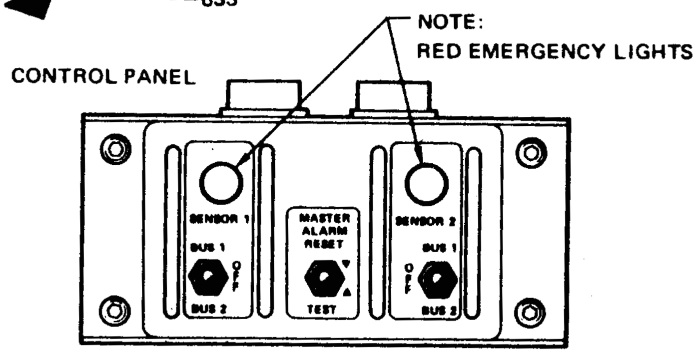
The OWS fire detection system is comprised of 12 ultraviolet sensors and seven associated control panels. The basic placement and arrangement of sensors and control panels is depicted in Figure 1. Exact locations of the fire detection sensors are defined by drawing No. 1B86999 (January 1971) for all sensors except the Waste Management Compartment sensor which is defined by drawing No. 1B79489 (January 1971).

The above locations have been used to determine the approximate area covered by the field of view for each sensor. The sensor field of view is a 120 degree cone and the installation alignment angles are: (a) aft compartment sensors cone centerlines are canted 30 degrees upward from the horizontal for floor mounted sensors and 30 degrees downward from the horizontal for ceiling mounted sensors, (b) forward compartment sensors cone centerlines are horizontal.

The projection of the conical field of view of each sensor on the floor and ceiling of its respective compartment has been established and straight line approximations developed for the intersections with the surrounding walls. This effectively defines the area which would be within the field of view for each sensor. Adjustments in the placement of the sensors were made based on the coverage definitions to provide the most effective viewing position for each sensor.







PANEL	FIRE DETECTION SENSORS
529 (LEFT)	FWD COMPT 1, 2
530 (RIGHT)	FWD COMPT 3
618 (LEFT)	EXP COMPT 2, 3
619 (RIGHT)	EXP COMPT 1
633	WARDROOM 1, 2
638 (LEFT)	WMC AND SLEEP COMPT 1
639 (RIGHT)	SLEEP COMPT 2, 3

Fire Detection System – Panels 529, 530, 618, 619, 633, 638, 639 (61A300026 GFE)

Fig I

Fire Containment

Protection provisions for containment of fires are as follows:

(a) Installation of fixed items. The majority of the fixed (permanently installed) flammable materials are small in size, separate items, or easily isolated component parts. Exceptions include the foam insulation, refrigerant, and wire harnesses. The general design approach followed is to contain and/or isolate the flammable material. Enclosure with metal (provides a large heat sink), wire troughs with fire breaks, or isolation by separation from other flammable materials are the commonly used approaches. Each usage and its installation and protection/isolation provisions are documented and submitted on a Materials Usage Form as discussed previously.

Fire Containment (Continued)

Special precautions and design provisions have been imposed and Incorporated with respect to the major usages of fixed flammable materials. These include the following:

(1) Polyurethane foam insulation installations are covered by a minimum of .003 inch thick aluminum foil. The tank wall insulation also includes use of a fiberglass liner which in turn is covered by the aluminum foil. All penetrations through the foam incorporate use of fiberglass and aluminum foil protective covers to isolate the foam from exposure to the OWS atmosphere. Polyurethane foam used within freezer walls is essentially sandwiched between metal walls of .030 minimum thickness. Extensive flammability testing was conducted to determine the minimum foil thickness which would provide the desired flammability protection.

(2) The refrigeration subsystem installation incorporates the following design provisions to eliminate potential leak paths for the refrigerant:

(a) all tubing joints within the OWS pressurized interior are brazed

(b) "O" ring sealed boss fittings replace use of MS flared fittings. This provides the interface seal between the CRES tubing and aluminum active components

(c) all active components are enclosed in a sealed, vacuum vented container.

(d) damage protection is provided by the use of foam insulation jackets around the refrigerant lines (thermal requirement) which in turn are covered by .050 inch minimum wall thickness aluminum shrouds.

In addition, extensive flammability testing was conducted using typical segments of refrigerant soaked insulated lines to substantiate the adequacy of the design approach.

Fire Containment (Continued)

(3) Electrical components and wiring installations incorporate the following special system design features, in addition to normal circuit protection devices:

(a) all encapsulated electronic modules are coated with a layer of plasma-arc sprayed aluminum (Metco No. 54) to preclude flame propagation.

(b) all wiring internal to the OWS is routed through a system of closed metal troughs containing fire barriers or non-flammable convoluted tubing

(c) the power control console is compartmented to prevent flame propagation.

(b) Stowed items. Flammability protection for stowed items is provided by the metal stowage cabinets. Installation of stowed items does not include any specific requirements to fire proof the item prior to placement in the cabinet. The stowage interface is concerned only with size, weight, vibration, shock, and flotation (zero-g) constraints.

Stowage restraints and/or packaging provided is non-flammable, where possible, (armalon bags for small items or non-flammable strap type restraints for larger installations).

Specific stowage concepts applied to significant usage of flammable materials (large mass) are:

ITEM	CONCEPT
Sleep restraints	Restrained in cabinet by straps except for the three in use which are protected by an armalon stowage bag when not occupied by a crew member.

