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Space Administration

Lyndon B. Johnson Space Center
Houston, Texas 77058

NSTS 07700-10-MVP-01
BOOK 3

SPACE SHUTTLE

SHUTTLE MASTER VERIFICATION PLAN

VOLUME I
GENERAL APPROACH AND GUIDELINES

BOOK 3
REQUIREMENTS EFFECTIVE FOR SSP CLOSEOUT

SEPTEMBER 28, 2011

REVISION LOG

REV LTR	CHANGE NO	DESCRIPTION	DATE
		BASELINE ISSUE (Reference: Space Shuttle PRCBD S100107Y, dated 8/25/11). *NOTE: Effective 9/12/11, the Change Management Support Tool (CMST) Application became active. DIR000019, dated 9/11/11, was issued to transfer an open action (1-1) from PRCBD S100107Y into CMST.*	09/28/11

PROGRAM DEFINITION AND REQUIREMENTS
SHUTTLE MASTER VERIFICATION PLAN
VOLUME I - General Approach and Guidelines
Book 3 - Requirements Effective for SSP Closeout

LIST OF EFFECTIVE PAGES

September 28, 2011

The current status of all pages in this document is as shown below:

Page No.	Change No.	PRCBD No.	Date
(i) - (iv)	Baseline	S100107Y	August 25, 2011
(1) - (4)	Baseline	S100107Y	August 25, 2011
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4-1 - 4-22	Baseline	S100107Y	August 25, 2011
A-1 - A-4	Baseline	S100107Y	August 25, 2011
B-1 - B-6	Baseline	S100107Y	August 25, 2011

DEVIATIONS/WAIVERS AUTHORIZED FOR REQUIREMENTS CONTAINED IN THIS DOCUMENT

This section contains only currently approved Deviations/Waivers to the requirements of NSTS 07700-10-MVP-01, as applicable to SSP Closeout.

NOTICE

Specific Deviation/Waivers contained within this document have been duplicated in NSTS 07700-10-MVP-01 - Book 1 due to overlapping effectivities resulting from Validation, Verification and Certification (VV&C) definition changes authorized by PRCBD S062235, dated 04/15/04.

All Deviations/Waivers which were impacted by VV&C definition change will be identifed within the corresponding “Requirement” with an italicized note.

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INDEX OF DEVIATIONS/WAIVERS AUTHORIZED FOR REQUIREMENTS CONTAINED IN THIS DOCUMENT

Number	Title	Para. No.	Page
1.	Acceptance Test (Reference Level II PRCBD S02130G, dated 2/14/89)	3.6.13 l.3.(c)(2), 3.7.1j	(1)

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DEVIATIONS/WAIVERS AUTHORIZED FOR REQUIREMENTS CONTAINED IN THIS DOCUMENT

1. REQUIREMENT: Paragraph 3.6.13 l.3.(c)(2) specifies as follows:

Due to overlapping effectivities, this Deviation/Waiver is duplicated in NSTS 07700-10-MVP-01 - Book 1. (PRCBD S062235, dated 05/14/04).

Acceptance Test - The requirements and tolerances on acceleration spectral density shall be defined in Johnson Space Center document SP-T-0023.

Paragraph 3.7.1j specifies as follows:

Environmental acceptance testing will be performed on selected hardware to screen out manufacturing defects, workmanship errors, and incipient failures not readily detectable by normal inspection techniques or through functional test. These tests will be in accordance with SP-T-0023.

DEVIATIONS: The above requirements shall be implemented on the Orbiter project as modified by the changes to specific paragraphs in SP-T-0023B as follows:

A. SPECIFIED REQUIREMENT: Paragraph 3.4.1.1b, Maximum Acceptance Vibration Test Levels, specifies that components which have an expected mission level greater than the minimum level, as defined by Figure 1, shall be tested to the greater of the two following levels:

1. Minimum acceptance acceleration spectral density levels defined by Figure 1.
2. Acceptance acceleration spectral density levels equal to 1/1.69 times the qualification test levels.

DEVIATION: For STS-28 and subs, all hardware for which acceptance vibration is required is tested to the minimum acceptance spectral density levels defined in Figure 1. This deviation also allows the acceptance accelerations spectral density levels to be equal to 2.2 dB (1/1.69 times the qualification test levels) below the qualification level.

This deviation is to be implemented on the Orbiter project based on the following guidelines:

a. Existing Equipment Designs: The test times and levels may be reduced appropriately to preclude requalification.

b. New Equipment Designs: Acceptance testing will be considered in accordance with the revised requirements for future hardware not presently under contract.

c. Existing Inventory Hardware: Reacceptance test to the revised requirements on a noninterference basis but shall be consistent with guideline A above.

d. Follow-On Hardware: Acceptance testing will be accomplished in accordance with the revised requirements, but shall be consistent with guideline A above.

B. SPECIFIED REQUIREMENT: Paragraph 4.5.2 Thermal Test, specifies that the minimum qualification testing required to verify the ability of the hardware to withstand the acceptance thermal test levels is defined to be 20° F above and 20° F below the temperature range of the acceptance test.

DEVIATION: For STS-28 and subs, the minimum qualification testing required to verify the ability of the hardware to withstand the acceptance thermal test levels is defined to be 5° F above and 5° F below the temperature range of the acceptance test.

This deviation is to be implemented on the Orbiter project based on the following guidelines:

a. Existing Equipment Designs: The test times and levels may be reduced appropriately to preclude requalification.

b. New Equipment Designs: Acceptance testing will be considered in accordance with the revised requirements for future hardware not presently under contract.

c. Existing Inventory Hardware: Reacceptance test to the revised requirements on a noninterference basis but shall be consistent with guideline A above.

d. Follow-On Hardware: Acceptance testing will be accomplished in accordance with the revised requirements, but shall be consistent with guideline A above.

AUTHORITY: Level II PRCBD S02130G, dated 2/14/89.

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SPACE SHUTTLE

SHUTTLE MASTER VERIFICATION PLAN

VOLUME I
GENERAL APPROACH AND GUIDELINES

BOOK 3
REQUIREMENTS EFFECTIVE FOR SSP CLOSEOUT

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FOREWORD

Efficient management of the Space Shuttle Program (SSP) closeout activities dictates that effective control of program activities be established. Requirements, directives, procedures, and system capabilities shall be documented, baselined, and subsequently controlled by SSP management.

Program Configuration Management (CM) requirements, procedures, etc., controlled by the Manager, Space Shuttle Program, are documented in this appendix. Requirements to be controlled by the NASA support element/project managers are to be identified, documented, and controlled by the element/project.

All elements of the SSP must adhere to these baselined requirements. When it is considered necessary by the Space Shuttle program element/project managers to change, waive or deviate from these requirements, an SSP Change Request (CR) shall be submitted to the Program Requirements Control Board (PRCB) Secretary. The CR must include a complete description of the change, waiver or deviation and the rationale to justify its consideration. All such requests will be processed in accordance with NSTS 07700, Volume XX - Book 2, Appendix 04 and dispositioned by the Manager, Space Shuttle Program, on a Space Shuttle PRCB Directive (PRCBD).

Dennis R. Davidson

Dorothy S. Rasco
Manager, Space Shuttle Program

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1.0 INTRODUCTION

1.1 PURPOSE

The Shuttle Master Verification Plan (SMVP) establishes and provides program visibility and control of the approach, requirements and plans for Verification, Validation and Certification (VV&C) of the Shuttle System for operational use. Approved documentation of the verification/validation constitutes certification.

1.2 SCOPE

The plan is applicable to all elements supporting SSP closeout and is the primary requirements identification and planning document for the Shuttle System VV&C program. It addresses both design and hardware verification and validation. Specific design verification/validation requirements related to the system and element Contract End Item (CEI) specifications are included.

Because a large percentage of the validation activity has been assigned to test and because of the relative cost of testing, a major portion of this plan involves identification of that effort. Analysis is covered in sufficient detail to reflect the scope of those activities and their relationship to the total VV&C activity.

1.3 MASTER VERIFICATION PLAN (MVP) ORGANIZATION

The plan is structured into the following volumes:

Volume I - General Approach and Guidelines. Introduces the overall plan, describes the approach to Shuttle System verification, and provides the VV&C program guidelines required to be applied throughout the Shuttle System. It also identifies the assigned program responsibilities, the documentation requirements, and the control of program requirements. A summary of the test program is included as Appendix A and a list of definitions are provided as Appendix B.

Volumes III and VI - Element Verification Plans. Contain element/project-level requirements and planning information. They are prepared by each element contractor supporting SSP closeout and consist of development and qualification tests and analysis required to provide element verification and validation of program requirements.

Volume III - JSC 07700-10-MVP-03, Orbiter Verification Plan, Volume III (MJ072-0004-3)

Volume VI - JSC 07700-10-MVP-06, Main Engine Verification Plan, Volume VI (RSS-8782)

Volume VIII - JSC 07700-10-MVP-08, KSC, Launch and Landing Site Return to Flight Reverification Plan, Volume VIII (KSC-STSM-09 Volume IV - Suppl.) Establishes the requirements and plans for verification/validation of the KSC Launch and Landing (L&L) site as a major program element. It treats those verification/validation activities which must be accomplished to assure readiness of the Ground System to support the flight elements.

1.4 VV&C PROGRAM RELATIONSHIPS

Figure 1-4-1A shows the interrelationship to VV&C for the program hierarchy multiple levels where VV&C activity can occur. The core definitions are common across these levels as found in Appendix B. For legacy VV&C basis, Figure 1-4-1B shows the inter-relationship of verification and certification to achieve readiness for operations. Legacy VV&C basis is used in heritage cases where traceability from the original certification bases to a current end item is held. The legacy program verification requirements are contained in NSTS 07700-10-MVP-01 - Books 1 and 2.

FIGURE 1-4-1A

MULTI-LEVEL VERIFICATION, VALIDATION, AND CERTIFICATION

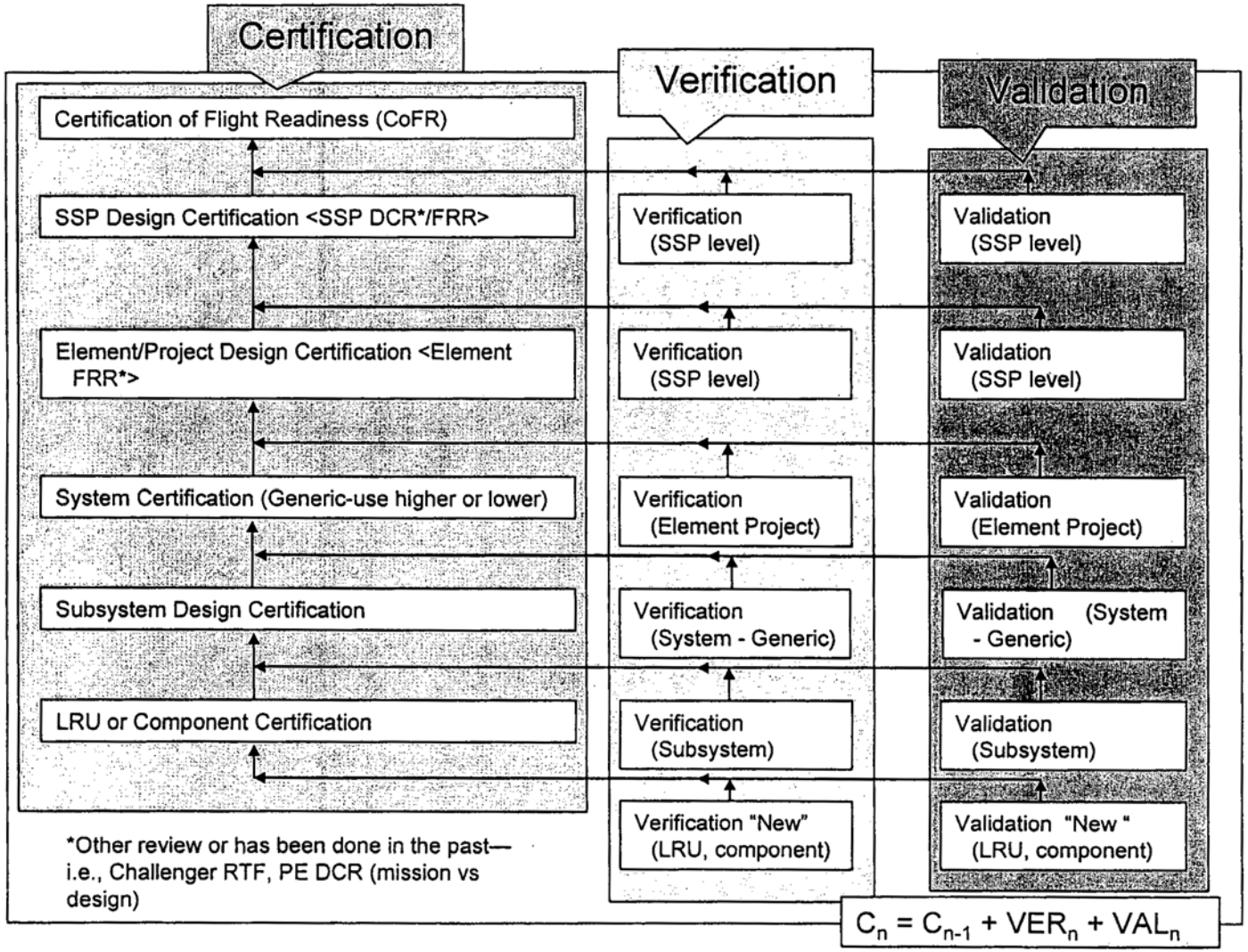
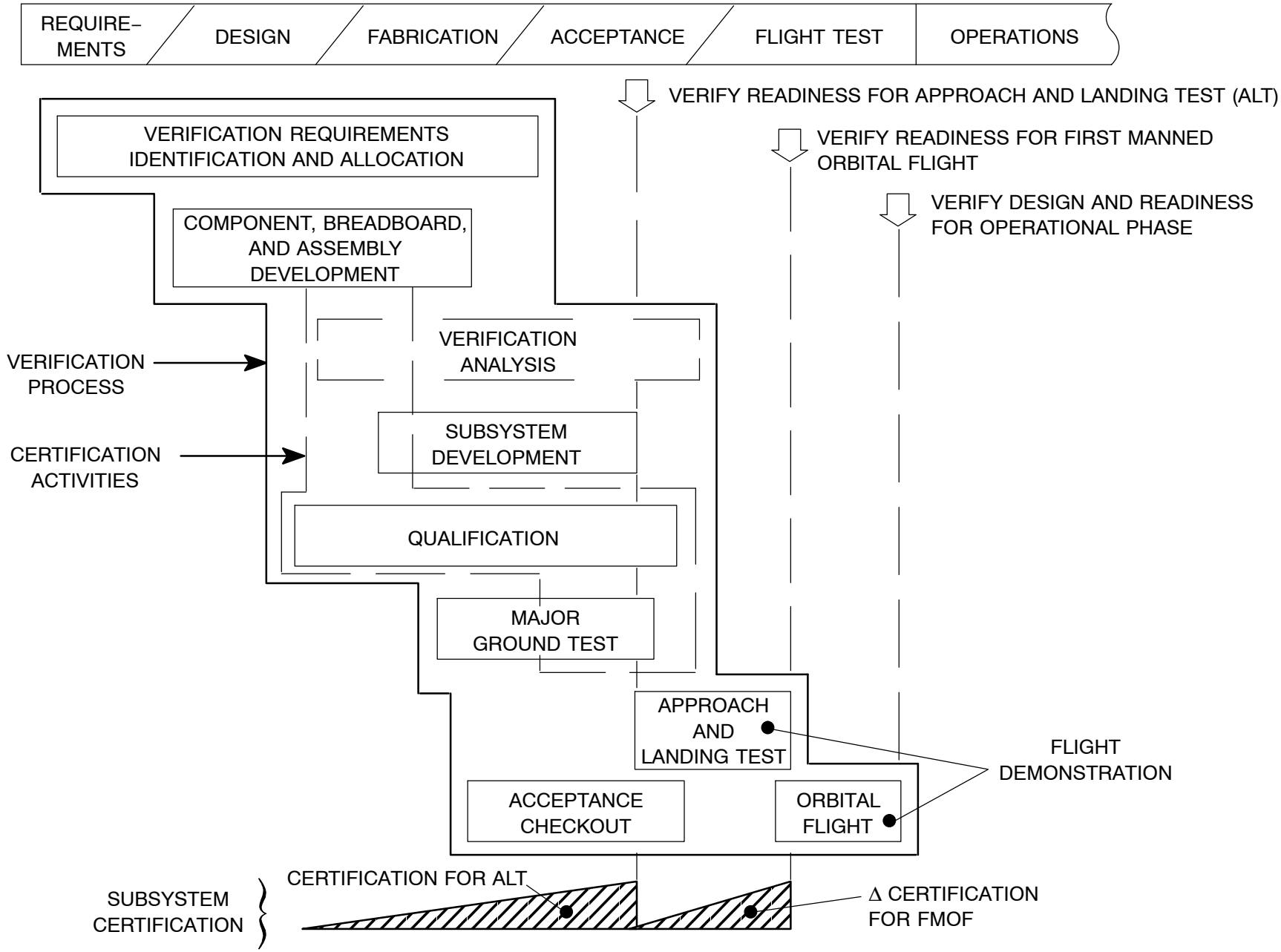


FIGURE 1-4-1B

VERIFICATION PROGRAM RELATIONSHIPS



2.0 APPLICABLE DOCUMENTS

The following documents of the date and issue shown form a part of this document to the extent specified herein. "(Current Issue)" is shown in place of a specific date and issue when the document is under Space Shuttle PRCB control. The current status of documents shown with "(Current Issue)" may be determined from NSTS 08102, Program Document Description and Status Report.

