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

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.

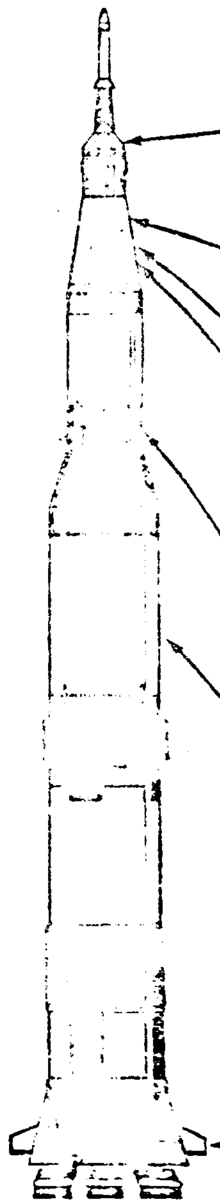
Specific conclusions are noted in the Apollo 15 report. In general the Panel concluded that those organizations involved in the review provided reasonable evidence that they have applied careful planning and responsible management to the design, development, and qualification of new and modified elements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

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 $\approx 270^{\circ}$ 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:

- o Redundant wiring and separate paths and accessibility for maintenance and inspection.
- o Lay-in cables as opposed to feed-through to avoid captive wire harness and precludes wire damage and allowance for slack for equipment removal.
- o Preclude adjacent connector interchangeability through: different shell size, angle potting, clamping, connector insert positioning, and identification marking.
- o Adequate circuit protection.
- o No unprotected wiring is routed inside the pressurized area.
- o 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