Fire Containment (Continued)

ITEM	CONCEPT
Towels	Rolled individually and stored in bundles. Usage is from a dispenser which is comprised of 24 towels in a metal container closed on five sides. The dispenser is installed within a metal cabinet. Only the rolled end of the towel cylinder is exposed to the atmosphere within the cabinet. Bulk stowage of replacement towels for the dispensers is within a cabinet restrained by straps.
Washcloths	Stowed in bundles of 28 cloths in a metal container closed on five sides. This container is installed within a metal cabinet. Cloths are extracted through an oval hole in the sixth side of the metal container.
Tissue/Wipes	Stowed in closed aluminized box. Used in a tissue/wipe dispenser at which time the ends of the box are punched out. The dispenser installation uses a spring loaded door which must be opened to remove a tissue/wipe. The dispensers are installed within a metal cabinet.
Bags (Trash, Urine, etc.)	Stowed in bundles, within metal cabinets and strap restrained. Exposure is limited to the usage duration only.

(c) Ignition Sources. All electrical equipment connecting to the power distribution system have been reviewed as potential ignition sources. This review assumed that the circuit breakers failed closed, all environmental seals leaked, and one or more components failed. Results of this review are that the wire gauge used in the circuit breakers and electrical components is less than that of the interconnecting wiring and acts as a fuse to open the circuit should failures occur.

Fire Containment (Continued)

In addition, the wiring installations use the enclosed trough and convoluated tubing approach which effectively enclosed all the wiring and isolates any malfunction from the remainder of the system.

The OWS main bus wiring internal to the control-display console was evaluated in greater depth since failures here can cause total loss of power and possibly cascading malfunctions. It was concluded that additional protection was warranted although only extremely peculiar short circuit conditions would cause burning of wire insulation. Typically this would be a short which would draw just enough current to cause the temperature to rise but not enough to trip the breaker (virtually impossible). Should this occur shorting of an adjacent wire would trip the breakers and open the circuit. No cascading failures are considered possible.

These wires have been designed with a completely redundant double insulation jacket to preclude possible short circuit failures as discussed above.

A review of potential hot spots (temperature >+160°F) was conducted as part of the possible coolanol hazards assessment. The results of this review have identified the following potentially sensitive areas.

Radiant heaters - for bus voltages not greater than 28 vdc, the temperature of the heater surface cannot exceed +160°F. Estimated maximum temperature with maximum bus voltage (32 vdc) exceeds +160°F (coolanol flash point). However, no astronaut safety hazard exists because these heaters are not active while the OWS is inhabited and no heater failure can occur at the temperature seen at maximum voltage.

Duct heaters - failure of all the fans (minimum of three failures) within a duct would allow the heater temperature to reach +260°F (maximum overtemperature). Operation of a single fan would limit the temperature to +150°F.

Fire Containment (Continued)

Static electricity discharge potential for all the OWS equipment is controlled by bonding requirements defined by OWS Design Memorandum No. 28 to assure compliance with Electrical Bonding specification MIL-B-5087B. Specific design requirements and maximum allowable DC resistance data for application to experiments, structural interfaces, conductive adhesives, portable equipment, and electrical AGE are included in this memorandum.

Conclusions reached relative to ignition sources are as follows:

- No electrical power distribution system ignition sources exist.
- Potentially sensitive hot spots (temperature +160°F) exist with the radiant heaters if the bus voltage is above 28 vdc and the duct heaters if four failures occur.
- Static electricity discharge potential has been eliminated from MDAC-supplied items.
- No flammables are located in proximity to any of the above possible sources.
- Radiant heaters and duct heaters are monitored by the fire detection sensors.

Fire Extinguishment

The OWS CEI Specification, CP2080J1C, establishes the requirement for mounting four fire extinguishers in the OWS. Two extinguishers are to be mounted in the crew quarters and two in the forward compartment. The extinguishers are to be furnished by the Government according to OWS GFP contract document DAC-56724A.

Specific fire extinguishers usage procedures as well as overall emergency operational procedures are the responsibility of Mission-Control NASA-MSC. MDAC is responsible only for the determination of the quantity of extinguishers required in the OWS to satisfy the primary mission safety requirements and to provide mounting provisions for these extinguishers.

Fire Extinguishment (Continued)

The fire extinguishers have been modified to incorporate a low velocity nozzle so that they may be used effectively against open fires. The previous design used a nozzle which fit into holes in the cabinet panels within the Apollo command module. The command module cabinet would then contain the expended foam. No such holes or panels exist in the OWS design. The approach used is to enclose OWS wiring, components, and stowed items within metal compartments and testing has been conducted to insure that this approach satisfies all fire containment requirements.

Toxicity Control

A computer program, P0327, has been created to provide a mechanism to collate and calculate offgassing rates for the non-metallic materials used in the OWS. The concern is with the potential buildup of toxic products above allowable limits for the materials used in the normal operating environment. The computer program calculations of total offgassing of carbon monoxide and total organics provides OWS Crew Systems personnel with data to assist in establishing the level of toxic contaminations. No program or data exist relative to toxic levels resulting from products of combustion. A fire, other than a minor localized one, in the Orbital Workshop causes an emergency situation which may be met at that moment by providing oxygen and masks located in the crew quarters.

NASA

AEROSPACE SAFETY ADVISORY PANEL

SPECIAL OWS INTEREST ITEM NO. 2

"In view of the Russian accident involving the loss of three cosmonauts which presumably resulted from inadequate containment of the atmosphere in the space capsule, we are naturally interested in any studies that you have done pertaining to the adequacies of closure of all hatches and other penetrations of the OWS shell which could potentially result in catastrophic loss of atmosphere. I believe that Houston has made an overall survey of this potential but we are particularly interested in the studies that MDAC may have made for those parts of the equipment for which they are responsible."

OWS Atmosphere Integrity

The OWS does not include the type of equipment (primary entry hatches) which was assumed to be the malfunctioning item which caused the Russian Astronauts' death. There are also other basic reasons why the OWS is a safe element of the Skylab in this respect. These reasons have different value with respect to a problem or accident occurrence and are listed for evaluation in any context under discussion.