NSTS 07700-10-MVP-01 - Book 1 (Current Issue)	Shuttle Master Verification Plan - Volume I, General Approach and Guidelines Book 1, Requirements Prior to April 15, 2004 Ref. Para. 1.4, Apx. A
NSTS 07700-10-MVP-01 - Book 2 (Current Issue)	Shuttle Master Verification Plan - Volume I, General Approach and Guidelines Book 2, Requirements Effective April 15, 2004 and Subsequent Ref. Para. 1.4, 4.2, Apx. A
JSC 07700-10-MVP-03	Orbiter Verification Plan, Volume III (MJ072-0004-3) Ref. Para. 1.3, 4.2
JSC 07700-10-MVP-06	Main Engine Verification Plan, Volume VI (RSS-8782) Ref. Para. 1.3, 4.2
JSC 07700-10-MVP-08	KSC Launch and Landing Site Return to Flight Reverification Plan, Volume VIII (KSC-STSM-09 Volume IV - Suppl.) Ref. Para. 1.3, 2.7, 4.2

NSTS 07700 Volume XX - Book 2, Appendix 04 (Current Issue)	Space Shuttle Closeout Requirements, Configuration Management Closeout Requirements Ref. Foreword, Para. 4.3.1
NSTS 07700 Volume XX - Book 2, Appendix 05 (Baseline Pending)	Space Shuttle Closeout Requirements, Information Management Closeout Requirements Ref. Para. 4.3.1
NSTS 07700, Volume XX - Book 2, Appendix 10 (Current Issue)	Space Shuttle Closeout Requirements, Flight and Ground System Specification Closeout Requirements Ref. Para. 2.2, 2.7, 2.9, 3.3, 3.6.13, 3.7.1, 3.9.3, 4.1, 4.2
NSTS 5300.4(1D-2) (Current Issue)	Safety, Reliability, Maintainability and Quality Provisions for the Space Shuttle Program Ref. Para. 3.7
NSTS 08171	Operations and Maintenance Requirements and Specifications Document (OMRSD) Ref. Para. 3.7.3
NSTS 22206 (Current Issue)	Requirements for Preparation and Approval of Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) Ref. Para. 3.7.3
FED-STD-101B January 15, 1969	Preservation Packaging and Packing Materials, Test Procedures Ref. Para. 3.6.13

MIL-STD-810B September 23, 1973	Material Standards for Environmental Test Methods Ref. Para. 3.6.13
SE-G-0020B October 20, 1993	Leakage Measurement of Helium and Nitrogen Test Gases Ref. Para. 3.2
SP-T-0023 (Current Issue)	Specification Environmental Acceptance Testing Ref. Para. 3.6.13, 3.7.1

2.1 INTEGRATED VV&C PROGRAM

2.2 VV&C PROGRAM SUMMARY

Verification/Validation is the activity necessary to support certification. Certification is the approved documentation of the completed verification/validation work. This document describes the verification/validation process and implementation planning for a program that determines that Shuttle systems meet all design, performance, and safety requirements. The process includes all development, qualification and acceptance testing, flight demonstration, appropriate preflight checkout, post-flight activities, and analyses/modeling necessary to support verification and validation that leads to certification. The primary objectives to be accomplished by the verification/validation process include:

a. Support to development of design

b. Verification that the design of components, assemblies, and subsystems meet performance requirements

c. Verification that the performance of combined subsystems, elements, and combined elements meets established requirements

d. Demonstration/Validation of the acceptability and readiness for intended use of deliverable hardware and software

Emphasis is to be placed on program/process planning to assure the most effective utilization of program resources, including schedule.

The accomplishment of these objectives is predicated upon the identification of verification/validation requirements derived from the performance and design requirements documented in NSTS 07700, Volume XX - Book 2, Appendix 10, Space Shuttle Closeout Requirements, Flight and Ground System Specification Closeout Requirements, and the element CEI specifications. The overall verification/validation program is keyed to these specifications in such a way that verification/validation activities are traceable to them on a paragraph-by-paragraph basis. Thus, each MVP is required to correlate the respective activities with NSTS 07700, Volume XX - Book 2, Appendix 10. The relationship of these requirements is established in NSTS 07700, Volume XX - Book 2, Appendix 10, Paragraph 4.0 of the specifications in matrices which relate the performance and design requirements to particular volumes of this plan. Tables in the requirements sections of each volume identify the verification/validation requirements, reference the source paragraph in the appropriate specification and identify the method of verification/validation.

The methods to be used include analysis, test or combinations of these. Each element contractor will determine requirements and document the verification/validation method

appropriate to each performance/design requirement from the element level through the component level. This determination will be made for both hardware and software. The degree to which a method or combination of methods can be used will be influenced by the requirement as it relates to the type of validation program (development, qualification, flight demonstration, and acceptance and checkout) and its objectives (schedule/milestones, major tests/events, etc.). Where test or flight activity is constrained by verification/validation, each element must identify such activities and provide sufficient management control to ensure verification/validation is completed or waived at the highest program level approving the requirement prior to test start or flight. In addition, the method selection must consider such factors as the available knowledge of the performance/design requirement based upon design analysis, design maturity, complexity of test articles, associated program cost, and risk. Element requirements will be documented in the appropriate volumes of this plan. The word "element" as used herein is applicable to each flight element and L&L site. Listed in Paragraph 3.4 are specific guidelines to be followed by all element contractors in allocating requirements to the appropriate implementation method.

The sections that follow describe the various VV&C program phases. Included are general guidelines and definitions to be used by all element contractors to assure that a consistent verification/validation approach is used throughout the program at all hardware levels. A summary of the verification/validation process is presented as Figure 2-1-1. The process starts with the translation of design and performance requirements into verification/validation requirements, and the allocation of these requirements to the appropriate method of resolution; test, analysis or a combination of these. With this determination, the objectives and conditions for analysis and/or testing are established, forming the basis for preparation of analysis plans and models or test plans and procedures. The results of the analysis and test activities are evaluated against the established requirements. Satisfactory confirmation of each requirement through verification and validation provides the necessary information to support certification.

2.3 DEVELOPMENT

Where analysis does not provide reasonable assurance that a candidate design or procedure is adequate, a development testing program will be implemented. Development is primarily concerned with those design evaluation and data gathering activities, conducted with minimum rigors and controls, that support the total design process and provide the engineering data base necessary to establish confidence that the hardware and software will meet specification requirements and that the manufacturing process will produce an acceptable product.

The data acquired will also be used to establish processes, procedures, and test levels to support subsequent hardware, design, production, verification, maintenance, and checkout. Development testing will include:

a. Standard laboratory testing to support material selection

b. Component, breadboard, and subsystem testing to identify the failure modes and the effects of environments and combination of design tolerances on performance

c. Major ground tests which acquire data from integrated subsystems or system levels to identify operational characteristics and develop operational procedures

2.4 CERTIFICATION

Certification shall be based on review of formal documentation that shows completion of applicable verification and validation requirements. Additional certification requirements may be imposed by the authority granting certification and shall be formally documented. At a minimum, certification consists of verification/validation efforts that include qualification tests, major ground tests, and other tests and/or analysis required to determine that the design of hardware from component through any particular system level as depicted in Figure 1-4-1A, meets requirements in the appropriate environment. Certification of element subsystems is performed incrementally as required to support the readiness of the individual Shuttle elements and Shuttle system for pre-established major program events.

Certification is based on verifying and validating all performance and design requirements that are invoked on each component and subsystem. Life, environment, and performance requirements will be accounted for.

The end product of certification is the establishment of a certified hardware list or end item formal document. Each element contractor is required to maintain a list of hardware that has been certified for intended use. The certification authority at the project/element level as shown in Figure 1-4-1A is the Space Shuttle Program (SSP) Project Managers. These lists will provide the basis for declaring the design as certified for each major event. Requirements for recertification are detailed in Paragraph 3.3.

2.5 ELEMENT/SYSTEM VERIFICATION AND VALIDATION

Verification/Validation is performed above the subsystem level to verify/validate the performance of combined subsystems, elements, and combined elements. A building block concept will be is used to accomplish this task. For each major program event, system readiness for that event will be based upon individual element readiness plus verification of all combined element performance requirements leading to certification. In turn, the readiness of each element will be dependent upon subsystem certification plus validation of all integrated and combined subsystem performance requirements. The major events of the legacy program included first firing of the main propulsion test

article, first approach and landing flight, first orbital flight, the STS-26 “Return to Flight (RTF)” Space Shuttle Design Certification Review (DCR), and the STS-114 RTF Space Shuttle DCR.

Analysis and testing are the primary methods used to verify and validate element and system performance. Major ground tests will validate the performance of integrated subsystems and combined elements. Flight demonstrations are the final step in validating the readiness of the system for operational use. Flight demonstrations may also be used to supplement ground testing by providing operating conditions that cannot be fully duplicated or simulated on the ground.

Element/System VV&C status will be maintained and reported for each flight until all applicable requirements are either verified, revised, waived, or have their applicability changed. Requirements for redoing VV&C are detailed in Paragraph 3.3.

2.6 ACCEPTANCE AND CHECKOUT TESTING

Flight hardware acceptance and checkout is accomplished through the use of a common set of ground rules or criteria. Acceptance testing, which verifies readiness of hardware for delivery to the customer, covers all hardware levels from supplier parts through vehicle end item acceptance and is normally accomplished at the site where the item is manufactured. Checkout testing generally covers all post-delivery test activities that verify the readiness of hardware for the intended use and culminates with the prelaunch activities at the operational site.

2.7 GROUND SYSTEM VERIFICATION/VALIDATION

The overall objectives of the ground support system verification program is to provide assurance that the ground system has been designed and manufactured in a manner that will support the development, acceptance test, and operational activities of the SSP.

In addition to acceptance testing, each element project office and L&L site shall identify and approve the test and/or analysis required for verification/validation in support of certification of Ground Support Equipment (GSE) and ground systems. Validation will be based on expected environmental conditions and operational constraints. Ground systems and/or components which are identified as critical (as defined in NSTS 07700, Volume XX - Book 2, Appendix 10) and/or have Safety Critical functions or characteristics shall be certified.

Verification/Validation of the L&L site ground system is described in NSTS 07700-10-MVP-08, Shuttle Master Verification Plan, Volume VIII (KSC Launch and Landing Site Return to Flight Reverification Plan, [KSC-STSM-09 Volume 4 - Suppl.]). L&L

site VV&C status shall be maintained and reported for each flight until all applicable requirements are either verified, revised, waived, or have their applicability changed.

2.8 GROUND TEST HARDWARE ASSESSMENT

In addition to components and element/system verification/validation/certification (Paragraphs 2.4 and 2.5), major test articles and GSE which will be exposed to performance or environmental requirements during tests which exceed operational requirements will require verification of capability to accomplish test objectives in the expected test environments prior to start of test. Verification of capability will be limited to those environments and test parameters which exceed operational requirements and results of the assessments will be made available at the test article acceptance review or prior to delivery of the test article from the suppliers facility, whichever is earlier. Verification updates will be provided at the test readiness review.

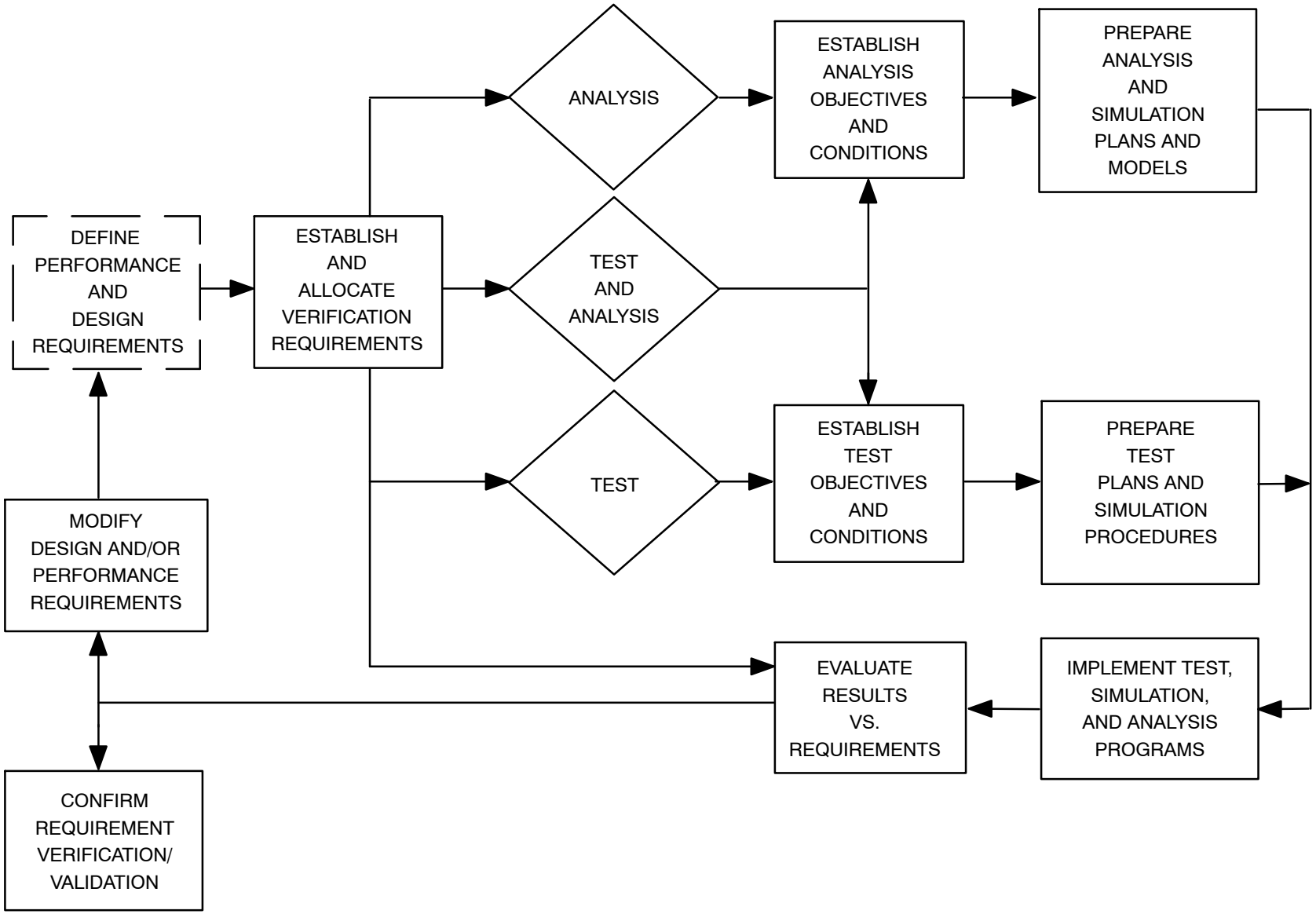
2.9 CLOSEOUT VERIFICATION

The verification process and activities identified in this document are essential for the support of SSP closeout activities. Verification for initial flights was sanctioned by a program DCR and a series of individual Flight Readiness Reviews (FRRs).

