tate automatic landings and to the horizontal situation indicators in the cockpit which are used as navigation aids for manual landings. Manual landings are currently planned during ALT flights with temporary engagement of the autoland system at higher altitudes. The MSBLS provides elevation and azimuth angles within $\pm$ 0.05 degrees and slant range within $\pm$ 100 feet. Single MSBLS data is not used until after separation, there are no concerns associated with mated flight activities.

The Safety Division has conducted a hazard analysis of the MSBLS and conducted inspections of the DFRC facility. Several issues are being tracked as a result of these activities. These include (1) the inability to verify antenna pointing and distance measurement accuracy in the relatively short period between orbiter drops and shuttle training aircraft runs, (2) unexplained deviations in antenna pointing accuracy which have occurred at DFRC, and (3) inability to verify the MSBLS ground station accuracy because ground station errors cannot be separated from overall system errors. Recommendations to resolve Items 1 and 2 above have been submitted to the tracking and communications development division. Studies have been directed to resolve the third issue as a result of several RID's submitted at the ALT CDR conducted in April 1976.

No issues have been identified relative to reliability of operation because of system redundancy, the short duration of the orbiter free flight, and the various system verifications, including those performed during the captive/active flights.

Delivery of waveguides has been impaired because of poor quality control. Rejection of waveguides has delayed start of qualification tests. If problems continue, certification of wave-guides for ALT may be impacted.

No issues have been identified relative to MSBLS integration into a combined autoland with manual takeover. Since MSBLS data is always displayed in the cockpit, there is no real transition in MSBLS when going from auto to manual.

Q. An ALT data-link systems review was conducted earlier at Palmdale. It was to serve as the final review of the total ALT microwave data system. What part was played by the S, R&QA people?

A. JSC, DFRC and RI/SD R&QA were present at the review and Safety was represented at the review. The review covered site activation planning and results of recent tests of the microwave system. Presentations were made by Pacific Telephone, GSFC and RI/SD. The minutes of the review have not been released at the time this is written although JSC ground data systems personnel have indicated that no major constraints were identified. This system is under contract to GSFC. JSC, SR&QA personnel do, however, support activities such as the ALT flight and ground operations planning group meetings where planning and issues associated with the data-link system are discussed. Although the system is required for integrated testing and system verification during ALT, it is not considered safety critical. Malfunction of the microwave link or the complex at Palmdale prior to the GO/NO GO transmission from Palmdale would result in a mission scrub. The system is not safety critical during Orbiter free flight.

Q. What tests are to be conducted to prove that the tailcone will stay affixed to the orbiter during mated flights? What would happen if the tailcone were to become partially and/or totally detached from the orbiter either during mated or during free flight?

A. The tailcone and its attach fittings are designed and certified for flight exactly like all other orbiter structure. All orbiter structure for ALT is certified primarily by analysis such as flight loads analysis, internal loads analysis, stress and fatigue life analysis, and flutter analysis. Tests that will be conducted to supplement these analyses include extensive wind tunnel tests and a mated orbiter/SCA ground vibration test. Also, because structural verification tests will not be conducted for ALT, the ALT flight operations will be restricted to ensure that the maximum flight loads on any portion of the orbiter structure do not exceed 75% of the limit load predicted by analysis.

Q. Have you considered the use of instrumentation such as simple bridging wires that would give you an early warning of a possible separation of the tailcone so that you could get back safely?

A. This sounds like a reasonable approach and will now be investigated. This was reviewed subsequently by RI/SD and determined not to be necessary because the analysis and ground testing were sufficient.

Q. If ammonia is being used anywhere on the Orbiter, is it safely vented overboard to preclude injurious effects on the orbiter or the 747?

A. The Ammonia Boiler System (ABS) for orbiter 101 consists of two systems, designated "A" and "B", each containing three K-bottles each. The bottles in each system are manifolded into a single line feeding through a solenoid isolation valve, a flow control valve, and finally into the ammonia boiler. The boiler exhaust port is located on the right aft fuselage at the base of the vertical tail and is directed upward. Maximum flow rate through the boiler exhaust will be approximately 2.25 pounds per minute.

An assessment of orbiter 101 materials compatibility with ammonia has been performed by Rockwell/Space Division. Under normal operating conditions, (assuming no tank/line ruptures), the Orbiter will be exposed to ammonia vapors only. Periodic inspections will be performed to verify normal operation. The fuselage, wings, and vertical tail are aluminum alloys containing less than 6% copper and are generally unaffected by ammonia. The crew module aluminum contains 6.8% copper, but is primed and painted and is thus protected. Electrical wiring and equipment are environmentally sealed. Rockwell/Space Division's assessment of both the fused silica tiles and the polyurethane Simulated Reusable Surface Insulation shows no anticipated incompatibility with ammonia.

As a result of orbiter 101 delta PDR RID 09.02.70, "Effects of Orbiter exhausts on Carrier A/C and Crew," an assessment was made on the 747 materials. The systems and components investigated included engine, APU's, air conditioning system, vertical tail structure, wiring and mechanical components, fuselage structure, and internal electrical systems. At the concentration of ammonia vapors predicted, no problems are anticipated. Aluminum has a corrosion rate of less than 1 mil per year for exposure to moist ammonia gas up to 212° F. Dry ammonia has no appreciable effect on aluminum.

7. Additional items of interest.

Another area of interest was the position of the hydraulic system lines, system-to-system, since the anomaly on the Orbiter 101 landing gear test proved that when hydraulic lines are positioned near one another there is a chance that anything that causes line failure in one can adversely affect others.

The program is reviewing the effectiveness of rudder and elevon rates and aerodynamic control qualities at this time and this will be followed by the Panel task teams.

Another area of continuing interest is the low APU fuel capacity inherent in the Orbiter 101 which makes it necessary to have the APU's turned off and on during the flight.

C. <u>Information Update</u>

A number of items have been of interest, e.g., contingency abort capability and planning, lightning protection, etc., which have been addressed since the task team reviewed the status of the Safety and Reliability aspects of OFT flight. This data could be placed under the OFT section of this report as well as in this section.

In continuing its review of abort planning and capability, with resultant risk or no risk acceptance, the Panel feels that it would be worthwhile to identify requirements for aborts other than those currently specified...Abort to orbit (ATO), return to launch site abort (RTLS), and Abort once around (AOA).

Lightning protection has been discussed in Section XII, External Tank and Solid Rocket Booster, and has been a subject of discussion in previous Panel reports. Because of the number of program initiated studies and the desire to make the Shuttle system as independent of environmental factors as possible, the panel will examine the results of the many activities now in process.

The emphasis being placed on the testing of the hydraulic system as a whole and the major components to assure safe and reliable operation during the Orbiter 101 and 102 flight activities will continue to be followed to help assure that nothing falls-through-the-crack. Areas such as the Dynatube connections which must be leak-tight(do you lock-wire these connections or not?), the fidelity of the test configurations in regard to the actual flight equipment (credibility of test results?), maturity of the hydraulic circulation pump (is the performance really known under operational conditions?), and the degree of instrumentation on actual first flights during which the total hydraulic system is to be operated.

TABLE VIII-I

ORBITER CONTRACTOR PROBLEM REPORTING REQUIREMENTS

Problem Notification---	All problems that occur during or subsequent to acceptance test shall be reported to JSC within 24-hours of occurance.
Problem Documentation--	A documented report shall be provided to JSC within 5 days of the reportable item identification.
Problem Disposition----	A documented report shall be submitted 21 work days after initial report to document the cause and corrective action or rationale for not implementing corrective action.
Open Problem List------	A report shall be submitted weekly beginning 21 days after the start of the certification program listing all open reportable problems and the status of actions being taken to resolve each.