1. The OWS volume is approximately 9,500 cubic feet. At 5 psia the mass of breathing atmosphere (oxygen and nitrogen) contained is 295 pounds. A catastrophic loss of atmosphere would require a much larger hole than would be related to a seal type leakage. Also, pressure is monitored and make-up gas is available.

2. The OWS does not have any EVA hatches or other large openings which are functional in orbit. The entry hatch at the forward end of the OWS is opened by the astronauts during initial activation and remains open into the AM for the duration of the mission.

3. The OWS is pressurized to 23-26 psia for launch. When the vehicle reaches orbit it has experienced full differential pressure prior to initial blowdown. The OWS is then repressurized to 5 psia with the breathing atmosphere. During these period of time the OWS pressures are monitored from the ground. This provides a gross evaluation of the structural and leakage integrity of the vehicle prior to crew launch.

4. The only OWS Habitation Area shell penetrations having relatively large openings are the trash airlock, which opens into the Waste Tank, and two scientific airlocks which penetrate the sidewalls of the forward compartment. Both of these items incorporate interlocks which prevent simultaneous operation of inner and outer doors.

5. The Habitation Area vent systems are closed with redundant sealing devices during periods of occupancy. These sealing devices are installed by the astronauts and venting is impossible with the seals in place.

OWS Atmosphere Integrity (Continued)

MDAC, Huntington Beach, has not made any special studies in relation to catastrophic loss of atmosphere. However, internal design reviews and formal design reviews with NASA/MSFC have been conducted on each system in the OWS which includes all shell penetrations. Reliability analyses have been conducted and contingency analyses forms documented for each OWS functional component incorporating an overboard leakage path. Static seals are individually checked to a degree of sensitivity compatible with the eight month's orbital stay time. Each overboard leakage point is tested during manufacturing, checked during vehicle systems checkout at Huntington Beach, and checked again at KSC prior to launch. In addition, MDAC will conduct a OWS Habitation Area Gross Leakage Rate (Mass Decay) Test. This will provide additional assurance that leakage integrity is obtained.

NASA

AEROSPACE SAFETY ADVISORY PANEL

SPECIAL OWS INTEREST ITEM NO. 3

The Panel was very impressed with the detailed attention and interest given to the acceptability of parts and components which are supplied by subcontractors or vendors. In order to more fully understand how this management system works we would like to have you describe it to us in terms of an example selected from a component critical for either safety or mission accomplishment. As a method of providing for us an understanding of the system we would suggest that you include (a) an outline of the basic process for receiving, inspection and acceptance testing of the component, (b) any changes introduced in this process during the last six months, and (c) a tabulation of the nature of any failures to meet acceptability of this component and the resolution of the problems resulting therefrom. The purpose of this example should be to give the Panel a management assessment indicative of the effectiveness of this system for control.

OWS Supplier Parts Management

The part selected to describe how the supplier parts management system operates is P/N 1B75338-503, Thermostatic Switch, which is produced by Elmwood Sensors, Inc. located at Cranston, Rhode Island. Elmwood Thermostatic Switches are utilized in the data acquisition system, the environmental control system and on the microbiological control unit. In the environmental control system and on the microbiological control unit, the thermostats are used as a back-up method of temperature control in the event the primary system fails. In the data acquisition system, the thermostat is the primary control for the multiplexer heater blanket. The multiplexer thermostat is considered Mission Safety Critical because if the thermostat fails to open or close, the multiplexer will be subjected to temperature extremes in excess of its qualified operational temperature. Loss of a multiplexer would result in the loss of vital telemetry data such as biomedical information on the health of the astronauts.

The Elmwood Thermostatic Switch was selected because of problems encountered with this item in our Receiving Inspection and Test Laboratories. The nature of the discrepancies caused the parts to be rejected and returned to Elmwood for redesign. The following outline of activities related to planning, receiving, inspection and testing of the Elmwood Switches, cross referenced to the applicable documentation, should serve to clarify the various facets of our Supplier Management system.

Planned MDAC Acceptance Activities and Implementing Documentation

1. Initiate Quality Management Plan as guide for preparation of the Quality Assurance portion of the Procurement Work Statement (Encl. 1).

2. Prepare Material Acceptance Plan which is the prime document to plan, route, inspect, test and record results for acceptability of supplier part (Encl. 2).

3. Impose MDAC Reliability Control Specification, RCS400-2 and Government Source Inspection (GSI) on supplier. (See Purchase Order, Encl. 3).

Planned MDAC Acceptance Activities and Implementing Documentation (Continued)

4. Verify supplier compliance with RCS400-2 by on-site audit. (See Survey Report, Encl. 4).

5. Conduct Supplier Hardware Assurance Review Program (SHARP) Survey to assure supplier understands engineering intent. (See SHARP Survey Report, Encl. 5).

6. Qualify supplier special processes; i.e., cleaning, soldering, welding, clean room, etc. See Records of Discussion, Encl. 6 and 7.

Receiving Inspection, Test Activity and Implementing Documentation

1. Perform Receiving First Unit Review. (See Encl. 8).

2. Verify MDAC approval of the following:
   a. Supplier's Product Inspection Plan (See SIR84112, Encl. 9).
   b. Supplier's Test Procedure (See SIR84112, Encl. 9).
   c. Supplier's hardware design (See page 3 of SIR84112, Encl. 9 and SIR85131, Encl. 9A.)

3. Verify Government Source Inspection was performed. (See Section A of MAP and QA Stamp buyout on first line of Section D. The QA Stamp buyout verifies all requirements marked "X" in Sections A, B and C were satisfactorily performed. Encl. 2).