Verifications in support of closeout activities shall be performed to demonstrate compliance of the Shuttle System and its individual elements with program design, safety, and performance requirements in NSTS 07700, Volume XX - Book 2, Appendix 10 and associated Project/Program Requirement Documents. Verification and validation of applicable requirements shall be performed on all new or modified element systems/subsystems hardware and software, combined element products, process changes, and operational changes associated with SSP closeout. The demonstrated certification shall include a comparison of verification documentation with current hardware and software design requirements and related processes and operations. Re-test, demonstration, inspection, or new analyses shall be required for any identified deficiencies in modified hardware and/or software compliance with the requirements. The guidelines for redoing VV&C are presented in Paragraph 3.3.

FIGURE 2-1-1

VERIFICATION/VALIDATION PROCESS FLOW



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3.0 VERIFICATION GUIDELINES

3.1 OBJECTIVES

This section provides guidelines for developing the element verification/validation plans. Alternate approaches may be proposed if there is a potential for reducing program cost without compromising safety and probability of mission success. These guidelines apply to verification/validation activities associated with closeout of the SSP.

3.2 GENERAL GUIDELINES

a. The objective of the verification/validation program is to demonstrate and document that the flight system and ground system satisfy specification requirements.

b. Component, subsystem, and system testing are to be planned as an integrated program (i.e., test plans for an individual element will be tailored to that element's operational requirements, considering all testing to be performed from development through orbital flight).

c. The test program will allow maximum use of all test data in satisfying verification/validation requirements and will achieve the basic objective of acquiring adequate confidence at minimum cost.

d. Maximum use of all test data will be made for development and standardization of formal checkout procedures, establishment of performance trends, supporting maintenance planning, and resolution of anomalies.

e. Early development testing must be flexible to accommodate the exploratory approach to hardware configuration, checkout, and operational procedures. As final design progresses, and when it is decided to utilize development testing to prove acceptance approaches and to certify hardware, testing will require more rigorous planning, control, surveillance, data, and documentation.

f. Pass-fail criteria or acceptance tolerance bands based on design requirements will be specified for all tests. Acceptance tolerance bands at the manufacturer's component or subsystem level will be based on allowable operational tolerance bands. These operational tolerance bands will be progressively reduced at the upstream acceptance points to allow for tolerance buildup.

g. The tolerance band for a given specification value will include instrumentation accuracy; facility and support equipment stimuli tolerance, test specimen tolerance stack-up or expected variation from specimen to specimen, external environment (pressure, temperature, humidity, etc.), test influence variations,

and component aging. The Root-Sum-Square (RSS) method will be used to combine tolerance methods. Where the RSS method is not appropriate for a specific situation, other statistical approaches that consider all the factors affecting system accuracy may be used if specified in the appropriate test plan.

Generally, the tolerance limits will:

1. For testing be as wide as possible to meet the test objective and minimize the accuracy requirement of the GSE
2. In test and checkout be equal to or greater than factory limits
3. In test and checkout be equal to or less than mission limits

h. The verification/validation program will confirm that critical failure modes and hazards identified by Failure Modes and Effects Analysis (FMEA) and hazard analysis, and other system analysis such as sneak circuit analysis or system assurance analysis have been eliminated by design or reduced to an acceptable level through the use of appropriate safety devices, warning devices, or special procedures, and by the controls listed on the Critical Items List (CIL) rationale for retention covering design, test, and inspection.

i. Verification/Validation program procedures will provide for safety of personnel and hardware by incorporating caution, warning, and safing instructions.

j. As a general guideline, off-limit testing will not be conducted. However, off-limit testing will be considered when:

1. When design margins are relatively small with respect to off-nominal abort conditions
2. When uncertainty exists in the definition of the design criteria
3. When single point failure modes exist
4. When failure mode analysis indicates that a credible probability of associated hardware failures will create an off-limit condition

Testing of this nature must have prior approval by NASA and must consider preservation of certification hardware.

k. Trend data gathered during the verification/validation program will establish a database to be used to support maintenance operations on the reusable elements of the Shuttle system during the development and operational phase.

l. Test methods used for leakage measurement and leak detection of components and subsystems shall be specified by each project element. SE-G-0020B,

Leakage Measurement of Helium and Nitrogen Test Gases, shall be used as a guide for detailed leakage measurement test procedures when Helium (He) or Nitrogen (N_2) are used as test gases.

m. A failure or unsatisfactory condition encountered during verification/validation/qualification/acceptance/checkout testing will require reporting and positive corrective action in accordance with contractual requirements, except for those failures that occur during those development tests that will not be used for certification.

n. Testing which uses computer systems as a portion of the test support shall utilize the Orbiter data processing system where such use will avoid duplicate or excessive ground support computer systems.

o. Interface Control Document Validation - Functional interfaces will be verified by major integrated ground tests combined with hardware acceptance and checkout, or by demonstration or prior usage, i.e., end item checkout prior to ship (in accordance with acceptance and checkout documentation) and functional checkout prior to flight operations (in accordance with applicable program requirements). All Criticality 1, 1R, 1S, and/or Safety Critical ground-to-flight element interface functions will be verified for safe and proper operation prior to connection of flight hardware to the ground system. Selected physical interfaces will be verified by measurement prior to element acceptance. The respective elements shall generate the necessary formal documentation that defines and controls the methods to be used to measure the physical interfaces.

3.3 REDOING VV&C GUIDELINES

a. Redoing VV&C must be accomplished by the elements if a design or design requirement has been changed or if program direction mandates redoing VV&C to support significant program reviews.

b. Redoing VV&C must be considered when flight, inspection, test, mission change, failure analysis, post-flight activities, or other data indicate that previously certified design requirements in NSTS 07700, Volume XX - Book 2, Appendix 10 are not being met.

c. When test or flight activity is constrained by recertification completion, the test or flight activity must not begin until recertification is completed or waived at the highest program level approving the applicable requirements.

d. Redoing VV&C must be considered when design or manufacturing process or source is changed that affects form, fit, function, safety and/or reliability.

e. Redoing VV&C must be considered when changes are made in fluids or materials used in processing or operation of hardware that affects form, fit, function, safety and/or reliability.

f. Recertification shall be considered when inspection, test, mission change, or other data indicate that a more severe environment or operating condition exists than that to which the equipment was originally certified.

g. Recertification involves review of available certification documentation. The supporting verification and validation data for the certification shall be assessed to determine if the status has been affected. This assessment shall be performed by comparing certification documentation with current hardware and software design requirements. Deficiencies, flaws, discrepancies, and/or inadequacies shall be identified and corrective action defined. Recertification shall be completed by approval of applicable verification/validation completion documentation as outlined in Paragraph 4.0 of this plan.

3.4 ANALYSIS GUIDELINES

a. Verification/Validation of hardware design below the element level will be accomplished by test and/or analysis. Verification/Validation of Shuttle and element performance requirements will use analysis wherever practical, to minimize or eliminate major ground tests and flight tests.

b. Analytical methods may be used in lieu of, in combination with, or in support of test to satisfy specification requirements.

c. Analyses may be used for verification or validation within the following guidelines when existing data is available or when ground test is not feasible or economical:

   1. Similarity analysis may be used in lieu of tests where it can be shown that the article is similar or identical in design, manufacturing process, and quality control to another article that has been previously certified to equivalent or more stringent criteria. Special effort shall be made to avoid duplication of previous tests from this or similar programs. If previous application is considered by the contractor to be similar, but not equal to or more severe, the delta verification/validation tests should concentrate on the areas of new or increased requirements.

   2. Analysis may be used when flight conditions cannot be accurately simulated on the ground and/or when it is not economically feasible to test for the entire spectrum of flight conditions. Examples of these are verification/validation of abort capability and pogo stability.

3. Other analytical methods, if selected for verification or validation, will utilize sound engineering approaches accompanied with the appropriate rationale and documented in the applicable certification plan.

d. Wherever analysis is used, the procedure and results will be documented in analysis reports. Conclusions reached will establish whether the equipment can be considered verified/validated as is or whether additional tests will be required to verify hardware capability to meet program requirements.

3.5 DEVELOPMENT TEST

a. Development tests will not be subject to the rigors and controls associated with VV&C and acceptance/checkout programs. However, adequate records of test configuration, test results and other pertinent data should be maintained so that this information could be made available to supplement other portions of the verification/validation program as required. The intent of this guideline is to capture valid data obtained from development tests utilizing hardware closely related to production configuration for possible use later in the program.

b. Turnaround checkout and maintenance plans and procedures will be developed during subsystem development and will be verified during the major ground tests.

c. Early software integration will be a key test program goal.

d. Maintenance and/or replacement time requirements will be refined in the development test period.

e. Experience gained during the development test program will be utilized to develop verification/validation and acceptance test procedures and support software.

f. Where new materials (including fluids and non-metallics) are to be used, or existing materials are to be used under new conditions, or where existing data cannot be traced to accepted sources, testing will be performed at the material level to establish material property values. Appropriate plans will be prepared to document material verification/validation programs. Particular emphasis will be placed on non-metallic materials verification/validation.

g. New nondestructive testing techniques or new applications of old techniques will be verified and validated during the development and qualification test programs.

h. (Reserved)

i. Adequacy of development flight instrumentation and operational flight instrumentation sensor locations will be verified during the development and verification/validation test phase.

j. A sinusoidal resonance search may be conducted as a part of development vibration tests of development hardware. Resonant frequencies of the test specimen will be determined by sweeping through the frequency range of each of the three mutually perpendicular axes of the test specimen from 5 to 2,000 Hertz (Hz) at an amplitude up to one-half g peak or at levels sufficient to determine resonances, but not high enough to affect hardware design. The search shall be a logarithmic sweep from 5 to 2,000 Hz at a rate no faster than one-half octave per minute so that all significant resonances may be recognized and recorded. Wherever possible, the identity of each resonance shall be given in terms of the resonant frequency, transmissibility, response band-width, damping, and the part in resonance, as determined by response data measured on or throughout the equipment.

3.6 CERTIFICATION PROGRAM

Certification planning will assure that necessary data from verification and validation activities [analysis, development (pre-declared), qualification, major ground test, acceptance, checkout, and flight test] are provided with minimum duplication of testing. These activities historically have been known as certification planning, certification program and/or certification tests.

3.6.1 Application of Certification

All flight hardware and software shall be certified. All ground hardware/software with critical functions or characteristics shall be certified. Items to be certified will be phased to support the first flight or preflight ground flow on which they will be used.

3.6.2 Certification Requirements

Certification requirements must be individually defined for each component or assembly considering its function, complexity, redundancy, design and maintenance requirements.

3.6.3 Piece Parts - Mechanical and Electronic, Electrical, Electromechanical

Mechanical piece parts and electrical, electronic, and electromechanical parts are certified and/or selected by the element contractor and are not a part of these certification guidelines.

3.6.4 Development Test Requirements (In Support of Certification)

Certification requirements may be satisfied during development testing in those cases where the following criteria are met:

Pre-declaration	The intent to use the test in support of certification is declared prior to test conduct
Configuration	Production configuration or approval (where allowed) for differences
Facilities	Certified
Inspection	Required
Test requirement/ procedure/pass-fail criteria	Formally approved
Acceptance, pre-functional and post-functional test	Required
Documentation	Submittal of configuration description, failure reports, and test results

3.6.5 Redundancy (Certification)

Where redundancy within a component or assembly is required, activities in support of certification will assure that the redundancy capability is verified and validated.

3.6.6 Certification of Mature Designs

Mature (off-the-shelf) hardware will require full verification/validation, the majority of which will be accomplished by analysis. The equipment capability shall be evaluated and documented utilizing a comparison matrix which includes considerations such as configuration, performance, and environment vs. Shuttle requirements. Additional test and/or analysis will be required where Space Shuttle environments are more stringent than previous qualification levels, where previous qualification did not include all Space Shuttle environments, or where minor modifications have been made; such verification/validation in support of certification to be accomplished by test or analysis.

3.6.7 Pre-Certification Acceptance

Full acceptance testing will be conducted on all test specimens prior to tests in support of certification. With prior approval, portions of the acceptance test may be combined with the test in support of certification.

3.6.8 Limits

Verification/Validation in support of certification will be structured to verify the full range of the design requirements, except as indicated under life certification guidelines.

3.6.9 Test Assembly Level

Testing will be conducted at the level of assembly which is most cost effective for fulfilling requirements in support of certification.

3.6.10 Number of Test Specimens

a. The number of test specimens applicable to verification/validation in support of certification will be determined by the element contractor and concurred with by the element project office.

b. The number shall be that which is required to demonstrate the design in applied environments, and is sufficient to verify/validate/certify the design including satisfaction of the life certification requirements given in Paragraph 3.6.15. Every effort will be made to keep the number of specimens to a minimum.

c. Sample sizes will not normally be selected to demonstrate hardware reliability statistically.

3.6.11 Configuration

Test hardware in support of certification will be of the same configuration and manufactured under the same production process as the flight hardware, unless differences are approved formally and adequately documented.

3.6.12 Specimen Installation

Test hardware in support of certification will be mounted in a manner simulating the actual mounting in the flight vehicle for all tests wherein the flight hardware will potentially be affected by mounting. This includes use of a coldplate, when tests are conducted on hardware to be mounted on coldplates for flight.

