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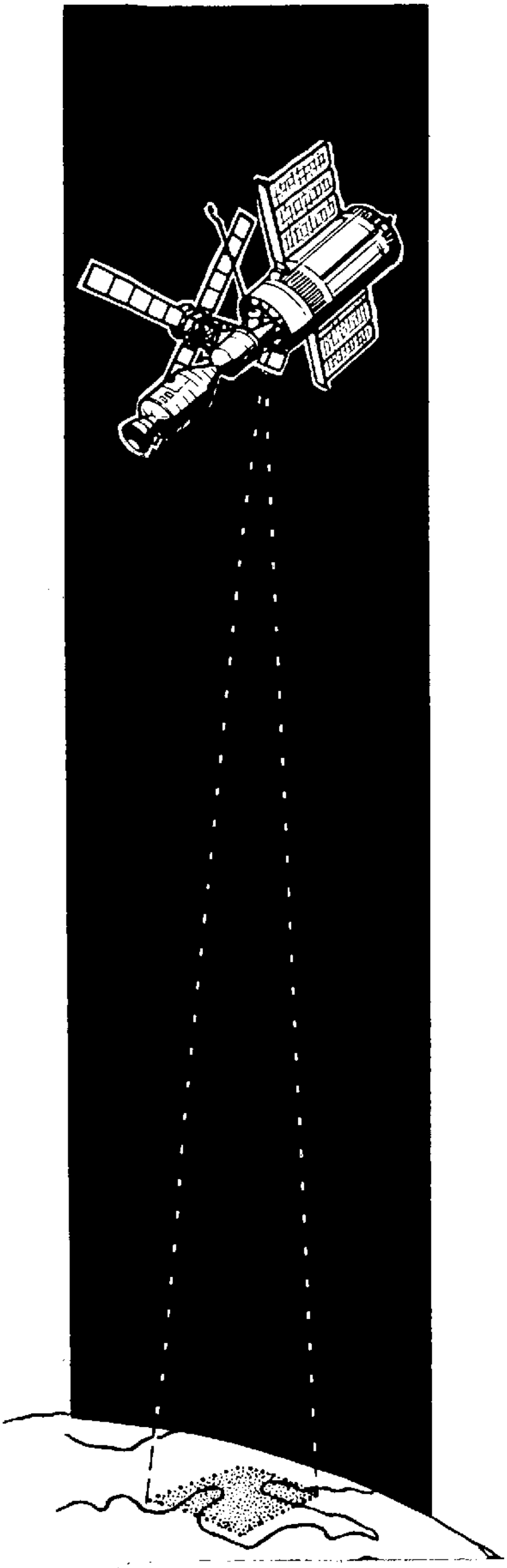

REPORT TO THE ADMINISTRATOR BY

DRA

THE NASA AEROSPACE SAFETY ADVISORY PANEL

ON THE SKYLAB PROGRAM

JANUARY 1973

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

OFFICE OF THE ADMINISTRATOR

4 January 1973

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 attached Skylab Report to the Administrator which also serves as our annual report for 1972. This two-volume report summarizes our activities and provides Panel conclusions and recommendations for your consideration. Panel reviews of NASA Center and Skylab contractors activities were conducted from September 1971 through 1972. Our detailed observations of the activities at the KSC will take place during the next few months and will result in a supplemental report.

Our efforts to date have provided ample evidence that the NASA/Industry team is mature and continues to apply careful planning and responsible management to the hardware, software and checkout operations. There are, however, some areas which continue to require emphasis in the months to come if the current high level of performance is to be maintained. These include mission operational areas and cluster change control and integrated testing as outlined in our conclusions and recommendations.

For the entire panel, I want to emphasize that this report and the panel efforts it represents were accomplished under the leadership of Dr. Charles D. Harrington as Chairman. His resignation as Chairman and as a member of the panel is a significant loss to the panel and to NASA as well.

Yours sincerely,

C. H. DUNN
Lt. General, USA
Chairman, Aerospace Safety
Advisory Panel

PANEL

Lt. Gen. Carroll H. Dunn, USA (Current Chairman, Dec. 1972 -)
Director, Defense Nuclear Agency
Washington, D.C.

Dr. Charles D. Harrington (Chairman, 1968 - 1972)
President, Douglas United Nuclear, Inc.
Richland, Washington

Hon. Frank C. Di Luzio
Special Assistant to
Senator Clinton P. Anderson
Washington, D.C.

Dr. Henry Reining, Jr.
Dean, von KleinSmid Center of
International and Public Affairs
University of Southern California
Los Angeles, California

Mr. Bruce T. Lundin
Director, Lewis Research Center
NASA
Cleveland, Ohio

Dr. John A. Hornbeck
Vice President, Bell Telephone
Laboratories, Inc.
Murray Hill, New Jersey

Dr. Harold M. Agnew
Director, Los Alamos Scientific Laboratory
University of California
Los Alamos, New Mexico

CONSULTANT

Dr. William A. Mrazek
Associate Director for Engineering
Program Development
Marshall Space Flight Center
Huntsville, Alabama

STAFF

Mr. Gilbert L. Roth
Special Assistant
Office of the Administrator
NASA
Washington, D.C.

Mr. Carl R. Praktish
Executive Secretary
Office of the Administrator
NASA
Washington, D.C.

Mrs. V. Eileen Evans
Administrative Specialist
Office of the Administrator
NASA
Washington, D.C.

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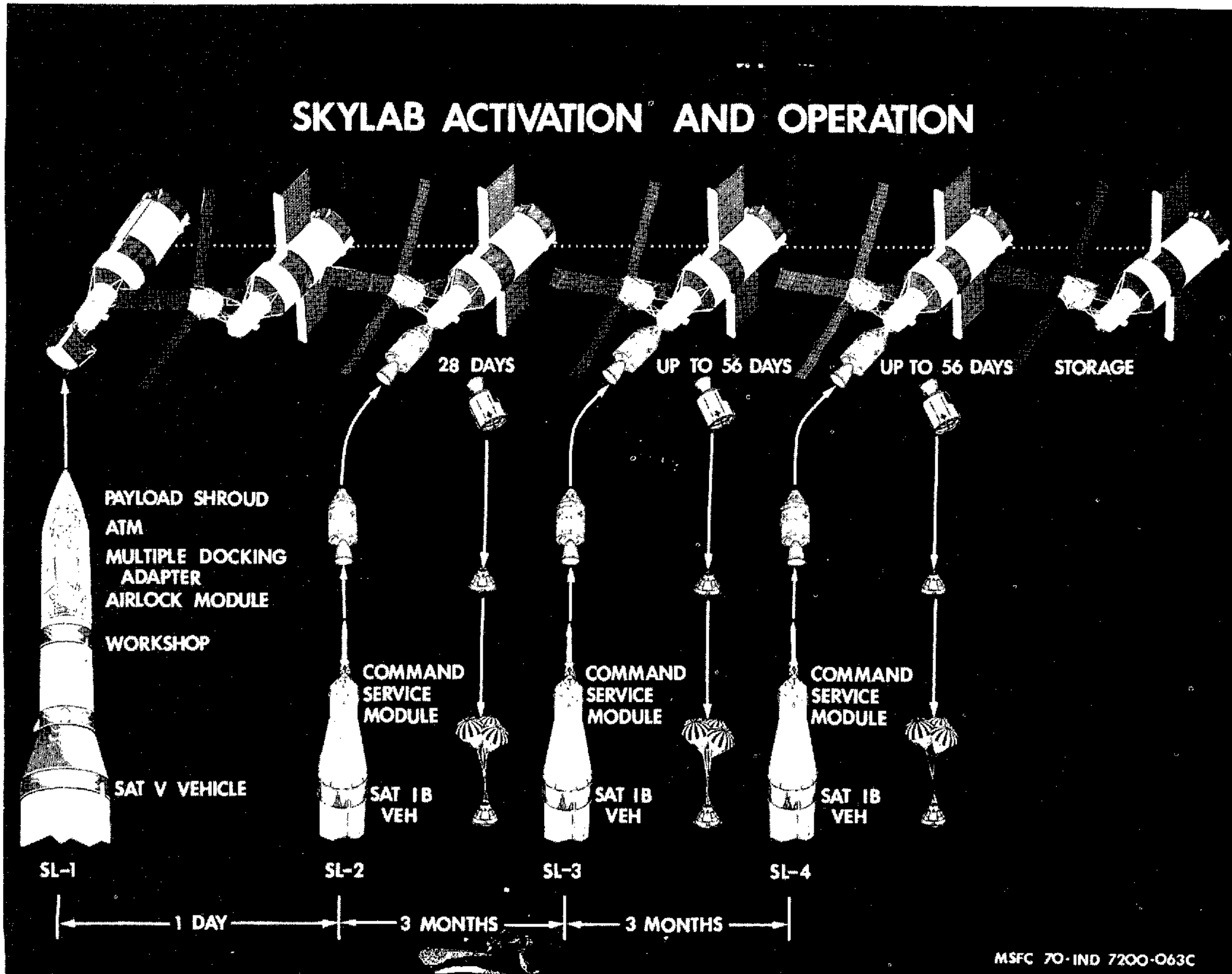