FIGURE VIII-1

ORBITER PROJECT PRACAS RELATIONSHIPS

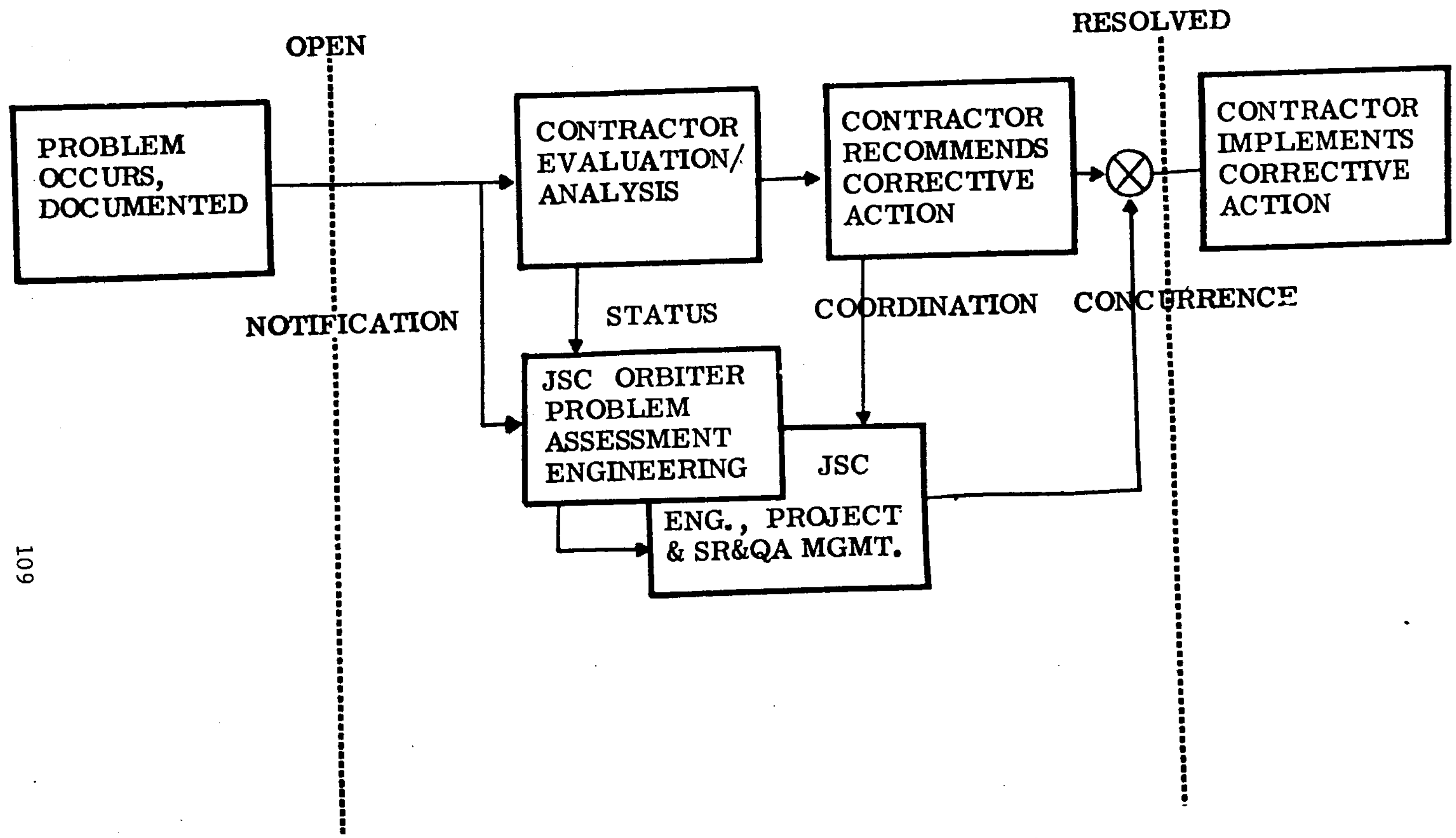
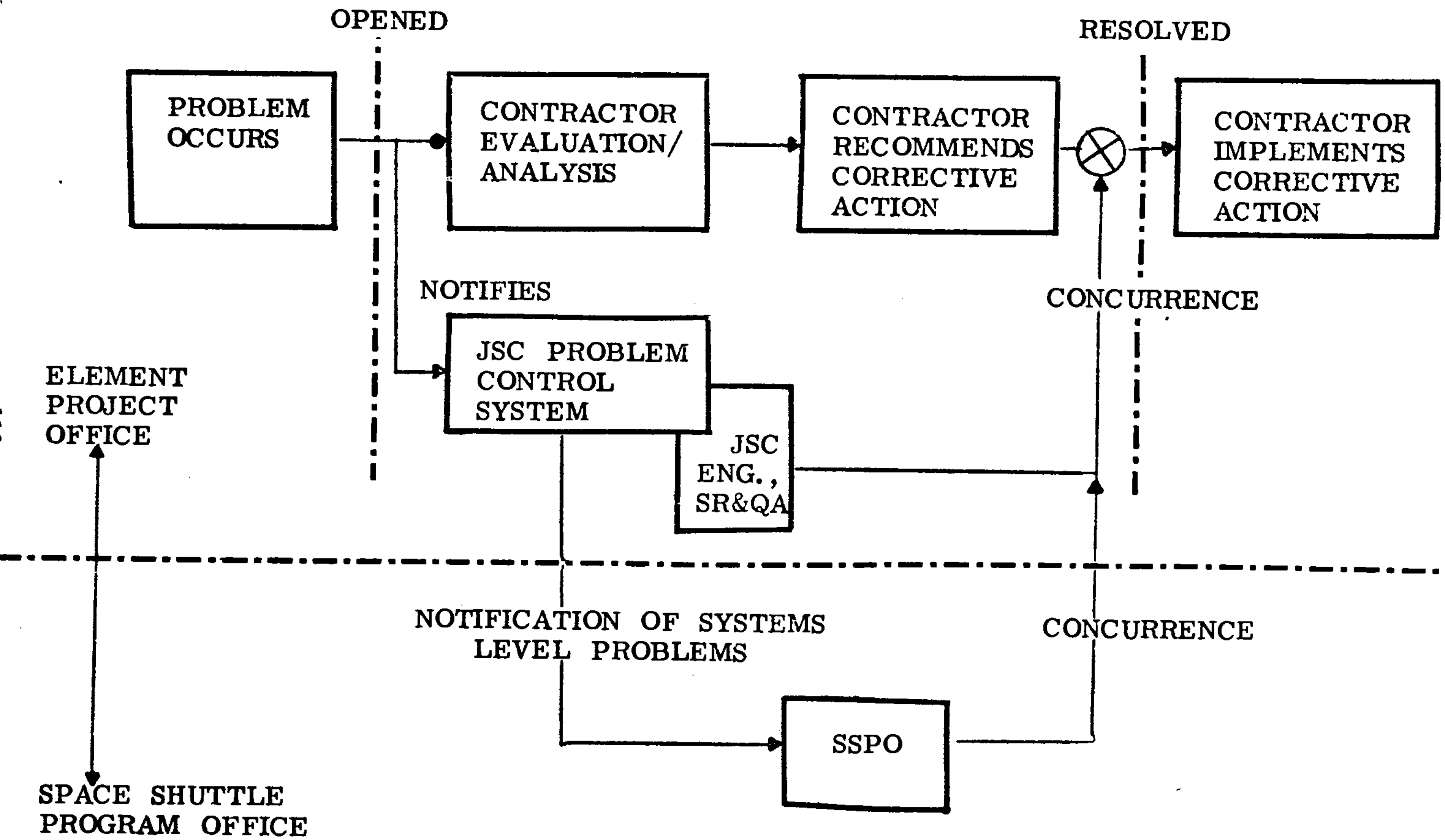


FIGURE VIII-2

SPACE SHUTTLE INTEGRATION PROBLEM REPORTING AND CORRECTIVE ACTION SYSTEM



ACTION ASSIGNEE: D.DUSTON SSM/TM: EG2/A.J.FARKAS

PROBLEM IDENTIFICATION:

LEVEL	TYPE	VEHICLE ON	CAUSE	FAIL MODE	TEST/OPER	PREVAIL. COND.	LOCATION	OCCURRED DATE	REPORT NUMBER
ELEMENT	UNSAT COND	101	DES- -	OUTPUT FALSE	CKO	FUNCTIONAL	RIPLM	05/20/76	A2768-01

HARDWARE IDENTIFICATION:

	PART NUMBER	PART NAME	MFG	SERIAL/LOT	DATE/TIME UPDATED	REFERENCE
TEST ARTICLE	V070-000002-101	ORBITER GENERAL	RIDNY	0101	09/21/76 133843	
NONCONFORMING ARTICLE	V070-000002-101	ORBITER GENERAL	RIDNY	0101		
NEXT HIGHER ASSEMBLY						

RESOLUTION DATE 09/17/76 WORK UNIT CODE

PROBLEM EFFECTIVITY:
MISSION NUMBER ALT
VEHICLE NUMBER 101
CRIT - STATUS 3- EXPL

PROBLEM DESCRIPTION:
DURING THE OV-101 FIRST POWER APPLICATION TO INSTALLED FLT COMPONENTS, USING FLIGHT WIRE HARNESSES AND DURING THE FIRST TEST CONDUCTED PER TCP ML0720-4501-101, POWER REACTANT SUPPLY AND DIST. AND POWER GEN. FUNCT. C/O THE MC432-0222-0016 EVENT OHD/ SM 65042-320016133 FOR FUEL CELL POWER PLANT NO. 2, H2 REACTANT SUPPLY VALVE (MC284-0429-0200) ON COCKPIT D AND C PANEL R2 MOVED HALFWAY BETWEEN GRAY AND BARBER POLE INDICATION WHEN THE VALVE WAS COMMANDED FROM OPEN TO CLOSE BY SWITCH S-29(ME452-0102-6205. THE EVENT IND. SHOULD BE FULL BARBER POLE. 1-THE SWITCH S29 WAS SUBSEQUENTLY CYCLED TO OPEN AND CLOSE THE VALVE

ANALYSIS:
A TOTAL OF 14 ON/OFF CYCLES. AFTER THE FIRST CYCLE THE ANOMALY DISAPPEARED AND DID NOT RECUR. 2-NONE. 3-THE ANOMALY OCCURRED DURING THE OV101 FIRST POWER APPLICATION TO INSTALLED FLIGHT COMPONENTS AND USING FLIGHT WIRE HARNESSES. 4-ANALYSIS INDICATED THE MOST PROBABLE CAUSE IS INTERNAL STICKING OF THE INDICATORS MOVEMENT, CAUSED BY A FOREIGN PARTICLE, WHICH AFTER ONE CYCLE WAS DISPLACED PERMITTING THE INDICATOR TO FUNCTION NORMALLY. 5-LAST TEST IS THE NORMAL PRE-FLIGHT SYSTEM READINESS CHECKS. 6-ANOMALY CAN BE DETECTED ON THE GROUND VIA PCM DOWNLINK AND CREW CAN OBSERVE THE O2 REACTANT

RESOLUTION:
VALVE INDICATOR (COMPARISON) TO EVALUATE THE CONDITION IN REAL TIME WHEN COMMAND IS SENT. 7-MISSION EFFECT-NONE. THERE ARE NO SAFETY HAZARDS INVOLVED WITH A RECURRENCE OF THIS ANOMALY. 8-A FAILURE OF THE INDICATOR WILL NOT EFFECT THE OPERATION OF THE FUEL CELL POWER PLANT. IT IS POSSIBLE THAT THE FUEL CELL DAMAGE COULD OCCUR IF REACTANT IS SUPPLIED TO ONE INLET ONLY; HOWEVER, THIS WOULD REQUIRE AN ACTUAL VALVE FAILURE IN ADDITION TO THIS ANOMALY (SECOND FAILURE) . THE CREW CAN EVALUATE THE CONDITION REAL TIME WHEN THE COMMAND IS SENT BY COMPARING THE O2 AND THE H2 REACTANT VALVE INDICATION. 9-NONE. 10-THE -0016 INDICATOR IS FOR OV101 ALT USE ONLY.

ACTION ASSIGNEE: G.FLETCHER SSM/TM: EG2/A.J.FARKAS

PROBLEM IDENTIFICATION:

LEVEL	TYPE	VEHICLE ON	CAUSE	FAIL MODE	TEST/OPER	PREVAIL. COND.	LOCATION	OCCURRED DATE	REPORT NUMBER
ELEMENT	FAILURE		MFG- -	FAILS OPEN	QAL	LIFE	EDISEL	06/11/76	A4543-01

HARDWARE IDENTIFICATION:

	PART NUMBER	PART NAME	MFG	SERIAL/LOT	DATE/TIME UPDATED	REFERENCE
TEST ARTICLE	MC452-0134-0007	SWITCH THUMBWHEEL DS	EDISEL	0001	09/09/76 163416	
NONCONFORMING ARTICLE	MC452-0134-0007	SWITCH THUMBWHEEL DS	EDISEL	0001		
NEXT HIGHER ASSEMBLY						

RESOLUTION DATE EST 09/24/76 WORK UNIT CODE

PROBLEM EFFECTIVITY:
MISSION NUMBER ALT
VEHICLE NUMBER 101 101
CRIT - STATUS 3- OPEN 3- OPEN

PROBLEM DESCRIPTION:
UNABLE TO CHECK SWITCH ELECTRICALLY, UNABLE TO MAKE CONTACT WITH SWITCH INTERNALLY.

REMARKS:

FIGURE VIII-3

SIGNIFICANT PROBLEMS

RESPONSIBILITY:	DATE REPORTED	PROBLEM REPORT:	PART NUMBER:
SUBSYSTEM MGR. W. SIMMONS SR&Q A ASSIGNEE W. HARVEY	9/29/76 EST. RESOLUTION 11/12/76	A5098	MC 325-0004-0012

ITEM: ONE WAY TRANSFER PYRO-DEVICE, CREW ESCAPE ENERGY TRANSFER SYSTEM

CRITICALITY 2

PROBLEM:

DURING LOT ACCEPTANCE TEST FIRINGS OF ONE-WAY TRANSFER, ONE UNIT FAILED TO FIRE HIGH ORDER AT AMBIENT CONDITIONS (EXPLOSIVE MIX DEFLAGRATED OR BURNED INSTEAD OF DETONATED). THIS LOT WAS BEING RETESTED AFTER A REBUILD DUE TO SIMILAR PROBLEMS WHICH OCCURRED 6/9/76. ORIGINAL PROBLEM WAS NOT DUPLICATED IN FAILURE ANALYSIS, BUT PRIMER POCKET WAS REDESIGNED AND PRIMERS WERE 100% SCREENED AS A CORRECTIVE ACTION.