3.6.13 Environmental Conditions

The environmental requirements for the Space Shuttle system are defined in NSTS 07700, Volume XX - Book 2, Appendix 10. Each element contractor will define the local induced environments for their equipment in the appropriate element level specification. The local induced environments shall encompass the environments expected while performing SSP closeout activities. The specific test requirements and test methods applicable to VV&C will be defined by each element contractor in the applicable hardware specifications. The most adverse environmental condition, considering transportation, handling, assembly, environmental acceptance test, checkout, storage, and flight, will be simulated in the test. Identified below are methods and procedures

which, in general, will apply to all elements. These specific methods and procedures are not all inclusive and testing to other environments, levels, or methods may be necessary depending upon the nature, criticality, or complexity of the hardware. When tests other than those defined herein are necessary, the test methods of MIL-STD-810B, Material Standards for Environmental Test Methods, will be used where applicable. Deviations from the test methods defined herein will be granted only where the new method or procedure is at least as rigorous or where prior approval has been given by the SSP. This deviation requirement can be met by documenting the deviations in the certification requirements document, and submitting these documents for SSP concurrence.

a. Humidity - MIL-STD-810B, Method 507, Procedure I, shall apply.

b. Salt Fog - MIL-STD-810B, Method 509, Procedure I, shall apply.

c. Fungus - MIL-STD-810B, Method 508, Procedure I, shall apply. This test may be eliminated if it can be shown that no fungus nutrient materials are used or that such materials have been adequately treated or are hermetically sealed to prohibit fungus growth.

d. Sand and Dust - MIL-STD-810B, Method 510, Procedure I, shall apply.

e. High and Low Temperature - MIL-STD-810B, Method 501 and 502, shall apply, as applicable.

f. Pressure (Positive External) - Equipment that is exposed to pressure such that the exposure results in a positive external differential pressure shall be placed in a chamber and the chamber pressurized such that the resulting differential pressure on the equipment for a period of not less than 15 minutes is equal to 1.5 differential pressure.

g. Altitude - MIL-STD 810B, Method 500, shall apply. These tests are not required if the space simulation tests defined below satisfy the requirements of Method 500.

h. Space Simulation (Thermal-Vacuum) - MIL-STD-810B, Method 517.1, shall apply for equipment that will be exposed to vacuum environments. The pressure levels in Table 517.1-I shall be used consistent with the expected application of the hardware and the purpose of the test.

i. Acceleration - MIL-STD-810B, Method 513, Procedures I and II, shall apply. For these tests, the longitudinal and lateral axis are with respect to the vehicle and the hardware shall be mounted to simulate the mounting position and shall be in the operating mode of the flight hardware at the time the acceleration being simulated would occur during flight.

j. Shock

1. For packaging transportation and ground operations, MIL-STD-810B, Method 516, Procedures II and V, and FED-STD-101B, Procedures 5005, 5007, 5008, 5012, 5016, 5018, and 5023, shall apply. The MIL-STD-810B, Procedure II and the FED-STD-101B procedures listed above may be eliminated if proof of adequate packaging crating can be demonstrated.

k. Acoustic Noise - For hardware and components, MIL-STD-810B, Method 515, Procedure I, shall apply. If the power of the facility is not sufficient to generate the entire band, the spectrum may be divided into a maximum of four frequency bands with test time in each band equal to the total complete spectrum duration. The necessity for conducting an acoustic test shall be determined based on the criteria given in MIL-STD-810B, Method 515. Test article suspension may vary from Method 515 where better simulation of actual service mounting configurations is desired. The tolerances on one-third octave band sound pressure levels shall be -2 to +4 dB.

l. Vibration

1. Sinusoidal resonance search - A resonance search may be conducted as a part of development vibration tests of development hardware. An equipment resonance search test shall not be conducted, as a general practice, as a part of certification of the flight hardware. However, where necessary, the test procedures of this Volume I, Book 3, Paragraph 3.5j, shall apply. For all vibration tests, resonance search tests of vibration fixtures without test articles shall be conducted according to the procedures of Paragraph 3.5j.

2. Sinusoidal sweep - For packaging and transportation, FED-STD-101B, Method 5020, shall apply. These tests may be eliminated if proof of adequate packaging and crating can be demonstrated.

Tests shall be conducted based on the following guidelines.

(a) Vibration input measurement - Vibration resulting from operation of the test specimen, excitation of higher harmonics, or other sources can cause distortion of the vibration input signal to the control readout. The control waveform shall be monitored to determine if distortion is present. If necessary, a tracking filter or other filtering device shall be used in the control circuit to eliminate or minimize distortion.

(b) Tolerances - Test tolerances shall be as follows:
Acceleration and Displacement Amplitude ±10%,
Frequency ±5%
Test Duration +10%,-0

3. Random vibration - The hardware shall be subjected to random vibration tests in each of three orthogonal axes to the acceleration spectral density levels, with consideration for the life certification guidelines of this Volume I, Book 3, Paragraph 3.6.13. Tests shall be conducted based on the following guidelines:

(a) Equalization procedures - The vibration system (vibrator, test fixture, and test specimen) shall be equalized in each test axis to obtain the specified vibration spectrum shape. The equalization technique (manual, automatic, closed loop, specimen removed, etc.) shall be at the discretion of the vibration test engineer except the following constraints shall apply:

The vibration control accelerometer signal and any response accelerometer signals shall be recorded (and identified by voice annotation) on magnetic tape for all acceptance and qualification vibration tests. The tape recorder shall record these signals whenever power is applied to the shaker system. System calibration information sufficient to allow analysis of the vibration signals subsequent to the test, shall also be recorded on the magnetic tape and any other applicable documentation. The magnetic tapes shall be maintained as part of the vibration test records until final test report approval by the buyer. The vibration control accelerometer(s) shall be located immediately adjacent to the test specimen mounting.

For random vibration testing, a dynamically similar dummy may be used in place of the test specimen, when possible, for pre-test equalizations. The final equalization prior to the test shall be accomplished using the test specimen and shall be conducted at the full specified random vibration level. The time expended during the final equalization shall be counted as part of the required test time for the random vibration test. The final equalization shall be verified by a narrow band analysis prior to initiation of the test.

(b) Verification of the test spectra - The test spectra shall be verified by narrow-band spectral analyses prior to and at intervals during the test by an analysis system that is independent from the analyzer equalizer used to control the test. To demonstrate that the test specimen has

been subjected to the specified random spectrum, the output of the control accelerometer system used to establish the test spectra and to determine the overall Root-Mean-Square (RMS) acceleration shall be tape recorded continuously. All random spectral analyses shall be performed as X-Y log-log plots of acceleration spectral density (g2/Hz) vs. frequency (Hz). In addition, the overall RMS acceleration shall be monitored continuously throughout the test. The spectral analyses and the overall RMS acceleration shall be included as part of the final test report.

(c) Tolerances

(1) Qualification test - The tolerances on acceleration spectral density shall vary with analyzer filter band-width. It is desirable that the analysis system provide more than 100 statistical degrees of freedom; however, the analysis system should never provide less than 50 degrees of freedom. Tolerances on acceleration spectral density are as follows:

Spectrum Freq. Band	Nominal Filter Band-width	Tolerance
10-100 Hz	10 Hz or less	+3 dB -1.5 dB
100-350 Hz	25 Hz or less	+3 dB -1.5 dB
350-2000 Hz	50 Hz or less	+3 dB -1.5 dB
10-100 Hz	5 Hz or less	+4.5 dB -1.5 dB
100-350 Hz	10 Hz or less	+4.5 dB -1.5 dB
350-2000 Hz	25 Hz or less	+4.5 dB -1.5 dB

Nominal filter band-widths are the difference in frequency as determined at the half power points.

Exceptions to the above acceleration spectral density tolerances in the frequency range of 200 Hz to 2000 Hz are permitted according to the following criteria which shall be used for approval of random vibration qualification tests:

The total number of peaks and valleys is not to exceed four in any combination which complies with the criteria below.

Peaks which exceed the upper tolerance limit are acceptable if there are no more than three, the tolerance limit is not exceeded by more than +3 dB, and the peak width at

the one-half power point is less than 5% of the center frequency of the peak.

Valleys which extend below the lower tolerance limit are acceptable if there are no more than three, the tolerance limit is not exceeded by more than -3 dB, and the valley width at 50% of the valley depth is less than 5% of the center frequency of the valley.

The tolerance of overall g rms shall be +15% and -5% measured by a true rms voltmeter with a 2000 Hz cutoff filter of at least 12 dB/octave.

The tolerance on frequency shall be ±10%.

The tolerance on test duration shall be +10%, -0.

(2) Acceptance test - The requirements and tolerances on acceleration spectral density shall be as defined in JSC document SP-T-0023, Specification Environmental Acceptance Testing.

Deviation/Waiver 1 is applicable to Paragraph 3.6.13 I.3.(c)(2). Refer to the Deviations/Waivers Section in front of the document.

3.6.14 Life Certification

Environmental and operational design life certification is a program requirement. The requirement must be individually specified for each component or assembly, considering its design, criticality and maintenance requirement. Life verification/validation may be achieved by test, analysis, or a combination thereof. A test duration less than design life is acceptable for verification/validation if a shorter duration is supported by analysis or relatable test experience.

Life certification may be accomplished incrementally where full life certification prior to usage is not practical. In this event flight hardware will be certified for limited life use based on an engineering evaluation of the test and/or analysis performed prior to the time of use. When full life verification/validation has not been completed and the hardware is normally refurbished/repaired as part of the turnaround activity, post-usage acceptance testing, teardown and inspection, and analysis shall be performed to verify that the hardware is acceptable for reuse.

3.6.15 Test Survival - Determination

A functional test to determine whether the test hardware in support of certification is performing within specification tolerance will be conducted after each environmental exposure (if equipment is nonoperating during the tests in support of certification).

3.6.16 Incipient Failure - Inspection

Those components requiring post-test disassembly to uncover incipient failure modes and latent defects will be identified and documented in approved certification plans. Disassembly will be accomplished to the extent possible.

3.6.17 Preservation of Dedicated Hardware

Consideration shall be made for preserving dedicated hardware for activities in support of recertification.

3.6.18 Fluid - Compatibility Certification

Certification of the hardware requires certification of compatibility of all associated fluids.

3.6.19 Test Facilities and Equipment

The test facilities, and equipment, including associated data acquisition and reduction equipment, will be suitable for the purposes of the test, properly configured and will bear evidence of valid and current calibration.

3.6.20 (Reserved)

3.6.21 Unattained Test Requirements

Unattained test requirements, which affect test specimen performance criteria and test environments, shall require notification and resolution prior to teardown of the test setup. If the parameter is controlled by the technical specification, a waiver from the highest program level approving the applicable requirement is required.

3.6.22 Logic

Certification logic and documentation flow with task responsibilities are shown in Figure 3-5-1.

3.6.23 (Reserved)

3.7 ACCEPTANCE AND CHECKOUT

These requirements apply to testing activities involving acceptance and checkout operations. Inspection guidelines related to acceptance activities are covered in NSTS 5300.4(1D-2), Safety, Reliability, Maintainability and Quality Provisions for the Space Shuttle Program.

3.7.1 Acceptance Test Requirements

a. Acceptance of supplier equipment will take place at the manufacturing source insofar as practical. This will provide the inspection and testing rigor necessary to assure that functional pre-installation testing by the element contractor will be minimized. Consideration will be given to pre-installation acceptance tests or inspections on components prior to installation into the next higher level of assembly when any of the following circumstances exist:

   1. No previous acceptance test was completed.
   2. Acceptability cannot be verified by test of higher level of assembly.
   3. Significant time has elapsed since the last test. Such period shall be determined from the age/life characteristics of the component.
   4. Where the component, once installed in the next higher assembly, is difficult to remove and requires significant schedule time to replace.
   5. Where prior failure history of the component indicates the need for preinstallation testing.
   6. Where the component, once installed in the next higher assembly, by its failure could damage the next higher assembly during test.

b. Test and pretest storage environments and conditions will be controlled to prevent compromising the quality and/or reliability of the article.

c. Test facilities and equipment will be suitable for the purposes of the test and will bear evidence of valid calibration.

d. Each measured parameter for acceptance testing will have a specified tolerance band of acceptability.

e. Government Furnished Equipment (GFE) that is installed and part of deliverable end item hardware will be tested and controlled as part of that end item.

f. Acceptance testing will require rigorous control, inspection, and documentation to assure that all elements of the Shuttle Program, including software, procedures, and GSE, meet the specified requirements (performance, function, configuration, etc.) and that no significant defects exist.

g. Checkout of alternate and redundant functional paths and modes will be required on deliverable components. This will be accomplished with minimum disturbance and at the most practical level of assembly.

h. Burn-in will be performed on hardware where aging is a factor to reduce early operational failures. Electronic components normally fall into this category.

i. Cycling tests will be performed on hardware where a wear-in period is required to assure proper seating or conditioning.

j. Environmental acceptance testing will be performed on selected hardware to screen out manufacturing defects, workmanship errors, and incipient failures not readily detectable by normal inspection techniques or through functional tests. These tests will be in accordance with SP-T-0023, Environmental Acceptance Testing.

EXCEPTION: 1. The above requirements shall be implemented on the Orbiter project for all existing and new designs as modified by changes to the specific paragraphs in SP-T-0023B as follows:

A. SPECIFIED REQUIREMENT: Paragraph 3.2.6 Retest Limit. The limit established for retest shall be such that the maximum permitted accumulation of environmental acceptance test exposure time does not exceed that part of the qualification test time designed to simulate acceptance test and provide margin demonstration.

EXCEPTION: For all Orbiter hardware for which acceptance thermal testing is required, retest limits, if any, shall be determined based upon hardware analysis and test performed in support of development, qualification and certification. Retest limits shall be established on a case-by-case basis to address known sensitivities of the hardware to environmental exposure and shall be documented in the appropriate design, certification and operations documentation. In the absence of documented thermal acceptance retest limits, no generic limit based upon qualification test duration shall be applied.

B. SPECIFIED REQUIREMENT: Paragraph 3.12 RETEST. In no case shall cumulative acceptance test time, plus expected mission time, exceed the qualification test time for a given environment.

EXCEPTION: For Orbiter hardware, the appropriate duration of thermal testing to support qualification objectives is determined based upon technical evaluation of hardware sensitivities to thermal exposure and mission requirements to be levied on the hardware, and does not necessarily envelope the entire duration of expected mission life thermal exposure. Therefore, there is no requirement to generically limit cumulative thermal acceptance test time plus expected mission time to the qualification test duration.

C. SPECIFIED REQUIREMENT: Paragraph 4.5.2 Thermal Test. The duration for the qualification testing to verify the ability of the hardware to withstand the acceptance thermal test shall include the refurbishment acceptance thermal requirements, if any, and/or up to five times the normal acceptance test duration to allow for retest.

EXCEPTION: For Orbiter hardware, the appropriate duration of thermal testing to support qualification objectives is determined based upon technical evaluation of hardware sensitivities to thermal exposure and mission requirements to be levied on the hardware. There is no requirement to generically limit cumulative thermal acceptance test time based upon the qualification test duration. Retest limits, if any, shall be established on a case-by-case basis to address known sensitivities of the hardware to environmental exposure and shall be documented in the appropriate design, certification and operations documentation. In the absence of documented thermal acceptance retest limits, no generic limit based upon qualification test duration shall be applied.

Deviation/Waiver 1 is applicable to Paragraph 3.7.1j.
Refer to the Deviations/Waivers Section in front of the document.

k. Reconveyance may be required whenever

1. The article or material does not meet the contract or contractor specification requirements

2. The inspection or test performed is not in accordance with test specifications or inspection and test procedures

3. Equipment malfunctions

4. Modifications, repairs, replacements, or rework of the article or material occur after the start of inspection or testing

5. The article or material is subject to drift or degradation during storage or handling (periodic intervals for reinspection or retest shall be established)

6. Specified by Material Review Board (retest shall be limited by consideration of remaining useful life and operating time for qualification)

Reacceptance will not always require a complete functional checkout of the subsystems involved. It may consist only of a verification of the disturbed interfaces and a functional demonstration of replaced Line Replaceable Units (LRUs).

l. Each element end item will be subjected to an integrated acceptance checkout after assembly. This test will be structured to demonstrate to the extent possible, satisfactory construction, operation, and performance of the item. This test will minimize the need for formal in-process or subsystem demonstrations during or following assembly or after any operation that would require reacceptance testing.

m. Subsystem performance evaluation (while installed in the flight vehicle) will use operational signals as stimuli insofar as possible.

n. Full utilization will be made of subsystem performance data from the preceding flight to verify/validate system performance and minimize ground checkout requirements for the next flight.

o. Proof testing shall be accomplished as required to satisfy the fracture control requirements of NSTS 07700, Volume XX - Book 2, Appendix 10.

p. Non-destructive test verification/validation methods and procedures shall be developed to support launch and turnaround operational requirements.

3.7.2 Checkout Functional Partitioning

This section defines the approach to Space Shuttle checkout functional allocations which shall be utilized by the applicable Shuttle organizations in implementing their respective areas of technical and management responsibility. The primary purpose of this requirement is to accomplish as much standardization and uniformity of checkout approach as is practical between each of the Shuttle test sites. The intent of this section is to define the optimum onboard/ground partitioning of checkout and servicing functions which are consistent with cost effective operations. The checkout philosophy and associated functional onboard/ground checkout partitioning guidelines which shall be utilized are defined herein. This section addresses the checkout and servicing functions of the onboard and ground systems in Shuttle operations at KSC (see Table 3.7.2-1) for installed subsystem and higher level testing. It defines conceptual guidelines for partitioning of these onboard and ground functions. The implementation of this

requirement will influence: (1) onboard hardware utilization, (2) onboard software design and utilization, and (3) ground hardware/software design and utilization.

a. General Partitioning Guidelines - General guidelines for the partitioning approach are as follows:

   1. If a function is required in-flight and the resultant onboard capability is applicable to ground checkout, the onboard function shall be utilized in support of ground testing.

