annual report to the nasa administrator by the aerospace safety advisory panel

volume I
summary report

march 1974

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

4 March 1974

OFFICE OF THE ADMINISTRATOR

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 fifth annual report covering our activities during calendar year 1973. This report summarizes our efforts on the multiple missions of the Skylab program, and our current work on the Space Shuttle and Apollo Soyuz Test Project.

The results of our Skylab reviews were provided to you in our individual SL-1/2, SL-3 and SL-4 letter reports prior to each mission phase. These indicated the maturity and continued competence of the NASA/Industry team in meeting program requirements.

We are continuing our detailed review of the Space Shuttle program, and will provide separate reports on this program at appropriate times. Because of our emphasis on Shuttle we have spent comparatively little time on the Apollo Soyuz Test Project, but do intend to review it more thoroughly during the coming year.

For the entire Panel, I want to thank you and George Low for your support during this past year and look forward to further significant contributions this year.

Sincerely,

H.K. Nason

Howard K. Nason
Chairman, Aerospace Safety Advisory Panel

ANNUAL REPORT TO THE NASA ADMINISTRATOR

by the

AEROSPACE SAFETY ADVISORY PANEL

VOLUME I - SUMMARY

March 1974

CONTENTS

ABBREVIATIONS AND DEFINITIONS

ASTP	Apollo Soyuz Test Project
CDR	Critical Design Review
CSM	Command and Service Modules
DM	Docking Module
ET	Shuttle External Tank
EVA	Extra Vehicular Activity
JSC	Johnson Space Center
KSC	Kennedy Space Center
MSFC	Marshall Space Flight Center
PDR	Preliminary Design Review
SRB	Solid Rocket Booster
SSME	Space Shuttle Main Engine
TPS	Thermal Protection System

Shuttle Element	The major subdivisions of the Space Shuttle program. In this case, the major hardware units: Orbiter, Space Shuttle Main Engine, External Tank, Solid Rocket Booster, Air Breathing Engines (if used), Ground Support Equipment, Facilities.
Risk Assessment	A comprehensive and structured process for estimating the comparative risks associated with alternative courses of action; also the product of such a process.

SUMMARY

The Panel reviews during 1973 have been directed toward three major programs: Skylab, Apollo Soyuz Test Project, and the Space Shuttle. The Skylab program recieved the greatest emphasis during this year's reviews in order to support the Administrator's decisions on launch readiness. The Space Shuttle reviews were initiated in the Fall of the year in parallel with a less intense review of the Apollo Soyuz Test Project.

The Panel has followed Skylab through development and fabrication since 1971. This year the emphasis was on launch readiness and mission operations. The Panel paid particular attention to (1) integration and checkout of the Skylab cluster which occurred for the first time at KSC, (2) preparations for and execution of mission operations including crew health monitoring, (3) personnel skill retention, and (4) specific problems resulting from Skylab testing and reviews of such items as the Saturn IB launch vehicle stress corrosion crack problem. Four written Skylab reports were made to the Administrator. A comprehensive two-volume report covering 1972 was submitted on January 4, 1973, to the Administrator to support his review of the Skylab decision and management systems at that time. This report identified those areas in which the Panel had reasonable confidence of success and those warranting continuing attention as the program approached integrated testing for the first time. The letter reports submitted to the Administrator prior to each Skylab launch provided Panel conclusions and recommended areas of interest for the Administrator's pre-launch reviews. As a result Skylab management's reviews of their decision system emphasized the significant problems and concerns of the Panel. As an example of the Panel's continuous review of the Skylab activities, Lt. Gen. Dunn, USA, Panel Chairman at the time, on behalf of the Panel participated during some of the in-house meetings leading up to the launch of Skylab 2 after the Skylab 1 failure, and was informed by telephone on several occasions during that time concerning the progress being made.* All of the items noted by the Panel were satisfactorily responded to by program management and performed as planned.

The Panel's extensive reviews of the Skylab program at both the NASA and contractor sites provided individual members a thorough background of this program from both a management and technical standpoint.

During 1973, the Panel began its review of the Apollo Soyuz Test Project and the Space Shuttle program using their Skylab experience. In order

*Mr. Bruce T. Lundin, the Director of the NASA-Lewis Research Center, also a Panel member, was Chairman of the Skylab 1 Investigation Board.

to get "on board" the Shuttle program during its early and crucial requirements definition period, the Panel devoted a majority of its "non-Skylab" time to activities at Space Shuttle NASA Centers and contractors. The status of development activities and management systems on the Apollo Soyuz program were reviewed as time permitted. This appeared to be a suitable approach because the Apollo-Soyuz system utilizes time-tested Apollo spacecraft modified to meet the new and unique requirements of this project and the Saturn IB launch vehicle. The Docking Module and a compatible docking system are the new items of hardware. Further, the Saturn IB launch vehicle excess payload capability permitted a relatively simple, reliable design for the Docking Module.

Based on limited Panel reviews conducted at NASA Headquarters, Johnson Space Center, and the Space Division of the Rockwell International Corporation, the Apollo Soyuz Test Project appears to be running on schedule and the management experience and systems associated with the Apollo and Skylab programs are being applied here. Testing to date does not indicate any major problems.

The Panel will be examining the Apollo Soyuz Test Project in greater detail as the flight systems proceed forward toward final manufacturing and qualification testing in mid-1974 and as mission preparations increase to support a 1975 launch. The basic approach on reviewing the flight systems will be to monitor insofar as possible (1) design modifications and test results indicating design and flight hardware adequacy, and (2) safety assessments on the spacecraft.

Prior to 1973 the Panel had been kept informed on the evolution of the Shuttle program on a general basis through the benefit of short briefings provided by program personnel. The Space Shuttle represents a major step forward in meeting future space flight operational requirements. NASA is appropriately utilizing its existing strengths in both personnel and technology derived from its many aerodynamical and space programs. However, they must develop a management and technology plan to meet the unique program goals. The Panel will therefore give particular attention to (1) the application of technical and management experience from prior programs and to (2) the development of new hardware and management concepts that will be required by this unique program. The Panel will monitor developing technical requirements as they challenge the technical management system. In our opinion the Orbiter thermal protection system; the flight control avionics including the "autoland system"; the main engine control electronics; and the mechanics of separation of the major "drop-away" elements, all involve new requirements and significant extension of knowledge beyond those used in previous aerospace programs. It is to these new technical elements, and to the reusability concept itself, that the Panel will apply its attention to the forthcoming months.

This Annual Report for 1973 should also be considered as the Panel's first interim report to the Administrator on the Apollo/Soyuz Test Project and the Space Shuttle program. At appropriate times, or upon request, during the Panel's review process additional reports will be provided.

INTRODUCTION

This annual report describes the Panel activities on the Skylab program for 1973, and provides results to date and planned future activities associated with the Space Shuttle program and the Apollo Soyuz Test Project. With these three programs being reviewed concurrently the Panel recognized the necessity of properly allocating its time to meet specific NASA needs with regard to each of these programs. Consequently, first priority was given to the Skylab program which resulted in special reports to the Administrator prior to each of the three missions. Second, the Panel gave special attention to the Space Shuttle at the critical time when program requirements were being evaluated and baselined. [The Panel will give priority to the Shuttle in the period ahead when the design is evaluated against these requirements and critical management and technical issues are being resolved.] Third, an initial evaluation of the Apollo Soyuz Test Project resulting in the opinion that the Panel could defer its intensive reviews of the ground verification and mission operational development phases of the program.

In all cases, the Panel's efforts are focused on those program activities that directly or indirectly impact on hazard identification, risk assessment and risk assumption, which in the final analysis affect crew safety and mission success. In doing this the Panel seeks to develop its assessments based on three points: (1) Have NASA and its contractors overlooked anything? (2) Are the right questions being asked of the right people in a timely manner? (3) Is program management proceeding in an effective fashion? The Panel then provides their conclusions and identifies those areas which in their opinion NASA should be aware of and where appropriate include in its reviews of specific program areas.

Panel activities and judgements resulting from these efforts are documented in this two-volume report. Volume I summarizes the scope of the Panel's review and their significant findings, conclusions, and recommendations stemming from those reviews. Volume II recognizes the need for specific background information, supporting details and discussions of specific items which concern the Panel.

Through these documents the members hope to provide the Administrator a perspective and independent judgement not otherwise available in NASA.

MODE OF PANEL OPERATION

The Panel Role

The Aerospace Safety Advisory Panel is a senior advisory group reporting to the Administrator and Deputy Administrator. The Panel provides judgements, i.e., findings, conclusions, recommendations, on the adequacy of overall program management policies and systems, with emphasis on those that bear upon safety and risk assessment. Over the years the Panel has evolved its role to include mission success as well as crew and public safety. The Panel feels that this broader examination of the programs and their management gives them more confidence than in limiting their inquiry to safety alone. The authority for the Panel is shown in appendix A.

Scope of Reviews

The Panel works through an extensive data gathering process wherein the members form and refine their judgements. Thus the Panel, either as a group or individually, visits appropriate NASA and contractor sites for briefings and discussions on topics of significance to the program currently being reviewed. They also attend internal NASA and contractor decision meetings to observe the process involved. The schedule of the Panel activities during 1973 is shown in table I.

The agendas are derived from the Panel members' interests and from the critical management and technical issues at the time. The agenda for each visit is coordinated by the Panel Chairman and staff with the Office of Manned Space Flight and Center management personnel to assure the availability of key personnel to present and discuss the data. The Deputy Administrator then reviews the agenda in order to provide additional information helpful to the Panel and to suggest additional requirements on items of particular concern to him. This procedure provides the necessary "closed loop" system to assure the maximum relevant data upon which the Panel can make useful judgements. The agenda for the Panel reviews conducted are shown in appendix B.

Skylab Program

The Panel initiated their review of the Skylab program in September 1971 and issued a two-volume report dated January 4, 1973 covering the major design, development and testing aspects of Skylab. The Deputy Administrator requested copies be given to all concerned organizations for their review and response to the points and questions in the report as well as appropriate additional comments on the status of the program. The summary response to this request is quite detailed and is included in appendix C.

Thus program management at all levels was given another occasion to review the decision process and management systems upon which they depended.

During the January to October 1973 period the Panel continued its review, providing comments and recommended areas of special interest in a letter report to the Administrator prior to each of the Skylab flights. These reports essentially covered all pre-launch activities, including test, checkout and mission preparations. These reports are shown in appendix D. As noted in the July 19th letter report, the Panel reviewed the Skylab 1 Investigation Board Report and utilized pertinent data from it for its reviews of the Skylab program as well as in Shuttle and Apollo Soyuz Test Project reviews. A Panel staff member, Mr. Gilbert L. Roth participated as the Panel observer to the Skylab 1 Investigation Board.

Apollo Soyuz Test Project (ASTP)

The primary objective of this program is to test the technical requirements and solutions for compatibility of systems for docking future manned spacecraft of the U.S. and the U.S.S.R. The mission is described in appendix E. In addition to examining the program system for the CSM, Docking Module and Saturn IB Launch Vehicles from the standpoint of quality, reliability, redundancy of hardware, materials control, and test qualification adequacy, the Panel intends to assess the impact on the safety of the total system that results from a "one time only" or single launch of the ASTP system. The Panel expects to examine the following areas in its upcoming reviews:

1. Critical failure modes analysis
2. Project documentation and the semantics of communications
3. Joint and Unilateral systems tests
4. Adequacy of contractor and vendor support
5. Personnel and skill retention from factory to KSC
6. Storage and shelf-life requirements and status (critical components)
7. Crew Training and Mission Simulations
8. Contingency planning
9. Materials control
10. Caution and Warning systems.

Space Shuttle Program

The Space Shuttle program generalized mission profile and mission description is shown in appendix F.

The Panel has developed an agenda based on experiences with the Apollo and Skylab programs and on Shuttle orientation briefings. The Panel recognized that it could not review all aspects of the Shuttle activities or management systems. Therefore priorities in its fact finding effort has been given to those areas deemed most critical for crew and public safety and, then, mission success. Obviously the focus of the Panel reviews will shift with program progress and problems, e,g., from consideration of management concepts and technical management systems to operating practices and system validation through the life cycle of design and development, manufacturing, flight preparation, and mission operations. The review process has been divided into four phases corresponding to the major program milestones leading up to the first horizontal flight with a separate set of activities to be conducted after that time. These review phases are concurrently:

Phase I:	Systems Requirements Review through the Preliminary Design Review. August 1973 - July 1974.
Phase II:	Preliminary Design Review through Delta (up-date) Preliminary Design Review. July 1974 - May 1975.
Phase III:	Delta Preliminary Design Review through Critical Design Review. May 1975 - April 1976.
Phase IV:	Critical Design Review through First Horizontal Flight. April 1976 - January 1977.

Figures 1A and 1B show the program schedule in some detail along with the relation with the four review phases mentioned above. To date the Panel has visited and conducted sessions at the following locations:

1. NASA Headquarters, Washington, D.C. (OMSF)
2. Johnson Space Center, Houston, Texas
3. Marshall Space Flight Center, Huntsville, Alabama
4. Flight Research Center, Edwards, California
5. Space Division, Rockwell International Corp., Downey, California
6. Rocketdyne Div., Rockwell International Corp., Canoga Park, California.

The major Shuttle program contracts are shown in table II and the geographic location of the facilities involved in the program are shown in figure 2.

Related Activities

During its reviews specific areas are identified by Panel members as requiring greater detail for proper understanding and evaluation. These areas are normally covered in a letter from the Panel Chairman to the proper program manager. Typical of these are the letters and responses shown in appendixes G (ASTP) and H (Shuttle). These are discussed in more detail in the appropriate sections of this report.

Projected Activities

The Panel has tentatively set the schedule of its activities as shown in the table below for the remainder of Phase I of the Shuttle review and for the ASTP. The activities for the second half of 1974 will be established prior to the completion of Phase I on the Shuttle and will reflect what the Panel considers to be the priorities at that time.

Projected Activities

January 1974	McDonnell Douglas Corp., St. Louis, Mo. Shuttle Orbiting Maneuvering Systems and Reaction Control System. (Completed)
February 1974	Shuttle Orbiter Preliminary Design Review Process (Completed)
March 1974	Presentation of the Panel's Annual Report to the Administrator
To be set	Space Shuttle Main Engine Electronic Controller Assembly
To be set	Ground Support Facilities at KSC
To be set	External Tank Status
July 1974	Space Shuttle Systems Preliminary Design Review
To be set	Solid Rocket Booster

PRINCIPAL FINDINGS AND CONCLUSIONS

Skylab Program

The Skylab program was a unique challenge in a number of ways: (1) integration of the total Skylab cluster for the first time at KSC, (2) long duration manned space flight, well beyond that of the Apollo experience, (3) one-of-a-kind orbiting cluster revisited by successive launches of new crews. Thus while Skylab benefited from Apollo management experience, Skylab management faced additional challenges which makes their record of achievement truly impressive. The Skylab mission demonstrated the significant role of the crew in managing the flight systems and necessary inflight repairs. The role of launch and mission operations personnel cannot be overstated. We offer our tribute to all of the dedicated and professional efforts of the Government-Industry team.

During the Skylab reviews the Panel's principal areas of concern included (1) systems integration at KSC, (2) the broad spectrum of activities associated with mission operations, crew training and health monitoring during the mission, (3) real-time mission problems such as the leakage of the Airlock Module coolant loop and its resupply with Coolanol, and the launch vehicle stress corrosion cracks, (4) age-life effects on system and component performance, (5) experiments and their interfaces with the crew, and (6) the review system used by management to assure flight readiness of the total Skylab vehicle. All of these Panel concerns were satisfactorily responded to by Skylab management.

The Skylab program will be completed by the time this report is published, but the lessons learned from it should be applied to the maximum degree possible on current programs such as the Space Shuttle and ASTP as well as major unmanned programs.

The Panel, as a result of its reviews, feels that the following significant observations on Skylab experience should be considered by current NASA programs:

1. There is ample evidence that the system developed by Skylab management for the resolution of anomalies and the retention of skilled personnel has been highly effective in meeting real-time resolution of day-to-day mission problems.

2. Skylab operations have confirmed man's value in maintaining onboard equipment and in their ability to take corrective action inside and outside of the space vehicle.

3. The possibility of human errors, particularly during test and checkout, is inherently ever-present in programs as complex as Apollo and Skylab. Experience in these programs has shown that the ability to respond in an adequate and timely fashion to such errors is a result of detailed contingency planning, personnel training and sureness in the management decision-making process.

4. Qualification and validation test planning and execution to meet program requirements without compromising safety, reliability and performance differed from the Apollo concept in that Skylab incorporated verification by similarity and/or analysis wherever possible. Program results are evidence that this system worked very well.

5. Skylab management systems for configuration control, interface engineering and control, weight control and documentation in general were streamlined to reduce redundancy and manpower without losing controls and visibility.

6. Contamination control was of vital importance to the long duration operation of experiments (internal and external) and the health of the crew. The Skylab system has been highly effective in understanding contamination problems and resolving them. Skylab mission data indicate that there were no unusual problems resulting from contamination sources, but that constant monitoring is valuable to assure continued contamination-free operation.

7. Control Moment Gyro #1 failed early in the final Skylab mission phase. The cause of the problem appeared to be either a lack of bearing lubrication or bearing instability. Control Moment Gyro #2 showed similar, but to a smaller magnitude, the same symptoms as CMG #1. Bearing temperature increases and wheel current increases were observed. CMG #1 was shut down and the Orbital Cluster was stabilized using CMG #2 and #3.

To lessen the CMG bearing loads and, hopefully increase bearing life, a software patch was implemented for bearing load relief during momentum dumps. In addition, as the problem persisted, manual control by ground command was implemented to reduce bearing temperature. The Panel's interest here is the cause of the CMG failure and its relation to the design and test review process involved. NASA and the contractors seemed to agree that the problem is generic but that the basic lubrication concept is sound; however, it may need some further development for future long-term, "zero G" space applications.

8. The contamination problem associated with close-tolerance hardware manifested itself in such items as the Service module reaction control system Quad B positive yaw engine oxidizer valve on Command and Service Module 117 during the second manned visit. As a result of analysis it appears that there is a need for all checkout personnel to exercise extreme care during vehicle checkout to prevent entry of contamination to assure that valves are not actuated without system pressurization, and to assure the cleanliness of the loaded propellants. This is particularly true of valves with teflon or teflon-like seats in which particles can be imbedded.

9. The Panel was impressed by the thoroughness of the Skylab 1 Investigation Board report on the meteoroid shield failure which occurred on May 14, 1973. The Panel agreed with the many suggestions made to improve the management system to preclude, insofar as possible, similar problems in the future. Of particular interest were the observations that "A major emphasis on status, on design details, or on documentation can detract from a productive examination of "how does it work" or "what do you think" and the utilization of "The experienced 'chief engineer'. who can spend most of his time in the subtle integration of all elements of the system under his purview, free of administrative and managerial duties, can also be a major asset to an engineering organization."

10. The Panel, after reviewing the Skylab 1 Investigation Board Report, endorses the Board's recommendations for application to current and planned programs.

Apollo Soyuz Test Project (ASTP)

Based on the briefings provided to the Panel it appears that the ASTP is progressing smoothly towards qualification testing and the final test and checkout to be conducted at KSC prior to launch.

The CSM design approach was to use a vehicle similar to the Skylab CSM's with minor variations to meet specific differences in mission requirements such as the retention of three fuel cells for electrical power generation, addition of docking system controls, modifying the electrical umbilical interfaces, and an integrated CSM and Docking Module telecommunications system. The new and modified components and systems are to be certified for flight through ground tests and where possible through similarity analyses. Because of the similarity of the CSM's in the ASTP, Apollo, and Skylab, the flight performance experience derived from Apollo and Skylab will be used to support and substantiate the ASTP test program.

The project has used to advantage the large payload capability of the Saturn IB launch vehicle to conservatively design the structure of the Docking Module with larger safety factors than the 1.4 value normally used. This permits minimizing the qualification test program. Further it makes possible the use of existing Apollo and Skylab hardware such as spare valves and controllers. Again, the new and modified systems and components are to be certified for flight through ground tests and where possible through similarity analyses.

The management systems developed on the Apollo and Skylab programs have been modified to be compatible with the size of the program. The small size of the program permits senior management to maintain close surveillance and strict control over levels of detail not otherwise possible on larger Apollo and Skylab programs. A set of five working groups has been set up to support the program:

1. Mission Model and Operations Plans
2. Guidance and Control
3. Mechanical Design
4. Communications and Tracking
5. Life Support and Crew Transfer.

The Specific areas handled by each of these Panels are shown in table III, which also shows a special Project Technical Director's Panel that deals with the ASTP general technical management.

The reliability, quality, and safety aspects of the program are being handled in much the same manner as the JSC/Contractor team operated in Apollo and Skylab. Safety Assessment Report requirements have been defined and the necessary agreements and implementation procedures are being worked out. Both the US and USSR have agreed to prepare documentation which describes the design practices, tests, or operational procedures which preclude or minimize the probability of the following:

1. Failure or inadvertant release of a docking systems structural latches,
2. Fire at any point in the mission and within spacecraft,
3. Loss of spacecraft pressure,
4. Inadvertant firing of pyrotechnics,
5. Inadvertant actuation of control or propulsive systems,
6. Sneak circuits operating equipment at an improper time,
7. Inadvertant commands from the ground stations to the spacecraft,
8. Structural weaknesses.

From the standpoint of mission training much has been accomplished and much is yet to be done. Joint crew training in both the United States and Russia is in process and will continue for the next year. Flight operations personnel are being identified and are undergoing team training in time to meet the projected flight schedule. Documentation is being produced in a timely manner to support training and mission requirements.

The Panel intends to examine the status of the above-mentioned observations to assure itself that there is continued progress toward the ASTP major milestones without jeopardizing crew safety. In addition, the Panel will also look at: the effects of limited communications between ground and orbiting spacecraft based on similar Skylab experience; the ability to sustain failure and retain full operational capability or safe mission continuation without damage to critical hardware or injury to the crew; the required personnel and special skills to support the ASTP missions, particularly in the area of launch vehicle support.

During the Panel's reviews in September and November two questions were raised:

1. Should ASTP interlock the Docking Module hatch at the Soyuz end of the Docking Module with the structure unlatching circuits?

2. Should ASTP conduct an integrated test with the Flight Command and Service Module, Docking Module and Soyuz in the docked configuration?

The ASTP Program Director's response to these questions is shown in appendix G. A summary of the response follows:

1. "Interlocking of the structural unlatching with the hatches is not recommended. The existing design and procedures provide adequate safeguards against inadvertant unlatching and the addition of interlocks would add unnecessary complexity."

2. "The Integrated testing of the CSM/DM/Soyuz is not being considered. The successful completion of the Gemini, Apollo, and Skylab programs with no, or minimal, vehicle integrated testing demonstrates the adequacy of sub-docked configuration testing,"

In summary, the Panel ASTP activities in 1973 were less intense than those for the Skylab and Shuttle programs. The Panel will examine the Apollo Soyuz Test Project in more detail in 1974 when spacecraft test and checkout takes place and the KSC preparations for a launch at Complex #39 go into high gear.