SKYLAB PROGRAM

A REPORT TO THE ADMINISTRATOR

by

THE NASA AEROSPACE SAFETY ADVISORY PANEL

Volume I - Summary Report

January 1973

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I. SUMMARY

The Skylab program represents a large and potentially significant step forward in manned space flight. Following closely on the Apollo program, Skylab will, through medical research and experimentation, through development of mission operations and work procedures, and by exploitation of many practical applications of space-based observations, do much to further both the definition of the role and the utilization of the capabilities of man in space. Such an extension of knowledge and capabilities naturally introduces many unknowns and new requirements beyond those of its predecessor programs. It is a new type of space mission. The extended flight duration, the lack of continuous contact with the ground, its one-of-a-kind nature, the possibility of unforeseen on-board human or equipment limitations, and the likelihood of conflicting priorities of real-time operation are either greatly extended by Skylab or new to manned space flight. It is to these expanded or new elements of space operation that the Panel has and will continue to direct its major attention during this review.

With its origins found basically in the Gemini and Apollo programs, many sources of real strength are apparent and fully utilized in Skylab. Outstanding among these strengths are the technical knowledge and experience of systems engineers, the skill and professionalism of mission operations personnel, and the effective management necessary to keep the many diverse elements of Skylab properly integrated. Not suprisingly, the Panel found the hardware composing the separate modules of Skylab to be available on time and of good quality.

The major challenge immediately ahead, and critical to the integrity of the entire program, is in two principal areas. One of these areas is the integration and checkout of the entire Skylab cluster at KSC prior to launch. The second is the method of control and decision making during the mission itself.

The total Skylab cluster now being assembled at KSC is a spacecraft of great technical complexity containing a broad scope and wide variety of experiments. The major modules involve many active interfaces and are being assembled for the first time at KSC. Integration, testing, checkout, and launch preparations are extensive, and complex tasks are proceeding on a very tight schedule. Overtime work in several areas is already high; several flight experiments are late; and several significant long-duration qualification tests are yet to be completed. Since Skylab is the first and only planned one of its kind, the work force is learning and performing its complex task without the familiarity with equipment and procedure that is developed by repeated operations.

The quality of the hardware seems good; the management processes in use appear effective; and the people on the job are both dedicated and experienced. However, much remains to be done on a schedule that has few, if any, allowances for unforeseen problems or surprises. The highly integrated and interactive nature of the cluster makes work-arounds due to late equipment and apparently insignificant changes a potential threat to the flight schedule and to the total program execution.

In this situation, it is particularly important that top program management give very special attention to these early indicators of possible problems ahead. A high change rate into January or February, the number of work-arounds being required, the amount of overtime necessary, and the unexpected events or problems experienced in checkouts are such factors to which management must be particularly sensitive. This sensitivity coupled with unusually prompt management action can resolve the problems and exert appropriate controls.

During the mission itself, unexpected events, real-time evaluations, and shifting of priorities among a multitude of tasks must be expected. While the detailed mission planning and control of time lines typical of Apollo must be developed as work-planning tools, the conduct of the mission will require a greater flexibility for immediate response to unforeseen limitations or unexpected opportunities. The operation of a long-duration mission is a new challenge. The procedures and techniques are being developed and are yet to be proved. This area thus remains a major concern to the panel. The training and retention of mission controllers and mission management throughout the long Skylab mission will also be a matter of continuing concern and one deserving of close attention.

II. INTRODUCTION

At the request of the Administrator, the Aerospace Safety Advisory Panel undertook an extensive review of the Skylab program. The Panel recognized that it could not review all significant activities or management systems. Therefore, priorities in our fact finding effort were given to those activities and systems we deemed most critical for crew safety and, then, mission success.

Therefore the Panel reviewed

a. Contractor development and manufacture of Skylab modules and the associated NASA management activities. This included fact finding trips to principal contractor and NASA management centers. These activities and our judgments thereon are documented in the Panel's Interim Report, which was included in the Panel's Third Annual Report.

b. NASA management activities for the evaluation of design and hardware maturity and mission operations planning and preparation. The Panel attended many of the significant internal reviews. Our activities and judgments on these activities are documented in this two-volume report. Volume I summarizes the scope of our review and our findings and conclusions. Volume II provides the supporting detail along with discussion on more specific items.

The Panel brought to this review questions developed through their individual experiences as executives and program managers. Their questions also reflected past reviews of the Apollo program. Thus, the members' desire is to provide the Administrator a perspective and independent judgment not otherwise available in NASA.

III. PANEL REVIEW

A. Scope of Panel Review

This review process combines four fact-finding phases to provide assessment and recommendations on management systems for hazard identification, risk assessment, and actions to minimize the effects of these hazards and risks. The first phase covered NASA and contractor technical management for the development of the Skylab modules. The second phase covered systems integration and the "design" and "hardware acceptance" review process. The third and fourth phases will focus on launch preparations at KSC and actual mission operations, respectively.

During Phase I the Panel surveyed the principal contractors. This survey provided a review of those systems having the greatest bearing on crew safety. Particular attention was given to the module systems for electrical power, environmental and thermal control, and habitability and crew accommodations. The following management controls were emphasized: (1) configuration and interface management, (2) vendor control, and (3) quality control of workmanship. The results of this activity, covering the period from September 1971 to February 1972, were included in the Panel's Third Annual Report.

Launch vehicles were reviewed as a part of Phase I. However, fact-finding visits began subsequent to the issuance of the Panel's Third Annual Report, and the results of that review are presented in this report. For the modified two-stage Saturn V launch vehicle, the Panel focused on (1) modifications to accommodate the Skylab payload, (2) resolution of prior flight anomalies, and (3) changes in personnel and management systems. For the Saturn I-B launch vehicle the Panel covered possible age-life and storage problems in addition to those items just noted for the Saturn V.

As previously indicated, the Phase II portion of the Skylab review centered on (1) NASA program management's visibility and control of contractor operations, (2) systems engineering and integration, (c) the review process for the evaluation of design and flight hardware, and (4) the planning process for mission operations. This was accomplished through scheduled Panel meetings at each NASA center and by attendance at significant NASA-contractor evaluation and hardware acceptance activities.

The schedule of Panel activities during Phases I and II is shown in table I.

To be reported on in the future is Phase III of the review process, which began in December 1972 at KSC with an initial look at the delivered Skylab hardware and its current posture. This phase will also cover the prelaunch period at KSC. Particular attention will be given to two areas: first, mission operation planning including time-line development, development of rules and procedures for the decision-making process during the mission, experiment priority, personnel training, and working level mission operational documentation; and second, KSC test and checkout activities, personnel skill retention and motivation, and prelaunch review system.

During Phase IV the Panel expects to examine the actual implementation of the specific mission operation procedures during the 8-month mission period.

B. Criterion for Assessment by the Panel

Primary consideration was given to the ability of the program management to anticipate and correct problems before they assume serious proportions. In assessing management actions the Panel examined the following areas:

a. Proof of design and hardware maturity of new and modified elements of GSE, launch vehicles, and CSM; new Skylab modules and components, OWS, ATM, AM, MDA, and experiments; and mission launch and operational plans and required documentation (abbreviations are defined in appendix B)
b. Utilization of safety functions and the risk assessment system
c. Adequacy of the review system to validate compatibility of specifications, drawings, hardware, and test results
d. Test failures and their analysis and resolution
e. Retention of critical knowledge and skills with diminishing contractor and vendor work loads
f. Program management's ability to integrate NASA-contractor-vendor efforts

C. Procedures

The Panel worked through an extensive data-gathering process whereby Panel members form and refine their judgments. Thus, the Panel, as a group or individually, visited the appropriate NASA centers and contractor sites for presentations on topics of significance to the Panel. The Panel also attended internal NASA and contractor decision meetings to observe the process involved.