   2. Where a specific preflight function requires the control of both onboard and ground systems, the ground system will normally be in control.

   3. Supervision of ground test activities shall be a ground system function.

   4. Checkout and servicing functions which cannot be performed by the ground system due to vehicle design characteristics will be performed onboard.

b. General Checkout Approach/Philosophy - The operational Shuttle objectives of rapid turnaround and reduced cost per flight shall be considered. In order to assure the earliest practical achievement of full operational capability, the onboard checkout functions shall be implemented in the earliest practical Orbiter integrated checkout configuration which is consistent with program cost and schedules, and maturity of design and checkout methods. This shall be accomplished to assure early validation of onboard checkout capability and to allow more definitive allocation of operational functions to either flight or ground systems. The general approach and philosophy which shall be implemented is defined as follows:

   1. Onboard Checkout and Servicing Functions

      (a) At the integrated vehicle level, the onboard checkout capability shall be utilized to perform checkout to a level consistent with the inherent onboard instrumentation, stimuli capability, and vehicle configuration. As a minimum, the onboard system will be utilized to validate Shuttle functional paths.

      (b) Where practical, stimulation and/or activation of vehicle subsystems shall be provided by the inherent flight software capability.

      (c) To the maximum extent possible, signal generation for stimuli to exercise vehicle subsystems shall be accomplished onboard. Execution of commands which initiate stimuli for checkout may be accomplished from the cockpit, the onboard computer, or the ground system.

      (d) The onboard computers shall be used to accomplish checkout to the functional path and support detailed checkout below the functional

path level. Onboard support of detailed checkout below the functional path may be accomplished by loading appropriate checkout programs into the onboard computer and/or by manual operations.

2. Combined Onboard/Ground Fault Isolation

Combined onboard and ground checkout capability shall be utilized to isolate failures to the line replaceable electronic unit or mechanical/servicing system module. Fault isolation to a group of units or modules may be allowed when it is clearly evident that ground turnaround time is not significantly impacted, SSP costs are not increased, or where further isolation is impractical due to resultant vehicle design penalties.

3. Ground Checkout and Servicing Functions

(a) Deleted.

(b) During the operational phase, ground checkout below the functional path shall be minimized. For functional path verification, the ground system shall be phased to a minimum operation required to monitor and record onboard checkout results, and support prelaunch operations and vehicle servicing. Checkout below the functional path will be allocated to the ground or onboard systems based on optimum turnaround considerations and cost effective operations. The ground system checkout capability will decrease in consonance with increased onboard capability.

c. Types of Checkout Software - Shuttle integrated system checkout will be performed by use of the following types of software or some appropriate combination thereof:

1. Onboard Software

(a) Flight Software - software required to fly the vehicle which is used to support ground checkout.

(b) Modified Flight Software - software required to fly the vehicle having minimal changes which with supplemental data allows operation of the software in flight modes will be used during Integrated Mission Phase testing for both the primary flight system and the backup flight system.

(c) Ground Checkout Software - (1) software required to communicate between the ground system and onboard computers, and (2) software not needed for flight but must be resident in the onboard computer during ground checkout.

2. Ground System Software - Software required for ground checkout/control and not provided by onboard software.

d. Implementation Plans - The Project offices shall submit implementation plans within 90 days of issuance of the requirements of this Paragraph 3.7.2.

e. Specific Checkout Function Allocation by Site - To assure proper consideration of final operational objectives, the following onboard/ground allocations are identified for each major checkout operations site.

3.7.3 Turnaround Maintenance and Assembly Requirements

a. Philosophy - The general philosophy is to achieve confidence in vehicle performance for safety and mission success through planned maintenance or assembly requirements. The program experience base for likelihood of occurrence and the risk levels, or severity of the effect, will be utilized to determine the maintenance interval requirements. Functional criticality and the inspection and verification required to confirm proper assembly and performance of systems and components will be utilized to define assembly requirements. The program goal is to minimize work while maintaining acceptable safety risks.

   Maintenance and assembly requirements implementation will be based on the use of data available during flight operations and planned integrated vehicle level operations to satisfy the maintenance requirements to the maximum extent practical. Remainder of requirements will be satisfied during integrated vehicle or element level operations. The program goal is to standardize the turnaround flows. Orbiter requirements, other than each flow intervals, will be assigned to Orbiter Maintenance Down Period (OMDP) intervals unless a different interval is specifically justified by the systems experience.

   The schedule risks for the discovery of infrequent, remote or improbable failures late in the processing, as a function of performing validations or checkouts at the integrated vehicle level, is accepted by the program.

b. Maintenance and Assembly Requirements - Maintenance and assembly requirements specified in NSTS 08171, Operations and Maintenance Requirements and Specifications Document (OMRSD), will be used as a reference in determining maintenance and assembly requirements for closeout activities. The division of requirements between flight and ground operations will be determined on the basis of the order of preference for maintenance and assembly implementation, as specified in Paragraph 3.7.3c. The maintenance requirements intervals for undisturbed reflight items will be specified for each functional redundancy path as a function of the program experience base for

likelihood of credible failure mode occurrence and the severity of the failure's effects for the loss of the function in accordance with those specified in Table 3.7.3.1. The following definitions are applicable to the terms used in Table 3.7.3.1.

1. Likelihood - The probability that a credible failure mode will occur and result in the loss of the function or functional redundancy. The likelihood can be defined by probabilistic determination, or by using the following system history definitions. Mission operating time or exposure should be considered in the determination of the likelihood.

2. Probable - Will occur several times in the life of the program. A general guideline for likelihood of occurrence would be 1 in 12 to 125 flights. System/Function may have experienced problems or unexplained anomalies for which corrective action has not been implemented or has been deferred based on the severity of the effect, redundancy, or expected frequency of occurrence. Or, has a suspect condition or adverse problem history trend on like or similar configurations which requires screening or inspection as the basis for flight worthiness. Or, has limited flight experience with the current configuration. Or, has wear concerns where the rate of degradation is not well characterized or is uncertain.

3. Infrequent - Likely to occur sometime in the life of the program. A general guideline for likelihood of occurrence would be 1 in 125 to 1,250 flights. System/Function may have experienced problems or in-flight anomalies closed as "explained" with probable cause(s), or as "closed" based on fault isolation, with corrective actions implemented. Confidence in the design has been restored based on certification and acceptance testing or limited flight experience with the current design. There has been no recurrence of the problems after implementation of the corrective action. Limited life or wear considerations are well understood or failure modes characterized by long term performance degradation that is detectable over multiple flights.

4. Remote - Unlikely, but possible to occur in the life of the program. A general guideline for likelihood of occurrence would be 1 in 1,250 to 12,500 flights. System/Function problems or anomalies have been isolated with corrective action implemented and recertification completed. Certification is completed for the design life of the item with positive margins. Extensive test experience and flight validation of the current configuration has been completed to establish high confidence in the function. Any limited-life items are well characterized and conservatively defined. Wear, if any, is characterized by detectable long-term degradation.

5. Improbable - So unlikely that it can be assumed occurrence may not be experienced in the life of the program. A general guideline for likelihood of occurrence would be greater than 1 in 12,500 flights. System/Function has no history of problems or anomalies for the current configuration. System has high design margins, a comprehensive certification program, and extensive ground test and flight experience to establish unusually high confidence in the hardware. Or, there are multiple applications of the current design on the flight vehicle with no history of problems or failures such that the accumulated flight experience establishes very high confidence in the design. Time or cycle limits are not a concern with the design.

6. Severity - A measure of the adversity of the loss or failure of a function. Generally associated with the (operational) criticality categories as defined in NSTS 22206, Requirements for Preparation and Approval of Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL).

Disturbed functional paths will be validated or checked out after reassembly. This will be accomplished by validation, except for functions for which connection quality/improper assembly is a factor in functional performance. In those cases, a performance checkout will be required. Replacement LRUs will be verified with appropriate test acceptance procedures prior to installation with interface/functional validation after installation. Emergency systems/functions, used only to control hazards or in emergency situations, will be validated or checked out on a periodic interval or life limit basis, unless the function has been disturbed or exercised. Emergency monitoring systems will be validated or checked out in accordance with the intervals, as specified in Table 3.7.3.1. Assembly requirements will be based on the functional criticality and confirming proper assembly and performance. For Criticality 1, 1R, 2 or 2R functions, inspections, validations or checkout to assure the design functional redundancy will be specified. The Orbiter thermal protection subsystem shall be inspected each flight and repaired, as required, to assure flight worthiness. Flight vehicle structures will be inspected periodically to assure structural integrity. The inspection intervals will be based on the program experience in the operation environments and adjusted based on inspection results and the goal of minimizing work. Interval will be based on analysis or fleet leader experience for fracture critical or cycle life limited structures. Zonal inspections will be developed consistent with access to the structural components. To the extent, practical OMDP intervals, or longer, will be used for Orbiter structures inspection. Invasive testing which may damage, degrade or present increased risk of failure because of equipment removal, limited access, or abnormal operations shall be avoided.

c. Maintenance and Assembly Implementation - Maintenance and assembly implementation will be planned with the goal of minimizing work. Implementation will be planned to use flight and integrated vehicle operations to the maximum extent practical.

1. For reflight of undisturbed systems/functions the order of preference in maintenance planning is:

   (a) Flight operations and active in-flight validation or checkout, to the extent practical without adding flight duration or mission success or safety risks.

   (b) Ground operations, to the extent consistent with flow optimization:

      (1) Integrated vehicle level test operations planned for validation or checkout and countdown.

      (2) Added integrated vehicle level test operations.

      (3) Element level test and operations.

2. Systems which are assembled at KSC will use the original equipment manufacturer or depot level validation or checkout, unless disturbed or invalidated prior to assembly. Validation or checkout, at the assembly level or at the integrated vehicle level, will be a function of optimization in flow planning.

d. Requirements Satisfaction - Validation or checkout will be performed and closed-loop accounted. Specified requirements are to be satisfied through analyses of data from flight or integrated vehicle test operations whenever the data is sufficient to satisfy the specified requirement. All data available during these operations will be monitored for operation within specified limits. Requirements not satisfied during flight or integrated vehicle operations at KSC will be satisfied though inspections or testing and data analyses during appropriate planned maintenance operations. Unplanned maintenance or assembly requirements will be used for revalidation or checkout of failed or unplanned disturbance of functions.

3.8 FLIGHT DEMONSTRATION

a. Flight demonstration will involve validation of mature systems and will not be considered a development test program.

b. Verification/Validation requirements allocated to flight demonstration will be limited to those that:

1. Require flight data to verify/validate mission capabilities
2. Are more cost effective to conduct in flight than by other methods
3. Will overcome definite inadequacies of other test methods

c. The ALT program will satisfy validation requirements for the phases of carrier aircraft, subsonic maneuvers and approach, landing, and rollout.

d. The flight demonstration program will demonstrate aspects which will include, but will not be limited to:

1. Evaluation of flight vehicle hardware characteristics and development of standardized operational procedures.
2. Correlation of data with ground test results and design analysis in support of system verification/validation.
3. Demonstration of overall system operation, including all elements, payloads, GSE, and facilities.
4. Verification/Validation and refinement of GSE, facilities, and procedures to obtain minimum time, high-confidence turnaround.
5. The number and types of objectives assigned to an individual flight will be selected to yield a maximum of useful engineering data and flight test time consistent with safe and efficient flight conduct. Any specific flight may embody a number of individual tests on different subsystems. Flight tests to demonstrate small performance or compliance fixes will be planned for and conducted concurrently with other tests. Data processing and analysis procedures will provide selected real time display and monitoring for mission control and safety, preliminary data for decision making, and final data for reports.

3.9 GROUND SUPPORT SYSTEM VERIFICATION/VALIDATION

The verification/validation program for GSE will include development, in-process and acceptance tests. Element Project Office will select GSE for certification based on expected environmental conditions, operational constraints or hardware failure which could cause loss of vehicle systems or personnel capability.

3.9.1 Development Testing

a. Design verification will be satisfied by analysis where possible. When analysis alone is inadequate to provide the required confidence, it will be supplemented by development testing.

b. Support equipment operation, procedures, and software will be developed during development test and verified/validated during the flight test programs.

c. When external environmental testing is included with development tests, the maximum environmental levels will normally be consistent with the most severe conditions anticipated for subsequent operational activity or testing. Higher levels will be on an exception basis only.

d. Development test data will be utilized to create and modify acceptance and operational checkout procedures.

e. (Reserved)

3.9.2 Certification

Support of certification may be accomplished by data from supporting test and/or analysis.

3.9.2.1 Design Analysis and Similarity Analysis

Support of certification of GSE by analysis will be performed in accordance with the guidelines in Paragraph 3.4.

3.9.2.2 Certification Testing

When required of GSE, tests in support of certification will be performed on production configured specimens to verify/validate that the functional performance of components and assemblies in specified environments is in compliance with design and performance specifications. Test requirements will be based upon the function of the equipment. Tests will be performed only to the extent necessary to qualify the critical function.

a. Testing of components and subassemblies, in support of certification, will be accomplished on the highest practical level of assembly.

b. External environments selected will be those which the hardware is expected to experience in its service life. Environmental test may be performed with one or several environmental parameters imposed, depending upon the probable dependence, test realism, and practicality of the test configuration. The environment levels and durations will be characteristic of the worst case operational conditions at any test site and will demonstrate the design integrity.

3.9.2.3 Development Test Requirements (In Support of Certification)

Certification requirements for ground support may be satisfied during development test if certain criteria are met. These criteria are identified in Paragraph 3.6.

3.9.3 Acceptance and Ground System Validation

a. All support equipment will be subjected to an acceptance verification/validation to demonstrate that the equipment satisfies design requirements as documented in applicable acceptance specifications. Ground System requirement verifications are assigned in the verification responsibility matrix in NSTS 07700, Volume XX - Book 2, Appendix 10, Table 4.1.

b. The acceptance test will be nondestructive and is to be planned such that rework or repair of the equipment will not be required following successful completion of the test. The test will encompass operation of the units or components in an ambient environment in its normal modes. Final acceptance of GSE will be accomplished at the functional set or station set level that the GSE is programmed for use, where the contractor has control of the related equipment and their interfaces. All other GSE will be accepted at the highest level of configuration under the contractor's control and validated at the using site at the functional set level. The acceptance checkout and station set validation test requirements will be structured to adequately verify the equipment and systems while minimizing unnecessary redundance of testing.

3.10 MAINTAINABILITY

Maintainability verification and incremental demonstration activity will be undertaken to assure that maintainability design requirements have been achieved and to confirm Shuttle system turnaround capability. The primary objective of the incremental demonstrations are an early and in-process evaluation of the maintainability characteristics of the Space Shuttle system, subsystems, and components. The maintainability characteristics and turnaround capabilities of systems and hardware will be progressively verified and demonstrated during design, ground development test, production, and flight test programs. Necessary adjustments to the turnaround plans as well as equipment design changes will be identified and implemented early to minimize cost impact and reduce the potential for development of major problems that could cause the Shuttle system to fail to meet the turnaround time requirement. Three basic methods of verification and demonstration will be used:

a. Analytical Predictions - The support requirement analysis process and quantitative maintainability allocation will be iterated as the Shuttle system design progresses. They will provide analytical predictions of design compatibility with the baseline turnaround plan.

b. Scheduled Demonstrations - Scheduled demonstrations will be conducted primarily for maintainability and operability audits. This process will use Preliminary Design Review (PDR) and Critical Design Review (CDR) mockups and, if necessary, test or production hardware.

c. In-Process Monitoring - Operation and maintenance actions conducted in the normal course of development, test, manufacturing, and flight test will be evaluated for actual time and manpower audit, and observation of the techniques used. Predetermined operation and maintenance parameters will be recorded during normal ground development test, manufacturing, and flight test operations, as specified in test plans and specifications.