EFFECTIVITY:	SCHEDULE IMPACT:
OV-101 & OV-102	SERIOUS IMPACT ON HARDWARE NEED DATE OF 10/25/76 FOR CREW ESCAPE SYSTEM BREADBOARD TESTS AT ROCKWELL AND SLED TESTS AT HOLLOMAN (STATIC 1/12/77)

STATUS:

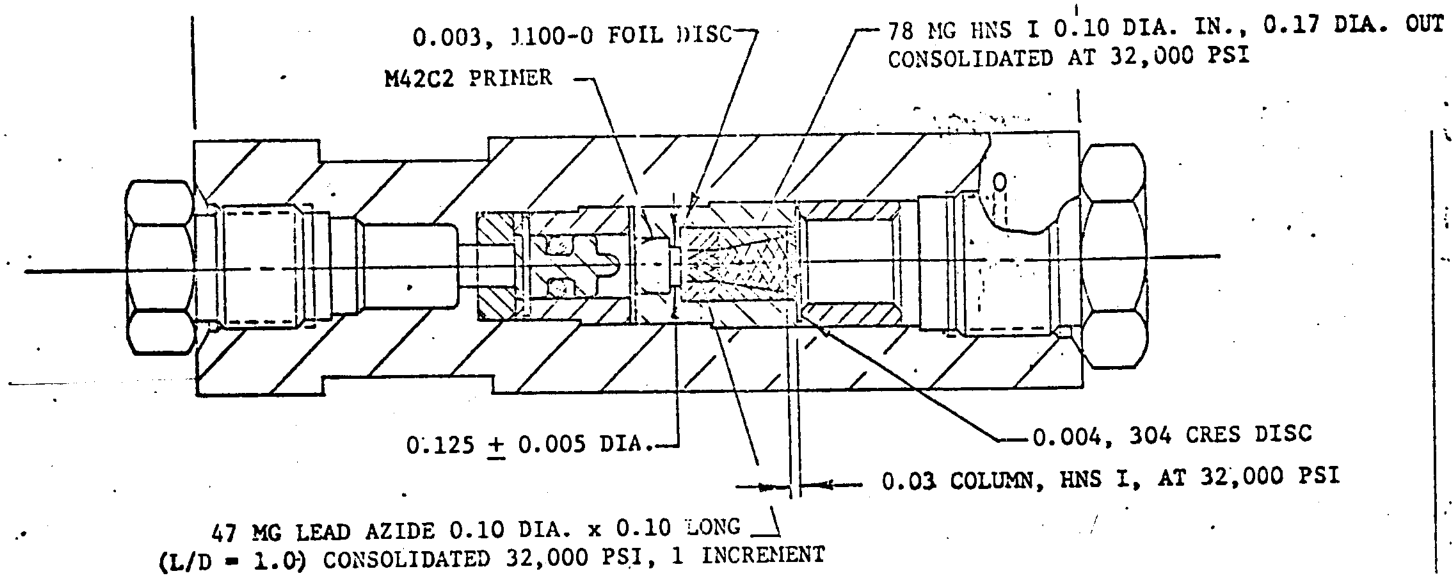
- SEVERAL DESIGN INTERFACES HAVE BEEN CHANGED: (SEE ATTACHED DRAWING)
  - A) PRIMER CHANGED TO SAME TYPE USED ON TIME DELAYS - M42C1 INSTEAD OF M42C2.
  - B) PRIMER FLASH HOLE DIAM. DECREASED
  - C) L/D COLUMN RATIO OF LEAD AZIDE REVISED TO 2.0 FROM 1.0 AND COLUMN LOAD PRESSURE REDUCED.
  - D) HNS "PANCAKE" FOLLOWING HNS OUTPUT CHARGE INCREASED TO 0.09 IN. FROM 0.03 IN.
- SECOND SOURCE VENDOR UNDER CONTRACT - QUAL DATA FOR F-14 DEVICE WAS REVIEWED 10/12/76 BY JSC & ROCKWELL AND CONSIDERED ACCEPTABLE WITH EXCEPTION OF TWO DESIGN PARAMETERS WHICH WILL REQUIRE WAIVERS (SEE ACTION REQUIRED). RI HAS PURCHASED PARTS FOR BREADBOARD TESTS.

ACTION REQUIRED:

- AT EXISTING VENDOR: REDESIGN DEVICE AS DESCRIBED ABOVE AND PERFORM LAT. (ROCKWELL TO CONTINUE PARALLEL EFFORT UNTIL F-14 WAIVER APPROVAL IS IMMINENT).
- AT SECOND SOURCE VENDOR: A) RI TO REVIEW AND FORMALLY APPROVE DOCUMENTATION INCLUDING ATP & QTP, B) REVISE SPEC. TO REFLECT NEW CONFIGURATION, C) SUBMIT WAIVERS FOR NON-GFE HNS AND NON-APPROVED (JSC 08060) PRIMERS UTILIZED IN F-14 PART.

STATUS: AS OF 10/25/76 **NEW:** [ ] **OPEN:** [X] **CLOSED:** [ ]

FIGURE VIII-4a



PRESENT ONE-WAY TRANSFER FITTING DESIGN

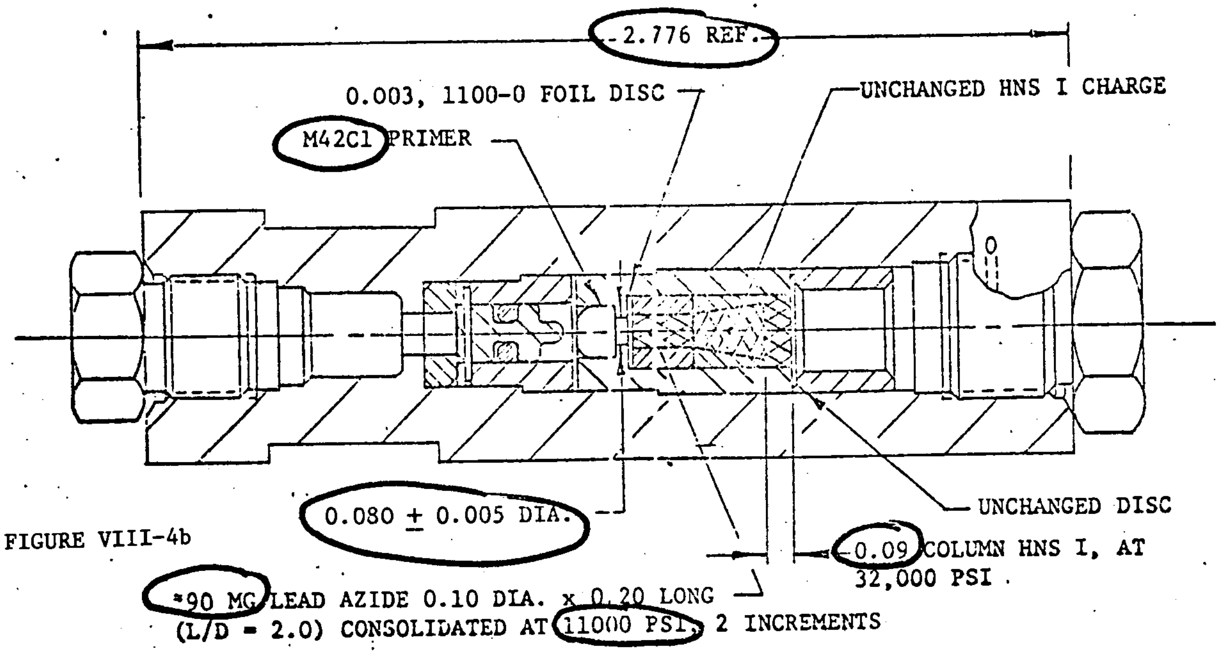


FIGURE VIII-4b

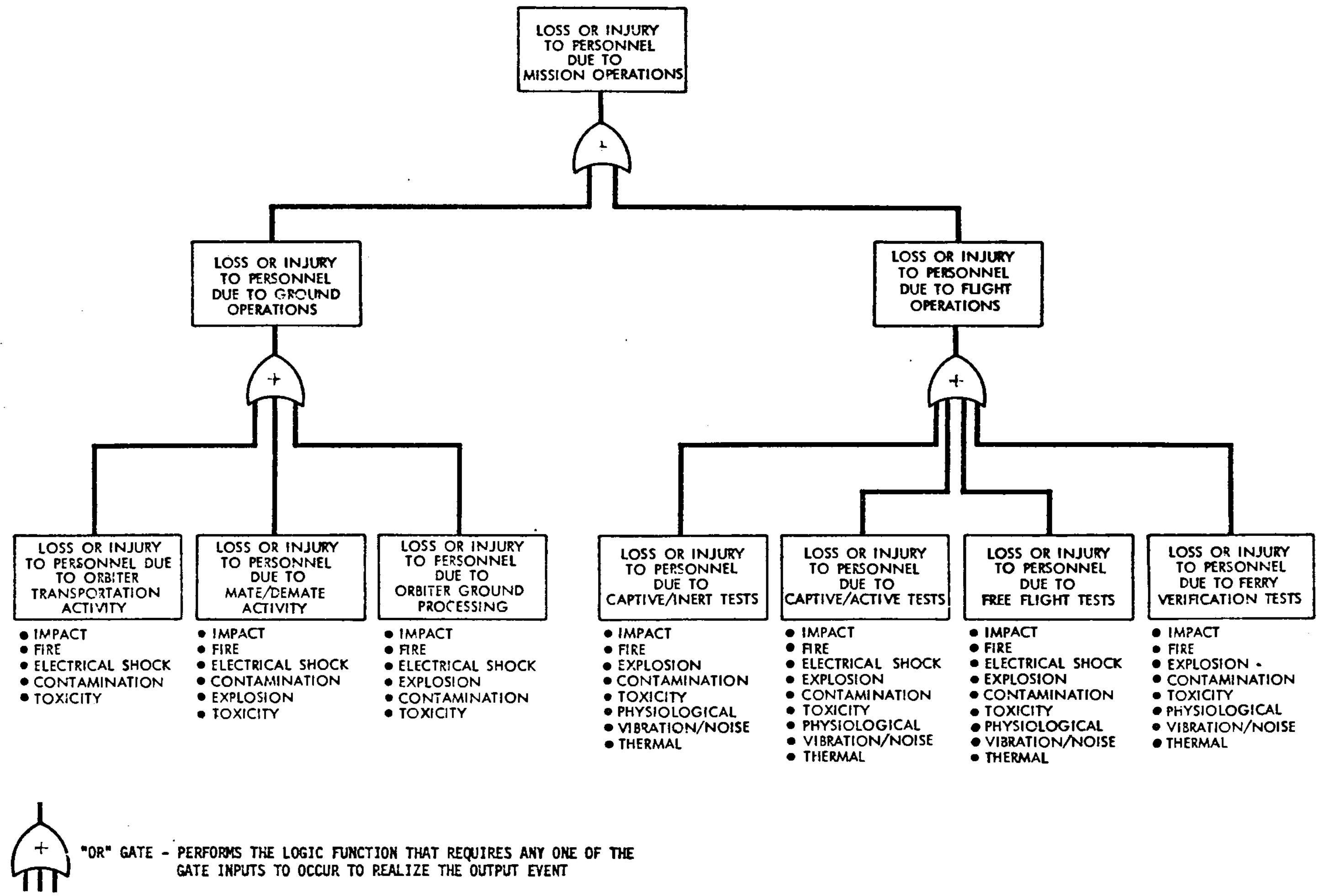
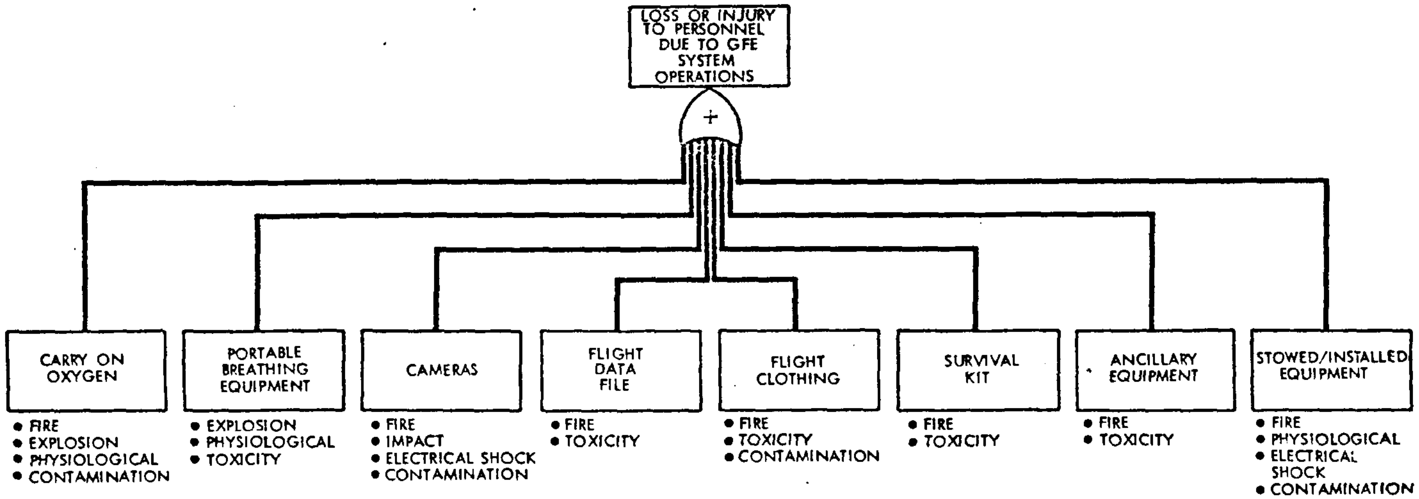