The Panel organized its activities to assure that appropriate data were brought before it. In addition, the agenda for each visit was coordinated by the Panel Chairman and staff with OMSF and Skylab management to assure the availability of key personnel to present and discuss such data. The Panel provided this agenda information to the Deputy Administrator for any additional requirements on items of particular concern to him. These procedures provide the maximum relevant data upon which the Panel can make useful judgments.

D. Phase I Assessment - Development and Fabrication of Modules

Based on the Phase I data-gathering activities the Panel noted its observations of the contractor's management adequacy. These are summarized here and are found in more complete form in the Panel's Third Annual Report. The Associate Administrator for Manned Flight and the Skylab Program Manager were most responsive to the Panel's assessments, and their reply to the report is found in appendix D in this volume.

Policies and Procedures - Contractor policies and implementing procedures for design and fabrication activities were found to be comparable to those of the Apollo program. The Panel paid particular attention to and was generally satisfied with the following areas: (1) systems engineering, (2) configuration management, (3) interface control, (4) test integration, (5) reliability, and (6) quality and safety. Specific areas of concern have either been resolved or are being actively pursued by appropriate management levels.

Planning - Each review provided significant 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. The process has effectively utilized prior government and industry experience. The planning process has been sufficiently flexible to respond to changing requirements, fund limitations, and the learning curve. An example of this was the ability to accommodate the recently approved Earth Resources Experiment Package (EREP) hardware and associated interface requirements.

Assignment of Responsibilities for Module Development - The Skylab program management responsibilities were assigned to the various NASA centers as shown in figure 1, with the Marshall Space Flight Center (MSFC) having the prime responsibilities. All contractors made use of experienced contractor personnel from previous manned spaceflight programs or related non-NASA activities. NASA management has been able to support contractor activities with task teams to meet specific test and manufacturing problems as they have arisen. Senior NASA and contractor management

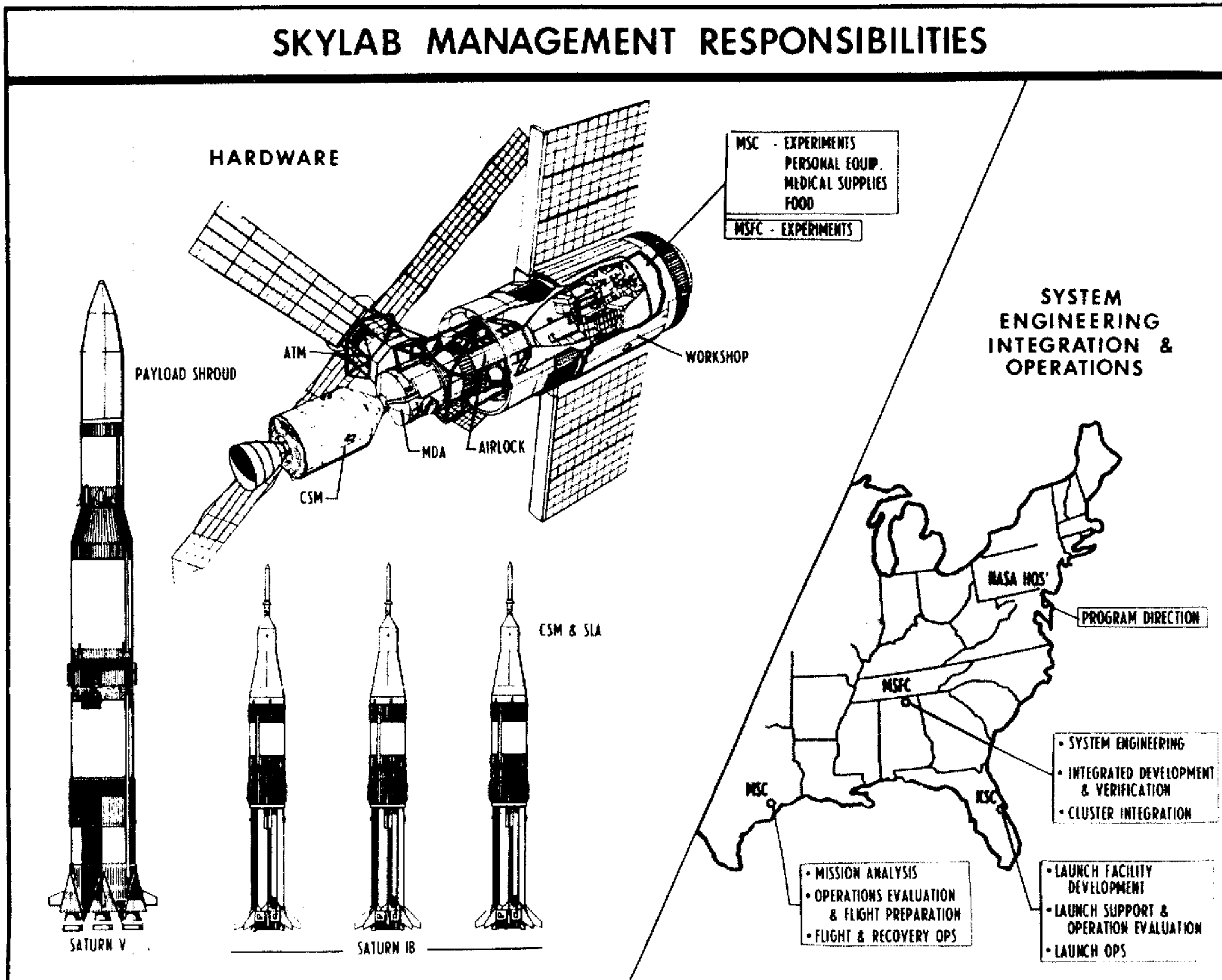
SKYLAB MANAGEMENT RESPONSIBILITIES
HARDWARE
MSC - EXPERIMENTS
PERSONAL EQUIP.
MEDICAL SUPPLIES
FOOD
MSFC - EXPERIMENTS
ATM
WORKSHOP
PAYLOAD SHROUD
MDA
AIRLOCK
CSM
CSM & SLA
SATURN V
SATURN IB
SYSTEM
ENGINEERING
INTEGRATION &
OPERATIONS
NASA HQS'
PROGRAM DIRECTION
MSFC
• SYSTEM ENGINEERING
• INTEGRATED DEVELOPMENT & VERIFICATION
• CLUSTER INTEGRATION
MSC
KSC
• MISSION ANALYSIS
• OPERATIONS EVALUATION & FLIGHT PREPARATION
• FLIGHT & RECOVERY OPS
• LAUNCH FACILITY DEVELOPMENT
• LAUNCH SUPPORT & OPERATION EVALUATION
• LAUNCH OPS

FIGURE 1

have met the challenge posed by diverse contractor locations and decentralized program management.

Control of Suppliers - The contractors were aware of their responsibilities in areas involving both in-house manufacturing and supplier activities. In-house monitoring and auditing sought to maintain a high level of quality and skill and to maximize safety in such areas as manufacturing processes and personnel training. All contractors indicated problems with one or more suppliers because of the current aerospace business posture and the relatively small Skylab hardware quantities involved. Control of the individual contractor's suppliers is a function of their current business load and prior relations as well as the criticality of individual items of hardware.

Interface Control - As in the Apollo program, Skylab, with its multiple hardware modules and geographically diverse locations, requires strict interface management between contractors and NASA centers. NASA directives, implementing procedures, contract requirements, and collective effort of working level personnel have tended to minimize interface problems. Apollo-type intercenter working groups, panels, and Configuration Control Boards (CCB's) continue to be the major force here. Examples of these activities are (1) Contamination Control Working Group, (2) Stowage Working Group, (3) Microbiological Working Group, (4) Materials Application and Evaluation Board, (5) Fire Hazards Steering Committee, (6) Vibroacoustic Test Control Board, (7) Flight Operations Planning Group, (8) Experiment Operations Panels, and (9) ICD Panels. We noted that Skylab management reviews showed some lag in the paper system, some inconsistencies in hardware interfaces in early stages of testing and problems in relations of experiments to modules. None of these were major in nature. Interface control at KSC, which will be examined in Phase III, is considered vital, since this will be the first time the vehicle systems come together as an integrated unit.

Launch Vehicles - This segment of the Phase I review was conducted after the issuance of the Panel's Third Annual Report. Therefore, it is included here as a separate Phase I review item, and is covered only in sufficient detail to provide understanding of launch vehicle status.

This review was aimed at determining (1) the status and problem resolution of Skylab launch vehicles and management systems, (2) management ability to maintain technical excellence in hardware and operations, and (3) interfaces between centers and contractors. Involved in the review were the Chrysler Corporation (S-IB), The Boeing Company (Saturn V), and MSFC Launch Vehicle Program Office, and the contractors for the S-II (North American Rockwell) and the IU (IBM Corporation).