Space Shuttle Program

The Space Shuttle program represents a major step forward in meeting future space flight operational requirements. The Shuttle program is unlike its predecessors in many ways:

1. It is reuseable (This applies to the Orbiter, Main Engines, and Solid Rocket Boosters).

2. Flight and ground operations must be cost-effective, i.e., the selected configurations provide the best balance between hardware cost and cost per flight to yield the greatest return for the investment.

3. The Shuttle provides the flexibility to place a wide range of payloads into orbit and to use more than one site for launch and landing.

4. The utilization of new types of hardware and advanced operational concepts such as the Thermal Protection System using multiple tiles and the fly-by-wire flight control system using computers (analog or digital) between the stick and the actuators. These present new technical challenges.

5. The development budget is constrained.

6. Ground operations require an Orbiter turnaround and launch capability within 14 days (160 hr of actual working time).

7. The Shuttle program is being conducted during a period of inflation, sporadic material shortages, energy conservation, and growing vendor problems.

The impact of these unique features of the Space Shuttle system and its program environment are considered by the Panel in their fact-finding activities.

Most major elements of the program are only now approaching Preliminary Design Review (PDR) with a total system PDR slated for mid-1974. The Space Shuttle Main Engine and Orbiter are the only elements to have passed this milestone. As a result, many of the element system designs are yet to be finalized, and the operational modes have not been firmly established. Thus the Panel concludes from its reviews that there are a fairly large number of uncertainties, open items and concerns which the Panel will examine further. Principal among these areas are the following:

1. Management Techniques

a. Systems Integration

The Space division, Rockwell International Corporation was selected as the Space Shuttle Program System Contractor in addition to its role as the Orbiter Contractor.

This System Contractor has been assigned an integration support role by JSC to assist in the implementation of an integrated management approach in all Space Shuttle program activities. The real life role and responsibilities of the contractor are now taking form and the current contractural agreement appears to require revision to reflect the evolving agreements and congruent expectations.

Working interfaces between the systems contractor and the other Shuttle element contractors are of particular significance in integrating the many parts of the Shuttle program, e.g., the separation of the Orbiter from the External Tank, and the separation of the Solid Rocket Booster from the External Tank, and the associated feed, drain, and vent problems for the propulsion systems. A Panel request concerning the LOX and Liquid Hydrogen fill, feed, and drain situation resulted in the detailed response shown in appendix H.

The Panel will give particular attention throughout this year to the management systems currently in place and their effectiveness in assuring visibility of potential hazards associated with the many system interfaces that are involved.

b. Subcontractor/Vendor Control

In light of the current economic environment the ability to secure suppliers, assure compliance with the high level of quality required, and to meet weight and schedule commitments poses some serious problems. Areas causing concern include: long lead times necessary to obtain castings, forgings, and other raw materials; cost escalation due to inflation and shortage of materials; low interest on the part of suppliers due to the short run quantities required for the Shuttle systems; energy shortage impacts on the suppliers in certain parts of the country. The Systems Contractor is currently preparing a management plan for "Common Hardware Procurement" to help ease some of the problems noted above.

c. Weight Control (Mass Properties)

Current weight estimates are within 3 to 5 percent of the baseline weight allocations for most of the Shuttle elements, i.e., Orbiter, SSME, and ET. Historical data from both space and aircraft program indicate that so small a margin at this point in time requires not only strict weight control measures but the possibility that further weight reductions through specific areas of redesign and component removal may be necessary.

2. Mission Design and Operations

a. Abort Requirements

Abort requirements, particularly intact abort, affect the structural design of the Orbiter, the use of alternate landing sites, payload restraints, crew survival equipment, and rescue modes in addition to the operational requirements for "Once Around Abort" and "Return to Landing

Site". The Panel's concern here is with the adequacy of the Shuttle flight and ground systems to accommodate aborts, the operational methodology and the inherent risks assumed because of trade-offs in the hardware, software, and mission design.

b. Ferry Mode and Horizontal Flight Test

The use of air-breathing engines has significant hazards and problems, including susceptability to foreign object ingestion, engine out capability, limited ferry range, and introduction of additional penetrations of the Thermal Protection System (TPS). Horizontal flight testing in this mode is considered to have limited value because the vehicle is not representative of the "clean" Orbiter used in normal missions. The safety of the ferry mode and adequacy of the horizontal flight test program are related concerns. Alternate ferry modes are already under study.*

c. Avionics

Avionics systems on board the Orbiter (communications, tracking, guidance, navigation, performance monitoring function, and flight control) are to some degree tied to the role of "man-in-the-loop" and to the constraints of the turnaround time requirements. These areas are covered separately in succeeding paragraphs. The avionics system as described to the Panel appears to be on the leading edge of the state-of-the-art, particularly the performance monitoring function and the autoland system. Associated concerns deal with the ability to achieve the reliability required within the constraints of weight allowances, minimum redundancy, and schedules.

d. Man-In-The-Loop

The role of the crew in the operation of such systems as the autoland system and the response to the caution and warning system is under continuing discussion. These discussions must resolve the crew's role and responsibilities in the nominal Shuttle operational mode, their role in contingency or emergency operations, and the associated development of "control and display" provisions to support their ability to form and act upon independent judgements. Therefore both the decision process itself and the evolving conclusions warrants continuing and timely review.

e. Turnaround Time Between Landing and Launch

While it is clear that the stipulated 160-hour turnaround time (two-shift, five-day-week basis) is driving many design features, it is not

*A recent decision has been made to remove the air-breathing engines and to utilize a modified C-5A or 747 aircraft to carry the Orbiter in a "piggy-back" configuration.

clear to the Panel whether this constraint is necessary or attainable nor what the impact would be of relaxing this requirement.

f. Cabin Environment

The choice of a 14.7-psia cabin pressure requires further clarification since few military or commercial aircraft operate at this pressure today. This may impact the justification for this atmospheric pressure on the basis of using off-the-shelf components.

3. Technology

a. Thermal Protection System (TPS)

As the design evolves the Panel is continuing to examine the ability to assure stable airflow over the multi-tiled TPS surface. This surface consists of thousands of individual tiles shaped to fit the airframe mold lines. Particular attention will be paid to the potential interferences resulting from the access doors, operational doors, Orbiter/External Tank attachment points and fuel lines, and other points of penetration. Additional areas of interest include the adequacy of the TPS for all weather conditions, bonding to the base structure, degree of maintenance required for reuseability, adequacy of the qualification test program, and potential operational problems resulting from the loss or damage to one or more individual tiles.

b. Shuttle All-Weather Capability

Hazards and resulting risks associated with Orbiter flight and ground operations in adverse weather conditions (rain, lightning, thunderstorms, sand, and dust) need to be examined to assure that systems such as the TPS and avionics maintain their operational capability. During emergency returns such as "Once Around Orbit" and "Return to Launch Site" which occurs prior to reaching velocities necessary for orbital flight, and even under normal orbital operational modes the Orbiter may encounter weather conditions other than those planned for the primary and alternate landing sites. The process for defining the natural environment warrents further review to assure that weather associated hazards are identified and the risk evaluated by the appropriate level of management.

c. Space Shuttle Main Engine Electronic Controller

The controller is a pressurized and thermally conditioned electronics package attached to the thrust chamber of the engine to control, monitor, and check out the engine performance and condition at all times during the mission. It includes a digital computer unit using plated wire memory units. These plated wire units are considered a high risk technology with which there is little experience. Testing of the design concept is underway. Plated wires were chosen because it was believed that magnetic cores would not provide the necessary response time. The Panel is seeking data supporting these requirements for response time since magnetic cores might well be sufficient to meet current requirements and would be more reliable.

d. Leaks and Fire Hazards

In a reuseable system that can not be fully pressure tested under actual operating temperatures prior to reuse (such as the cryogenics systems on board the Orbiter) there is a concern with regard to the difficulties in assuring the integrity of the systems, particularly the cryo-seals. The Orbiter's aft engine room, covering the last 18 feet of fuselage, represents an unusual fire hazard because of the large, complex high-pressure systems carrying flammables. Thus the design criteria and test program to assure leak integrity is of added significance.

e. Solid Rocket Booster

There are three areas that the Panel will cover in its initial review of the Solid Rocket Booster. These areas are:

(1) What hazards, if any, result from the reuse concept and what risks have been accepted?

(2) Will the verification and qualification program provide adequate assurance that reuse will not be a hazard to the crew?

(3) The impact of the Solid Rocket Booster separation motors plume (combustion products) on the Thermal Control System.

Panel identified some points which required further clarification to assure adequate understanding of the Shuttle Program management and hardware design approach. A letter, appendix H, was forwarded to the JSC Program Manager for this purpose, and his reply is also included.

<u>Overall Shuttle Status</u>

The current status of the Shuttle program may be characterized as having an established organization at nearly all levels and a management plan to achieve the performance and schedule objectives while keeping costs to a minimum consistent with those goals. The engineering management systems, built on the experience of the Apollo and Skylab programs, appears to be adequate as described. Test organizations at the Orbiter contractor to support both the Orbiter and Integration roles have not been fully established at this time. The Panel feels that the various levels of Shuttle management adequately perceive the technical and management challenges to be resolved and the need to fully define the hardware and operational requirements as soon as possible. The cooperation received by the Panel during its visits to the NASA and contractor sites has been excellent.

Future Shuttle Reviews

Planned reviews by the Panel include visits to cover such areas as:

(1) Ground Support for launch preparation, refurbishment, range safety, post landing safing, and support facilities. KSC is the major site considered here

(2) NASA Centers doing technology work in support of the Space Shuttle program

(3) Contractors for critical and pacing systems and subsystems

(4) Contractors for major program elements such as the External Tank and Solid Rocket Motor

(5) Major Design Reviews

The Panel will also return to principal NASA Centers and contractors to review the continuing management of the program and status of major technical and management challenges.

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). In addition, the Panel has been rechartered pursuant to Section 14 (b) of the Federal Advisory Committee Act, (PL 92-463, October 6, 1972). The duties of the Panel are set forth in both the 1968 Act and in NASA Management Instruction 1156.14A dated January 18, 1973: "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."

Over the years the Panel has evolved its role to include not only safety per se, but has included mission success as a consideration that it should be concerned with, as well as crew or public safety. We feel that this broader consideration of the programs and their management gives us more confidence in the more limited area of safety alone.

APPENDIX B

PANEL FACT-FINDING SESSIONS

The agenda for each of the significant Panel fact-finding sessions during the year 1973 are included here. These agenda indicate the extent of the Panel's examination of the Skylab, ASTP, and Shuttle programs and the areas covered during visits to the NASA sites and the contractor locations.

Date: February 12-13 Location: KSC

1. Skylab Design Certification Review Data
2. Intercenter Operational Relationships
3. Skylab Dual Launch Planning
   a. SL-1/2 Integrated Checkout Flow
   b. SL-1/2 Launch Countdown
   c. Launch Mission Rules
4. Rescue Vehicle Launch Planning
5. Apollo 17 Terminal Countdown Sequencer Problem
6. Launch Vehicle Operation Status-Apollo 17 and Skylab SL-1/2
   a. SL-2 Checkout difference between launch complex 37 and 39
   b. SL-2 test flow
   c. Test results to date
   d. Modification/Open Work Status
   e. Procedure Status
   f. Launch Team Readiness
   g. Alert Status
7. Tour of Launch Control and checkout operation areas
8. Spacecraft Operations Status
   a. Schedule posture of AM/MDA/OWS and problems encountered and resolution
   b. ATM Posture
   c. Modification and test change notices
   d. Equipment stowage
   e. Work remaining

Date: March 12-13 Location: JSC

1. Skylab Program Office Orientation Briefing
2. Flight Control Division Briefings
   a. Flight Operations Team - roles, responsibilities, problems
   b. Huntsville Operations Support Center (HOSC)
   c. Contamination Assessment and Control Plan
   d. Experiment Return Items Control Plan
   e. Mission Rules Summary
   f. Flight Controller training, Simulation, Status and Schedules
   g. Mission Control Center Manning Status and Shift Plans
   h. S-IVB De-orbit Plan
3. Flight Support Division
   a. MCC Hardware/Software Status
   b. STDN Skylab Configuration Status
4. Crew Procedures Division
   a. SL-2 Crew Utilization Status
   b. Procedures Generation Status (Nominal and emergency)
   c. Flight Data File Configuration for SL-3 and SL-4
5. Flight Crew Integration
   a. Skylab Loose Equipment Management Plan
   b. Training Hardware Status and Utilization

6. Crew Training and Simulation Division
   a. Crew Training Status
   b. SL-3/SL-4 requirements as a result of SL-2 experience
   c. Crew overview of SL-2
7. Life Science Directorate
   a. Health Stabilization Plan
   b. Mobile Laboratory Operation
   c. Medical Data
8. Apollo Spacecraft Program Office
   a. CSM Status
9. Skylab Hardware Qualification Status
10. SL-1 Stowage status
11. Rescue Planning Status
12. System Safety Status and overview
13. Visit one-g trainers and view skylab simulation work.

Date: April 9-10 Location: MSFC

1. Saturn Workshop Pre-Flight Readiness Review Results
2. Skylab Hardware Integrity Review
3. Orbital Workshop Status
4. Multiple Docking Adapter Status
5. Airlock Module Status
   a. Coolant Loop Bladders
   b. ATM C&D/EREP Coolant Loop Contamination
   c. Batteries
6. Payload Shroud
7. ATM Experiment
8. Corollary Experiments
9. SWS Integration Electrical Support Equipment
10. Reliability and safety Assessment
11. Systems Integration/Software
12. Mission Operations
13. FRR Summary

Date: May 13-15 Location: KSC

Observation of the final checkout procedures and preparations leading to the launch of SL-1/2. Observation of the Launch Control Center operations and theirintegration with MCC.

Date: June 6-7 Locatiom: JSC

1. Skylab; observe and discuss Mission Control Center Operations.
2. Flight Management Team Activites and Decisions
3. Program Status, problems and resolution process
4. Experiments Planning and trade-offs
5. Safety Considerations, M509, Astronaut Maneuvering Equipment,and T020, Foot Controlled Maneuvering Unit.
6. Medical Status
7. Mission Control Status

8. Space Shuttle Program
    a. Space Shuttle Program Overview
    b. Management Interfaces
    System Evolution and Technical Baseline
9. Orbiter Project Status
    a. Technical Baseline
    b. Contractor and NASA tasks and relationships

Date: July 16-17 Location: MSFC

1. Skylab SL-3 Flight Readiness Review Summary
2. SL-2/SL-3 Accomplishments/Status
    a. Medical Experiments
    b. EREP
    c. CSM
        - SL-2 Performance
        - SL-3 Readiness for flight
    d. JSC GFE and Experiments
    e. Stowage
    f. Mission preparation
    g. Cluster Systems
    h. ATM Experiments
    i. Corrollary Experiments
    j. Launch Vehicle
        - SL-2 Performance
        - SL-3 Readiness for flight
3. Program Managers assessment
4. Systems Safety assessment

Date: September 10-11 Location: JSC

1. Space Shuttle Overview
2. Management Integration
3. Systems Engineering & Integration
4. Orbiter Project
    a. Organization
    b. Contract Description
    c. Orbiter Description
    d. Approach to Cost-Effectiveness
5. Flight Control
    a. Avionics; automations
    b. Man-in-the=loop; Manual Takeover
6. Mission Operations
    a. Reference Mission Descriptions: Nominal and Abort modes
    b. EVA/Rescue
    c. Docking/Payload Station
7. Reliability
    a. Redundancy; Fail Operationally/Fail Safe
    b. Design Against Loss of Critical Functions

8. Apollo Soyuz Test Project
    a. Status
    b. Challenges and Problems
9. Skylab, Current Status
10. Shuttle Facilities

Date: October 25-26 Locations: MSFC and JSC

1. Shuttle Projects Office (MSFC) Overview
    a. MSFC Program responsibilities
    b. Description of Hardware and current status
    c. Organization and Key Personnel
    d. Reviews and Information Flow
    e. Shuttle Implementation of Board and Prior Program Experience
2. Space Shuttle Main Engine (MSFC)
    a. Project Overview
    b. Description of Engine Operation
    c. Design and Development; Major Design Challenges
    d. Operation and GSE
    e. Quality, Reliability and Safety
    f. Summary Status
3. External Tank (MSFC)
4. Skylab Operational Status (MSFC)
5. Skylab Mission Operations (JSC)
6. Skylab Data Systems (JSC)
7. Skylab GFE and Experiment Anomaly Closures (JSC)
8. Skylab CSM's 117 and 118 Anomaly Closures(JSC)
9. SL-4 CSM Stowage (JSC)
10. Medical Status (JSC)
11. Flight Crew status
12. Space Shuttle (JSC)
    a. Thermal Protection System
    b. Penetrations and doors
    c. Reuseable surface insulations
    d. Hydraulic fluid selection, use and challenges
    e. Orbiter Flight Characteristics, Payload capabilities and constraints.
    f. Flight control/ Man-In-The-Loop

Date: November 19-20 Location: Space Division, Rockwell Int. Corp.
Downey, California

1. Shuttle Program from the viewpoint of the Orbiter Contractor
   Baselines, Schedules, Costs, Challenges, Roles and Responsibilities
2. On-site examination of the Mock-ups and Fabrication Facilities
3. System Integration and Shuttle Requirements
4. NASA Resident Office
5. Orbiter Program
    a. Organization and Key Personnel
    b. Current detailed schedules and major milestones

c. Major In-House Reviews
d. Baseline description
e. Design Challenges
f. Ferry mode of operation
g. Problem areas

6. Technical Management System
   a. Configuration Management
   b. Drawing Release and Control
   c. Reliability, Quality and Safety
   d. Materials Control
7. Performance Management System
8. Apollo Soyuz Test Project
   a. CSM modifications
   b. Docking Module Description
   c. Manufacturing Status
   d. Test Program
   e. Hazard Analysis
9. Visit ASTP Hardware and fabrication facilities
10. Visit Test facilities for ASTP

Date: December 17-18 Locations: Rocketdyne Div., RI Corp. at Canoga Park, California
Flight Research Center at Edwards, California

1. SSME Fact Finding at Rocketdyne
   a. Program Responsibilities
   b. Organization
   c. SSME Design
      - Baseline Description
      - Major Changes since SSME PDR
      - Significant Design Challenges and their status
      - Drawing Release and Control
   d. SSME Controller
      - What it is
      - What it does
      - Status and Potential Problems
      - Factors of Confidence in achieving goals
   e. Development
      - Test Philosophy
      - Test Program
      - Test Results
   f. Engine Safety
      - Leakage from lines and engine
      - Caution and Warning system
      - Hazards Identification
      - Fire extinguishment Capabilities
      - Risk Assessment

g. Assurance Disciplines
   - Reliability
   - Quality
h. Integration
   - Integration into Orbiter and System
   - Working relationships with Integration Contractor
   - Interfaces and their control
i. Tour of Manufacturing Facilities and Mockups
j. SSME Facilities
   - COCA
   - MCC Fabrication Center
   - Component Labs
   - Proof and burst
k. Management
   - Program Management System
   - Configuration Management
l. Procurement
   - Subcontractor Management
   - Materials control
m. Program Status
   - Schedules and Major Milestones
   - Potential Schedule problems and concerns
n. Orbiter Reaction Control Engines
o. NASA Resident Office

2. Shuttle program at FRC
   a. Flight Research Center Overview
      - Organization
      - Current Projects
      - Description of Edwards Complex and supporting areas
   b. FRC Experience related to Shuttle
      - X-15, B-70, Delta Wings
      - Lifting Bodies (HL-10, M2-F1, M2-F3, X24A, X24B)
      - Fly-By-Wire
   c. Plan for Shuttle Facility at FRC
   d. Horizontal Flight Test Planning
   e. Discusion of Mother Ship and associated areas
   f. Facility tour

APPENDIX C

RESPONSE TO PANEL'S 1973 ANNUAL REPORT

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

REPLY TO ATTN OF: MQ

MAR 28 1973

Lt. Gen. C. H. Dunn, USA
Chairman, Aerospace Safety Advisory Panel
National Aeronautics and Space Administration
Washington, D. C. 20546

Dear General Dunn:

We distributed the very fine Aerospace Safety Advisory Panel Skylab Report to the Manned Space Flight Centers and have compiled their comments on the points and questions raised in the report. At the request of Dr. Low, I am forwarding to you the enclosed copy of my memo to Dr. Low on the current status of these points and questions together with the detailed Center comments.

As you can see we have made excellent progress on the closeout of the points raised in the report and will ensure the complete closeout prior to launch.

Sincerely,

Dale D. Myers
Associate Administrator
for Manned Space Flight

Enclosure

MLQ MAR 8 1973

MEMORANDUM

TO: AD/Deputy Administrator

FROM: M/Associate Administrator for Manned Space Flight

SUBJECT: Aerospace Safety Advisory Panel Skylab Report

As per your request of January 26, 1973, same subject, we have distributed the report to the Centers and have consolidated their comments in the enclosure. The problem areas addressed by the report are summarized in paragraph 11 of Section IV, "Conclusions and Recommendations" of Volume 1, and in the Summary of Volume II. For reasons of clarity and conciseness we have limited our response to you to these main items, although we have also reveiwed a number of minor points brought out throughout the report but not necessarily contained in the summary. This added information will be forwarded to the panel in addition to a copy of this memo with its enclosure.

We agree completely that the various points brought out by the report are items of continuing concern to our management and we feel that our current and scheduled efforts are adequate to handle these and such additional problems that may arise in the normal course of events. As you can appreciate, this excellent report will lend emphasis to our attention to these problem areas.

The ATM, AM/MDA and Workshop are presently in joint integrated system testing at KSC. The integrated systems testing between the CSM (116) and the AM/MDA was completed in December 1972. Although the integrated testing and data reviews have not been completed to date, the results so far have shown that we have a satisfactory set of flight hardware in checkout that compares quite favorably to the first flight articles of the preceding programs at KSC.

The three Skylab Payload Modules have been undergoing checkout at KSC for the past half year and although we had numerous problems, we are only two weeks over our initial launch schedule established 2 years ago with less than three months remaining of processing time. Over half the difficult testing is completed, with much of the remaining time scheduled for mission simulation, servicing and preparation for launch.

Apollo 17 anomalies have been evaluated to determine their impact on the Skylab Program and have led for example to a modification to the Terminal Countdown Sequencer to make it triply redundant so as to avoid a re-occurance of the Apollo 17 launch delay.

Our favorable progress to date is the result of several factors such as:

a. Post-delivery modifications have been kept at a tolerable level and equipment delivery schedules have been satisfactory.

b. The close, responsive relationships established between KSC, MSFC, JSC and Headquarters technical and management personnel have led to expeditious problem solving and decision making.

I will continue to closely monitor status of the checkout program and will keep you informed on our progress during the remaining critical weeks.

