National Aeronautics and
Space Administration

NSTS 07700–10–MVP–01
REVISION D
NOVEMBER 5, 1993

Lyndon B. Johnson Space Center
Houston, Texas 77058

REPLACES
NSTS 07700–10–MVP–01
REVISION C

SPACE SHUTTLE

SHUTTLE MASTER VERIFICATION PLAN

VOLUME I
GENERAL APPROACH AND GUIDELINES

REVISION LOG

REV LTR	CHANGE NO	DESCRIPTION	DATE
		BASELINE ISSUE (Reference: Level II PRCBD SS00035)	4/27/73
A	1	REVISION A (Reference: Level II PRCBD S00610) also includes PRCBD S00716, dated 6/18/74.	7/26/74
B	26	REVISION B (Reference: Level II PRCBD S40129, dated 7/23/86) also includes PRCBD S40349 and Changes 2 thru 25.	11/24/86
C	29	REVISION C (Reference: Level II PRCBD S40465R2, dated 9/18/87) also includes Changes 27 and 28.	9/22/87
D	54	REVISION D (Reference: SSP DOC–130, dated 9/1/93) also includes S004600F, S004600G, S004600J, S052730A, S071024NR1, SSP DOC–057, SSP DOC–064, SSP DOC–106, SSP DOC–123 and Changes 30 thru 53.	11/05/93

CHANGE SHEET

FOR

PROGRAM DEFINITION AND REQUIREMENTS
SHUTTLE MASTER VERIFICATION PLAN
VOLUME I - General Approach and Guidelines

CHANGE NO. 77

Program Requirements Control Board Directive Nos. S002130L/(1-1), dated 5/11/01; S002130M/(3-1), dated 4/26/01; S061691/(2-1), dated 5/9/01 and SSP DOC-501.(3)

May 21, 2001

Robert H. Heselmeyer
Secretary, Program Requirements
Control Board

CHANGE INSTRUCTIONS

1. Remove the following listed Deviation/Waiver (D/W) pages and replace with the same numbered attached D/W pages:

D/W Page	PRCBD No.
(vii)	S061691
(viii)	
(45)	S061691
(46)	

2. Remove the following listed pages and replace with the same numbered attached pages:

Page	PRCBD No.
v	
vi	S002130L
2-3	
2-4	S002130M

3-5	
3-6	S061691
3-13	S002130L, SSP DOC-501
3-14	S002130L
3-14A - 3-14D (Add)	S002130L
3-15	S002130M
3-16	
3-17	SSP DOC-501
3-18	S002130L
3-18A - 3-18D (Add)	S002130L
3-19 - 3-20	S002130L

NOTE: A black bar in the margin indicates the information that was changed.

3. Remove the List of Effective Pages, dated April 25, 2001 and replace with List of Effective Pages, dated May 21, 2001.

4. Sign and date this page in the space provided below to show that the changes have been incorporated and file immediately behind the List of Effective Pages.

____________________________________ __________
Signature of person incorporating changes — Date

PROGRAM DEFINITION AND REQUIREMENTS
SHUTTLE MASTER VERIFICATION PLAN
VOLUME I - General Approach and Guidelines

*REVISION D (Reference PRCBD Nos. S004600F, dated 10/9/92; S004600G, dated 6/23/93; S004600J, dated 10/21/93; S052730A, dated 10/20/93; S071024NR1, dated 3/6/92; SSP DOC-057; SSP DOC-064; SSP DOC-106; SSP DOC-123 and SSP DOC-130)

LIST OF EFFECTIVE PAGES

May 21, 2001

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

Page No.	Change No.	PRCBD No.	Date
(i) - (iv)	Rev. D	*	November 5, 1993
(v)	71	SSP DOC-459	March 13, 2000
(vi)	72	S061468	May 22, 2000
(vii)	77	S061691	May 9, 2001
(viii)	72	S061468	May 22, 2000
(1) - (29)	Rev. D	*	November 5, 1993
(30) - (32)	71	SSP DOC-459	March 13, 2000
(33)	74	S061366R3	September 11, 2000
(34)	71	SSP DOC-459	September 11, 2000
(35)	71	S061444	April 13, 2000
		SSP DOC-459	March 13, 2000
(36)	72	S061468	May 22, 2000
(37)	73	S061491	June 28, 2000
(38)	74	S061546	September 5, 2000
(39)	74	S061546	September 5, 2000,
		S071934A	September 5, 2000
(40) - (41)	76	S061509AR2	April 4, 2001
(42)	75	S063132N	February 28, 2001
(43) - (44)	76	S002130K	April 16, 2001
(45)	77	S061691	May 9, 2001
(46)	76	S002130K	April 16, 2001
i	Rev. D	*	November 5, 1993
ii	56	S052558E	July 29, 1994
iii	56	SSP DOC-260	May 16, 1995
iv - v	Rev. D	*	November 5, 1993
vi	77	S002130L	May 11, 2001
vii - viii	Rev. D	*	November 5, 1993
ix	56	S060618	June 12, 1995
x	Rev. D	*	November 5, 1993

LIST OF EFFECTIVE PAGES

May 21, 2001

Page No.	Change No.	PRCBD No.	Date
1-1 - 1-4	Rev. D	*	November 5, 1993
2-1 - 2-2	Rev. D	*	November 5, 1993
2-3	67	S094902D	October 12, 1999
2-4	77	S002130M	April 26, 2001
2-5 - 2-6	57	SSP DOC-296	February 16, 1996
2-7 - 2-10	Rev. D	*	November 5, 1993
3-1	Rev. D	*	November 5, 1993
3-2	56	S060561	June 13, 1995
3-3 - 3-5	Rev. D	*	November 5, 1993
3-6	77	S061691	May 9, 2001
3-7 - 3-12	Rev. D	*	November 5, 1993
3-13	77	S002130L	May 11, 2001,
		SSP DOC-501	May 16, 2001
3-14 - 3-14D	77	S002130L	May 11, 2000
3-15	77	S002130M	April 26, 2001
3-16	63	S060935	August 12, 1997
3-17	77	SSP DOC-501	May 16, 2001
3-18 - 3-20	77	S002130L	May 11, 2001
3-21 - 3-26	75	S060614CE	March 6, 2001
3-27 - 3-35	Rev. D	*	November 5, 1993
3-36	56	S060618	June 12, 1995
3-37 - 3-38	Rev. D	*	November 5, 1993
4-1	Rev. D	*	November 5, 1993
4-2 - 4-3	58	SSP DOC-307	May 9, 1996
4-4 - 4-24	Rev. D	*	November 5, 1993
A-1 - A-2	Rev. D	*	November 5, 1993
A-3	56	S071024BT	December 30, 1994
A-4 - A-6	Rev. D	*	November 5, 1993
A-7	65	S014503AD	August 14, 1998
A-8	Rev. D	*	November 5, 1993
A-9	73	S061461	June 19, 2000
A-10 - A-24	Rev. D	*	November 5, 1993
B-1 - B-6	Rev. D	*	November 5, 1993
C-1 - C-22	Rev. D	*	November 5, 1993
C-23 - C-25	67	S094902D	October 12, 1999
C-26 - C-30	71	SSP DOC-459	March 13, 2000

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. Deviations/Waivers to these requirements that were approved prior to the STS 51–L accident have been rescinded and are retained in Appendix C of this volume for historical purposes.

THIS PAGE INTENTIONALLY LEFT BLANK

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

Number	Title	Para. No.	Page
1.	Rescinded (Reference Level II PRCBD S40019R3, dated 8/26/87)	Apx C	(1)
2.	Rescinded (Reference Level II PRCBD S40019R3, dated 8/26/87)	Apx C	(1)
3.	Rescinded (Reference Level II PRCBD S40019R3, dated 8/26/87)	Apx C	(1)
4.	Rescinded (Reference Level II PRCBD S40019R3, dated 8/26/87)	Apx C	(1)
5.	Rescinded (Reference Level II PRCBD S40019R3, dated 8/26/87)	Apx C	(1)
6.	Rescinded (Reference Level II PRCBD S40019R3, dated 8/26/87)	Apx C	(1)
7.	Retired per Change Action Request (Reference Level II PRCBD S41230ZR3, dated 3/27/89)	Apx C	(1)
8.	Retired per Change Action Request (Reference Level II PRCBD S60154R9, dated 4/27/89)	Apx C	(1)
9.	Retired per Change Action Request (Reference Level II PRCBD S076233R3, dated 3/26/90)	Apx C	(1)
10.	Retired per Change Action Request (Reference Level II PRCBD S76349, dated 11/15/88)	Apx C	(1)
11.	Retired (Reference Level II PRCBD S50751, dated 8/15/89)	Apx C	(1)
12.	Acceptance Test (Reference Level II PRCBD S02130G, dated 2/14/89)	3.6.14 I.3(c).(2), 3.7.1j	(1)
13.	Acceptance Criteria (Reference Level II PRCBD S02130H, dated 3/7/89)	3.7.1j	(3)
14.	Acceptance Criteria (Reference Level II PRCBD S98463, dated 3/11/89)	3.7.1j	(7)
15.	Turnaround Checkout Requirements (Reference Level II PRCBD S50866, dated 10/31/89)	3.7.3a.1, 3.7.3b.1	(7)

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

Number	Title	Para. No.	Page
16.	Turnaround Checkout Requirements (Reference Level II PRCBD S76616A, dated 12/20/89)	3.7.3a.2	(9)
17.	Turnaround Checkout Requirements (Reference Level II PRCBD S76656, dated 1/12/90)	3.7.3a.2	(10)
18.	Turnaround Checkout Requirements (Reference Level II PRCBD S76656, dated 1/12/90)	3.7.3b.2	(13)
19.	Turnaround Checkout Requirements (Reference Level II PRCBD S76675, dated 1/15/90)	3.7.3a.1, 3.7.3a.2	(15)
20.	Retired per Change Action Request (Reference Level II PRCBD S061531L, dated 5/3/90)	Apx C	(16)
21.	Turnaround Checkout Requirements (Reference Level II PRCBD S052151, dated 7/19/90)	3.7.3a.2	(16)
22.	Turnaround Validation/Checkout Requirements (Reference Level II PRCBD S076984, dated 3/14/91)	3.7.3a.2	(17)
23.	Turnaround Validation/Checkout Requirements (Reference Level II PRCBD S076984A, dated 3/14/91)	3.7.3a.2	(18)
24.	Turnaround Validation/Checkout Requirements (Reference Level II PRCBD S076984B, dated 3/14/91)	3.7.3a.2	(19)
25.	Turnaround Validation/Checkout Requirements (Reference Level II PRCBD S076984C, dated 3/14/91)	3.7.3a.2	(20)
26.	Turnaround Validation/Checkout Requirements (Reference Level II PRCBD S076984D, dated 3/14/91)	3.7.3a.2	(21)

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

Number	Title	Para. No.	Page
27.	Turnaround Validation/Checkout Requirements (Reference Level II PRCBD S076984E, dated 3/18/91)	3.7.3a.2	(23)
28.	Turnaround Validation/Checkout Requirements (Reference Level II PRCBD S076984F, dated 3/18/91)	3.7.3a.2	(24)
29.	Turnaround Validation/Checkout Requirements (Reference Level II PRCBD S076984G, dated 3/14/91)	3.7.3a.2	(25)
30.	Turnaround Validation/Checkout Requirements (Reference Level II PRCBD S076985F, dated 3/18/91)	3.7.3a.2	(26)
31.	Turnaround Validation/Checkout Requirements (Reference Level II PRCBD S076987B, dated 4/16/91)	3.7.3a.2	(27)
32.	Turnaround Validation/Checkout S076987C, dated 4/16/91)	3.7.3a.2	(28)
33.	Retired (Reference Space Shuttle PRCBD S094902D, dated 10/12/99)	Apx C	(30)
34.	Retired (Reference Space Shuttle PRCBD S094902D, dated 10/12/99)	Apx C	(30)
35.	Retired (Reference Space Shuttle PRCBD S074070E, dated 3/24/97)	Apx C	(30)
36.	Retired per SSP DOC–459 (Reference Space Shuttle PRCBD S074058D, dated 8/30/96)	Apx C	(30)
37.	Retired per SSP DOC–459 (Reference Space Shuttle PRCBD S074848, dated 2/7/97)	Apx C	(30)
38.	Retired per SSP DOC–459 (Reference Space Shuttle PRCBD S060810A, dated 3/18/97)	Apx C	(30)

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

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

THIS PAGE INTENTIONALLY LEFT BLANK

DEVIATIONS/WAIVERS AUTHORIZED FOR REQUIREMENTS CONTAINED IN THIS DOCUMENT

1. **REQUIREMENT:** Rescinded. (Reference Level II PRCBD S40019–R3, dated 8/26/87). See Appendix C.

2. **REQUIREMENT:** Rescinded. (Reference Level II PRCBD S40019–R3, dated 8/26/87). See Appendix C.

3. **REQUIREMENT:** Rescinded. (Reference Level II PRCBD S40019–R3, dated 8/26/87). See Appendix C.

4. **REQUIREMENT:** Rescinded. (Reference Level II PRCBD S40019–R3, dated 8/26/87). See Appendix C.

5. **REQUIREMENT:** Rescinded. (Reference Level II PRCBD S40019–R3, dated 8/26/87). See Appendix C.

6. **REQUIREMENT:** Rescinded. (Reference Level II PRCBD S40019–R3, dated 8/26/87). See Appendix C.

7. **REQUIREMENT:** Retired per Change Action Request. (Reference Level II PRCBD S41230Z–R3, dated 3/27/89). See Appendix C.

8. **REQUIREMENT:** Retired per Change Action Request. (Reference Level II PRCBD S60154–R9, dated 4/27/89). See Appendix C.

9. **REQUIREMENT:** Retired per Change Action Request. (Reference Level II PRCBD S076233–R3, dated 3/26/90). See Appendix C.

10. **REQUIREMENT:** Retired per Change Action Request. (Reference Level II PRCBD S76349, dated 11/15/88). See Appendix C.

11. **REQUIREMENT:** Retired. (Reference Level II PRCBD S50751, dated 8/15/89). See Appendix C.

12. **REQUIREMENT:** Paragraph 3.6.14 I.3(c).(2) specifies as follows:

    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.

13. REQUIREMENT: Paragraph 3.7.1 Acceptance Criteria

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.

WAIVER: The above requirement shall be implemented on the External Tank as modified by the changes to specific paragraphs in SP–T–0023B as follows:

A. SPECIFIED REQUIREMENTS: Paragraph 3.4.2.1b Maximum Acceptance Thermal Test Levels. Components which have an expected mission level greater than 100°F temperature sweep shall be tested to the greater of the two following levels:

1. Minimum acceptance test thermal levels (100°F temperature sweep) as defined by Figure 2 or
2. Acceptance test levels equal to the temperature sweep spectral density resulting from the range limits of 20°F lower than the minimum and 20°F higher than the minimum qualification levels.

   The lower temperature limit should be below freezing (30°F) wherever possible. The initial temperature excursion should be in the direction of the expected flight operating temperature of the equipment (hot or cold) so that the specified temperature extreme is achieved at least twice.

   Paragraph 3.4.2.2 Duration. The acceptance thermal test duration shall allow a minimum of one and one–half temperature cycles, stabilized at extremes for one hour and allowing a functional/continuity check on all circuits at the temperature extremes as well as during the temperature transition. The optimum number of temperature cycles shall be established on a case–by–case basis for each hardware type selected for environmental acceptance testing.

WAIVER: For External Tanks, ET–23, ET–27, ET–28, ET–29, ET–31 and subs, 74L4 level sensors are tested to temperature extremes that do not meet the requirements as specified in SP–T–0023 Paragraph 3.4.2.1b(2). Additionally, the requirement for one and one–half temperature cycles stabilized at extremes for one hour, as specified in Paragraph 3.4.2.2, is not met for this level sensor.

Qual:	LO_2 +500° F	Acceptance:	LO_2 +150° F
	–320° F		–320° F

Qual:	LH_2 +360° F –423° F	Acceptance:	LH_2 –150° F –320° F

RATIONALE: Operational constraints supersede the acceptance requirements of SP–T–0023B, i.e., the level sensor temperature must stabilize in less than two minutes.

Cryo shock of short duration and narrower temperature range is more severe than the requirements of SP–T–0023B.

EFFECTIVITY: ET–23, ET–27, ET–28, ET–29, ET–31 and subs; 74L4 level sensors.

B. SPECIFIED REQUIREMENT: Paragraph 3.4.1.2b Maximum Acceptance Thermal Test Levels. Components which have an expected mission level greater than 100°F temperature sweep shall be tested to the greater of the two following levels:

1. Minimum acceptance test thermal levels (100°F temperature sweep) as defined by Figure 2, or
2. Acceptance thermal test levels equal to the temperature sweep resulting from the range limits of 20°F lower than the maximum and 20°F higher than the minimum qualification levels.

The lower temperature limit should be below freezing (30°F) wherever possible. The initial temperature excursion should be in the direction of the expected flight operating temperature of the equipment (hot or cold) so that the specified temperature extreme is achieved at least twice.

WAIVER: For External Tanks, ET–23, ET–27, ET–28, ET–29, ET–31 and subs, the ET switch module, P/N PD7100082, is environmentally acceptance tested to extremes that do not meet the requirements as specified in Paragraph 3.4.2.1b(2) for the temperature range limit of 20°F lower than the maximum qualified level.

Qual:	+250° F –85° F	Acceptance:	+140° F –70° F

RATIONALE: The switch module is installed in a controlled environment and is never subjected to temperatures greater than 120°F.

Controlled prelaunch environment is from +32°F to 120°F. The expected operating temperature will be from 0°F to 85°F.

EFFECTIVITY: ET–23, ET–27, ET–28, ET–29, ET–31 and subs; switch module P/N PD7100082.

AUTHORITY: Level II PRCBD S02130H, dated 3/7/89.

C. SPECIFIED REQUIREMENT: Paragraph 3.4.1.1.3 Levels. Acceptance Vibration Tests shall be conducted to levels as severe as possible within the boundaries specified in the following paragraphs.

a. Minimum acceptance vibration test levels – The acceptance vibration test levels and test spectrum defined by Figure 1 shall be the minimum test criteria.

b. Maximum acceptance vibration test levels – 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.

WAIVER: For External Tanks, ET–23, ET–27, ET–28, ET–29 and subs, the ET low pressure transducer, P/N PD7400106, is environmentally tested to levels and/or spectra which are not compatible with the minimum AVT spectra as identified in SP–T–0023B, Paragraph 3.4.1.1.3.

RATIONALE: This transducer is a Crit. III component and is used for ground operation only during cryo load.

No failures on more than 60 transducers used for cryo tankings.

EFFECTIVITY: ET–23, ET–27, ET–28, ET–29, ET–31 and subs; ET low pressure transducer P/N PD7400106.

AUTHORITY: Level II PRCBD S02130H, dated 3/7/89.

14. REQUIREMENT: Paragraph 3.7.1 Acceptance Criteria

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.

DEVIATION: The above requirement shall be implemented in the MSFC–SSME project as modified by the change to Paragraph 3.4.2.1.b(2) in SP–T–0023B as shown below.

SPECIFIED REQUIREMENT: Paragraph 3.4.2.1.b(2) – Acceptance thermal test levels equal to the temperature sweep resulting from the range limits of 20°F lower than the maximum and 20°F higher than the minimum qualification levels.

DEVIATION: The SSME controller assembly and FASCOS are acceptance tested thermally to the same temperature as qualification.

RATIONALE: The SSME project considers this slight over–testing during acceptance test to be beneficial in screening hardware/workmanship discrepancies and not detrimental to controller life. There have been more than 100 acceptance test procedures performed on more than 25 units with thermal cycle levels equal to that used to acceptance test the qualification unit. To date, no hardware damage, life reductions, or performance degradations have been experienced as a result of the current test procedures. Based on this experience, no change in unit acceptance testing is planned.

EFFECTIVITY: STS–26 thru STS–999.

AUTHORITY: Level II PRCBD S98463, dated 3/11/89.

15. REQUIREMENT: Paragraph 3.7.3 Turnaround Checkout Requirements

a. Philosophy – The philosophy for accomplishing turnaround checkout is presented below. If a waiver to any of these requirements is necessary, it shall be in accordance with Paragraph 4.4.

1. In general, checkout or inspection of all Shuttle Vehicle systems or subsystems critical to flight safety or mission success will be performed before each flight to verify that performance is satisfactory to support operations.

b. Checkout Requirements – The following minimum checkout requirements apply during turnaround operations:

1. All safety of flight–critical functions (Criticality 1 and 1R items) which are one– failure tolerant or less shall be verified by test unless the test is considered to be invasive or illogical. Rationale to avoid invasive or illogical tests shall be approved in accordance with Paragraph 3.7.3c.

DEVIATION: The frequency (specified in Para. 3.7.3a.1) of the Water Spray Boiler (WSB) Bellows H_2O to GN2 leak check (Criticality 1 and 1R items, identified in Para. 3.7.3b.1) shall be performed at intervals not to exceed five (5) flights, rather than before each flight (as specified in Para. 3.7.3a.1 above), for the effectivity identified below.

RATIONALE: The Water Spray Boiler Bellows Assembly is constructed of Inconel 718 and is Tig welded to the tank end fitting. The design safety factor – proof pressure of 1.5 and burst pressure of 2.0. Maximum operating pressure is 37 psig. The Water Tank Bellows Assembly was certified with the following results:

a. To withstand 2000 full stroke cycles

b. Random vibration 100 mission equivalency (tank 100% and maximum pressure)

c. Shock tested

d. Mission profile test at maximum heat load

e. Thermal cycle test

The WSB water is sampled after each flight to verify water composition is within specification. The water used to service the WSB is distilled or deionized water conforming to SE–S–0073, Paragraph 6.1, Table 6.1.

Inconel 718 is very low in the galvanic series of metals and alloys in sea water. Low pH and increased temperature do not generally favor pitting attack. Inconel is highly resistant to corrosion, not effected by stress, and has excellent resistance to oxidation at high temperatures.

There is no history of failure for the WSB Bellows Assembly.

EFFECTIVITY: STS–31 thru STS–999

AUTHORITY: Level II PRCBD S50866, dated 10/31/89.

16. REQUIREMENT: Paragraph 3.7.3 Turnaround Checkout Requirements

a. Philosophy – The philosophy for accomplishing turn–around checkout is presented below. If a waiver to any of these requirements is necessary, it shall be in accordance with Paragraph 4.4.

2. The approach shall be to maintain assurance of two–failure tolerance (fail op/fail safe) when available for all safety of flight critical functions. Critical functions that are two–failure tolerant or greater and have demonstrated high confidence should be verified to one–failure tolerance (fail safe) for each mission with the remaining levels of redundancy being verified periodically as long as resulting mission rules are acceptable and CIL retention rationale is still appropriate. Critical functions that are two–failure tolerant and have not demonstrated high confidence shall be verified to two–failure tolerance (fail ops/fail safe) prior to each flight.

Functions which affect mission success (Criticality 2 and 2R items) will be classified as mandatory or highly desirable. The mandatory functions will be verified to the first level of redundancy as appropriate. Highly desirable functions will be verified as operational.

WAIVER: This waiver allows one–failure tolerance (fail safe) verification of aerosurface and SSME thrust vector control effector systems every third Orbiter turnaround flow.

RATIONALE: The SSME TVC and aerosurface FRT identifies performance degradation of the ASAs, ATVCs and SSME TVC Dynamic Pressure Feedback (DPF) assemblies that would be caused by degrading components. If the FRT is not performed every flow, performance degradation of one or more ASAs, ATVCs or DPFs (which are 1R3 components) would go undetected. Since the ASAs, ATVCs and SSME DPFs are considered highly reliable, and no history of degraded performance exists in the NSTS program, OMRSD RCN OV9153 was approved (reference PRCBD No. 53116F) to perform the FRT every third turnaround flow of an Orbiter.