4. Verify receipt of supplier's Certificate of Conformance for process requiring qualification by MDAC. (Encl. 2 and 10).

5. Review supplier test data for conformance to MDAC requirements. (See Acceptance Test Data Sheet SR021 and MAP, Encl. 11 and 2).

6. Perform visual/mechanical inspections to requirements of MDAC Spec Control Drawing 1B75338. Part rejected on FARR 502 020 298 because of improper potting. (Encl. 12).

7. Perform MDAC Acceptance Test (Electrical/Performance Parameters) per MDAC Product Acceptance Test Procedure (PATP). (See PATP and FARR 502 027 376, Encl. 13 and 14).

8. Verify performance of Seal Leak Test by outside laboratory (Isovac Engineering). (See Isovac Test Certification results and FARR 502 028 596, Encl. 15 and 16).

   NOTE: No changes to the above basic supplier management process have been introduced in the last six months, however, several remedial actions were taken as listed below.

Product Acceptability

1. The initial planned acceptance activities progressed satisfactorily up to the point of Receiving Inspection and Test. The following is a summary of product discrepancies discovered during inspection and test:

   a. Bondizing ineffective
   b. Encapsulation defective
   c. Insulation resistance low
   d. Switch points out-of-tolerance
   e. Leakage rate excessive

2. Subsequent to the initiation of the rejection reports, a Supplemental Failure Analysis was initiated and an extensive evaluation of the problems was performed by MDAC Engineering both in-house and at the supplier's facility. (See SFA #W019, Action Item Summary Sheet and MM&RE report, Encl. 17, 18 and 19.)

3. Following these evaluations, all -503 configured parts were withdrawn from MDAC usage and a redesign -511 was initiated. Included in this redesign is both new controlling criteria in the Specification Control Drawing and a revision of the supplier's engineering, manufacturing and inspection procedures. (See Stop Order Encl. 20.)

4. Present status of the Thermostatic Switch is Interim Use Parts are being used for Phase I (Power Off) of checkout, "L" change to the drawing has been released calling for use of the -511 configuration and the supplier's revised drawings have been reviewed and approved by MDAC Engineering. Elmwood Sensors has been given a production go-ahead and new parts are scheduled for delivery on or about 3 December. (See SIR87439, Encl. 21. and L Change EO, Encl. 22).

NASA

AEROSPACE SAFETY ADVISORY PANEL

SPECIAL OWS INTEREST ITEM NO. 4

Since check-out testing of the OWS is planned to commence on November 6 the Panel would like to have you identify those items of flight hardware that are not expected to be available and/or installed on the workshop at that time. We would like to have your management system for the followup of such "shortages", particularly in regard to such assurance that the proper check-out test program will be applied as these items become available at subsequent dates.

OWS Hardware Status for Checkout

The spacecraft hardware status is controlled and monitored in terms of remaining open work. OWS hardware status was reviewed on 4 November 1971 for NASA and MDAC management as part of the Readiness Review for start of Phase I (Power Off) Checkout. The prediction for start of checkout was forecast to be 6,390 hours of remaining open work (Chart 1), however, on 6 November, checkout started with 6,109 actual hours open. The open work has been divided into four categories (Chart 1) with typical examples in each category (Charts 2-5). This open work has been scheduled into established modification periods during checkout such that is supports and is compatible with the various phases of tests. (Chart 6).

For the start of checkout, custody of OWS-1 was transferred from Manufacturing Operations to the Vehicle Checkout Laboratory (VCL). To complete this transaction, the appropriate "turnover" documentation was prepared and included a copy of the daily Automated Work Plan (AWP) which contains a complete breakdown and listing of open jobs and part numbers. Turnover AWP is enclosed. (Cht. 7)

OWS Hardware Management

The management system to track and follow-up on OWS parts is centralized into twice daily meetings with the company president, program manager, director and supervisors. The meetings are conducted in the tower building next to the spacecraft where magnetic boards are located which post the real time status of all open jobs on the spacecraft. Discussions are made and directions issued at these meetings to improve part availability dates and properly schedule the installation effort consistent with the test phases. The status as posted on the magnetic boards is photographed and disseminated to the involved agencies daily. A copy of the 11 November 1971 magnetic board status is also enclosed. (Encl. 8)

"Shortage" Management During Checkout

To assure that shortages are not overlooked during checkout, the VCL maintains practice of redlining a Test and Checkout Procedure (TCP) when it is necessary to work around a part shortage. This type of revision, however, is used as an internal technique only. The test procedure itself remains open until the proper component is installed and that portion of the procedure that has been redlined is then conducted in accordance with the original requirement.

In cases where components are changed after checkout, the Company uses a technique whereby any such change must have retest requirements specified on the installation paper. These retest requirements then become part of the data package and remain with the spacecraft until the rework has been accomplished and the installation paper can be sold off.

NASA

AEROSPACE SAFETY ADVISORY PANEL

SPECIAL OWS INTEREST ITEM NO. 5

As qualification tests have been conducted on the habitability support and electrical power systems, significant discrepancies have presumably been identified and classified according to cause as design problems, workmanship problems, or test procedure difficulties. We would appreciate receiving a historical review of your experience in this area.

OWS Qualification Test Review

In reply to the request for a historical review of the significant discrepancies identified in the habitability support and electrical power systems during qualification testing, the attached items with noted malfunctions constitute a synopsis of the major problems to date.