Figure VIII-5a ALT Mission Operations Fault Tree



"OR" GATE - PERFORMS THE LOGIC FUNCTION THAT REQUIRES ANY ONE OF THE GATE INPUTS TO OCCUR TO REALIZE THE OUTPUT EVENT

Figure VIII-5b ALT GFE Fault Tree

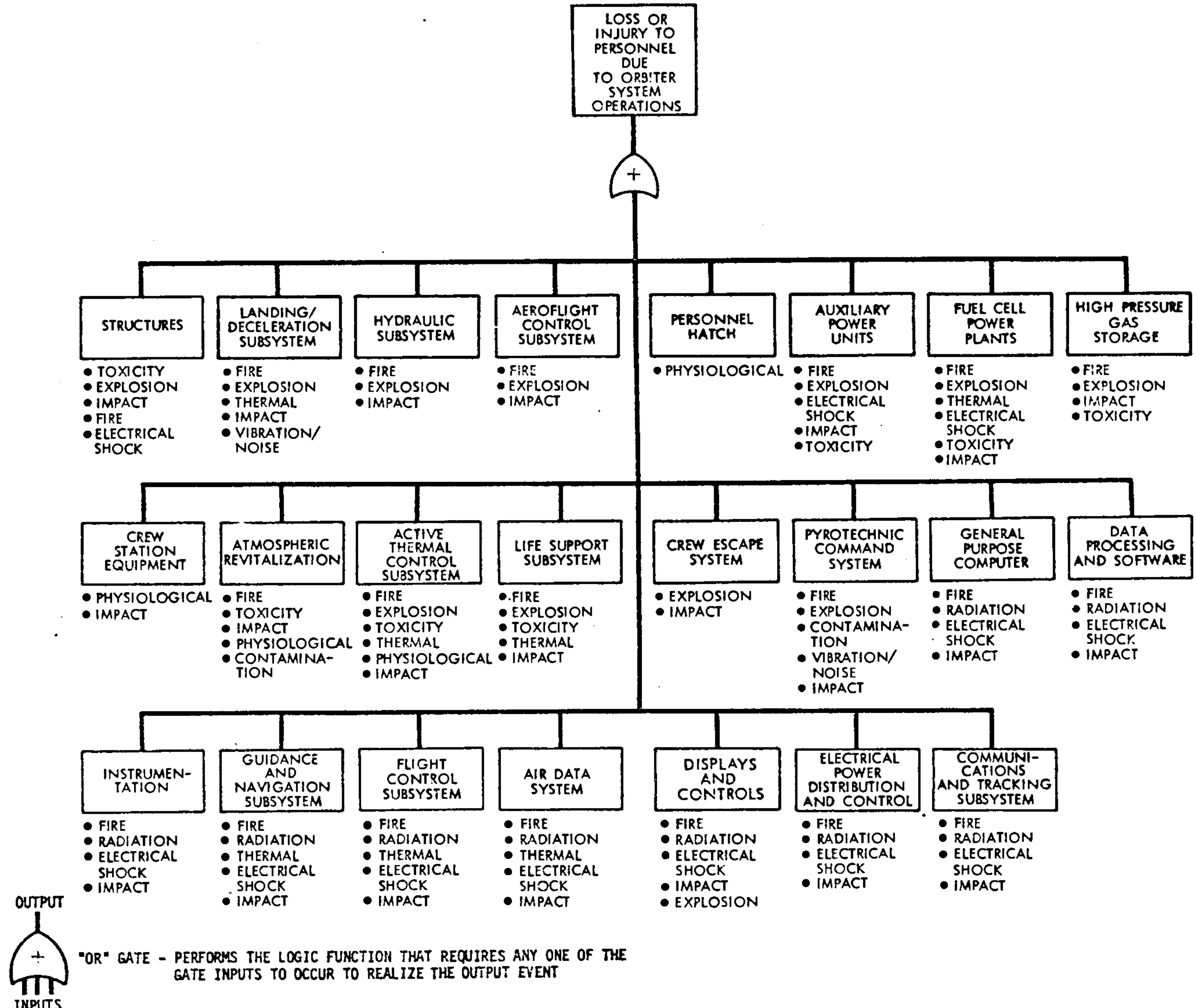


Figure VIII-5c ALT Orbiter System Fault Tree

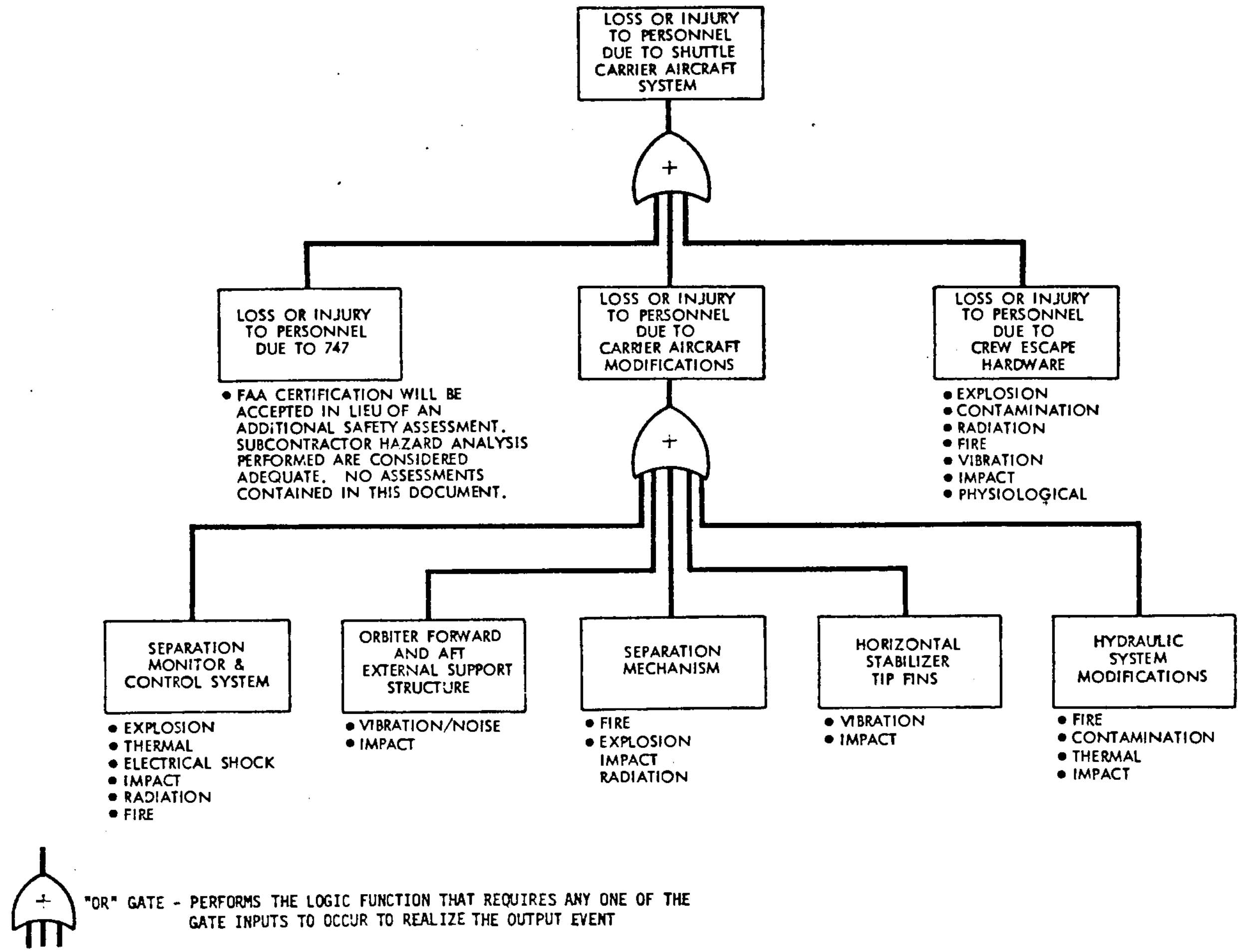
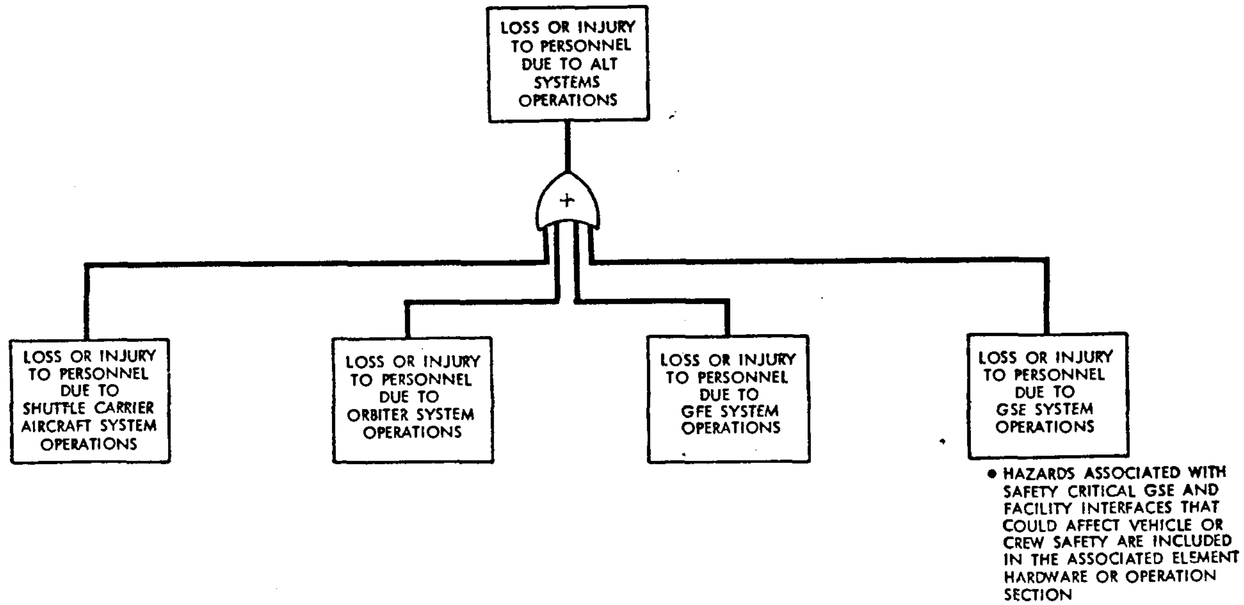