EFFECTIVITY: STS–31, STS–35 thru STS–999

AUTHORITY: Level II PRCBD S76616A, dated 12/20/89.

17. REQUIREMENT: Paragraph 3.7.3 Turnaround Checkout Requirements

a. Philosophy – The philosophy for accomplishing turnaround checkout is presented below. If a waiver to any of these requirements is necessary, it shall be in accordance with Paragraph 4.4.

2. The approach shall be to maintain assurance of two–failure tolerance (fail op/fail safe) when available for all safety of flight critical functions. Critical functions that are two–failure tolerant or greater and have demonstrated high confidence should be verified to one–failure tolerance (fail safe) for each mission with the remaining levels of redundancy being verified periodically as long as resulting mission rules are acceptable and CIL retention rationale is still appropriate. Critical functions that are two–failure tolerant and have not demonstrated high confidence shall be verified to two–failure tolerance (fail ops/fail safe) prior to each flight.

Functions which affect mission success (Criticality 2 and 2R items) will be classified as mandatory or highly desirable. The mandatory functions will be verified to the first level of redundancy as appropriate. Highly desirable functions will be verified as operational.

WAIVER: The above requirement is waived for the following APU items:

a. Fuel isolation valve circuits

b. Fuel tank/line–heater circuits

c. Fuel pump gas generator heater circuits and allows checkout every five missions

RATIONALE: Approval of RCN OV9199M1 authorized revision of NSTS 08171, Operations and Maintenance Requirements and Specifications Document (OMRSD), to require the above specified APU items to be checked out every five missions based upon the following rationale:

APU Fuel Isolation Valve
OMRSD: V46AL0.400

The following two–failure scenarios result in continuous power to the fuel isolation valve resulting in fuel decomposition and valve rupture in the absence of fuel flow and are checked by this OMRSD paragraph. There are sufficient temperature measurements on the fuel isolation valve and a valve open indication to detect a powered on valve and sufficient time to take corrective action.

(1) a. Type III driver fails on 05–6N–2014

b. Type III driver fails on 05–6N–2014

c. Type IV driver fails on 05–6N–2014

Any two of these drivers could fail “on” undetected and the isolation valve circuit would function normally.

(2) a. Toggle switch fails contact–to–contact short (of pole that has circuit breaker) 05–6N–2013

b. Circuit breaker fails closed 05–6N–2015

c. Diode shorts 05–6N–2022

Fuel Isolation Valve Grounding Circuit
OMRSD: V46AL0.420

The following failure scenario is checked by this OMRSD paragraph and results in continuous power to the fuel isolation valve resulting in fuel decomposition and valve rupture in the absence of fuel flow.

a. Toggle switch fails contact–to–contact (of pole that has circuit breaker) 05–6N–2013

b. Circuit breaker fails closed 05–6N–2015

c. Diode shorts 05–6N–2025

d. Hybrid driver fails on 05–6N–2014

APU Fuel Tank/Line Heater
OMRSD: V46L0.540
V46L0.550
V46L0.560

The following failure scenario is checked by these OMRSD paragraphs and results in continuous power to the heater resulting in fuel decomposition and line rupture in the absence of fuel flow. There are sufficient temperature measurements to detect a failed–on heater and sufficient time to take corrective action.

a. Type III driver fails on 05–6N–2059

b. Type III driver fails on 05–6N–2059

c. Type IV driver fails on 05–6N–2059A

Any two of these three drivers could fail “on” undetected and the heater circuit would function normally.

Gas Generator/Fuel Pump APU
OMRSD: V46L0.570
V46L0.580
V46L0.590

The following failure scenario is checked by these OMRSD paragraphs and results in continuous power to the heater resulting in fuel decomposition and line rupture in the absence of fuel flow. There are sufficient temperature measurements to detect a failed–on heater and sufficient time to take corrective action.

a. Type III driver fails on 05–6N–2073

b. Type III driver fails on 05–6N–2074A

c. Type IV driver fails on 05–6N–2074

Any two of these three drivers could fail "on" undetected and the heater circuit would function normally.

Failure History

There are a total of 293 3–amp circuit breakers per vehicle with no failed–closed field or flight failures.

There are a total of 653 Type III hybrid load drivers per vehicle with one failed–on flight failure.

There are a total of 72 Type IV load drivers per vehicle with no field or flight failures.

There are a total of 1661 lamp lead diodes per vehicle with no reported failures.

There are a total of 51 3–amp lead diodes per vehicle with no reported failures.

There are approximately 890 toggle switches per vehicle with one failed–closed field failure. This failure was a high–impedance contact–to–contact short.

EFFECTIVITY: STS–31, STS–35 and subs

AUTHORITY: Level II PRCBD S76656, dated 1/12/90.

18. REQUIREMENT: Paragraph 3.7.3 Turnaround Checkout Requirements

b. Checkout Requirements – The following minimum checkout requirements apply during turnaround operations:

2. All high–confidence safety–critical functions shall be verified to the one–failure tolerant level unless the test is considered to be invasive or illogical. The rationale to justify a critical function as high–confidence shall be approved by the PRCB and documented in the OMRSD. Rationale to avoid

invasive or illogical tests shall be approved in accordance with Paragraph 3.7.3c.

WAIVER: The above requirement is waived for the APU fuel isolation valve circuits and allows checkout every five missions.

RATIONALE: Approval of RCB OV9199M1 authorized revision of NSTS 08171, Operations and Maintenance Requirements and Specifications Document (OMRSD), to require the APU fuel isolation valve circuits to be checked out every five missions based upon the following rationale:

The following two–failure scenarios result in continuous power to the fuel isolation valve resulting in fuel decomposition and valve rupture in the absence of fuel flow and are checked by OMRSD Paragraph V46AL0.400. There are sufficient temperature measurements on the fuel isolation valve and a valve open indication to detect a powered on valve and sufficient time to take corrective action.

(1)	a.	Toggle switch fails closed	05–6N–2013
	b.	Circuit breaker fails closed	05–6N–2015
(2)	a.	Toggle switch fails closed	05–6N–2013
	b.	Type IV hybrid driver fails on	05–6N–2014

Failure History

a. There are a total of 293 3–amp circuit breakers per vehicle with no failed–closed field or flight failures.

b. There are a total of 72 Type IV load drivers per vehicle with no field or flight failures.

c. There are approximately 890 toggle switches per vehicle with one failed–closed field failure. This failure was a high–impedance contact–to–contact short.

EFFECTIVITY: STS–31, STS–35 and subs

AUTHORITY: Level II PRCBD S76656, dated 1/12/90.

19. REQUIREMENT: Paragraph 3.7.3 Turnaround Checkout Requirements

a. Philosophy – The philosophy for accomplishing turnaround checkout is presented below. If a waiver to any of these requirements is necessary, it shall be in accordance with Paragraph 4.4.

1. In general, checkout or inspection of all Shuttle Vehicle systems or subsystems critical to flight safety or mission success will be performed before each flight to verify that performance is satisfactory to support operations.

2. The approach shall be to maintain assurance of two–failure tolerance (fail op/fail safe) when available for all safety of flight–critical functions. Critical functions that are two–failure tolerant or greater and have demonstrated high confidence should be verified to one–failure tolerance (fail safe) for each mission with the remaining levels of redundancy being verified periodically as long as resulting mission rules are acceptable and CIL retention rationale is still appropriate. Critical functions that are two–failure tolerant and have not demonstrated high confidence shall be verified to two–failure tolerance (fail ops/fail safe) prior to each flight.

WAIVER: The frequency of the fire bottle content level checkout (OMRSD File III Vol. 62AQ0.021) shall be performed at intervals not to exceed two (2) flights or six (6) months, rather than “before each flight” as specified in Paragraph 3.7.3, subparagraphs a.1 and a.2.

RATIONALE: No failure history for the fire bottle.

No detectable leakage on any fire bottles. (12 years history on three of OV–102 bottles and more than six years on the other nine bottles OV–103 & OV–104).

Flight exposure time without redundant fire suppression is short (ascent/entry).

Redundancy (hand held extinguisher) available all other times.

Testing is intrusive (requires removal of system components).

The fire bottle is qual tested for 100 mission life, 20g shock/axis, 5–24 hr. temp. cycles (60° to 125° F), vibration 0.09g sq/Hz for 48 min/axis, 24 hrs. at 135° F salt fog test. Burst test at 2500 psig. Acceptance test – proof at 1000 psig, leak check at 500 psig, leak tested after charging (NTE 1X10 ng 6 cc/sec at 130° to 150° F). Charged with extra 0.25 lb of Halon 1301 which is equal to a 10–year allowable leak rate. Weigh after charging for pressure switch check. Tested to safety factor equal to or greater than four. Hydrostatic proof test prior to recharging a 1050 psia.

EFFECTIVITY: STS–31, STS–35 and subs

AUTHORITY: Level II PRCBD S76675, dated 1/15/90.

20. REQUIREMENT: Retired per Change Action Request. (Reference Level II PRCBD S061531L, dated 5/3/90). See Appendix C.

21. REQUIREMENT: Paragraph 3.7.3 Turnaround Checkout Requirements

a. Philosophy

2. The approach shall be to maintain assurance of two–failure tolerance (fail op/fail safe) when available for all safety of flight–critical functions. Critical functions that are two–failure tolerant or greater and have demonstrated high confidence should be verified to one–failure tolerance (fail safe) for each mission with the remaining levels of redundancy being verified periodically as long as resulting mission rules are acceptable and CIL retention rationale is still appropriate. Critical functions that are two–failure tolerant and have not demonstrated high confidence shall be verified to two–failure tolerance (fail ops/fail safe) prior to each flight.

WAIVER: The above requirement is waived for the Ku–band direct stow switch checkout and allows checkout every five (5) flights.

RATIONALE: Requires improbable failure, two switch contacts failed closed. Failure prior to Ku–band deploy will result in a phase to phase short, when attempting Ku–band deploy (circuit breaker tripping).

Toggle switch (889 per vehicle) one failed–closed field failure. The failure was a high–impedance contact–to–contact short.

Failure is readily evident through MCA Ops status readout (stow relay activated) and verification of circuit breaker blown during ground testing.

For failure in flight, the Ku–band antenna must first successfully be deployed, and payload bay mechanical bus AC2 and AC3 must be powered (these switches are not routinely left on).

Jettison capability is verified each flow during pyrotechnics operations in V55AI0.010 and V55AI0.020 Ku–band antenna jettison verification.

EFFECTIVITY: STS–35, STS–37 thru STS–999

AUTHORITY: Level II PRCBD S052151, dated 7/19/90.

22. REQUIREMENT: Paragraph 3.7.3 Turnaround Validation/Checkout Requirements

a. Philosophy – The general philosophy for accomplishing turnaround shall be to assure single fault tolerance of critical functions every flow/flight and check out all functional paths periodically.

2. The approach shall be to maintain assurance of single–failure tolerance (fail safe) when available for all safety of flight–critical functions. Critical functions that are two–failure tolerant or greater should be validated to one–failure tolerance for each mission with the remaining levels of redundancy being checked out periodically as long as resulting mission rules are acceptable and CIL retention rationale is still appropriate.

WAIVER: This waiver allows LV42/LV43 D&C bus redundancy verification to be performed every vehicle fifth flight for OV–102, Flt

11; OV–103, Flts 12 and 13 and OV–104, Flt 8. Beginning with OV–102, Flt 12 thru Flt 999; OV–103, Flt 14 thru Flt 999; OV–104, Flt 9 thru Flt 999 and OV–105, Flt 1 thru Flt 999, this waiver allows verification to be performed during each vehicle OMDP.

RATIONALE: Requires improbable sequence of failures, undetected diode failure (CIL No. 05–6J–2319–2) followed by a switch failure, resulting in the described 1R2 criticality.

Three AMP blocking diode (51 per vehicle) – no failure history.

Toggle switch (889 per vehicle) one failed–closed field failure. This failure was a high–impedance contact–to–contact short.

Switch operation is verified during performance of V41AA0.100 each flow.

EFFECTIVITY: OV–102, Flt 11 thru Flt 999
OV–103, Flt 12 thru Flt 999
OV–104, Flt 8 thru Flt 999
OV–105, Flt 1 thru Flt 999

AUTHORITY: Level II PRCBD S076984E, dated 3/14/91.

23. REQUIREMENT: Paragraph 3.7.3 Turnaround Validation/Checkout Requirements

a. Philosophy – The general philosophy for accomplishing turnaround shall be to assure single fault tolerance of critical functions every flow/flight and check out all functional paths periodically.

   2. The approach shall be to maintain assurance of single–failure tolerance (fail safe) when available for all safety of flight critical functions. Critical functions that are two–failure tolerant or greater should be validated to one–failure tolerance for each mission with the remaining levels of redundancy being checked out periodically as long as resulting mission rules are acceptable and CIL retention rationale is still appropriate.

WAIVER: This waiver allows LO2 PV7 D&C bus redundancy to be performed every vehicle fifth flight for OV–102, Flt 11; OV–103, Flts 12 and 13 and OV–104, Flt 8. Beginning with OV–102, Flt 12 thru Flt 999; OV–103, Flt 14 thru Flt 999; OV–104, Flt 9 thru Flt 999 and OV–105, Flt 1 thru Flt 999, this waiver allows verification to be performed during each vehicle OMDP.

RATIONALE: Requires improbable sequence of failures, undetected diode failure (CIL No. 05–65–2012A–2) followed by a switch failure, resulting in the described 1R2 criticality.

One AMP switchscan diode (1,661 per vehicle) – no failure history.

Toggle switch (889 per vehicle) one failed–closed field failure. This failure was a high–impedance contact–to–contact short.

Switch operation is verified during performance of V41AB0.070 each flow.

An alternative path exists (approximately four SCFM per bleed check valve) through the POGO system to the SSME HPOTP seal and released over board.

EFFECTIVITY: OV–102, Flt 11 thru Flt 999
OV–103, Flt 12 thru Flt 999
OV–104, Flt 8 thru Flt 999
OV–105, Flt 1 thru Flt 999

AUTHORITY: Level II PRCBD S076984A, dated 3/14/91.

24. REQUIREMENT: Paragraph 3.7.3 Turnaround Validation/Checkout Requirements

a. Philosophy – The general philosophy for accomplishing turnaround shall be to assure single fault tolerance of critical functions every flow/flight and check out all functional paths periodically.

2. The approach shall be to maintain assurance of single–failure tolerance (fail safe) when available for all safety of flight critical functions. Critical functions

that are two–failure tolerant or greater should be validated to one–failure tolerance for each mission with the remaining levels of redundancy being checked out periodically as long as resulting mission rules are acceptable and CIL retention rationale is still appropriate.

WAIVER: This waiver allows LV56–E1 GH2, LV57–E2 GH2, LV58–E3 GH2 flow control valve control bus redundancy verification to be performed every vehicle fifth flight for OV–102, Flt 11; OV–103, Flts 12 and 13 and OV–104, Flt 8. Beginning with OV–102, Flt 12 thru Flt 999; OV–103, Flt 14 thru Flt 999; OV–104, Flt 9 thru Flt 999 and OV–105, Flt 1 thru Flt 999, this waiver allows verification to be performed during each vehicle OMDP.

RATIONALE: Requires improbable sequence of failures, undetected diode failure (CIL No. 05–6J–2235–2) followed by a switch failure, resulting in the described 1R2 criticality.

Three AMP blocking diode (51 per vehicle) – no failure history.

Toggle switch (889 per vehicle) one failed–closed field failure. This failure was a high–impedance contact–to–contact short.

Switch operation is verified during performance of V41AD0.010 (.020, and .030) each flow.

EFFECTIVITY: OV–102, Flt 11 thru Flt 999
OV–103, Flt 12 thru Flt 999
OV–104, Flt 8 thru Flt 999
OV–105, Flt 1 thru Flt 999

AUTHORITY: Level II PRCBD S076984B, dated 3/14/91.

25. REQUIREMENT: Paragraph 3.7.3 Turnaround Validation/Checkout Requirements

a. Philosophy – The general philosophy for accomplishing turnaround shall be to assure single fault tolerance of critical functions every flow/flight and check out all functional paths periodically.

2. The approach shall be to maintain assurance of single–failure tolerance (fail safe) when available for all safety of flight critical functions. Critical functions that are two–failure tolerant or greater should be validated to one–failure tolerance for each mission with the remaining levels of redundancy being checked out periodically as long as resulting mission rules are acceptable and CIL retention rationale is still appropriate.

WAIVER: This waiver allows requirement inboard fill and drain valve D&C control bus redundancy verification to be performed every vehicle fifth flight for OV–102, Flt 11; OV–103, Flts 12 and 13 and OV–104, Flt 8. Beginning with OV–102, Flt 12 thru Flt 999; OV–103, Flt 14 thru Flt 999; OV–104, Flt 9 thru Flt 999 and OV–105, Flt 1 thru Flt 999, this waiver allows verification to be performed during each vehicle OMDP.

RATIONALE: Requires improbable sequence of failures, detected diode failure (CIL No. 05–6J–2280–2) followed by a switch failure, resulting in the described 1R2 criticality.

Three AMP blocking diode (51 per vehicle) – no failure history.

Toggle switch (889 per vehicle) one failed–closed field failure. This failure was a high–impedance contact–to–contact short.

Switch operation is verified during performance of V41AB0.101 each flow.

EFFECTIVITY: OV–102, Flt 11 thru Flt 999
OV–103, Flt 12 thru Flt 999
OV–104, Flt 8 thru Flt 999
OV–105, Flt 1 thru Flt 999

AUTHORITY: Level II PRCBD S076984C, dated 3/14/91.

26. REQUIREMENT: Paragraph 3.7.3 Turnaround Validation/Checkout Requirements

a. Philosophy – The general philosophy for accomplishing turnaround shall be to assure single fault tolerance of critical functions every flow/flight and check out all functional paths periodically.

2. The approach shall be to maintain assurance of single–failure tolerance (fail safe) when available for all safety of flight critical functions. Critical functions that are two–failure tolerant or greater should be validated to one–failure tolerance for each mission with the remaining levels of redundancy being checked out periodically as long as resulting mission rules are acceptable and CIL retention rationale is still appropriate.

WAIVER: This waiver allows PV12, PV13 and PV22 LH2 inboard fill and drain topping and high point bleed valves D&C control bus redundancy verification to be performed every vehicle fifth flight for OV–102, Flt 11; OV–103, Flts 12 and 13 and OV–104, Flt 8. Beginning with OV–102, Flt 12 thru Flt 999; OV–103, Flt 14 thru Flt 999; OV–104, Flt 9 thru Flt 999 and OV–105, Flt 1 thru Flt 999, this waiver allows verification to be performed during each vehicle OMDP.

RATIONALE: Requires improbable sequence of failures, undetected diode failure (CIL No. 05–6J–2280–2) followed by a switch failure, resulting in the described 1R2 criticality.

Three AMP blocking diode (51 per vehicle) – no failure history.

Toggle switch (889 per vehicle) one failed–closed field failure. This failure was a high–impedance contact–to–contact short.

Switch operation is verified during performance of V41AB0.121, V41AB0.131, and V41AB0.221 for PV12, PV13, and PV22, respectively, each flow.

EFFECTIVITY: OV–102, Flt 11 thru Flt 999
OV–103, Flt 12 thru Flt 999
OV–104, Flt 8 thru Flt 999
OV–105, Flt 1 thru Flt 999

AUTHORITY: Level II PRCBD S076984D, dated 3/14/91.

27. REQUIREMENT: Paragraph 3.7.3 Turnaround Validation/Checkout Requirements

a. Philosophy – The general philosophy for accomplishing turnaround shall be to assure single fault tolerance of critical functions every flow/flight and check out all functional paths periodically.

2. The approach shall be to maintain assurance of single–failure tolerance (fail safe) when available for all safety of flight critical functions. Critical functions that are two–failure tolerant or greater should be validated to one–failure tolerance for each mission with the remaining levels of redundancy being checked out periodically as long as resulting mission rules are acceptable and CIL retention rationale is still appropriate.

WAIVER: This waiver allows PV4 E1 LH2, PV5 E2 LH2 and PV6 E3 LH2 prevalve D&C bus redundancy verification to be performed every vehicle fifth flight for OV–102, Flt 11; OV–103, Flts 12 and 13 and OV–104, Flt 8. Beginning with OV–102, Flt 12 thru Flt 999; OV–103, Flt 14 thru Flt 999; OV–104, Flt 9 thru Flt 999 and OV–105, Flt 1 thru Flt 999, this waiver allows verification to be performed during each vehicle OMDP.

RATIONALE: Requires improbable sequence of failures, undetected diode failure (CIL No. 05–6J–2221–2) followed by a switch failure, resulting in the described 1R2 criticality.

One AMP switchscan diode (1,661 per vehicle) – no failure history.

Toggle switch (889 per vehicle) one failed–closed field failure. This failure was a high–impedance contact–to–contact short.

Switch operation is verified during performance of V41AB0.040, V41AB0.050, V41AB0.060 for E1, E2, & E3, respectively, every flow.

EFFECTIVITY: OV–102, Flt 11 thru Flt 999
OV–103, Flt 12 thru Flt 999
OV–104, Flt 8 thru Flt 999
OV–105, Flt 1 thru Flt 999

AUTHORITY: Level II PRCBD S076984E, dated 3/18/91.

28. REQUIREMENT: Paragraph 3.7.3 Turnaround Validation/Checkout Requirements

a. Philosophy – The general philosophy for accomplishing turnaround shall be to assure single fault tolerance of critical functions every flow/flight and check out all functional paths periodically.

2. The approach shall be to maintain assurance of single–failure tolerance (fail safe) when available for all safety of flight critical functions. Critical functions that are two–failure tolerant or greater should be validated to one–failure tolerance for each mission with the remaining levels of redundancy being checked out periodically as long as resulting mission rules are acceptable and CIL retention rationale is still appropriate.

WAIVER: This waiver allows the LO2 and LH2 17" disconnect shaft seal leakage test to be performed every other flow rather than every flow for OV–102, Flt 11 thru Flt 999; OV–103, Flt 12 thru Flt 999; OV–104, Flt 8 thru Flt 999 and OV–105, Flt 1 thru Flt 999.

RATIONALE: Cryogenic leakage is to be verified during loading operations. (CIL 03–1–0407–4, LO2 and CIL 03–1–0408–4, LH2)

Safe leakage levels are guaranteed by HGDS LCC limits.

EFFECTIVITY: OV–102, Flt 11 thru Flt 999
OV–103, Flt 12 thru Flt 999
OV–104, Flt 8 thru Flt 999
OV–105, Flt 1 thru Flt 999

AUTHORITY: Level II PRCBD S076984F, dated 3/18/91.

29. REQUIREMENT: Paragraph 3.7.3 Turnaround Validation/Checkout Requirements

a. Philosophy – The general philosophy for accomplishing turnaround shall be to assure single fault tolerance of critical functions every flow/flight and check out all functional paths periodically.

2. The approach shall be to maintain assurance of single–failure tolerance (fail safe) when available for all safety of flight–critical functions. Critical functions that are two–failure tolerant or greater should be validated to one–failure tolerance for each mission with the remaining levels of redundancy being checked out periodically as long as resulting mission rules are acceptable and CIL retention rationale is still appropriate.

WAIVER: This waiver allows PV7 LO2 and PV8 LH2 relief shutoff valve seat leak check verification to be performed every other vehicle flight for OV–102, Flt 11 thru Flt 999; OV–103, Flt 12 thru Flt 999; OV–104, Flt 8 thru Flt 999 and OV–105, Flt 1 thru Flt 999.

RATIONALE: PV7 function verified by performance of V41AZ0.100, MPS pneumatic low press decay test – actuator decay check; V41BI0.070, PV7 relief shutoff valve response time and companion File IX, DV41BI0.070, nominal poppet open/close response time.

Good failure history on RSOV seat leakage. (CIL No. 03–1–0414–3) relief valve (RV6) leakage is verified during V41AY0.140 every flow.