FAILURES RELATED TO DESIGN PROBLEMS

	LINE ITEM	TITLE	PROBLEM	CORRECTION/STATUS
1.	DA-3	Forward Signal Conditioning Panel	High temperature failure in 5-volt excitation module.	Seventeen components (resistors, capacitors, and transistors) were changed to those of different values. Item retested satisfactorily. Unit now in vibration and shock
2.	EC-11	Thermal Control Assembly	EMI failure of Driver Module.	Inductor filter added to circuit. Unit retested satisfactorily. Line Item closed.
3.	ES-3,-4	Zero G Connector, Phase II Zero G Connector	Manual operating force failure. Also, alignment pin failure during vibration.	Dri-lube added to mechanical lever mechanism. Longer pin inserted with different bonding cement. Item retested satisfactorily. Unit now in temperature life cycle.
4.	HS-8	Water Storage Assembly	Heater Blanket failed insulation resistance.	Connector potting compound and blanket material changed. Retested satisfactorily. Item active in biocide test.
5.	HS-10	Food Reconstitution Water Dispenser Assembly	Leakage problems in life cycles.	Gaskets and "O" rings changed to different configuration and material. Retested satisfactorily. Line Item closed.
6.	HS-11	Drinking Water Dispenser	Leakage problems in life cycles.	Gaskets and "O" rings changed to different configuration and material. Retested satisfactorily. Line Item closed.
7.	HS-12	Water Heater	Vibration failure of mounts.	Redesigned method of attachment and increased strength of mounts. Retested satisfactorily. Line Item closed.

	LINE ITEM	TITLE	PROBLEM	CORRECTION/STATUS
8.	HS-14	Microbiological Equipment	Biocide failure Iodine Injector (redesign). Vibration failure Waste Container (redesigned).	Bellows guide rings added to Waste Container and material in bellows of Iodine Injector changed to hastiloy "C". Both in fabrication for re-test.
9.	HS-24	Trash Disposal Airlock	Outboard hatch lever failed (seized) life cycles (redesigned). Pressure gage failed vibration.	Hatch lever mechanism redesigned to operate differently plus dri-lube being added to moving parts. Pressure gage redesigned by vendor. Both items in fabrication for retest.
10.	HS-27	Fecal Collector Blower (Apollo Evaluation)	Vibration failure of mounts. Mount structural beafed-up.	Structural strength of mounts increased plus new mounting technique incorporated. Item retested satisfactorily. Line Item closed.
11.	HS-48	Wash Cloth Squeezer	Mechanical linkage and bag leakage problems.	Mechanical linkage re-designed to increase structural strength and method of operation. Bag material changed. Both in fabrication for retest.
12.	CA-16	Spare Equipment Stowage Container	Vibration failure in stress relief pins between cover and locker body.	Hinge and pins redesigned to increase structural pins between cover strength. Item in fabrication and locker body for re-test.

FAILURES RELATED TO MANUFACTURING PROBLEMS

	LINE ITEM	TITLE	PROBLEM	CORRECTION/STATUS
1.	HS-2	Waste Management Subsystem	Waste Processor chamber seal leakage failure. Manufacturing and Inspection problem with debris (metal clips) in seal grooves.	Seal groove cleaned properly and new seal installed. Unit retested satisfactorily.
2.	HS-19	Refrigeration Subsystem	Low temperature failure of temperature transducer (open circuit).	X-rays indicated a cold solder joint had been made. Also x-rays taken to verify production unit acceptability.
3.	HS-26	Vacuum Outlet System	Ball valve stem seal leakage due to improper installation.	Seals removed and correctly installed. Item retested satisfactorily. Line Item active in test.
4.	HS-55	Urine Centrifugal Separator Assembly	Vibration failure of pilot pickup tube due to improper installation	Another pilot pickup tube installed correctly and unit retested satisfactorily. Line Item active in test.

FAILURES RELATED TO PROCEDURAL PROBLEMS

	LINE ITEM	TITLE	PROBLEM	CORRECTION/STATUS
1.	ES-11	OWS Relay Modules	Modules cracked during shock test due to incorrect shock levels.	Revised specification and re-tested another module satisfactorily. Line Item closed.
2.	HS-8	Water Storage Assembly	Procedural problem resulted in dome collapse.	Procedure corrected and safety check valves added to test equipment. Unit given special test to verify acceptability. Unit accepted by engineering and presently in 8 month biocide test.

NASA

AEROSPACE SAFETY ADVISORY PANEL

SPECIAL OWS INTEREST ITEM NO. 6

The Panel showed particular interest in your management control identified as the Problem Control Center. We would appreciate a list of the problems currently identified and listed as active in this management control area and also a brief description of how the management system resolves these problems, using a single significant item as an example.

Problem Control Center (PCC)

The charter for the Problem Control Center as well as a functional flow chart are contained in enclosed Standard Practice 10.015-ACL. (Encl. 1)

List of Active Problems

The enclosed list of active problems is the same list as carried on the PCC board and presented to NASA and MDAC management on 4 November 1971 during the OWS Checkout Readiness Review. (Encl. 2)

The list contains 22 open nonconformances. Each was evaluated for impact on start of Phase I (Power Off) of checkout and was determined not to be a constraint. As may be noted in the "status" column, Interim Use Material (IUM) parts were employed as a work around in some cases. The majority (13 of 22) of the items have been resolved insofar as the installed hardware is concerned but remain open for management and/or recurrence control action. All items except one (Radiator Bypass Valve) are electrical and are targeted for resolution prior to Phase II (Power On) of Checkout which is scheduled to start 3 January 1972.

Sample Problem Handled by PCC

P/N 1B79441-1, Inductor

Supplier - Vanguard Electric Company

Failure Report - FARR 502 024 146 dated 30 April 1971 (Encl. 3)

Discrepancy - Loose leads found by Receiving Inspection on 85 of 85 incoming Inductors from supplier.

Problem Chronology:

- 4 May 1971 PCC became cognizant of problem and initiated preliminary investigation.
- 5-6 May 1971 PCC reviewed problem witn Receiving Inspection and Development Engineering personnel.
- 7 May 1971 PCC classified FARR as significant problem, notified management and posted problem on the PCC board.

