

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. Considerations on Interlocking Apollo/Soyuz Structural Unlatching with the Hatches

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 sequential 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 sequential 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 hardware 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,

A handwritten signature in cursive script that reads "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.

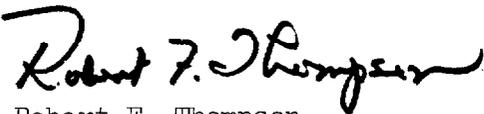
b. The effect on weight of any design and/or requirement change is presented to management before that change is approved or disapproved.

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 Orbiter 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

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

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.

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
<ul style="list-style-type: none"><li>● ECLSS- dry weight increase in fan size, weight, and power</li><li>● Gas available for cabin pressure maintenance</li><li>● Weight of nonmetallic materials, i.e., ducts, wiring, crew equipment, etc.</li><li>● Larger inverters for fan cooling</li></ul>	<ul style="list-style-type: none"><li>● Structure</li></ul>

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.

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PROCESS OF  
WEIGHT MANAGEMENT

66

North American  
Aerospace Group

Space Division  
Rockwell International

Enclosure 3

## PROCESS OF WEIGHT MANAGEMENT

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- 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. KOHEVAR			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. FOURS		DESIGN: A. ZEITLIN			
SECTION: AVIONICS		STRESS: (NOT APPLICABLE)			
GROUP: GUIDANCE & NAVIGATION		WEIGHT: J. FROST			
13.1	GUIDANCE & NAVIGATION	ALLOCATED WEIGHT	OVER OR UNDER	STATUS WEIGHT	CURRENT WEIGHT CHANGES

WEIGHT REVIEWS

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SUPERVISORY WEIGHT CONTROL MEETING

● AREA COVERED

TOTAL VEHICLE IN SEGMENTS BY GROUP RESPONSIBILITY

● ATTENDANCE

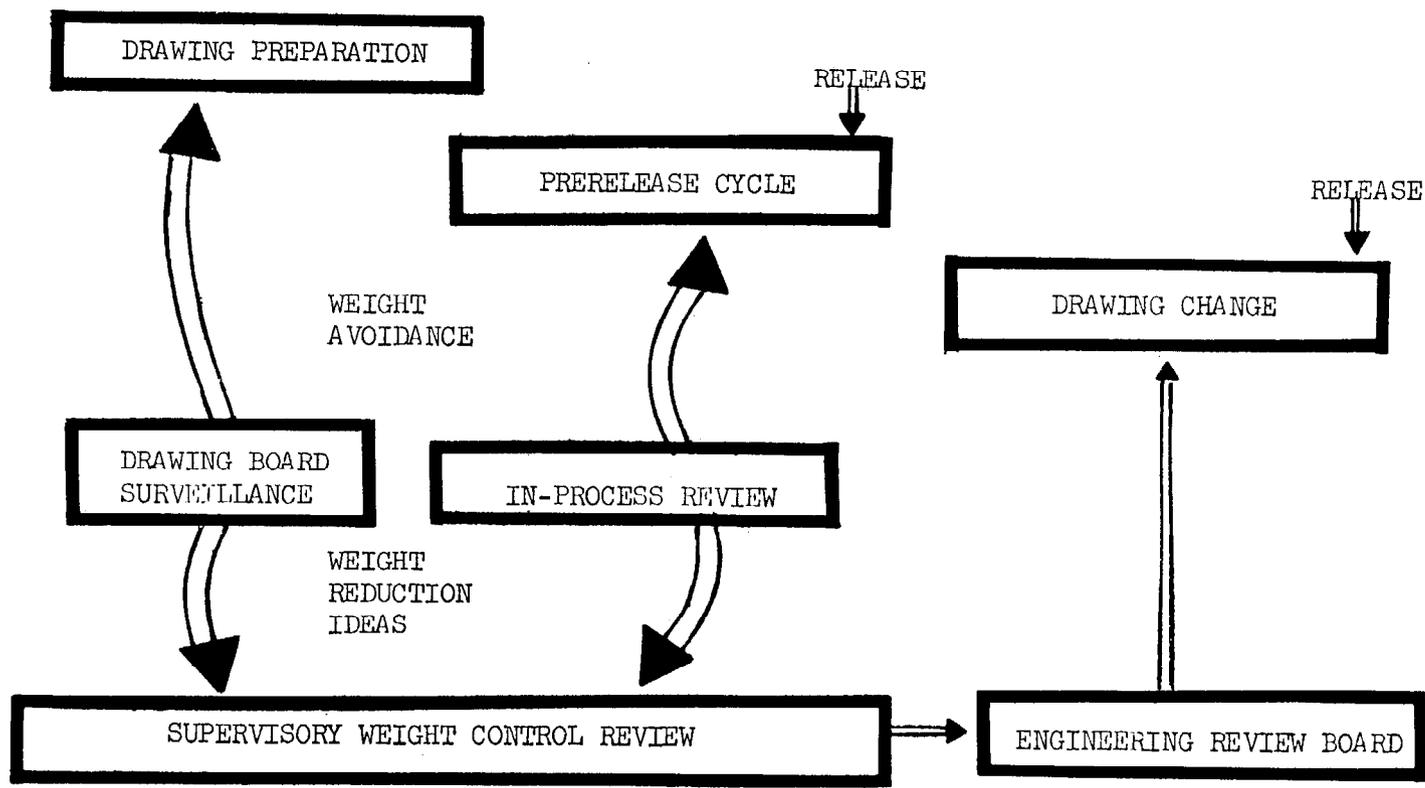
PROJECT ENGINEER - CHAIRMAN  
WEIGHT CONTROL SUPERVISOR AND/OR LEAD ENGINEER  
DESIGN SUPERVISOR AND/OR LEAD ENGINEER  
STRESS SUPERVISOR AND/OR LEAD ENGINEER  
WEIGHT ENGINEER  
DESIGNER  
SPECIALISTS AS REQUIRED  
MANUFACTURING

● 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

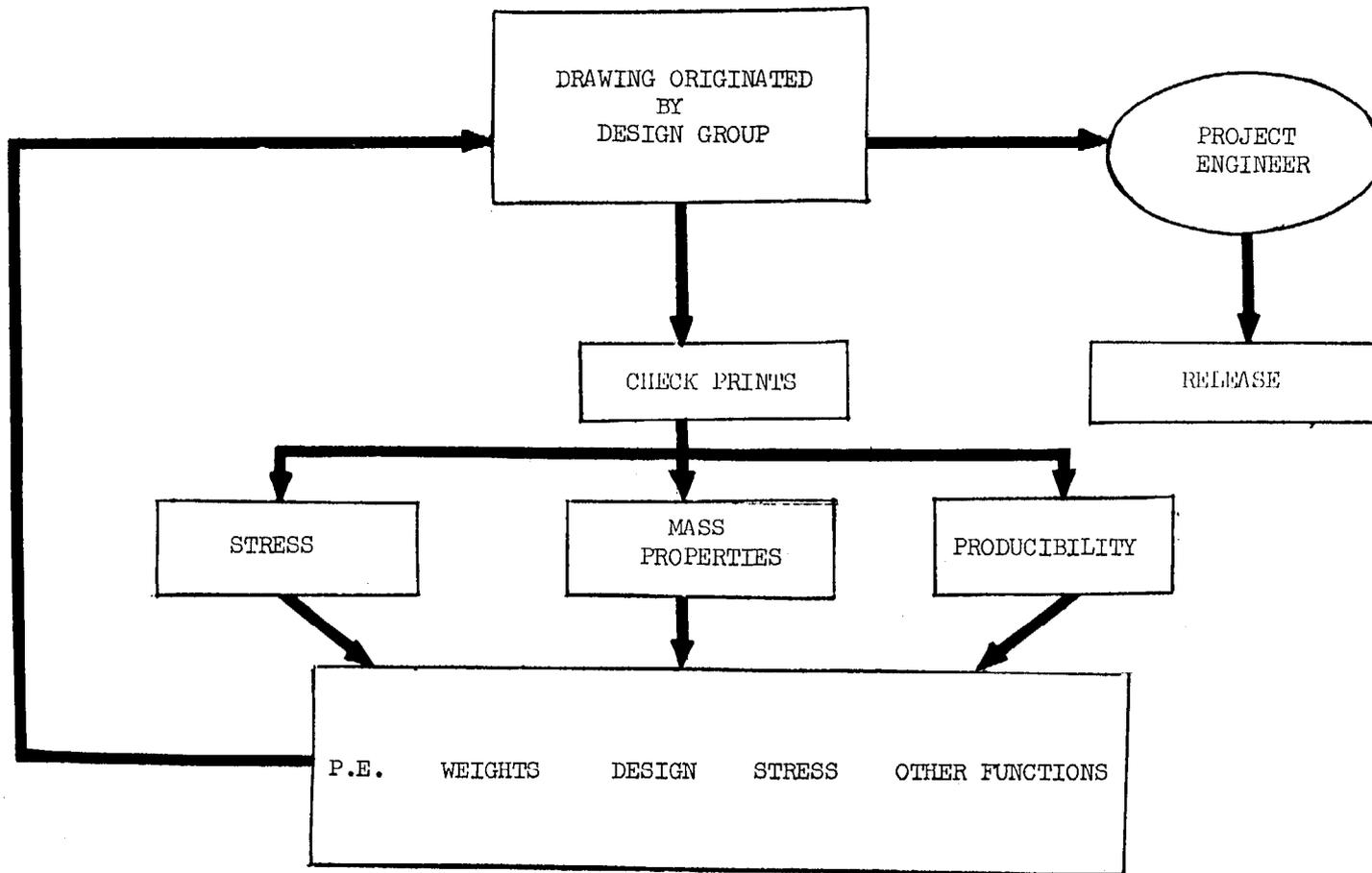
MANAGEMENT CRITERIA

OVERALL WEIGHT CONTROL



MANAGEMENT CRITERIA (concluded-)