Original signed by
D. D. Myers

Dale D. Myers

Enclosure

MQ/CPWood:en:2/27/73:x53122

OMSF RESPONSE TO THE ASAP
SKYLAB REPORT OPEN ITEMS

The following interium responses are submitted in reply to the ASAP request in paragraph II, Volume 1 of the Panel's report on the Skylab Program. In general, action is and has been under way in all areas. Most actions will be completed by and reported at FRR. Any items not completed by then will be listed as open items and will be tracked for completion prior to launch. Any launch impact will be carefully assessed at that time:

a. Item

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 item include

(1) Ergometer anomalies
(2) Urine collector insufficiency
(3) Metabolic analyzer anomalies

Answer

1. Ergometer anomalies included the pedals coming off and failure of a load module. The pedal problem has been resolved by adding a lock washer for use with the Nylock screw and welding the retaining lock in place. The load module failure has been resolved by a redesign to prevent bearing misalignment and subsequent contact under high loads between rotor and stator. Also a spare load module is now being flown.

2. Urine collector insufficiency has been overcome by replacing the 2,000 milliliter urine bags with a redesign of the system to provide 4,000 milliliter capacity urine collection bags.

3. Metabolic analyzer anomalies included:

a) Mode I operation is unsatisfactory -- corrected by eliminating mode I operation which had been provided for redundancy.

b) Calibration shifts at 5 psia produced by N_2 concentration -- eliminated by inhibiting the two-gas control system to keep the N_2 concentration constant during the conduct of experiment M 171.

c) High CO_2 readings indicate high respiration quotient -- corrected by cabin air inlet system redesign to improve calibration stability. No problem involving high CO_2 readings has occurred with the flight article.

d) High water vapor content entering the mass spectrometer -- corrected by proper setting of the calibration gas. No problem of this type has occurred with flight article.

e) Minute volume and vital capacity readings erroneous or inoperative -- problem traced to an unscreened I.C. Only screened components will be used on flight hardware.

f) Moisture collects in expiration hose -- a cleaning rod has been introduced for use in conjunction with utility wipes and Betadyne wipes to keep hose clean and dry.

g) Crewman bit through a Teflon sheath of a temperature probe -- probe is being redesigned to included a metal sheath. Acceptance testing of the retrofit is scheduled for completion by the first of March.

h) Mass spectrometer outlet requires standpipe extension -- an extension has been made to the standpipe to prevent the cabin air from back mixing with the sample and introducing error.

b. Item

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.

Answer

The MSFC personnel assigned to support both the prelaunch activities at KSC and the prelaunch and mission support at JSC are identified together with the guidelines and requirements for the mission support function. Good working relationships have been established between the MSC and MSFC personnel and the effectiveness of the support are being demonstrated in the mission planning simulations.

c. Item

Sneak Circuit Analysis status.

Answer

MSFC Sneak Circuit Analyses are over 95% completed and are supporting the Critical Activation Reviews. MSFC will support the Skylab in this area with a minimum team throughout the mission. MSC Sneak Circuit Analyses are over 90% completed. Further status on both Centers will be reported at FRR.

d. Item

Testing to complete the Corona assessment.

Answer

Corona testing has been completed. All items are cleared to fly and Corona operational procedures have been identified.

3

e. Item

Suit drying station problems and suit availability for emergencies.

Answer

Satisfactory suit drying procedures have been developed. The suits will be stored about the MDA radial docking port when not in the drying or suit donning station. This location allows the greatest flexibility for contingency suited operations since O_2, communications, and H_2O are readily available in the area.

f. Item

Crew procedures for reaction to the loss of cluster pressure.

Answer

Crew procedures have been developed and the crews are training for this emergency condition. A safety evaluation was performed and the procedures were found to be acceptable. A rate of climb indicator calibrated to indicate approximate time remaining for crew action has been added to augment information from the caution and warning system.

g. Item

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

Answer

Loose objects in the habitation area as a possible crew inhalation hazard is recognized and it is also recognized that we cannot guarantee that all such particles have been eliminated at the time of launch. This is particularly true since it is not practical to tumble clean some of the larger modules in the cluster. The situation has been evaluated and actions have been taken and practical methods/procedures established for minimizing this concern including:

(1) Use of the Skylab Oxygen Mask Assembly/Secondary Oxygen Pack during cluster activation operations.

(2) Habitation area cleanup/housekeeping procedures are included in the crew timeline.

(3) A continuing and concerted effort to eliminate debris during manufacture, test and checkout.

(4) The incorporation of cabin air filtration screens and trap system. It should also be noted that particulate removal capability is inherent in the design of the mol sieve.

h. Item

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

Answer

Qualification testing is continuing and should be complete by the FRR. At present time, three tests remain on Orbital Workshop and one remains on the ATM. All others are completed.

i. Item

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

Answer

(1) The Qualification testing of the HNS tension tie cutter was successfully completed in October 1972 and flight certification was signed off on January 3, 1973.

(2) A delta qualification test on the modified CSM descent battery was successfully completed in October 1972. The results of this test and the original qualification test were reviewed and the flight certification was signed off on January 24, 1973.

(3) The control of the CSM RCS during entry and the post flight safing and decontamination operations for Skylab will be the same as those used on Apollo 17, CM 114. The procedures were successfully demonstrated on Apollo 17, and in addition, extensive ground testing and procedure verification dry runs were conducted to assure the adequacy of these operations. The Apollo 17, CM 114, deactivation/deservicing operations are considered certified for the Skylab vehicles.

j. Item

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

5

Answer

The Skylab Program Office is currently reviewing the closeout action taken on the Apollo 17 anomalies. All of the launch vehicle anomalies are actively being closed out and have no known impact on the Skylab Missions. The CSM anomalies are currently being processed. Several of the CSM anomalies have been identified as having potential Skylab impact and are currently being worked. We hope to close out all of these items by the FRR.

APPENDIX D

PANEL'S PREMISSION REPORTS TO THE ADMINISTRATOR

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

OFFICE OF THE ADMINISTRATOR

October 30, 1973

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

Dear Dr. Fletcher:

The Aerospace Safety Advisory Panel has continued to conduct a series of fact-finding reviews on the Skylab Orbiting Cluster; SL-4 flight systems and crew; mission operations and the medical reports on the SL-3 crew. As a result of these discussions with Headquarters, MSFC and JSC program management, the Panel presents the following comments for your information:

1. Based on the data provided to the Panel the launch of SL-4 is not constrained by any known unacceptable conditions.

2. Degradation in the performance of the Skylab systems and experiments through aging is not significant. Flight anomalies that were discussed, such as the AM coolant system leak, are receiving appropriate management attention. The anomalies should not jeopardize crew safety or grossly impair achievement of mission objectives.

3. Mission Control teams and overall mission operations management is ready to support the SL-4 mission. As expected there has been a growing proficiency on their part over the duration of the SL-2 and SL-3 missions particularly in handling the extensive communication and information processing requirements which are new with Skylab missions. Continuing attention to the pressures on ground personnel in supporting the last mission (SL-4) must be a part of the management task.

4. With regard to the SL-4 flight systems, there is confidence in the maturity and capability of the spacecraft and launch vehicle. The spacecraft (CSM) has experienced a low number of anomalies during acceptance testing and final checkout at KSC. The appropriate corrective measures have been taken in respect to the malfunctioning RCS Quads. The "E-Beam" stress corrosion cracks in the launch vehicle do not appear to present a risk given the controls established and being implemented.

5. Medical status of the SL-3 crew indicates a pattern of adaptation to space and re-adaptation to earth similar if not superior to that for the SL-2 crew. Anomalies are receiving appropriate medical review.

6. The SL-4 crew training has met its objectives and they appear ready to go.

7. The Panel suggests that the following items be included in the Administrator's Review for Skylab SL-4:

(a) Status of Launch Vehicle "E Beam" cracks and resultant launch constraints.

(b) The need for, and the hazards associated with, the EVA to integrate the CBRM #3 and #5 as a single functioning unit.

(c) The hazards associated first with the reservicing of the AM Coolanol system, and then those resulting from a pressurized system itself if the suspected internal leaks are a fact.

(d) The definition of the RCS "B & D" Quad anomalies and the corrective action taken.

(e) Plans for reviewing the status of the crew, flight systems and consumables with emphasis on the period beyond the 59 day mission.

(f) The extent of the EVA workload on the S193 antenna and the planning and controls to be exercised.

(g) The basis for confidence in the repair effected on the S-IB fuel tanks.

(h) Management activities to minimize "end of the program" fatigue and human errors on the Skylab rescue vehicle.

Sincerely,

Howard K. Nason
Chairman
Aerospace Safety Advisory Panel

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

OFFICE OF THE ADMINISTRATOR

July 19, 1973

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

Dear Dr. Fletcher:

The Aerospace Safety Advisory Panel has conducted a series of fact-finding activities in response to your request for comments on Skylab SL-3 prior to its launch. These activities included real-time observations of early flight and mission elements associated with SL-2, and a review of performance and anomalies during the SL-1/SL-2 mission and during the checkout of SL-3.

As a result of these efforts the Panel presents the following comments for your information:

1. Based on the data available to the Panel we have found no reason not to launch the SL-3.

2. The Panel is pleased with the SL-2 crew health program procedures and endorses the continuance of the current program for the new SL-3 crew with no relaxation of procedures. To the best of our knowledge the medical experts have provided an independent assessment of all procedures and findings. The Panel is satisfied with this process. We also suggest that a formal senior management review be conducted at a suitable time prior to entry into mission durations beyond that of current experience. This review should cover data to that time and procedures for the period ahead, and should include continuous detailed monitoring and evaluation by management.

3. The mission operations management system based on SL-2 appears satisfactory in terms of procedures for real-time decision-making and detailed scheduling. As a result of the data availability from Skylab there are computer and communication problems and data overload. These are recognized, but do not represent safety hazards to the mission. We commend senior management's continuing attention to the pressures on ground personnel in supporting the lengthy SL-3 mission.

4. We plan to review Bruce Lundin's Skylab Investigation Board Report in greater detail in terms of its implications for subsystem management and the formal "as designed" and "as built" programmatic reviews. These data will be factored into future Panel reviews as appropriate.

5. The Panel recommends that the following topics be included in the Administrator's Review for SL-3:

a. The actions taken by Skylab management on the docking probe for SL-3 as compared to those actions initiated as a result of the Apollo 14 docking probe anomalies.

b. The analysis and changes to preclude the "thrust failure cut-off circuit" from being momentarily energized as occurred on SL-2.

c. The plans to replace the Workshop rate gyro processors which have experienced a number of anomalies.

d. The extent of the planned EVA's for the new "sun shade" as well as additional work to deploy a number of experiments external to the Workshop which were originally designed for extension through the Solar-SAL.

e. Provisions to assure safe use by the crew of a portable voltmeter proposed for circuit checking during the SL-3 mission.

Yours sincerely,

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

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

OFFICE OF THE ADMINISTRATOR

April 10, 1973

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

Dear Dr. Fletcher:

The Aerospace Safety Advisory Panel is submitting this letter report as a supplement to the two-volume Skylab report provided you in January. The Panel has continued its fact-finding and inspection surveys during the past several months. These activities have been directed toward final SL-1 and SL-2 pre-launch and mission preparations including integrated tests, checkout, training and mission operations planning. The Panel sought to develop its assessment based on three points: has NASA overlooked anything? are the right questions being asked in a timely manner? and is program management proceeding in an orderly fashion?

This report provides our conclusions and identifies those areas that the Panel feels the Administrator should include in his own Skylab reviews prior to the initial launch of SL-1/-2. For completeness we have appended to this report those items the Panel identified in its January report as requiring closure.

The Panel's conclusions are summarized as follows:

1. As the Panel anticipated in its January report the delivered open work as well as hardware and software modifications overloaded the success oriented schedule resulting in a rescheduling of the initial launch. The current schedule also has little allowance for further major unforeseen problems or surprises. It is important to note, however, that Skylab management has been able to handle the workload and rescheduling without any apparent compromise to good management control of the pre-launch process. In line with this, we note that a great deal of attention has been given to contingency planning to provide procedures and appropriate personnel to allow stowage and testing to be conducted on the launch pad, and to permit the limited operational testing of EREP and some other experiments after rollout of SL-1 in the latter part of April.

2. A number of problems might have been expected to appear during integrated testing at KSC because of the complexity of the modules

and the number of interfaces. The data we have on the testing of systems, both in the individual module and integrated across the cluster, indicated relatively few problems. The Skylab cluster appears to compare quite favorably to the first flight article of preceding programs at KSC. Provisions for real time management of the cluster systems and experiments critical to mission success are, in the Panel's view, adequate.

3. The experiments are complex packages and some were developed relatively late in the program to take advantage of research opportunities provided by the Skylab. Therefore, not surprisingly, they have experienced the greater number of test failures. This is true both of the experiments and the related data collection and stowage systems. Final management decisions on flight status will no doubt be covered at the SL-1 Flight Readiness Review. Program management feels that in this research and development mission there are more than enough experiment opportunities to fully utilize the available flight time. As in the case of cluster flight systems, management during the mission itself is critical.

4. The crew faces a considerable task of managing systems, experiments and housekeeping in a new flight environment. The SL-2 crew commander feels that the training objectives have been met and they are ready to fly Skylab as currently configured. Procedures for inflight medical monitoring of the crew in this unique environment appear ready. The mission has been planned on a success schedule to assure training for every possible opportunity in flight. In other words, the flight planning approach provides the baseline for that which can be most optimistically accomplished on the Skylab missions. However there will be a learning process during flight along with problems and opportunities that will require revision of the flight plan. The Panel stated their concern in January---"The procedures and techniques are being developed and are yet to be proved." It is noted now that substantial progress has been made and extensive use of various training and mission planning simulations to verify the procedures and techniques are in progress. We found that program management is sensitive to this area. As an example, the initial activation period has been extended some 6 to 8 hours as a result of management, crew and mission operations reviews. There will logically be pressure to try to recover so-called lost time in flight and troubleshoot problem equipment. Therefore it is important to reiterate that time for crew rest and personal requirements must not be compromised.

5. Because of the unforeseen limitations and the research opportunities that will be encountered in flight the Panel focused on the management system for detailed mission planning and the management capability to respond to the daily situations. These

were in the process of evaluation at the time of our earlier reports. Our most recent review indicates the organization and operational procedures for overall mission operations, flight plan control, and real time decision-making have been effectively established and initial implementation, through mission simulation, is under way. At the time of our review much remained to be done in the way of documentation and bringing the computers on-line. The considerable progress that has been made in recent weeks indicates these problems can and should be resolved in a timely fashion.

6. The Skylab review system provides a continuing opportunity to assure that the right questions have been asked at all levels in a timely fashion. In support of this MSFC has instituted a major team effort to examine the Skylab documentation and assure that it is current and complete. In addition a formal Intercenter Subsystems Data Review Board, supported by detailed intercenter systems teams, provided a formal detailed final review of the KSC test programs and their results to assist in assessing the flight readiness of the Skylab cluster and experiments for launch. This attention to "homework" provides confidence that the information necessary for knowledgable management judgements should be available.

7. The disposition of spent Skylab hardware remaining in orbit following the completion of the program has been considered by the Panel. The controlled deorbit of the SIV-B/IU stages of the SL-2,-3 and -4 appear to offer no problem. It is understood that the Skylab program is currently continuing its examination of the many facets associated with the orbit decay of SL-1 hardware. The Panel recognizes the inherent problems here and requests a review of this area as soon as practical.

The Panel cannot fairly second-guess management decisions involving judgement. These decisions rightfully are the responsibility of the managers who make them. The Panel can judge in general whether the right questions are being asked beforea decision is made. With this criterion in mind the Panel has, in the past, attended the design certification reviews and the flight hardware acceptance reviews. We plan to continue this approach for the flight readiness review process. Since these reviews occur subsequent to the date of this report we will have to advise you at a later time of any additional comments pertinent to the launch of SL-1/2.

We would suggest that the Administrator's Review provide you:

1. Proof of design maturity and mission readiness of flight systems. This would include identification of those systems that may prove sensitive or difficult during activation and in-flight operations. Thus they should include the significant results from

the Intercenter Subsystems Data Review as well as the traditional summary of the FRR. Included should be the Attitude Pointing Control System, EREP and tape recorder, Airlock Module flight instrumentation, and TV camera equipment.

2. The basis for confidence in the risk assessment process and a profile of the critical risks accepted by program management. This would include provisions for evacuation and rescue in case of major fire, pressure loss or failure of life support systems.

3. Plans to resolve currently known problems. These will have been defined during the pre-FRR reviews conducted at each Center.

The Panel will, as you have requested, monitor mission experience and provide you our assessment prior to each subsequent flight.

Yours sincerely,

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

ATTACHMENT

Those items the Panel identified in the January report requiring closure.

Comment: The SOCAR team indicated that there is a deficiency in the contamination data capability because no measurement of the composition of the Skylab environment is available. Knowing the contaminates composition would serve a threefold purpose: combined with the quartz crystal microbalance output it would help establish "go-no-go" criteria for experiments in real time; it would provide a basis for a correction factor to experiment data affected by the environment; and it would enable a more direct determination of the sources of contamination. The proposed mass spectrometer noted in the previous listing is suggested for this purpose.

Response: Contamination math model is operational at MSFC and redline values have been established for each experiment. The current estimates are that contamination levels are at least a factor of 10 below any experiments susceptibility level. Mission rules have been developed and the console procedures are being finalized. The onboard contamination sensors include the following: T027/S073 Cloud Surface Brightness; T025 for size, number, general motion of particles; Quartz Crystal Microbalance (8 units) for de termination of total mass deposited on a surface.

Comment: Treated cardboard has been placed in many stowage containers to alleviate the launch environment. These large quantities of cardboard are then discarded. The manner in which this is to be accomplished still appears to be unresolved. A secondary problem attendant to this material is the problem of shedding when the material is handled. Obviously this is not just a hardware concern but also an operations concern since the crew interfaces with this material.

Response: The cardboard shedding problem has been corrected by the addition of "flourel" to all cut surfaces which receive abrasion. The cardboard disposal problem has been resolved by providing for stowage of the cardboard in beta laundry bags below the lower level of the workshop floor.

Comment: Concern exists (re the fire extinguishers) that during prelaunch storage as well as during zero-g storage in orbit the yield of foam may degrade to an unacceptable level.

Response:. A verification program is in progress to study the effects of long-time storage (one-g and zero-g) on the foam yield of the Skylab fire extinguisher. Previous testing of two extinguishers indicates that after a 56-day storage, the extinguisher meets the minimum Apollo requirement of 1.75 cubic feet of foam. Two other tests yielded 3 cubic feet after 180 days and 1 cubic foot after 260 days; however, the quantity of 3 cubic feet is questionable because a complete history of the extinguisher from conditioning to discharging is not available. Additional data points are desirable for periods between 2 and 3 months; therefore, a stowage test of 80 days was initiated January 9, 1973, to run through April 1, 1973. Also, a 60-day test was initiated February 28, 1973, with an estimated completion of April 28, 1973. It is anticipated that zero-g will not have any effects on stratification of the foam; however, the SL-2 CM unit will be returned after the flight (approximately 30 days zero-g) and the foam yield will be evaluated. It should also be noted that a water-fed fire hose has been provided for wetting down the crew and the escape path.

Comment: With respect to the Service Module, thermal control tests were conducted to assure adequacy of current paint system as a result of paint blisters observed during CSM 112 EVA on Apollo.

Response: During thermal vacuum ground testing and on the Apollo 15 mission, blisters were observed in the thermal control coating on the SM (service module). Two types of coating are used; a silicone base, and an aluminum base. The blisters in the aluminum base coating do not propagate into each other, but crack and self-relieve. The blisters in the silicone base coating do propagate, however, from a series of small bubbles into one large blister. It was verified through additional testing that no changes were necessary for the aluminum base coating. Corrective action for the silicone base coating was to provide relief spots to prevent propagation of the small bubbles into a large blister. This corrective action was verified by testing.

Comment: The CSM electrical power system nonpropulsive vents used to vent the hydrogen and the oxygen were discussed, and it appears that omly the hydrogen vent was tested to assure adequacy. The oxygen vent was assumed to work on the basis of similarity. One could question the validity of such an assumption since the working fluids are different.

Response: Certification of the CSM nonpropulsive oxygen venting was based on analysis and was signed-off in September 1972. The analysis showed a maximum torque of 0.095 newton meters at a maximum flow rate of 1.04 lbs/hr which is well below the specification limit of 0.20 newton meters.

Comment: The question of how long the crew can use the cluster if the ECS fails is one that must be answered in contingency planning.

Response: Multiple or double failures are required within the life support system (i.e., loss of oxygen, loss of mole sieves, etc.) to render the cluster hazardous to the crew. Loss of either oxygen supply or CO_2 removal (mole sieve) capability cannot occur with sufficient rapidity to preclude safe egress to the CM.

Comment: The operational acceptability of the oxygen consumption analysis at 5 psig appears to be somewhat of a problem.

Response: The M171 Metabolic Activity Experiment had two modes of operation. Mode 1 being unsatisfactory only Mode 2 operation will be used. No problem of calibration shifts existed at 14 psia, but the N_2 concentration change at 5 psia produced a calibration shift. This has been obviated by disabling the two-gas control system to keep the workshop N_2 concentration constant during the conduct of experiment M171.

Comment: The posture of documentation and acceptability of the small hardware elements of M487 are not known by the Panel at this time.

Response: A temperature sensor failed. After discussions with the P.I. and since there are three of these instruments in the kit, it was decided not to pursue a corrective course of action and use the sensor as is noting the shift. Container discrepancies have been corrected. Required documentation is almost complete.

Comment: The following documentation needs to be updated: Skylab biomedical failure mode and effects analysis (FMEA) for the hardware; the mission level FMEA; the operational data book (ODB).

Response: The biomedical FMEA has been completed and the results factored into the ground and flight documentation to assure ability to meet failure induced contingencies. Mission level FMEA's continue to be conducted to assure up-to-date documentation at the time of SL-1/2 launch. The results of these studies are being factored into mission documentation on a continuous basis. The Operational Data Books have been completed.

Comment: Among the items still open with regard to the EREP are: discrepancies on S192, S193, S194 requiring rework at the vendors; ESE and functional interface verification for S192 and 193 at KSC; Flight filters and desiccants for S190B qualification and delivery.

Response: EREP has continued to receive careful attention by the contractors, PI's, and NASA and has undergone considerable testing since the Panel's visit in May 1972. The most recent activity included end-to-end systems testing at KSC during which a failure occurred in the S193 microwave altimeter. The altimeter was returned to GE for failure analysis and repair, and has recently been redelivered to KSC. The end caps in the Malaker coolers for the S192 multispectral scanner are currently being replaced because of a failure which occurred during qualification testing. The coolers are being reworked at JSC with all work scheduled for completion prior to the simulated flight test at KSC. In summary, although there are still some open items, all of EREP essentially works now, and reasonably consistent performance is being obtained during KSC testing. The qual test status will be covered during the Panel's visit in March 1973.