Sample Problem Handled by PCC (Continued)

- 10 May 1971 PCC prepared initial Problem Report. (Encl. 4)
- 12 May 1971 convened and chaired a meeting of representations of all involved departments to brief the problem and to devise a recovery plan. (Encl. 5)
- 13 May 1971 Engineering issued Stop Orders on all next assemblies, established new drawing configuration and initiated necessary revision to applicable drawings. (Encl. 6)
- 20 May 1971 PCC issued "Recovery Plan" summary sheet to program management which statused progress to date. (Encl. 7)
- 24 May 1971 Problem held in PCC pending shipment of new parts.
- June 1971 Receiving Inspection performed at MDAC on new parts and verified acceptable.
- June 1971 Problem closed by PCC.

SAFETY PANEL QUESTIONS

1. Specific role MMC is playing in the contamination problem noted by Mathew's Team Review.

Answer - MMC has a variety of integration tasks concerning contamination. The objective of these tasks is to establish component/module contamination constraints and assure that these levels are reflected in appropriate design requirements specifications. They can basically be broken up into four major areas which are; 1) contamination control, ground operations; 2) on-orbit contamination assessment; 3) contamination modeling and analysis; and 4) ground tests.

Contamination control-ground operations establishes and assesses contamination levels, controls, and requirements applied to each module, experiment and GSE during periods of manufacturing, testing, handling, and transportation (including KSC operations).

On-orbit contamination assessment includes the determination of contamination sources, composition, and quantities of contamination to determine problem areas and recommend corrective action. This analysis is also used to determine the susceptibility of experiments and operational surfaces to contamination. Plans and procedures for real time mission evaluation of contamination for the Cluster is also established.

Analytical modeling and analysis covers developing analytical models that will predict the behavior of the contaminant cloud and surface desposition to establish the effects on operational conditions and materials. Baseline data for all models will be developed through reviews of industrial experimental test programs and ground tests programs which have been developed to provide specific data for these models.

The Skylab Contamination Ground test program is being run to obtain data on contaminate cloud behavior and surface deposition in a simulated space environment using the actual Skylab hardware where possible. Data generated by these tests will be used in the analysis effort previously described to check the validity of the math models in making pre-mission predictions of the extent and nature of contamination problems likely to be encountered.

2. Does MMC have as a SE&I task the assurance that cluster has across-the-board, consistent panel nomenclature, coordinate axes, etc?

Answer - There are no current SE&I tasks to assure that the cluster has across-the-board consistent panel nomenclature. Information on the status of the individual modules will be forthcoming since the module contractors are currently under contract to produce a document on panel nomenclature and MMC is planning to propose such a document for the experiments.

2. (Continued)

A level of commonality in this area has been accomplished through normal MMC participation in the various program reviews (PDR, CDR, C^2F^2, etc.). This type of activity will continue.

The Cluster Requirements Specification (CRS) requires that all modules eventually meet the requirements therein on the labeling of coordinate axes. There is no SE&I task to track compliance of this item.

The use of different types of switches, lighting, meters, etc. is another area of inconsistency for which no SE&I task exists. This situation has occurred by the levying of different constraints on the various contractors. For example, the ATM C&D console employs EL lighting and separate switches and circuit breakers whereas, the OWS employs overhead lighting and combination switches/circuit breakers.

The extent of inconsistency in the above areas as well as other areas will be determined during the planned Skylab Systems/Operations Compatibility Assessment Review (SOCAR). With this information, changes to the hardware will be recommended in order to accomplish cluster wide consistency, or ground rules and constraints will be changed where the Skylab schedule does not allow for hardware changes.

3. Rationale behind the extent of testing electronic boxes (Flight Units). Question arose on the "Using up of life" of boxes.

Answer - The design integrity of electronic Systems and Components is verified by development and qualification tests performed by the vendor during the development phase. Final confirmation of the flight article performance is accomplished by acceptance testing immediately prior to delivery by the vendor. The acceptance test provides the assurance that the flight hardware will perform in accordance with the technical criteria established in the end item specification. These components do not undergo any additional testing to verify their specific performance characteristics. They are, however, functionally operated after installation or incorporation into a higher assembly or system to verify performance on a total systems basis. In summary, the concept is one of taking proven components and electronic modules (Black Boxes) and incorporating them into vehicle systems, and then testing the complete vehicle system.

A final mission simulation test is then performed on the total integrated vehicle to insure mission compatibility of all systems and readiness for flight.

This concept results in a minimum testing of flight hardware prior to flight while achieving the required degree of assurance of hardware performance.

3. (Continued)

Components which have limited life in terms of operating time or number of cycles are identified and special controls have been established to limit and control the ground usage and test of these items.

4. CRT on ATM C&D Panel - how are these made "Safe"

Answer - Both types of Cathode Ray Tubes (CRTs) used in the ATM C&D Console include design features and qualification testing that demonstrates that they are safe under the conditions considered. These same conditions could cause hazardous ruptures when the glass faces of the CRTs are unprotected.

The design approach for one type of CRT, used for the two 6 1/2 inch monitors, was to apply an epoxy type coating over the glass face of the tubes. The design technique for the other CRT, the 1 1/2 inch X-Ray Scope, was to install the tube in a protective metal sleeve with a transparent end cap. This end cap has a Pyrex glass face and a Lexan plastic inner shield bonded to the metal sleeve. Specific design details are available upon request.