3.11 SSP GFE VERIFICATION/VALIDATION/CERTIFICATION

3.11.1 GFE Flight Hardware

GFE flight hardware VV&C shall follow the guidelines prescribed for flight element/ system VV&C.

3.11.2 GFE Ground Hardware

GFE ground hardware VV&C shall follow the guidelines prescribed for ground system VV&C.

TABLE 3.7.2-1
KSC OPERATIONS, TEST AND CHECKOUT ACTIVITY

TEST AND CHECKOUT ACTIVITY	GROUND		ONBOARD		REMARKS
	MANUAL	COMPUTERIZED	COCKPIT MANUAL	COMPUTERIZED	
KSC SHUTTLE VEHICLE SUBSYSTEM OPERATIONS AND REVERIFICATION 1. Begins at Landing Rollout Point or Receiving Elements 2. Ends at Orbiter Integrated Checkout or Element Mate with Orbiter 3. Includes: a. LRU fault isolation, removal and replace b. Functional activation and checkout on subsystem oriented Test Checkout Procedures (TCP) basis	1. Local control and monitor of selected GSE 2. Position, alignment and installation 3. Keyboard manipulation	1. Remote control and monitor of selected GSE 2. Flight data record or playback, evaluation, and anomaly display 3. Realtime data recording and display 4. Load and reverify on-board computers 5. Data monitor, evaluation, and display 6. Support LRU fault isolation 7. Issue uplink commands/ data 8. Perform element checkout prior to mate	1. Switch activations 2. Display monitoring 3. Keyboard manipulation 4. Manipulate vehicle controls 5. Control onboard data recording and dump	1. Data acquisition 2. Display generation 3. Execute test routines 4. Verify selected systems to lowest functional path 5. Perform self test 6. Execute computer command stimuli application 7. Perform redundancy switching and verification	1. Checkout includes payload carrier interfaces only. 2. BME, BTE activities omitted because of strictly ground activities.
INTEGRATED SHUTTLE CHECKOUT 1. Begins with Integrated Orbiter Systems checkout at Orbiter Processing Facility (after mate with Orbiter for other elements) 2. Ends with Rollout to Pad 3. Includes: a. Functional path verification b. Interface tests c. Payload compatibility tests	1. Local control and monitor of selected GSE 2. Position, alignment and mate to ET/SRB 3. Keyboard manipulation	1. Remote control and monitor of selected GSE 2. Realtime data recording and display 3. Load and verify onboard computers 4. Data Monitor, evaluation and Display 5. Issue Uplink Commands/ Data 6. Support LRU Fault Isolation	1. Switch activation 2. Display monitoring 3. Keyboard manipulation 4. Manipulate vehicle controls	1. Data acquisition 2. Display generation 3. Verify systems to lowest functional path 4. Perform self test 5. Execute commanded stimuli application 6. Perform redundancy switching and verification 7. Control on-board data recording and dump 8. Checkout payload carrier interfaces	1. Subsystem level test routines (both onboard and ground) done on anomaly indication. 2. ET/SRB interface simulated before mate.

TABLE 3.7.2-1
KSC OPERATIONS, TEST AND CHECKOUT ACTIVITY - Concluded

TEST AND CHECKOUT ACTIVITY	GROUND		ONBOARD		REMARKS
	MANUAL	COMPUTERIZED	COCKPIT MANUAL	COMPUTERIZED	
SERVICING/PRELAUNCH ACTIVITIES 1. Begins with Rollout to Pad 2. Ends with lift-off 3. Includes: a. Verification of Shuttle Vehicle to pad interface b. Hazardous servicing c. Launch readiness reverification d. Countdown	1. Manual use of selected GSE 2. Position, alignment and hookup to pad interface 3. Keyboard manipulation	1. Monitor and display data 2. Data recording and play-back 3. Control and monitor select GSE 4. Control and monitor select facility support and safety equipment 5. Provide uplink checkout and servicing commands 6. Provide critical automatic safing functions 7. Provide offline data processing 8. Initiate and support launch sequence 9. Provide quick-look stripout data 10. Support checkout and fault isolation below functional path levels 11. Load and verify onboard computers	1. Switch activation 2. Display monitoring 3. Keyboard manipulation 4. Manipulate vehicle controls	1. Data Acquisition 2. Display generation 3. Execute test routines 4. Verify systems lowest functional path 5. Perform self tests 6. Execute computer commanded stimuli applications 7. Perform redundancy switching 8. Control onboard data recording and data dump 9. Support LRU fault isolation	Note 1: During Pad Clear operation parallel switch control from ground is used in lieu of manual cockpit switches.

TABLE 3.7.3.1

TURNAROUND VALIDATION AND CHECKOUT REQUIREMENTS

LIKELIHOOD				
Probable	No Checkout Required	Validation Each Flow and Checkout at Intervals	Checkout Each Flow	Not Allowed
Infrequent	No Checkout Required	Validation to Fail-Safe Each Flow and Checkout at Intervals	Validation Each Flow and Checkout at Intervals	Not Allowed
Remote	No Checkout Required	Checkout at Intervals	Validation Each Flow and Checkout at Intervals	Checkout Each Flow
Improbable	No Checkout Required	Checkout at Intervals	Checkout at Intervals	Validation Each Flow and Checkout at Intervals
	Criticality 3	Criticality 1R**, 2R	Criticality 1R*, 1S, 2	Criticality 1

SEVERITY

*Single-Failure tolerant

**Two-Failure tolerant or greater

FIGURE 3-5-1

CERTIFICATION LOGIC AND DOCUMENTATION FLOW

LEGEND
O – ORIGINATE
R – REVIEW
A – APPROVE
S – SELECTED APPROVALS

RESPONSIBILITY			DOCUMENTATION	CONTENTS
SYSTEM CONTRACTOR	ELEMENT CONTRACTOR	NASA		
R	O	A	SUBSYSTEM CERTIFICATION PLANS	REQUIREMENTS, INDEX, CERTIFICATION METHODS, CONSTRAINTS LOGIC, AND SCHEDULES
	O	R	COMPARISON MATRIX	MATURE HARDWARE PERFORMANCE AND CAPABILITY EVALUATION
	O	R	CERTIFICATION REQUIREMENT	ENVIRONMENTS, SEQUENCE, PASS/FAIL CRITERIA, LEVEL DURATION, AND SPECIMEN
	O	R–S	TEST REQUEST	SCHEMATIC TEST SETUP, RIGORS, AND CERTIFICATION REQUIREMENT INFORMATION
	O	S	PROCEDURES	TEST AGENCY DETAILED INSTRUCTION FOR EACH RUN
	O	R	ANALYSIS, TEST	
	O	R	TEST/ANALYSIS REPORT	FORMAL TEST OR ANALYSIS REPORT
	O	A	CERTIFICATION APPROVAL REQUEST	COVER SHEET LISTING TEST REPORTS FOR APPROVAL
R	O	R	CERTIFICATION STATUS REPORT	MONTHLY STATUS OF HARDWARE, TEST, AND DOCUMENTS
	O	R	CERTIFIED HARDWARE LIST	LIST OF CERTIFIED AND APPROVED HARDWARE

4.0 RESPONSIBILITIES, DOCUMENTATION AND CONTROLS

This section defines the basic division of responsibilities between NASA and element contractors in the planning and implementation of the Space Shuttle VV&C program. Also included is a description of the requirements for preparation, review and approval of program documentation, and the controls established to assure program objectives are accomplished in a timely and cost effective manner. These requirements are to be included in procurement specifications as appropriate for application to subcontractor and supplier support activities.

4.1 RESPONSIBILITIES

Table 4.1-1 lists the major responsibilities and associated documentation that will govern the element contractors and NASA in implementing the Space Shuttle VV&C program and in formulation of detailed verification plans. The major divisions of activity are:

a. Requirements identification - This activity involves the determination of element VV&C requirements. The SMVP is developed based on these requirements and results in assigning element contractors and Government agencies the responsibility for planning and implementing verification programs to satisfy assigned requirements. As NSTS 07700, Volume XX - Book 2, Appendix 10 requirements are assigned, requirements traceability of SSP physical and functional requirements throughout all levels of the Program shall be provided. Elements/Projects and design centers subject to the SSP baseline shall assure traceability to their respective requirement documents.

b. Planning, implementation, and evaluation - This activity includes the detailed VV&C program planning, preparation of individual test plans and procedures, implementation of the plans, and evaluation and reporting of the results. Specific documentation is discussed in Paragraph 4.2. As indicated in Table 4.1-1, each element contractor and Government agency is responsible for:

    1. Preparing required plans and procedures
    2. Implementing the approved element VV&C program
    3. Supporting element and interface tests conducted by element contractors, or Government agencies
    4. Providing required status and evaluation reports

4.1.1 VV&C Program Status

An integral part of the VV&C task is tracking and statusing the progress of VV&C activities. To accomplish this task, each contractor or Government agency will be required to

establish a system which displays the element incremental VV&C points and the constraints associated with each VV&C point, and reflects the status of the VV&C activities. A suitable approach for display of incremental VV&C points and constraints is the VV&C network. Figure 4-1-1 contains the top level VV&C network for the Shuttle system. It is to be followed by all element contractors in planning and implementing the individual element level networks and is to be used as a guide by the element contractors in the preparation of their respective plans. Top-level element networks or equivalent, plus lower level subsystem networks (reference Figure 4-1-2) are to be included in the respective verification plans. The element contractors and Government agencies will be responsible for:

a. Developing the details for all networks associated with their element

b. Maintaining these networks and statusing their VV&C activities relative to the established incremental points

Each flight element project, and L&L site, utilizes a tracking system that shows approved VV&C completion, maintains VV&C status, and documents the VV&C process. Each element will provide a SSP VV&C summary and status for their respective items for major program reviews. In addition each element contractor is responsible for contributing necessary data and documentation to support major program reviews and significant test readiness reviews. Requirements for program review documentation support are established in Paragraph 4.2.

4.2 DOCUMENTATION

The documentation established for the SSP VV&C program is identified in Table 4.2-1. The contents of each document are also summarized in the table. A primary objective of the system is to provide traceability from top level design and performance specifications, through lower tier requirements documents, down to test and/or analysis data which supports VV&C of those requirements. This traceability begins with NSTS 07700, Volume XX - Book 2, Appendix 10, Table 4.1, and continues into element specifications, as applicable, where the system and element level design requirements are documented. Requirements for VV&C of each of these specifications are documented in the appropriate volume of the SMVP (Volumes II through VI and VIII) where the VV&C method is established based upon the guidelines provided in this volume of the SMVP. The VV&C requirements are expanded and grouped into individual requirements documents according to implementation method, (i.e., major ground test, flight test, acceptance test and checkout, etc.). These requirements documents form the basis and justification for the combined element and element level test programs. Implementation of these programs is carried out through subservient detailed requirements, plans, and procedures as identified in the table. Data from these programs is utilized to obtain VV&C status. Those program elements performing SSP closeout

activities will be responsible for the preparation of the appropriate volume of the SMVP and associated lower level documents. Table 4.2-2 summarizes documentation requirements for major program reviews. Copies of all element certification data shall be retained.

4.3 CONTROLS

A number of controls are established which are to be reflected in the verification plans developed by each element contractor. These controls which represent specific conditions and constraints are exercised through the documentation system.

4.3.1 Documentation Controls

VV&C documentation control shall be in accordance with NSTS 07700, Volume XX - Book 2, Appendices 04 and 05. Particular emphasis must be placed on VV&C documentation change control. Each VV&C requirement, regardless of the level (e.g., component, subsystem element) will be identified with an approved source. Specific requirements to be satisfied will be identified in each implementation plan. Approved changes to design/performance requirements will have a corresponding approval of VV&C requirement changes. Approval will also be necessary to acknowledge that VV&C requirements are not affected by the design changes.

4.3.2 Implementation Controls

In addition to documentation, controls have been established regarding implementation of verification plans. Readiness reviews are scheduled prior to the start of major tests or test series. The primary objectives are to confirm that all constraints have been removed and that, based on all available data, there is reasonably high confidence in achieving test objectives. The element contractor will schedule the readiness review for individual element and major subsystem tests. Final authority to proceed (readiness approval) shall be furnished by NASA.

4.4 DEVIATION/WAIVER (D/W) GUIDELINES

The following guidelines will be utilized for processing D/Ws to the MVP turnaround checkout criteria (reference Paragraph 3.7.3) relative to all Criticality 1, 1R, 1S, 2, or 2R hardware items:

a. A critical function, whose requirement for checkout is not documented program-level documents, in accordance with the MVP turnaround checkout philosophy, shall require a waiver to the MVP from the responsible design project office. CIL retention rationale may be used in lieu of an MVP waiver.

b. A critical function, which is not checked out because the testing would be invasive, illogical, or limited by design, must have an approved CIL properly stating the processing requirements. In this event, a waiver to the MVP is not required.

c. Approved waivers to the MVP will reference the applicable FMEA number and will be documented in the appropriate document, FMEA cross reference matrix in applicable file(s) and on specific intent and rationale sheets if applicable.

D/Ws are not required for Criticality 3 functions.

TABLE 4.1-1

VV&C PROGRAM RESPONSIBILITIES

Test Program	Activity	NASA		Element Contractor	Document Title
		Program Office	Project Office		
System element verification	Requirement identification	Approve system-level requirements document	Approve element-level requirements document	Define and allocate element-level require-ments (SMVP Volumes III, VI, and VIII	Shuttle Master Verification Plan Volume I, General Approach and Guidelines Volume III, Orbiter Verification Plan Volume VI, ME Verification Plan Volume VIII, Launch and Landing Site Verification Plan
	Planning implementation and evaluation	Approve system-level plans	Approve element-level plans Prepare SMVP Volume VIII (KSC)	Prepare element-level verification plans (SMVP Volumes III, VI, and VIII)	
		Review system-level reports	Review element-level reports	Support system-level verification analysis and prepare element-level verification analysis reports	Verification Analysis Reports
Subsystem certification	Requirements identification		Approve Requirements document	Define requirements	Subsystem Certification Plans
	Planning implementation and evaluation	Review plans	Approve plans	Prepare certification plans	
			Selected test procedure approvals	Prepare test procedures	Certification Test Procedures
				Conduct test readiness reviews	
			Selected test surveillance	Conduct test	

TABLE 4.1-1

VV&C PROGRAM RESPONSIBILITIES - Continued

Test Program	Activity	NASA		Element Contractor	Document Title
		Program Office	Project Office		
Subsystem certification (cont)	Planning imple-mentation and evaluation (cont)	Monitor system certification status	Review reports and provide certification approval. Provide monthly status reports to system contractor and Program Office	Perform analysis and prepare reports. Prepare status reports and provide monthly certification status to Project Office	Certification Status Reports Certified Hardware List
Element acceptance test	Requirements identification	Review interface related acceptance requirements	Approve requirements document	Define requirements	Test and Checkout Requirements Document
	Planning implementation and evaluation	Review	Approve plans	Prepare element-level plans	Acceptance Checkout Plans
			Approve selected procedures	Prepare test procedures	TCP
			Provide integrated test readiness approval	Conduct ground test readiness reviews	
			Conduct acceptance FRRs	Support	
			Provide test director function	Conduct ground tests	
			Perform acceptance flight	Support	

TABLE 4.1-1

VV&C PROGRAM RESPONSIBILITIES - Concluded

Test Program	Activity	NASA		Element Contractor	Document Title
		Program Office	Project Office		
Element acceptance test (cont)	Planning implementation and evaluation (cont)		Perform analysis and review reports	Perform data reduction and analysis and prepare reports	Test Summary Reports
			Provide acceptance approval	Conduct post-test acceptance readiness reviews	

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TABLE 4.2-1

DOCUMENTATION CONTENT SUMMARY

Document Title (*Generic Titles)	Contents
Requirements	
Shuttle Master Verification Plan Volume I General Approach and Guidelines	Overall approach to Shuttle system verification. Verification program guidelines. Program responsibilities, documentation, and control. Test Program summary.
Shuttle Master Verification Plan Volumes III, VI and VIII Element Verification Plans	Verification programs applicable to individual elements. Element-level requirements and planning information. Prepared by each element contractor.
Shuttle Master Verification Plan Volume X Master Flight Test Assignments Document	Flight verification requirements for complete Shuttle Vehicle and transport aircraft.
*Subsystem Certification Requirements and Plans	Detailed element subsystem certification requirements and resolution methods. Subsystem component certification requirements and methods. Individual plan for each subsystem.
*Major Ground Test Requirements Documents	Verification requirements to be satisfied by a major ground test program. Test article configuration. Separate documents for each major ground test program.
*Acceptance Test and Checkout Requirements Document	Element factory acceptance checkout requirements with pass/fail limits. General requirements for retest, quality assurance, and safety.