STRUCTURAL DRAWING FLOW (IN PROCESS REVIEW)



SUMMARY OF WEIGHT INCENTIVE PROGRAM FOR ORBITER SUBSYSTEM WEIGHT CONTROL

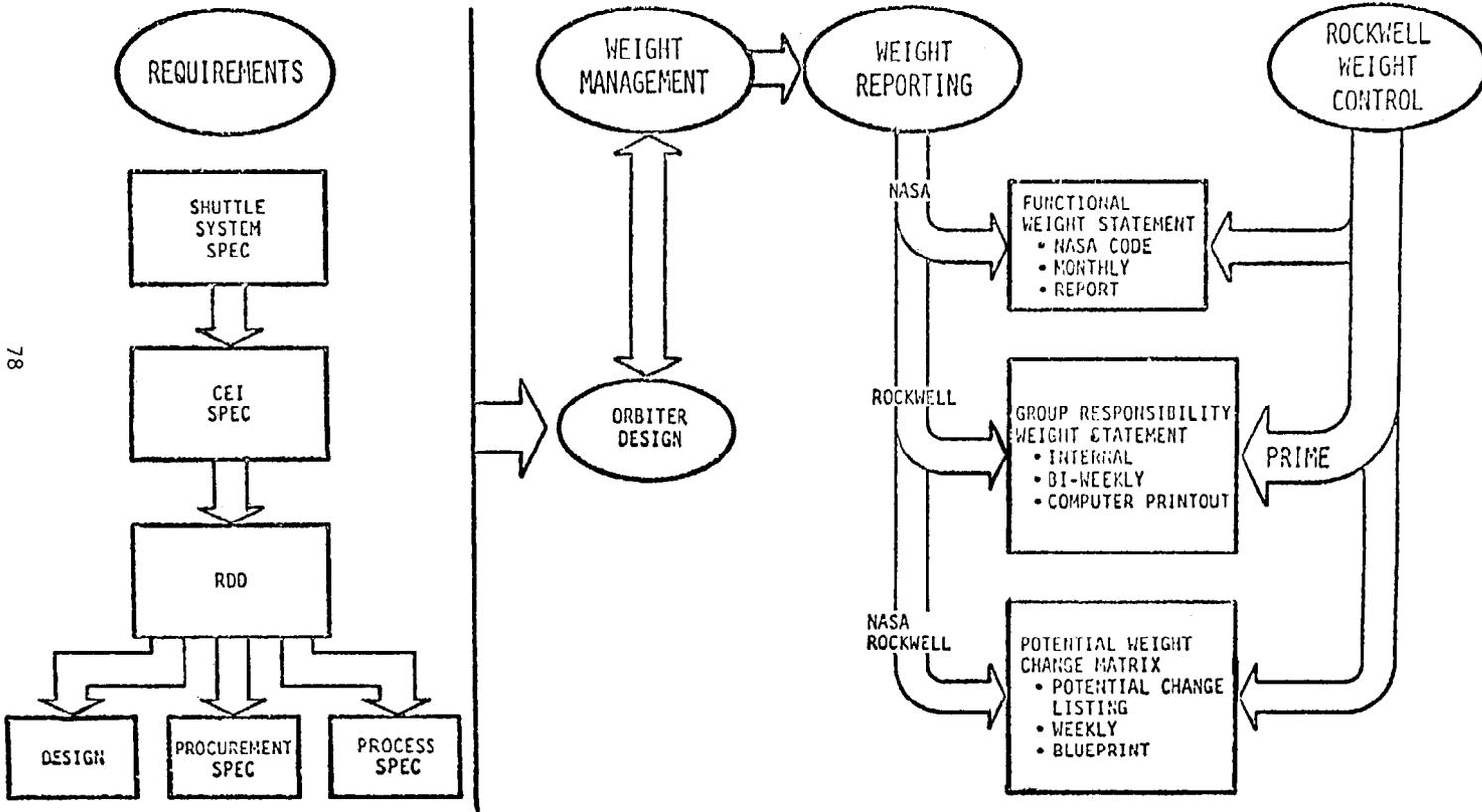
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Enclosure 4

Enclosure 4

WEIGHT MANAGEMENT

# WEIGHT MANAGEMENT





# GROUP RESPONSIBILITY WEIGHT STATEMENT

GROUP RESPONSIBILITY SUMMARY REPORT #15  
INCLUDING PENDING CHANGES JAN 15, 1974

16 JAN 74

	ALLOCATED WEIGHT	OVER OR UNDER	STATUS WEIGHT	CURRENT WEIGHT CHANGES
DIRECTOR:				
J E CARNEY - AIRFRAME DESIGN	7000.0	0	7000.0	
R E FIELD - PROVL & APV	36632.0	0	36632.0	
P H MAYER - MECH., HYDRAULIC, LANDING	15040.0	0	15040.0	
W OWENS - POWER, ACCESS	6501.0	0	6501.0	
D S LEVINE - AERONAUTICS SUB SVS	8301.0	0	8301.0	
J A KING - AERONAUTICS DATA PROG	1240.0	0	1240.0	
D G WEISMAN - CHIEF PROJECT ENGINEER	404.0	0	404.0	
ENGINEERING MANAGEMENT	1424.0	0	1424.0	

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

GROUP RESPONSIBILITY SUMMARY REPORT #15  
INCLUDING PENDING CHANGES JAN 15, 1974

16 DEC 73

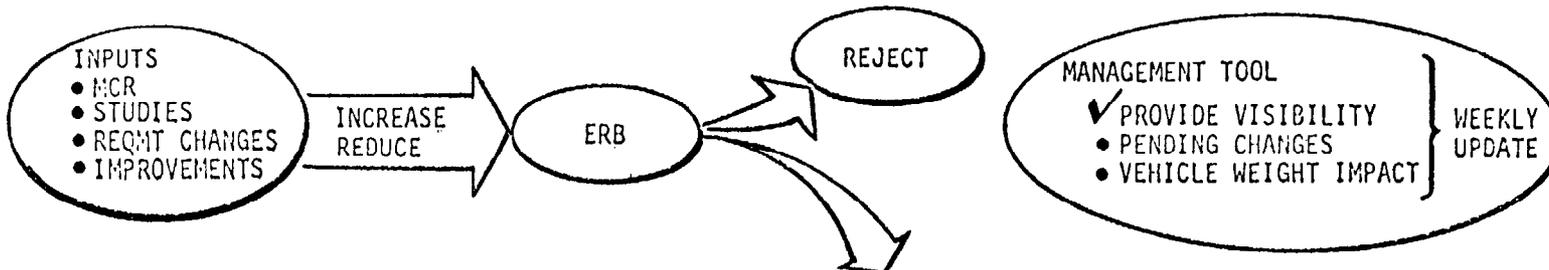
	ALLOCATED WEIGHT	OVER OR UNDER	STATUS WEIGHT	CURRENT WEIGHT CHANGES
DIRECTOR: J E CARNEY - AIRFRAME DESIGN				
✓ MANAGER: R ROCHEVAR - STRUC DESIGN 1.0 WING GROUP-GENERAL	10401.0	1595.0	11996.0	
MANAGER: R ROCHEVAR - STRUC DESIGN 2.0 TAIL GROUP-FAIRCHILD	2857.0	216.0	3073.0	
MANAGER: R ROCHEVAR - STRUC DESIGN 3.0 WING GROUP-GENERAL DYNAMICS	12096.0	1139.0	13235.0	