The two types of CRTs were subjected to the same standard impact test. This test consists of dropping a 50 gram steel ball from a height of eight (8) feet on the CRT faceplate. The results of the first drop on the TV Monitor CRT were satisfactory (no breakage) but impacted two (2) inches from the edge so the test was repeated. The second impact test resulted in a crack at the back of the TV tube. The test was considered satisfactory as the exposed surface, the faceplate of the CRT, did not break or fail.

The test results for the X-Ray Scope were satisfactory as there was no failure under these test conditions. Test results are available for conditions in excess of the requirements.

5. Question on "Closed loop" of changes at MSC that impact crew timelines and procedures.

Answer - During the recent Safety Panel review, it was pointed out that there was no closed loop configuration control system between the hardware change system and the procedures change system. This deficiency in the system has also been pointed out to CPD personnel. The Chief of the Crew Procedures Division has accepted an action item to investigate the control of all crew data. He in turn has assigned TRW to generate an initial "Crew Data Control Plan". A steering committee to input and critique this plan will be formed prior to February 24, 1972.

6. MMC-MDAC-E relationships on handling of MDA at MDAC-E. Include problems noted by MDAC-E's handling of MDA upon receipt at St. Louis.

Answer - MMC is experiencing the usual problems that could be expected of two large aerospace companies trying for the first time to work together. Generally MDAC-E has been cooperative, and does react to our needs. No major problems presently exist. There are several points of disagreement with respect to how to keep records, and general ways of doing business. However, these are being worked jointly, and satisfactory compromise solutions are expected.

7. Question on glass window re:

- Flight and Test articles from same batch?
- Design of installation. Hornbeck says it should be in compression only. MMC says no.

Answer - See attached letter to Dr. John A. Hornbeck.

8. Electrical wire in some cases not covered by metal or other cover to protect against inadvertant step on or other punishment.

Answer - Exposed cabling falls into three categories:

1. Cabling attached to items that involve in-flight maintenance and replacement. This is the category that most obviously falls into a class that might result in usage as a handhold, see the attached photograph. Every effort has been made to make the service loop as protected and as short as possible and still meet the requirements for easy astronaut service.

2. Cabling attached to components that are temporarily stowed for launch and then relocated. Obviously this is a temporary situation that is not an item of major concern.

3. Items not individually covered but are protected by surrounding structure or equipment. The basic approach to internal MDA wiring has been to minimize the possibility of wire damage by astronaut contact by either use of covered cable trays or placement of wiring in such a manner that there is little probability of accidental contact. All exposed wiring has been subject to detailed reviews by both MMC personnel and the astronauts based on this ground rule.

While we feel the present design has met our objectives it will be carefully monitored during training exercises and subsequent crew reviews such as participation in ground tests and C^2F^2 exercises. Any deficiencies noted will be corrected prior to flight.

9. More specifics on "open work" being shipped to KSC for MDA.

Answer - At the present time no modification kits for installation at KSC are programmed for any MMC built hardware. We are exercising top level management control of this situation and require the signature approval of the Vice President of Manned Space Systems before any such work will be authorized. There are several potential changes that will probably impact GFP installed in the MDA although the only fully defined item is a requirement to reinstall the Proton Spectrometer after rework and recalibration at MSFC.

10. Final results of analyses and closeout of Centaur examination.

Answer - The results of the Centaur report have been reviewed in depth by the Directors of Manufacturing and Test and of Quality. In addition Mr. Gerald Brewer of Langley who was a member of the investigating panel has been personally contacted at some length to get further insight to the problems uncovered. At this point in time we feel that wherever action was warranted we have initiated steps to achieve the necessary improvement. Closeout can only be achieved by monitoring the effectiveness of these actions.

11. Do you have a safety standard for operation of fork lifts and other materials handling equipment?

Answer - The Martin Marietta Corporation has a safety standard for the operation of company vehicles. This standard is V-4.0 dated 1-4-71 and is applicable to any company vehicle, including fork lifts.

The standard requires a periodic physical examination, requires a safety check list for the vehicle which must be completed prior to each operation of the vehicle and stipulates other requirements/safe practices while operating the vehicle.

12. When have the contents of this safety standard been reviewed with your materials handling equipment operators?

Answer - Safety Standards are periodically reviewed in the Industrial Safety "tool box" safety meetings.

13. Are your materials handling equipment operators regularly examined and certified?

Answer - Materials handling personnel receive regular physical examinations but are not certified for the job except in the case of crane operators/riggers.

14. Do your industrial safety personnel review procedures for lifting and transporting high value hardware? Do they approve and sign?

Answer - MMC safety personnel review and approve all procedures involving movement of high value hardware.

15. Are your industrial safety personnel involved in planning and advising on safe movements of high value hardware?

Answer - MMC safety personnel are involved in planning and actual move operations of all high value hardware.

16. Do your personnel involved in lifting and moving high value hardware have regular safety meetings? Do industrial safety personnel attend these meetings?

Answer - The movement team is always assembled for a pre-move meeting in which all pertinent details, including safety provisions, are discussed. Industrial safety and System Safety personnel attend these meetings.

MARTIN MARIETTA CORPORATION

DENVER DIVISION

POST OFFICE BOX 179 DENVER, COLORADO 80201 TELEPHONE (303) 794-5211

January 25, 1972

Dr. John A. Hornbeck
Sandia Laboratories
Albuquerque, New Mexico 87115

During your review of the Martin activity on Skylab on January 10th, you suggested a professional look at the MDA/EREP window installation. I would appreciate your identification of such a professional. We will proceed to contact that individual to arrange for his review of the design. Two consultants have previously been involved.

The first consultant that we engaged on the S190 Window was Mr. Joseph A. Kies who visited us on December 17, 1970. For many years Mr. Kies worked for the Naval Research Laboratory at White Oak, Maryland under the direction of Dr. G. R. Irwin who is a noted authority and has developed the technique of fracture mechanics on brittle materials.