Comment: The habitation area configuration during periods of leakage control is the normal manned orbital configuration (i.e., OWS/AM hatch open, and pneumatic and solenoid vent port plugs installed). There was a proposal to leave the solenoid vent port unplugged. A change to the specification permitting habitation area pressures below 22 psia during launch and a common bulkhead delta P larger than 7.5 psi were being considered.

Response: The solenoid vent ports will not be plugged, so that the ground may exercise contingency control over venting.

Comment: With regard to the ATM deployment mechanism MDAC-East was to establish, through analysis and test, the minimum margin for deployment when one or both trunnion bearings are jammed or "frozen". Test were initiated to verify the analysis.

Response: Testing has been satisfactorily completed and verified the analysis.

Comment: One of the questions for the Phase III review is whether moisture can or has seeped in (point where Solar Array System attaches to the OWS structure in the folded position) and could when frozen impact the deployment mechanism.

Response: No moisture has seeped into the SAS/OWS area during its time at KSC. Preventative measures, including covers and dry gas purging are being used to preclude any extraneous material from entering this area.

APPENDIX E

APOLLO SOYUZ TEST PROJECT MISSION DESCRIPTION

The Apollo Soyuz Test Project results from a joint US/USSR agreement made May 24, 1972, for cooperation in the peaceful exploration and utilization of space. The ASTP involves the rendezvous and docking of an Apollo-type spacecraft with a Soyuz-type spacecraft while in earth orbit. Its primary objective is to test the technical requirements and the solutions for a compatible rendezvous and docking system for future manned spacecraft. This will lend experience in conducting joint flights by US and USSR spacecraft, including, in case of necessity, rendering aid in emergency situations.

The nominal mission sequence begins with the launch of the Soyuz spacecraft with two cosmonauts into a 125-nautical mile circular orbit with an inclination of 51.8° to the equator. The Apollo spacecraft with three astronauts follows about 7.5 hours later into a low earth orbit, 81 x 90 nautical miles, at an inclination of 51.8°. The mission sequence is shown in figure 3.

After orbit insertion, the Apollo spacecraft will separate, turn around to extract the docking module from the SLA (Spacecraft Lunar Module Adapter carried over from the Apollo missions), and begin a series of maneuvers to rendezvous and dock with the Soyuz. Docked duration for the nominal mission is planned for approximately 2 days. During this time the astronauts and cosmonauts will perform joint activities, including exchange of crewmen to both spacecraft.

After final separation, the two spacecraft will continue to orbit the earth for approximately 7 hours to conduct various other joint experiments. The planned mission duration for the Apollo spacecraft is approximately 11 days; for the Soyuz, approximately 6 days. The prime recovery area for the Apollo vehicle is in the Pacific near Hawaii; for the Soyuz vehicle it is Kazakhstan.

The ground rules for management of the real time operation have been established. Each spacecraft will be controlled by its respective control center. Consulations between control centers will be held for decisions affecting joint activities. These joint activities will normally be conducted according to mission documentation, which includes contingency plans. Each country will provide a team of technical specialists whose primary role would be to provide technical information to the host country flight director upon his request. One of the ground rules agreed to early in the negotiations was that flight crews would be trained in the other's language to facilitate communication with each other and the Control Centers. The host country will have primary responsibility for deciding appropriate action for a given situation in the host vehicle. Any television will be immediately transmitted to the other Control Center.

APPENDIX F

SPACE SHUTTLE MISSION DESCRIPTION

Major elements of a typical Space Shuttle mission are depicted in figure 4. Various reference missions used in defining the requirements for the Shuttle program are shown in table IV. During launch, hold-down is provided until the main engines and the solid rocket boosters provide a thrust equal to the weight of the total vehicle system. Pitch and roll into the preferred attitude for the selected launch azimuth are initiated after the vehicle clears the launch tower approximately 5 seconds after liftoff. The maximum loads normal to the flight path can be expected about 60 seconds after liftoff for the due-east mission which is shown in figure 4. Maximum dynamic pressure of approximately 650 pounds per square foot occurs at about 40 000 feet. Upon burnout, the SRB's are separated, small solid rocket motors forcing the empty cases away from the orbiter plus external tank combination, which continue into orbit with continued burning of the SSME's. The released SRB's fall in an arc and are decelerated by a parachute system deployed between 25 000 and 16 000 feet. The SRB cases and retrieval system are recovered from the ocean and returned to a specified point for refurbishment and reuse.

The external tank is separated before the orbiter is inserted into an elliptical orbit at a nominal perigee of 60 nautical miles altitude. The retrorocket system decelerates the ET, resulting in an atmospheric reentry and impact in a preselected remote ocean area.

At apogee, 100 nautical miles, the orbit is modified to the one desired by using the orbital maneuvering subsystem (OMS). Orbital operations involving payload deployment, observation, experiments, or other activities are then performed.

After orbital operations have been completed, the OMS provides the velocity change necessary to perform the deorbit maneuver. The orbiter enters the atmosphere at a flight path angle of approximately one degree with an angle of attack of the orbiter of 34 degrees. A deceleration glide is then performed to reach the desired landing site. Through a well regulated terminal area energy management (TAEM) program initiated at about 70 000 feet the final approach and landing is completed. A "blackout" period occurs during the entry from about 250 000 down to 130 000 feet during which communications will be lost in much the same manner as the entry of the Apollo/Skylab CM. The orbiter can reach landing sites as far as 1100 nautical miles on either side of its flight path existing in the 400 000- to 50 000-foot altitude, and the downrange position during entry is determined by the temperature capability of the TPS.

Launch Control Centers and Mission Control Centers will be utilized with the vehicle operating in the "spacecraft mode" in a manner similar to that found in prior manned programs.

APPENDIX G

APOLLO SOYUZ TEST PROJECT RESPONSE TO PANEL REQUEST

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

JAN 4 1974

REPLY TO ATTN OF: MAQ

MEMORANDUM

TO: APA/Chairman, Aerospace Safety Advisory Panel

FROM: MA/Program Director, Apollo/Soyuz Test Project

SUBJECT: Aerospace Advisory Panel ASTP Review Open Items

During the Aerospace Advisory Panel reviews on September 11 and November 20, 1973, the following two questions were raised:

1. Should we interlock the Docking Module hatch at the Soyuz end of the DM with the structure unlatching circuits?

2. Should we conduct an integrated test with the Flight CSM, DM and Soyuz in the docked configuration?

Enclosed are our comments on those two subjects.

Chester M. Lee

Enclosure

Enclosure

1. <u>Considerations on Interlocking Apollo/Soyuz Structural Unlatching with the Hatches</u>

Two methods of interlocking the U.S. docking module (DM) and the Soviet orbital module (OM) hatches with the structural unlatching can be considered. Position sensors on the hatches or pressure sensors in the tunnel could be utilized.

In order to be effective, position sensors on both the Apollo and Soyuz hatches would have to be interlocked with both docking systems. This would require routing of the interlock circuitry through umbilicals which can be connected only after the hatches are opened. Also, this approach insures only that the hatches are closed and provides no assurance of pressure integrity. An override would be required as some contingencies require undocking with a hatch open and the crew secured in the command module. The complexity of this approach is such that it is of questionable practicality. The introduction of any interlock device complicates the system design and is warranted only if the existing design presents an unacceptable hazard. The Apollo and Soyuz designs provide adequate safeguards against inadvertent unlatching. The safeguards are being documented in safety assessment reports ASTP 20101, and ASTP 20201. The basic provisions are as follows:

a. Apollo

An overcenter latch design is used so that interface pressure cannot cause unlatching. Unlatching can only be accomplished by operation of the latch drive gearbox. The electrical design employs dual protection in that the latch drive power and logic circuit breakers are opened after latching is achieved and the panel switches are spring loaded to the off position. Therefore, no single fault or crew action can cause inadvertent unlatching.

b. Soyuz

The Soyuz also employs an overcenter latch design but their electrical design is somewhat different from Apollo. Three sequencial operations, the first being power enable, by the crew or ground command are required to mechanically release the Soyuz latches. Pyrotechnic release also requires three sequencial operations by the crew and cannot be accomplished by ground commands. Therefore, no single fault by flight or ground crew action can cause inadvertent unlatching.

The design philosophy on both the Apollo and Soyuz is consistent with that utilized throughout Apollo to preclude other inadvertent functions which compromise crew safety.

Our current crew procedures limited the time when the DM and OM hatches are open. The hatches are opened for crew transfer but then are immediately closed to permit the DM to serve as an airlock. We are never in a posture where the Soyuz hatch is closed and the DM hatch is left open. The closing of both hatches is almost a simultaneous operation. Our agreements with the U.S.S.R. require the concurrence of both crews prior to unlatching. Also, hatch integrity checks are performed by reducing and monitoring the tunnel pressure prior to undocking.

In summary, interlocking of the structural unlatching with the hatches is not recommended. The existing design and procedures provide adequate safeguards against inadvertent unlatching and the addition of interlocks would add unnecessary complexity.

2. Integrated Testing with the Flight CSM, DM and Soyuz Docked

Based on past experience on Apollo and other programs, total integrated testing is not considered necessary to verify mission operational capability. The performance of sub-docked configuration testing (module level test using simulators of the interfacing module) has been demonstrated to be program cost effective while adequately providing verification of compatibility. The following paragraphs summarize the ASTP CSM-DM-Soyuz approach for the assurance of docked compatibility.

The mechanical docking interface will be verified by mating the DM and CSM in the USA and the DM docking system and the Soyuz Spacecraft in the Soviet Union.

The hardwire interface between the Soyuz and CSM consists of TV, cable communications, and electrical power circuits. It should be noted that the USA equipment operating in Soyuz will be powered from the CSM and the USSR equipment operating in the CSM/DM from the Soyuz power system. The integrity of the wire installed between the USA J-box within the flight Soyuz and the DM interface will be verified by testing which includes continuity checks, isolation checks, cross-talk checks and frequency response measurements. The interface performance tests will be conducted in the USA utilizing simulators which contain Soyuz and Apollo communications and TV equipment. This testing will assure that the end-to-end performance requirements for cable communications and the TV are satisfied. It is felt that all factors impacting communications systems performance, except the EMI effects of the Soyuz vehicle which are considered in "Radiated EMI," will be satisfactorily tested. Connector mechanical mated checks will be performed on the DM and Soyuz using a gage connector (master tool).

It should also be noted that the CSM/DM/Soyuz electrical interface consists only of intercom communications and television which are not considered to have any crew safety implications.

Both the USA and USSR are performing analyses to determine the capability of pyrotechnic circuits to survive in the RF environments of spacecraft and ground transmission sources. The analyses will consider both the firing circuit design characteristics and the results of RF compatibility tests performed to date. It is presently planned that if insufficient data exists for the frequency bands and power levels associated with the CSM and Soyuz, additional testing will be required. These decisions however are pending the results of joint review.

The primary radiated EMI concerns associated with the ASTP mission are:

a. The intermodulation product effects on CSM communications receivers.

b. The EMI effects of the internal Soyuz environment on the USA television and cable communications systems via interfacing circuits. Radiation from within the Soyuz through the hatches affecting the CSM is considered extremely remote since at least one tunnel hatch will be closed during docked modes of operation. Any effects of radiated EMI upon DM instrumentation through the hatches are expected to be minimal and occurring only while the DM/Soyuz hatches are open. The radiation effects of Soyuz transmitters on internal CSM and DM equipment should be minimal due to the attenuation afforded by the CSM outer structure and, since the power output from the Soyuz transmitters is not higher than from RF sources experienced on previous CSM missions (LM and SWS).

The intermodulation effects of the composite CSM, DM, and Soyuz are currently being evaluated at JSC. The effects of the Soyuz internal environment on the television and cable communications system are expected to be minimal, if at all, but can be determined by performing tests on a powered-up Soyuz vehicle in the USSR. The requirement for this test is still under consideration.

In summary, the integrating testing of the CSM/DM/Soyuz is not being considered. The successful completion of the Gemini, Apollo, and Skylab programs with no, or minimal, vehicle integrated testing demonstrates the adequacy of sub-docked configuration testing.

APPENDIX H

SPACE SHUTTLE INFORMATION REQUESTS AND RESPONSES

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

OFFICE OF THE ADMINISTRATOR

October 30, 1973

Mr. Robert F. Thompson
Manager, Space Shuttle Program (LA)
Lyndon B. Johnson Space Center
National Aeronautics and Space Administration
Houston, Texas 77058

Dear Bob:

On behalf of the entire Panel, I want to express our appreciation for the briefings which you and your staff have provided for us on the Shuttle program. We did, however, identify a few points where we do not feel we have an adequate understanding and concerning which we would appreciate further information and insight. These particular aspects of the program are as follows. To assure that individual Panel members have full access to this material written responses rather than further briefings would be best.

1. It is our understanding that the application of quantitative objectives to reliability requirements and redundancy designs is to be handled in a somewhat different fashion for Shuttle than was the case for Apollo and Skylab. If this be so, we would appreciate a clearer insight into the rationale for such a change in approach to reliability.

2. We would like to better understand the rationale for the selection of a 14.7 psia cabin atmosphere and some of the trade-offs involved in this choice. The use of this cabin atmosphere was said to "reduce uncertainties" but how it may relate to design and development requirements, to "off-the-shelf" procurement and to various operational factors is not clear to us.

3. To what extent could ejection seats and ejection modules be used in operational flights as well as test flights and what penalties would be associated with such use?

4. Weight control has been a driver on technical managers in earlier programs. What specific steps have been taken by NASA and its contractors to reduce the possible adverse effects that weight increase trends bring with them?

The entire matter of abort requirements and abort capabilities of the Shuttle is, of course, of considerable interest to the Panel. Without identifying specific points and questions at this time, we would appreciate a special briefing and discussion of this entire matter at some mutually convenient time.

In addition, for your information, various Panel members have individually expressed continuing interest in several other areas which they intend to continue to study. These areas include mission profile details; External Tank-Orbiter interfaces; thermal protection, especially tile integrity; Ferry mission logic; Solid Rocket Booster recovery logic; and the effects of cost philosophy on mission integrity.

I appreciate that providing us with the information requested in the preceding numbered list represents an additional burden for busy people but it is this kind of help that will enable us to both better understand your program and offer informed views to the Administrator. Please direct your reply to the Panel offices at NASA Headquarters (Code APA), or feel free to discuss any questions you may have directly with that office.

Sincerely,

Howard K. Nason

Howard K. Nason
Chairman, Aerospace Safety Advisory Panel

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS 77058

REPLY TO
ATTN OF: LA

FEB 6 1974

TO: NASA Headquarters
Attn: APA/Secretary, Aerospace Safety Advisory Panel

FROM: LA/Manager, Space Shuttle Program

SUBJECT: Response to Action Items Resulting from the Shuttle Presentation to the Aerospace Safety Advisory Panel on October 26, 1973

This memorandum is in reply to Mr. Howard Nason's request that further information be forwarded regarding a few points wherein the Aerospace Safety Advisory Panel did not believe they had an adequate understanding. Clarifications of the listed four areas of interest are offered as follows:

Question: "1. It is our understanding that the application of quantitative objectives to reliability requirements and redundancy designs is to be handled in a somewhat different fashion for Shuttle than was the case for Apollo and Skylab. If this be so, we would appreciate a clearer insight into the rationale for such a change in approach to reliability."

Answer: Reliable and safe vehicles are a NASA objective, which can be achieved by applying and accomplishing detailed activities such as:

a. Defining reliability, safety, and other design criteria early in the design phase.

b. Evaluating designs for compliance with design criteria.

c. Utilizing numerics in the comparison of designs during trade studies.

d. Analyzing designs for single-failure points and hazards, and, either eliminating the single-failure points and hazards, or developing specific techniques, methods, and/or procedures for control of them.

e. Adding redundancy for crew safety and mission success.

f. Using controlled parts and materials, evaluating off-the-shelf hardware for compliance with parts and material requirements, and resolving any noncompliance based on a detailed evaluation procedure.

g. Reporting, analyzing, and developing corrective measures for hardware failures.

h. Certifying compliance with design and operational requirements through a rigorous ground- and flight-test program.

The conduct of successful programs, through accomplishment of the above type of activities, is evidenced by the history of past programs such as Mercury, Gemini, and Apollo. Numerical goals were established for these programs; however, the follow-on Gemini and Apollo activities associated with predictions and assessments were suspended in the early program phases because of questionable results caused by the lack of credible failure-rate data. It was also realized that good engineering and analyses were contributing more to the inherent reliability and safety of the vehicle than were the activities required as a result of the establishment of numerical goals.

Launch and mission success or safe return numerical goals and the attendant prediction or assessment activity have not been applied to the Space Shuttle Program; however, past manned space flight experience provides confidence that the objective of achieving a highly reliable and safe Space Shuttle vehicle is capable of being met.

Question: "2. We would like to better understand the rationale for the selection of a 14.7 psia cabin atmosphere and some of the trade offs involved in this choice. The use of this cabin atmosphere was said to "reduce uncertainties", but how it may relate to design and developments requirements, to "off-the-shelf" procurement, and to various operational factors is not clear to us."

Answer: The 14.7 psia cabin pressure level was selected over lower pressure levels because of its over-all programmatic and technical advantages and minimization of impacts to hardware selection, testing, and program funding. A summary of this rationale is contained in enclosure 1 and a summary of the trade offs for the 10 psia study is contained in enclosure 2.

Question: "3. To what extent could ejection seats and ejection modules be used in operational flights as well as test flights and what penalties would be associated with such use?"

Answer: (This response interprets the question as implying an escape capability for all crewmen and passengers to be flown.) Considering the base-lined fuselage configuration which provides for four crewmen on the top deck and six passengers on the lower deck, the following statements can be made:

a. The two ejection seats currently being provided for flight test could be retained for operational missions with the provision that only two crewmen would be able to fly. This would result in operational limitations on the Space Shuttle system which is intended to carry additional personnel for payload-oriented activity.

b. To provide four ejection seats on the upper deck, major interior cabin structural and layout modifications would be involved at a minimum, and might result in modifications affecting fuselage mold-line. This would result in escape capability for two pilots and two payload-oriented crewmen, but would compromise the capability for carrying passengers on the lower deck.

c. To provide an escape module for the upper deck crew and/or the lower deck passengers, a major redesign of the Orbiter would be involved which would be prohibitive in terms of complexity, weight, and total Orbiter design change.

In summary, the current design concept is incompatible with providing escape capability for a full crew and/or passengers.

Question: "4. Weight control has been a driver on technical managers in earlier programs. What specific steps have been taken by NASA and its contractors to reduce the possible adverse effects that weight increase tends to bring with them?"

Answer: Weight control has been a prime concern on earlier programs and continues to be on the Space Shuttle Program. Weight control procedures were implemented at the inception of the Space Shuttle Program and will continue throughout the program duration. Each project office (Orbiter, External Tank, Solid Rocket Booster, and Space Shuttle Main Engine) and each element contractor are assigned a control weight for their element by the Space Shuttle Program Office. The Space Shuttle Program Office has established a control weight to the total system, including element interfaces. These control weights have been established based on design and system performance requirements. Weight control is maintained in the following manner:

a. Status reports are updated and presented to Project and Program Management on a monthly basis.

b. The effect on weight of any design and/or requirement change is presented to management before that change is approved or disapproved.

c. Any weight changes (resulting from component maturity, test results, etc.) are reviewed for work-around and performance-margin effect before acceptance. The process of weight management for the Orbiter is described in enclosure 3. At present, no major anomalies in Orbiter component weight reporting have been identified that would indicate a serious Orbiter weight problem; however, as a result of the historical trends of previous projects, a system review is being conducted to establish confidence in current reported system weights. The results of this review should provide an understanding of system performance margins, define and control sizing ground rules for the solid rocket booster, and provide an understanding of schedule/cost flexibility and margins. For the Oribiter element, the wing and environmental control systems are being selected for a detailed comparison with other aircraft/spacecraft developments. In addition to the ongoing weight management process and the previously mentioned system weight review, a weight incentive program has been initiated by each element project office and contractor. The incentive programs are designed to stress the importance of weight control on the system-subsystem managers/lead engineers who are directly responsible for system-subsystem design. A summary of the incentive program for the Orbiter system-subsystem weight control is described in enclosure 4. A similar weight incentive program for external tank, solid rocket booster, and space shuttle main engine is in the process of being implemented.

It is our belief that the preceding paragraphs, along with the enclosures, should answer any questions that the Aerospace Safety Advisory Panel may have had in the areas of interest listed in Mr. Howard Nason's letter of October 30, 1973.

We appreciate the Panel's attention to the Space Shuttle and highly respect any opinions they may have concerning the program. If further information is needed in these areas, or in any matter concerning the Space Shuttle, please do not hesitate to contact Mr. Scott H. Simpkinson, Manager for Flight Safety, of my office.

Robert F. Thompson

Robert F. Thompson

4 Enclosures
1. Rationale for Selection of 14.7 Psia Atmosphere on Shuttle
2. Study Results of Impact to go from 14.7 Psia to 10.0 Psia Cabin Pressure
3. Process of Weight Management
4. Summary of Weight Incentive Program for Orbiter Subsystem Weight Control

cc:
NASA Hqs., M/Dale D. Myers
NASA Hqs., MH/Myron S. Malkin
NASA Hqs., MD-T/Charles J. Donlan

Enclosure 1

RATIONALE FOR SELECTION OF 14.7 PSIA ATMOSPHERE ON SHUTTLE

1. Compatibility with Russian/U.S. rescue, future space station atmosphere, and manned shuttle payloads.

- Precludes need for special airlocks and related hardware/provisions, and operational procedures.

- Simplified international agreements and technical interfaces.

2. Precludes need for additional validation, testing, and correlations associated with lower cabin pressures.

a. Physiological- Physical adaptation and physiological tolerances of passengers are correlative from ground-to-flight conditions. Precludes need for special testing, validation programs, or provisions required to accommodate personnel to lower pressures.

b. Hardware- Precludes need for expensive and time-consuming ground-test facility use in testing systems, subsystems, and individual components at lower atmospheric pressures.

c. Experiments and Payloads- Have ground-to-flight correlation for carry-on experiments and small payloads carried in manned laboratories (animals, insects, etc., for medical-type payloads). Precludes impact to payload suppliers.

3. Greater use of off-the-shelf hardware and components.

4. No special flammability concerns due to oxygen-enriched atmosphere.

5. No special materials requirements or development, materials and configuration testing, and materials screening and tracking systems.

6. Lower materials outgassing.

7. No special requirements for facility and cabin closeout enrichment such as that which would be required at lower pressures.

8. No special manned configuration verifications required over horizontal flight test for other systems ground tests.

Enclosure 2

STUDY RESULTS OF IMPACT TO GO FROM 14.7 PSIA TO 10.0 PSIA CABIN PRESSURE

Conclusion:

Minor weight advantage involved in reducing cabin pressure to 10 psia is more than offset by programmatic cost, schedule, and facility implications of going to this pressure. Retain 14.7 psia base line.