GROUP RESPONSIBILITY SUMMARY REPORT #15  
INCLUDING PENDING CHANGES JAN 15, 1974

10 DEC 73

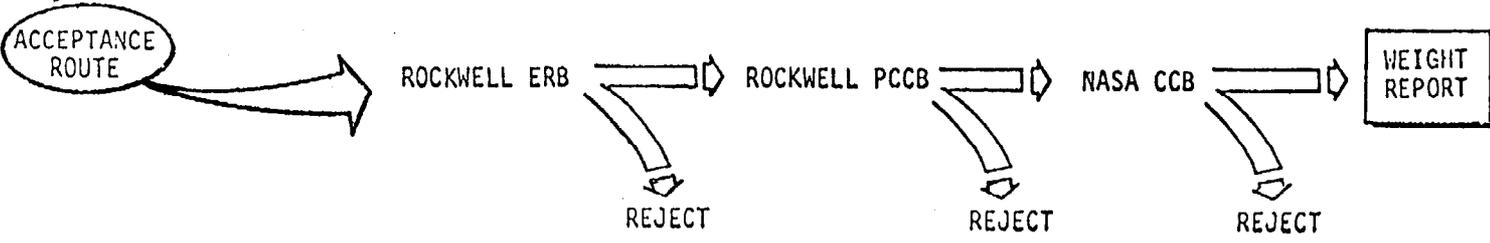
MANAGER:	DESIGN:	GROUP:	WING	WING AREA	WING	WING	WING	WING
R ROCHEVAR	ROCKWELL/SHEARWATER	STRUC DESIGN	1.0	10401.0	1595.0	11996.0	10401.0	1595.0
1.0.1.0.0	1.0.1.0.0	1.0.1.0.0	1.0.1.0.0	1.0.1.0.0	1.0.1.0.0	1.0.1.0.0	1.0.1.0.0	1.0.1.0.0
1.0.1.0.1	1.0.1.0.1	1.0.1.0.1	1.0.1.0.1	1.0.1.0.1	1.0.1.0.1	1.0.1.0.1	1.0.1.0.1	1.0.1.0.1
1.0.1.0.2	1.0.1.0.2	1.0.1.0.2	1.0.1.0.2	1.0.1.0.2	1.0.1.0.2	1.0.1.0.2	1.0.1.0.2	1.0.1.0.2
1.0.1.0.3	1.0.1.0.3	1.0.1.0.3	1.0.1.0.3	1.0.1.0.3	1.0.1.0.3	1.0.1.0.3	1.0.1.0.3	1.0.1.0.3
1.0.1.0.4	1.0.1.0.4	1.0.1.0.4	1.0.1.0.4	1.0.1.0.4	1.0.1.0.4	1.0.1.0.4	1.0.1.0.4	1.0.1.0.4
1.0.1.0.5	1.0.1.0.5	1.0.1.0.5	1.0.1.0.5	1.0.1.0.5	1.0.1.0.5	1.0.1.0.5	1.0.1.0.5	1.0.1.0.5
1.0.1.0.6	1.0.1.0.6	1.0.1.0.6	1.0.1.0.6	1.0.1.0.6	1.0.1.0.6	1.0.1.0.6	1.0.1.0.6	1.0.1.0.6
1.0.1.0.7	1.0.1.0.7	1.0.1.0.7	1.0.1.0.7	1.0.1.0.7	1.0.1.0.7	1.0.1.0.7	1.0.1.0.7	1.0.1.0.7
1.0.1.0.8	1.0.1.0.8	1.0.1.0.8	1.0.1.0.8	1.0.1.0.8	1.0.1.0.8	1.0.1.0.8	1.0.1.0.8	1.0.1.0.8
1.0.1.0.9	1.0.1.0.9	1.0.1.0.9	1.0.1.0.9	1.0.1.0.9	1.0.1.0.9	1.0.1.0.9	1.0.1.0.9	1.0.1.0.9
1.0.1.0.0	1.0.1.0.0	1.0.1.0.0	1.0.1.0.0	1.0.1.0.0	1.0.1.0.0	1.0.1.0.0	1.0.1.0.0	1.0.1.0.0

# POTENTIAL WEIGHT CHANGE MATRIX

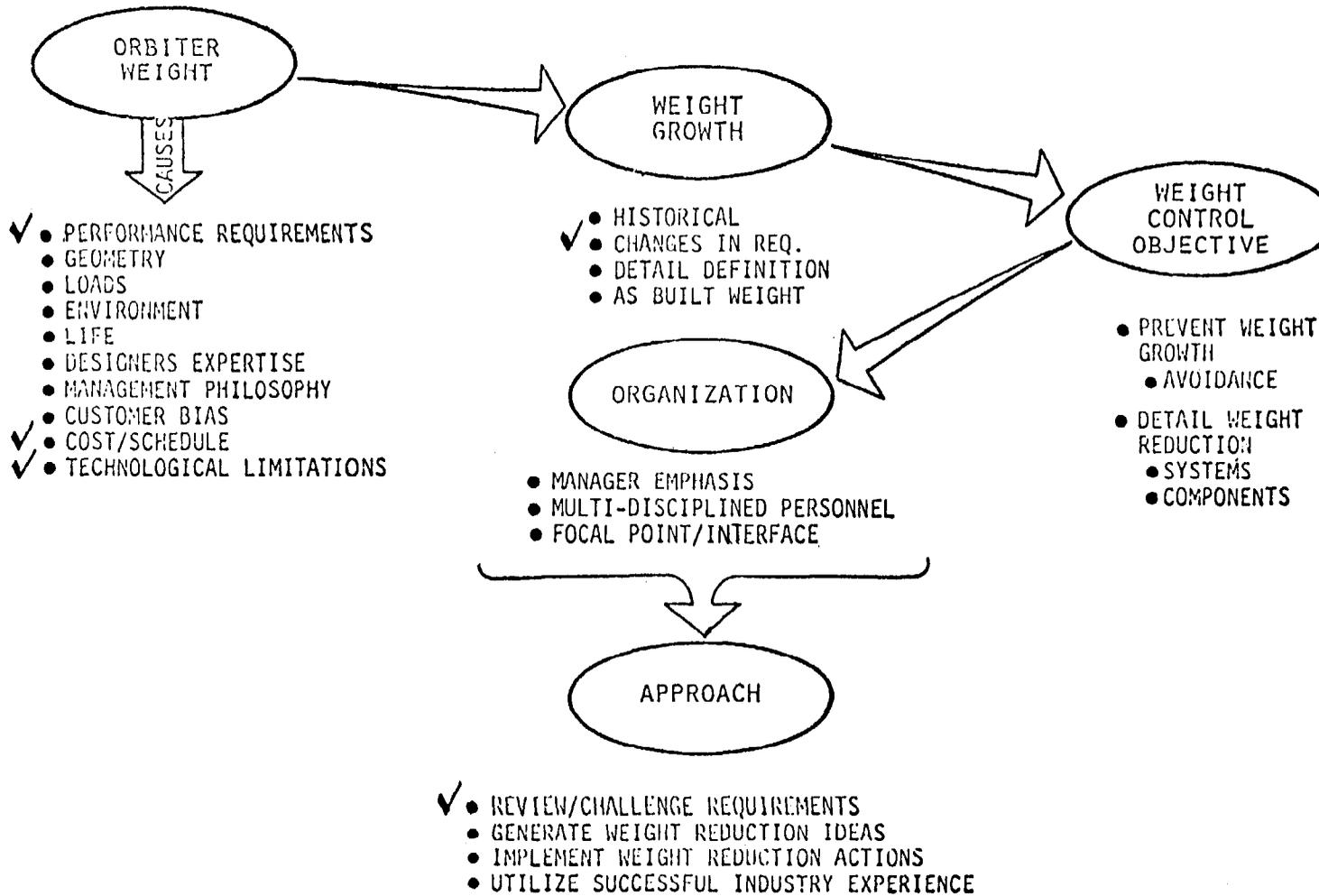


NASA CODE			1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0/ 18.0	20.0/ 22.0	23.0/ 25.0	26.0/ 29.0		
Seq No/ NACH No.	Title/Issue	Req Source	Wing	Tail	Body	TPS/ TCS	Land	Ascent Prop.	Cruise Prop.	DMS	RCS	Prime Power	Elect Distr	Hyd Distr	Surf. Contr	Avionics	ECLSS	Pers Accel PL	Vis Emulsi Changpt	Pers and Prior	Res-d and Reserve	Expnd Fluids
10232)	A - Jettison Coated Radiator																-246		-246	+1		
178 10256)	Launch Pad Servicing A Manual B Semi Automatic C Full Loading				+26 (+25)	+26 (+25)				0 (+10)			(+15)						+65 (+75) (178U)			
132	Aux Propulsion Update																					
	A - Aux RCS Inlet				+100						+50									+160		
	B - AMS Equipment control unit									+228										+228		
	C - Alt OMS Struc ure Strng																				+876	
	D - Alt RCS Struc ure Strng				+876																+876	
	E - Integrated Struc ure Strng									+88												