Both Dr. Irwin and Joe Kies have retired from NRL after many years in the government service and Dr. Irwin is now a Professor in Mechanical Engineering at Lehigh University at Bethlehem, Pennsylvania. Mr. Kies is now a consulting engineer working for himself at the address 5407 Surrey Street, Chevy Chase, Maryland 20015. Mr. Kies is also consultant on a deep submergence vessel with glass windows for the Naval Research Laboratory and has also done consultant work for the Bureau of Standards in Washington. During his association with Dr. Irwin at NRL, Joseph Kies was in charge of all the experimental laboratory work associated with Dr. Irwin's fracture mechanics investigation.

The second consultant who helped us on the S190 Window was Mr. Leighton Orr who visited us on September 30, 1971 to discuss the results of our breaking strength tests on BK-7 glass.

Mr. Orr is Head of the Physical Testing Department, Glass Research Center, PPG Industries, Pittsburgh, Pennsylvania. He has been associated with Pittsburgh Plate Glass for over 20 years and it was here that he developed the concentric-ring method of testing glass specimens. Mr. Orr has been directly involved with the physically testing of literally thousands of pieces of glass, to determine the breaking strength of glass and, wherever possible, the cause of the failure by identifying the point at which the failure started whether it be surface scratch, surface crush, deep fissure, etc. Mr. Orr stated that we were conducting our tests properly and did not suggest any changes in our test procedure. He plans to retire in February, 1972.

A question with regard to whether the windows in the Program all came from the same glass melts was left unanswered during the meeting. Enclosure one supplies that information.

K. P. Timmons
Program Director
Skylab/MSFC

KPT:pn

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ENCLOSURE 1

BK-7 GLASS MELT DATA

OHARA GLASS COMPANY

	Usage	Melt No.	Structural Testing
1.	Experimental (Uncoated) Test Model - S190 Window (Full Size)	5210	18.6 PSI Press. (Window) Vibration, Shock, Impact
2.	Development Model S-190 Window (Full Size)	3948	18.6 PSI Press. (Window) Vibration, Shock
3.	Qualification Model S-190 Window (Full Size)	3948	30. PSI Pressure (Glass) 18.6 PSI Press. (Window) Vibration, Shock
4.	Flight Unit S-190 Window (Full Size)	5262	30 PSI Pressure (Glass) 12 PSI Press. (Window) Low Level Random Vibration
5.	Backup Unit S-190 Window (Full Size)	3705	Ditto
6.	Spare Glass No. 1 (Uncut)	5390	None
7.	Spare Glass No. 2 (Uncut)	5478	None
8.	Test Specimens (57) (6" Dia x 1/4)	5066	11 PSI Pressure Concentric Ring
9.	Test Specimens (63) (6" Dia x 1/4)	6010	11 PSI Pressure Concentric Ring
10.	Test Specimens (40) (6" Dia x 1/4)	5507	11 PSI Pressure Concentric Ring

John -
The working pressure during the manned mission is 5 PSID. Unmanned it is less.

Ken T

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

MAR 21 1972

REPLY TO ATTN OF: MM

TO: APA/Special Assistant, Aerospace Safety Panel

FROM: MM/NASA Director for Life Sciences

SUBJECT: Suggested Response to Action Item, December 1971, Aerospace Safety Advisory Panel Meeting - "ICONS"

Following the comments by Dr. Harold Agnew at the Aerospace Safety Advisory Panel meeting, the Office of Life Sciences undertook a review of the subject of ICONS (Stable isotopes of C, O, N and S). This examination looked at the subject of ICONS at two levels: (1) their use and application to Skylab (i.e., Skylab Medical Experiments Altitude Test /SMEAT/ and flight experiments); and (2) their subsequent applicability as a method for future measurements of biological factors.

The conclusions drawn from this review are as follows:

1. The availability of quantities of the various ICONS, up to now, has been quite limited. As a result, the experience with the use of these materials in ground-based laboratories is also quite limited at this time.

2. Until a sufficiently extensive data base is available upon which to reach a decision to substitute the use of an ICONS technique as a replacement for standardized and well established techniques, ICONS should not be recommended for use in flight programs such as Skylab (i.e. SMEAT and flight). It is concluded therefore that the substitution of ICONS techniques on Skylab is not advisable. As was presented at the Safety Advisory Panel meeting, the Skylab SMEAT is to be performed as near a ground-base dress rehearsal for the medical experiments to be done on the Skylab flights. The SMEAT therefore cannot be considered as a separate and discrete entity from the flight tests. Thus, the use of ICONS for the SMEAT is considered unacceptable as a substitute for a current onboard measurement or as a new ground technique to collect data for Skylab.

Attachment F

3. Extensive ground-based experience is also needed to establish the value of ICONS as a means for obtaining both new types of data and new measurements for the future. The use of ICONS do appear most promising and offers potential as a future research tool for biological measurements. To this end, NASA Life Sciences will continue to examine ICONS as a developing technology.

4. ICONS will be discussed at the next Life Sciences Committee (LSC) meeting (the scientific advisory group for NASA Life Sciences) in April. Dr. Wright Langham from Los Alamos is being asked by the LSC Chairman to present the AEC experience with these materials to the committee. Through this presentation and discussion, the LSC will have the opportunity to recommend what course NASA should take relative to the use of ICONS for the future.

The above review and the NASA conclusions, discussed above, were reached following Dr. Agnew's comments at the Aerospace Safety Advisory Panel meeting. We considered his comments about ICONS as being offered as a means for improving our data return from the Skylab ground testing program. We wish to thank Dr. Agnew for his comments because we feel that he has focused our attention to a very promising technique for the future.

Charles A. Berry M.D.

Charles A. Berry, M. D.