Study Results:

a. Weights and equipment changes-

Increased weight for 10 psia configuration	Decreased weight for 10 psia configuration
• ECLSS- dry weight increase in fan size, weight, and power	• Structure
• Gas available for cabin pressure maintenance	
• Weight of nonmetallic materials, i.e., ducts, wiring, crew equipment, etc.	
• Larger inverters for fan cooling	

New weight trade off savings of approximately 135 pounds.

Equipment/hardware redesigns for lower pressures.

b. Flammability/materials-

- Increased fire hazard
- Increased materials screening tests, selection/monitoring, and greater materials development
- Potential cabin configuration tests at 2 million dollars (rough estimate)
- Potential cost increase to avionics and other hardware for potting and other material changes
- Degraded durability of nonmetallic materials used at lower pressure

c. Testing costs and facilities-

Significant increase in costs, manpower, and facilities for hardware and components undergoing design verification test and qualification in chamber tests (Avionic's air revitalization system and other hardware).

Examples:

- Design verification test and qualification tests at vendor in chamber instead of at ground level.

- Delta test at Johnson Space Center for manned configuration verification with potential changes in chamber, support hardware, etc., to support Johnson Space Center tests.

- Horizontal flight test performed at 14.7 psia- Predelivery acceptance and preflight acceptance tests performed for this pressure. Delta tests for lower pressures.

d. Experiments/payloads-

Spacelab, other payloads, and in-flight Orbiter experiments are based upon one-to-one correlation of in-flight atmosphere to 14.7 psia ground atmosphere. Political, cost, design, and procedural problems associated with change in pressure level to lower than ambient pressures.

e. Medical-

For passengers and scientists flown on the Space Shuttle, the use of lower than 14.7 psia pressures may dictate assessment, validation, or testing programs to ensure physiological adaptation and tolerances are acceptable. Data available on medical/physiological status/physical tolerances based upon 14.7 psia atmosphere.

PROCESS OF
WEIGHT MANAGEMENT

North American
Aerospace Group

Space Division
Rockwell International

Enclosure 3

PROCESS OF WEIGHT MANAGEMENT

- OBJECTIVE
- RESPONSIBILITIES
- WEIGHT ALLOCATIONS/GROUP RESPONSIBILITY
- WEIGHT REVIEWS
- MANAGEMENT CRITERIA

OBJECTIVE

- WEIGHT CONTROL

  CONCEIVE AND IMPLEMENT WEIGHT REDUCTIONS TO EXTENT POSSIBLE WITH GUIDELINE CONSTRAINTS.

  MAINTAIN CONTROL OF THE WEIGHT DURING IMPLEMENTATION OF APPROVED CHANGES.

  JOINT EFFORT OF DESIGN, ANALYSIS, PROJECT ENGINEERING, MASS PROPERTIES, AND MANUFACTURING.

- WEIGHT REPORTING

  PREDICT ADVERSE WEIGHT TRENDS EARLY TO ALLOW CORRECTIVE ACTION AT A MINIMUM PROGRAM RISK.

RESPONSIBILITIES

- MASS PROPERTIES

  REPORT AND ALLOCATE

  WEIGHT IMPACTORS

- STRESS

  OPTIMUM STRENGTH

  MINIMUM WEIGHT

- ANALYTICAL FUNCTIONS

  OPTIMUM CRITERIA

  APPLICABLE REQUIREMENTS

- PROJECT ENGINEER

  SURVEILLANCE OF WEIGHT AND DESIGN PROGRESS

  CHAIRS WEIGHT REVIEW MEETINGS

- DESIGN ENGINEER

  PRODUCES WEIGHT EFFECTIVE DESIGN

  RESPONSIBLE FOR MEETING OR BEATING WEIGHT ALLOCATIONS

WEIGHT ALLOCATIONS/GROUP RESPONSIBILITY

- PURPOSE

  REPORT ALLOCATED AND STATUS WEIGHT VARIATIONS

- CONTENTS

  ORBITER NO. 3 WEIGHT SUMMARY

  ALLOCATED AND STATUS WEIGHTS TO DETAIL LEVEL

- FORMAT

  WEIGHT DATA BY DESIGN GROUP RESPONSIBILITY

  DIRECTOR, MANAGER, AND SUPERVISOR LEVEL

WEIGHT ALLOCATIONS/GROUP RESPONSIBILITY (continued-)

FORMAT- (TYPICAL)

GROUP RESPONSIBILITY SUMMARY REPORT NUMBER ________

INCLUDING PENDING CHANGES DATED ____________________

MANAGER: R. KOCHEVAR — DESIGN: I. VICTOR

SECTION: STRUCT. DESIGN — STRESS: J. GOBLE

GROUP: BODY GROUP — WEIGHT: A. KUSANO

3.0 BODY GROUP	ALLOCATED WEIGHT	OVER OR UNDER	STATUS WEIGHT	CURRENT WEIGHT CHANGES

WBS

1.3.1.1.1 BASIC STRAIGHT-FORWARD BODY (3.1)

WEIGHT ALLOCATIONS/GROUP RESPONSIBILITY (concluded-)

FORMAT- (TYPICAL)

GROUP RESPONSIBILITY SUMMARY REPORT NUMBER ________

INCLUDING PENDING CHANGES DATED ________________

MANAGER: W. FOUTS

SECTION: AVIONICS

GROUP: GUIDANCE & NAVIGATION

DESIGN: A. ZEITLIN

STRESS: (NOT APPLICABLE)

WEIGHT: J. FROST

13.1 GUIDANCE & NAVIGATION	ALLOCATED WEIGHT	OVER OR UNDER	STATUS WEIGHT	CURRENT WEIGHT CHANGES

SUPERVISORY WEIGHT CONTROL MEETING

- AREA COVERED

  TOTAL VEHICLE IN SEGMENTS BY GROUP RESPONSIBILITY

- ATTENDANCE

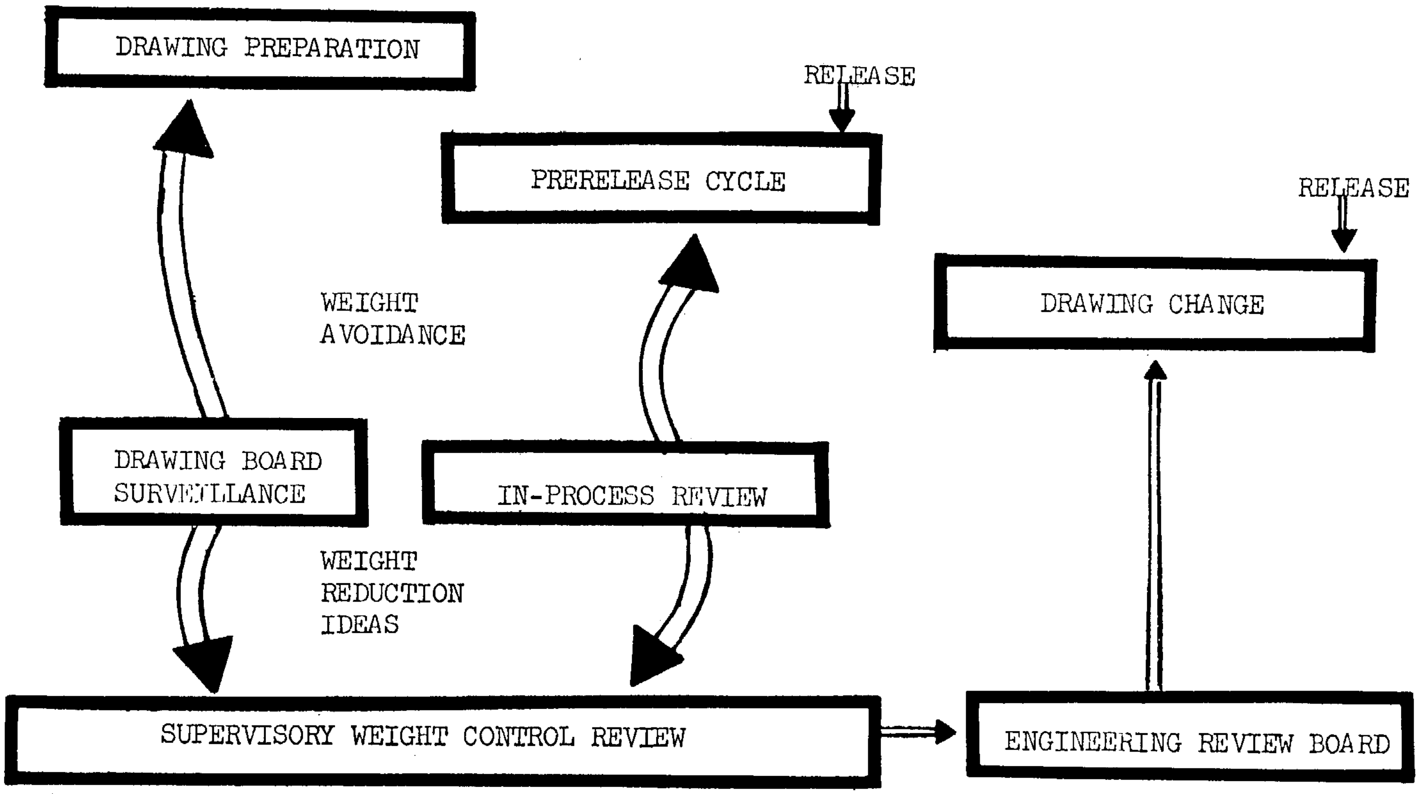
  PROJECT ENGINEER - CHAIRMAN
  WEIGHT CONTROL SUPERVISOR AND/OR LEAD ENGINEER
  DESIGN SUPERVISOR AND/OR LEAD ENGINEER
  STRESS SUPERVISOR AND/OR LEAD ENGINEER
  WEIGHT ENGINEER
  DESIGNER
  SPECIALISTS AS REQUIRED
  MANUFACTURING

- ACTIVITIES

  EVALUATION OF WEIGHT REDUCTION PROPOSALS
  GENERATION OF "NEW" WEIGHT REDUCTION IDEAS
  EXERCISING OF IDENTIFIED WEIGHT GROWTH
  QUESTIONING OF DESIGN REQUIREMENTS
  REVIEW OF WEIGHT STATUS AND PROJECTIONS

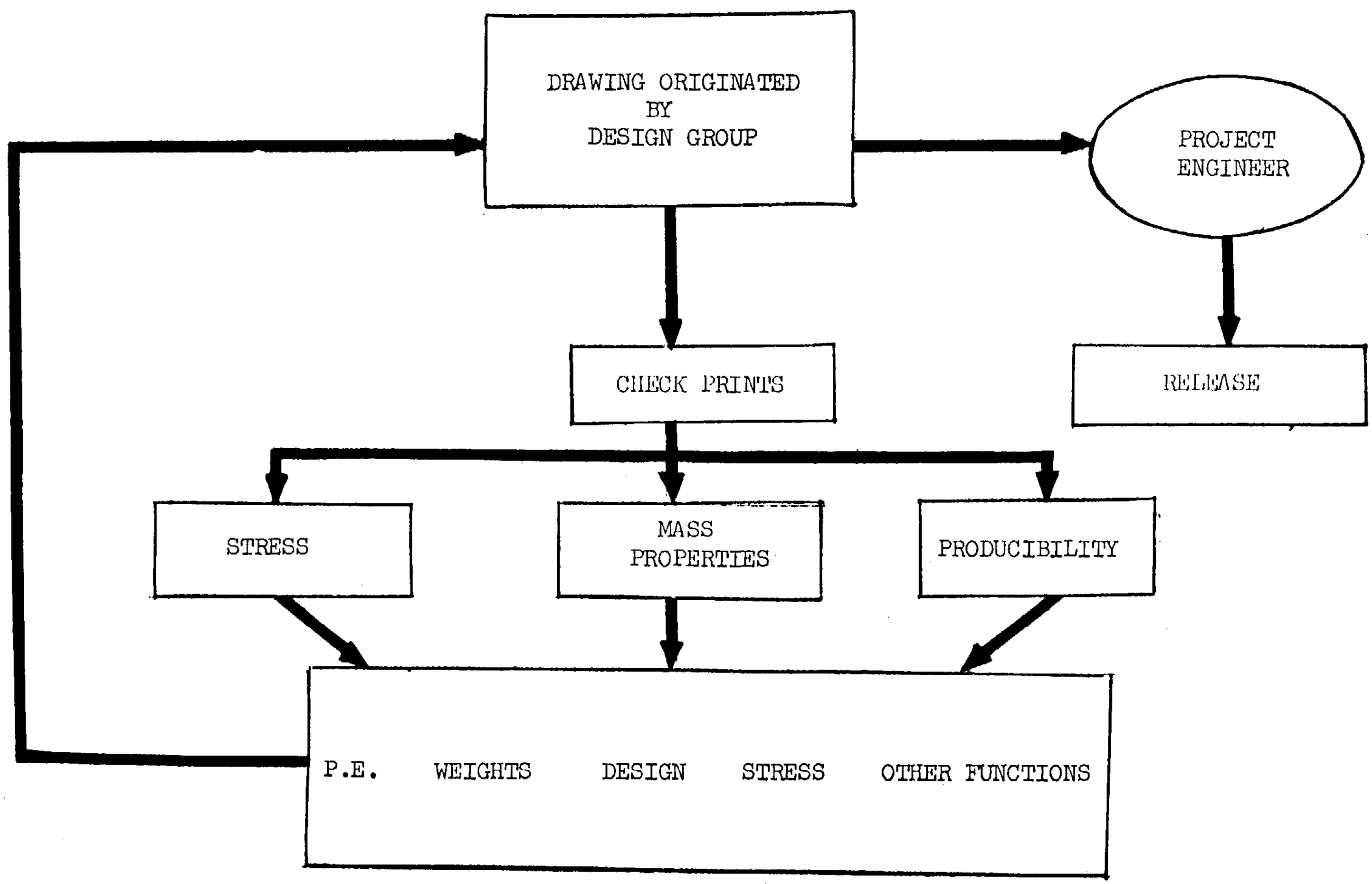
MANAGEMENT CRITERIA

OVERALL WEIGHT CONTROL



MANAGEMENT CRITERIA (concluded-)

STRUCTURAL DRAWING FLOW (IN PROCESS REVIEW)