PV8 function (CIL No. 3–1–0437–4) verified by performance of V41AZ0.100, MPS pneumatic low press decay test – actuator decay check; V41BI0.080, PV8 relief shutoff valve response time and companion File IX, DV41BI0.070, nominal poppet open/close response time.

Good failure history on RSOV seat leakage.

Relief valve (RV5) leakage is verified during V41AY0.130 every flow.

EFFECTIVITY: OV–102, Flt 11 thru Flt 999
OV–103, Flt 12 thru Flt 999
OV–104, Flt 8 thru Flt 999
OV–105, Flt 1 thru Flt 999

AUTHORITY: Level II PRCBD S076984G, dated 3/14/91.

30. REQUIREMENT: Paragraph 3.7.3 Turnaround Validation/Checkout Requirements

a. Philosophy – The general philosophy for accomplishing turnaround shall be to assure single fault tolerance of critical functions every flow/flight and check out all functional paths periodically.

2. The approach shall be to maintain assurance of single–failure tolerance (fail safe) when available for all safety of flight critical functions. Critical functions that are two–failure tolerant or greater should be validated to one–failure tolerance for each mission with the remaining levels of redundancy being checked out periodically as long as resulting mission rules are acceptable and CIL retention rationale is still appropriate.

WAIVER: This waiver allows verification of the LH2 backup propellant dump switch to be performed every fifth vehicle flight for OV–102, Flt 11 thru Flt 999; OV–103, Flt 12 thru Flt 999; OV–104, Flt 8 thru Flt 999 and OV–105, Flt 1 thru Flt 999.

RATIONALE: Requires improbable failure, (CIL No. 05–6J–2163–4), 2 switch contacts failed–closed.

Toggle switch (889 vehicle) one failed–closed field failure. This failure was a high–impedance contact–to–contact short.

Circuit is verified each flow during performance of V41BI0.150, (PV17) LH2 RTLS inboard dump valve response time and V41BI0.160, PV18 LH2 RTLS outboard dump valve response time.

EFFECTIVITY: OV–102, Flt 11 thru Flt 999
OV–103, Flt 12 thru Flt 999
OV–104, Flt 8 thru Flt 999
OV–105, Flt 1 thru Flt 999

AUTHORITY: Level II PRCBD S076985F, dated 3/18/91.

31. REQUIREMENT: Paragraph 3.7.3 Turnaround Validation/Checkout Requirements

a. Philosophy – The general philosophy for accomplishing turnaround shall be to assure single fault tolerance of critical functions every flow/flight and check out all functional paths periodically.

2. The approach shall be to maintain assurance of single–failure tolerance (fail safe) when available for all safety of flight critical functions. Critical functions that are two–failure tolerant or greater should be validated to one–failure tolerance for each mission with the remaining levels of redundancy being checked out periodically as long as resulting mission rules are acceptable and CIL retention rationale is still appropriate.

WAIVER: This waiver allows the water spray boiler bellows H_20–to–GN_2 leak check test to be performed every vehicle fifth flight for OV–102, Flt 11 and OV–103, Flt 12. Beginning with OV–102, Flt 12 thru Flt 999; OV–103, Flt 13 thru Flt 999; OV–104, Flt 9 thru Flt 999 and OV–105, Flt 1 thru Flt 999, this waiver allows verification to be performed during each vehicle OMDP.

RATIONALE: The water spray boiler bellows assembly is constructed of Inconel 718 and is TIG welded to the tank end fitting. The design safety factor–proof pressure of 1.5 and burst pressure of 2.0. Maximum operating pressure is 37 psig. The water tank bellows assembly is tested:

a. To withstand 2000 full stroke cycles

b. Random vibration 100 mission equivalency. (Tank 100% and maximum pressure)

c. Shock tested

d. Mission profile test at maximum heat load

e. Thermal cycle test

The WSB water is sampled after each flight to verify water composition is within specification. The water used to service the WSB is distilled or deionized water conforming to SE–S–0073, Paragraph 6.1, Table 6.1.

Inconel 718 is very low in the galvanic series of metals and alloys in sea water. Low PH and increased temperature do not generally favor pitting attack. Inconel is highly resistant to corrosion, not affected by stress, and has excellent resistance to oxidation at high temperatures.

There is no history of failure (CIL No. 06–3A–0608–1) for the WSB bellows assembly.

EFFECTIVITY: OV–102, Flt 11 thru Flt 999
OV–103, Flt 12 thru Flt 999
OV–104, Flt 9 thru Flt 999
OV–105, Flt 1 thru Flt 999

AUTHORITY: Level II PRCBD S076987B, dated 4/16/91.

32. REQUIREMENT: Paragraph 3.7.3 Turnaround Validation/Checkout Requirements

a. Philosophy – The general philosophy for accomplishing turnaround shall be to assure single fault tolerance of critical functions every flow/flight and check out all functional paths periodically.

2. The approach shall be to maintain assurance of single–failure tolerance (fail safe) when available for all safety of flight critical functions. Critical functions that are two–failure tolerant or greater should be validated to one–failure tolerance for each mission with the remaining levels of redundancy being checked out periodically as long as resulting mission rules are acceptable and CIL retention rationale is still appropriate.

WAIVER: This waiver allows the LOX/LH_2 umbilical retract actuator timing test to be performed every vehicle fifth flight for OV–102, Flt 11 and OV–103, Flt 12. Beginning with OV–102, Flt 12 thru Flt 999; OV–103, Flt 13 thru Flt 999; OV–104, Flt 9 thru Flt 999 and OV–105, Flt 1 thru Flt 999, this waiver allows verification to be performed during each vehicle OMDP.

RATIONALE:

a. Performance of this test is difficult due to the invasive nature of the test.

   1. To perform test, the actuators must be de–pinned at the plate (three actuators per plate) with the plate being supported.

   2. The actuators must be de–pinned one at a time so that the remaining two actuators will support the plate to prevent the plate from dropping.

   3. Cycle life concern for the plate extension by MPS.

b. De–pinning of the plate requires a KSC technician to position himself awkwardly within the belly of the Orbiter AFT to de–pin the actuators. (Possible ancillary damage).

c. Test is very time consuming.

d. Actuator function along with additional testing is verified every flow in:

   1. Requirement V58AR0.010 ET LOX/LH_2 umbilical retract actuator verification. The test verifies the actuators will extend and retract from MEC command every flight.

   2. Requirement V58AR0.020 LOX/LH_2 umbilical retract actuator uncommanded extension. The test verifies that no uncommanded extension of the actuators occurs while hydraulic supply pressure is >2900 PSIA while actuators are fully retracted on a periodic (I–5) basis.

   3. Requirement V58AR0.040 umbilical retract actuator post–flight inspection. The requirement visually verifies actuators are fully retracted into the mechanical

locks with no evidence of binding or cocking of attached umbilical plate.

4. Requirement V58AR0.050 umbilical retract actuator free float verification. The test verifies the retract actuator smoothly extends when manually extended toward tank for umbilical connection with the hydraulic system depressurized.

e. There is no history of a failure during NSTS for this failure mode (actuator full extend and retract within 3–10 seconds of command – CIL NO. 02–6–C05–4).

EFFECTIVITY: OV–102, Flt 11 thru Flt 999
OV–103, Flt 12 thru Flt 999
OV–104, Flt 9 thru Flt 999
OV–105, Flt 1 thru Flt 999

AUTHORITY: Level II PRCBD S076987C, dated 4/16/91.

33. REQUIREMENT: Retired. (Reference Space Shuttle PRCBD S094902D, dated 10/12/99). See Appendix C.

34. REQUIREMENT: Retired. (Reference Space Shuttle PRCBD S094902D, dated 10/12/99). See Appendix C.

35. REQUIREMENT: Retired. (Reference Level II PRCBD S074070E, dated 3/24/97). See Appendix C.

36. REQUIREMENT: Retired per SSP DOC–459, dated 3/13/00. (Reference Space Shuttle PRCBD S074058D, dated 8/30/96). See Appendix C.

37. REQUIREMENT: Retired per SSP DOC–459, dated 3/13/00. (Reference Space Shuttle PRCBD S074848, dated 2/7/97). See Appendix C.

38. REQUIREMENT: Retired per SSP DOC–459, dated 3/13/00. (Reference Space Shuttle PRCBD S060810A, dated 3/18/97). See Appendix C.

39. REQUIREMENT: Paragraph 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.

WAIVER: The above requirement is waived for Part Numbers 10399–0059–601, –602, –603, and –604, to allow use of a supplemental SRB data acquisition system still fully contained by canister and precluding any detrimental effects to the capability of the SRB.

RATIONALE: The modification incorporates relocation/repackaging of relays, a microphone, batteries, and a new top cover which provides easier access to the video recorder tape. All possible DAS anomalies are still contained within the canister and all margins of safety are positive.

EFFECTIVITY: STS–83 thru STS–999

AUTHORITY: Space Shuttle PRCBD S074070E, dated 3/24/97.

40. REQUIREMENT: Retired per SSP DOC–459, dated 3/13/00. (Reference Space Shuttle PRCBD S040975E, dated 4/4/97). See Appendix C.

41. REQUIREMENT: Retired per SSP DOC–459, dated 3/13/00. (Reference Space Shuttle PRCBD S011583K, dated 3/7/97). See Appendix C.

42. REQUIREMENT: Paragraph 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.

WAIVER: The following non-certified equipment is required to be used to support the ferry flight operations for OMDP-2 OV-102 at KSC and Palmdale:

At Palmdale: Two (2) rented self-propelled serial platforms (60 ft genie and a 120 ft JLG).

At KSC: One (1) 170 ft condor truck mounted serial platform (owned by KSC, recently returned from factory refurbishment).

One (1) 111 ft bronto truck mounted serial platform (borrowed from factory to replace the KSC owned 180 ft bronto which is being modified by the factory).

Request waiver to program requirements to allow the use of non-certified equipment to on-load Orbiter at KSC and off-load Orbiter at Palmdale in support of ferry flight.

RATIONALE: The serial platforms that will be used are commercial equipment that conform to industry standards. The equipment will have a pre-operation checkout prior to use. The equipment has been load tested per KSC requirements and the equipment will be used by certified operators. A safety risk assessment has been performed (reference Risk Assessment 5453-99-RA-047) to identify the inherent risks associated with the specified equipment. Controls will be implemented to mitigate the identified risks.

EFFECTIVITY: OV-102, OMDP-2

AUTHORITY: PRCBD S063132AR5, dated 9/29/99.

43. REQUIREMENT: Paragraph 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.

WAIVER: The following non-certified equipment is required to be used to support the S0004 operations for OV-103 STS-103:

(1) 170′ Condor truck mounted aerial platform

(1) 180′ Bronto truck mounted aerial platform

RATIONALE: The aerial platforms that will be used are commercial equipment that conform to OSHA and industry standards.

The equipment will have a pre-operation checkout prior to use. The equipment has been load tested per KSC requirements and the equipment will be used by certified operators.

A system assurance analysis has been performed on both pieces of equipment. Reference SAA09FT01-018 for the Bronto 180 and SAA09FT01-005 for the Condor 170.

EFFECTIVITY: STS-103

AUTHORITY: PRCBD S061355, dated 10/29/99.

44. REQUIREMENT: Paragraph 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.

WAIVER: The following non-certified equipment is required to be used to support critical operations at KSC:

One (1) 170 ft Condor truck mounted aerial platform

One (1) 180 ft Bronto truck mounted aerial platform

Request waiver to program requirements to allow the use of non-certified equipment to perform critical operations at KSC.

RATIONALE: The aerial platforms that will be used are commercial equipment that conform to OSHA and industry standards. The equipment will have a pre-operation checkout prior to use. The equipment has been load tested per KSC requirements and the equipment will be used by certified operators. A systems assurance analysis has been performed on both pieces of equipment (reference SAA09FT01-018 and SAA09FT01-005).

EFFECTIVITY: Non-flight specific not to exceed 10/31/00

AUTHORITY: Space Shuttle PRCBDs S061366, dated 11/30/99; S061366R1, dated 2/11/00; S061366R2, dated 5/1/00 and S061366R3, dated 9/11/00.

45. REQUIREMENT: Paragraph 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.

WAIVER: The above requirement is being waived for the following non certified equipment required to be used to support critical operations at KSC.

(1) 170' Condor truck mounted aerial platform

(1) 180' Bronto truck mounted aerial platform

RATIONALE: The aerial platforms that will be used are commercial equipment that conform to OSHA and industry standards.

The equipment will have a pre-operation checkout prior to use. The equipment has been load tested per KSC requirements and the equipment will be used by certified operators. Rental equipment will be tested per KSC requirements and a risk assessment performed.

A systems assurance analysis has been performed on both pieces of USA-owned equipment. Reference SAA09FT01-018 for the Bronto 180 and SAA09FT01-005 for the Condor 170.

EFFECTIVITY: Non-flight specific not to exceed 08/10/00

AUTHORITY: Space Shuttle PRCBD S061406, dated 2/11/00.

46. REQUIREMENT: Paragraph 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.

WAIVER: The above requirement is being waived for the following non–certified equipment required to be used to support landing operations at Dryden:

One 150–ft Condor truck mounted aerial platform

RATIONALE: The aerial platform that will be used is commercial equipment that conforms to OSHA and industry standards.

The equipment will have a pre-operation checkout prior to use. The equipment will be load tested per KSC requirements, the equipment will be used by certified operators and a risk assessment performed.

EFFECTIVITY: STS–99

AUTHORITY: Space Shuttle PRCBD S061414, dated 2/23/00.

47. **REQUIREMENT:** Paragraph 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.

WAIVER: The above requirement is being waived for the following non–certified equipment required to be used to support critical operations at White Sands:

One 800–ton demag mobile crane

One 250–ton link belt mobile crane

Three aerial lift platforms (equivalent to two 60–ft JLG and one 150–ft Condor used at Dryden)

One T300 or equivalent tow vehicle

RATIONALE: The equipment that will be used is commercial equipment that conforms to OSHA and industry standards.

The equipment will have a pre-operation checkout prior to use. The equipment will be load tested per NASA requirements, the equipment will be used by certified operators and a risk assessment performed.

EFFECTIVITY: STS–99

AUTHORITY: Space Shuttle PRCBD S061415, dated 2/23/00.

48. **REQUIREMENT:** Paragraph 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.

WAIVER: The following non–certified equipment is required to be used to support the PDU removal operations for OV–104 STS–101:

One freeze block unit

RATIONALE: The equipment that will be used is commercial equipment that conforms to industry standards and is similar to other freeze block equipment that has been in use for critical operations at KSC.

The equipment will have a pre-operation checkout prior to use. The equipment has been tested per KSC requirements and the equipment will be used by trained operators. An existing OMI that has been used for KSC freeze block units will be modified for this operation.

A risk analysis has been performed on all pieces of equipment.

EFFECTIVITY: STS–101

AUTHORITY: Space Shuttle PRCBD S061444, dated 4/13/00.

49. REQUIREMENT: Paragraph 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.

WAIVER: The following non–certified equipment is required to be used to support the PDU removal operations for OV–104 STS–101:

250 ton and 40 ton mobile cranes
Three electric self propelled aerial platforms

RATIONALE: The aerial platforms and mobile cranes that will be used are commercial equipment that conform to OSHA and industry standards and have been in use for critical operations at KSC for many years.

The equipment will have a pre-operation checkout prior to use. The equipment has been load tested per KSC requirements and the equipment will be used by certified operators.

A systems assurance analysis has been performed on all pieces of equipment.

EFFECTIVITY: STS–101

AUTHORITY: Space Shuttle PRCBD S061445, dated 4/13/00.

50. REQUIREMENT: Paragraph 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.

WAIVER: The above requirement is being waived for the following non-certified equipment to be used to support critical operations at KSC:

(1) OPF Bays 1 and 2 AFT bridge (PMN A70-0883)

RATIONALE: The AFT bridges are required for payload bay bucket operations. The bridge drive control circuitry was modified to support JIB hoist installation. The JIB hoist mod was not completed and the AFT bridge system was re-validated and put into use. Re-certification paperwork was pending JIB hoist MOD completion.

After the original AFT bridge drive modification was completed, a single point failure was identified (PLC) and modifications are in work to correct the SPF (PRCBD S061360 provides non-flight specific waiver of NSTS 07700 CIL reporting requirement).

The AFT bridges have been thoroughly tested since the original MOD. The user interface and operational procedures have not changed. The equipment will have a pre-operation checkout prior to use. The equipment will be used by certified operators. E-stops are still in place for emergency use.

A systems assurance analysis has been performed on all AFT bridges. Reference SAA (09FTP3.014). Certification of the AFT bridges will be completed after the current modification to correct the single point failure has been corrected.

EFFECTIVITY: Non-flight specific

AUTHORITY: Space Shuttle PRCBD S061468, dated 5/22/00.

51. REQUIREMENT: Paragraph 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.

WAIVER: Allow an alternate method of removing and installing an Orbiter fuel cell with the airlock and tunnel adapter installed. Alternate method involves linking two pieces of lifting GSE and a vendor supplied lifting fixture. Existing GSE documentation does not certify this configuration.

RATIONALE: Alternate method involves linking two pieces of lifting GSE and a vendor supplied lifting fixture. Existing GSE documentation does not certify this configuration. Boeing GSE design has approved the suggested solution. The blue lifting fixture is vendor supplied equipment and is used to lift the fuel cell in and out of the shipping container, but is not used to lift the fuel cell over other flight hardware. It does not have a proofload tag, but is on a list of KSC equipment that has been exempted from this requirement. The factor of safety on the lifting fixture is 4.5 and the qualification unit was proofloaded to 600 pounds.

EFFECTIVITY: STS-106

AUTHORITY: Space Shuttle PRCBD S061491, dated 6/28/00.

52. REQUIREMENT: Paragraph 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.

WAIVER: The following non-certified equipment is required to be used to support SRB post-flight and refurbishment operations:

10/10/40 ton bridge crane at Hanger AF, CCAFS

RATIONALE: The cranes are tested, inspected, maintained and operated in accordance with the NASA safety standard for lifting devices and equipment, NSS/GO-1740.9. The crane is tested under 100% load annually to verify proper operation of all functions. The crane is operated by trained and certified operators. There is a crane monthly, semi-annual, and annual maintenance program in place. The RF pendant includes three means to turn on/off power to operate:

a. The crane-key switch

b. On/off switch

c. Operator e-stop

If the RF control signal for any crane motion becomes ineffective, crane motion automatically stops. A radio frequency authorization was issued for the control frequency. The pendant and RF e-stop systems operate independently of the PLC. The Joint Base Operations Support Contractor (JBOSC) has design and maintenance responsibility for the crane. The JBOSC will continue to maintain the crane to safe operating conditions and has initiated update of the FMEA/CIL/hazards analyses.

EFFECTIVITY: STS-92, STS-97, STS-106

AUTHORITY: Space Shuttle PRCBD S061546, dated 9/5/00.

53. REQUIREMENT: Paragraph 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.

WAIVER: This waiver will allow usage of T-9RG008121-1 dolly and T-5701699-0-122 plate assembly to support SSME turbomachinery handling for post-flight inspections and turnaround in the SSMEPF through July 2001.

RATIONALE: Interim use of this tool is requested to support SSME turbopump processing at KSC. Currently, the approved single GSE dolly requires flight hardware assets to be transferred/lifted in the SSMEPF pump room to support inspections and testing. Approval of this request would reduce lifting and movement of flight assets.

Rocketdyne T-tool designs meet intent of the Level II criteria for “delivered GSE” but do not have the formalized controls of “delivered GSE”. Contract requirements do not allow for “site unique” T-tool equipment to be used at the launch site, therefore, Level II authorization is required for use at KSC.

EFFECTIVITY: Non-flight specific not to exceed 7/31/01

AUTHORITY: Space Shuttle PRCBD S071934A, dated 9/5/00.

54. REQUIREMENT: Paragraph 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.

WAIVER: The above requirement is being waived to allow use of the SDC in the CLCS bin/basis and the ATXS/Sonet data transmission systems during Shuttle processing.

RATIONALE: The SDC system/data was fully tested and validated as part of the SDC ORR (3/99). To ensure data integrity between systems, data checks and problem notification are performed. The SDC has been used successfully from March, 1999 thru June, 2000. A review of the anomalies by SDC engineering showed 201 anomalies, 97 of these were vendor hardware problems and 104 software problems. The analysis showed none of these anomalies were related to data integrity. The SDC hardware and software is configuration controlled and changes are managed by the integrated data system CCB. A risk assessment has been performed. Based on a consequence score of 5 and a likelihood score of 2, the overall score is 10 = yellow risk.

Analysis of testing by NASA and USA Shuttle engineering for retrieval products delivered for HMF concluded that all requirements identified for the release were tested and verified against the established functional and system level requirements. Testing was successfully completed at the HMF to demonstrate that the data retrieved from the SDC was not corrupted with the support workstation in a controlled configuration. Testing with other software applications executing concurrently with the data retrievals provided additional confidence in the data integrity of the system. This testing was witnessed by NASA and USA engineering personnel as well as quality assurance. Once CLCS is transitioned to operations, it will be configuration controlled and change managed similar to SDC.

EFFECTIVITY: STS-100 and STS-104

AUTHORITY: Space Shuttle PRCBDs S061509AR1, dated 9/6/00 and S061509AR2, dated 4/4/01.

55. REQUIREMENT: Paragraph 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.

WAIVER: The above requirement is being waived for the following non-certified forklift equipment is required to be used for the critical operation of lifting longeron bridges out of shipping containers at KSC logistics facility:

(2) forklifts HE# 401-255 (PMN K60-0145) and 401-223 (PMN K60-0147)

RATIONALE: The forklifts that will be used are commercial equipment that conform to OSHA and industry standards.

The equipment has been in use in the logistics facility for a number of years. It will have a pre-operation checkout prior to use. The equipment has been load tested per KSC requirements and the equipment will be used by certified operators.

A risk analysis has been performed on both pieces of equipment. (Reference 5453-01-RA-010).

EFFECTIVITY: NFS not to exceed 8/27/01

AUTHORITY: Space Shuttle PRCBD S063037A, dated 2/28/01.

56. REQUIREMENT: Paragraph 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.

WAIVER: The above requirement is being waived for the following non-certified equipment required to be used to support the ferry flight operations for OV-102, OMDP-2 at Palmdale.

(3) Rented self propelled aerial platforms (60' JLG's 600S)

(1) Rented self propelled aerial platform (150' Condor)

RATIONALE: The aerial platforms that will be used are commercial equipment that conform to industry standards.

The equipment will have a pre-operation checkout prior to use. The equipment has been load tested at the manufacturer and the equipment will be used by certified operators at both Palmdale and Dryden. This will be accomplished per USA OP001138 "use of rented or borrowed heavy equipment for critical operations".

A safety risk assessment has been performed.

EFFECTIVITY: OV-102, OMDP-2

AUTHORITY: Space Shuttle PRCBD S063132N, dated 2/28/01.

57. REQUIREMENT: Paragraph 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.

WAIVER: The above requirement is being waived for the following non-certified equipment required to be used to support on-load for ferry from Dryden for OV-104, Flt 23.

(1) Rented self propelled aerial platform (150' Condor)

RATIONALE: The aerial platforms that will be used are commercial equipment that conform to industry standards.

The equipment will have a pre-operation checkout prior to use. The equipment has been load tested at the manufacturer and the equipment will be used by certified operators at both Palmdale and Dryden. This will be accomplished per USA OP001138 "use of rented or borrowed heavy equipment for critical operations".

A safety risk assessment has been performed.

EFFECTIVITY: OV-104, Flt 23 (ferry flight)

AUTHORITY: Space Shuttle PRCBD S063132N, dated 2/28/01.

58. REQUIREMENT: Paragraph 3.6.14 l.3(c).(2) Acceptance Test.

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

A. SPECIFIED REQUIREMENT: Paragraph 3.4.1 Acceptance Vibration Test

3.4.1.1 Levels. Acceptance vibration tests shall be conducted to levels as severe as possible within the boundaries specified in the following paragraphs.

a. Minimum Acceptance Vibration Test Levels - The acceptance vibration test levels and test spectrum defined by Figure 1 shall be the minimum test criteria.

b. Maximum Acceptance Vibration Test Levels - 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.