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# WEIGHT CONTROL DEVELOPMENT

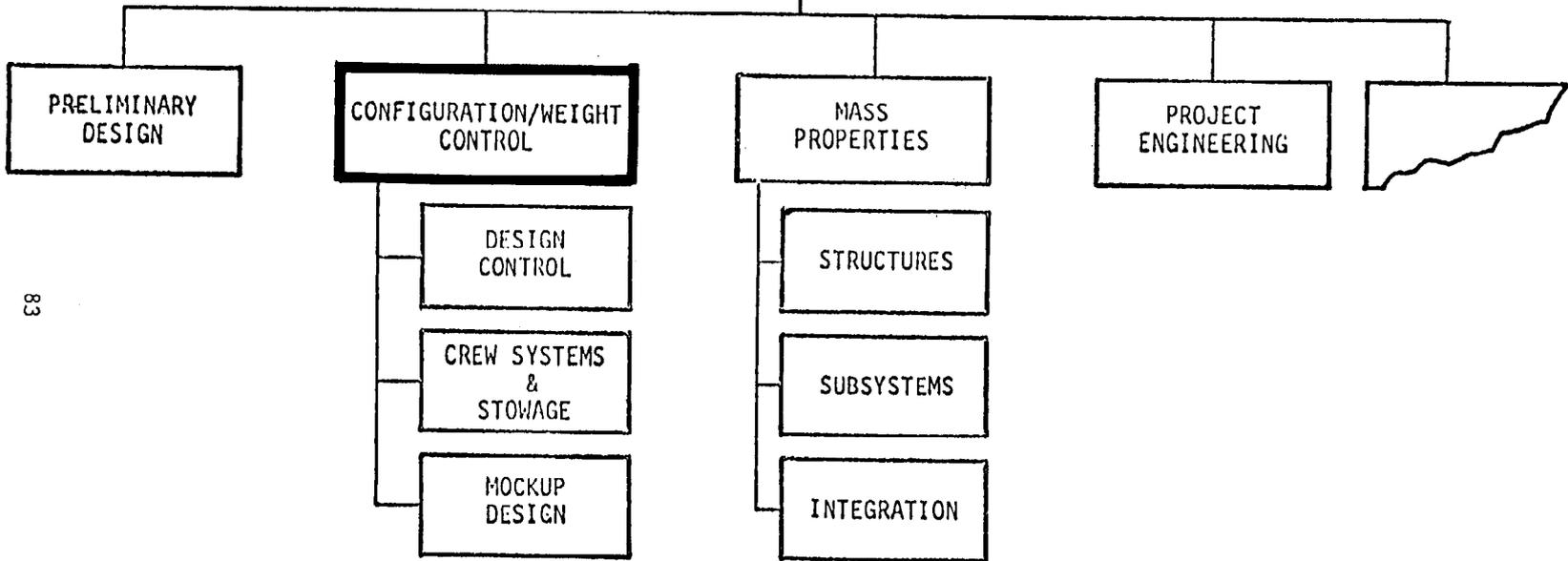


# PROJECT ENGINEERING

REVISED ORGANIZATION

- COMBINE WEIGHT CONTROL WITH DESIGN CONTROL
- INCREASE TALENT POOL
- ACCELERATE WEIGHT REDUCTION ACTION

CHIEF PROJECT ENGINEER



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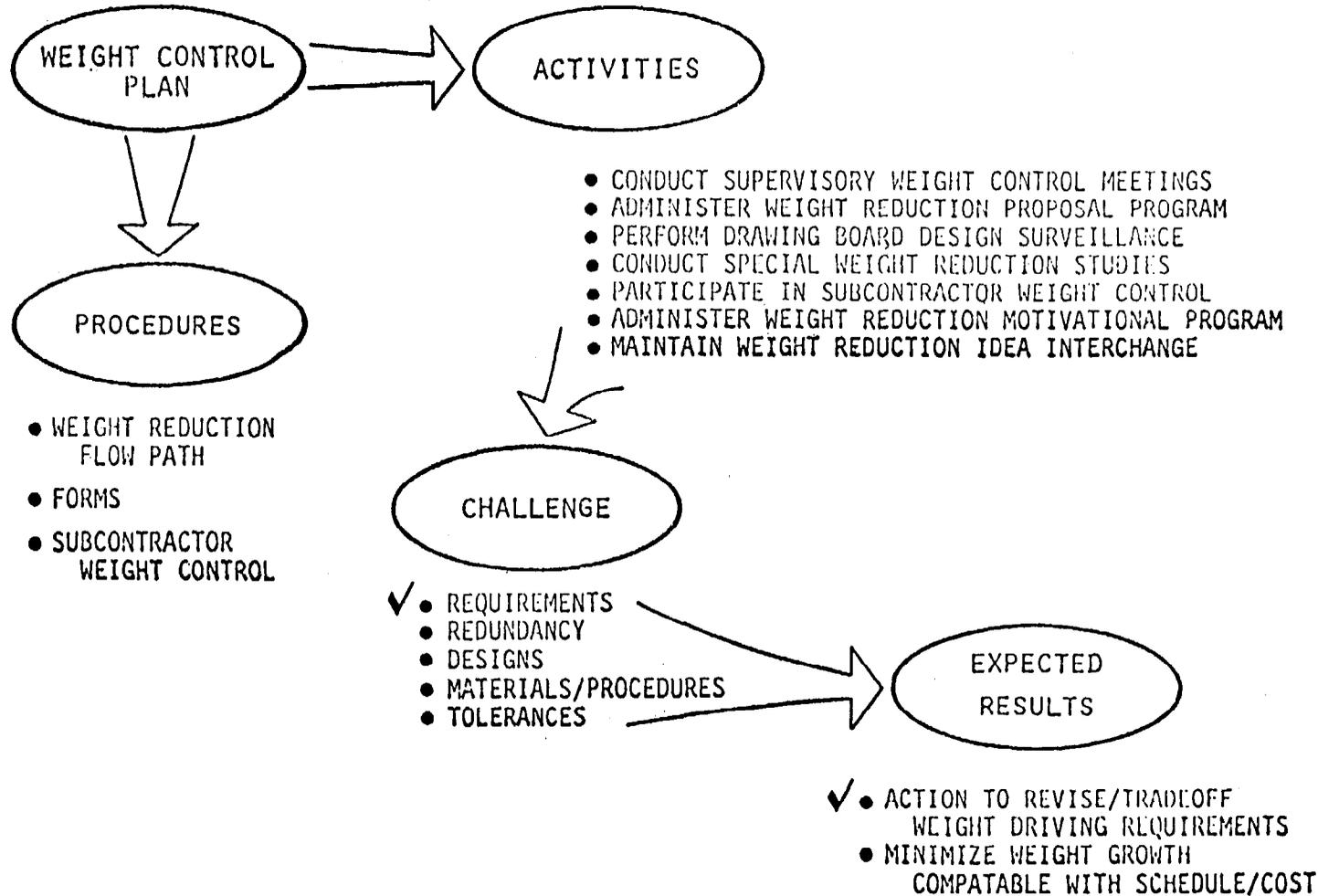
- ✓ AVAILABLE PERSONNEL
- EXCELLENT DESIGN TALENT
  - DESIGN CHALLENGE

- ✓ 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

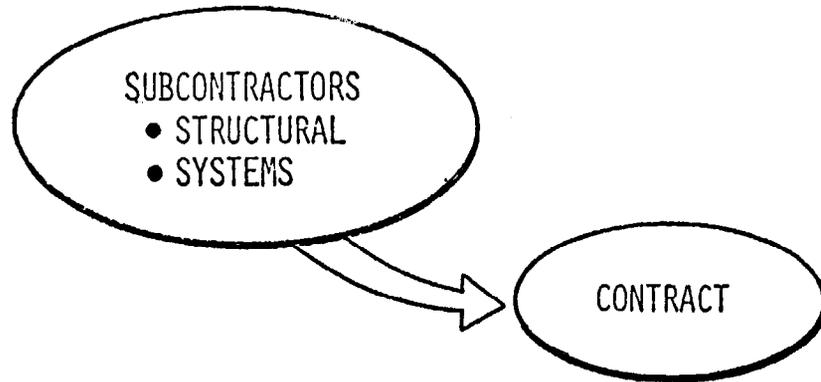
NO.	STUDY	Δ ESTIMATED WEIGHT CHANGE (LB)		CHANGE IN REQUIREMENT
		DRY	WET	
1	FROM 4 TO 3 APU SYSTEMS	-222	-416	✓
2	FROM 4 TO 3 HYDRAULIC SYSTEMS	-483	-708	✓
3	ELIMINATE PAYLOAD BAY LINER	-315		✓
4	FACTOR OF SAFETY REDUCTION MATERIAL ALLOWABLE DEGRADATION AT END OF LIFE (500 FLIGHTS) NOW - ENTIRE AREA 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	✓

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## WEIGHT REDUCTION STUDIES (CONT)

NO.	STUDY	ESTIMATED WEIGHT CHANGE (LB)		CHANGE IN REQUIREMENT
		<u>DRY</u>	<u>WET</u>	
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 desirability 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.