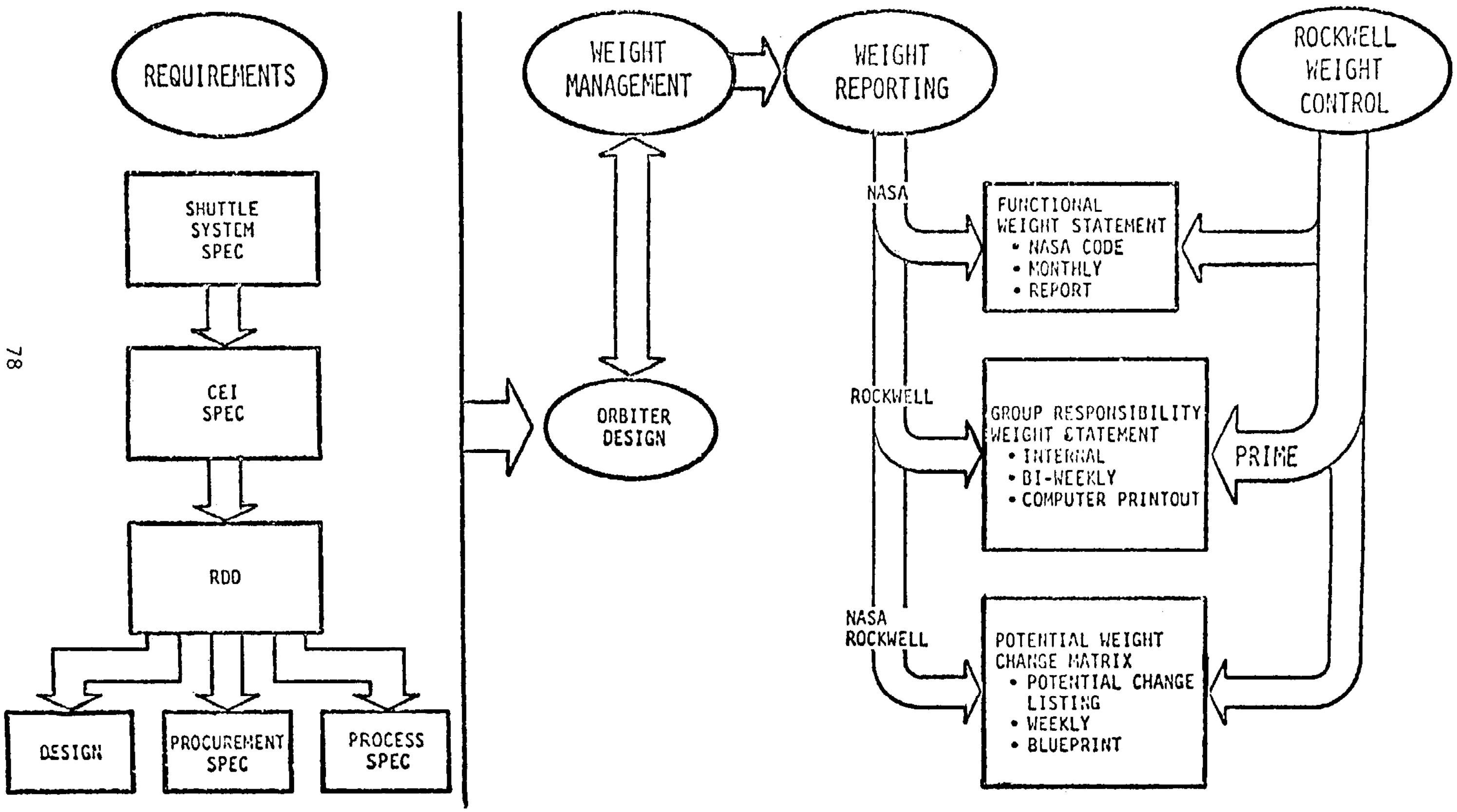
SUMMARY OF WEIGHT INCENTIVE PROGRAM FOR ORBITER SUBSYSTEM WEIGHT CONTROL

Enclosure 4

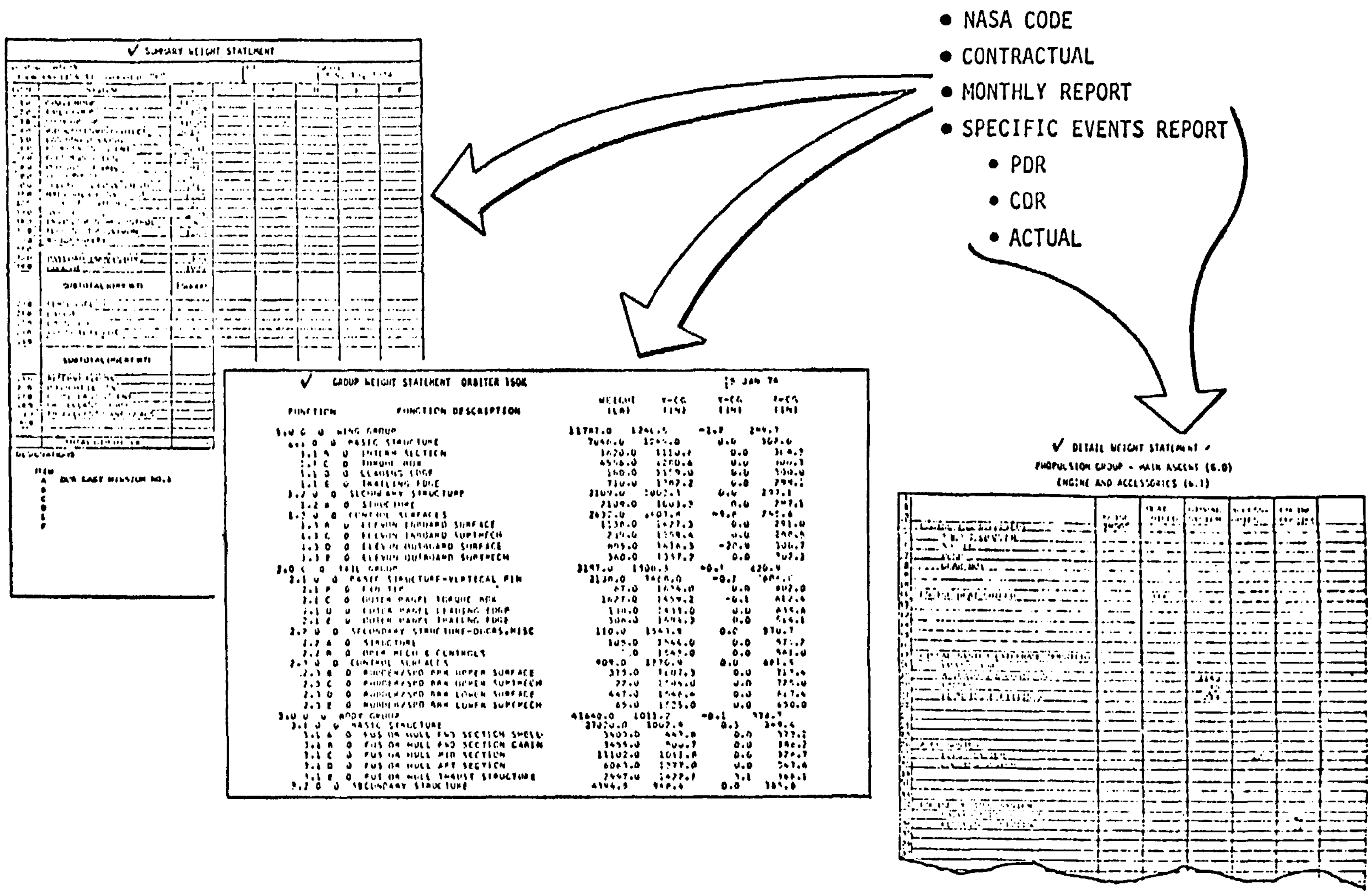
Enclosure 4

WEIGHT MANAGEMENT

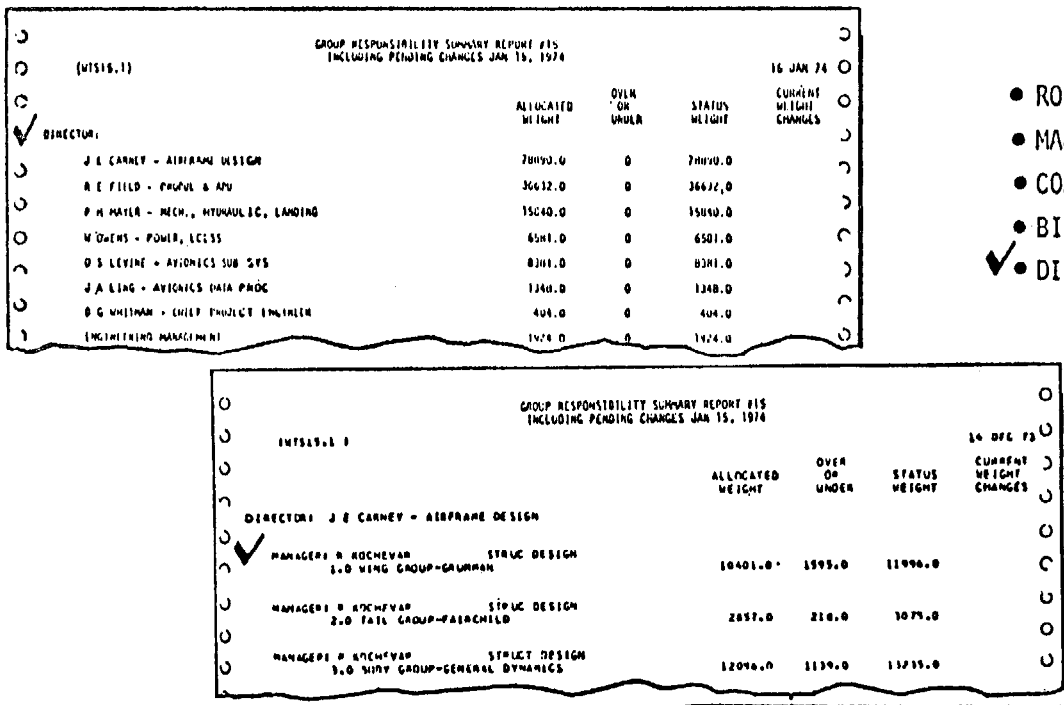
WEIGHT MANAGEMENT



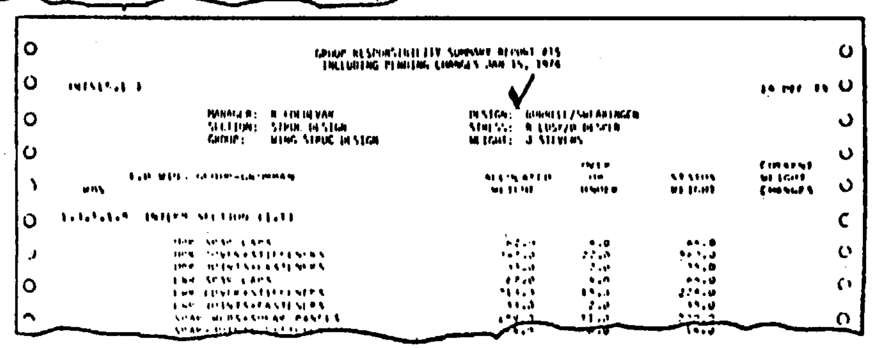
FUNCTIONAL WEIGHT STATEMENT



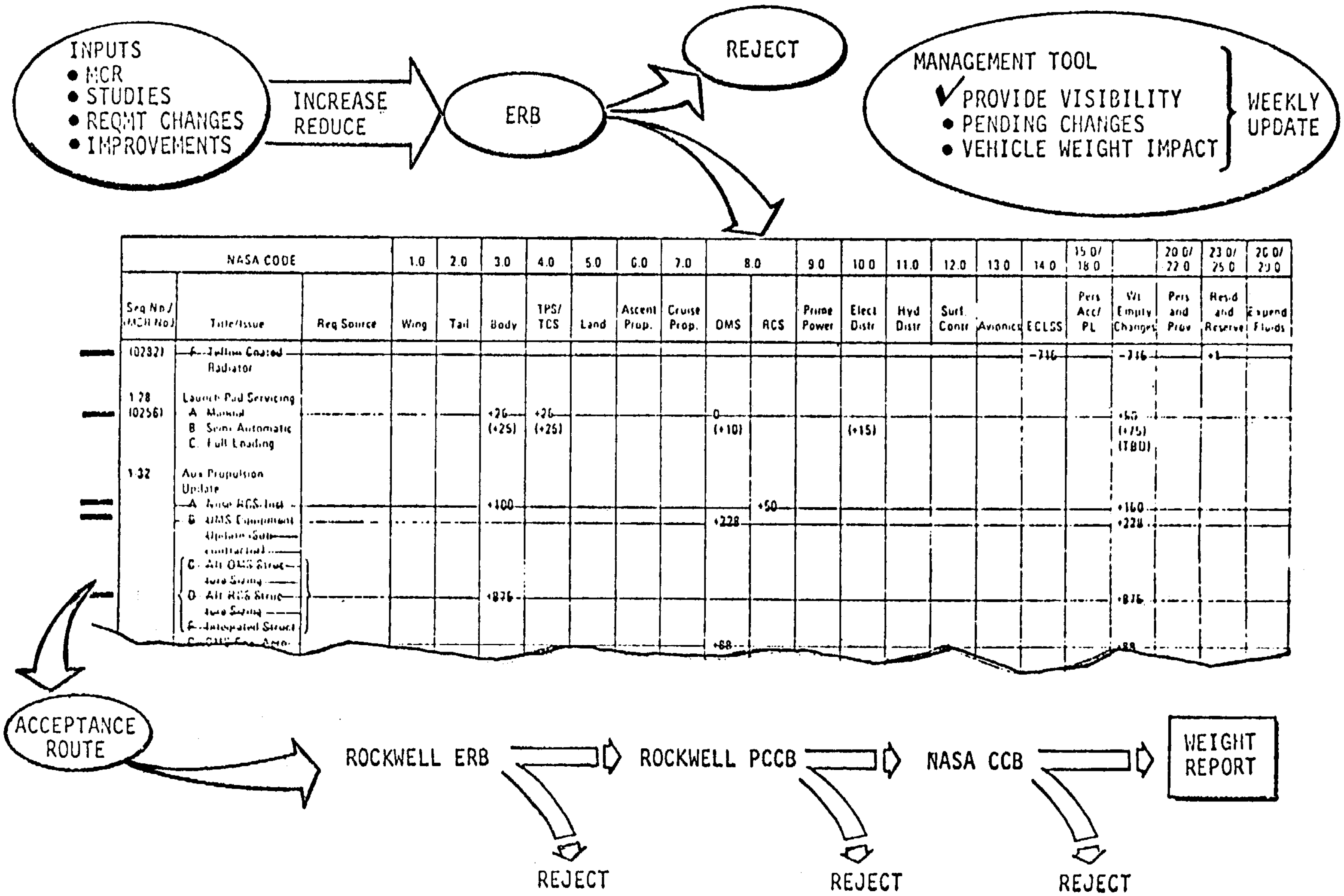
GROUP RESPONSIBILITY WEIGHT STATEMENT



- ROCKWELL INTERNAL RESPONSIBILITY
- MAJOR GROUPINGS SIMILAR TO NASA CODE
- COMPUTER PRINTOUT
- BIWEEKLY
- ✓ DIRECT WEIGHT/BOGEY
  - ALLOCATION
  - RESPONSIBILITY

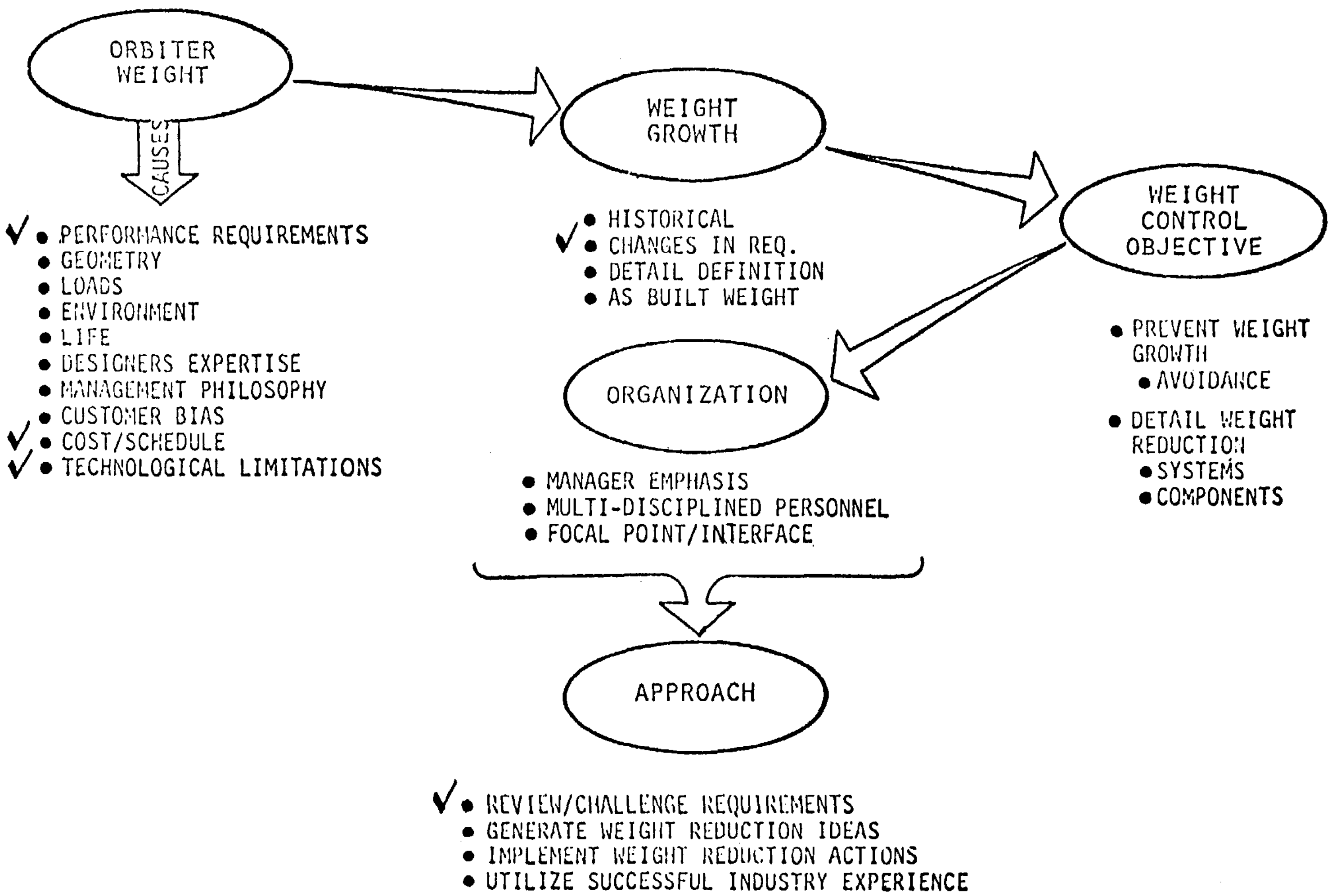


POTENTIAL WEIGHT CHANGE MATRIX

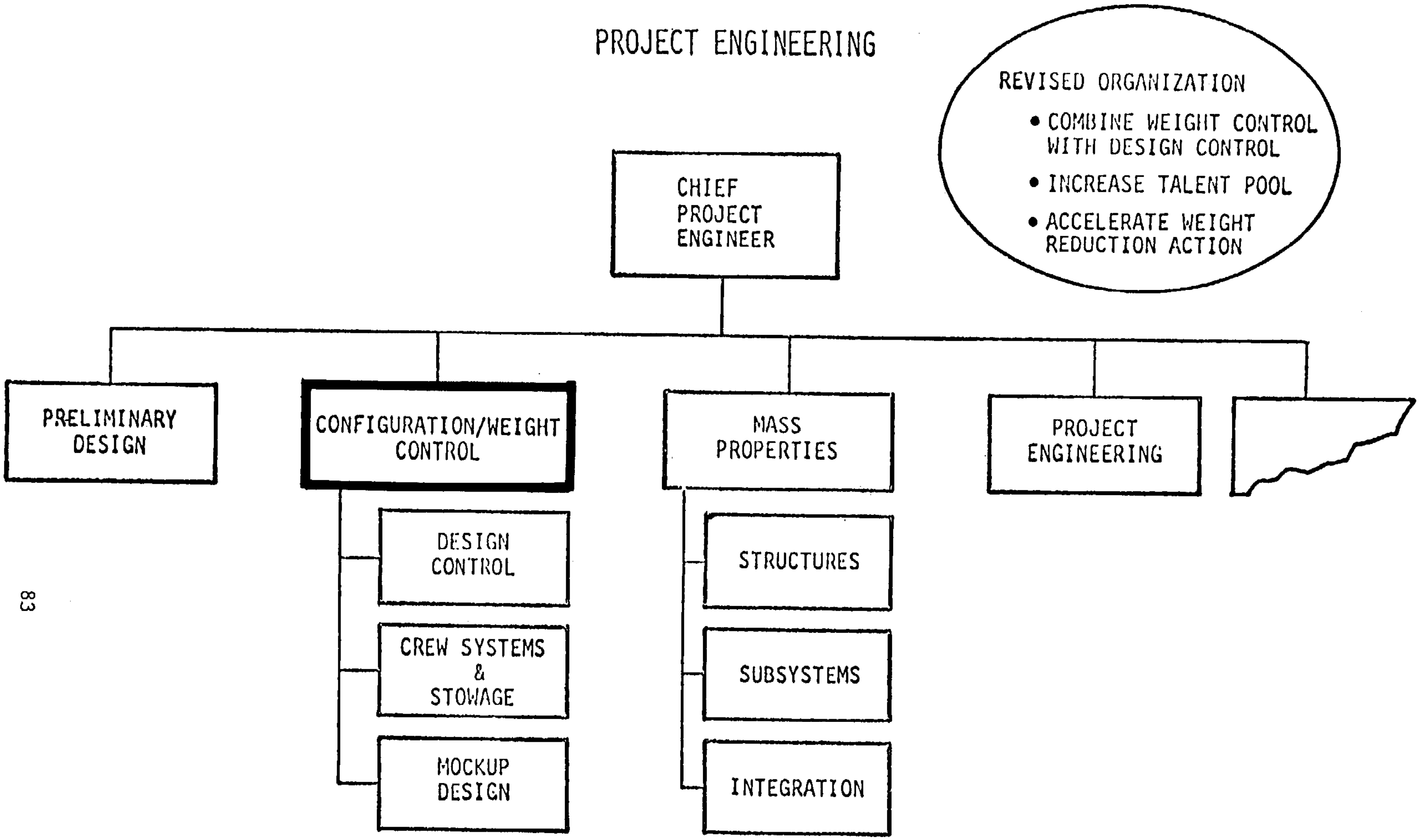


NASA CODE			1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0		9.0	10.0	11.0	12.0	13.0	14.0	15.0/18.0		20.0/22.0	23.0/25.0	26.0/29.0
Seq No/MCR No	Title/Issue	Req Source	Wing	Tail	Body	TPS/TCS	Land	Ascent Prop.	Cruise Prop.	OMS	RCS	Prime Power	Elect Distr	Hyd Distr	Surf. Contr	Avionics	ECLSS	Pers Acc/PL	Wt Empty Changes	Pers and Prov	Resid and Reserve	Expend Fluids
(02821)	F. Teflon Coated Radiator																-716		-716		+1	
1-28 (02561)	Launch Pad Servicing A. Manual B. Semi Automatic C. Full Loading				+26 (+25)	+26 (+25)				0 (+10)			(+15)						[illegible] (+75) (TBD)			
1-32	Aux Propulsion Update																					
	A. Nose RCS Inst				+100						+50								+160			
	B. OMS Equipment Update (Subcontractual)									+228									+228			
	C. Aft OMS Structure Sizing; D. Aft RCS Structure Sizing; E. Integrated Struct				+876														+876			
	G. OMS [illegible]									+68									+88			

WEIGHT CONTROL DEVELOPMENT



PROJECT ENGINEERING



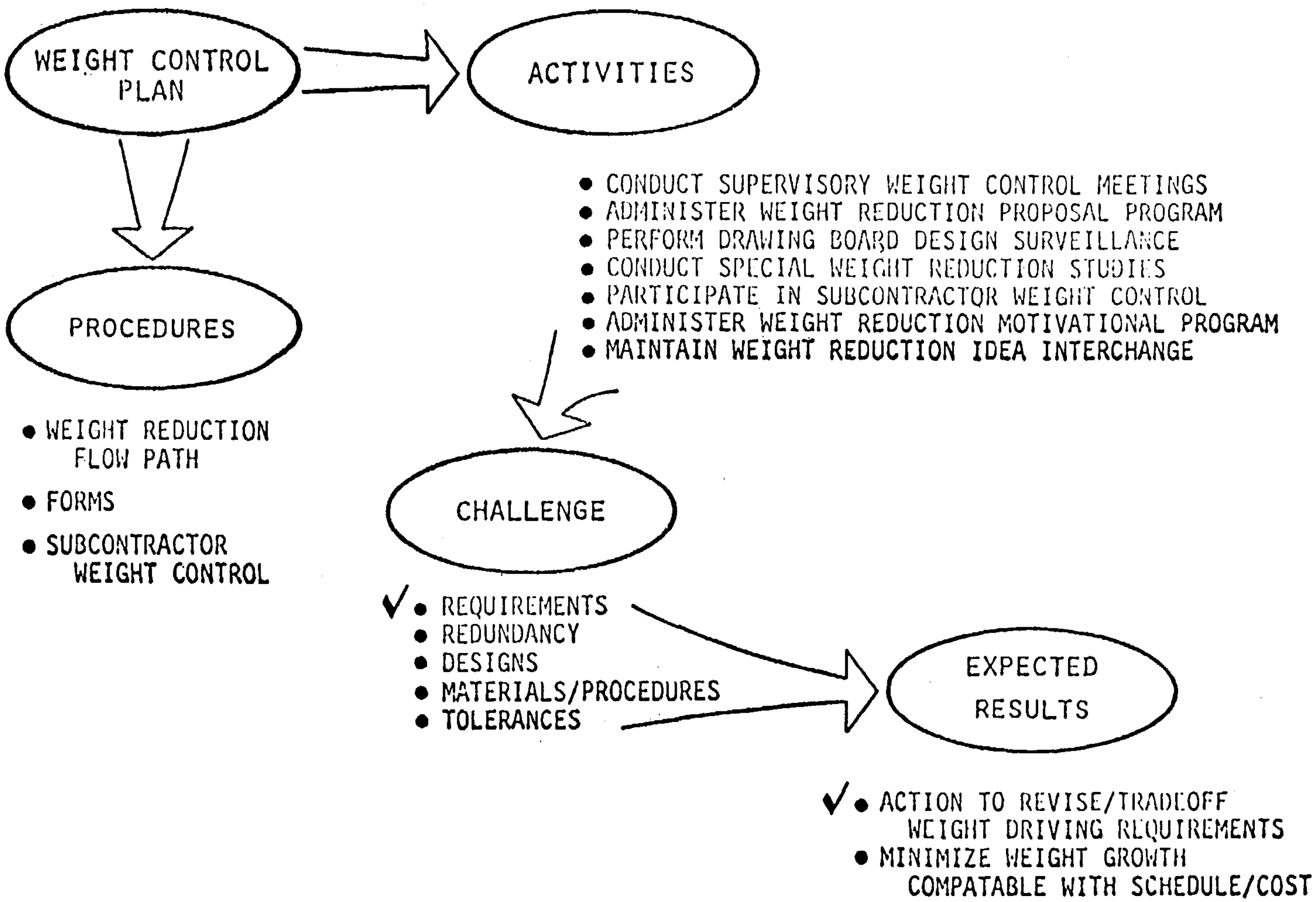
✓ AVAILABLE PERSONNEL
- EXCELLENT DESIGN TALENT
- DESIGN CHALLENGE

✓ EMPHASIS GROUP
- DESIGN CONTROL
- WEIGHT CONTROL

✓ NORMAL MASS PROPERTIES GROUP FUNCTIONS
- WEIGHT REPORTING
- WEIGHT ENFORCEMENT

✓ ENFORCEMENT GROUP
- STRUCTURE
- SYSTEMS

WEIGHT CONTROL IMPLEMENTATION



WEIGHT REDUCTION STUDIES

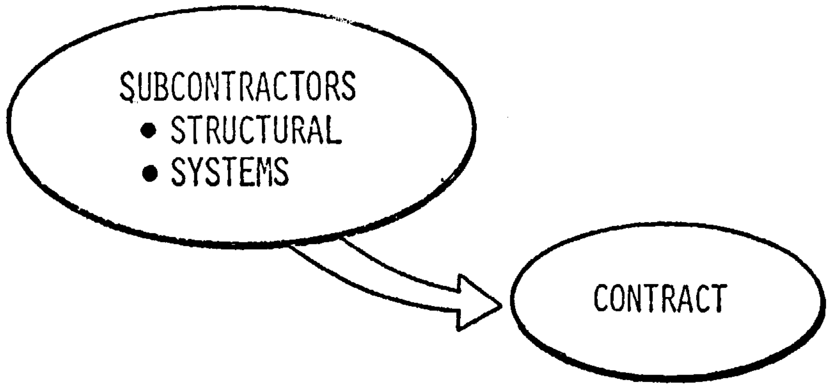
○ PENDING COMPLETE INVESTIGATION

NO.	STUDY	Δ ESTIMATED WEIGHT CHANGE (LB)		CHANGE IN REQUIREMENT
		DRY	WET	
1	FROM 4 TO 3 APU SYSTEMS	-222	-416	✓
2	FROM 4 TO 3 HYDRAULIC SYSTEMS	-483	-708	✓
3	ELIMINATE PAYLOAD BAY LINER	-315		✓
4	FACTOR OF SAFETY REDUCTION MATERIAL ALLOWABLE DEGRADATION AT END OF LIFE (500 FLIGHTS) NOW – ENTIRE AREA AT 350°F DEFINE ACTUAL AREA AT 350°F DEFINE AREA NOT AT 350°F & REDUCE TPS THICKNESS			✓
5	SIMPLIFY PVO SYSTEM LESS COMPARTMENTS EVALUATE MIXTURES WITHIN COMPARTMENTS OPTIMIZE ΔP FOR STRUCTURE VS PVD SYSTEM			
6	ELIMINATE 8 PSI MIN PRESSURE CABIN OPERATION ADDITIONAL REGULATION SYSTEM NOT REQD	WEIGHT AVOIDANCE		✓

WEIGHT REDUCTION STUDIES (CONT)

NO.	STUDY	ESTIMATED WEIGHT CHANGE (LB) DRY	WET	CHANGE IN REQUIREMENT
7	OPTIMIZE RCS DELETE COMMON TANK CONSTRAINTS REDUCE CONTINGENCY PROPELLANT			✓
8	ESTIMATE EMERGENCY EGRESS PANEL	-40		
9	NO BATTERIES	-51		
10	PAYLOAD INSTALLATION PROVISIONS ITEMIZE IN PAYLOAD ACCOMMODATIONS (CODE 21) (ALL FLIGHT HARDWARE) PAYLOAD (CODE 22) (SPECIFIC FLIGHT HARDWARE)			✓
11	65,000K LANDED PAYLOAD USE CONSTANT NW FOR LANDING PAYLOADS IN EXCESS OF 32,000 LB	WEIGHT AVOIDANCE		✓
12	REDUCE RCC AREAS FURTHER THERMO INVESTIGATION			
13	REDUCE REDUNDANCY PHILOSOPHY			✓
14	REDUCE CABIN/AIRLOCK/DOCKING MODULE INTERFACE RING DIAMETER			

SUBCONTRACTOR WEIGHT CONTROL PLAN



- PERFORMANCE REQ
- SCHEDULE REQ
- INTERFACE REQ
- SPECIFICATION WEIGHT
- ✓ WEIGHT EFFORT
  - PERFORM WEIGHT STUDIES
  - PROVIDE WEIGHT ANALYSIS DATA
  - PROVIDE REPORTS
  - VERIFY BY WEIGHING
- ✓ MASS PROPERTIES REPORTS
  MONTHLY
  ROCKWELL FORMAT
- ETC
- ✓ COST PLUS AWARD FEE

AWARD FEE IS DEPENDENT ON TOTAL CONTRACT PERFORMANCE

- WEIGHT IS MAJOR PERFORMANCE DRIVER

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

IN REPLY REFER TO: MHQ

May 8, 1973

MEMORANDUM

TO: APA/Executive Secretary, Aerospace Safety Advisory Panel

FROM: MH/Director, Space Shuttle Program

SUBJECT: Presentation to the A.S.A.P. on April 10, 1973

In discussion of the high temperature reusable surface insulation (RSI) for the shuttle thermal protection system (TPS), Dr. Mrazek postulated that trapped moisture in the tiles could result in a disastrous failure as water turned to steam on reentry. This led to a suggestion by Dr. Agnew that it might be appropriate to indicate in the RFP the desireability of non-porous RSI tile from the moisture absorption view-point. The following information is furnished in response to this discussion.