WAIVER: The above requirement is waived to allow the acceptance acceleration spectral density levels for the Altitude Switch Assembly (ASA) to be more than 2.3 dB (1/1.69 times the qualification test levels) below the qualification level and to be below the minimum test spectrum defined by Figure 1.

The ASA is acceptance tested to levels lower than those required by SP-T-0023 for one minute per axis.

RATIONALE: The test values chosen for the ASA are adequate to screen for manufacturing defects, workmanship errors and incipient failures without jeopardizing the life of the component. The ASA is a Criticality 3 component, which operates after SRB separation. Therefore, there is no flight safety concern.

EFFECTIVITY: STS-100, STS-104, STS-105, STS-107 thru STS-999

AUTHORITY: Space Shuttle PRCBD S002130K, dated 4/16/01.

59. REQUIREMENT: Paragraph 3.7.1j Acceptance Test Requirements. 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, Environmental Acceptance Testing. Environmental acceptance testing for the SRB RSS will be performed in accordance with applicable range safety requirements as documented in USAF EWR 127-1, Eastern and Western Range 127-1, Range Safety Requirements.

A. SPECIFIED REQUIREMENT: Paragraph 3.4.2 Acceptance Thermal Test.

Paragraph 3.4.2.2 Duration. The acceptance thermal test duration shall allow a minimum of one and one-half temperature cycles, stabilized at extremes for one hour and allowing a functional/continuity check on all circuits at the temperature extremes as well as during the temperature transition. The optimum number of temperature cycles shall be established on a case-by-case basis for each hardware type selected for environmental acceptance testing.

WAIVER: The above requirement is waived to allow the forward and aft Integrated Electronics Assemblies (IEAs) to be subjected to one thermal cycle during acceptance testing. Functional/continuity checks are not performed on the IEA or the ASA during thermal transitions.

RATIONALE: Prior to acceptance testing, IEAs receive five thermal cycles during Manufacturing Checkout (MCO). Each cycle in MCO is the same as the acceptance thermal cycle. Therefore, IEAs effectively receive six thermal cycles prior to delivery.

The 3.5 hours needed to functionally test an IEA significantly exceeds the thermal transition time.

Testing the ASA at extreme and ambient temperatures is adequate to screen for manufacturing defects, workmanship errors and incipient failures. The ASA is a Criticality 3 component, which operates after SRB separation. Therefore, there is no flight safety concern.

EFFECTIVITY: STS-100, STS-104, STS-105, STS-107 thru STS-999

AUTHORITY: Space Shuttle PRCBD S002130K, dated 4/16/01.

60. REQUIREMENT: Paragraph 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.

WAIVER: The above requirement is being waived for the following non-certified equipment required to be used to support landing operations at Dryden.

(1) Condor 150 (or suitable) rental replacement for the Condor 150 truck mounted aerial platform (currently under repair/refurb).

RATIONALE: The aerial platform that will be used is commercial equipment that will be processed per operating procedure USA001138.

EFFECTIVITY: STS-100

AUTHORITY: Space Shuttle PRCBD S061691, dated 5/9/01.

THIS PAGE INTENTIONALLY LEFT BLANK

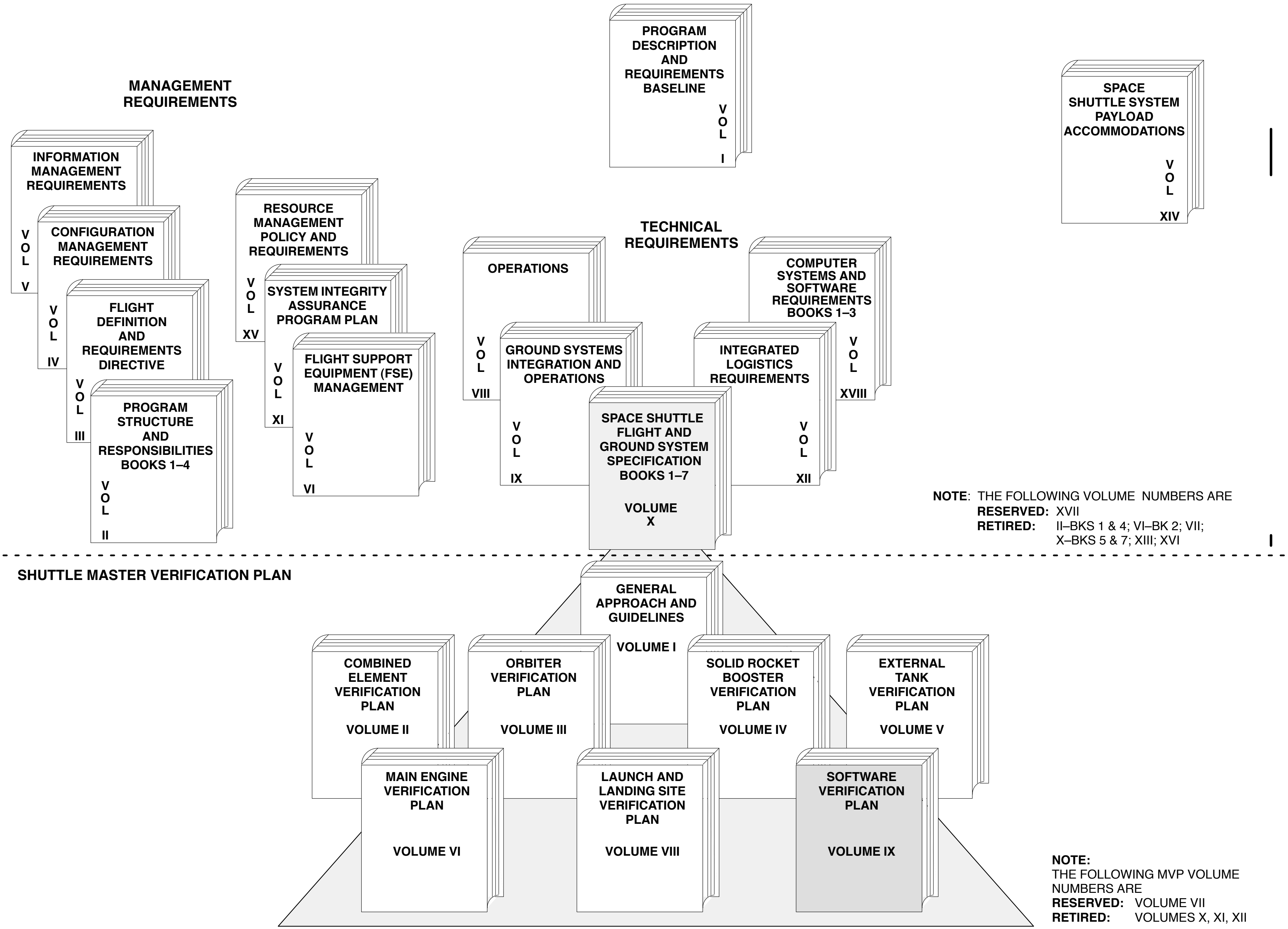
NSTS 07700–10–MVP–01

SPACE SHUTTLE

SHUTTLE MASTER
VERIFICATION PLAN

VOLUME I
GENERAL APPROACH AND GUIDELINES

SPACE SHUTTLE
PROGRAM DEFINITION & REQUIREMENTS – NSTS 07700



FOREWORD

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

Program requirements, directives, procedures, etc., controlled by the Director, Space Shuttle Operations, are documented in the volumes of this document, NSTS 07700. The accompanying illustration identifies the volumes that make up the Space Shuttle Program Definition and Requirements. Volume I contains overall descriptions of the NSTS 07700 documentation. Requirements to be controlled by the NASA project managers are to be identified, documented, and controlled by the project.

Volume I of the Shuttle Master Verification Plan contains the general approach and guidelines for verification planning and the implementation of verification requirements. All Space Shuttle verification effort shall conform to the requirements contained herein. Element level verification plans documented as Volumes III through VI and VIII are approved and controlled by the respective NASA element/project offices, with review for system compatibility by the Deputy Program Manager's Office. Element level volumes are maintained as directed by the respective element/project offices. The Office of Primary Responsibility (OPR) for this volume is the Space Shuttle Systems and Cargo Engineering Office.

All elements of the SSP must adhere to these baselined requirements. When it is considered by the Space Shuttle Program element/project managers to be in the best interest of the SSP 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 IV, and dispositioned by the Director, Space Shuttle Operations, on a Space Shuttle PRCB Directive (PRCBD).

Brewster H. Shaw, Jr.
Program Manager, Space Shuttle

THIS PAGE INTENTIONALLY LEFT BLANK

CONTENTS

NSTS 07700-10-MVP-01

CONTENTS

CONTENTS

APPENDICES

NSTS 07700–10–MVP–01

TABLES

FIGURES

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 of the Shuttle System for operational use.

1.2 SCOPE

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

Because a large percentage of the verification 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 verification program.

1.3 MASTER VERIFICATION PLAN ORGANIZATION

The plan is structured into the following volumes:

<u>Volume I – General Approach and Guidelines</u>. Introduces the overall plan, describes the approach to Shuttle System verification, and provides the verification 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 verification requirements. A summary of the test program is included as Appendix A and a list of definitions are provided as Appendix B.

<u>Volume II – Combined Element Verification Plan</u>. Identifies the combined element and system–level verification requirements and the methods established for verification of each requirement. It also describes the analysis and test programs to be conducted at the Shuttle System level and on other configurations that incorporate two or more elements.

<u>Volume III, IV, V, and VI – Element Verification Plans</u>. Contain element–level requirements and planning information. They are prepared by each element contractor and consist of development, qualification, analysis, and tests required to provide element verification. Volumes III, IV, V, and VI are for the Orbiter, Solid Rocket Booster (SRB), External Tank (ET), and Main Engine (ME), respectively. The intent of Volume VI will be met by the following Space Shuttle Main Engine (SSME) documents:

a. Design Verification Specifications

b. SSME Program Development Plan

Volume VIII – Launch and Landing Site Verification Plan – KSC. Establishes the requirements and plans for verification of the Kennedy Space Center Launch and Landing site as a major program element. It treats those verification activities which must be accomplished to assure readiness of the Ground System to support the flight elements.

Volume IX – Computer Systems and Software Verification Plan. Contains acceptance criteria for testing software for Space Shuttle computer system's (flight or ground) and contains requirements for hardware/software verification testing of Space Shuttle computer systems (flight, ground and communication interfaces).

Volume X – Deleted. (Reference: PRCBD S20040)

Volume XI – Deleted. (Reference: PRCBD S41472C)

Volume XII – Deleted. (Reference: PRCBD S41472C)

1.4 VERIFICATION PROGRAM RELATIONSHIPS

The major phases and significant milestones of the program are displayed in Figure 1–4–1. Shown below the phase bar and the milestones are a series of bars representing the activities which fall within the verification process. The scope of the verification process is depicted by the heavy outline.

The dashed line circumscribes the activities which are included within the definition of certification. The triangles at the bottom of the figure indicate that the design will be certified incrementally and the certification status of individual components or assemblies will be maintained relative to established requirements for the first approach and landing, the First Manned Orbital Flight (FMOF), and operational readiness verification.

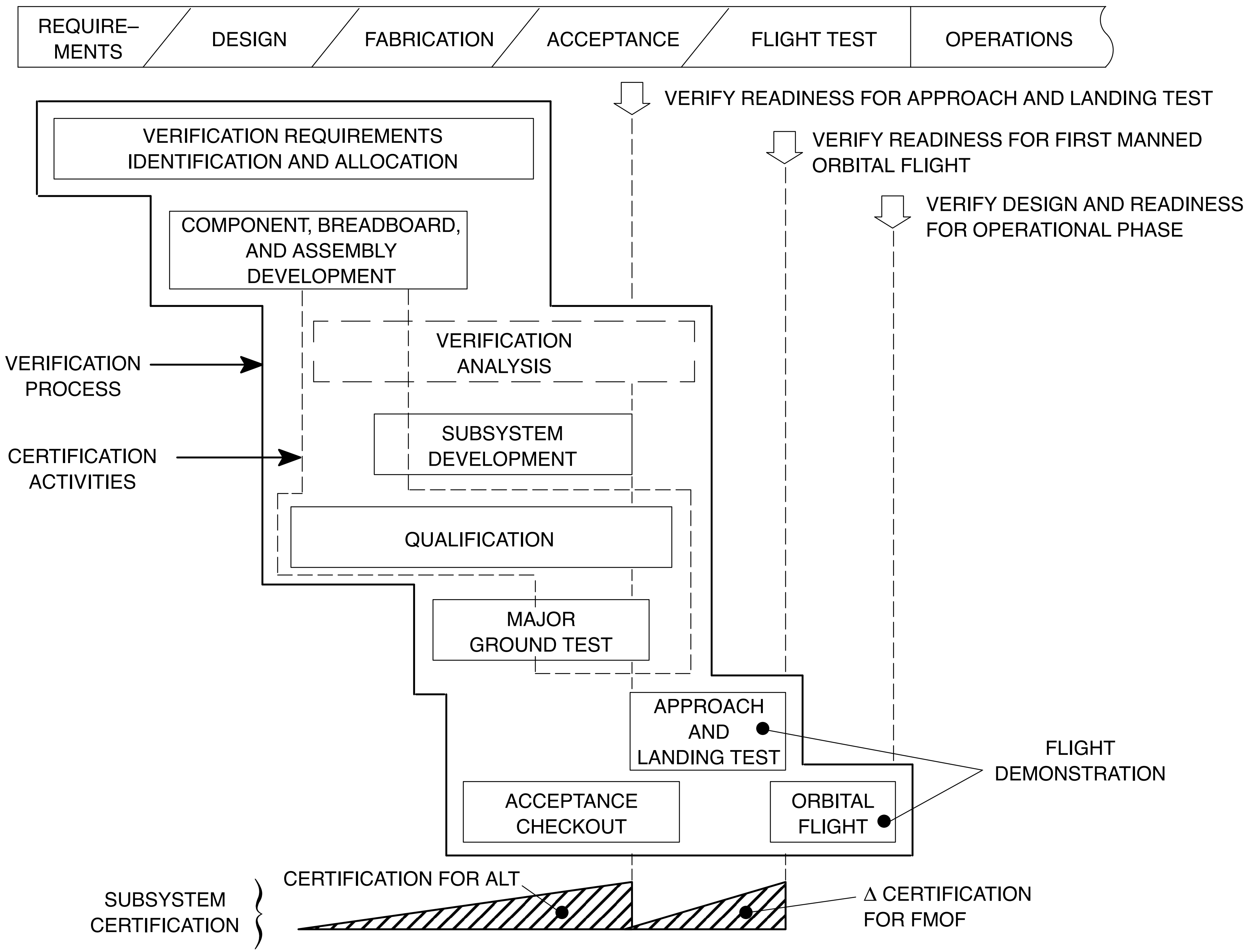
The definitions derived from Figure 1–4–1 and used in the plan are contained in Appendix B.

1.4.1 Payload and Payload Carrier Verification Requirements

The verification requirements for payload equipment mounted or stored in the Orbiter crew compartment and the payload bay are contained in NSTS 07700, Volume XIV, Space Shuttle System Payload Accommodations (NSTS 14046, Payload Interface Verification Requirements).

FIGURE 1–4–1

VERIFICATION PROGRAM RELATIONSHIPS



THIS PAGE INTENTIONALLY LEFT BLANK

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, Volume IV (Current Issue)	Configuration Management Requirements Ref. Para. 4.1
NSTS 07700, Volume V (Current Issue)	Information Management Requirements Ref. Para. 3.3, 4.1, 4.1.1, 4.3.1
NSTS 07700, Volume X (Current Issue)	Space Shuttle Flight and Ground System Specification Ref. Para. 2.2, 2.7, 2.9, 3.3, 3.6.14, 4.1.1
NSTS 07700, Volume X, Book 1 (Current Issue)	Space Shuttle Flight and Ground System Specification, Requirements Ref. Para. 3.6.14, 3.9.3, 4.2
NSTS 07700, Volume X, Book 2 (Current Issue)	Space Shuttle Flight and Ground System Specification, Environment Design, Weight and Performance and Avionics Events Ref. Para. 3.6.14

NSTS 07700, Volume XI (Current Issue)	System Integrity Assurance Program Plan Ref. Para. 4.1.1
NSTS 07700, Volume XIV (Current Issue)	Space Shuttle System Payload Accommodations Ref. Para. 1.4.1
NSTS 07700–10–MVP–02 (Current Issue)	Shuttle Master Verification Plan, Volume II, Combined Element Verification Plan Ref. Para. 4.2
JSC 07700–10–MVP–03	Orbiter Verification Plan, Volume III Ref. Para. 4.2, Apx. A
JSC 07700–10–MVP–04	Solid Rocket Booster Verification Plan, Volume IV Ref. Para. 4.2
JSC 07700–10–MVP–05	External Tank Verification Plan, Volume V Ref. Para. 4.2
JSC 07700–10–MVP–06	Main Engine Verification Plan, Volume VI Ref. Para. 4.2
JSC 07700–10–MVP–08	KSC Launch and Landing Site Return to Flight Verification Plan, Volume VII Ref. Para. 2.7, 4.2

NSTS 07636 (Current Issue)	Lightning Protection Test and Analysis Requirements Ref. Para. 3.6.25
NSTS 08117 (Current Issue)	Requirements and Procedure for Certification of Flight Readiness Ref. Para. 4.1.1
NSTS 08121 (Retired)	Integrated Separation Systems Verification Plan Ref. Apx. A
NSTS 08171 (Current Issue)	Operations and Maintenance Requirements and Specifications Document (OMRSD) Ref. Para. 3.7.3, 4.4
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
EWR 127–1	Eastern and Western Range 127–1, Range Safety Requirements Ref. Para. 3.7.1j
FED–STD–101B Jan. 15, 1969	Preservation Packaging and Packing Materials, Test Procedures Ref. Para. 3.6.14
JSC 08663 Volume I	Shuttle Avionics Integration Laboratory (SAIL) Project Plan Ref. Apx. A

NSTS 14046 Oct. 29, 1992	Payload Interface Verification Requirements Ref. Para. 1.4.1
MIL–STD–810B Sept. 23, 1973	Material Standards for Environmental Test Methods Ref. Para. 3.6.14
NSTS 5300.4(1D–2) (Current Issue)	Safety, Reliability, Maintainability and Quality Provisions for the Space Shuttle Program Ref. Para. 3.7
SD72–SH–0172A April, 1974	Space Shuttle Orbiter Materials Control and Verification Plan Ref. Apx. A
SE–G–0020B Oct. 20, 1993	Leakage Measurement of Helium and Nitrogen Test Gases Ref. Para. 3.2
SL–E–0001 (Current Issue)	Specification, Electromagnetic Compatibility Requirement Ref. Para. 3.6.22
SL–E–0002 (Current Issue)	Specification, Electromagnetic Interference Characteristics, Requirements for Equipment Ref. Para. 3.6.22
SP–T–0023 (Current Issue)	Specification Environmental Acceptance Testing Ref. Para. 3.6.14, 3.7.1

2.1 INTEGRATED VERIFICATION PROGRAM

2.2 VERIFICATION PROGRAM SUMMARY

Verification is the process of planning and implementing a program that determines that Shuttle systems meet all design, performance, and safety requirements. The verification process includes all development, certification and acceptance testing, flight demonstration, appropriate preflight checkout, post–flight activities, and analysis necessary to support verification. The primary objectives to be accomplished by the verification process include (1) support to development of design, (2) certification that the design of components, assemblies, and subsystems meet performance requirements, (3) verification that the performance of combined subsystems, elements, and combined elements meets established requirements, and (4) demonstration of the acceptability and readiness for intended use of deliverable hardware and software. Emphasis is to be placed on verification program planning to assure the most effective utilization of program resources, including schedule.

The accomplishment of these objectives is predicated upon the identification of verification requirements derived from the performance and design requirements documented in NSTS 07700, Volume X, Space Shuttle Flight and Ground System Specification and the element CEI Specifications. The overall verification program is keyed to these specifications in such a way that verification activities are traceable to them on a paragraph–by–paragraph basis. Thus, each master verification plan is required to correlate the respective activities with NSTS 07700, Volume X. The relationship of these requirements is established in NSTS 07700, Volume X, Book 1, 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 requirements, reference the source paragraph in the appropriate specification and identify the method of verification.

The methods to be used include analysis, test or combinations of these. Each element contractor will determine requirements and document the verification 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 verification program (development, certification, flight demonstration, and acceptance and checkout) and its objectives (schedule/milestones, major tests/events, etc.). Where test or flight activity is constrained by verification, each element must identify such activities and provide sufficient management control to insure verification 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 and system level requirements will be documented in the appropriate volumes of this plan. The word “element” as used herein is applicable to each flight element and launch and landing 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 verification program phases. Included are general guidelines and definitions to be used by all element contractors to assure that a consistent verification approach is used throughout the program at all hardware levels. A summary of the verification process is presented as Figure 2–1–1. The process starts with the translation of design and performance requirements into verification 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. Confirmation of the satisfaction of each requirement provides an additional increment in the overall system verification.

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 (1) standard laboratory testing to support material selection, (2) component, breadboard, and subsystem testing to identify the failure modes and the effects of environments and combination of design tolerances on performance, and (3) major ground tests which acquire data from integrated subsystems or system levels to identify operational characteristics and develop operational procedures.

2.4 CERTIFICATION

Certification consists of qualification tests, major ground tests, and other tests and/or analysis required to determine that the design of hardware from component through subsystem level meets requirements. Certification of element subsystems is performed incrementally as required to support the readiness verification of the individual Shuttle elements and Shuttle system for pre–established major program events.

Certification requirements will be based on verifying all performance and design requirements which 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. Each element contractor is required to maintain a list of hardware that has been certified for intended use. These lists will provide the basis for declaring the design as certified for each major event. Requirements for recertification are detailed in Paragraph 3.6.21.

2.5 ELEMENT/SYSTEM VERIFICATION

Verification is performed above the subsystem level to verify the performance of combined subsystems, elements and combined elements. A building block concept will be 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. In turn, the verification of each element will be dependent upon subsystem certification plus verification of all integrated and combined subsystem performance requirements. The major events include first firing of the main propulsion test article, first approach and landing flight, first orbital flight, and the “return to flight” Space Shuttle Design Certification Review.

Analysis and testing will be the primary methods used to verify element and system performance. Major ground tests will verify the performance of integrated subsystems and combined elements. Flight demonstrations will be the final step in verifying 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 Verification 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 reverification are detailed in Paragraph 3.3.

2.6 ACCEPTANCE AND CHECKOUT

Flight hardware acceptance and checkout is accomplished through the use of a common set of ground rules or criteria. Acceptance, 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 generally covers all post–delivery test activities which verify the readiness of hardware for the intended use and culminates with the prelaunch activities at the operational site.

2.7 GROUND SYSTEM VERIFICATION

The overall objectives of the ground support system verification program will be 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 Space Shuttle Program. In addition to acceptance testing, each element project office and launch and landing site shall identify the test and/or analysis required for the certification of Ground Support Equipment (GSE) and ground systems. Each element project office will identify and approve that GSE for certification which requires additional testing or analysis required in addition to acceptance testing. Certification 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 X, Space Shuttle Flight and Ground System Specification) and/or have Safety Critical functions or characteristics shall be certified. Verification of the launch and landing site ground system is described in JSC 07700–10–MVP–08, Shuttle Master Verification Plan, Volume VIII (KSC Launch and Landing Site Verification Plan). Launch and landing site verification status shall be maintained and reported for each flight until all applicable requirements are either verified, revised, waived, or have their applicability changed. Contingency landing site equipment design and verification requirements are the same as primary landing site ground equipment.

2.8 GROUND TEST HARDWARE ASSESSMENT

In addition to components and element/system verification (Para. 2.4 and 2.5) major test articles and ground support equipment 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 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.