TABLE 4.2-1

DOCUMENTATION CONTENT SUMMARY - Continued

Document Title (*Generic Titles)	Contents
Test requirements and Specification Document for Orbiter Approach and Landing Test	Defines the mandatory test and checkout requirements to be accomplished during the ALT program at FRC.
Approach and Landing Test Requirements Document	Verification requirements to be satisfied during ALT program. Orbiter flight configuration. Instrumentation requirements.
Preflight Test Requirements and Specification Document for Orbital Flight Test	Detailed turnaround and prelaunch checkout requirements for Shuttle system and each element to be satisfied prior to orbital flight.
Orbital Flight Test Requirements Document	Combined element and element verification requirements to be satisfied in flight during OFT program.
GSE Station Set Specification, Section 4.0	Verification requirements for each station set. Applies to both combined elements and single elements.
Plans	
*Major Test Article Plans	Implementation plan to satisfy verification requirements specified in major ground test requirements documents. Test logic, constraints, objectives, and test schedules.
*Acceptance/Checkout Plans	Implementation plan to satisfy requirements specified in acceptance test and checkout requirements document. Identify acceptance checkout procedures to be performed on each end item.

TABLE 4.2-1

DOCUMENTATION CONTENT SUMMARY - Continued

Document Title (*Generic Titles)	Contents
Ground Operations Plan Approach and Landing Test (Part of Shuttle System Ground Operations Plan)	Implementation plan to satisfy the preflight checkout requirements. Routine maintenance and checkout operations prior to each flight.
Approach and Landing Test Plan (draft)	Contractor's recommended overall approach to accomplishment of test program. Summary description of proposed test flights. Overall schedule and contractor's supporting roles to NASA. Official plan published by NASA.
System Integrated and Element Ground Operations Plans - Orbital Flight Test (Part of Shuttle System Ground Operations Plan)	Detailed planning of Shuttle system (and elements) ground operations for OFT. Test and checkout functions associated with preparation of each element for mating and preparation of Shuttle stack for flight.
Shuttle System Orbital Flight Test Plan (draft)	Overall objectives, logic, guidelines, test schedules, and support requirements. Official plan published by NASA.
*Test Facility Activation/ Deactivation Plans	Objectives, responsibilities, activities, and schedules for activation and deactivation of facilities and GSE for major test articles, ALT, and OFT. Implementation plan to satisfy requirements in Section 4.0 of GSE Station Set Specification.
Implementing Procedures	
*Certification Test Procedures	Step-by-step sequential operations to be performed in conducting subsystem certification tests. Procedure requirements established in Subsystem Certification Plans.

TABLE 4.2-1

DOCUMENTATION CONTENT SUMMARY - Continued

Document Title (*Generic Titles)	Contents
*Development Test Procedures	Step-by-step sequential operations to be performed in conducting major ground tests. Procedure requirements established in individual major ground test plans.
*Element and Combined Element Test and Checkout Procedures	Step-by-step sequential operations to be performed in conducting factory checkout and acceptance and preflight ground checkout. Success criteria.
*Detailed Flight Test and Mission Plans	Sequence of operations to be performed in conducting flight portion of ALT and OFT program. Prepared by NASA for each flight. Requirements established by ALT and OFT requirements document.
Reports	
*Certification Status Reports	Progress and status of subsystem certification activities. Reflects accomplishments and planned activities relative to program schedules.
*Test Reports	Results of major ground tests and flight test with emphasis on summarizing degree of compliance with specification requirements. Prepared at conclusion of each major test or sequence of tests.
*Test Summary Reports	Brief report summarizing results from each test performed in accordance with approved test procedure. Summarize compliance with specification requirements.

TABLE 4.2-1

DOCUMENTATION CONTENT SUMMARY - Concluded

Document Title (*Generic Titles)	Contents
Analysis Verification Reports	Results of specific verification analysis activity. Prepared at conclusion of each major analysis activity or series of related analyses.
Verification Status Reports	Reports provided by each element contractor to their respective project office and the system contractor and by the system contractor to the program office semiannually. Additional status reports to be provided to support major program and test readiness reviews. These reports will provide incremental status of the element and system verification activity, including problem areas.
Lists	
Certified Hardware/GSE Lists	Formal listing of certified hardware or GSE.

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TABLE 4.2-2

DOCUMENTATION REQUIREMENTS FOR MAJOR PROGRAM REVIEWS

Item Description	Element Contractor Responsibility by Review Milestone				Remarks
	SRR	Element PDR	Element CDR	Major Test Readiness Reviews	
Shuttle System Specification	Updated preliminary draft for approval	Subsequent updates as required			NASA approval and control post-SRR
Element CEI Specification	(Orbiter) (Part 1) Preliminary draft for review	(Part 1) updated draft for approval / (Part 2) Preliminary draft for review	(Part II) Approval and control	Subsequent updates as required	NASA approval and control post-PDR for Part 1
Shuttle Master Verification Plan	Updated preliminary draft of Volumes I and II for approval Preliminary draft of Volume III for review	Updated Volumes I and II; Volumes III and subsequent volumes for approval	Subsequent updates as required		NASA approval and control post-SRR for Volumes I and II; Volumes III and subsequent volumes post-PDR
Major Ground Test Requirements Documents		Updated draft for review	Subsequent update as required		Incremental review to support individual test programs
Acceptance Test and Checkout Requirements Documents		Initial draft for review	Review and approval		Subsequent updates as required
Subsystem Certification Requirements and Plans		Preliminary draft for review			*Updates as necessary before implementation
Certification Reports				Review and approval	
Preflight Test Requirements and Specification Document - Ferry/ALT/OFT			Initial submittal of OFT checkout requirements ALT checkout requirements 6 months before CDR		Subsequent updates as required
Approach and Landing and OFT Requirements and Documents	Initial draft for review	Preliminary draft for review	Subsequent updates as required		
GSE Station Set Specification	Updated draft for review	Subsequent updates as required			

NOTE: Item descriptions in the matrix are provided for NASA review, approval, and control. Those descriptions identified by milestone activity as requiring effort other than approval and control are provided as data supplements for that milestone.

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FIGURE 4-1-1

SHUTTLE SYSTEM VERIFICATION NETWORK

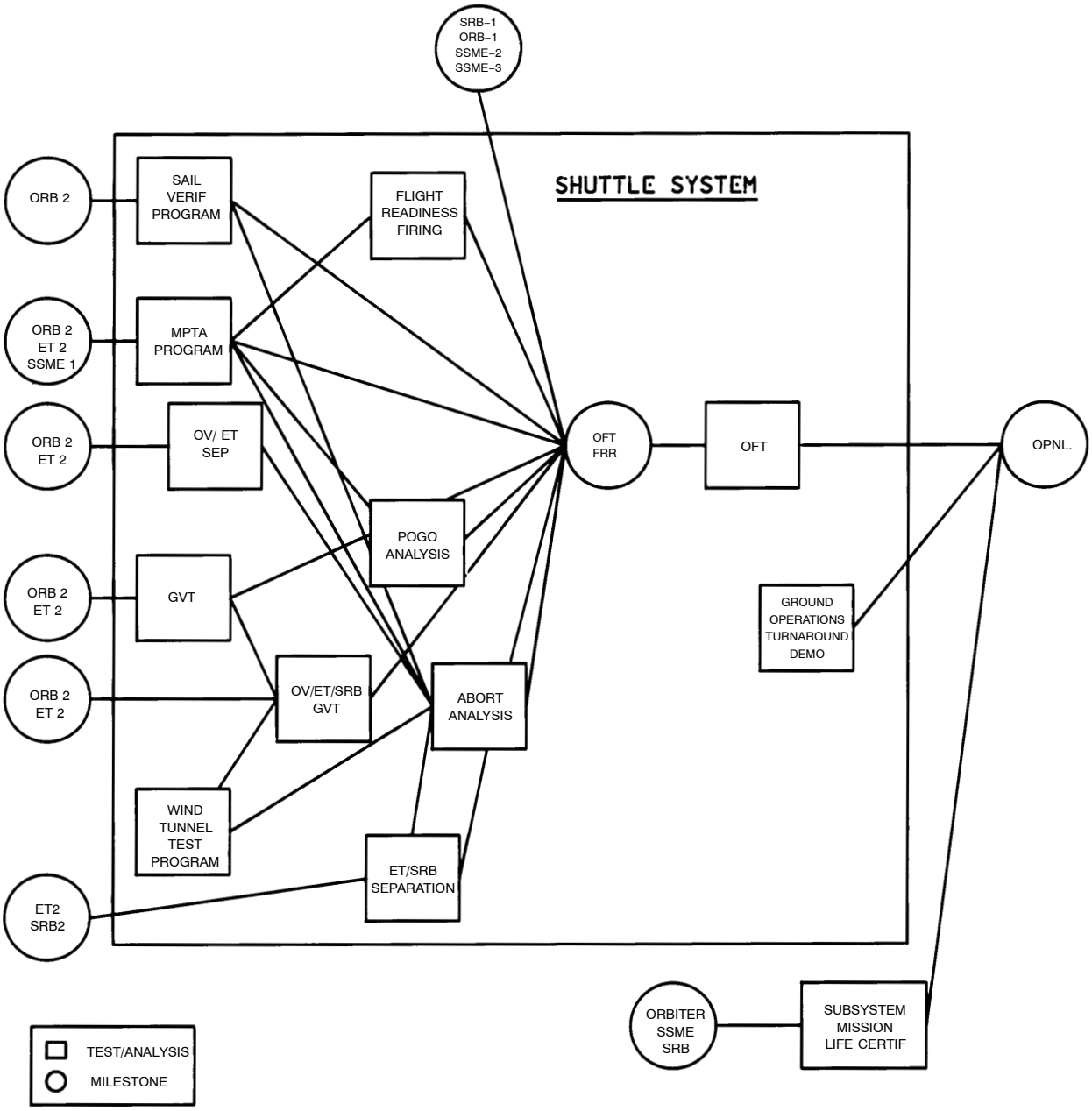


FIGURE 4-1-1a

SHUTTLE SYSTEM VERIFICATION NETWORK (ORB AND SPACE SHUTTLE MAIN ENGINE [SSME])