Figure VIII-5d ALT SCA Fault Tree



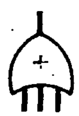
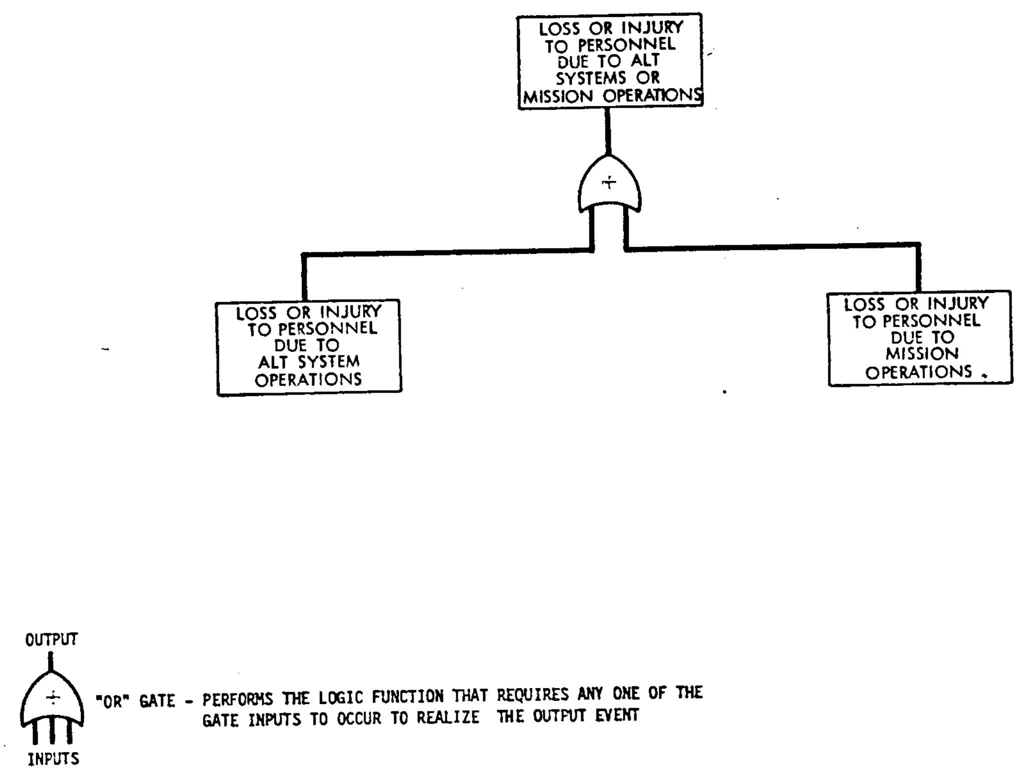

"OR" GATE - PERFORMS THE LOGIC FUNCTION THAT REQUIRES ANY ONE OF THE GATE INPUTS TO OCCUR TO REALIZE THE OUTPUT EVENT

Figure VIII-5e ALT System Operations Fault Tree



"OR" GATE - PERFORMS THE LOGIC FUNCTION THAT REQUIRES ANY ONE OF THE GATE INPUTS TO OCCUR TO REALIZE THE OUTPUT EVENT

Figure VIII-5f ALT Project Fault Tree

IX. CONFIGURATION MANAGEMENT AND INTERFACE CONTROL

A. Introduction

The general significance of the configuration management system for the Panel is that it assures that the program knows what is in fact being designed, built and tested so that the real risks are identified and dealt with. It forces a necessary degree of discipline on every level of a complex program and thus is an inherant technical and administrative activity of any NASA and DOD program. The system does not force the use of unnecessary paper or levels of management but does require that there be sufficient documentation to assure that management, design and user organizations have timely information necessary for effective decision making, risk assessment and program control.

Because of the significance of this system the Panel made it a point to emphasize in its last Annual Report that the Panel had not yet completed consideration of other important system integration issues such as configuration management, interface control and interaction between Shuttle system elements but that it intended to do so as soon as feasible in terms of its large workload. This section reports on the Panel's review to meet this commitment before the ALT flights. In fact the Panel felt that an examination and assessment of the Configuration Management System as it is both documented and implemented is one of the basic steps in assessing the adequacy of the ALT management system in establishing a real basis for confidence in achieving mission success and flight safety.

The Panel in designing its review of this area considered the demands the system must successfully meet.

1. The system must support the programs' ability to produce hardware and software that is capable of being qualified and certified for flight, and then can be maintained, replaced, or modified as information on operational characteristics becomes available through flight tests.

2. The Shuttle Program is as diverse as its predecessors, the Apollo Program, Skylab, and the Apollo Soyuz Test Project. It has numerous prime contractors and technical support spread all over the country and there is bound to be some degree of non-standardization as well as coordination problems. These will be difficult to overcome even with the dedicated people known to be working these areas.

3. Element and integrated system aggregate risk assessments must be based on knowledge of the "as-built" and "as-tested" hardware and software. Accepted risks and their justification must also be based on such known configurations.

4. Development, qualification, and acceptance testing schedules are extremely tight and overlap with manufacture and installation requirements. Therefore, hardware and software mismatches and materiel problems, resulting from inadequate configuration management, can lead to schedule and cost impacts. Inadequacies therefore must be minimized.

Therefore, the Panel focused on the following elements of the configuration management system:

1. The system as documented.

a. Level I, II, III and IV requirements and procedures.

b. Organizational responsibilities and intercenter relationships.

c. Relationship with Master Verification Plan.

d. Configuration accounting system and repositories.

2. The system as implemented.

a. Degree of configuration control being applied to each element to determine current baselines.

b. The processing of actual hardware/software changes from inception to completion.

c. Documentation to relate the "as-designed" to the "as-built" to the "as-tested" hardware/software.

d. Activities of the Space Shuttle Program Configuration Management Panel (SSPD #6), the Level I, II and III Program Requirements Control Boards (PRCB's) and the systems engineering support provided to these activities.

e. Use of Configuration Management products to support the Space Shuttle Review system, e.g., CDR's, DCR's, and Flight Readiness Reviews.

f. The relationship between logistics (maintenance, spares, etc.) and the Configuration Management System.

g. Relationship between Safety, Reliability Quality Control and the Configuration Management System.

Since the following fundamental terms are used in this section of the report, they are defined to avoid any confusion.

1. Configuration Management System. The total system to (a) identify and document the functional and physical characteristics of all program hardware and software and the major test operations on them, and (b) control the processing of changes to the hardware, software, test functional and physical characteristics.

2. Configuration Management. The set of policies and procedures to implement the system. These must cover requirements, identification, control, accounting and verification.

3. Interface Control or Management. The specific set of policies and procedures to govern situations where one element, such as the Orbiter, is dependent on another, such as the External Tank. The interface or two-dimensional plane between elements must be designed and manufactured so that when the elements come together they match in every detail physically and operationally. The control of the internal interfaces such as between the electrical generating and distribution system and the flight control system within the Orbiter is within a single NASA Center and single prime contractor. On the other hand Interface Control is between elements which means between prime contractors and NASA Centers. Thus a change considered by the management of one element must be considered in terms of its impact on the other element and their integrated operation.

The observations that follow are based on the program responses to specific questions, direct quotes from briefing material and notes made during discussions.

B. Observations

1. General Information.

The Space Shuttle program has streamlined the configuration management methodology which evolved through Apollo, Skylab and Apollo Soyuz. Paperwork has been reduced, efficiency increased and changes made to some basic operating principles.

The four levels of the program are shown in Figure IX-1 along with the elements that make up each level. In addition there is a system of Boards - the Program Requirements Control Board (PRCB) the Cost Limit Review Boards (CLRB's) and the Change Control Boards (CCB's). These are shown in Figure IX-2.

Briefly the established prerogatives for each level are:

Level I - Program Director controlled requirements and direction.

Level II - Program Manager controlled requirements and direction that normally affects more than one project office.

Level III - Project Manager controlled requirements and direction that clearly affects a single project office.

Level IV - Project Element/NASA design activity/contractor controlled requirements implementation and direction that clearly affects only the respective element for which the design activity/contractor has responsibility.

The Program Director located at NASA Headquarters, has a single document that covers the Level I activities (Program Directive #1C, July 5, 1973, "Establishment of Change Procedures To Space Shuttle Program Requirements - Level I Control Documents.") The Program Directors Program Requirements Control Board does not meet often as most of the Level II PRCB operations are conducted at JSC with teleconference arrangements to both NASA Headquarters and other appropriate NASA Centers and contractors. During these board operations the Level I input is made informally to those managers making Level II decisions. On the other hand the Cost Limit Review Board at Level I is quite active, meeting on the average of once each month to make decisions transmitted to it via Level II or determined as necessary at Level I itself. There is no program directive establishing this CLRB and defining its operation; but, since it has been in action for some years, it is not expected to require such documentation at this late stage of the program. The Program Director in Washington uses the CLRB to control costs and the PRCB to control "reserves", i.e., computer memory reserve capacity or electrical power generation capacity reserves.

The workload at Level II requires the services of three Civil Service persons and nine RI contractor support persons. The nature of such work also requires the part-time use of technical personnel from other NASA divisions at JSC.