Definition of external (forcing function) test environments which exceed flight environments for combined element tests shall be the responsibility of the system contractor. Detail or local zonal test environments definition, including all internal environments shall be the responsibility of the test article supplier. Performance requirements definition shall be the responsibility of the test article supplier.

Test activity affected by this requirement consist only of the following:

a. Main Propulsion Test

b. Flight Readiness Firing

c. Mated Vertical Ground Vibration Test

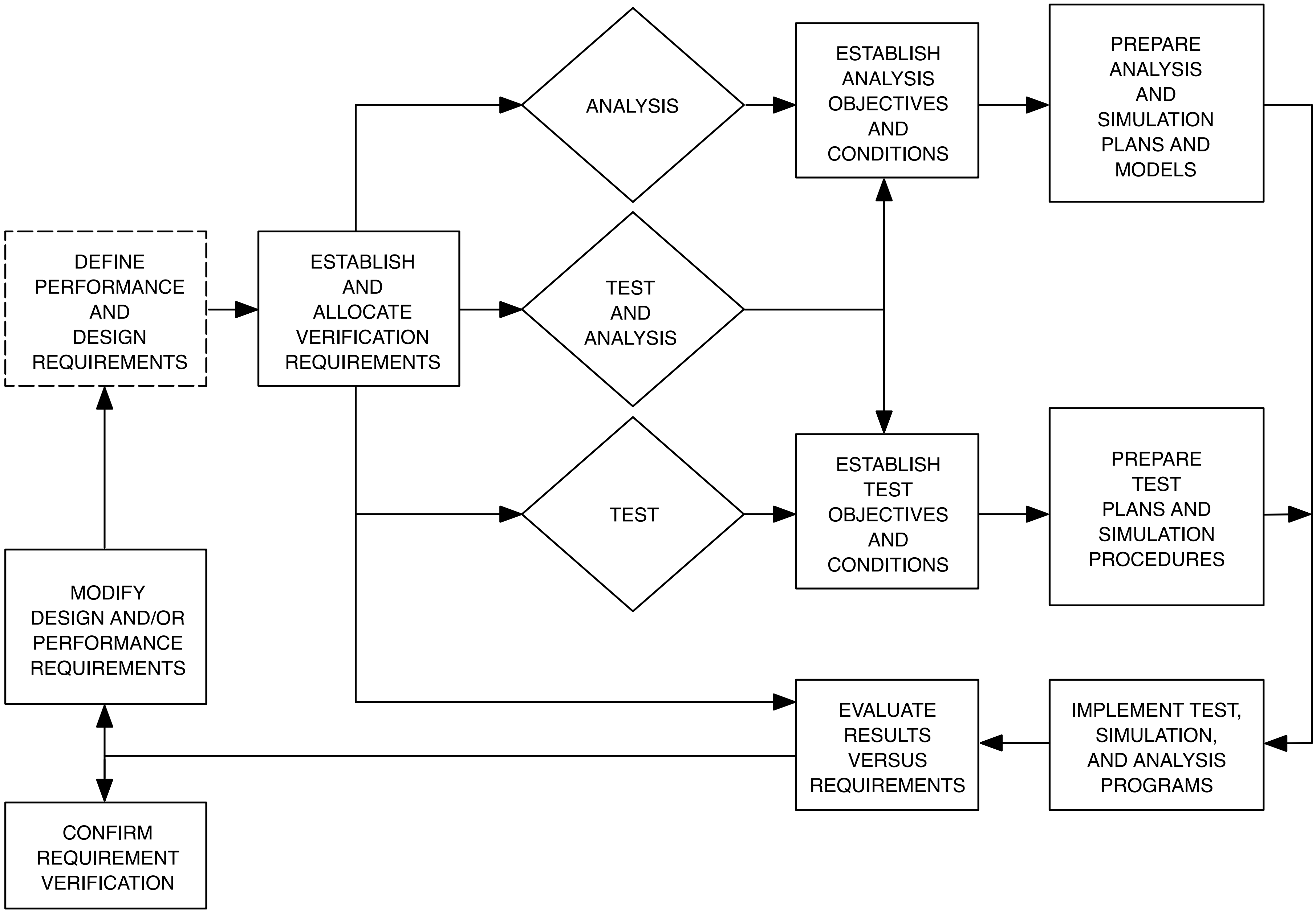
2.9 RETURN TO FLIGHT REVERIFICATION

The verification process and activities identified in this document are essential for the "return to flight" policies stated by the Space Shuttle Program. Verification for initial flights was sanctioned by a program design certification review and a series of individual flight readiness reviews.

The reverification for "return to flight" shall be performed to assess all element's compliance with the hardware and software design requirements in NSTS 07700, Volume X, Space Shuttle Flight and Ground System Specification. This assessment includes an evaluation of all previous verification activities performed by the elements and shall use all available verification data and documentation. This assessment shall compare verification documentation with current hardware and software design requirements. Re–test, demonstration, or new analyses shall be required to verify identified deficiencies in the available documentation and to verify modified hardware and/or software. The guidelines for reverification are presented in Paragraph 3.3. Reverification for "return to flight" shall be sanctioned by a Design Certification Review and a complementary Flight Readiness Review (FRR).

FIGURE 2–1–1

VERIFICATION PROCESS FLOW



3.0 VERIFICATION GUIDELINES

3.1 OBJECTIVES

This section provides guidelines for developing the element and combined element verification 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 activity through the life of the Space Shuttle Program.

3.2 GENERAL GUIDELINES

a. The objective of the verification 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 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 program will confirm that critical failure modes and hazards identified by Failure Mode Effect 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 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 program will establish a data base to be used to support maintenance operations on the reusable elements of the Shuttle system during the 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 He or N_2 are used as test gases.

m. A failure or unsatisfactory condition encountered during verification 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 (ICD) Verification – 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 NSTS 08171, Operations and Maintenance Requirements and Specifications Documents [OMRSDs]). 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 REVERIFICATION GUIDELINES

a. Reverification must be accomplished by the elements if a design or design requirement has been changed or if program direction mandates reverification to support significant program reviews.

b. Reverification must be considered when flight, inspection, test, mission change, failure analysis, post–flight activities, or other data indicate that previously verified design requirements in NSTS 07700, Volume X, Space Shuttle Flight and Ground System Specification are not being met.

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

d. Reverification involves review of available verification documentation. This assessment shall be performed by comparing verification documentation with current hardware and software design requirements. Deficiencies, flaws, discrepancies, and/or inadequacies shall be identified and corrective action defined. Reverification shall be completed by approval of applicable verification completion documentation as outlined in Paragraph 4.0 of this plan and NSTS 07700, Volume V, Information Management Requirements, 1R 2MT–14.

3.4 ANALYSIS GUIDELINES

a. Certification of hardware design below the element level will be accomplished by test and/or analysis. Verification 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 certification 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 certification 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 of abort capability and pogo stability.

   3. Other analytical methods, if selected for certification or verification, 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 certified 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 certification 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 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 and during the approach and landing and Orbital Flight Test (OFT) programs.

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 certification 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 verification plans will be prepared to document material verification programs. Particular emphasis will be placed on non-metallic materials verification.

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

h. Electromagnetic Compatibility (EMC) analyses will be performed on components and subsystems to support hardware design and installation selection during the development phase. EMC testing should be minimized and limited to that necessary to reduce the risk of finding significant problems in the final EMC verification during vehicle integrated testing.

i. Adequacy of Development Flight Instrumentation (DFI) and Operational Flight Instrumentation (OFI) sensor locations will be verified during the development and verification 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 2000 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 2000 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 analysis, development, (pre-declared) qualification, major ground test, acceptance, checkout, and flight test are provided with minimum duplication of testing.

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.

Deviations/Waivers 39, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57 and 60 are applicable to Paragraph 3.6.1.
Refer to the Deviations/Waivers Section in front of the document.

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 EEE

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 (For 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 for 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, certification will assure that the redundancy capability is verified.

3.6.6 Certification of Mature Designs

Mature (off-the-shelf) hardware will require full certification, 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 versus Shuttle requirements. Additional certification 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 certification to be accomplished by test or analysis. For items requiring minor modifications or are not fully certified to Space Shuttle environments, testing and/or analysis is required on the design modifications or additional environments only, if cumulative and interaction effects do not exist. If such effects do not exist, complete certification is required.

3.6.7 Pre-Certification Acceptance

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

3.6.8 Certification Limits

Certification will be structured to verify the full range of the design requirements, except as indicated under life certification guidelines.

3.6.9 (Deleted)

3.6.10 Test Assembly Level

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

3.6.11 Number of Test Specimens

a. The number of test specimens applicable to 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 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.

3.6.12 Configuration

Certification test hardware 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.

3.6.13 Specimen Installation

Certification test hardware 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.

3.6.14 Environmental Conditions

The environmental requirements for the Space Shuttle system are defined in NSTS 07700, Volume X, Book 2, Requirements. Each element contractor will define the local induced environments for their equipment in the appropriate element level specification. The specific test requirements and test methods applicable to certification 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 Space Shuttle Program. This deviation requirement can be met by documenting the deviations in the certification requirements document, and submitting these documents for JSC 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. The longitudinal and lateral axis test levels shall be as defined in NSTS 07700, Volume X, Space Shuttle Flight and Ground System Specification. For these tests, the longitudinal and lateral axis are with respect to the launch 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.

2. For mission phases, MIL-STD-810B, Method 516, Procedures III and IV, shall apply. Shock requirements shall be as specified in NSTS 07700, Volume X, Space Shuttle Flight and Ground System Specification. A shock response spectra test method may be used in addition to or instead of Procedure IV, in which case the following tolerance shall apply: +6 dB, -3 dB applied to spectrum acceleration when analyzed with a one-sixth octave band shock spectrum analyzer using a Q of 10.

k. Acoustic Noise - For hardware and components, MIL-STD-810B, Method 515, Procedure I, shall apply except that one-third octave band sound pressure levels and test times shall be defined in NSTS 07700, Volume X. 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, Paragraph 3.5.J, shall apply. For all vibration tests, resonance search tests of vibration fixtures without test articles shall be conducted according to the procedures of Paragraph 3.5.J.

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.

For flight environment simulation, tests will be conducted to the requirements defined in NSTS 07700, Volume X, Space Shuttle Flight and Ground System Specification, with consideration for the life certification guidelines of Paragraph 3.6.15. In addition, 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 established in NSTS 07700, Volume X, Space Shuttle Flight and Ground System Specification, with consideration for the life certification guidelines of this Volume I, Paragraph 3.6.15. 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 (g^2/Hz) versus 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) Certification 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 certification 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 Johnson Space Center document SP-T-0023, Environmental Acceptance Testing.

Deviations/Waivers 12 and 58 are applicable to Paragraph 3.6.14l.3.(c).(2). Refer to the Deviations/Waivers Section in front of the document.

EXCEPTION: 1. The above requirement shall be implemented on the RSRM project as modified by the changes to specific paragraphs in SP-T-0023B as follows:

A. SPECIFIED REQUIREMENT: Paragraph 3.4.1.1 Levels. Acceptance vibration tests shall be conducted to levels as severe as possible within the boundaries specified in the following paragraphs.

a. Minimum acceptance vibration test levels - The acceptance vibration test levels and test spectrum defined by Figure 1 shall be the minimum test criteria.

b. Maximum acceptance vibration test levels - Components which have expected mission levels 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.

Paragraph 3.4.1.2 Duration. The acceptance vibration test duration shall be a minimum of 30 seconds per axis. One minute per axis is considered optimum, however, the time shall be sufficient to allow a functional/continuity check on all circuits during the acceptance vibration test, according to Paragraph 3.8.

EXCEPTION: This exception allows the acceptance acceleration spectral density levels to be equal to 2.3 dB (1/1.69 times the qualification test levels) below the qualification level. This exception, also, allows a minimum of 3 minutes per axis duration for the acceptance vibration test.

This exception is to be implemented on the MSFC-RSRM project based on the following guidelines:

A. Existing equipment designs: The test times, levels, and cycles may be reduced appropriately to preclude requalification.

B. New equipment designs: Qualification shall be conducted to permit acceptance testing to the revised requirements.

C. 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 3.4.2.1 Temperature Levels. Acceptance thermal tests shall be conducted to levels as severe as possible within the boundaries specified in the following paragraphs:

a. Minimum acceptance thermal test levels - The acceptance thermal test control temperature range shall be a minimum of a 100° F temperature sweep, and test shall be performed in accordance with the minimum test criteria defined by Figure 2.

b. Maximum acceptance thermal test levels - Components which have expected mission levels greater than a 100° F temperature sweep shall be tested to the greater of the two following levels:

(1) Minimum acceptance test thermal levels (100° F temperature sweep) as defined by Figure 2, or

(2) Acceptance thermal test levels equal to the temperature sweep resulting from the range limits of 20° F lower than the maximum 20° F higher than the minimum qualification levels.

The lower temperature limit should be below freezing (30° F) whenever possible. The initial temperature excursion should be in the direction of the expected flight operating temperature of the equipment (hot or cold) so that the specified temperature extreme is achieved at least twice.

Paragraph 3.4.2.2 Duration. The acceptance thermal test duration shall allow a minimum of one and one-half temperature cycles, stabilized at extremes for one hour and allowing a functional/continuity check on all circuits at the temperature extremes as well as during the temperature transition. The optimum number of temperature cycles shall be established on a case-by-case basis for each hardware type selected for environmental acceptance testing.

EXCEPTION: This exception allows a minimum of five temperature cycles (one cycle is denoted on Figure 2). The number of temperature cycles greater than 5 may be established if the history of a hardware type indicates this to be desirable.

This exception is to be implemented on the MSFC-RSRM project based on the following guidelines:

A. Existing equipment designs: The test times, levels, and cycles may be reduced appropriately to preclude requalification.

B. New equipment designs: Qualification shall be conducted to permit acceptance testing to the revised requirements.

C. Follow-on hardware: Acceptance testing will be accomplished in accordance with the revised requirements, but shall be consistent with Guideline A. above.

3.6.15 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 certification may be achieved by test, analysis, or a combination thereof. A test duration less than design life is acceptable for certification 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 certification 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.

3.6.16 Test Survival - Determination

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

3.6.17 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.

3.6.18 Preservation of Dedicated Hardware

Consideration shall be made for preserving dedicated hardware for recertification activities.

3.6.19 Fluid - Compatibility Certification

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

3.6.20 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.

3.6.21 Recertification

Hardware and/or software recertification will be required:

a. When design or manufacturing process changes have been made which affect form, fit, function safety and/or reliability

b. When the manufacturing source is changed

c. When changes are made in specifications, manufacturing processes or procurement source for any fluids or other materials used in processing or operating the hardware

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.

Whenever recertification is required, and verification of a design requirement is based on that certification, the supporting data for the verification shall be assessed to determine if the status has been affected. Where test or flight activity is constrained by verification/certification, the test or flight activity must not begin until recertification and/or reverification has been completed waived at the highest program level approving the requirements.

THIS PAGE INTENTIONALLY LEFT BLANK

3.6.22 Electromagnetic Compatibility

a. Element-level contractors shall identify the applicable test requirements for each electronic/electrical procurement in accordance with the Space Shuttle Specification, SL-E-0002, Specification, Electromagnetic Interference Characteristics, Requirements for Equipment.

b. Final EMC verification will be performed during the element level manufacturing integrated checkout by demonstrating compatibility in accordance with the EMC plan and the Space Shuttle Specification, SL-E-0001, Specification Electromagnetic Compatibility Requirement.

3.6.23 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.

3.6.24 Logic

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

3.6.25 Lightning Protection

Element-level contractors shall conduct analysis and tests for the direct and indirect efforts of lightning in accordance with NSTS 07636, Lightning Protection Test and Analysis Requirements.

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 pre-installation 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. Environmental acceptance testing for the SRB RSS will be performed in accordance with applicable range safety requirements as documented in USAF EWR 127-1, Eastern and Western Range 127-1, Range Safety Requirements.

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.

Deviations/Waivers 12, 13, 14 and 59 are applicable to Paragraph 3.7.1j.
Refer to the Deviations/Waivers Section in front of the document.

EXCEPTION: 2. The above requirement shall be implemented on the RSRM project as modified by the changes to specific paragraphs in SP-T-0023B as follows:

A. SPECIFIED REQUIREMENT: Paragraph 3.4.1.1 Levels. Acceptance vibration tests shall be conducted to levels as severe as possible within the boundaries specified in the following paragraphs.

a. Minimum acceptance vibration test levels - The acceptance vibration test levels and test spectrum defined by Figure 1 shall be the minimum test criteria.

b. Maximum acceptance vibration test levels - 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.

Paragraph 3.4.1.2 Duration. The acceptance vibration test duration shall be a minimum of 30 seconds per axis. One minute per axis is considered optimum, however, the time shall be sufficient to allow a functional/continuity check on all circuits during the acceptance vibration test, according to Paragraph 3.8.

EXCEPTION: This exception allows the acceptance acceleration spectral density levels to be equal to 2.3 dB (1/1.69 times the qualification test levels) below the qualification level. This exception, also, allows a minimum of 3 minutes per axis duration for the acceptance vibration test.

This exception is to be implemented on the MSFC-RSRM project based on the following guidelines:

A. Existing equipment designs: The test times, levels, and cycles may be reduced appropriately to preclude requalification.

B. New equipment designs: Qualification shall be conducted to permit acceptance testing to the revised requirements.

C. 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 3.4.2.1 Temperature Levels. Acceptance thermal tests shall be conducted to levels as severe as possible within the boundaries specified in the following paragraphs:

a. Minimum acceptance thermal test levels - The acceptance thermal test control temperature range shall be a minimum of a 100° F temperature sweep, and test shall be performed in accordance with the minimum test criteria defined by Figure 2.

b. Maximum acceptance thermal test levels - Components which have expected mission levels greater than a 100° F temperature sweep shall be tested to the greater of the two following levels:

(1) Minimum acceptance test thermal levels (100° F temperature sweep) as defined by Figure 2, or

(2) Acceptance thermal test levels equal to the temperature sweep resulting from the range limits of 20° F lower than the maximum 20° F higher than the minimum qualification levels.

The lower temperature limit should be below freezing (30° F) whenever possible. The initial temperature excursion should be in the direction of the expected flight operating temperature of the equipment (hot or cold) so that the specified temperature extreme is achieved at least twice.

Paragraph 3.4.2.2 Duration. The acceptance thermal test duration shall allow a minimum of one and one-half temperature cycles, stabilized at extremes for one hour and allowing a functional/continuity check on all circuits at the temperature extremes as well as during the temperature transition. The optimum number of temperature cycles shall be established on a case-by-case basis for each hardware type selected for environmental acceptance testing.

EXCEPTION: This exception allows a minimum of five temperature cycles (one cycle is denoted on Figure 2). The number of temperature cycles greater than 5 may be established if the history of a hardware type indicates this to be desirable.

This exception is to be implemented on the MSFC-RSRM project based on the following guidelines:

A. Existing equipment designs: The test times, levels, and cycles may be reduced appropriately to preclude requalification.

B. New equipment designs: Qualification shall be conducted to permit acceptance testing to the revised requirements.

C. Follow-on hardware: Acceptance testing will be accomplished in accordance with the revised requirements, but shall be consistent with guideline A. above.

k. Reconveyance may be required whenever (1) The article or material does not meet the contract or contractor specification requirements, or (2) the inspection or test performed is not in accordance with test specifications or inspection and test procedures, or (3) equipment malfunctions, or (4) modifications, repairs, replacements, or rework of the article or material occur after the start of inspection or testing, or (5) the article or material is subject to drift or degradation during storage or handling (periodic intervals for reinspection or retest shall be established), or (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 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 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 X, Space Shuttle Flight and Ground System Specification.

p. Non-destructive test verification 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 Palmdale, Edwards AFB, and KSC 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 inflight 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, Shuttle Program costs are not increased, or where further isolation is impractical due to resultant vehicle design penalties.

3. Ground Checkout and Servicing Functions

(a) During the DDT&E phase of the Shuttle Program, the ground system shall perform checkout to the detailed level below that which is provided by the onboard capability. During DDT&E, special design validation and flight simulation support may be accomplished by the ground system to assure preflight readiness.

(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 (PFS) and the Backup Flight System (BFS).

(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 will be specified in NSTS 08171, Operations and Maintenance Requirements and Specifications Document (OMRSD) and will be based on flight intervals, time, cycles, assembly level or disturbed function basis. 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, Turnaround Validation and Checkout Requirements. 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 (IFAs) 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 (TPS) 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 (OEM) 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 as specified in NSTS 08171, 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 verification of mature systems and will not be considered a development test program.

b. Verification requirements allocated to flight demonstration will be limited to those that (1) require flight data to verify mission capabilities, (2) are more cost effective to conduct in flight than by other methods, or (3) will overcome definite inadequacies of other test methods.

c. The approach and landing test program will satisfy verification 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.

   3. Demonstration of overall system operation, including all elements, payloads, ground support equipment, and facilities.

   4. Verification and refinement of ground support equipment, facilities, and procedures to obtain minimum time, high-confidence turnaround.

e. 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.

f. 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.

g. Flight tests demonstration of abort requirements is not required. Abort capability will be verified primarily by analysis, supplemented with ground test as required.

h. The approach and landing test program and the early orbital flights will be limited to two crewmen.

3.9 GROUND SUPPORT SYSTEM VERIFICATION

The verification program for Ground Support Equipment (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 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. Electromatic compatibility will be verified during integrated checkout by demonstrating proper vehicle system operation. Susceptibility characteristics will be determined at the subassembly level (black box) only when failure or premature function could cause loss of vehicle systems, loss of personnel capability, or destruction of ground systems.

3.9.2 Certification

Certification may be accomplished by test and/or analysis.

3.9.2.1 Design Analysis and Similarity Analysis

Certification of ground support equipment by analysis will be performed in accordance with the guidelines in Paragraph 3.4.

3.9.2.2 Certification Testing

Certification tests when required of ground support equipment will be performed on production configured specimens to verify 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. Certification testing of components and subassemblies 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 (for 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 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, Table 4.1 in NSTS 07700, Volume X, Book 1, Requirements.

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 GOVERNMENT FURNISHED EQUIPMENT VERIFICATION/CERTIFICATION

3.11.1 Government Furnished Equipment Flight Hardware

Government Furnished Equipment (GFE) flight hardware verification and certification shall follow the guidelines prescribed for flight element/system verification and certification.

3.11.2 Government Furnished Equipment Ground Hardware

Government Furnished Equipment ground hardware verification and certification shall follow the guidelines prescribed for ground system verification and certification.

TABLE 3.6–I
PALMDALE OPERATIONS, TEST AND CHECKOUT ACTIVITY

(Page 1 of 2)

	GROUND		ONBOARD		
TEST AND C/O ACTIVITY	MANUAL	COMPUTERIZED	COCKPIT MANUAL	COMPUTERIZED	REMARKS
I. PREINSTALLATION AND MAJOR ASSEMBLY TESTING 1. Major Module Level 2. Assembled Structural Vehicle Level 3. Subsystem Acceptance and Pre–installation	1. Elec. circuits continuity, insulation resistance, imped, etc. 2. Plumbing/ducting leak proof, flow, cleanliness, etc. 3. Built–in components (relays, values, resistors, etc. Exercise and activate manual use of BME, STE hand–held GSE	Special test equipment may be automated in some receiving or test areas			No onboard/ground partitioning required.
II. SUPPORT – SUBSYSTEMS ACTIVATION AND CHECKOUT 1. Prerequisite Functions a) Electrical Power b) Water Coolant Loops (leak, func. and servicing) c) Freon Coolant Loops d) Hydraulics 2. Activation and Tests a) DP&S Prog. Load b) OP Instrumentation	Local control and monitor of selected GSE	1. Load and verify onboard CPU 2. Monitor and display data 3. Data recording and play-back 4. Uplink C/O commands 5. Monitor and control selected GSE	1. Switch activations 2. Monitor displays 3. Keyboard test selection	1. Execute computer commanded stimuli applications 2. Perform self test 3. Execute called test routines 4. Data acquisition 5. Display generation	Support – Subsystems verification is required prior to performing checkout activities.
III. SUBSYSTEM CHECKOUT AND PRELIMINARY SERVICING	A. Local control and monitor of selected GSE	1. Load and verify on board CPU 2. Monitor evaluation, and display data 3. Data recording and play-back 4. Control and monitor selected GSE 5. Perform C/O and fault isolation below functional path level 6. Provide quick–look stripout data 7. Perform off–line data pro-cessing 8. Uplink checkout com-mands	1. Switch activations 2. Display monitoring 3. Keyboard test selections 4. Keyboard data and status callups 5. Manipulate vehicle controls	1. Data acquisition 2. Display generation 3. Execute testing routines	1. CEI specifications will define each vehicle configuration. 2. A common data base for measure-ments, stimuli, and calibrations for both the ground and onboard checkout systems is required. 3. During individual S/S testing, some C/O may be accomplished by using OB computers and other testing by cockpit switch activation and ground monitoring of PCM.