A number of tests have been conducted to determine effects of such conditions as steam generation resulting from moisture trapped inside an RSI tile, freeze-thaw cycle, pressure lag within a tile and unvented tiles. Of these, the only deleterious effects resulted from unvented tiles, in which case portions of the coating were lost. Such coating damage would be non-catastrophic should it occur operationally and would simply entail replacing the tile during the maintenance cycle. However, since current designs provide for venting, this failure mode is highly unlikely.

Specifically, steam generation in a tile was not a problem. The tiles are very porous and thus prevent build-up of pressure differential. More important is the self-insulating characteristic. Although the temperature at the surface may be very high, the temperature gradient through the material is very steep so that, at very little depth, there is only a small temperature rise. Therefore, any moisture in the tile is gradually vaporized and vented. At worst, a completely saturated tile, which is an extremely unlikely condition, may lose some of its coating in an off-design trajectory dispersion.

In summary, the characteristics of the tile, while allowing moisture penetration also allows it to escape harmlessly.

I appreciate the Panel's attention on this point and am happy I can advise you that we do not seem to have a problem.

"Original Signed by L.E. Day for"

M.S. Malkin

EXTERNAL TANK

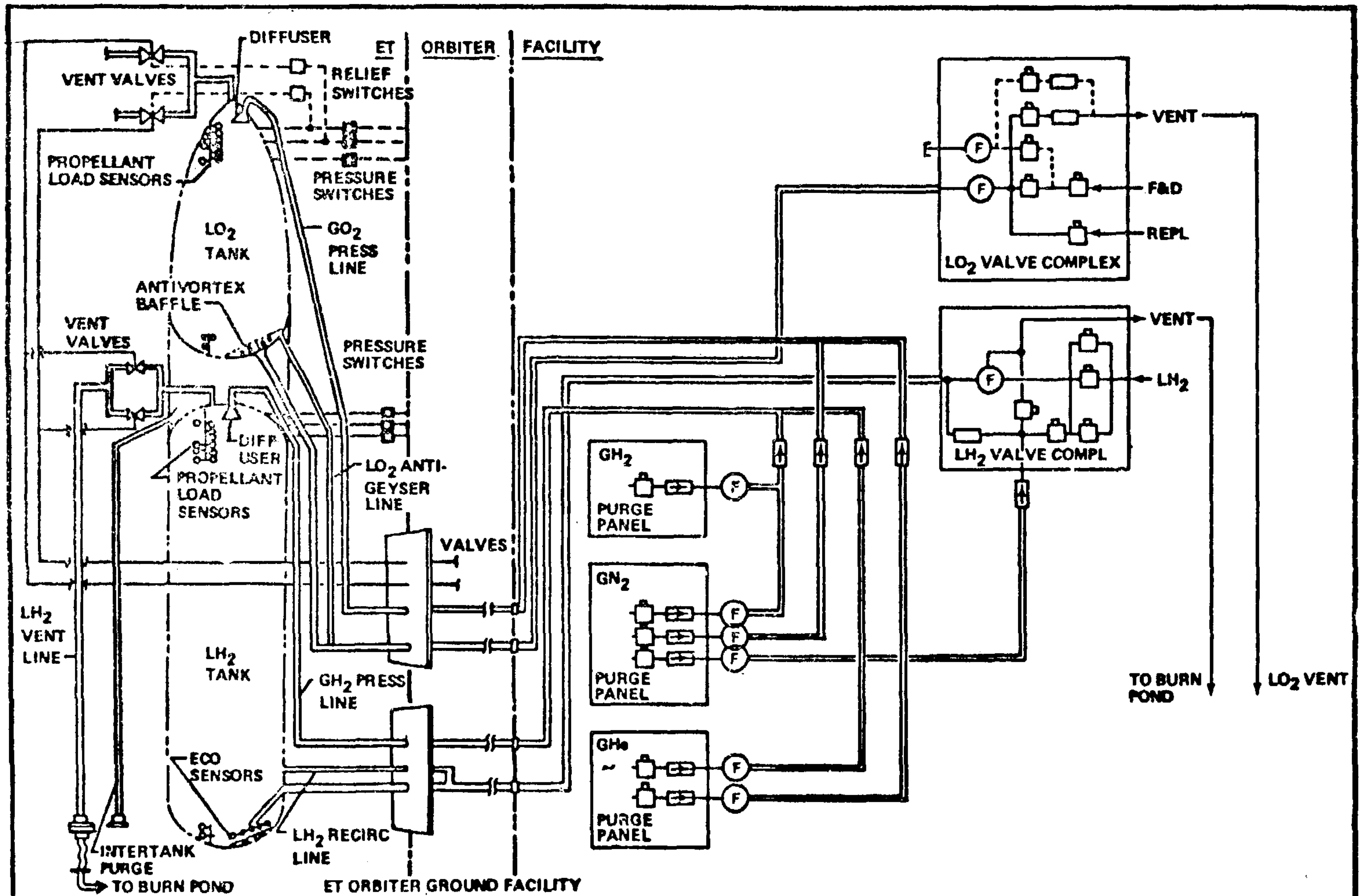
LO_2 AND LH_2 FILL, FEED, AND DRAIN LINES

Separate LO_2 and LH_2 lines control and transfer propellants from the tanks to the ET/Orbiter interface. Both lines are 17 inches in diameter and contain flex joints and sliding supports for thermal and mechanical movement.

The propellant lines contain 17 inch diameter disconnects at the ET/Orbiter interface. The disconnects are mechanical devices that contain a shutoff valve in each section (one on the Orbiter side and one on the ET side of the interface). Engagement of the two sections provides line flow capability when the shutoff valves are in the open position. The shutoff valve actuation mechanism is designed to preclude inadvertent closure during engine firing. Prior to Orbiter/ET separation, the shutoff valve on each side of the interface is actuated closed.

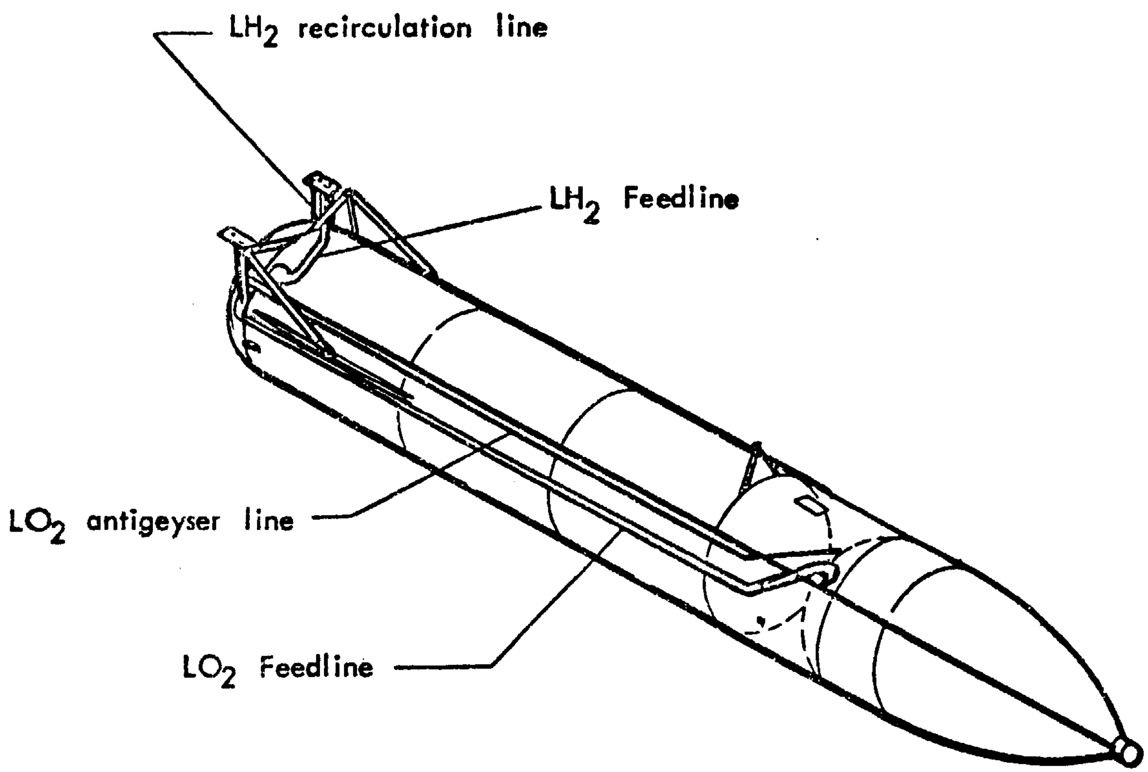
The fluid trapped between the two closed valves, (maximum of 3.0 ft^3) is allowed to dump freely as the disconnect sections are disengaged. During normal operation, the closed valve on the Orbiter side serves as a closeout of the main engine feed system to prevent system contamination. The closed valve on the ET prevents a thrust reaction due to liquid or gas leakage. This disconnect design and separation sequence is new and is the result of the current interface definition studies.

ET PROPULSION SUBSYSTEM

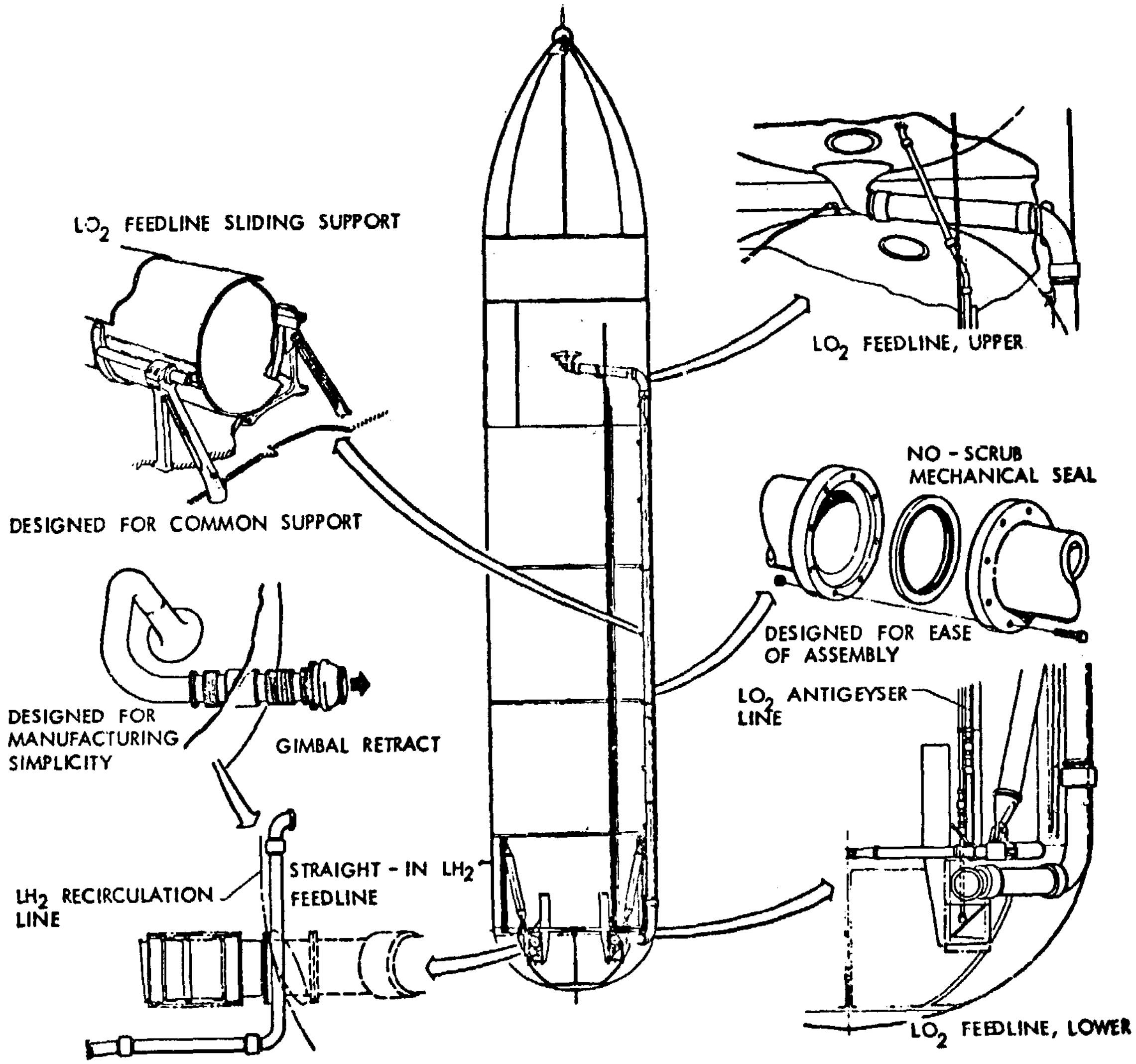


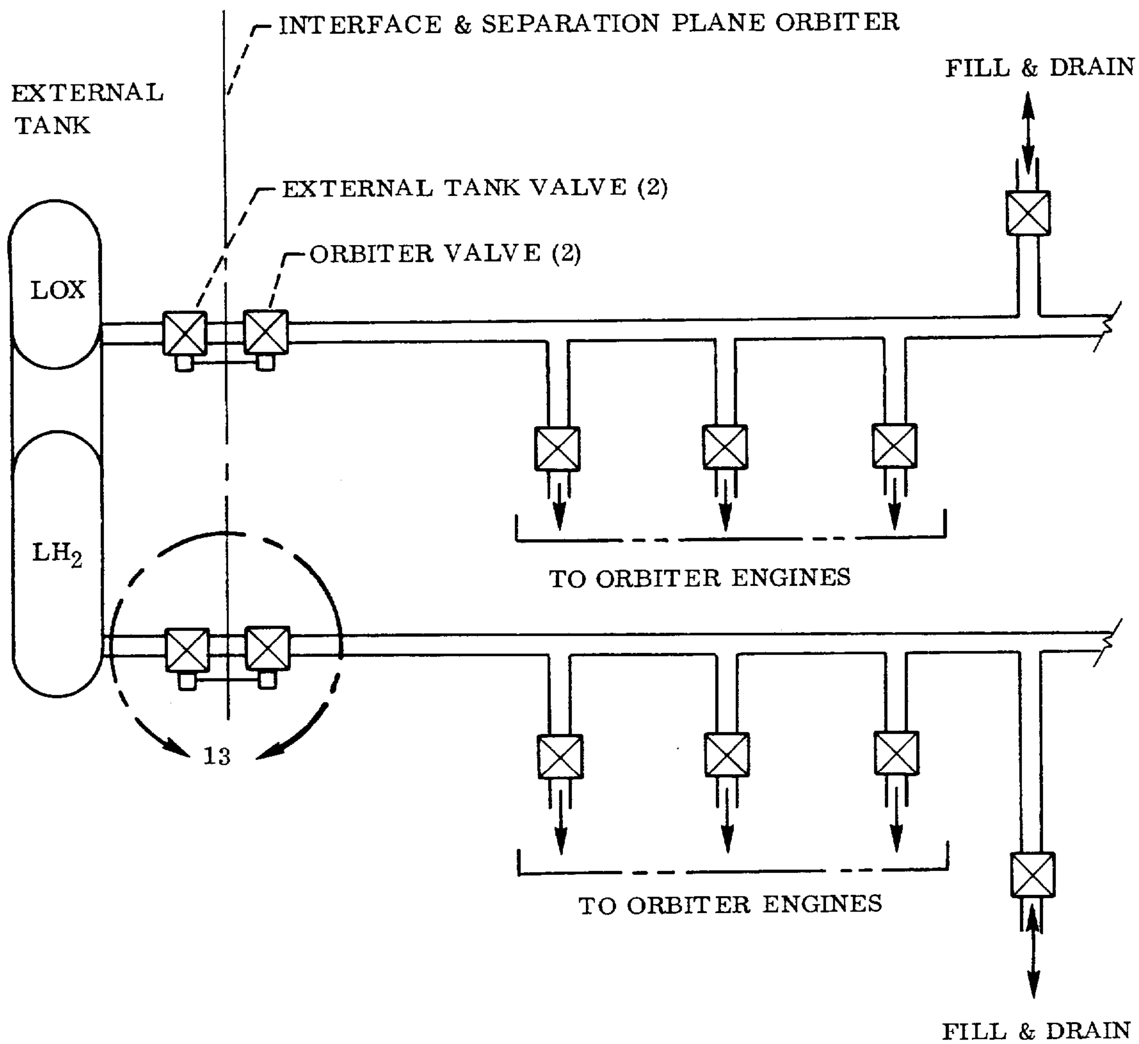
FEED, PRESSURIZATION AND PURGE SCHEMATIC

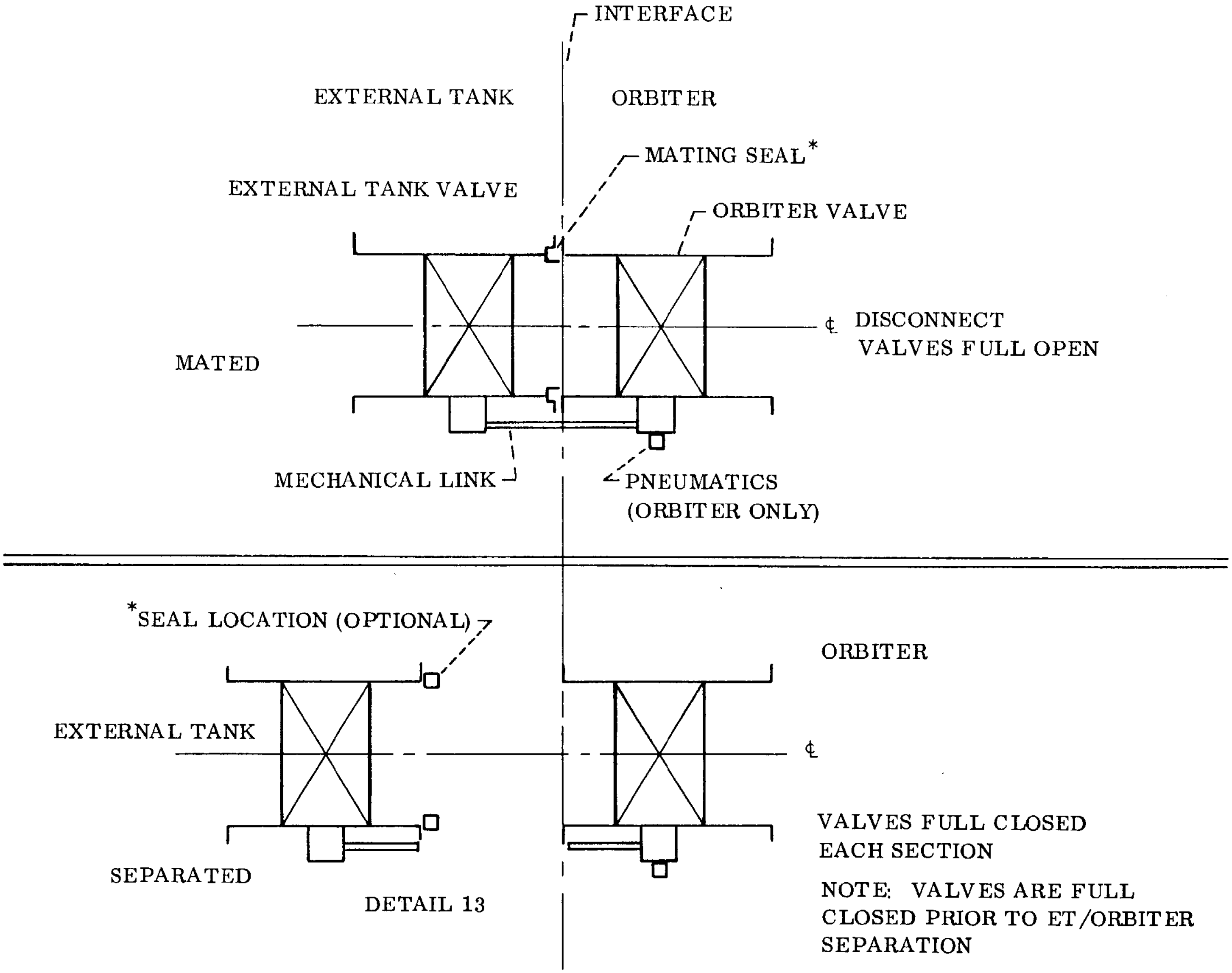
PROPELLANT FEED



PROPELLANT FEEDLINE ARRANGEMENT




INTERFACE & SEPARATION PLANE ORBITER
FILL & DRAIN
EXTERNAL
TANK
EXTERNAL TANK VALVE (2)
ORBITER VALVE (2)
LOX
LH_2
TO ORBITER ENGINES
13
TO ORBITER ENGINES
FILL & DRAIN


INTERFACE
EXTERNAL TANK
ORBITER
MATING SEAL*
EXTERNAL TANK VALVE
ORBITER VALVE
MATED
DISCONNECT
VALVES FULL OPEN
MECHANICAL LINK
PNEUMATICS
(ORBITER ONLY)
*SEAL LOCATION (OPTIONAL)
ORBITER
EXTERNAL TANK
VALVES FULL CLOSED
EACH SECTION
SEPARATED
NOTE: VALVES ARE FULL
CLOSED PRIOR TO ET/ORBITER
SEPARATION

DETAIL 13

TABLE I

SCHEDULE OF PANEL REVIEWS - 1973

January 19	NASA Headquarters, Washington, D.C.	Panel Skylab report to the Administrator
February 12-13	KSC, Florida	Skylab test, checkout, launch preparations
March 12-14	JSC, Houston, Texas	Skylab mission planning, training, status
April 9-10	JSC, Texas and NASA Hqs, Wash. D.C.	Skylab pre-launch status and report to the Administrator. Orientation ASTP, Shuttle
May 14-15	KSC, Florida	Skylab launch preparations and contingency plan
June 6-7	JSC, Houston, Texas	Skylab mission operations and repair status Shuttle program management review
July 16-17	MSFC, Huntsville, Alabama	Skylab status and pre-mission review
September 10-11	JSC, Houston, Texas	Shuttle management concepts and tech. problems ASTP management concepts and challenges
October 25-26	MSFC, Huntsville, Ala and JSC, Texas	Skylab-4 pre-mission review. Shuttle SSME and Systems integration activities
November 19-20	Space Div., Rockwell Int., Downey, Calif.	Shuttle orbiter and Systems Integration ASTP briefing
December 17-18	Rocketdyne Div., RI, Canoga Park, Calif. FRC, Edwards, California	Shuttle SSME and FRC Shuttle participation

SPECIAL BRIEFINGS AND PARTICIPATION AT IN-HOUSE MEETINGS

1. Pre-Meetings to provide clear understanding of Panel requirements prior to fact-finding sessions were conducted throughout the year. Panel Chairman and Panel Staff met with program management at various sites.
2. Attendance at Flight Readiness Reviews (FRR) at MSFC, JSC and KSC. Pre-FRR meetings attended by Panel members on an individual basis along with Panel Staff attendance. (Skylab Program, SL-1/2, SL-3,SL-4)
3. Panel Chairman and individual members received special briefings from Headquarters program management on Skylab, ASTP and Shuttle. This comprised some nine (9) separate sessions.
4. Panel members and Panel Staff attended the week-long, August 13-17, System Requirements Review (SRR) conducted at Rockwell International, Downey, California.