Page 2

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<sub>2</sub> AND LH<sub>2</sub> FILL, FEED, AND DRAIN LINES

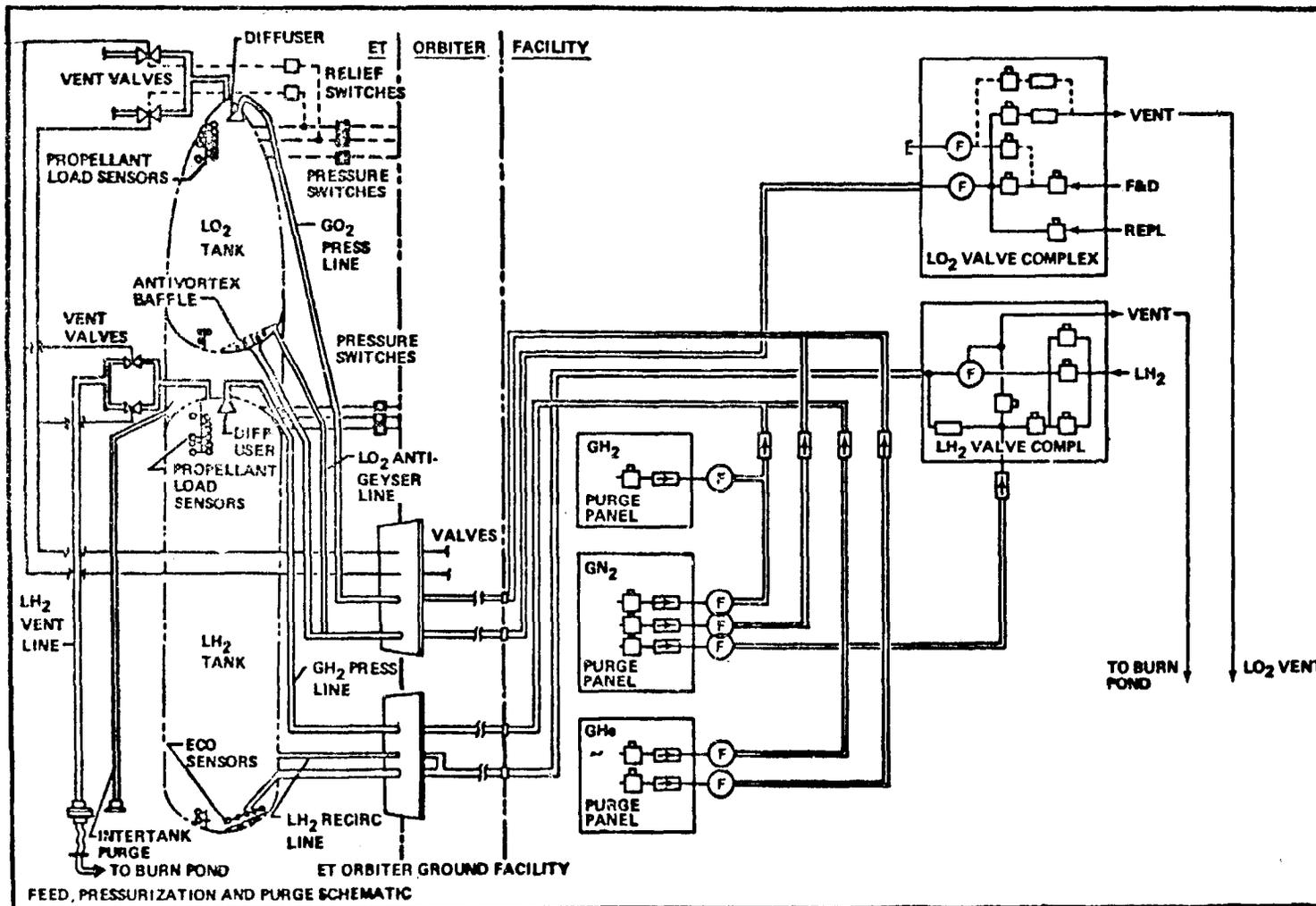
Separate LO<sub>2</sub> and LH<sub>2</sub> lines control and transfer propellants from the tanks to the ET/Orbiter interface. Both lines are 17 inches in diameter and contain flex joints and sliding supports for thermal and mechanical movement.

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.

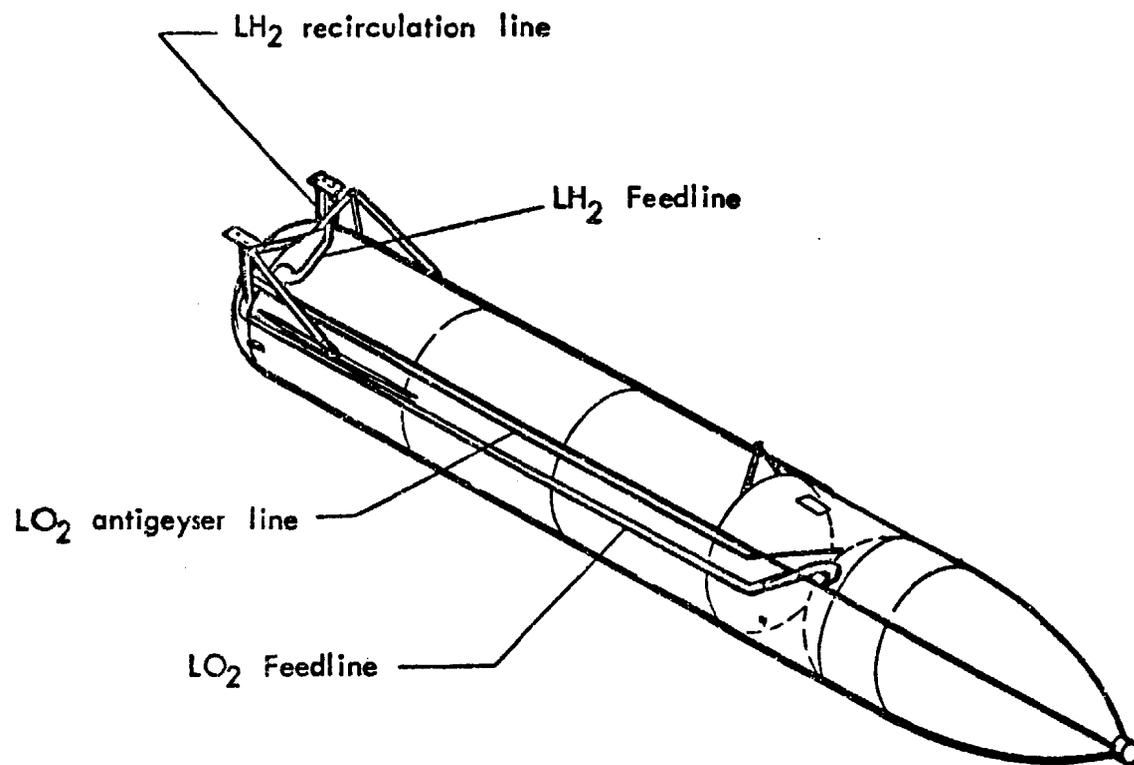
The fluid trapped between the two closed valves, (maximum of 3.0 ft<sup>3</sup>) is allowed to dump freely as the disconnect sections are disengaged. During normal operation, the closed valve on the Orbiter side serves as a closeout of the main engine feed system to prevent system contamination. The 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