A brief discussion of the Apollo-Skylab mission differences and the history of the S-IB stages is necessary for an understanding of launch preparation activities. The first stage of the Saturn I-B built by Chrysler was last used to launch the Apollo 7 mission on October 11, 1968. The remainder of the stack (S-IV-B and IU) have been flown on Apollo missions up to the present time. In the case of the first Skylab launch, SL-1, the major differences include an abbreviated stack consisting of the S-IC, the S-II, and a revamped IU which becomes a part of the orbiting cluster. Skylab payload weights have been shown to be well within the modified launch vehicle capability. Differences are noted in table III. In the case of the SL-2, SL-3, and SL-4 missions the Saturn I-B vehicle configuration is essentially the same as that used on the Apollo 7 in 1968. Modifications include an increase of the H-1 engine rating from 200,000- to 205,000-pound thrust and the ability to use the spacecraft guidance system as backup to the launch vehicle guidance system. The launch from Complex 39B rather than the now inactivated Complex 37 requires the use of a large pedestal structure because of the difference in height of the S-IB launch vehicle and the launch tower service arms at this complex.

The first Skylab launch, SL-1, still has a number of open requirements to be fulfilled. These include (1) control, stability, and dynamics analyses, which should be available for checking purposes in early 1973, (2) final verification of aerodynamics analyses, scheduled for the end of 1972 and early 1973, and (3) final analyses of tracking and communications requirements, scheduled for early 1973.

During its visit to Michoud and through subsequent information, the Panel examined the possibility of structural sag for vehicles held in long-term storage, utilization of MSFC manpower to manage the launch vehicle programs, malfunction vs manpower history, the consequence of reduced interlocks, and the IBM and General Electric Company roles. Because the Panel did not visit the last two contractors, it requested background data on their current activities. With respect to General Electric's role, the Panel received data on (1) significant problems encountered in building up to meet contract requirements, (2) their responsibilities on SL-1, SL-2, SL-3, and SL-4 GSE design, test, installation, manufacturing, and input to KSC operations, and (3) current and projected manpower levels. With respect to the IBM role, the Panel received data on (1) manpower history, (2) rationale for specific skill retention, and (3) interface with other modules since IU-513 is an integral part of the orbiting cluster.

Because the modified Instrument Unit stays with the cluster in orbit, it was subjected to additional extensive qualification tests. During vibroacoustic tests the modified Skylab IU was found to be more responsive to vibration than the equivalent Apollo unit. Twenty-two components failed, but after modifications were made all units passed their qualification retests. Such programs provide a high level of confidence in the ability of this IU to meet mission requirements.

E. Phase II - Module Acceptance and Cluster Integration

During Phase II the Panel focused on the review system of the NASA centers for module acceptance and cluster integration. The responsibilities of the NASA organizations for systems integration are shown in tables IV to VII. The interrelation is complex but does recognize existing expertise and availability of management effort.

As the Panel reviewed the management systems, the following observations appeared particularly significant in forming our judgments.

Intercenter Relations - The organizational relations, both within and among centers and contractors, consist of many horizontal and vertical threads. The Panel through its fact finding activities was able to survey these relations as actually practiced. The formal communication and decision-making process, in the main, worked well. The complex intercenter and intercontractor interfaces resulting from MSC as the flight operations center utilizing MSFC developed spacecraft modules and individual systems being distributed across modules have at times resulted in data exchange and decision delays. They have also raised concerns regarding how Skylab systems design integration and performance are certified in light of the fact that design reviews have generally been on a module basis.

The Mathew's Review Board, convened to examine the Skylab program in light of the Apollo 13 experience, expressed concern in 1971 that past reviews of the overall cluster appeared to be made on a module-by-module basis. As a result of this, the Skylab Systems/Operations Compatibility Assessment Review (SOCAR) activities were initiated in November 1971 and conducted through June 1972. The SOCAR primary objectives listed below are indicative of its value to the Skylab Program and to the Panel in assessing program status and ability to resolve problems. The SOCAR objectives are

a. To assess the Skylab systems design integration and performance characteristics based on updated engineering analysis, simulations, and actual hardware test experience

b. To assess the operational readiness of Skylab through a detailed review of the mission documentation, plans, and techniques to be used by the operations team for the conduct of the actual mission

SOCAR did (a) furnish a vehicle for personnel responsible for planning the mission operational activities to come into direct working contact with those who designed and developed the hardware, (b) increase rapport between centers and expand upward communications to provide management with better program visibility, (c) provide a forum for the contractor, principal investigator or their representatives, and center personnel to discuss problems of mutual concern and to exchange new ideas to resolve new and old problems on a more timely basis, (d) help to expedite updating and planning for operational documents such as the Operational Data Book, Skylab Operations Handbook, and Skylab Flight Mission Rules, and (e) provide an excellent basis for the design certification process which followed.

Many of the SOCAR teams did not have KSC participants. This added to the difficulty of examining the compatibility between Skylab Orbital Assembly design and requirements from the point of view of KSC responsibility.

On the whole, however, the SOCAR was a major step in achieving inter- and intra-center and contractor cooperation, commonality of technical understanding, and continued motivation and a sense of teamwork. Retaining the framework of the SOCAR team structure keeps it available as a problem solving mechanism throughout the remainder of the program.

Program Review Process - The Panel observed the Design Certification Reviews and NASA Hardware Acceptance Reviews to evaluate the maturity of the hardware prior to delivery to the KSC.

The Design Certification Review (DCR) process is described in Skylab Program Directive 17, dated March 7, 1972:

"The DCR's are supported by the normal Center design review processes. They involve examining the design performance and verification of the major contract end items, the integrated cluster systems, the significant crew and experiment interfaces and mission operations activity to assess and certify that the equipment and operational elements can accomplish the planned Skylab missions. Specifically, the Skylab DCR's are conducted to:

1. Assess and certify the adequacy of the performance design requirements and verification programs of the major Skylab end items and their interfaces as a complete space vehicle system for flight worthiness and manned flight safety.
2. Assess and certify the design adequacy of the Launch Complex, Mission Control Center and the Spaceflight Tracking and Data Network; and
3. Assess and certify compliance with established Safety and Program Reliability goals. (Numerical reliability goals are excluded)."

The Panel examined the hardware management in terms of the following questions: (1) How well are the design requirements known and controlled? (2) How well do the substantiating data prove requirements? (3) What problems were encountered and resolved? (4) What are the remaining open items and the assessment of their impact on KSC? (5) What are the risks associated with critical items? (6) What are the risks associated with waivers and deviations?

The Panel representatives and staff attended those DCR's noted in table VIII. The following general observations can be made. The press of delayed hardware delivery, extended qualification testing, and anomaly resolution caused compression of the DCR schedule. Nonetheless the preparation and conduct of the reviews appear to have been thorough and to have covered the hardware and test verification. Some areas require furthur evaluation because of results from such tests as the Skylab Medical Experiments Altitude Test (SMEAT), the late delivery and test of experiments, and the late plans for stowage of equipment.

The coverage of the following areas appeared to be consistently good:

a. Identification of single failure points and rationale for acceptance
b. Identification of critical components for mission and crew safety
c. Caution and warning system analysis
d. Critical/redundant backup components
e. In-flight maintenance
f. Sneak circuit analyses
g. Waivers and deviations affecting reliability and safety

Predelivery and Turnover Review and Spacecraft Acceptance Reviews were conducted to assess module acceptability and its readiness for shipment to KSC. The reviews were conducted with Headquarters, MSFC, MSC, and KSC present at the contractor's site. Documentation was evaluated in advance to assure a realistic statement of the readiness of the hardware for launch preparations. Senior management met to review (1) the manufacturing and test history of the flight hardware, (2) variations from the design requirements, and (3) the open work to be completed before judgment can be reached on flight readiness.

In most cases a "walk-through inspection" was made by a team of qualified experts from the development centers to cover visible manufacturing quality, safety items, and general vehicle condition.

The "give-and-take" approach taken in these reviews produced constructive debate on every aspect of the design, fabrication, test, and end use of the hardware.

These reviews appear to have been effective in providing hardware and software that fulfill the end item specifications.

Skylab Medical Experiment Altitude Test (SMEAT) - During the Panel's attendance at the various in-house reviews the impact of the SMEAT was discussed. The SMEAT was a 56-day chamber test performed at MSC with a three man crew. The primary test objective was to obtain and evaluate baseline medical data on those medical experiments which reflect the effects of the Skylab environment. In addition, this test evaluated data reduction and data handling procedures.