TABLE II

SHUTTLE PROGRAM CONTRACTS

- Orbiter/System Integration - R.I. Space Division
  - Flight control systems------------------------Honeywell
  - Data processing & software requirements--------IBM
  - Orbital maneuvering system pods---------------MDAC
  - Vertical stabilizer----------------------------Republic
  - Wing---Grumman
  - Mid-fuselage-----------------------------------General Dynamics
  - Ground maintenance & operations support--------American Airlines

- Main Engine - R.I. Rocketdyne Division
  - Controller-------------------------------------Honeywell
  - Hydraulic actuator-----------------------------Hydraulic Research Inc.

- External Tank------------------------------------Martin Marietta Corporation

- Solid Rocket Booster-----------------------------Thiokol Chemical Corporation
  (Solid rocket motor; the total SRB to be defined later)

TABLE III

APOLLO SOYUZ TEST PROJECT WORKING GROUPS

Working Group 0	Technical Project Director - General Technical Management
Working Group 1	Mission Model and Operations Plans - Trajectories - Crew Activities and Plans - Training - Experiments
Working Group 2	Guidance and Control - Spacecraft to spacecraft rendezvous tracking req'mts - Docking aids - Optics and orientation lights - Control systems
Working Group 3	Mechanical Design - Docking system - Hatches - Connector - Installation
Working Group 4	Communications and Tracking - Spacecraft to spacecraft and spacecraft to earth voice communications - Spacecraft to spacecraft radio tracking equipment - Cable communications for voice and television
Working Group 5	Life Support and Crew Transfer - Equipment and conditions affecting crew transfer

TABLE IV

REFERENCE MISSIONS

- Three reference missions are being used to establish requirements for shuttle hardware, software, and operations

  - Mission 1
    Geosynchronous satellite placement and retrieval operations with space tug

  - Mission 2
    Unmanned satellite refurbishment and orbital experiment operations

  - Mission 3

    One revolution payload delivery or retrieval operation

SPACE SHUTTLE PROGRAM SCHEDULE

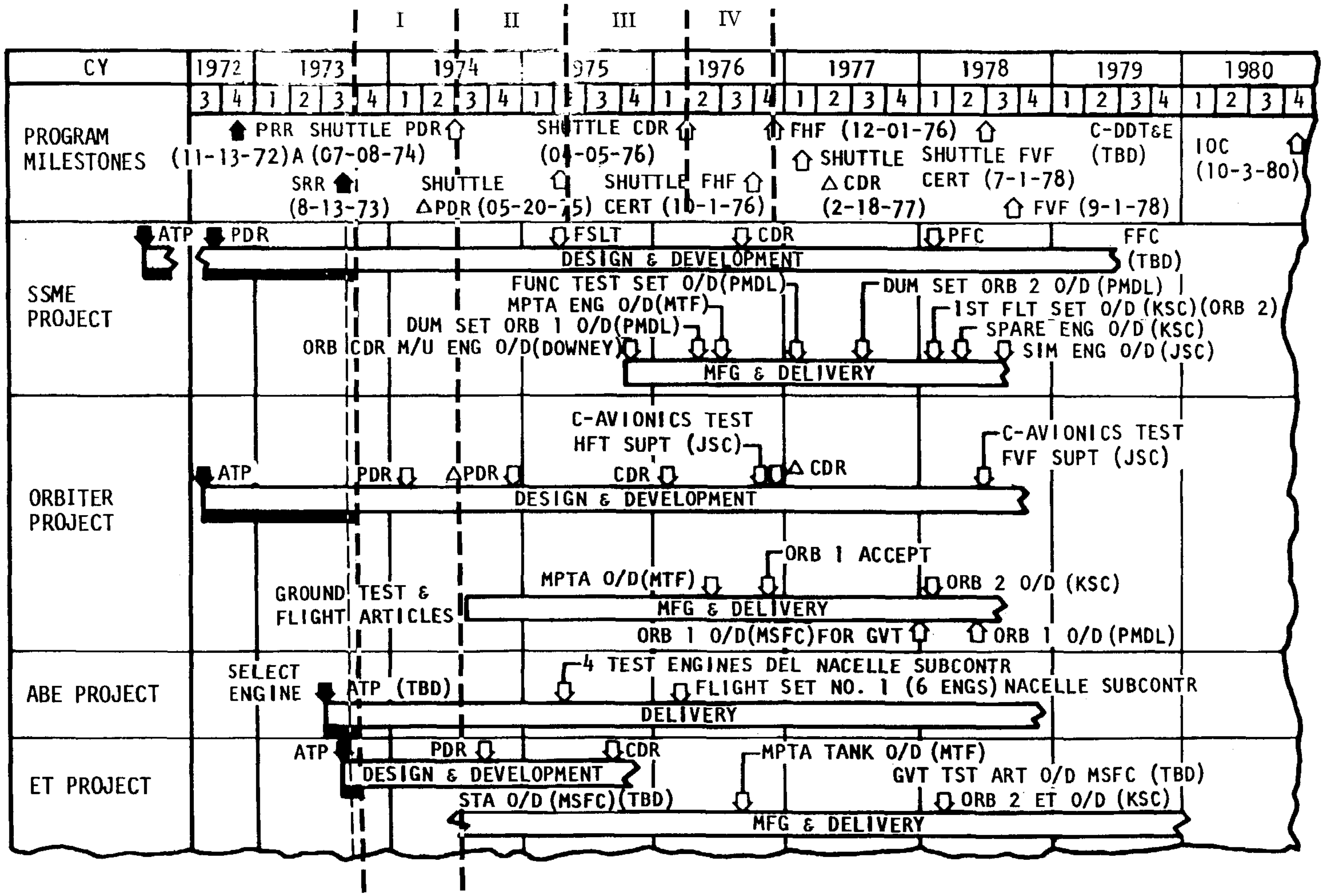


Figure 1A

SPACE SHUTTLE PROGRAM SCHEDULE (CONT)

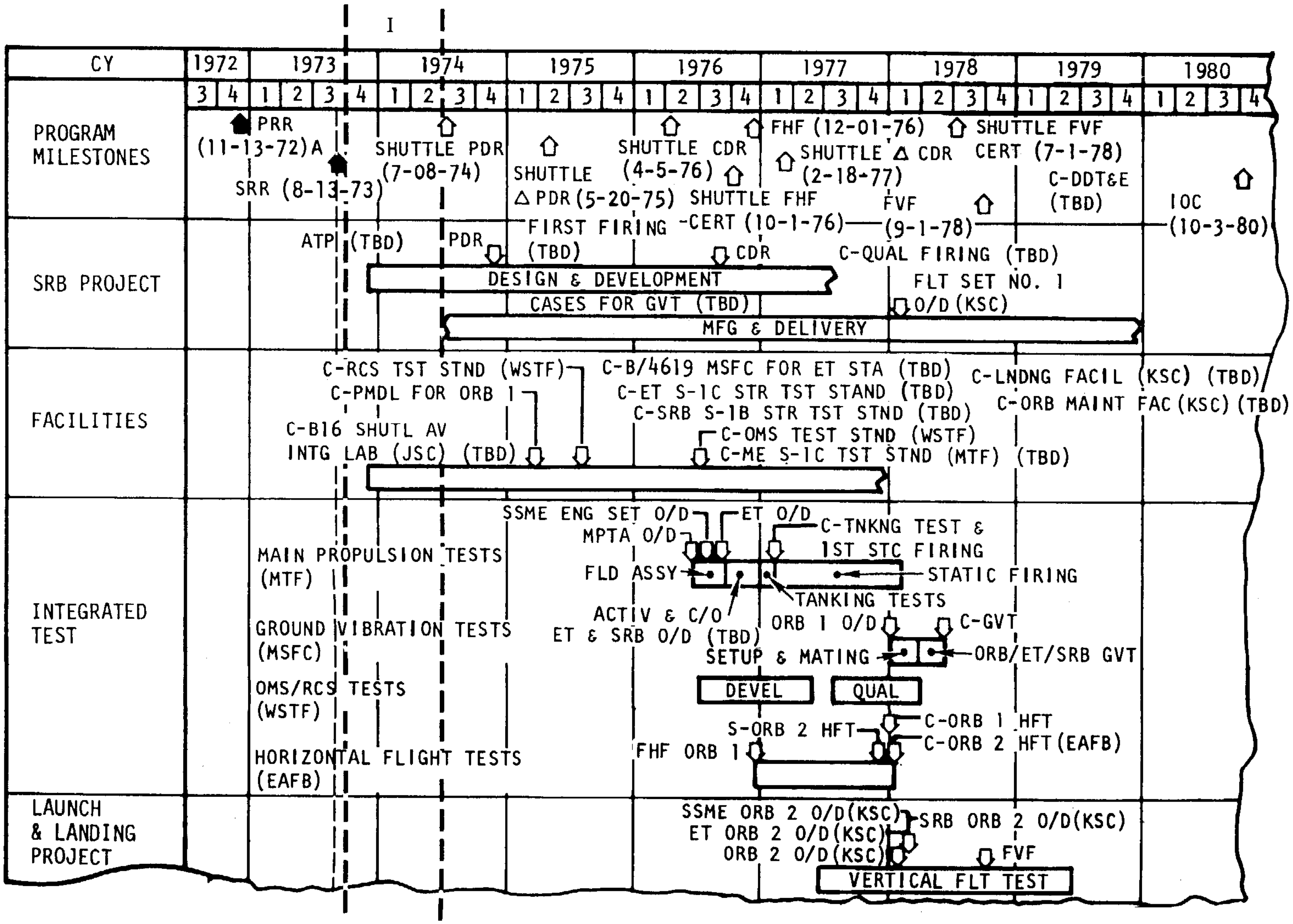


Figure 1B

SPACE SHUTTLE
POTENTIAL FACILITIES UTILIZATION

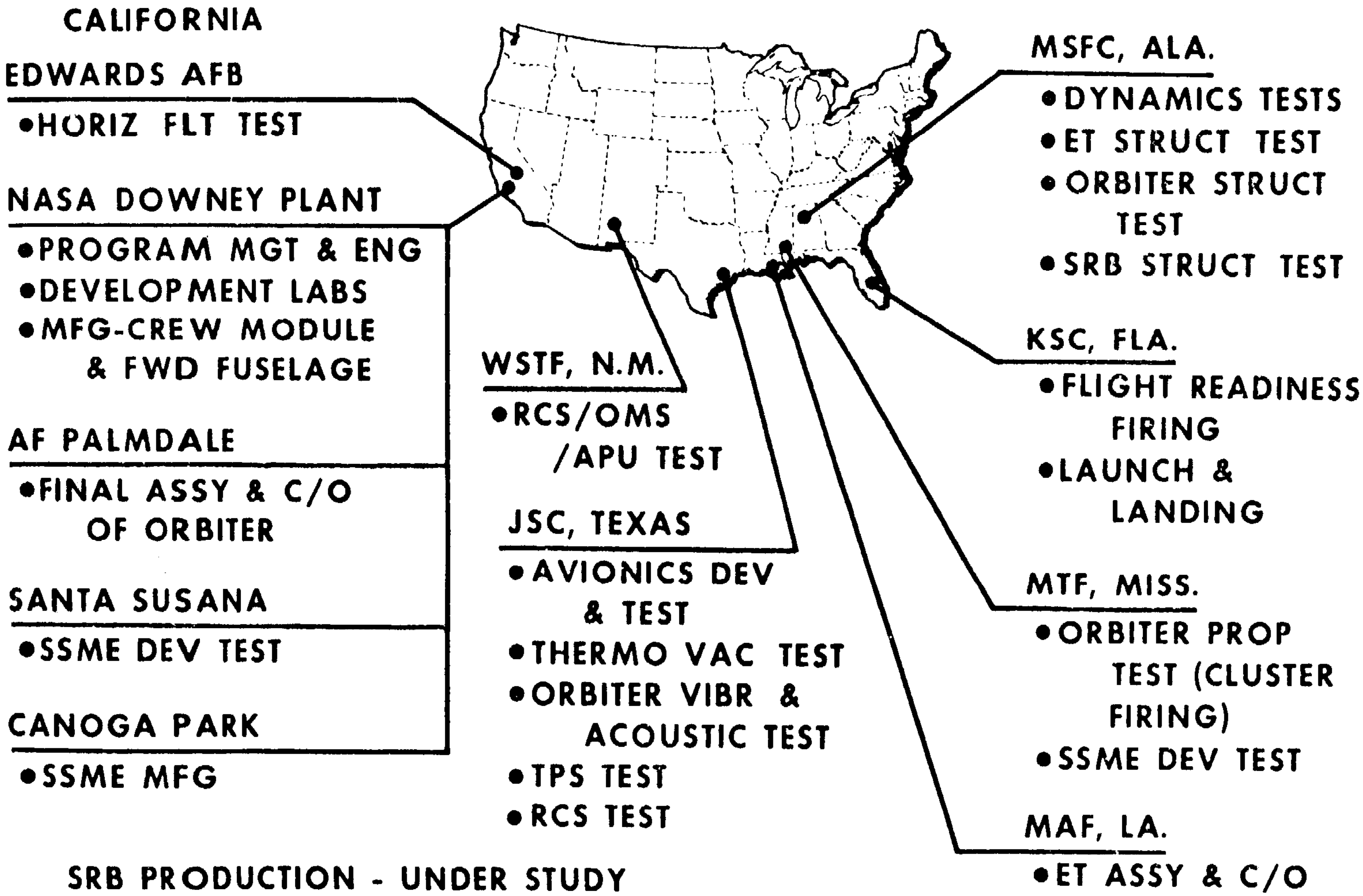


Figure 2

APOLLO/SOYUZ TEST PROJECT
MISSION PROFILE

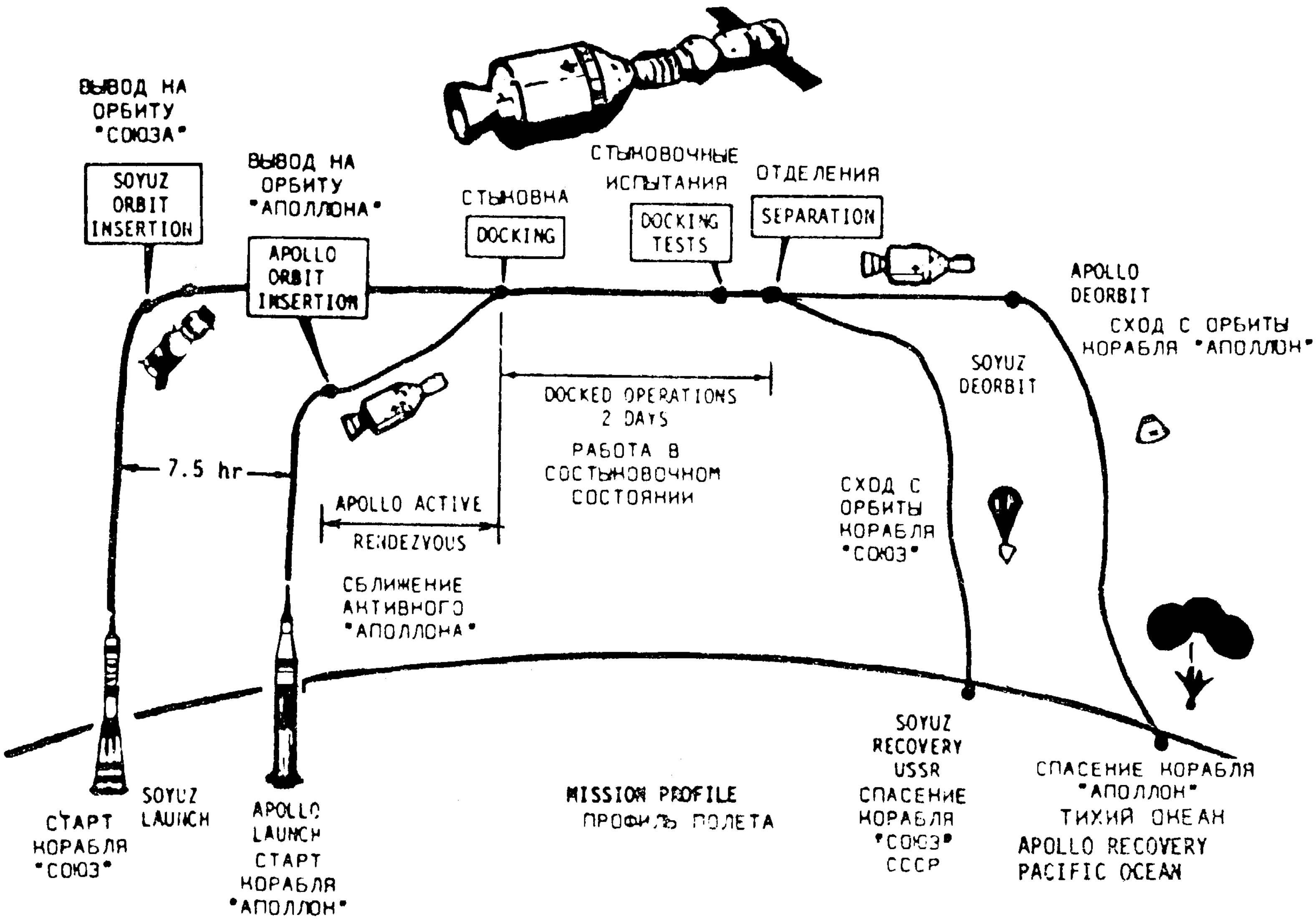


Figure 3

SPACE SHUTTLE MISSION PROFILE
DUE EAST LAUNCH FROM KSC

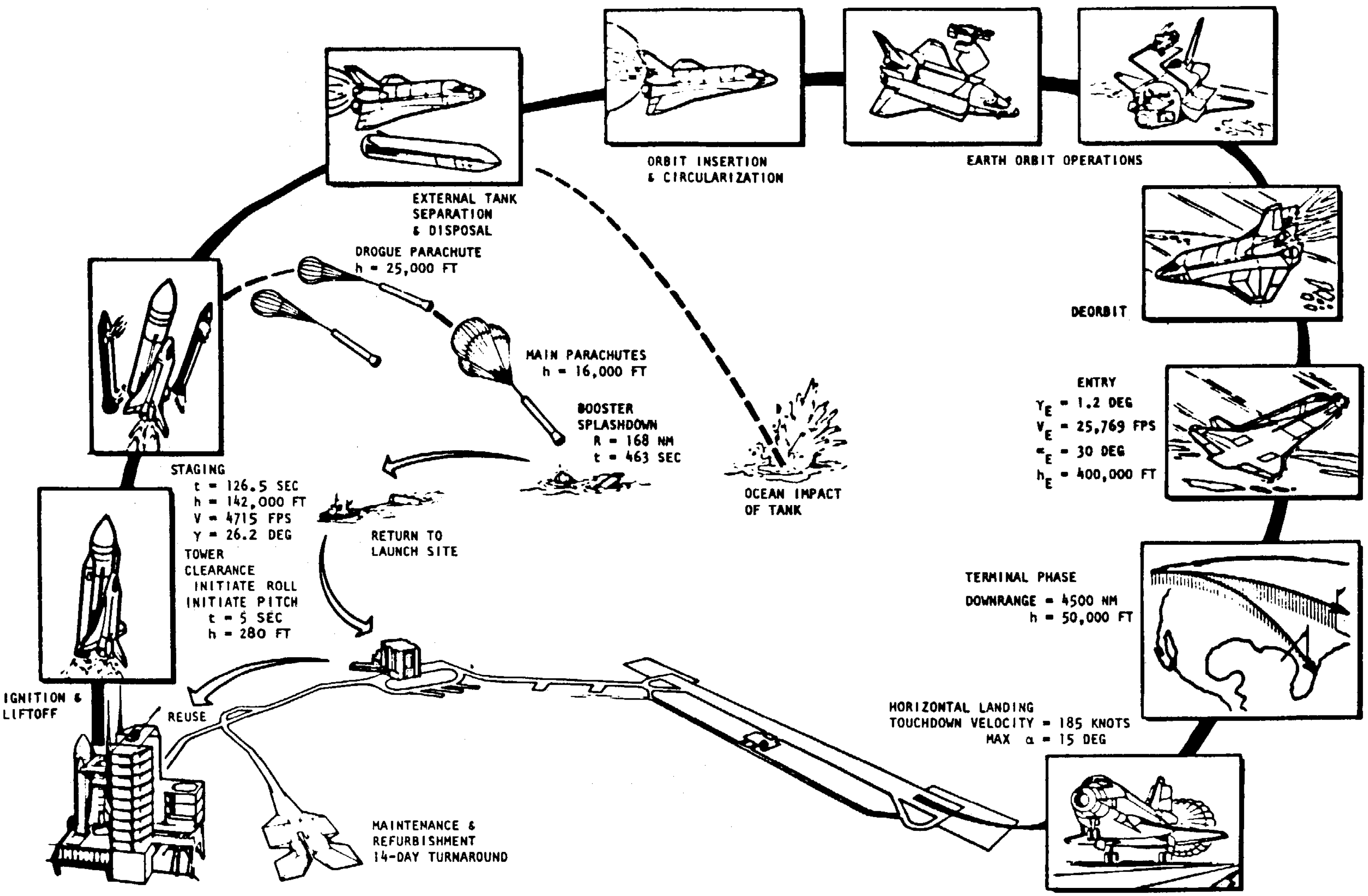


Figure 4