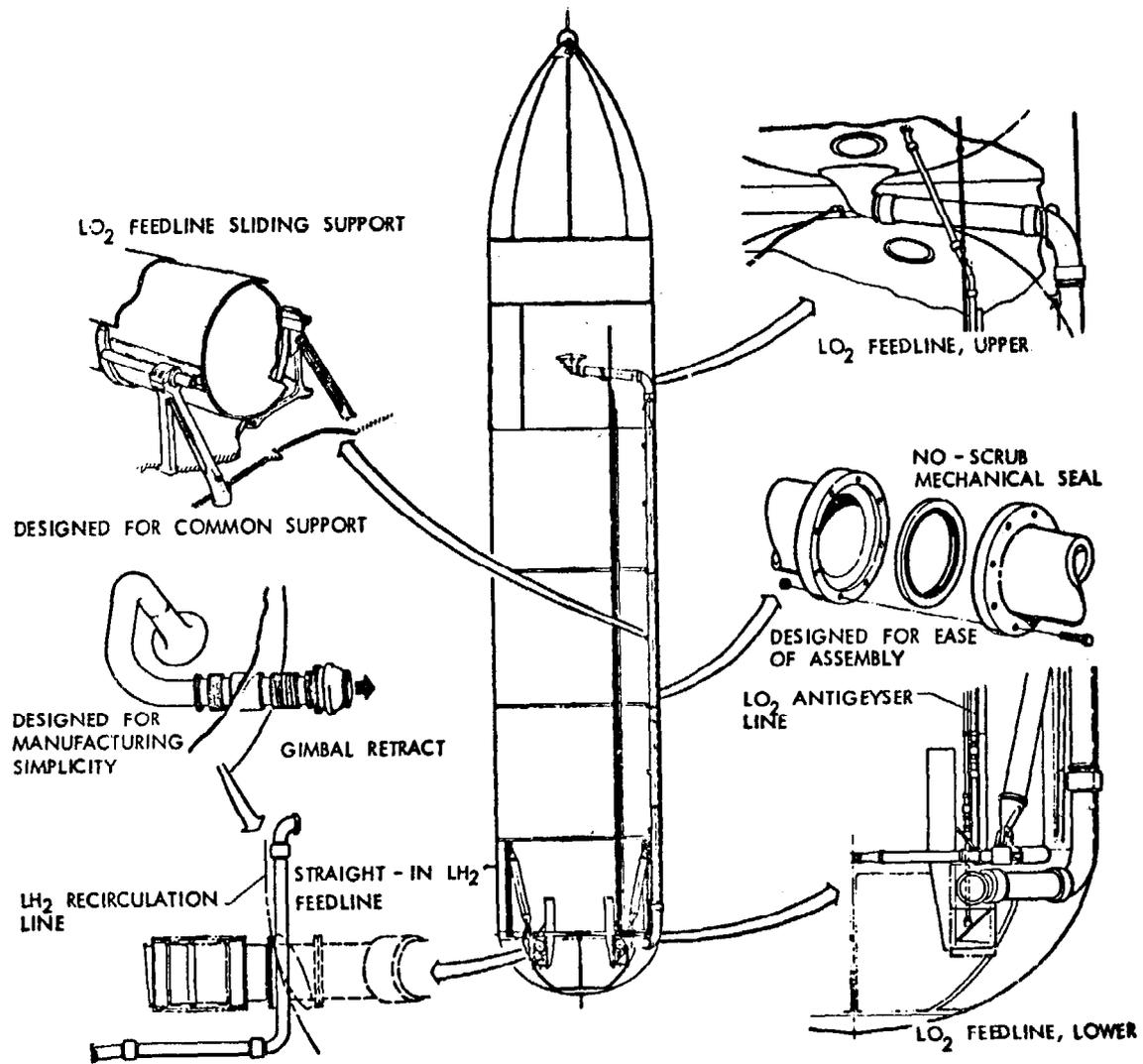
T6

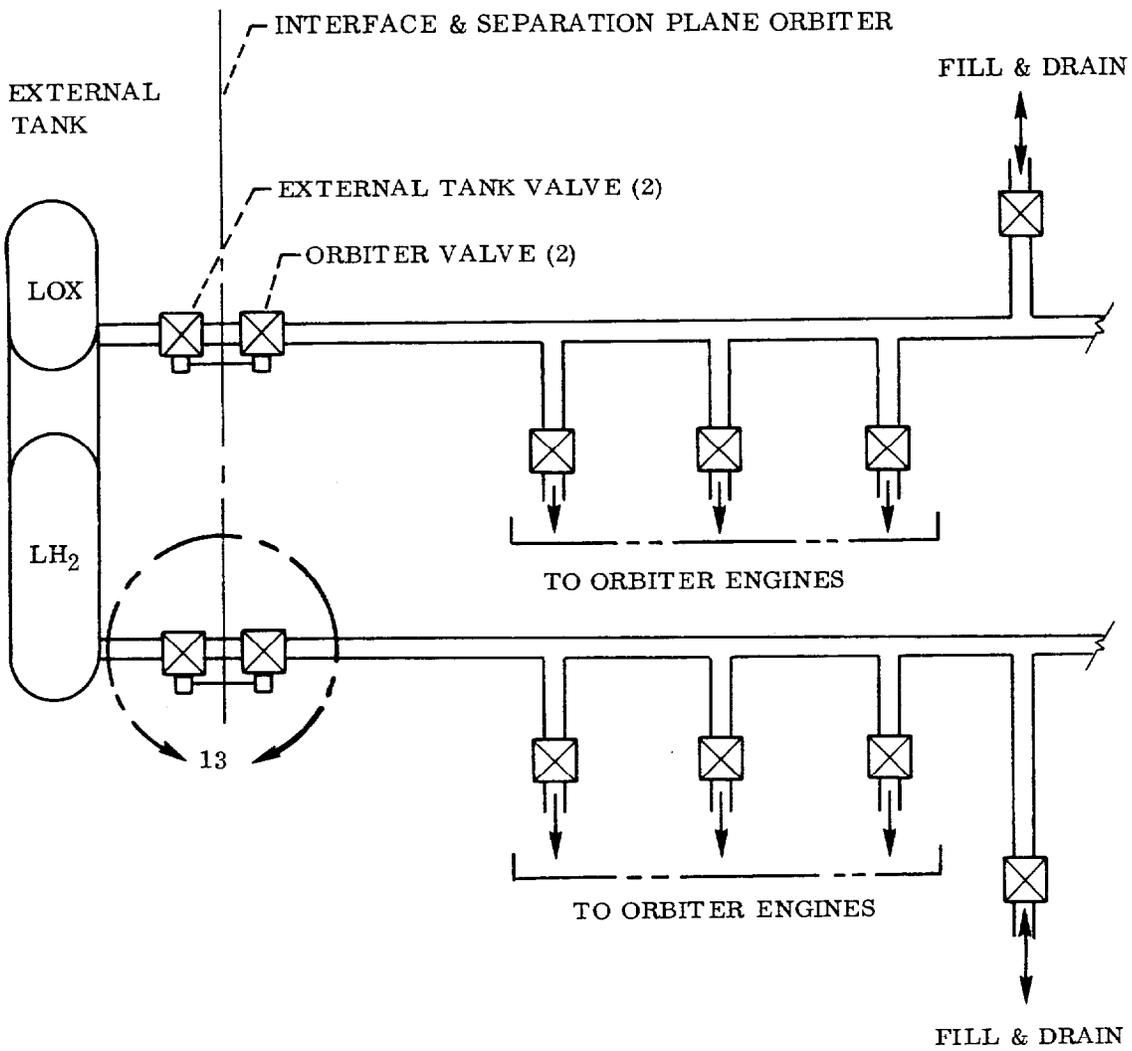


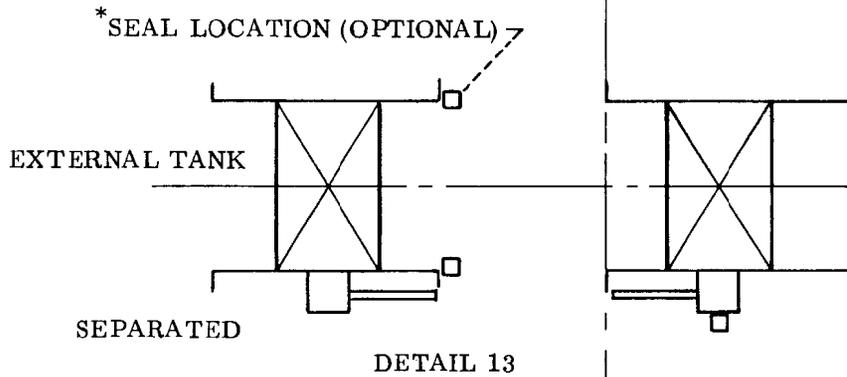
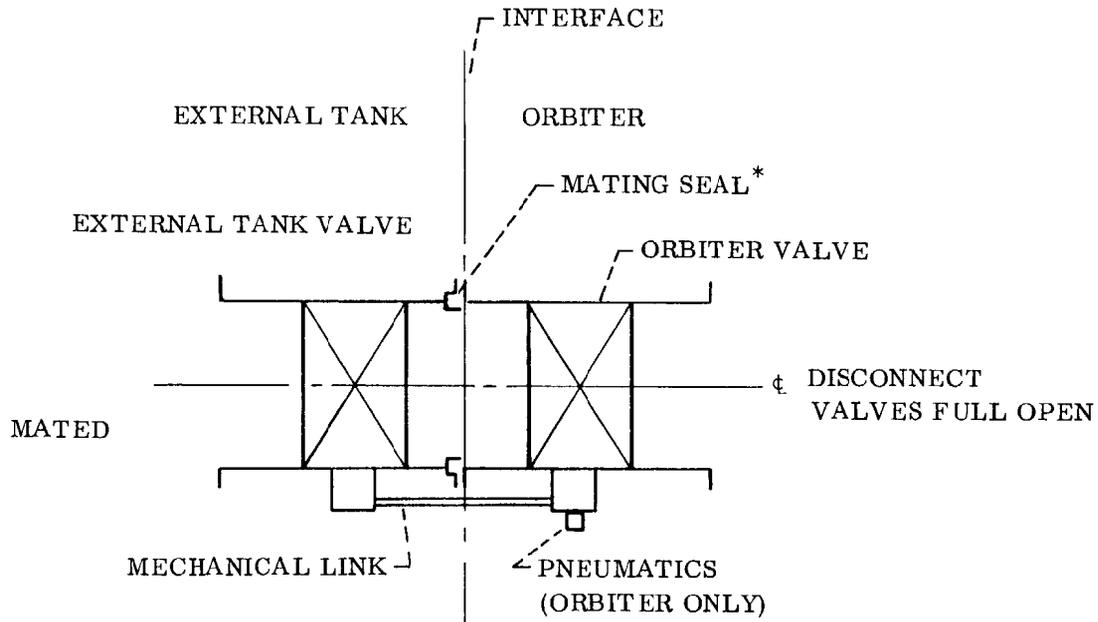
PROPELLANT FEED