TABLE 3.6–I
PALMDALE OPERATIONS, TEST AND CHECKOUT ACTIVITY – Concluded

(Page 2 of 2)

	GROUND		ONBOARD		
TEST AND C/O ACTIVITY	MANUAL	COMPUTERIZED	COCKPIT MANUAL	COMPUTERIZED	REMARKS
IV. <u>INTEGRATED ORBITER CHECKOUT</u> 1. Combined Systems Tests – Closed Loop 2. Mission Modes Sims 3. Abort Modes Sims	A. Local control and monitor of selected GSE	1. Load and verify onboard CPU 2. Monitor, evaluation, and display data 3. Data recording and play-back 4. Control and monitor selected GSE 5. Provide quick–look stripout data 6. Provide simulator responses and off –limits simulations 7. Uplink C/O commands	1. Switch activations 2. Display monitoring 3. Keyboard test selections 4. Keyboard data and status callups 5. Manipulate vehicle controls	1. Data acquisition 2. Display generation 3. *Execute testing routines 4. *Verify systems to lowest func. path 5. Perform self test 6. Execute computer command stimuli applications 7. Perform automatic redun-dancy switching 8. Control onboard data recording 9. Recorded data dump	* Phased implementation consistent with Orbiter development and schedule
V. <u>GROUND TESTS</u> 1. APU Operations 2. Onboard Elec. Power 3. Onboard Hyd. Power	A. Local control and monitor of selected GSE	1. Load and verify flt. prog. into onboard 2. Verify onboard recorded data	1. Switch activations 2. Display monitoring 3. Keyboard test selections 4. Keyboard data and status callups 5. Manipulate vehicle controls	1. Data acquisition 2. Display generation 3. Perform self test 4. Control onboard data recording	

TABLE 3.6–II
EDWARDS AFB OPERATIONS, TEST AND CHECKOUT ACTIVITY

NOTE: Tentative Partitioning
Pending ALT Definition

TEST AND C/O ACTIVITY	GROUND		ONBOARD		REMARKS
	MANUAL	COMPUTERIZED	COCKPIT MANUAL	COMPUTERIZED	
I. HANGER AREA 1. Non–Hazardous Servicing 2. Contingency Testing 3. Subsystem Flight Readiness Testing	Local control and monitor of selected GSE	1. Load and verify onboard computer loads 2. Monitor, evaluate and display data 3. Data recording and playback 4. Uplink C/O command 5. Perform off–line data processing	1. Switch activations 2. Monitor displays 3. Keyboard test selections 4. Keyboard data and status callups 5. Manipulate vehicle controls	1. Data acquisition 2. Monitor displays 3. *Execute testing routines 4. *Verify systems to lowest func. path 5. Perform self test 6. Execute computer commanded stimuli applications 7. Perform required automatic redundancy switching	1. The SAIL at JSC provides integrated avionics test and checkout data for the ALT configuration. 2. *Onboard checkout routines will be implemented to the degree possible within cost and schedule constraints.
II. FLIGHT LINE 1. Preflight Activities 2. Post–Flight Activities	Local control and monitor of selected GSE	Monitor and record data	1. Switch activations 2. Monitor displays 3. Keyboard data and status callups 4. Keyboard test selections	1. Data acquisition 2. Display generation 3. *Verify systems to lowest func. path 4. Execute computer commanded stimuli applications 5. Perform self tests	* Onboard checkout routines will be implemented to the degree possible within cost and schedule constraints.
III. SAFING AREA	A. Control and monitor of: 1. Hazardous servicing units 2. Elec. power and ground cooling	1. Monitor and record data 2. Uplink servicing commands	Activate switches	Data Acquisition	Cockpit unmanned during hazardous servicing.

TABLE 3.6–III
KENNEDY SPACE CENTER OPERATIONS, TEST AND CHECKOUT ACTIVITY
(Page 1 of 2)

TEST AND C/O 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 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 3.6–III
KENNEDY SPACE CENTER OPERATIONS, TEST AND CHECKOUT ACTIVITY – Concluded
(Page 2 of 2)

TEST AND C/O ACTIVITY	GROUND		ONBOARD		REMARKS
	MANUAL	COMPUTERIZED	COCKPIT MANUAL	COMPUTERIZED	
SERVICING/PRELAUNCH ACTIVITIES 1. Begins with Rollout to Pad 2. Ends with Liftoff 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 pro-cessing 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	Criticality 3	Criticality 1R**, 2R	Criticality 1R*, 1S, 2	Criticality 1
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

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

THIS PAGE INTENTIONALLY LEFT BLANK

4.0 RESPONSIBILITIES, DOCUMENTATION AND CONTROLS

This section defines the basic division of responsibilities between Government agencies, (NASA or the U.S. Air Force as applicable), the system integration contractor, and element associate contractors in the planning and implementation of the Space Shuttle verification 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–I lists the major responsibilities and associated documentation that will govern the system and element contractors and Government agencies in implementing the Space Shuttle verification program and in formulation of detailed verification plans. The major divisions of activity are:

a. Requirements identification – This activity involves the determination of system level and element verification requirements. The Shuttle Master Verification Plan is developed based on these requirements and results in assigning an element contractors and Government agencies the responsibility for planning and implementing verification programs to satisfy assigned requirements. As requirements are assigned, requirements traceability shall be maintained as defined in NSTS 07700, Volume IV, Configuration Management Requirements, Paragraph 3.1.10 and Appendix B, and in the NSTS 07700, Volume V, Information Management Requirements, 1R 2MT–14.

b. Planning, implementation, and evaluation – This activity includes the detailed verification 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–I, each element contractor and Government agency is responsible for (a) preparing required plans and procedures, (b) implementing the approved element verification program, (c) supporting element and interface tests conducted by the system integration contractor, other element contractors, or Government agencies and (d) providing required status and evaluation reports.

4.1.1 Verification Program Status

An integral part of the verification task is tracking and statusing the progress of verification activities. To accomplish this task, each contractor or Government agency will be required to establish a system which displays the element incremental verification points and the constraints associated with each verification point, and reflects the status of the verification activities. A suitable approach for display of incremental verification points and constraints is the verification network. Figure 4–1–1 contains the top level verification network for the Shuttle system. It is to be followed by all element contractors in planning and implementing the individual element level network 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 (Figure 4–1–2) are to be included in the respective verification plans. The element contractor and Government agencies will be responsible for (1) developing the details for all networks associated with their element and (2) maintaining these networks and statusing their verification activities relative to the established incremental points.

Each flight element project, launch and landing site, and the Space Shuttle Systems Integration Office will develop a tracking system which will show approved verification completion, maintain verification status, and document the verification process. Data from this system shall be submitted to the Space Shuttle Systems Integration Office in accordance with NSTS 07700, Volume V, Information Management Requirements, 1R 2MT–14, and be made available to support certification of flight readiness (reference NSTS 08117, Procedure for Certification of Flight Readiness). Supporting objective test data or analysis reports, as applicable, will be identified and the location of data will be shown. Retrieval of this data must support management decisions for flight or major test readiness.

Status of verification and compliance with the NSTS 07700, Volume X, Space Shuttle Flight and Ground System Specification requirements, and supporting test configuration identifications shall be available for the Program Compliance Assurance and Status System (PCASS, Reference NSTS 07700, Volume XI, System Integrity Assurance Program Plan) as specified in NSTS 07700, Volume V, 1R 2MT–14. The Space Shuttle Systems Integration Office will provide assessment of compliance with the requirements of this Master Verification Plan, and an assessment of flight element, launch and landing site, and combined element compliance with design requirements in the Space Shuttle Flight and Ground System Specification (NSTS 07700, Volume X). The Space Shuttle Systems Integration Office will provide the integrated assessment and status of SSP verification for major program reviews. Each element will provide SSP verification 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 system established for the SSP verification program is illustrated in Figure 4–2–1. The contents of each document are summarized in Table 4.2–II. 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 verification of those requirements. This traceability begins with NSTS 07700, Volume X, Book 1, Requirements, Table 4.1, and continues into element specifications, as applicable, where the system and element level design requirements are documented. Requirements for verification of each of these specifications are documented in the appropriate volume of the Shuttle Master Verification Plan (Volumes II through VI and VIII) where the verification method is established based upon the guidelines provided in this volume of the Shuttle Master Verification Plan. The verification requirements are expanded and grouped into individual requirements documents according to implementation method, (i.e., major ground test, flight test, acceptance test and c/o, 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 shown in the figure. Data from these programs is utilized to obtain verification status.

Each program element will be responsible for the preparation of the appropriate volume of the Shuttle Master Verification Plan and associated lower level documents. After each volume of the Shuttle Master Verification Plan has been approved, it shall be submitted to the Space Shuttle Systems Integration Office for review to insure compliance with the provisions of this volume of the Shuttle Master Verification Plan. Table 4.2–III summarizes documentation requirements for major program reviews.

Copies of all element certification data shall be retained. Certain data items shall be made available to the Space Shuttle Systems Integration Office, System Integration Contractor, and other program elements as defined in Paragraph 4.1.1 above.

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

Verification documentation control shall be in accordance with the Information Management Requirements document (NSTS 07700, Volume V, Information Management Requirements).

Particular emphasis must be placed on verification documentation change control. Each verification requirement, regardless of the level (i.e., 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 verification requirement changes. Approval will also be necessary to acknowledge that verification 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. The System Contractor will schedule reviews for combined element and total system tests (i.e., major ground test, approach and landing test). Final authority to proceed (readiness approval) shall be furnished by NASA.

4.4 DEVIATION/WAIVER GUIDELINES

The following guidelines will be utilized for processing Deviations/Waivers 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 in NSTS 08171, OMRSD, in accordance with the MVP turnaround checkout philosophy, shall require a waiver to the MVP from the responsible design project office. CIL waivers may serve as the applicable waiver. An OMRSD RCN may serve to identify the need to waive an MVP violation.

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 waiver 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 NSTS 08171, OMRSD, FMEA cross reference matrix in applicable file(s) and on specific intent and rationale sheets if applicable.

d. Deviations/Waivers are not required for Criticality 3 functions.

TABLE 4.1–I

VERIFICATION PROGRAM RESPONSIBILITIES

			NASA			
Test Program	Activity	System Contractor	Program Office	Project Office	Element Contractor	Document Title
System element verification	Requirements identification	Define system level (SMVP Volumes I and II)	Approve system-level requirements document	Approve element-level requirements document	Define and allocate element-level requirements (SMVP Volumes III through VI and VIII	Shuttle Master Verification Plan Volume I, General Approach and Guidelines Volume II, Combined Element Verification Plan Volume III, Orbiter Verification Plan Volume IV, SRB Verification Plan Volume V, ET Verification Plan Volume VI, ME Verification Plan Volume VIII, Launch and Landing Site Verification Plan
	Planning implementation and evaluation	Prepare system-level plans and review element-level plans (SMVP Volumes I and II)	Approve system-level plans	Approve element-level plans Prepare SMVP Volume VIII (KSC)	Prepare element-level verification plans (SMVP Volumes III through VI and VIII	
		Prepare system-level verification analysis reports	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	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–I

VERIFICATION PROGRAM RESPONSIBILITIES – Continued

Test Program	Activity	System Contractor	NASA		Element Contractor	Document Title
			Program Office	Project Office		
Subsystem certification (cont)	Planning implementation and evaluation (cont)	Review and track certification status Identify potential problems to program office	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
Approach and landing test program	Requirements identification	Review	Approve system level reqmts doc	Approve element level documents & allocate reqmts	Define and document element level reqmts	Orbiter Test Requirements and Specification Document
Preflight test and checkout	Planning implementation and evaluation	Review	Review	Prepare and approve ground checkout plan (KSC) Review and concur (JSC)	Support preparation	Orbiter Ground Operations Plan
				Approve selected procedures (KSC)	Prepare checkout procedures	Test and Checkout Procedures
				Direct checkout activity (KSC)	Conduct checkout	
				Provide readiness requirements and approval (KSC)	Conduct test readiness reviews	
				Perform data reduction (KSC)		
				Perform analysis and review reports (KSC)	Perform data analysis	
				Provide checkout completion approval (KSC)	Conduct post-checkout reviews	
		Review	Review and concur	Prepare (JSC)	Support prep of summary test report	Flight test summary reports
Approach and landing test program	Requirements identification	Review	Review and document	Collect, define, review, and approve requirements	Provide detailed flight test requirements	Orbiter test Requirements document Carrier test Requirements document
		Review	Develops and documents	Review, provide inputs and implement	Review	MVP VOLX-Master flight test assignments document

TABLE 4.1–I

VERIFICATION PROGRAM RESPONSIBILITIES – Continued

Test Program	Activity	System Contractor	NASA		Element Contractor	Document Title
			Program Office	Project Office		
Approach and landing test program (cont)	Planning implementation and evaluation	Review test plan	Review test plan	Prepare and approve plan and detailed flight test plans	Review	Orbiter Flight Test Plan
				Conduct preflight readiness reviews	Support preflight readiness reviews	
				Conduct flight test	Support flight test	
				Perform data reduction	Support data reduction	
				Perform analysis and review analysis reports	Perform data analysis	
				Conduct post–flight debriefing	Conduct post–flight debriefing	
		Review	Review	Prepare test reports	Support preparation test reports	
Orbital flight test preflight test and checkout	Requirements identification	Define system-level requirements and document	Approve requirements document	Concur with element contractor inputs to system-level requirements (JSC/MSFC)	Support system-level requirements identification	Operation and maintenance requirements and specification document
		Integrate all element pre-mate requirements	Review requirements document	Approve pre-mate requirements (JSC/MSFC)	Define and document element pre-mate requirements	Operation and maintenance requirements and specification document
	Planning implementation and evaluation	Support prep of integrated ground operations plan		Prepare and approve integrated ground operations plan (KSC)	Support preparation of integrated ground operations plan	System Integrated Ground Operations Plan - OFT
		Support preparation of integrated OMP	Concur with Integrated OMP	Prepare and approve operation and maintenance plan (KSC) (JSC/MSFC concurrence)	Support preparation	Operation and maintenance plan
		Prepare system-level Operation and maintenance instructions		Approve system-level operation and maintenance instructions (KSC) Review(JSC/MSFC)	Support preparation of system-level operation and maintenance instructions	Operation and maintenance instructions
				Approve system-level operation and maintenance instructions (KSC) Review(JSC/MSFC)	Prepare element test Operation and maintenance instructions	Operation and maintenance instructions

TABLE 4.1–I

VERIFICATION PROGRAM RESPONSIBILITIES – Continued

Test Program	Activity	System Contractor	NASA Program Office	NASA Project Office	Element Contractor	Document Title
Orbital flight test preflight test and checkout (cont)	Planning implementation and evaluation (cont)	Support		Conduct system-level test readiness reviews (KSC)	Support	
		Support system-level tests		Direct test and checkout activity (KSC)	Conduct test	
				Perform data reduction (KSC)		
		Perform system-level data analysis and support post-test reviews		Review analysis and conduct post-test reviews (KSC)	Perform element-level data analysis, support system-level analysis, support post-test reviews, and prepare test summary reports	Test Summary Reports
		Declare system readiness for launch	Conduct launch and flight readiness reviews		Declare element readiness for launch	
Orbital flight test (OFT)	Requirements identification	Identify system-level requirements, integrate all element-level requirements, document initial draft, and submit subsequent changes	Approve and document requirements	Compile and document element-level requirements.	Provide detailed flight test requirements	System Orbital Flight Test Requirements Document
		Review	Develop, document and implement	Review and provide inputs	Review and provide inputs	MVP VOL X – Master Flight Test Assignments Document
	Planning implementation and evaluation	Support prep of draft orbital flight test plan	Prepare flight test plan and release	Concur with element contractor inputs to orbital flight test plan		System Orbital Flight Test Plan

TABLE 4.1–I

VERIFICATION PROGRAM RESPONSIBILITIES – Continued

Test Program	Activity	System Contractor	NASA		Element Contractor	Document Title
			Program Office	Project Office		
Orbital flight test (OFT) (Cont)	Planning implementation and evaluation (Cont)	Support	Prepare and release detailed mission plans	Support	Support	
		Support	Conduct flight test and direct mission support	Support	Support	
				Perform data reduction	Support	
		Support flight test data analysis	Review analysis reports	Perform analysis and prepare reports	Support flight test data analysis	
		Support	Conduct post-mission reviews	Support	Support	
Major ground test - element	Requirements identification	Review requirements document	Review requirements document	Approve requirements document	Define requirements	(Test Title) Requirements Document
	Planning implementation and evaluation	Review plans	Review plans	Approve plans	Prepare implementation plans	(Test Title) Plan
				Approve selected test procedures	Prepare test procedures	Development Test Procedures
				Provide test readiness approval for selected tests	Conduct test readiness reviews	
				Provide test surveillance and test director function for selected tests	Conduct or support test	
				Review reports and provide test completion approval	Perform analysis and prepare selected reports	Test Reports
Major ground test - combined elements	Requirements identification	Define test requirements and documents	Approve test requirements documents	Support review of requirements	Support definition of requirements	(Test Title) Requirements Document
	Planning implementation	Prepare implementation plans	Approve plans	Support review	Support preparation of plans	(Test Title) Plan

TABLE 4.1–I

VERIFICATION PROGRAM RESPONSIBILITIES – Continued

Test Program	Activity	System Contractor	NASA		Element Contractor	Document Title
			Program Office	Project Office		
Major ground test - combined elements (cont)	Planning implementation (cont)	Prepare test procedures	Review and approve selected procedures	Support review of procedures	Support procedure preparation	Development Test Procedures
		Conduct test readiness reviews	Provide test readiness approval for selected tests	Support review	Support	
		Conduct test	Provide test surveillance and test director function for selected tests	Support and surveillance	Support	
		Perform analysis and prepare reports	Approve reports	Review and support test completion approval	Support analysis	System Contractor Test Reports
Major ground test - flight readiness firing (FRF)	Requirements identification	Define and document requirements	Approve requirements document	Concur with requirements (JSC/MSFC)	Support definition of requirements	Flight Readiness Firing Requirements Document
	Planning implementation and evaluation	Prepare flight readiness firing plan		Approves FRF plan (KSC)	Support preparation of FRF plan	Flight Readiness Firing Plan
		Prepare test procedure		Approve test procedure (KSC)	Support preparation of test procedure	Test and Checkout Procedures
		Support		Conduct test readiness review (KSC)	Support	
		Support		Conduct test (KSC)	Support test	
		Perform data analysis and support post-test reviews		Review analysis and conduct post-test reviews (KSC)	Support analysis, prepare test summaries, and support post-test reviews	System Contractor Test Reports
Element acceptance test	Requirements identification	Review interface related acceptance requirements	Review interface related acceptance requirements	Approve requirements document	Define requirements	Test and Checkout Requirements Document

TABLE 4.1–I

VERIFICATION PROGRAM RESPONSIBILITIES – Concluded

Test Program	Activity	System Contractor	NASA		Element Contractor	Document Title
			Program Office	Project Office		
Element acceptance test (cont)	Planning implementation and evaluation	Review	Review	Approve plans	Prepare element-level plans	Acceptance Checkout Plans
				Approve selected procedures	Prepare test procedures	Test Checkout Procedures
				Provide integrated test readiness approval	Conduct ground test readiness reviews	
				Conduct acceptance flight readiness reviews	Support	
				Provide test director function	Conduct ground tests	
				Perform acceptance flight	Support	
				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	
Carrier aircraft flight test	Requirements identification	Review	Collect, define, approve and implement		Recommend detailed flight test requirements	Flight test requirements document

TABLE 4.2–II
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 Volume II Combined Element Verification Plan	Verification programs planned for combined elements (two or more elements). Top–level requirements applicable to combined elements. Verification method.
Shuttle Master Verification Plan Volumes III through IV 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.

TABLE 4.2–II
DOCUMENTATION CONTENT SUMMARY – Continued

Document Title (*Generic Titles)	Contents
*Acceptance Test and Checkout Requirements Document	Element factory acceptance checkout requirements with pass/fail limits. General requirements for retest, quality assurance, and safety.
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 approach and landing test 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 orbital flight test 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.

TABLE 4.2–II
DOCUMENTATION CONTENT SUMMARY – Continued

Document Title (*Generic Titles)	Contents
*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.
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 orbital flight test. 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/Deactiva–tion 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.

TABLE 4.2–II
DOCUMENTATION CONTENT SUMMARY – Continued

Document Title (*Generic Titles)	Contents
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.
*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.

TABLE 4.2–II
DOCUMENTATION CONTENT SUMMARY – Concluded

Document Title (*Generic Titles)	Contents
*Test Summary Reports	Brief report summarizing results from each test performed in accordance with approved test procedure. Summarize compliance with specification requirements.
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.

TABLE 4.2–III

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 & Landing and Orbital Flight Test 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.