Many hardware and operational problems surfaced during the test. Most of these appear to have been resolved, and those that remain concern the medical ergometer, the metabolic analyzer, and the redesign of the urine collection system. In addition, the Skylab mission time lines being developed at MSC will take into account the crew experience with the medical tests and housekeeping requirements.

The Panel was assured that a concerted effort was under way to resolve all the problems in a timely manner. A final report is expected on SMEAT in January 1973.

The Panel intends to examine this area further during Phase III to assure closure of open items and to develop an understanding of any impact on the work load at KSC.

IV. CONCLUSIONS AND RECOMMENDATIONS

In summary, the Panel is satisfied with (1) the technical management system for development and fabrication of the modules, spacecraft, and launch vehicles, (2) the process of design and hardware acceptance reviews, and (3) the risk assessment activities. Areas requiring management attention in the period ahead are (1) checkout activity, (2) integrated testing, and (3) preparations for and execution of mission operation.

1. The large extension of man's role in space afforded by Skylab presents many new challenges to the various echelons of program management. Among these new elements of manned space flight are the extended mission duration, the absence of continuous contact with the ground, the first-of-a-kind nature of the hardware and mission, the very complexity and scope of the equipment, and the need for flexibility of response to unforeseen limitations or opportunities during the mission. To date, program management has been able, within the limits of available experience and knowledge, to respond to these new challenges and resolve the many new problems and requirements that have been encountered.

2. The technical management system for design and fabrication of the modules appears adequate based on our review of contractors and the results of the design certification and module acceptance reviews.

3. The traditional system safety and reliability functions were augmented with a number of special working groups. They considered such areas as critical mechanisms, electric circuit malfunctions, and microbial and contamination control. The Panel is satisfied with the comprehensiveness of this risk assessment effort. Apollo experience was used in the systematic identification and evaluation of Skylab efforts. Finally, while there are flammable materials on board, the risk associated with them has been evaluated by management. This risk has been minimized by isolating flammable materials from ignition sources and propagation paths. This is a prudent and reasonable approach.

4. Cluster integration and the compatibility of the systems with operating requirements have been under review by numerous working groups, intercenter panels, and SOCAR. The system of review was generally satisfactory. However, the full effectiveness of system integration can be better evaluated after KSC testing.

5. Since the Skylab CSM's are a modification of the very successful Apollo CSM's and the contractor appears to be maintaining the technical management systems and skills, the Panel has a high degree of confidence in the capability of the CSM to do its assigned job. Past Apollo anomalies have been evaluated for their impact on Skylab.

6. In the Panel's opinion the launch vehicle stages have received the necessary attention during storage. The system for poststorage checkout and review appears

comprehensive. Modifications made to the stages do not impact crew safety. While launch teams for the Saturn V are present from Apollo, the development of new teams with appropriate skills for the S-IB will require continuing management attention.

7. Checkout and launch preparations of the cluster will be more extensive than those for Apollo because of the complexity of the modules and the number of interfaces involved. Module systems will be integrated into the cluster configuration for testing. Many of these interfaces will be functionally integrated for the first time. Experiments and other stowage items still have to be fitted aboard the modules. Problems will undoubtedly occur. Therefore, senior program management will need to closely monitor the system for the resolution of these problems to assure that risk assessment is accomplished at the appropriate level of management.

Based on the Apollo learning curve the operation of ground support equipment will again have to be carefully planned and controlled to avoid overexcitation of flight systems during test activities.

8. In order to obtain a confidence factor in qualifications by "similarity," the Panel requests a review of those problem areas encountered during checkout at KSC, where the item had been previously qualified by similarity rather than actual testing.

9. The extensive checkout and launch preparations of the cluster are to be completed within a tight schedule having a minimum of "unscheduled time" available for additional work. Therefore, senior program management must control additional work and be prepared to respond promptly to early indications of problems. Among those factors warranting particular management attention are (1) a high change rate in January and February, (2) the amount of overtime necessary, and (3) the unexpected events or problems experienced in checkout.

10. The Skylab program provides more opportunities for experiments and astronaut activities than can be accommodated during the available mission time. This must be accepted by all to assure realistic expectation of mission activities and results. Priorities will have to be maintained and time lines carefully planned accordingly. Adequate time must be provided for crew rest and personal requirements.

While the detailed mission planning and control of time lines typical of Apollo must be developed as work planning tools, the conduct of the mission will require a greater flexibility of response to accommodate unforeseen limitations or unexpected opportunities. Additional scientific opportunities will undoubtedly be discovered in flight. Housekeeping and experiment tasks may take more time in orbit than planned. This will require that the initial time line not be fully committed. Also, it will require a management system to revise priorities and time lines during the mission. The flow of information to mission controllers, the assembly and display of this information to mission managers, and procedures for near-real-time evaluation and operational decisions are areas requiring management's attention in the period ahead.

11. A number of significant open items and concerns noted by the Panel are highlighted as areas for further attention. The pace of the Skylab program and the normal problem solving process will to some extent have already closed or provided planned closures for a good many of the items noted. However, further test and checkout experience may indicate that, in fact, some may not have been successfully closed. Therefore, the Panel requests it be informed as to the final disposition made of the open items noted here.

a. The Skylab Medical Experiment Altitude Test (SMEAT). This test appeared successful in meeting the objectives set. It did, however, surface a number of hardware and operational problems. The more significant open items include

(1) Ergometer anomalies

(2) Urine collector insufficiency

(3) Metabolic analyzer anomalies

b. MSFC support of medical experiment hardware. The extent and mode of MSFC participation prior to and during the mission in support of medical experiment hardware developed by MSFC should be resolved at the earliest date. The hardware includes the ergometer and the metabolic analyzer.

c. Sneak Circuit Analysis status.

d. Testing to complete the Corona assessment.

e. Suit drying station problems and suit availability for emergencies.

f. Crew procedures for reaction to the loss of cluster pressure.

g. Results of further studies on the susceptability of the crew to dangers inherent in the inhalation of particulates during a mission.

h. Completion of hardware verification through qualification testing. At the time of the Panel review in November 1972 the qualification test status was

Module	Tests Remaining
Orbital Workshop	28
Airlock Module	10
Multiple Docking Adapter	0
Apollo Telescope Mount	4
Payload Shroud	1

i. Closure of three major open items on CSM:

(1) Adequacy of the tension-tie cutter and explosive charge system

(2) Qualification of the descent battery

(3) The discharge and/or safing of the RCS propellant system during reentry

j. Evaluation of Apollo 17 anomalies for their impact on Skylab cluster, launch vehicle hardware, and ground support equipment.

APPENDIX A

PANEL AUTHORITY

The Aerospace Safety Advisory Panel was established under Section 6 of the National Aeronautics and Space Administration Authorization Act, 1968 (PL 90-67, 90th Congress, 81 Stat. 168, 170).

The duties of the Panel are set forth as follows:

"The Panel shall review safety studies and operations plans referred to it and shall make reports thereon, shall advise the Administrator with respect to the hazards of proposed or existing facilities and proposed operations and with respect to the adequacy of proposed or existing safety standards, and shall perform such other duties as the Administrator may request."

APPENDIX B

ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

Skylab Orbital Assembly

AM	Airlock Module
MDA	Multiple Docking Adapter
OWS	Orbital Workshop
CSM	Command and Service Module
ATM	Apollo Telescope Mount
IU	Instrument Unit

Major Module Systems

ECS	Environmental Control System
TCS	Thermal Control System
EPS	Electrical Power System
HSS	Habitability Support System
CAS	Crew Accommodation System
SAS	Solar Array System

Other Major Hardware

PS	Payload Shroud
L/V	Launch Vehicle
SAT-V	Saturn V Launch Vehicle
SAT-IB	Saturn IB Launch Vehicle
GSE	Ground Support Equipment
CFE	Contractor Furnished Equipment
GFE	Government Furnished Equipment
MCC-H	Mission Control Center - Houston
LCC	Launch Control Center
EREP	Earth Resources Experiment Package
C&D	Control and Display

Skylab Reviews, Mission Terms

SOCAR	Systems/Operations Compatibility Assessment Review
DCR	Design Certification Review
PDTR	Predelivery and Turnover Review