# PROPELLANT FEEDLINE ARRANGEMENT







ORBITER

⊕

VALVES FULL CLOSED  
EACH SECTION

NOTE: VALVES ARE FULL  
CLOSED PRIOR TO ET/ORBITER  
SEPARATION

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

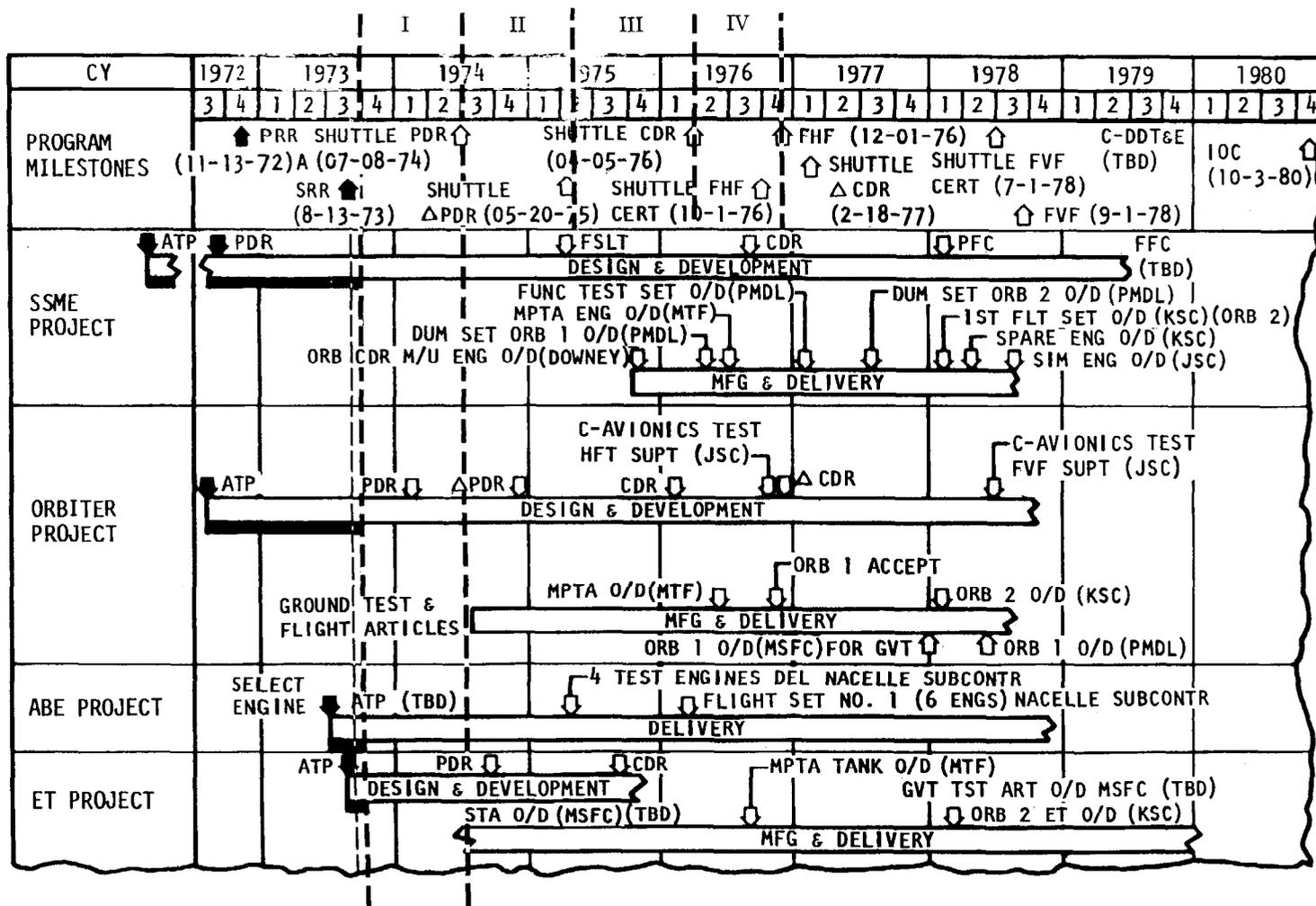


Figure 1A

100