THIS PAGE INTENTIONALLY LEFT BLANK

FIGURE 4–1–1

SHUTTLE SYSTEM VERIFICATION NETWORK

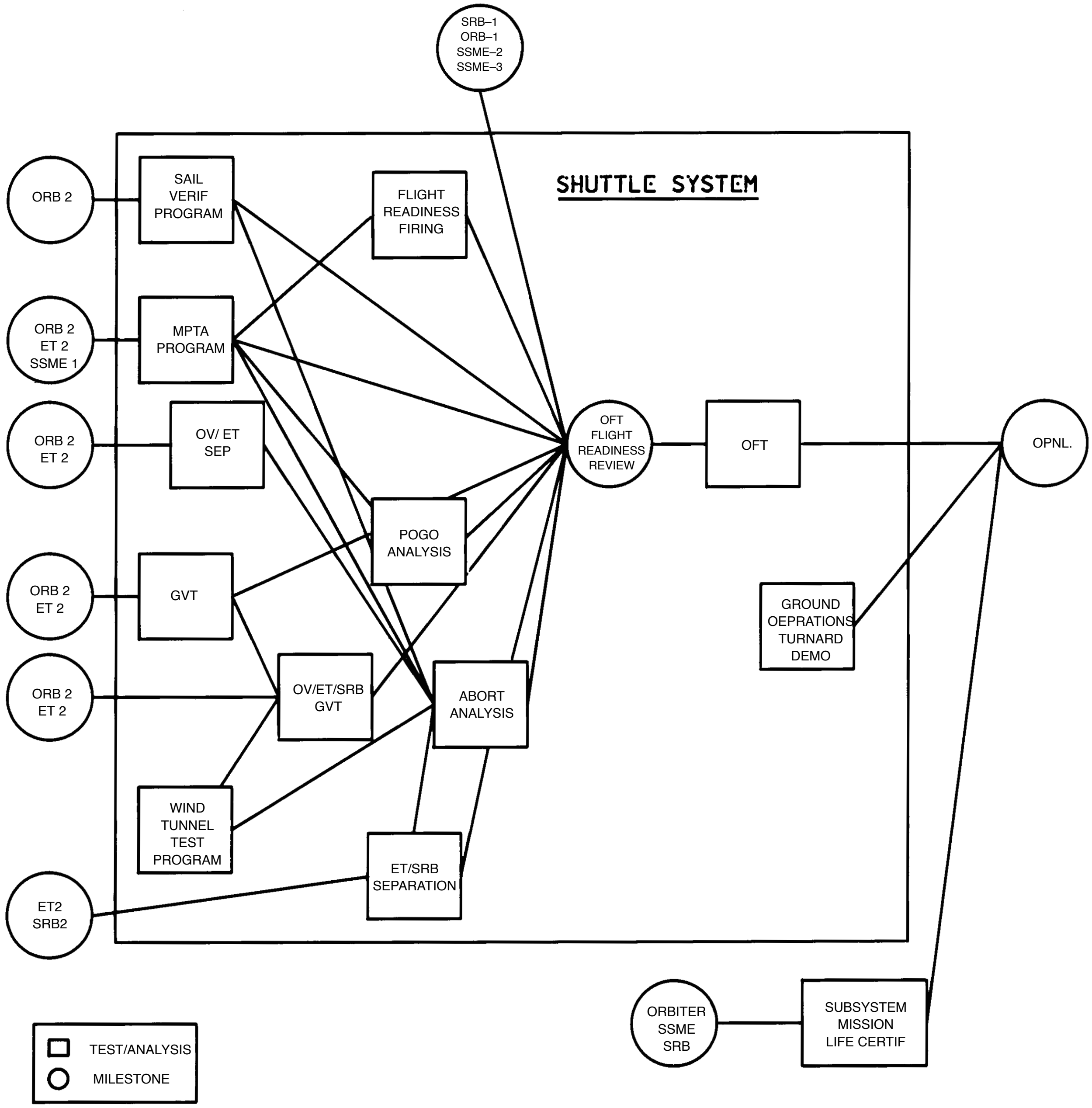


FIGURE 4–1–1a

SHUTTLE SYSTEM VERIFICATION NETWORK (ORB AND SSME)

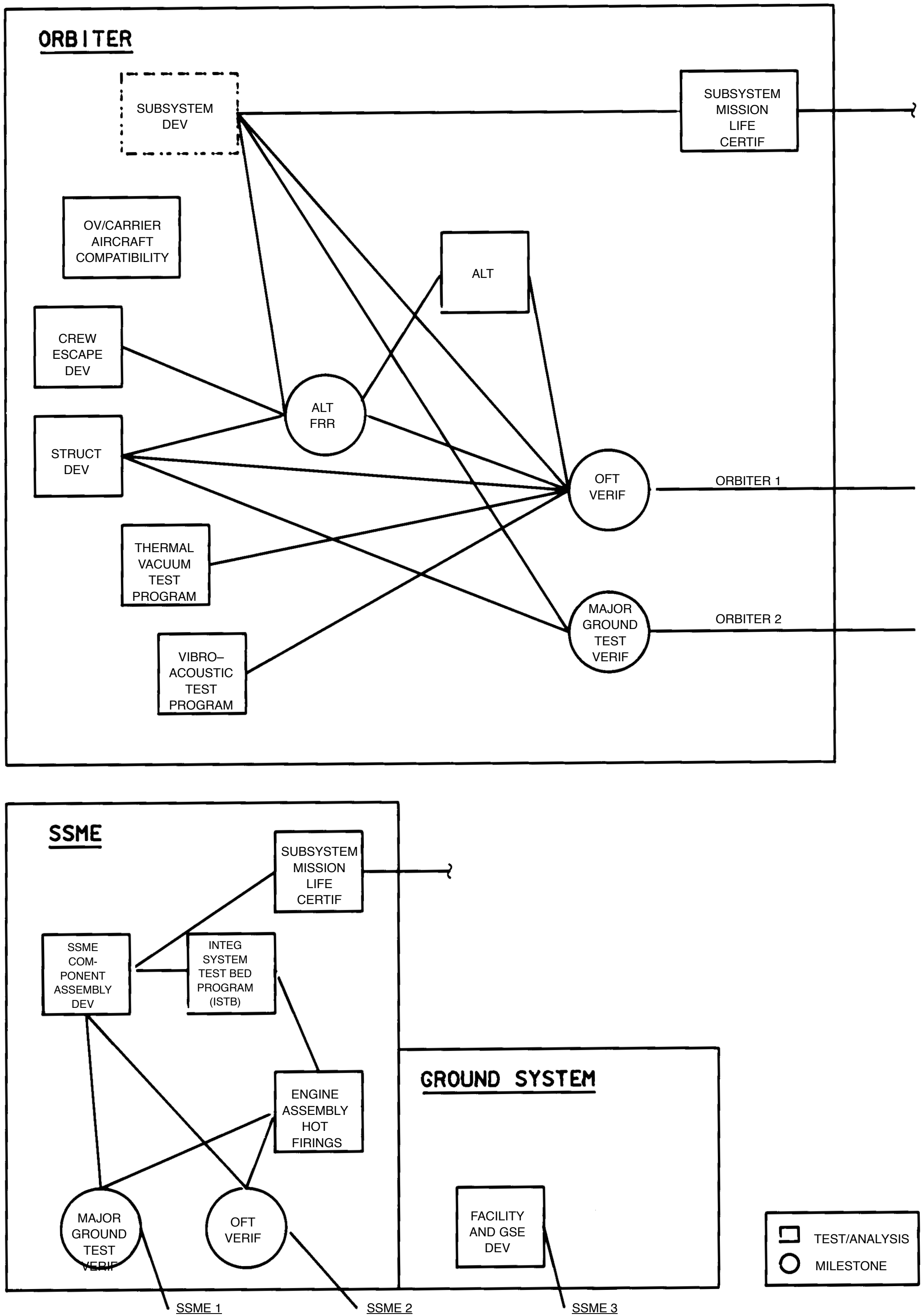


FIGURE 4–1–1b

SHUTTLE SYSTEM VERIFICATION NETWORK (ET AND SRB)

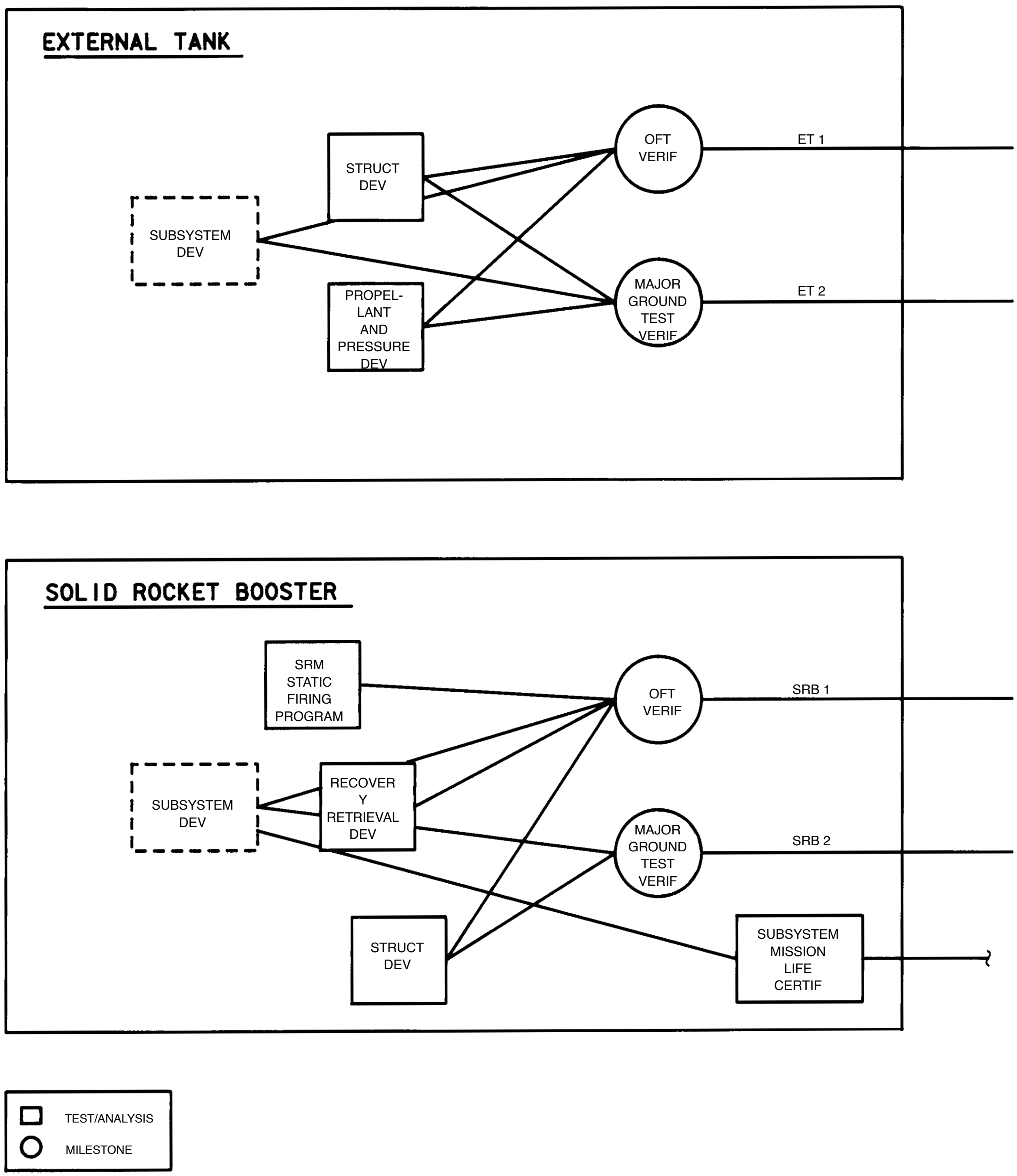


FIGURE 4–1–2

ORBITER VERIFICATION NETWORK

FIGURE NOT AVAILABLE ELECTRONICALLY

Refer to Foldout Figure in Book

FIGURE 4–1–3

SSP VERIFICATION NETWORK

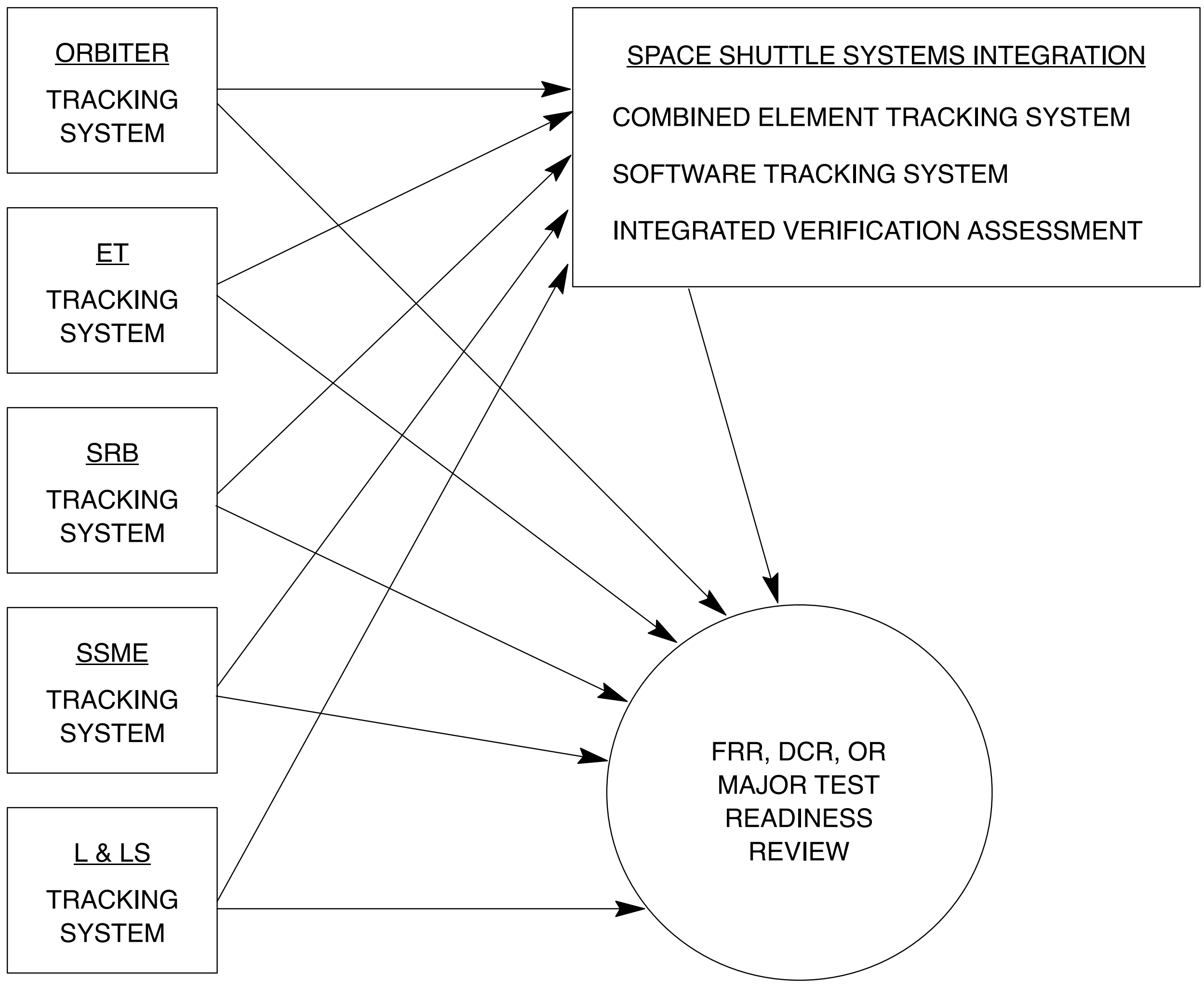


FIGURE 4–2–1

(TBD)

APPENDIX A

SHUTTLE SYSTEM AND ELEMENT TEST PLAN SUMMARY

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX A

SHUTTLE SYSTEM AND ELEMENT TEST PLAN SUMMARY

1.0 SHUTTLE TEST PROGRAM SUMMARY

This appendix summarizes the Shuttle System and element level test programs. It is provided purely for information purposes and to give an overview of the planned test programs which make up the test portion of the Shuttle Master Verification Plan (SMVP).

Although every attempt will be made to keep this summary current, the information it contains has no contract or directive status. Such control is contained in the body of the various SMVP Volumes and not in this appendix.

1.1 COMBINED ELEMENT TEST PROGRAMS

The Shuttle System combined element–level test programs include significant major ground tests as well as the orbital flight test required to final verification of the integrated system elements.

1.1.1 Ground Vibration Test

The Shuttle System structural dynamic characteristics used for load, POGO, flutter and flight control system analysis will be verified by a major Ground Vibration Test (GVT) program. The program will include modal vibration testing of components (i.e., Reusable Solid Rocket Motor [RSRM] segment, External Tank [ET] LOX tank), tests of the Orbiter (horizontal) both soft suspended and hard mounted to ground through simulated ET linkage; a test of an ET mated to an Orbiter (vertical); and a test of a mated Solid Rocket Booster (SRB)/ET/Orbiter Configuration (vertical). The GVT also includes modal vibration testing of one–fourth scale structural replica Shuttle models of individual elements and of mated ET/Orbiter and Orbiter ET/SRB configurations. The vertical tests will be performed using a soft suspension system and with various amounts of fluid simulation in the ET to investigate the effects of various propellant loadings. The tests will be used to obtain structural dynamic characteristics to confirm mathematical model predictions. The test articles will be mass–ballasted to flight configuration.

1.1.2 Main Propulsion Test

The Main Propulsion Test (MPT) program will provide the initial integration of the clustered Space Shuttle Main Engines (SSME) into the Main Propulsion Subsystem (MPS), including the ET and associated Ground Support Equipment (GSE). This program will be conducted at the Stennis Space Center (SSC) and is structured to achieve specific test objectives to allow incremental buildup of confidence in the Main Propulsion Test Article (MPTA), GSE, and facilities. The activation program includes installation and checkout of GSE and the assembly, installation, and checkout of the major elements of the test article in the test stand. The test program includes cryogenic tanking tests, initial engine cluster development firings, and verification of the capability of the final configuration of the main propulsion system to accommodate nominal and off–nominal modes. A contingency period is planned during which the test article will be placed in a standby mode and be available for investigation of any problems encountered during the initial phase of the orbital flight test program and to serve as a test bed for evaluation of engineering changes.

1.1.3 Ground Test for Orbital Flight

Ground tests prior to the First Manned Orbital Flight (FMOF) are initiated by an activation program to validate facility, GSE, and element interfaces. After this initial site activation effort has been completed, comprehensive element checkout will be initiated to minimize combined element testing after stacking. Each element will be exposed to the pre–established phases of the ground turnaround cycle to support development and verification of the procedures, techniques, support equipment, and facilities to be used in the operations phase.

A cryogenic tanking test of the ET and the Orbiter Main Propulsion System will be performed with the first Space Shuttle Vehicle prior to the Flight Readiness Firing (FRF). This test is to verify the integrity and compatibility of the launch facility with the flight hardware. This test will afford the incremental development and confidence in the loading sequence and drain operations necessary to accomplish the “all–up” loading operation to be used for FRF.

A FRF utilizing the Orbiter, SRB and ET will be conducted prior to the first orbital flight to complete the activation program and to provide the final prelaunch validation of flight hardware and sections of the operational countdown. Following this FRF, functional subsystem checkouts and inspections will be performed to verify that there were no adverse effects from this firing and that the Shuttle Vehicle is ready for flight.

1.1.4 Orbital Flight Test

The orbital flight test program will demonstrate Shuttle System flight–worthiness and mission capability and will extend the Orbiter’s flight envelope from the approach and landing flight test program to include mated ascent, separation, orbit insertion, on–orbit operations, and entry. This phase will also verify the recovery capability of the booster and compatibility among all elements of the Shuttle System. The orbital flight test program presently consists of six manned flights. A program option provides for an unmanned first flight.

1.1.5 Shuttle Avionics Integration Laboratory (SAIL)

The Shuttle Avionics Integration Laboratory (SAIL) functions to perform avionics system integrated testing in direct support of the Space Shuttle Program (SSP) and will support hardware/software verification for the integrated Space Shuttle flight elements. The SAIL provides a central facility where the avionics and related hardware (or simulations of the hardware), flight software, flight procedures, and associated GSE are fully integrated for testing. The laboratory provides a test bed for the verification of all avionic interfaces of the Shuttle Program elements which includes the Orbiter integrated avionics hardware and software, and the SRB, SSME and the ET avionics interfaces with the necessary software for exercising these interfaces. Elements of the KSC Launch Processing System (LPS) hardware are installed in the SAIL facility and use the integrated Orbiter systems as a validation tool for the LPS interface.

The laboratory is modified to support operational mission testing. The SAIL is used, as priorities dictate, for mission evaluation, realtime simulation of in–flight problems for analysis and followup anomaly investigations, verification of Orbiter/payload compatibility, determining limitations of avionics system capabilities, and for the evaluation of procedures. The specific SAIL test functions and responsibilities allocated to the Shuttle project are presented in JSC 08663, Volume I, SAIL Project Plan.

The purpose of the SAIL is to support verification of the integrated avionics hardware and software to meet system requirements for each flight phase. This is accomplished through sequential levels of systems testing including 6–DOF closed–loop simulations for each flight phase.

The MSFC Mated Elements System (MMES) comprises all of the hardware and software furnished to SAIL by MSFC. The MMES is made up of element avionics subsystem and components (and associated support equipment) and a Mated Elements Simulator (MES). Since only selected hardware items of the SRB, SSME and ET are provided, the remaining hardware functions are simulated by the MES. Development and verification of the integrated MMES was completed at MSFC and the system was delivered to JSC for incorporation into the SAIL.

Direct support for final closed–loop system tests is planned through interface with the Shuttle Dynamic Simulator (SDS). Attitude and translation signals provide apparent vehicle response for onboard control and display systems as well as the dynamic out–the–window scene display for viewing by astronauts functioning the SAIL during closed–loop testing.

1.1.6 Wind Tunnel Test – Shuttle

Data from the wind tunnel test program will support all program milestones with respect to requirement definitions, design development, refinement, and verification of the

Shuttle System. Data obtained for the atmospheric flight regimes associated with ascent, separation, and abort conditions. Tests will be conducted in the major categories of aerodynamics, air loads, heat transfer, and structural dynamics. Two basic test cycles are programmed prior to Preliminary Design Review (PDR): the first supported the Preliminary Requirements Review (PRR) configuration definition; the second will support configuration verification for PDR. Subsequent test phases will be supported with new and modified models after PDR. A third phase will be completed before the Critical Design Review (CDR). These phases will progressively refine and expand the test data to support certification for First Manned Orbital Flight (FMOF). Problems that may be uncovered in flight testing will be supported by tunnel testing as required. A heavy test load is planned early in the program to support key configuration trades and design definition.

1.1.7 Software Development and Software Production Facilities

The Software Development Facility and Software Production Facility (SDF/SPF) supports flight computer software development from program design through program verification. The SDF provides for the generation of onboard computer programs which includes the development of individual program modules and complete integrated programs. The SPF provides for program verification which includes facilities for static or dynamic program and module checkout utilizing digitally–simulated environment, vehicle, and subsystem modules. A common set of math models is utilized in the generation of the simulated environment of a flight and consists of the environment (Earth's atmosphere, gravity forces, etc.), vehicle (active and passive vehicle, mass property changes, etc.), and subsystems (e.g. Inertial Measurement Unit [IMU], GYROS, Reaction Control System [RCS], Thrust Vector Control [TVC], Main Propulsion System [MPS]).

The facilities utilize actual DPS computers, simulated buses, simulated avionics and simulated vehicle. The facility(s) includes a program management system which accommodates the storage, indexing, and retrieval of a variety of different types of data, including source programs, object programs, load modules, test initialization data, test results, schedules, change notices, and documentation. To the extent that other computational facilities require copies of Orbiter computer programs, the facility provides this service.

1.1.8 Shuttle System Umbilical and Separation System Verification

The verification program for the Shuttle umbilical and separation systems is an integrated effort involving the NASA centers, their hardware contractors, and the system contractor. The program objectives are to verify that the umbilical and separation systems hardware are ready for first launch and subsequent operational use. This program covers all Shuttle Vehicle ground preflight and T–0 umbilicals, the element–to–element umbilicals, the element–to–element separation hardware, the Orbiter Access Arm (OAA), and the SRB support/holddown posts.

1.1.8.1 Umbilical Systems Verification

A series of umbilical system tests will be performed from the component through the integrated umbilical level to provide verification that umbilical system requirements have been satisfied. These tests will initially be performed at element contractor facilities on components and major assemblies. The integrated umbilical tests will be performed at the Launch Equipment Test Facility (LETF) at KSC. Final verification will be a fit check at the pad, mating with the Shuttle Vehicle, and the first launch and separation. Details of the umbilical verification programs are described in NSTS 08121, Space Shuttle Systems Integrated Separation Systems Verification Plan (retired by PRCBD S014503AD).

1.1.8.2 Separation Systems Verification

Tests will be performed on the ET–SRB and ET–Orbiter subsystems components/elements to verify that their operational performance is within the design limits. The tests will supplement analyses, computer simulations, and software verification as well as data from other planned tests for verification of the overall system.

Qualification tests will be performed on separation system component/elements (e.g., forward and aft separation attachments, SRB Pc pressure transducer, electrical umbilical, and backup separation cue accelerometer and manual switch). Separation tests will be conducted on the forward and aft attachments separately for critical load conditions. The forward and aft attachments will be tested for structural capability separately for critical load conditions.

The SRB Booster Separation Motor (BSM) and ignition system will be verified for performance during qualification test firings. Altitude ignition tests will be conducted as part of BSM development and verification programs to verity start and performance characteristics of the BSM.