In addition there are Level III and IV systems at the project level that must function effectively to assure an adequate total system for decisions made here that are not reviewed at higher management levels.

Interface controls are under the purview of the Systems Integration Office at Level II and their mode of control and use follow that for normal Level II operations.

The operation of this system is discussed in more detail in the following sections.

2. Configuration Management Requirements

The basic philosophy used in developing the requirements is: "This document has been jointly developed by the Manned Spaceflight Centers, and represents a careful application of the experience gained in previous NASA, military, and commercial space and aircraft programs."

To be effective from the standpoint of producing hardware and software in a timely, orderly manner within the cost constraints, configuration control by NASA is established only "when and where it is necessary and when it will tend to stabilize program efforts. Caution must be taken to prevent premature control and control at too low a level of detail."

These requirements are set forth in JSC 07700, Volume IV, "Configuration Management Requirements," baselined March 2, 1973 and a Revision A issued in April 1974. Changes are made as required by reorganizations, personnel changes or to meet the demands of the ongoing Shuttle program. Through November 1976 sixteen changes to this document have been processed and incorporated.

The additional documentation used by the program and examined by the Panel are as follows:

a. "Level II Baseline Description and Status Report," JSC 08102, published monthly and contains about 70 pages of computer printout.

b. "Space Shuttle Orbiter/System Integration Contractor Configuration Management Plan," SD73-SH-022A, June 23, 1975 issued by Rockwell International, Space Division.

c. "Shuttle Carrier Aircraft Project, Configuration Management Manual," JSC 08140, January 13, 1975.

d. "Space Shuttle Program Configuration Management Panel," SSPM Directive No. 6A, July 3, 1974. This directive established this Panel as a mechanism for reviewing, assessing, advising and guiding the proper integration of configuration management activities across the program.

3. Configuration Identification.

Identification refers to the manner and documentation for describing in detail all program hardware and software. Requirements and configuration are identified in detail for the practical purpose of producing hardware and software which meets or exceeds specified requirements and is a baseline used for control and accounting of changes as they occur.

The baseline at each level of the program requires those types of data shown in Table IX-I. Note that the interfaces are taken into account in these listings.

An integral part of the identification process is the assurance of hardware traceability. Traceability is the identification technique of correlating historical records to each item. These records are valuable in resolving hardware problems, understanding age-life characteristics and helping to assure reliable and safe flight and ground equipment.

To illustrate the set of documentation required for a project (Level III) here is the documentation required for the Shuttle Carrier Aircraft:

a. All the applicable requirements of the NASA Level I and II baselines.

b. Specification MJ510-0001-1, "Shuttle Carrier Aircraft Contract End Item Specification - Design and Performance Requirements." Baselined by the Shuttle Carrier Aircraft Project Manager on April 9, 1976.

c. Specification JSC-08943, "Flight Test Requirements - Volume I - Shuttle Carrier Aircraft." Baselined by Orbiter and SCA Projects on December 12, 1975.

Configuration Identification includes the Interface Control Documents (ICD's) used to control interfaces between two or more participating contractors and government agencies. In effect the ICD's augment the contractural specifications by documenting the requirements and agreements between interfacing contractors and/or NASA. The content of these ICD's can be seen on Table IX-II which is from ICD #2-17001, "Orbiter/Carrier Aircraft, Ferry and ALT. This particular ICD is unique in that two configurations are presented, both of which involve the Orbiter and the 747 aircraft, that is, ferry flights and the ALT.

Identification also includes drawings - a drawing tree for both flight and ground systems (this is in effect a directory of drawings), engineering drawings and a part number control system.

4. Configuration Control.

The baseline as established at any given time must be protected from inadvertant and/or unauthorized changes. The baseline is normally a product of such configuration reviews as the Preliminary Design Review (PDR) and the Critical Design Review (CDR). In addition to these traditional reviews, the Space Shuttle program has added a series of incremental design reviews. For instance there is a system of reviews to consider the design in light of prior testing and before proceeding to the next step of the program. These are called Customer Acceptance Readiness Reviews (CARR's) or Configuration Inspections (CI's) Thus there was a Phase I configuration inspection in the Spring of

1976 which reviewed the design in light of testing and whether it was ready to proceed through individual subsystem testing. Then a Phase II review was held in October 1976 to consider what had been learned about the design from this individual subsystem testing. A Phase III review in late January 1977 considered the proof of design in the light of integrated testing. The Phase III review authorizes the program to proceed with final testing and delivery of the vehicle.

Configuration control is maintained through strict change management. Change management is effected through the use of Configuration Control Boards (CCB's) which are shown in Figure IX-2. The Level I and II CCB's are referred to as Program Requirements Control Boards (PRCB's). The membership of these boards has been established so that every change request receives a thorough going-over by the board and by the supporting technical and administrative groups. For instance, the Level III Orbiter CCB is supported by the Orbiter Configuration Control Panel, the GSE Configuration Control Panel, Orbiter Software Design Review Board and those Technical Status Reviews required as a part of the normal technical design information flow between NASA and its contractors.

The change control flow is shown schematically in Figure IX-3. One should note the placement and use of the CLRB which is a distinct change from previous programs. The Level I PRCB contains about 10 members, while the Level I CLRB contains 6 members. The Level II PRCB contains about 29 members and the Level II CLRB contains only 5 members. Each level, of course, has its own authorities and responsibilities and the PRCB and CCB's control all items not affecting the next higher level of management. However, in the case of high cost items, the CLRB operates concurrently with the PRCB and quoting from Volume IV, JSC 07700, Page 4-4, "The Level II Cost Limit Review Board is the controlling authority for all Level III changes with projected expenditures which deviate from program and project cost plans by more than $500,000 in any fiscal year. All Level III changes with a dollar value in excess of $500,000 in any fiscal year shall be dispositioned by the Level II CLRB and, if approved, shall be forwarded to the Level I CLRB for dispositioning. Level II changes with a dollar value exceeding $500,000 in any fiscal year, or $1,000,000 total for payload related changes shall be processed through the Level II PRCB or CLRB; and, if approved, forwarded to the Level I PRCB or CLRB for disposition. Level I changes regardless of dollar value are forwarded to the Level I PRCB for disposition."

It was noted that in the case of the Shuttle Carrier (the 747), the dollar value was different. Level II is to be notified by a memorandum from the SCA Project Manager when the change value exceeds the figure of $300,000 at any time.

The Panel task team examined samples of changes transmitted to the CLRB as well as the minutes of such Boards. The system appears to be working well and the degree to which encumberances slow down the system is not known at this time. However, the personnel with which this was discussed indicated that no time was lost in the process and it may even preclude things from "falling into the crack." Since the same paper is used at each level, the amount of paper is not too great and the approvals are readily apparent. The task team examined a number of PRCB Minutes and Directives to ascertain the depth of material covered, action items and distribution. A sample "change package" was selected (actually several were examined) at random to provide an example of the system and how it worked in real life. The change selected was identified by No. R01911, "Gimbal Actuators - 3 port versus 4 port." It affected the Orbiter and the Space Shuttle Main Engine and the Solid Rocket Booster which use such actuators. The change was originated in the engineering division at JSC and superceded a previous change request. The paperwork indicated that this was a mandatory change costing as much as four million dollars during a four year period. Level III Orbiter CCB approved and authorized the forwarding of this change to Level II on August 5, 1975 since the cost was over the $500K limit. The Level II CLRB approved the forwarding of this change to Level I on August 29, 1975, and Level I approval was given on October 16, 1975. The change was, at the same time, undergoing assessment and impact analyses by the cognizant technical organizations so that the change was fully evaluated in terms of cost, schedule, engineering and safety, reliability and quality assurance requirements. It was then reviewed and approved by the Level II PRCB because it affects more than one project as well as being a high-cost item. The directive to implement the change was issued on October 21, 1975 with specific actions to be accomplished by the end of November 1975. At that time an addendum to the original directive was prepared and signed out February 28, 1976. The close out paper shows the actions taken by the appropriate MSFC project offices and contractors. Direction was given to the contractor and

NASA internal documentation was modified accordingly. Project reviews assure that the change was made.

A special effort was made to review the configuration control as applied to the most significant items or elements of the Approach and Landing Test Project. These elements included the test vehicles and supporting GSE, support resources and the operating plans and procedures. Table IX-III succinctly shows the item, control mechanism and the accounting. The activities are divided between JSC, DFRC, KSC, and Rockwell International, Space Division.

4. Configuration Accounting.

The accounting portion of the configuration management system provides visibility to every level of management and working organizations as to the status of the baseline, changes to the baseline and actual hardware configurations and software posture. In addition, almost all of the myriad groups in the Space Shuttle program require such data for safety analyses and assessment, reliability and quality assurance assessment, weights, status reporting, logistics, mission planning, etc.

Configuration accounting activities are divided into two areas: (a) baseline accounting and reporting, and (b) configuration verification and accounting. Item (b) will be discussed separately. Each NASA Center and their contractors utilize different systems to provide the required data. These systems were developed by each organization from their prior programs. Since the necessary data is provided there is no need for uniformity in the system. Because of the focus on ALT and Orbiter, this discussion will center on Level II at JSC and their support by Rockwell, and the Level III at JSC covering the Orbiter and the 747.

The current system at Program Level II and Orbiter Level III is called the "Baseline Accounting and Reporting System" (BARS). It uses the Rockwell International/Space Division computer system and software. The BARS system has the capability of recording, integrating, statusing, and reporting data for the NASA Levels I, II, and III baseline requirements. Rockwell, as the System Contractor, has personnel located at JSC, MSFC and KSC to perform the required duties. NASA and other element contractors submit on a regular basis to the System Contractor such information as:

a. Level II Change Requests

b. Level II Documentation Changes

c. Engineering Change Proposals (all projects, Level III)

d. NASA CCB and PRCB Directives

e. Level II Change Evaluations

f. Listings of ICD's and specifications, and updates

g. NASA Technical Directives (all projects)

h. Contract Change Authorizations (all projects)

i. Other Closeout Documentation (Level II, III and All Projects)

j. CCB Agenda and Minutes on All Projects

A good deal of this data from the NASA Centers is put into the system through a remote terminal setup at JSC, KSC and MSFC which links them to the Downey Computer Unit.

The output of this BARS setup can be formatted in any form required by management or the technical organizations. There are, of course, many specifically identified reports produced because they fit a continuing real need by user groups. For example, the baseline documents listing noted before, Level II Change Status Reports each week, PRCB Level II actions status reports each week, and so on.

5. Configuration Verification

Configuration verification is accomplished by Rockwell International Space Division in support of Level II and III program management. They use the data from the individual Prime Contractors as well as the Configuration Accounting System and manufacturing and quality control reporting systems. Thus they are able to provide:

a. Requirements verification used at all major reviews of the hardware and software.

b. Verification of the original baseline configuration and the changes to it.

c. Verification to ensure that the "as built" configuration is compatible with the "as designed" configuration and the "as tested" configuration and that any differences are understood.

In addition to this work, a system level hardware/software verification method is being developed to support the first OFT test, checkout and flight programs.