COFW	Certificate of Flight Worthiness
FRR	Flight Readiness Review
FMEA	Failure Mode and Effects Analysis
SFP	Single Failure Point
SMEAT	Skylab Medical Experiments Altitude Test
EVA	Extravehicular Activity
SL-1	First Skylab Launch: Saturn V and Orbital Assembly less CSM
SL-2	Second Skylab Launch: Saturn IB with CSM 116
SL-3	Third Skylab Launch: Saturn IB with CSM 117
SL-4	Fourth Skylab Launch: Saturn IB with CSM 118

NASA and Industry Organizations

OMSF	Office of Manned Space Flight, Washington, D. C.
MSFC	Marshall Space Flight Center, Huntsville, Alabama
MSC	Manned Spacecraft Center, Houston, Texas
KSC	Kennedy Space Center, Florida
MDAC-W	McDonnell Douglas Astronautics Company, Huntington Beach, California
MDAC-E	McDonnell Douglas Astronautics Company, St. Louis, Missouri
MMC	Martin Marietta Corporation, Denver Division, Denver, Colorado
NR	North American Rockwell Corporation, Downey, California

Definitions

Saturn Workshop	The in-orbit space assembly which includes the Orbital Workshop (OWS), Airlock Module (AM), Multiple Docking Adapter (MDA), and Apollo Telescope Mount (ATM)
Orbital Assembly	The Saturn Workshop plus the docked CSM
Group-Related Experiments	Experiments that are closely related to each other either through common focus of study or by integration into a single subsystem; these are the medical, solar astronomy (ATM), and Earth resource experiments
Corollary Experiments	Experiments other than group-related or passive type that require significant in-flight crew support and are not closely related to each other
Passive Experiments	Experiments whose associated in-flight crew support requirements are almost nonexistent

Constraint	A restriction that influences the mission profile, or time line, and for mission planning purposes cannot be violated
Single Failure Point (SFP)	A single item of hardware which, if it failed, would lead directly to loss of a part, system, mission, or crew member
Principal Investigator (PI)	An individual that NASA has contracted with for the development and delivery of experiment hardware, analyses of returned data, or both

APPENDIX C

SKYLAB MISSION DESCRIPTION

The Skylab program capitalizes on the capabilities and resources developed in the Gemini and Apollo programs. It has been established for four explicit purposes: (1) to determine man's ability to live and work in space for extended periods, (2) to extend the science of solar astronomy beyond the limits of Earth-bound observations, (3) to develop improved techniques for surveying Earth resources from space, and (4) to increase man's knowledge in a variety of other scientific and technological regimes.

The Skylab will function throughout three long-duration manned flights and two intervening periods of unmanned operation. A different three-man crew will inhabit and operate the orbital assembly as a habitable workshop and will perform a number of physical science, biomedical science, Earth applications, and space applications experiments. Certain experiments and tests will be performed under ground control during the unmanned periods. The deployed space vehicle is shown in figure 2, and the baseline mission data are shown in table IX.

The Orbital Workshop has crew provisions, living quarters and food preparation and waste management facilities for the three-man crew, plus a large number of mission experiments. It is flanked by two solar arrays generating electrical power. The Workshop is to be deactivated between manned missions and left in orbit, awaiting the arrival of the next Skylab crew. The OWS is a modified Saturn V, S-IV-B stage.

The Airlock Module provides a pressurized passageway for the crew and can be readily depressurized for extravehicular activity. It is also the supply, distribution, and control center for the atmosphere and thermal control of the cluster; and it contains equipment for electrical power control and distribution and supports the communication system.

The Multiple Docking Adapter serves as the interface for linking Apollo Command and Service Modules with the cluster. It contains controls and displays for the Apollo Telescope Mount plus storage areas for equipment.

The Apollo Telescope Mount is a solar observatory enabling observation, monitoring, and recording of the structure and behavior of the Sun. The system provides attitude control and experiment pointing for the entire cluster. Power is provided by the windmill-like solar array.

The Apollo Command and Service Modules are much like those for lunar missions, but are modified to extend life of the modules for the prolonged periods when they are docked to the MDA of the Skylab. Additional modifications have been made to accommodate the many different items being brought back for ground based study.

SKYLAB - MANNED ORBITAL SCIENTIFIC SPACE STATION

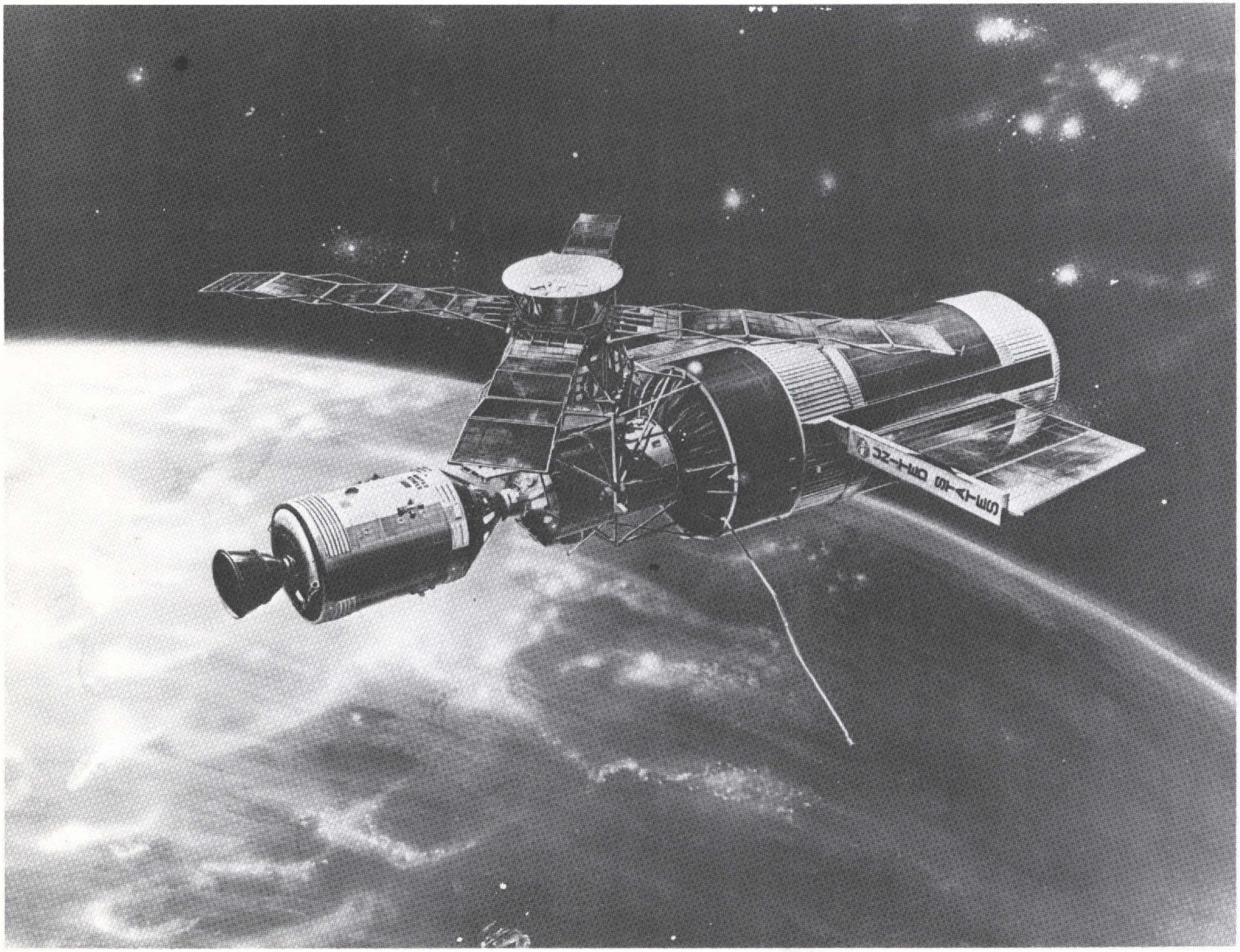

FIGURE 2

Other components of the basic Skylab Space System include the Saturn V launch vehicle, used to place the orbital cluster (OWS, AM, MDA, ATM) into Earth orbit in an unmanned condition; the Payload Shroud, used to protect and support the upper portion of the cluster during the boost period; the Saturn IB launch vehicles, used to put the CSM's in orbit; and the supporting ground equipment.

APPENDIX D

RESPONSE TO PANEL'S INTERIM REPORT

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

REPLY TO
ATTN OF: MQ

JUN 27 1972

MEMORANDUM

TO: A/Administrator

FROM: M/Associate Administrator for Manned Space Flight

SUBJECT: Third Annual Report of the Aerospace Safety Advisory Panel

The subject report has been reviewed by both the Apollo and Skylab Program Offices with copies made available to Center Program Offices and concerned contractors.