# SPACE SHUTTLE POTENTIAL FACILITIES UTILIZATION

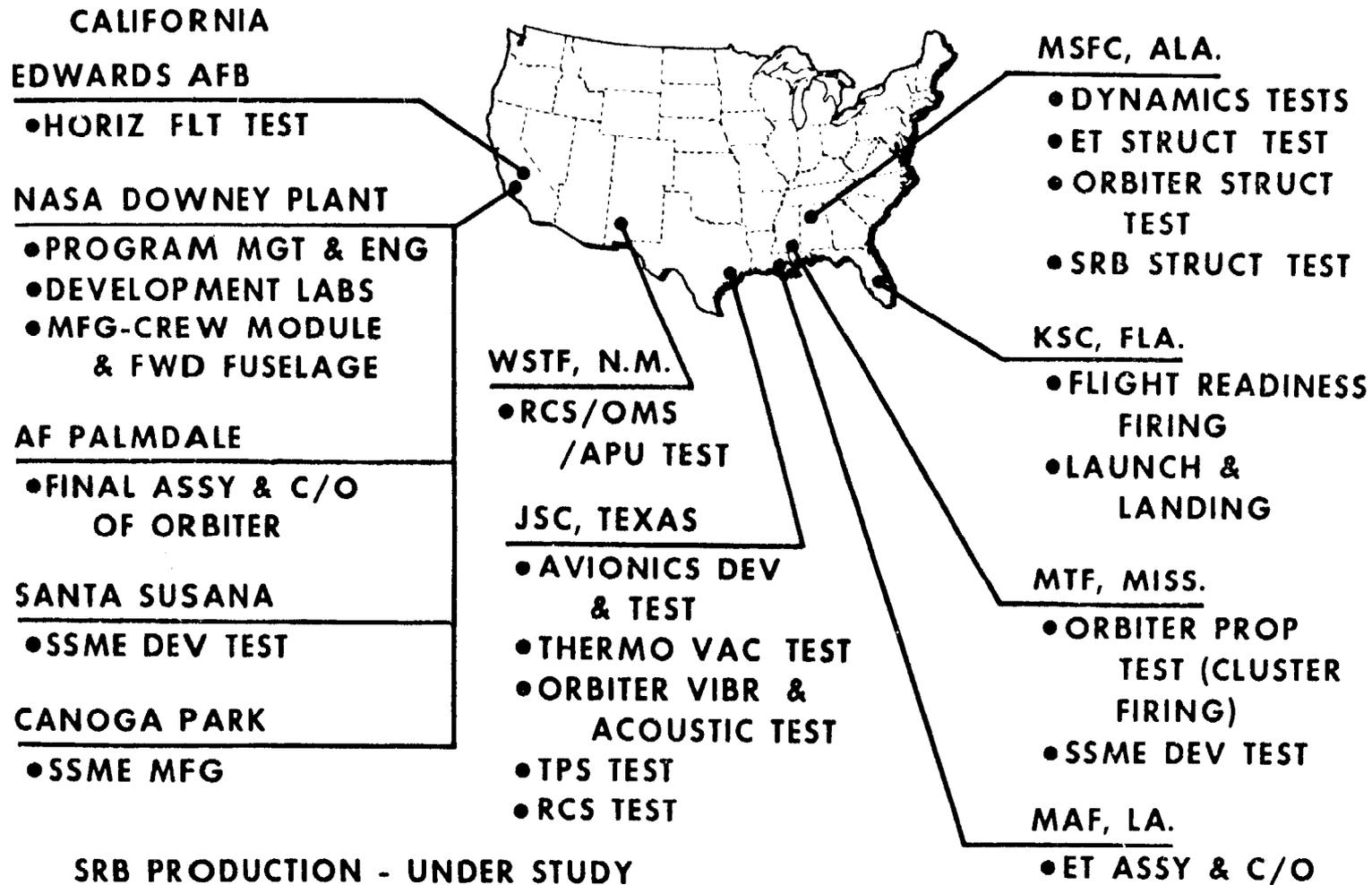


Figure 2

# APOLLO/SOYUZ TEST PROJECT MISSION PROFILE

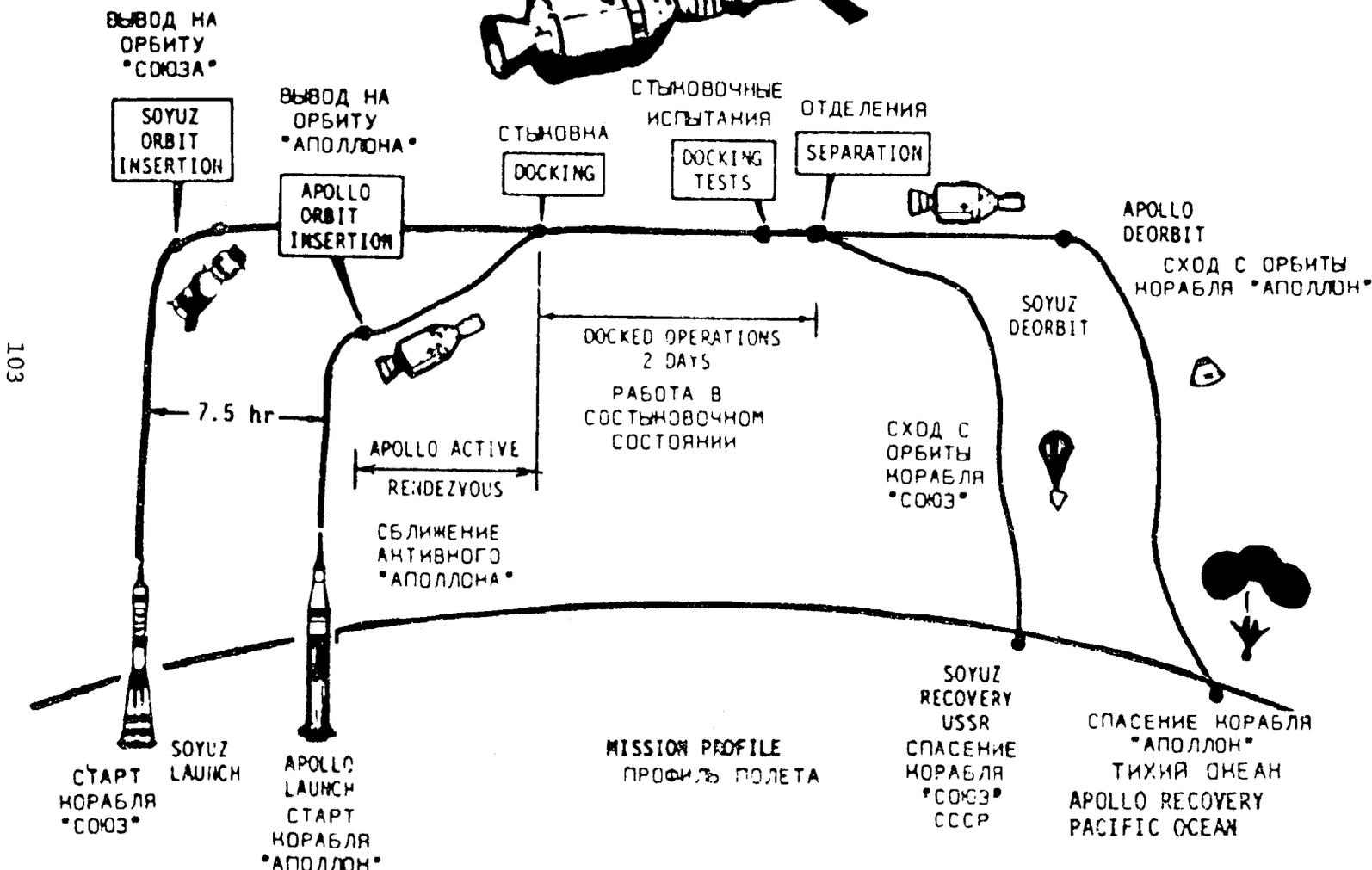


Figure 3

# SPACE SHUTTLE MISSION PROFILE DUE EAST LAUNCH FROM KSC

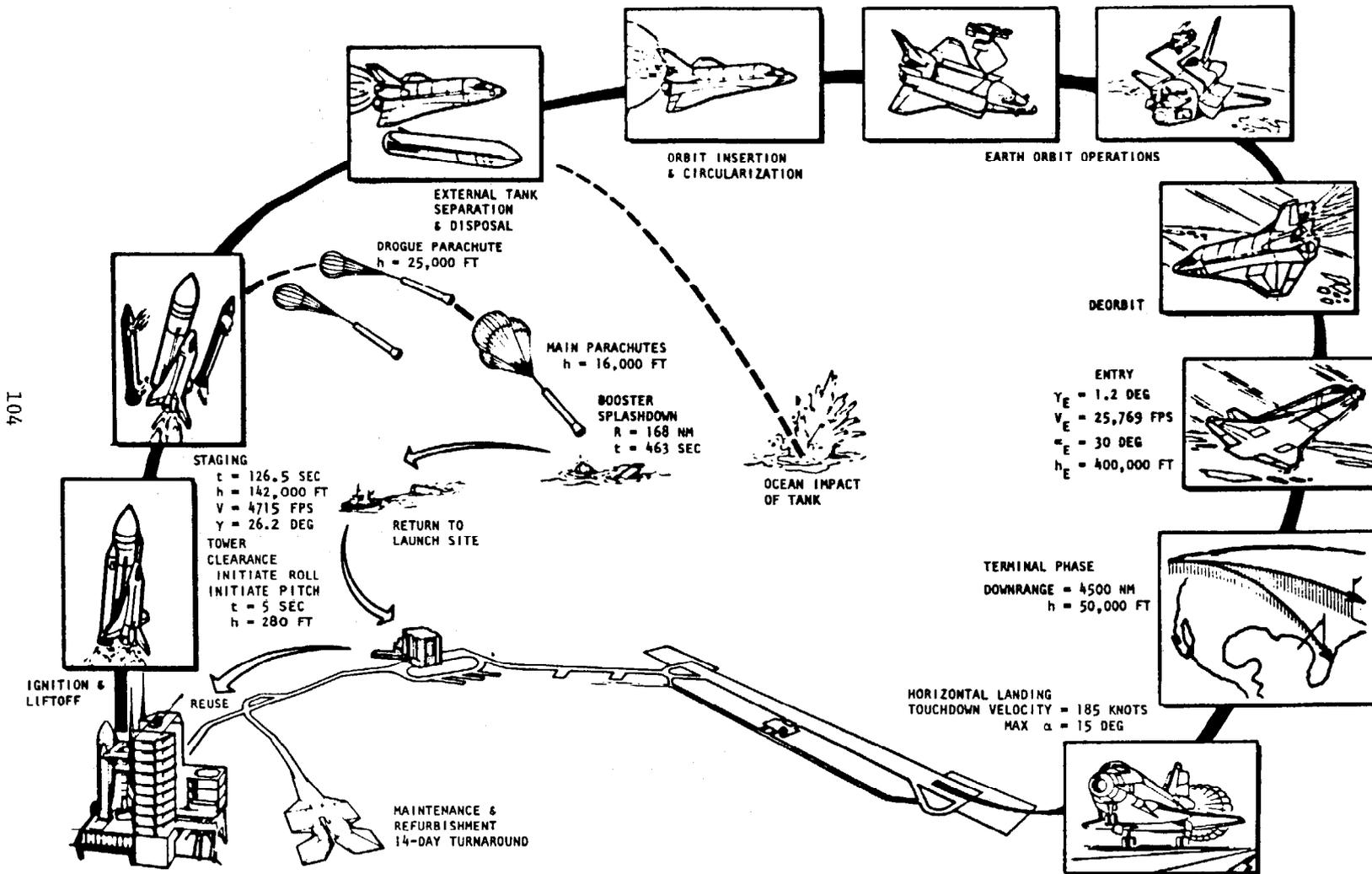


Figure 4