The PRCB action items are closed by furnishing the Level II PRCB secretary with the following types of documentation to show the PRCB direction has been implemented:

a. Configuration Control Board Directives

b. Contract Change Authorizations

c. Change Orders

d. Supplemental Agreements

e. Technical Directions

f. Directive-Type Memo's or Letters.

When all actions on PRCB directives have been closed, the Level II PRCB secretary will sign a "closeout" block on the directive.

6. Ground Support Equipment Configuration Management

The "station set" concept has been used in managing GSE. A "station set" is an integrated system of GSE units to accomplish a specific function or functions. Functional systems within a station set are identified as "sub-sets." The method of configuration management for these station sets is the same as described for other elements of the Shuttle hardware and software. There is no requirement for traceability on GSE but much of this could be obtained through the current accounting system.

7. Major Ground Test Articles

Test articles required to support such tests as the Ground Vibration Tests, Main Propulsion Tests, and Vibro Acoustic Tests are essentially covered by the same configuration management system described previously. This, of course, is necessary when dealing with items of flight hardware being used in the tests to assure that changes do not adversely effect the hardware.

8. Interface Documents and Their Control

All ICD's have been baselined. There are twenty-one Level II ICD's which cover the interfaces between the major elements of the Shuttle program, e.g., between Orbiter and External Tank, etc.

A list of these is shown in Table IX-IV. This does not include ICD's which interface the Payloads, or the memorandum of understanding that have been developed between such NASA Centers,as JSC/GSFC on communications and computers, and DFRC/JSC on the operation of the ALT program. Interface managers are assigned to each of nine interface areas. They direct the continuing activities, coordinate accomplishment of working group action items and manage preparation and maintenance of the individual ICD's. The top group that oversees all of this is the "System Integration Review" or SIR group at Level II.

9. Shuttle Software Configuration Management

Shuttle software is supplied to the Rockwell International/Space Division as GFE (Government Furnished Equipment). The types are:

a. Vehicle flight software

b. Vehicle ground test software

c. Laboratory software

d. Engineering design aids

e. Laboratory support software

For our purposes, the software follows the path noted below from inception to validation:

Specified By	Coded By	Verified By	Validated By
Rockwell	Rockwell	Rockwell	Shuttle Avionics Integration Laboratory, or SAIL in JSC
NASA	NASA	Vendors	
Vendors	Vendors	IBM-Houston	
IBM-Houston	IBM-Houston	G.E. Co.	
G.E. Co.	G.E. Co.	-	

Given its development cycle and end use software requires configuration management controls similar to the ones for hardware. In summary, the

Shuttle Software Operations Plan and functional directive are being released to provide project-wide common procedures for software similar to hardware procedures and current software is being controlled like hardware through the engineering and quality assurance review system. These items are being followed to completion by the Level II Space Shuttle Configuration Management Panel at JSC.

10. Responses from Program/Project Personnel to Specific Questions.

As a part of its examination of the Shuttle Configuration Management system the task team, during this the first review of this system, posed a series of questions which have been answered by JSC as follows:

Q. What is the situation of the GSE re configuration management?

A. All items of GSE are under strict configuration management after CDR baselining. Any changes other than "make work" must come through the Orbiter change system for approval prior to making the change. Major modifications come back through a CDR and Design Review Board for approval. Orbiter 101 ALT utilizes certain non-GSE items that are required for test and checkout but are below the level of GSE. These are standard tool crib tools, such as wrenches, scopes, etc. plus certain work stands and special test equipment used in manufacturing that have application in the ALT program. The use of these equipments are controlled by the test and checkout procedures which are approved by the NASA. Also, periodic calibration is performed on equipment which requires calibration, again the test and checkout procedure requires a current calibration on the equipment prior to use in the tests.

Q. The Master Verification Plan and Requirements Documents are many and detailed. When changes are made in the MVP and/or in hardware or software, what concrete methods assure compatibility between these documents, changes, and the test program? How close to flight configuration are the test items used for 1/4-scale testing as well as the MPTA and so on?

A. Shuttle development, as with past programs, is success oriented with regards to development, qualification and acceptance testing. This approach is necessary in order to meet development schedules as well as to prevent excessive costs associated with extension of hardware development schedules which would be required to allow full qualification prior to hardware delivery and installation or qualification. While problems will be encountered, such as the hydraulics problem, which will require rework/redesign, the overall effect of the concurrent development/production is considered cost and schedule effective.

The conditions noted regarding potential failures of hardware causing damage to flight and test hardware due to concurrent development/test of the hardware can and has happened; however, the development data used to confirm design concepts prior to hardware production generally prevent catastrophic failure of the hardware under test. In major tests, such as the MVGVT, MPTA and FRF, the element supplying the test article is required to establish capability of the hardware to survive test conditions at the hardware acceptance and test readiness reviews. While this cannot assure no failures, particularly where test conditions have not been adequately established, it is expected to greatly decrease risks of any major failures.

The master verification plans (Level II) are used as the basis for each sub-tier (element) verification plan. Deviations/variations to the Level II requirements are negotiated with the element project offices/contractors at the time of approval of the Level III plan. The Level III plans are Type I documentation, requiring NASA CCB/PRCB approval. Detail test requirements for element hardware are reviewed and approved under the umbrella of the Level III verification plan. If the Level II plan/requirements change, this change requires Level II PRCB approval with appropriate direction to the elements for their implementation. Deviation to Level II Master Verification Plans require Level II approval.

Q. GSE Preliminary Design and Critical Design Reviews are conducted on a fairly continuous basis. How does configuration management system keep up with these activities?

A. Approved changes from PDR's/CDR's are transmitted to the contractor(s). For major impact changes, the contractor prepares a Master Change Record (MCR) which is evaluated for ICD impact by a systems integration and ICD group. The MCR then goes to a contractor engineering change board at which time ICD impact is identified. If a change affects an ICD the contractor prepares a Preliminary Interface Revision Notice (PIRN) to change the ICD.

For minor impact changes, engineering orders (EO's) are prepared to change drawings. The EO's are evaluated for ICD impact by the System Integration and ICD Group. If the affected drawing is identified as one which impacts an ICD per a master matrix, then a PIRN is written.

PIRN's are technically coordinated and submitted into the appropriate Level II or Level III configuration change system.

Q. What is the program posture on application of controls to documents/hardware/software which must be adequate and timely?

A. While the ICD's themselves are Class I documents, during this phase of the Shuttle program the design drawings have not been baselined as Level II or III documents requiring Class I controls. Design changes reflecting ICD requirements are subject to RI/SD program manager's control utilizing the Master Change Record (MCR) system. During Orbiter/Shuttle formal design review, the design is jointly validated to contract requirements, including ICD's, by NASA and RI/SD.

Q. To what degree are test conductors being confronted by "red-lined" drawings?

A. Test conductors functionto procedures (i.e., test and checkout procedures, TCP's) rather than drawings. Test variances, TVAR's, are the primary means of documenting changes after TCP release. Redlining of TCP's during test are incorporated and authorized by TVAR which reflect the required NASA approvals. Minimal redlining of drawings for manufacture/assembly are authorized. Such redlined drawings are impounded by Quality Assurance and verified to subsequently released updated drawings.

Q. For those areas under Class I control, are you running into the age-old problem of making the paper look like the hardware?

A. Make-work design changes during manufacture/assembly/test are strictly controlled by the RI/SD nonconformance system as documented by Standard Operating Procedure Series J-04. In practice, the system requires the implementing paperwork to remain open until the design change (i.e., EO) is released and verified.

Q. What is the situation with GSE controls versus past practices?

A. On the Shuttle program the pendulum was swung to the extreme in the other direction and even items that are normally classified as "factory equipment" are identified and controlled as GSE. All non-GSE items, especially GFE, are identified and controlled at the GSE station set level.

Q. Are there any EO problems and drawing revisions?

A. The only drawings with more than 10 EO's outstanding are structure drawings which are primarily multi-sheet drawings. Engineering Release Operations continuously monitors this requirement and keeps the responsible senior project engineers informed of such items.

Q. Summarize what the Shuttle Configuration Management system provides.

A. The Space Shuttle system:

1. Provides a systematic approach to the definition of the program management, technical and cost baselines.

2. Provides the Space Shuttle Program Manager with the required visibility (in concert with all program/project management representatives) to make decisions that change the program baselines.

3. Insures that all affected program/project elements have reviewed and evaluated the proposed changes to the program baseline.

4. Identifies to program manager the cost, schedule, weight, etc., impacts of such changes.

5. Precludes unauthorized change to the program baseline.

6. Provides visibility of the changing baseline.

7. Provides the mechanism to insure proper communication and implementation of baseline change decisions.

8. Provides a structured approach to program direction.

9. Provides the mechanism for positive verification of the implementation of the program baseline and changes to it.

C. Information Update

A memorandum of agreement is in process to cover the Range Safety System hardware and control documentation, to provide a basis for the orderly processing of changes and the maintenance of configuration control over the commonality hardware delivery dates, allowable temperatures for the system, qualification test requirements and so on. This is being done at MSFC to cover the external tank and the solid rocket booster projects that are under their management.

There is a current effort to assure management that all of the interface areas are being covered by the proper technical and management personnel. As an example the following interfaces which affect the Orbiter are being examined to assure their proper resolution:

1. T-0 umbilical disconnect bending loads
2. Orbiter roll control during vertical mate
3. SRB ignition overpressure measurements
4. OMS pod and payload bay door graphite epoxy water absorption
5. All of the Payload to Orbiter to Ground interfaces
6. Orbiter/ET ice accretion in the umbilical door cavity

TABLE IX-I

The NASA Space Shuttle Baselines

Level I	a.	Program definition
	b.	Program characteristics
	c.	Program interface requirements
	d.	Program verification requirements
Level II	a.	Level I requirements
	b.	System responsibility allocations
	c.	System schedules
	d.	System budget and cost allocations
	e.	Management System requirements
	f.	Information requirements
	g.	System design and performance requirements
	h.	System interface requirements, excluding interfaces to be controlled by a single project office.
	i.	System verification (acceptance, certification) requirements
	j.	Commonality requirements
	k.	Standard design and construction requirements applicable to the total system
	l.	Other applicable allocated requirements
	m.	Training requirements
Level III	a.	Level I and II requirements
	b.	Design and performance requirements
	c.	Interface requirements
	d.	Verification requirements
	e.	Design and construction standards and specifications
	f.	Training requirements
	g.	Design concepts, approaches, and solutions at the appropriate time
	h.	Product configuration descriptions at the appropriate time.

NOTES:

1. Level I documents include Program Directive #1C, the Program Approval Document (PAD), and other applicable Headquarters input.
2. Level II baseline is best described in the Volumes I through XVIII of JSC 07700, "Space Shuttle Level II Program Definition and Requirements."
3. Level III baseline contains specific requirements applicable to a particular project or element of the total system, e.g., Solid Rocket Booster, Orbiter, External Tank, Space Shuttle Main Engine, Launch Support System.