The Apollo Program Office has participated with the Panel in its activities and is aware of each of the points noted in the report. The Panel has received thorough briefings here in Washington, at the MSF Centers, and at various contractor plants concerning areas of particular interest to the Panel, as well as others selected by the Apollo Program Office for the general interest of the Panel.

In the case of Skylab, the report was written part way through the Panel review cycle, and most of the questions raised by the Panel have been addressed in subsequent meetings with the Skylab Program Office. The attached Skylab report addresses all of the Panel's questions. A final meeting with the Skylab Washington staff will be held in August, where any remaining questions can be answered.

I feel that the actions taken and those presently underway in both the Apollo and Skylab Programs are properly directed towards maintaining a high degree of safety and mission success. I appreciate the efforts of the Panel members and feel the comprehensive series of reviews has significantly contributed to both the Apollo and Skylab Programs.

Dale D. Myers

Dale D. Myers

Enclosures
Skylab Report
ASAP Report

cc: ASAP Panel

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

REPLY TO
ATTN OF: MQ

26 JUN 1972

MEMORANDUM

TO: M/Associate Administrator for Manned Space Flight

FROM: ML/Director, Skylab Program

SUBJECT: Comments on Third Report of the Aerospace Safety Advisory Panel

I have reviewed the subject report and have extracted from it Skylab areas of question or concern as expressed by the Panel. Attached is a detailed response or status report on actions underway for each of these areas. Several answers have been provided in ASAP meetings held since report publication, but these are nevertheless included for the record.

I appreciate the efforts expended by the Panel in their comprehensive reviews and hope that any remaining areas of concern can be addressed at our final meeting in Washington scheduled for August 1972.

William C. Schneider

Attachment
a/s

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Areas of Concern and Responses to These Areas

1. Page 14 of Report

"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."

Response - Concern was valid and is a continuing area of attention. Working interfaces had been pre-planned through a group of documented interface working agreements but these did not contain some of the more detailed subjective problems which have surfaced as a result of working together. In retrospect, many of the problems could not have been anticipated in pre-planned agreements and needed the actual face-to-face exposure to bring them to light. Examples are:

a. Difference in cleanliness between Martin Marietta and MDAC-E clean rooms. This turned out to be primarily a question of degree of discipline on things like personnel access controls, carry-in materials, associated documentation, etc. rather than a fundamental difference in requirements.

b. Difference of opinion on degree of detail which should be written into factory checkout procedures for flight crew participation as prepared by MSFC contractor, MDAC-W and as reviewed by MSC Flight Crew personnel.

Both of these subjective kinds of differences have been and will continue to be resolved by quick management actions as they surface.

2. Page 23 of Report

"In the MDAC-W response the question of fire extinguishment and toxicity controls is one that appeared to require further examination."

Page 31 of Report

"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 unusable, elements of the ECS such as the molecular sieve."

2

Response - The question of materials selection for toxicity of combustion products is actually a paradoxical one. Skylab has selected materials whose flammability characteristics in the Skylab application are primarily either non-burning or self-extinguishing. The paradox lies in the act that generall', the better a material's flammability characteristics are, the more toxic its combustion products. Skylab has chosen to use the selection approach, which either will eliminate or limit the size of the fire. The proposed contingency action to counteract toxic combustion products is an operational solution - isolate the crew from such products via portable masks and oxygen bottles, extinguishing the fire if deemed advisable, retreating to the CSM and venting cluster atmosphere, followed by a bake-out of MOL sieves and re-pressurization with a new atmosphere.

At the request of the Washington Program Office, MSFC ran a group of widely-used, typical spacecraft materials through combustion tests to determine their effects on ECS components. The tests validated the above described operational solution and these results were presented to the Panel at the MSFC meeting held after publication of the ASAP Report.

An additional detailed briefing by the Headquarters Skylab staff on this entire area is on the agenda for the Washington Program Office meeting with the Panel now scheduled for August 1972.

3. Page 25 of Report

"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."

3

<u>Response</u> - Both the NASA Safety Office (via their OMSF co-located personnel) and the SFHSC have been very much involved in all the developments associated with the fire detection and extinguishment developments as well as the materials selection program being utilized on Skylab. In fact, the SFHSC provided results of their fire sensor studies which influenced the program to go to the U-V sensors. Mr. Guy Cohen, who is a member of the SFHSC has repeatedly briefed the Committee on all aspects of the flammability and fire extinguishment status of the program and has factored recommendations from the Committee into the program.

4. Page 29 of Report

"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 category, but in a system such as the EPS and ECS 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."

<u>Response</u> - In the ECS system, above information is incomplete. Long duration tests <u>are</u> being run on the active elements of the ECS <u>as a system</u> in addition to component life test.

In the EPS, the program has consciously focused on <u>active items subject to possible wearout</u> and run long duration tests on such sub-systems and components (e.g. charger battery regulator modules as a sub-system and also inverter assemblies).

On the OWS, key sub-systems of the refrigeration system (e.g. pump package assemblies) are being run for long duration.

To adequately pick up additional "playing together problems" electrical system breadboards are being run for extended periods with parametric type testing, for procedure validation, for malfunction and for contingency procedure training for both flight and ground crews.

4

5. Page 29 of Report

"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 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."

Response - Results of the Surveyor items returned from the Moon by Apollo 12 have been published in two reports:

1. "Surveyor III Parts and Materials-Evaluation of Lunar Effects" - Hughes Report No. SSD00628R - January 22, 1971

2. "Results of Tests of Surveyor III TV Camera" - Hughes Report No. SSD00545R - January 22, 1971

Approximately 150 copies of the report were distributed, including 50 universities and to paint and optical specialists at:

IITRI	Eastman Kodak
GE	MDAC-E
Grumman	Comsat
Lockheed	LaRC
Martin Marietta	MSFC
North American	MSC
TRW	GSFC
Aerospace	ARC
Bendix	JPL

Representatives of the above organizations attended a meeting at JPL in January 1971 at which the results were discussed.

Note that IITRI (Illinois Institute of Technology Research Institute) is our supplier for the S13G thermal paint being used on Skylab.

6. Page 33 of Report

"A problem with principal investigators for medical experiments was noted in that the PIs are only 'one-deep' in many cases and may require qualified PI backup."

Response - Today's status is that there is a co-principal investigator for 13 of the 16 medical experiments. In all cases however, there is in addition to the PI and the co-PI, a Principal Coordinating Scientist whose responsibility it is to oversee and integrate all efforts within a body system or functional area. It is felt that this provides adequate coverage for the program of medical experiments.

7. Page 37 of Report

"Currently mission-level critical item status, a part of mission level FMEA effort, is such that some 32 items out of 49 submitted in 1971, are still under review."

Response - The mission level FMEA is an on-going program and as such, it seems most appropriate to provide an update on current status:

As of May 31, 1972, there are now 95 critical item candidates identified. These are classified as follows:

70	Single Failure Points
20	Critical Backup Redundant Components
5	Launch Critical Components
95	

Disposition action has been taken on 47 of these candidates.

Note: At time of above report item, wherein 49 items had been identified, the FMEA was at revision level "B." Since that time, revision "C" was released with 29 items and revision "D" was just released with an additional 17 items.

This effort is being carefully tracked for program impact and pressure is being maintained to complete it. It was also the subject of a significant finding at the recently completed Headquarters R&QA Audit of MSFC, identified as item #C-29 of the audit report.