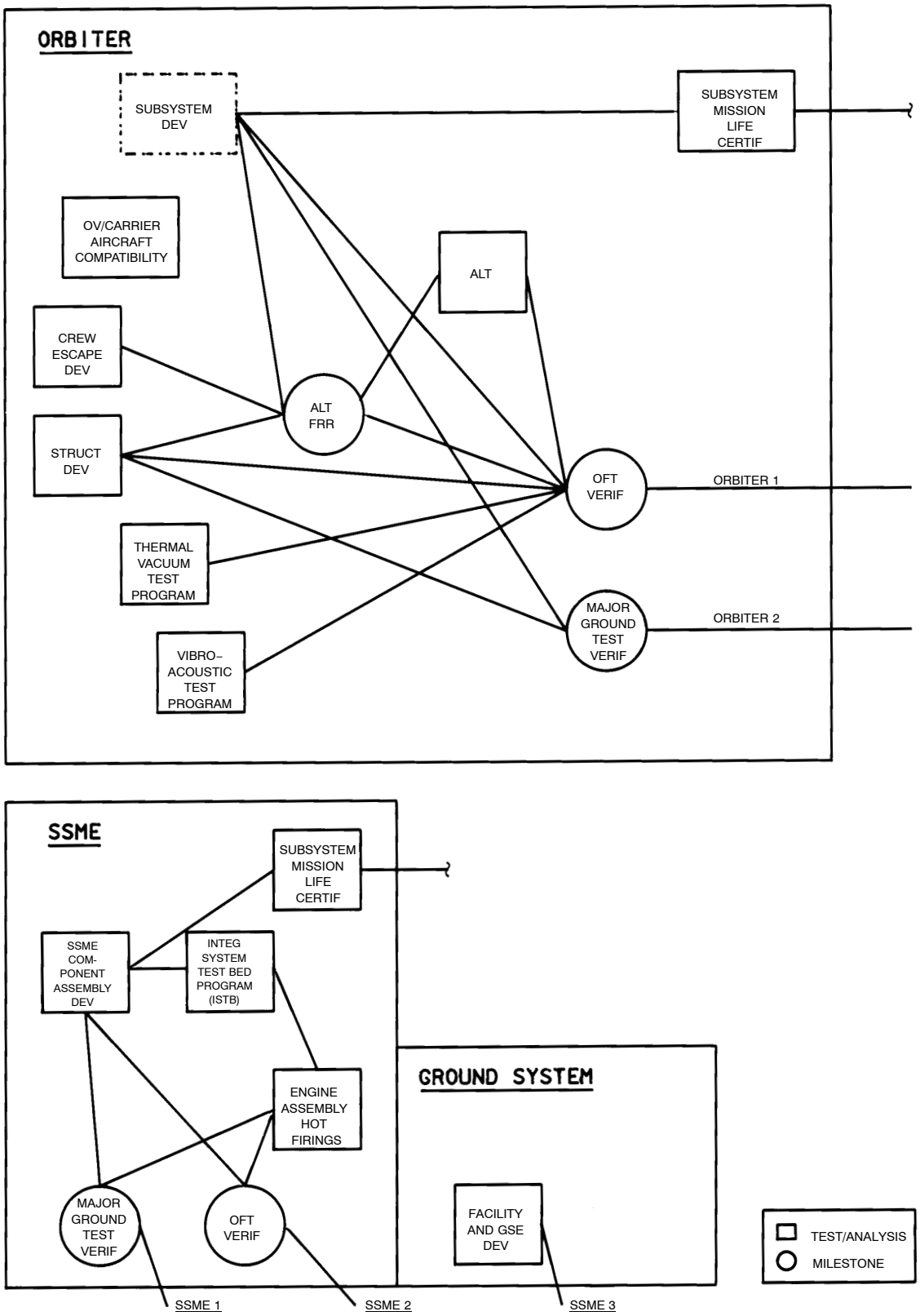


FIGURE 4-1-2

ORBITER VERIFICATION NETWORK

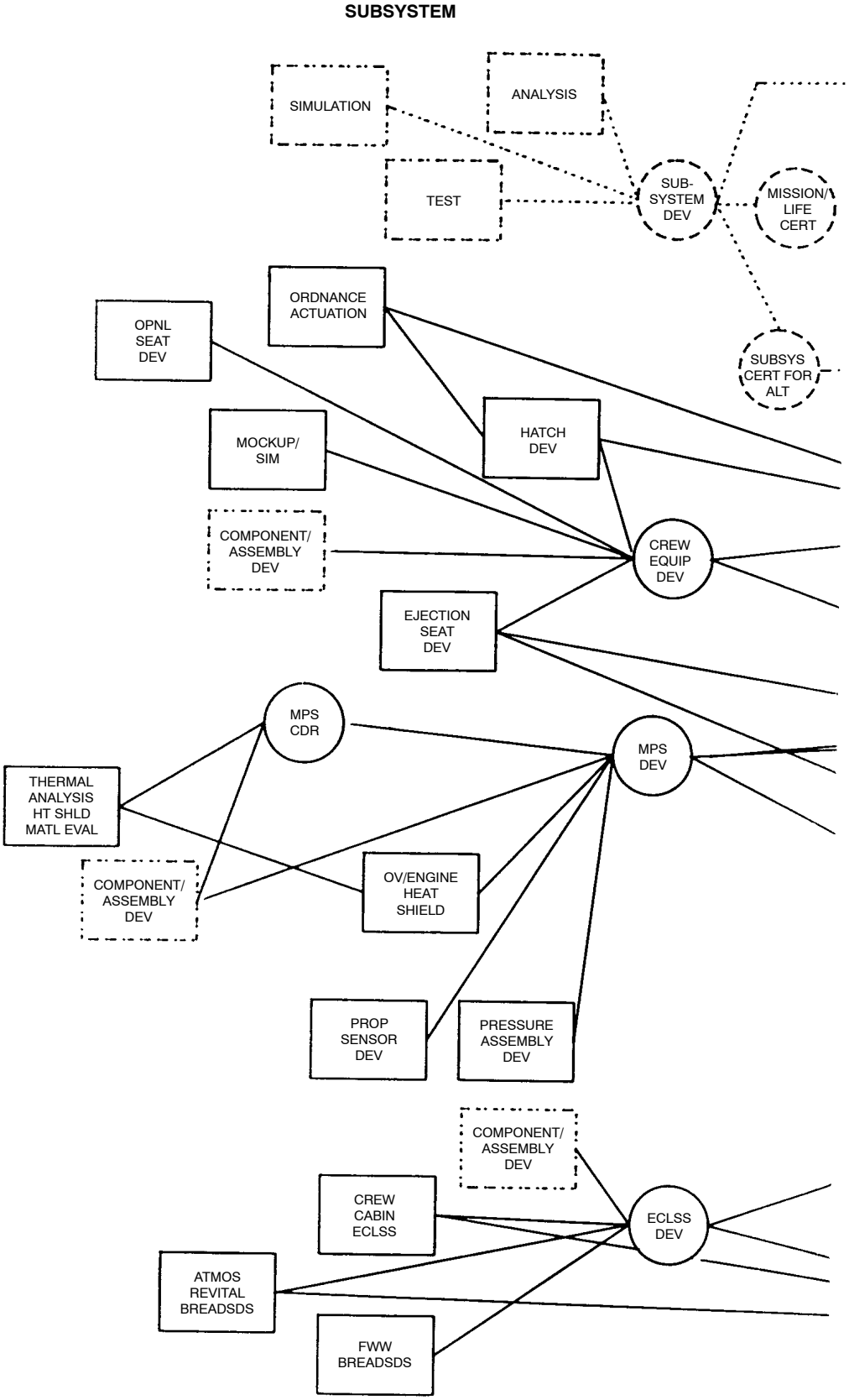


FIGURE 4-1-2a

ORBITER VERIFICATION NETWORK

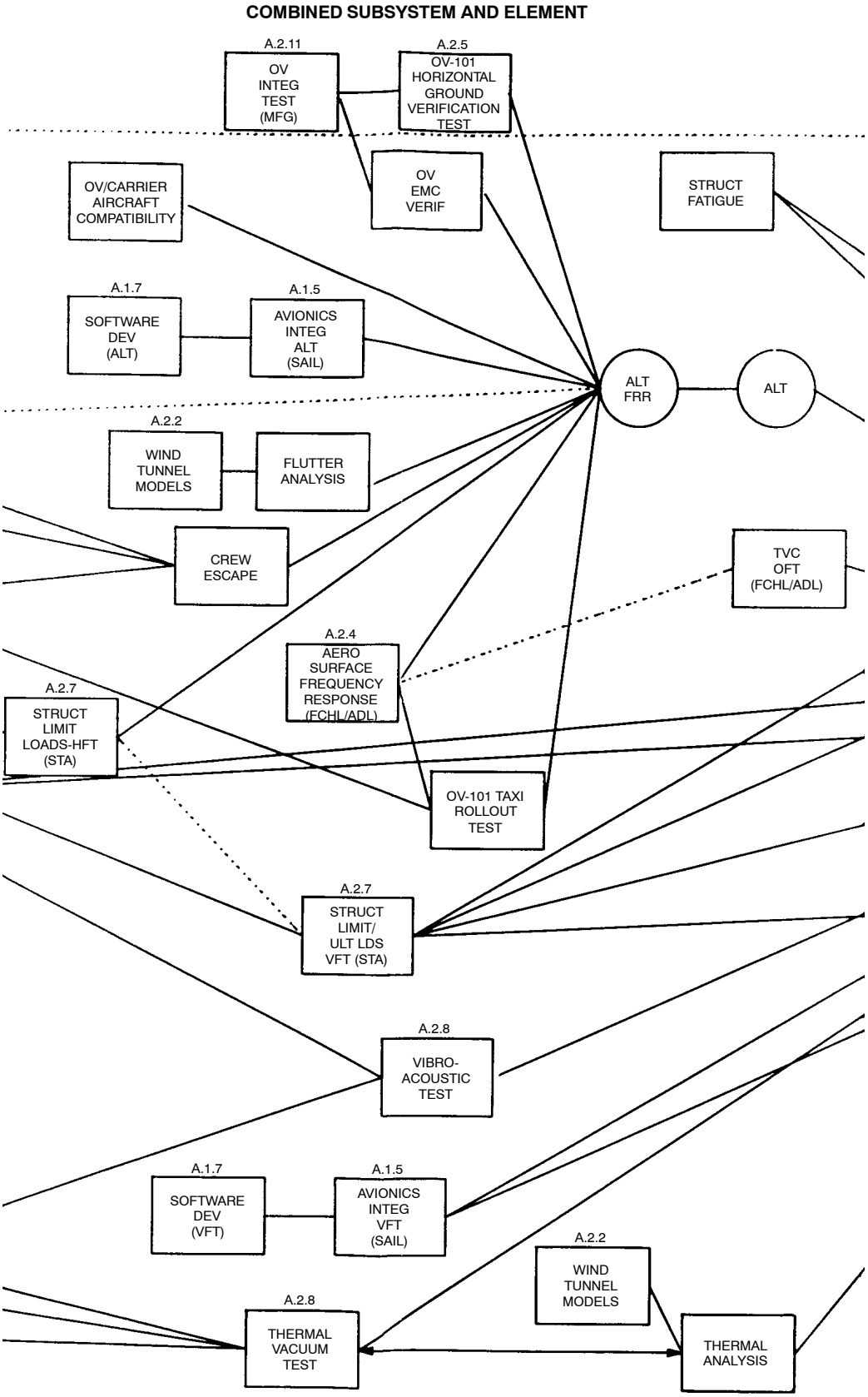
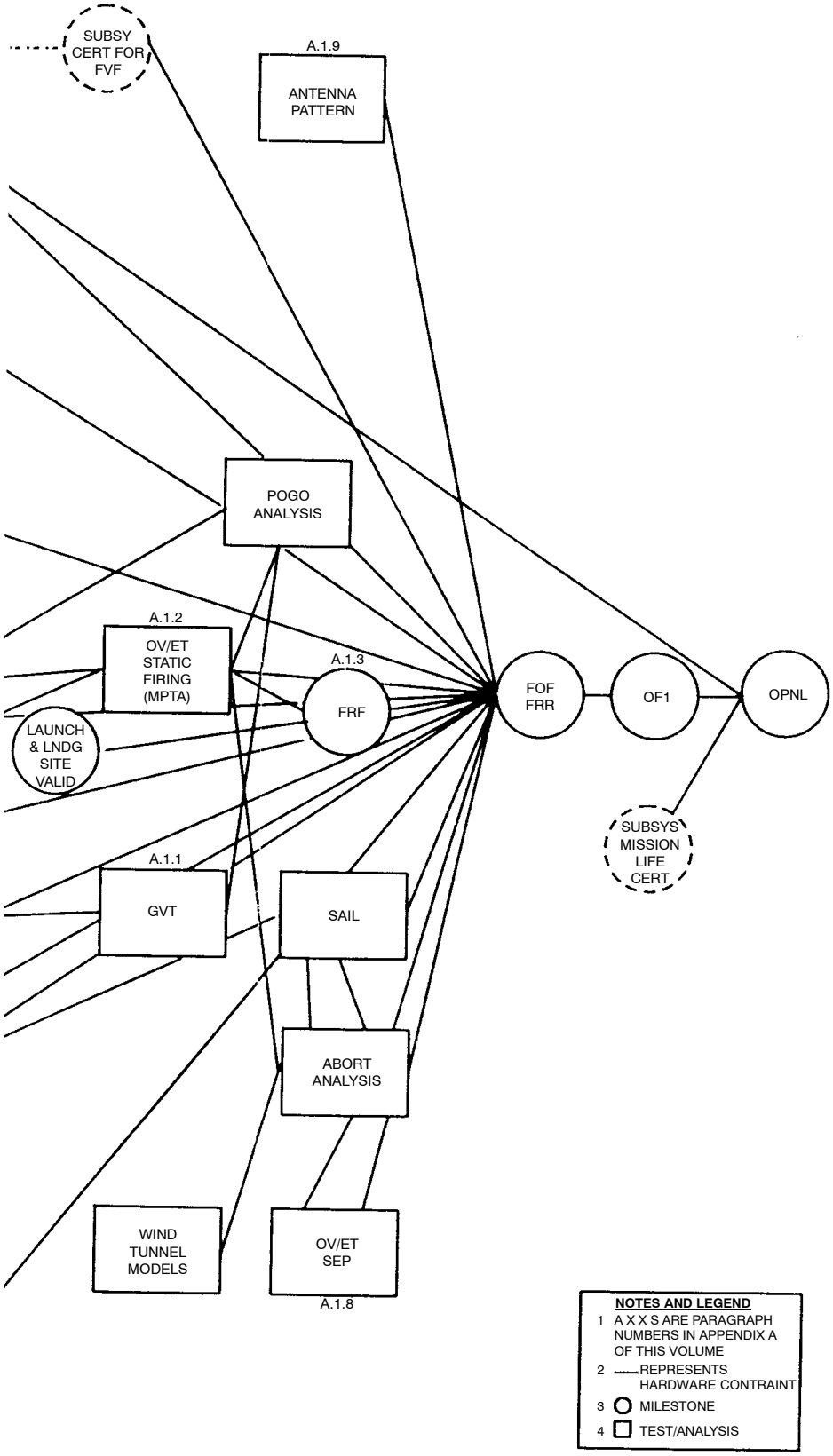


FIGURE 4-1-2b

ORBITER VERIFICATION NETWORK

COMBINED ELEMENT



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APPENDIX A

SHUTTLE SYSTEM AND ELEMENT TEST PLAN SUMMARY

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APPENDIX A

SHUTTLE SYSTEM AND ELEMENT TEST PLAN SUMMARY

Refer to NSTS 07700-10-MVP-01 - Books 1 and 2
for legacy program system and element test plan summaries

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APPENDIX B

SMVP DEFINITIONS

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APPENDIX B

SMVP DEFINITIONS

Acceptance Testing - Tests to determine that a part, component, subsystem, or system is capable of meeting performance requirements prescribed in purchase specification or other documents specifying what constitutes the adequate performance capability for the item in question.

Assessment - A verification method employing inspection and/or review of design techniques to verify design features which are impossible to verify by test methods-features such as finishes, tolerances, bonding, identification and traceability, safety wiring, warning and servicing labels, bill of materials, etc.

Certification - A formal documentation of the verification and validation results. Certification requires review and assessment of verification and validation records by a certifying authority. A certification authority may impose additional inspection, test, analysis, or demonstration activities to close any gaps in requirements.

Checkout - An operation accomplished by ground or flight testing which provides a quantitative measurement of system performance for comparison to predefined specification limits.

Design, Development, Test and Evaluation (DDT&E) - The DDT&E phase of the Shuttle including ALT and the initial earth orbital development flights.

Development Testing - That testing performed with minimum rigors and controls to verify a design approach.

Flight Demonstration - Validation of the performance of the flight vehicles under predetermined flight conditions.

Flight Simulation Support - The utilization of ground systems during DDT&E to support vehicle flight simulations to provide validation of total system performance prior to launch.

Functional Paths - A serial set of one or more functional elements (e.g., LRUs) constrained by the following:

a. It is either the only path capable of performing the given function, or it is the smallest set (shortest string) of serial elements for which identical or similar serial elements can be substituted by automatic or manual control (onboard or via GSE) to perform the same function via a redundant path for fail safe or fail operational capability.

b. The string may contain non-controllable redundancies within itself to assure a satisfactory MTBF for the string (e.g., redundant components within an LRU), but must not contain redundancies needed to provide fail operational or fail safe capabilities.

c. Any point along a path which supports several “downstream” paths must constitute the termination point of the “up-stream” functional path and the starting point of “downstream” functional paths.

GSE Station Set - The GSE and associated software to provide overall ground support to a specific activity or phase of vehicle assembly, test or launch.

Illogical or Invasive Testing - Illogical testing may involve a level of risk greater than the gain in confidence provided by an each flight validation/checkout of the function. Additionally, there may be cases where hardware design prohibits validation during ground or flight tests, or for some other reason such validation or checkout is considered illogical.

Inherent Flight Software - That flight software which can be utilized to support ground testing without modifications, except constants and limits, which will not affect flight software sequence execution or timing.

Integrated Vehicle Level - The Orbiter or Shuttle Vehicle configuration which includes all subsystems planned for a particular test location.

Item - With respect to the verification and validation definitions, the scope of an item can be anything from a single component to an entire system.

Life Test - A test structured to validate that design life requirements have been met.

Limit Load - The maximum load expected on the structure during mission operation, including intact abort. For statistical purposes, limit loads will be based on NASA approved criteria.

Major Ground Tests - Those ground tests which involve the combination of system elements, complex facilities, large or expensive hardware segments or a combination of the above.

Maximum Operating Pressure - The maximum pressure applied to a pressure vessel by the pressurizing system with the pressure regulators and relief valves at their upper limit and with the maximum regulator fluid flow rate.

Off-Limit Overstress Conditions - The levels above design limit conditions to which an item may be subjected by testing to obtain additional information and engineering confidence. The off-limit or overstress condition may be environmental, load or time depending upon the particular test mode.

Operating Life - The maximum operating time/cycles which an item can accrue before replacement refurbishment without risk of degradation of performance beyond acceptable limits.

Pre-Installation Tests - Tests performed on hardware just before installation in a higher level of assembly to re-verify compliance with functional requirements.

Proof Factor - A multiplying factor applied to limit (maximum operating) pressure to obtain proof pressure.

Proof Pressure - The pressure to which components are subjected to fulfill the acceptance requirements of the specification in order to give evidence of satisfactory workmanship and material quality, and to establish the maximum undetected flaw size in a pressure vessel. Proof pressure is the product of maximum operating pressure times the proof factor.

Proof Test - A structural test generally conducted on pressure vessels, miscellaneous structural components, structural assemblies or mechanisms to ensure confidence in the manufactured article.

Qualification Tests - Those tests conducted as part of the certification program to demonstrate that design and performance requirements can be realized under specified conditions.

Shuttle System Elements - Those elements which, when combined, form the Shuttle system. As discussed in this document, these elements consist of the following: Orbiter, SRB, ET, Main Engine (ME), and Payloads and Payloads Carriers.

Special Design Validation Support - The utilization of specialized programs and procedures for detailed evaluation, emulations, or simulations to provide vehicle design validation assurance during early checkout operation.

Stimuli Capability - That capability built into the Orbiter design for mission operations and checkout which is accessible to the ground via the ground command decoders and onboard computer systems to set discrete functions and vary analog and digital stimuli.

Ultimate Load - The product of the limit load multiplied by the ultimate factor of safety. It is the maximum load which the structure must withstand without rupture or collapse. Ultimate Factor of Safety - The factor by which the limit load is multiplied to obtain the ultimate load.

Validation - Determination that an item meets its intended purpose in its operating environment. For models/analysis tools, design environments and simulations, validation is the determination that the item accurately reflects the subject being modeled (i.e., it is a valid model or database). For software, validation also is the determination that requirements are correct and complete (i.e., it is a valid requirement).

Verification - Determination that an item meets its requirements.

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