TABLE IX-II

ICD TABLE OF CONTENTS, ICD-2-17001

TABLE IX-III

APPROACH AND LANDING TEST CONFIGURATION CONTROL

Controlled Item	Control Mechanism	Configuration Accounting
Orbiter 101 and Rockwell provided ground support equipment	Orbiter manager's CCB meeting at JSC or DFRC, and when necessary delegating such authority to a CCB meeting at DFRC. Expedited changes to be dealt with by ALT Office Representative at DFRC. All changes must pass CCB. The GSE will be handled by Senior KSC person resident at DFRC.	Rockwell/NASA ALT Orbiter team using RI/SD computer system.
Shuttle Carrier Aircraft, aircraft modifications and modification-related special GSE	Shuttle Carrier Aircraft CCB. a. pre-ALT changes through SCA project manager's CCB b. APD No. 1300, Rev.1 defines the specific functions during ALT.	Rockwell/NASA ALT Orbiter team using Manual system.
Shuttle Carrier Aircraft, basic aircraft and standard GSE	JSC Aircraft Operations Division	DFRC Maintenance Division, manual system. American Airlines as far as possible.
Mate/demate Device (MDD), Hanger and mission oriented equipment. Also secondary landing site facilities.	KSC Level III and IV CCB's	KSC accounting system
Mission Control Center-JSC, network and data processing facilities	The Data Systems Analysis Directorate at JSC will control through its own CCB.	Data Systems Analysis Directorate in combination with its own system
DFRC Control Room and supporting data rooms. Particularly to test the inert Orbiter/747	DFRC Line management.	DFRC own system Deliver data base to JSC's "Active Orbiter Team"

TABLE IX-III Continued

Controlled Item	Control Mechanism	Configuration Accounting
Special Equipment, e.g., KSC provided ground support equipment, the MSBLS, crew procedures, etc. are handled by the organization directly involved in providing such items. Turn-around support for the Orbiter and Shuttle Carrier Aircraft is under the control of the ALT Test Support Coordination Group.		
Documentation such as:		
a. Mission Objectives and Flight Test Requirements	ALT Project Manager's CCB. The costs involved come from Orbiter. This will probably be the same for OFT.	Active Orbiter and 747 Flight Test Teams will do this.
b. Test Specification Requirements Document used for flight test vehicle test and checkout	Orbiter CCB has approval authority on this items.	JSC Program Operations Office
c. Mission Plans and Operational documentation (mission rules, etc.)	ALT Organization and line management review and approval (Flight Operations Division at JSC)	Active Orbiter and SCA Test Teams
d. Flight crew plans (subordinate to items in (c) above.	Crew Procedures Change Board and Line Management review and approval	Flight Operations Directorate, crew and Procedures division
e. Turnaround plans, operations, (management plans and agreements) Checkout procedures, Test and Checkout Procedures, Test Methods)	ALT Organization CCB	ALT Orbiter Ground Team

TABLE IX-IV

SPACE SHUTTLE LEVEL II
INTERFACE CONTROL DOCUMENTS

ICD No.	SUBJECT
2-CD001	Main Propulsion Test Article, Physical
2-CD002	Main Propulsion Test Article, Electrical
2-CD003	Main Propulsion Test Article, Fluid
2-CD004	Ground Vibration Test, Facility
2-0A001	Space Shuttle/VAB at KSC
2-0A002	Space Shuttle/Pad at KSC
2-1A001	Orbiter/Landing Station
2-1A002	Orbiter/Processing Station
2-1A003	Orbiter/Hypergol Station
2-1D003	Orbiter/Secondary Landing Station
2-1D004	Orbiter-Mate-Demate
2-2A001	External Tank/Receive and Checkout
2-2A003	Flight Vehicle/Launch Processing System Complex
2-4A001	Solid Rocket Booster/Receiving and Checkout
2-4A002	Solid Rocket Booster/Retrieval
13M15000	Orbiter/Space Shuttle Main Engine
2-12001	Orbiter/External Tank
2-14001	Orbiter/Solid Rocket Booster
2-24001	External Tank/Solid Rocket Booster
2-17001	Orbiter/Carrier Aircraft
2-00001	Moldlines

SPACE SHUTTLE PROGRAM

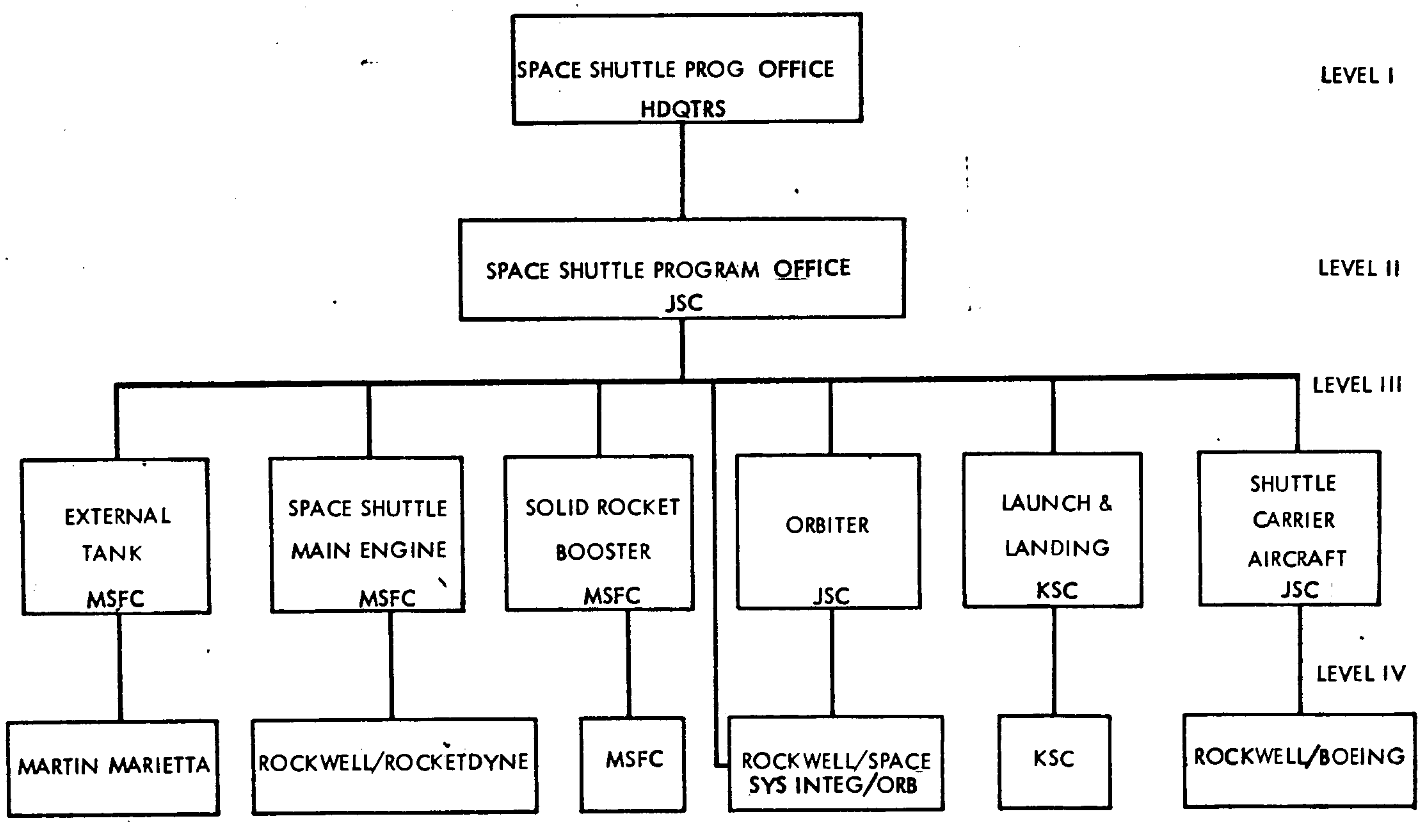


FIGURE IX-1

PRCB/CLRB/CCB STRUCTURE

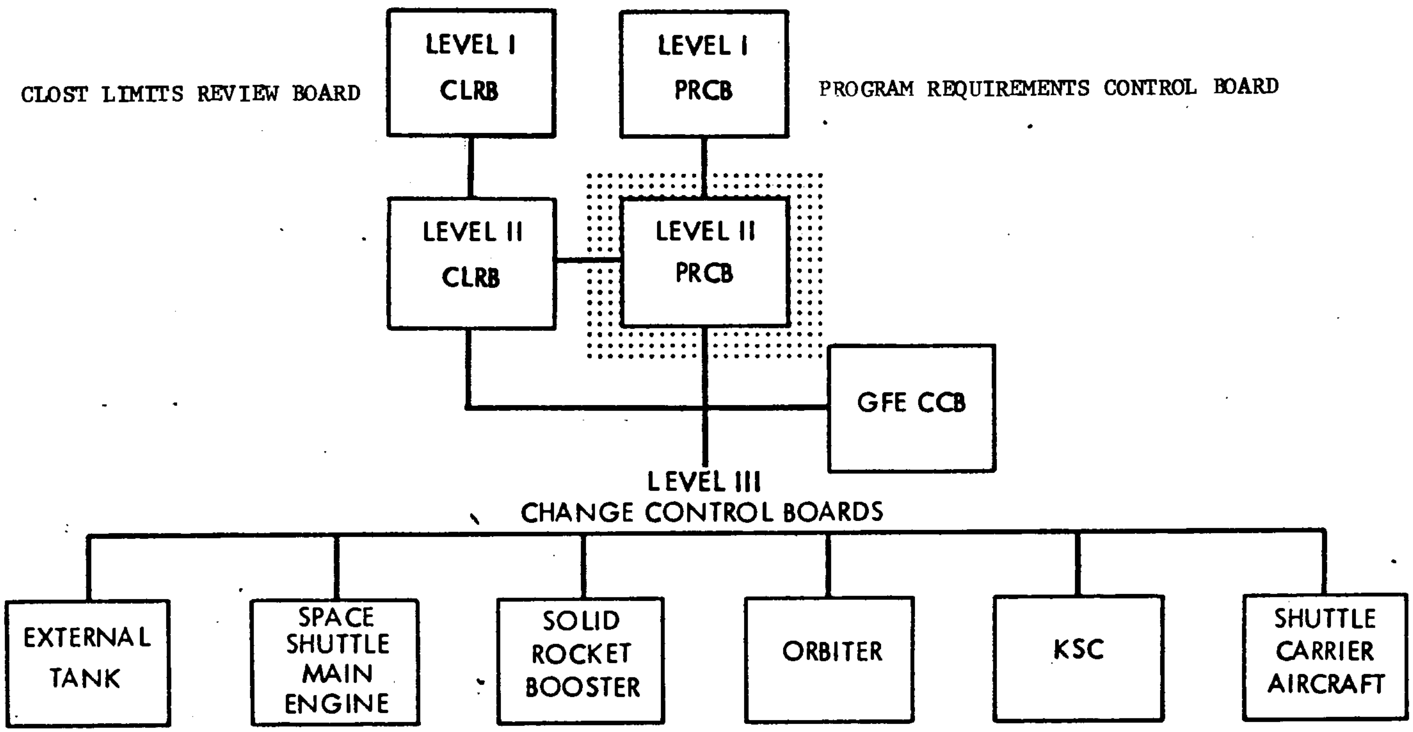


FIGURE IX-2