TABLE I

SCHEDULE OF PANEL ACTIVITIES

PHASE I	
September 14-15, 1971	Washington, D.C. (OMSF and Skylab Program)
October 18-19, 1971	McDonnell Douglas, Huntington Beach, California
November 8-9, 1971	McDonnell Douglas, St. Louis, Missouri
December 13-14, 1971	Washington, D.C. (Life Sciences Division)
January 10-11, 1972	Martin-Marietta Corporation, Denver, Colorado
February 14-15, 1972	North American Rockwell Corporation, Downey, California
March 13-14, 1972	Chrysler/Boeing/MSFC Launch Vehicle, Michoud, Louisiana
PHASE II	
April 10-11, 1972	MSFC, Skylab Program Office, Huntsville, Alabama
May 8-9, 1972	MSFC, Skylab Program Office, Houston, Texas
June 12-13, 1972	KSC, Skylab Program Office, Cape Kennedy, Florida
June 19-23, 1972	OWS Pre-DCR, McDonnell Douglas, Huntington Beach, California
July 13, 1972	MSFC Skylab Experiments Pre-DCR, Huntsville, Alabama
July 27, 1972	Saturn I-B Turnover Meeting, Michoud, Louisiana
August 10-11, 1972	Formal DCR for CSM and Selected MSC Experiments, MSC, Houston, Texas
August 31-September 1, 1972	Pre-DCR Mission Operations, MSC, Houston, Texas
September 5-6, 1972	OWS, PDTR at MDAC-West, Huntington Beach, California
September 12-14, 1972	ATM Product Turnover Review, MSC, Houston, Texas
September 15, 1972	DCR for Mission Operations, MSC, Houston, Texas
September 28, 1972	SMEAT Review, MSC, Houston, Texas
September 27-29, 1972	AM/MDA Acceptance Review, MDAC-East, St. Louis, Missouri
October 2-3, 1972	DCR-Module and Experiment Hardware, MSFC, Huntsville, Alabama
November 9-10, 1972	Washington, D.C. (Skylab Program Up-Date)

TABLE II

MSFC END ITEM DEVELOPMENT RESPONSIBILITIES

ITEM	CONTRACTOR
Saturn Workshop	McDonnell Douglas Astronautics Company
Airlock Module	McDonnell Douglas Astronautics Company
Payload Shroud	McDonnell Douglas Astronautics Company
Multiple Docking Adapter	MSFC (Structural Design and Fabrication), Martin Marietta Company (Final Assembly and Experiment Integration)
Apollo Telescope Mount	MSFC
Selected Medical Experiments	MSFC (in Support of MSC)
Launch Vehicles	Apollo Furnished
Assigned Experiments	MSFC, Various PI's and Contractors
Systems and Payload Integration	MSFC, Martin Marietta Company

TABLE III

SATURN V LAUNCH VEHICLE

	Skylab (SL-1)	Apollo
Vehicle Configuration	Skylab Workshop Payload	Apollo Lunar Landing Payload
Boost Acceleration Limit	4.7 g	4.0 g
S-IC Shutdown Sequence	1-2-2	1-4
Terminal Stage	S-II	S-IVB
Orbital Mission Requirements	Initial Attitude Control Signals and Deployment Sequencing for the SWS; Structural Support for 8 Months	Attitude Control Signals, Maneuver and Deployment Sequencing, Maneuver Computations
Launch Azimuth	40.88°	72 to 100°
Tower Clearance Maneuver	Yaw and Pitch	Yaw
Crew	0	3
Emergency Detection System	Open Loop Eliminate Abort Feature Retain Critical Functions T/M	Closed Loop Abort Capability Critical Functions T/M

TABLE IV

NASA HEADQUARTERS (OMSF) ROLE

DETERMINATION AND INTERPRETATION OF REQUIREMENTS
Program objectives
Technical and scientific (e.g., PI's data requirements)
Higher authority (e.g., PAD)
DEVELOPMENT AND ISSUANCE OF PLANS AND REQUIREMENTS
Program specification
Work authorization directive
Program plans and requirements document
Level I schedules and resource plans
Experiment management procedures
Policy letters
Program plans and requirements documents
COORDINATION, IMPLEMENTATION, AND FEEDBACK
Intercenter panels, CCB's, ICD's
Formal reviews (e.g., PDR, CDR, Programmatic)
Formal reports
Frequent visits and teleconferences
Skylab executives' meetings
NEW DIRECTIVES TO CENTERS
CCB directives
Revisions to formal plans (e.g., schedule, work authorization)
Other directives

TABLE V

MSFC ROLE

SYSTEMS ENGINEERING AND INTEGRATION

Direction and Conduct of Systems Engineering Development and Verification Testing

Conduct of Integrated Technical Reviews and Assessments

Establishment of Development Requirements and System Verification Plans to Assure Totally Integrated Systems

Development and Verification of Orbital Assembly and Launch Vehicle Software Programs

Control of Systems Level Documentation and Performance of Systems Trade Studies and Analyses

Above Activities Are Performed in Concert With MSC, KSC, and Headquarters, Using Facilities Best Suited to Accomplish the Testing; Examples:

- Neutral buoyancy training by MSC at MSFC
- Integrated payload vibration and acoustic testing at MSC
- Cluster systems testing at KSC
- Thermal vacuum testing at MSC

MODULE MODIFICATION AND DEVELOPMENT

- Orbital Workshop
- Airlock
- Multiple Docking Adapter
- Payload Shroud
- ATM System
- ATM Experiments
- Experiments
- Module GSE
- Launch Vehicles
- Launch Vehicle GSE

DEVELOPMENT OF CERTAIN MEDICAL EXPERIMENT HARDWARE AND THE MEDICAL EXPERIMENT SUPPORT SYSTEM FOR MSC

EXPERIMENT DEVELOPMENT RESPONSIBILITY FOR 32 EXPERIMENTS

- Science (9)
- Medical (1)
- Technical (21)
- Operational (1)

STUDENT EXPERIMENT RESPONSIBILITY (19)

EXPERIMENT SUPPORT EQUIPMENT

TABLE VI

MSC ROLE

DEVELOPMENT OF THE CSM, SLA, AND SUPPORTING GSE
DEVELOPMENT OF SELECTED EXPERIMENTS AND SUPPORTING GSE
PROVISION AND TRAINING OF FLIGHT CREWS
DEVELOPMENT OF CREW SYSTEMS, MEDICAL EQUIPMENT, FOOD, AND OTHER CREW-SUPPORT HARDWARE
SELECTED DESIGN VERIFICATION TESTS
MISSION ANALYSIS, INCLUDING MISSION REQUIREMENTS DEVELOPMENT AND FLIGHT PLANNING
EXECUTION OF MISSION CONTROL, FLIGHT OPERATIONS, AND RECOVERY ACTIVITY
MISSION EVALUATION
EXPERIMENTS (31) Medical (17) Solar physics (1) Earth observations (6) Astrophysics (3) Crew operations (1) Technology (3)
EXPERIMENT SUPPORT EQUIPMENT

TABLE VII

KSC ROLE

CONDUCTS SKYLAB LAUNCHES
ASSUMES READINESS RESPONSIBILITY FOR ALL HARDWARE THAT IS LAUNCHED
IS RESPONSIBLE FOR LAUNCH FACILITIES AND THEIR READINESS
CONDUCTS TESTS AND CHECKS OUT ALL HARDWARE AND DOES TROUBLE SHOOTING
DOES HAZARD AND CONTINGENCY PLANNING
PARTICIPATES IN
Requirements reviews
Design reviews
Intercenter panels
Change impact reviews
Changes resulting from KSC activities

TABLE VIII

REVIEWS ATTENDED BY PANEL AND STAFF

Design Certification Reviews	
Orbital Workshop, Pre-DCR	June 19-23, 1972
Experiments, MSFC Responsibility, Pre-DCR	July 13, 1972
Command and Service Module, Formal DCR	August 10-11, 1972
Mission Operations, Pre-DCR	August 31-Sept. 1, 1972
Formal Mission Operations DCR	September 15, 1972
Formal Module and Experiments DCR	October 2-3, 1972
Formal Cluster DCR	October 19, 1972
Predelivery and Turnover Review and Spacecraft Acceptance Review	
Saturn I-B PDTR	July 27, 1972
Orbital Workshop PDTR	September 5-6, 1972
ATM PDTR	September 12-14, 1972
AM/MDA SAR	September 27-29, 1972

TABLE IX

SKYLAB MISSION DATA

Mission	SL-1 and SL-2		SL-3	SL-4
Objectives	Establish the Skylab orbital assembly in Earth orbit Obtain medical data Perform in-flight experiments		Perform unmanned SWS operations Reactivate the orbital assembly Obtain medical data Perform in-flight experiments	Perform unmanned SWS operations Reactivate the orbital assembly Obtain medical data Perform in-flight experiments
Space vehicle/launch	SL-1	SL-2	SL-3	SL-4
Launch vehicle	Saturn V (S-IC and SII) 513	Saturn IB 206	Saturn IB 207	Saturn IB 208
KSC launch complex	39A	39B	39B	39B
Payload	Saturn workshop OWS AM MDA ATM Experiments	CSM 116 Three-man crew Experiments	CSM 117 Three-man crew Experiments	CSM 118 Three-man crew Experiments
Orbital inclination	50°	50°	50°	50°
Orbital altitude	~234 n mi	~234 n mi	~234 n mi	~234 n mi
Launch interval (from SL-1 launch)	---------------	1 day	~90 days	~180 days
Manned flight duration	---------------	Up to 28 days	Up to 56 days	Up to 56 days