A scale model wind tunnel test will be performed to determine forces and moments acting on the SRB, ET, and Orbiter prior to and during separation. Data from this test and a mass properties analysis will support the mated vehicle flight control math model. Release and post separation characteristics of the system will be verified through the separation dynamics math model.

1.1.9 Combined Element Antenna Pattern Test

The Orbiter mounted antennas are derived from an antenna development and test program which includes scale model simulation and pattern testing of all possible flight configurations of the Shuttle. The Shuttle flight configurations as they affect antenna pattern testing, are:

a. Combined Orbiter, SRB, and ET

b. Combined Orbiter and ET

c. Orbiter alone with landing gear nondeployed

d. Orbiter alone with landing gear deployed

e. Orbiter alone with payload bay doors open

f. Orbiter alone with forward RCS doors open

1.1.10 Electronic Systems Test Laboratory (ESTL)

The Electronic Systems Test Laboratory (ESTL) will be utilized to provide combined payload–Orbiter element, and ground communications system development testing and performance evaluation. This program will be accomplished at JSC using both prototype and qualifiable nonredundant Orbiter hardware in conjunction with payload, relay satellite, Space Tracking and Data Network, Extravehicular Activity (EVA), and Air Force Satellite Control Facility hardware and equipment. Interface capability with the SAIL (Ref. 1.1.5) will be provided and exercised as required.

The ESTL test program consists of detailed systems level tests, involving spacecraft and ground station operationally configured equipment, conducted in a laboratory environment with the objective of providing a high degree of assurance that all terminals of the communication systems are compatible and perform as expected during all phases of the planned mission.

The test program commences with communication and tracking system development tests (using prototype Orbiter hardware), proceeds to system performance verification (using qualifiable Orbiter hardware), and continues throughout flight test and ultimately provides Shuttle operations support.

1.1.11 SRB Plume Attenuation Tests

The verification of whether satisfactory communications with the ground stations can be maintained during the SRB burn period of the ascent phase will be accomplished by special tests at Thiokol/Wasatch Division near Brigham City, Utah. Verification will include evaluation of RF link performance degradation due to the SRB plume for S–Band communications (uplink and downlink), Ultra High Frequency (UHF) Air Traffic Control voice communication, and UHF Range Safety Command communication. Flight hardware will be used whenever available. Development hardware and other test equipment used will be compatible with flight hardware. These tests will be accomplished before the first orbital flight test.

1.1.12 Hardware Simulation Lab

The Hardware Simulation Lab (HSL) provides a facility to test and verify SSME Avionics System using a complement of flight hardware integrated with an analytical engine model. The facility provides the capability to build and verify the SSME flight software. It can also support test and launch sites in anomaly resolution.

The primary utilization is to provide the checkout and operational software for both single engine tests and for flight.

The facility consists of SSME flight type avionics hardware (pressure, temperature, speed and flow transducers, igniters, fascos, valve activators, and controller) and custom simulation consoles for the rest of the engine and Orbiter interfaces.

1.1.13 Shuttle Ground Operations Simulation

The LPS consists of a checkout computer complex and equipment interfacing with the Shuttle Vehicle and launch facilities during ground operations. A means of exercising the LPS to verify the operations of the system and software and to maintain ground operations personnel Shuttle test proficiency, is required. The Shuttle Ground Operations Simulator (SGOS) provides this capability.

The objective of the SGOS is to provide the capability for simulating the Shuttle Vehicle, payload interfaces, GSE equipment, and launch station facilities required for operation. The purpose of SGOS simulations is to provide for application programs verification, the initial LPS activation verification, system modification verification, and ground crew training during the Shuttle operational phase. The SGOS does not provide environmental or flight dynamics simulation.

The SGOS digital simulations are resident in the LPS Shuttle Data Center (SDC). Hardware required to support simulations also interfaces with the SDC, and the overall simulation complex interfaces with the LPS checkout, control and monitor subsystem. The simulated systems may be used selectively in part–task simulation or collectively in all up systems simulation. LPS operation in the simulation mode and the operational mode are mutually exclusive.

1.2 ORBITER TEST PROGRAM SUMMARY

Briefly described in the following paragraphs is the element level test effort planned to verify the Orbiter.

1.2.1 Material and Process Evaluation

Material and process evaluation tests will be conducted in four basic categories: material control, fracture control, material characteristics development, and processing development. Material and fracture control plan development will be based primarily on existing government material control guideline documents. Tests will supplement available data, particularly in fracture mechanics and material characterization for unique processing and environmental effects on material allowables. Thermophysical, mechanical, and optical properties will be determined for new nonmetallic materials under consideration. Coatings for on–orbit thermal control will be evaluated for both one–entry and multiple use and determination attachment and refurbishment techniques. Specific materials control and verification planning information is contained in SD72–SH–0172, Space Shuttle Orbiter Materials Control and Verification Plan.

1.2.2 Orbiter Wind Tunnel Test Program

Like Shuttle–level testing, Orbiter wind tunnel testing will be integrated to support established program milestones associated with design requirement definitions and verification. Data will be obtained for the atmospheric flight regimes associated with entry, transition, cruise, landing, ferry, and abort conditions.

As in the case of the Shuttle wind tunnel program, two basic test cycles are programmed prior to PDR: the first to support the PRR configuration definition, the second to provide configuration verification for PDR. Subsequent test phases will be supported with new and modified models after PDR. A third phase will be completed before CDR. These phases will progressively refine and expand the test data to support verification for FMOF. Specific problems which may be uncovered in flight testing will be supported by tunnel testing as required.

1.2.3 Subsystem Development and Certification

The development and certification planning identified for each Orbiter subsystem is presented in JSC 07700–10–MVP–03, Shuttle Master Verification Plan, Volume III, Orbiter Verification Plan. Included is a short subsystem description, a listing of the principal test requirements with accompanying identification of primary and secondary sources of verification data, a verification logic diagram, and a discussion of the more significant tests and test facilities.

1.2.4 Flight Control Hydraulics Laboratory

The Flight Control Hydraulics Laboratory will serve as an Orbiter control element integration tool and will be used for verification of hydraulics checkout, servicing, and maintenance procedures. It will consist of a full–scale iron–bird fixture containing power sources, intermediate control linkages, control surfaces, and controlling avionics. Flight–control end–to–end tests will complement the analytical prediction of transfer functions used in simulation studies at the various avionics laboratories.

Testing will confirm redundancy management procedures with respect to shutoff and control valve sequencing, failure monitoring, control servo and Thrust Vector Control (TVC) servo–actuator channel shutoff, and fault isolation. Evaluations will be conducted on component characteristics such as friction, hysteresis, and dead zones associated with mechanical linkages, power actuator load sharing; and failure transients. Assessments will be made of the dynamic interaction between flight control and hydraulic power generation and distribution, including verification of pump and servo–actuator stability. Closed–loop testing of the flight controls and avionics will be accomplished by interfacing with the near–by Avionics Development Laboratory (ADL).

1.2.5 Vibroacoustic Tests

The criteria for environmental vibration and acoustic testing of subsystem components and conditions for acoustic fatigue tests of structural segments will be substantiated by analysis of data obtained during the Main Propulsion Test (MPT) programs.

One of these test programs is the MPT program at Stennis Space Center (SSC) where an Orbiter aft fuselage consisting of production and/or simulated structure, subsystems and components will be subjected to clustered SSME development firings. Acoustic closeouts will be located at the forward interface closeout structure, 1307 bulkhead, the OMS/RCS pods and vertical stabilizer interface.

The other test program will subject structural panels to acoustic fatigue tests at flight noise levels for extended duration (greater than 100 missions exposure) to verify panel structural adequacy and operational life. The latter tests will be performed at the JSC acoustic laboratories.

Payload bay vibration and acoustic environments for use in testing payloads will be verified by analyses of acoustic data that will be measured during the 6.4% model hot rocket engine firing tests, IS–2 model wind tunnel tests, development flight tests, and acoustic transmission loss tests of panels.

1.2.6 (Deleted)

1.2.7 Major Structural Tests

Static and fatigue structural tests will be conducted on a complete Orbiter airframe assembly and a separate crew module assembly. The airframe test article will include all primary and required secondary structure (less the crew module) along with selected portions of the external TPS and mechanical system hardware. Specifically excluded are the landing gear, all plumbing, wiring and equipment items. The airframe test article will be enclosed in a steel truss loading structure and anchored to reaction tiedowns. Critical horizontal flight limit loads will be applied first, followed by structural fatigue tests (100 missions times a scatter factor of four) and ultimate load tests for both horizontal and vertical flight critical design conditions. When required, elevated external skin temperatures will be achieved with a closed loop radiant heat systems.

The crew module will include all primary and required secondary structure, as well as windows, hatches, miscellaneous control system backup structure, seat supporting structure, and miscellaneous shelves, special fittings, access doors and mechanical hardware. Specifically excluded are the crew seats, plumbing, wiring and equipment items. The Crew Module Test Article will be enclosed in a suitable steel truss loading fixture and anchored to reaction tiedowns.

Initially the crew module will be pressure cycled for its critical pressure fatigue spectrum (100 missions times a scatter factor of four) followed by limit and ultimate load structural tests for critical design conditions.

1.2.8 Orbiter Horizontal Ground Vibration Tests

A horizontal Ground Vibration Test (GVT) or Orbiter 101 will be conducted prior to the first approach and landing test. Vibration will be induced with electrodynamic shakers to conduct frequency–amplitude surveys and modal dwells. The vehicle will be tested both soft–mounted on a suspension system and securely bolted to the floor (rigid mounted). Soft suspension will assure that the rigid body frequencies of the vehicle are less than one–third of the lowest elastic wing, fin, fuselage, or coupled mode to be excited. Modes of interest include vertical and lateral bending and torsion of the fuselage, as well as bending and torsion modes of the wing and vertical fin (including the control surfaces) and coupled modes. Satisfactory correlation of analytical predictions of modal frequencies, shapes, and damping characteristics with measured test data will support verification of the Orbiter–ET structural dynamic characteristics. Similar correlation with the Orbiter structural dynamic characteristics used to predict flutter, dynamic loads, and control stability, will relieve a constraint on the approach and landing test program.

1.2.9 Shuttle Avionics Integration Laboratory

The SAIL, situated at JSC, includes a nearly complete set of avionics hardware and software to be used in six–degree–of–freedom, closed–loop simulation for verification of avionic capability to meet the mission requirements. Certain of the SAIL activities are oriented toward verification of the combined element configuration while much of the remaining activities are directed toward Orbiter element avionics verification. The SAIL Orbiter verification program is summarized herein while Paragraph 3.6 of Volume 2 describes the SAIL facility and its combined element verification program.

The Orbiter avionics verification program within the SAIL utilizes the Orbiter portion of the avionics test system primarily in a six–degree–of–freedom closed–loop realtime simulation mode of the Orbiter single element flight phases. However, open–loop test and integration of the Orbiter avionics and selected non–avionics interfaces will also be accomplished in the SAIL as warranted. The SAIL effort supports the Orbiter integration development phase and continues throughout the avionics verification program. The SAIL will also support the Orbiter avionics during the flight test/operational program phases by evaluation of design changes, evaluation of mission performance and anomalies, and by aiding in mission planning, flight and preflight procedures development and systems familiarization.

1.2.10 Avionics Development Laboratory

The Avionics Development Laboratory (ADL) will perform development tests on the Orbiter avionics and associated software. These tests will include simulations required to support the development and evaluation of a closed–loop, limited redundancy GN&C, and System Management/Performance Monitor (SM/PM) capability required for Approach and Landing Flight Test (ALT). Limited evaluation and development testing for other ALT and OFT equipment and subsystems will also be included.

1.2.11 Acceptance

Acceptance includes Orbiter manufacturing checkout for NASA acceptance of deliverable prime items as well as contractor acceptance of supplier–fabricated equipment. The primary purpose of acceptance is to verify, that Orbiter hardware meets performance requirements and to detect manufacturing defects. It includes final integrated checkout, post–checkout operations, and post–modification checkout.

Primary factors in the acceptance checkout program are maximum effort at the vehicle level to avoid redundant checks, cost for simulators, and duplicate sets of GSE for lower–assembly–level tests and maximum use of supplier acceptance test data to satisfy preinstallation test requirements.

1.2.12 Approach and Landing Flight Test

The approach and landing flight test program will provide data which will be used in conjunction with analysis, wind tunnel, and ground test to evaluate the vehicle's stability and control, and subsystem operation in order to verify the capability of the vehicle to meet airworthiness and performance requirements dictated by the terminal phases of the operational and ferry missions. This program involves vehicle ground tests prior to the first drop flight, preliminary flight evaluation, flying quality investigation, subsystem verification, and demonstration of the unpowered terminal flight phase. Orbiter 101 will be used for this program. Orbiter 101 configuration will be oriented toward the subsystems required for atmospheric flight. In general, the subsystems required exclusively for space operations will not be provided. Although actual payloads will not be flown, structures sufficient to demonstrate the effect of payload weight, center of gravity, and inertias on vehicle approach and landing performance will be carried.

The Transport aircraft is the Shuttle Carrier Aircraft Boeing 747, NASA N905N1.

1.2.13 Ground Support Equipment Tests

The GSE test program will include verification of both the ground software and hardware. Where equipment is newly designed or where extensive design modifications have been incorporated in existing equipment, a development test program will be implemented to verify design adequacy. This development testing may be accomplished at the laboratory level or at the major ground or flight test sites.

Selected GSE will undergo a certification program to verify the equipment's ability to meet performance requirements under operating environment conditions. Where feasible, the certification test program will occur concurrently with major ground test programs.

Orbiter Ground Support Equipment accumulated at the station–set level will be given a final validation after installation at the using site.

1.2.14 Maintainability Demonstration

The maintainability characteristics and turnaround capabilities of Orbiter hardware will be progressively verified and demonstrated during design, ground development test, production, and flight test programs. Three basic methods of verification and demonstration will be used—analytical predictions, schedules demonstrations, and in–process monitoring. Mockups will be used to provide data for feedback to design as early as possible.

1.2.15 Electronic Systems Test Laboratory

The ESTL, situated at JSC, includes a nonredundant set of Orbiter Communication and Tracking Hardware to be used for radio frequency end–to–end communication and tracking system development test (prototype hardware) and performance verification (qualifiable hardware). The major function of the ESTL is directed toward combined element communications and tracking verification. Combined element testing is discussed in Paragraph 3.11 of Volume 2; Orbiter element testing is summarized herein.

The ESTL program consists of end–to–end Radio Frequency (RF) systems tests to assure that operation of the Orbiter and ground (including TDRS) RF communication systems meet program requirements when subjected to electrical conditions similar to those to be encountered during operational missions. Orbiter hardware to accomplish the ESTL objectives will consist of nonredundant prototype and qualifiable hardware. Interface capability with SAIL (Ref. 1.2.9) will be provided and exercised as required.

The ESTL will also support the Orbiter Communication and Tracking system during flight test and operational program phases by evaluation of space and ground subsystem design changes, evaluation of mission performance, anomaly investigation, and by aiding in mission planning and procedures development.

1.3 SOLID ROCKET BOOSTER TEST SUMMARY

This section will present a summary of tests to be performed on the SRB element. A preliminary listing is shown in Table A3–I.

1.4 EXTERNAL TANK SYSTEM TEST SUMMARY

This section will present a summary of the testing planned to be performed on the ETS element. A preliminary listing is shown in Table A4–I.

1.5 MAIN ENGINE TEST SUMMARY

This section will present a summary of tests to be performed on the Main Engine element. A preliminary listing shown in Table A5–I.

1.6 PAYLOAD AND PAYLOAD CARRIER TEST SUMMARY

This section will present a summary of tests to be performed to integrate the various payloads with the Orbiter.

1.7 LAUNCH AND LANDING SITE TEST SUMMARY

This section will present a summary of tests to be performed to verify readiness of the launch and landing site to interface with and support operations of the program flight elements.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE A3–I
PRELIMINARY SOLID ROCKET BOOSTER TESTS

Test Category and Test Article Description	Objective
Material and process evaluation Material coupons	Support material, fracture control plans. Support material characteristics and processing development. Establish material allowables.
Refurbish and reuse verification	Verify ability to refurbish and reuse SRB.
Motor development firings Flight–weight case and nozzle Flight ordnance devices Ground test instrumentation	Confirm structural integrity. Verify ballistic performance. Verify motor design and manufacturing processes. Establish vibro–acoustic and thermal environment. Verify acceptability of design changes. Establish factors for predicting ballistic performance of production motors.
Motor qualification firing (PFRT) Full–scale, flight weight motor assembly less nose fairing and recovery system	Validate production processes and facilities. Verify operational GSE and procedures. Verify repeatability of motor performance.
Thrust Vector Control (TVC) subsystem TVC system and actuator	Verify performance. Verify design.
Separation subsystem SRB attachments/separation mechanism/ordnance/and disconnects	Verify acceptability of separation design. Validate stress analysis. Verify design margins.
Separation motors Full–scale flight weight motor assembly	Verify motor performance. Verify motor design.

TABLE A3–I
PRELIMINARY SOLID ROCKET BOOSTER TESTS – Continued

Test Category and Test Article Description	Objective
Ignition system Hydroproof, adhesion, and static firing tests of ignition system components (safe and arm device, pyrotechnic booster charge, initiating pyrogen igniter, main pyrogen igniter)	Verify hardware and propellant grain structural integrity. Verify ballistic performance and ignition system reliability.
Recovery system Drogue chute scale model wind tunnel tests and aircraft drop test. Single full–scale main chute aircraft drop tests with scaled suspension weights	Evaluate aerodynamic damping coefficients and dynamic spin modes. Verify ability to stabilize rocket case. Verify main chute aerodynamic deployment. Verify SRB component survivability.
Retrieval and reuse Water flotation, retrieval and reuse tests of full scale expended SRB case from initial development tests	Evaluate protective coatings and materials. Verify stability during flotation and two conditions.
Structure development Fully assembled SRB status structural test article	Verify materials selection. Validate stress analysis and design margin. Verify structural integrity for critical design limit and ultimate loads.
Vibroacoustic test of the SRB forward section and nose	Verify vibroacoustic design and test criteria for equipment and structure and to qualify selected equipment items for flight.
GSE development New and redesigned equipment GSE qualification Selected GSE GSE certification Applicable station sets	Assure concurrent development of GSE. Verify equipment reliability and safety. Verify that equipment functions as intended. Verify that equipment meets requirements under operation conditions and environ–ment. Verify that integrated GSE and facility sys–tems meet requirements.

TABLE A3–I
PRELIMINARY SOLID ROCKET BOOSTER TESTS – Concluded

Test Category and Test Article Description	Objective
Avionics subsystem Component/assembly breadboard Subsystem functional and environ–mental tests (sequencer batteries, beacon, instrumentation)	Verify design selection. Verify subsystem performance.
Integrated subsystem test	Verify that SRB subsystems perform satisfactorily as an integrated system.

TABLE A4–I
PRELIMINARY EXTERNAL TANK TESTS

Test Category and Test Article Description	Objective
Material and process evaluation Material coupons, elements, joints, and fasteners	Support material, fracture control plans. Support material characteristics and processing development. Establish material allowables.
Structural development Structural elements, components panels, fittings, and subassemblies	Optimize design. Achieve design approach confidence.
External tank/SRB separation test (performed by SRB contractor) SRB–to–tank attach fitting backup structure External tank/orbiter separation test (performed by Orbiter contractor) Tank–to–orbiter attach fittings, disconnects, feedlines release mechanisms and circuit logic, simulated section of fluid lines, and supports accommodating umbilical	Achieve design approach confidence. Verify functional performance of product design.
Tank subsystem test (component and subsystem level) Point–level sensors and controllers Transducers Disconnects and lines	Verify component subsystem functional and structural integrity under operational environments.
LO_2 tank intertank and nose section subassembly static structural test	Validate stress analysis and verify of LO_2 tank and intertank structural integrity.
LH_2 tank, intertank, and aft skirt substructural test	Validate stress analysis and verification of LH_2 tank and intertank structural integrity.
LO_2 tank aft bulkhead assembly ground vibration test	Correlate dynamic mathematical model predictions of LO_2 tank fluid–structural coupled modes.

TABLE A4–I
PRELIMINARY EXTERNAL TANK TESTS – Concluded

Test Category and Test Article Description	Objective
Separate intertank strength (static loads) test	Verify structural integrity of tank sections not fully tested with LO_2 and LH_2 tank tests.
Tank development and qualification test of TPS minitank and panels TPS test	Support validation of analytical methods. Prove integrity of TPS.

TABLE A5–I
PRELIMINARY MAIN ENGINE TESTS

Test Category and Test Article Description	Objective
Material and process tests Material coupons	Support material, fracture control plans. Establish material characteristics and design allowables. Support development of material processing.
Component tests Turbine blades Injector elements Seals and bearings Valves Heat exchanger Combustion system assembly Ducts and lines Sensors	Verify flow characteristics. Verify rotary performance. Verify environmental resistance. Establish vibration characteristics (natural frequencies, forcing frequencies, etc.). Evaluate mechanical operation.
Subsystem tests LO_2 and LH_2 turbopump assemblies Preburners Ignition system Combustion system Integrated subsystem test bed	Verify component compatibility. Establish pump and turbine disc critical speeds. Establish preliminary calibration of propellant and purge flows. Support analytical verification of system performance.
Engine static firings Sea–level configuration Altitude configuration Preliminary flight certification Final flight certification	Verify engine performance. Evaluate throttling characteristics. Verify nozzle integrity and efficiency. Establish engine durability/life capability. Establish vibro–acoustic and thermal environments and soak–back characteristics. Determine engine calibration requirements (propellant flow, valve timing, etc.). Verify combustion stability.
GSE development New and redesigned equipment	Assure concurrent development of GSE. Verify equipment reliability and safety. Verify that equipment will function as intended.

TABLE A5–I
PRELIMINARY MAIN ENGINE TESTS – Concluded

Test Category and Test Article Description	Objective
GSE qualification Selected GSE	Verify that equipment meets requirements under operating conditions and environ– ment.
GSE verification Applicable station sets	Verify that integrated GSE and facility systems meet requirements.

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX B

SHUTTLE MASTER VERIFICATION PLAN DEFINITIONS

THIS PAGE INTENTIONALLY LEFT BLANK

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 – Qualification tests, major ground tests, and other tests and analysis required to determine that the design of hardware from the component through the subsystem level meets requirements.

a. Certification by testing – The process of conducting tests which normally are considered qualification tests plus specific additional tests of components and subsystems and higher levels of assemblies required to certify that the hardware design meets established design requirements. Certification testing does not generally include development, piece–part qualification, acceptance, or checkout tests except where such tests are specifically identified as required for certification.

b. Certification by analysis

   1. Analysis performed to satisfy certification objectives when testing under simulated mission conditions is not feasible or cost effective, or the need exists to extrapolate test data beyond the performed test points.

   2. Analysis performed to show that an article is similar or identical in design, manufacturing process, and quality control to another that has been previously certified to equivalent or more stringent criteria.

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

DDT&E – The design, development, test, and evaluation phase of the Shuttle including Approach and Landing Test (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 – Verification 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 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.

Life Test – A test structured to certify 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, Solid Rocket Booster (SRB), External Tank (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 verification 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 – A qualitative determination that the operation of a subsystem, subassembly, or component is satisfactorily performing its function to support operations. Validation is accomplished by review of ground or flight data and does not provide assurance that the operation is within performance specification limits.

Verification – The process of planning and implementing a program that determines that the Shuttle System meets all design, performance, and safety requirements. The verification process includes certification, development testing, acceptance testing, flight demonstration, preflight checkout, and analysis necessary to support the total verification program.

APPENDIX C

ARCHIVED DEVIATIONS/WAIVERS

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX C

ARCHIVED DEVIATIONS/WAIVERS

1.0 PURPOSE AND SCOPE

The purpose of this Appendix is to retain those Deviations/Waivers rescinded as a result of the STS–51L accident and retired due to the expiration of effectivity.

1.1 RESCINDED DEVIATIONS/WAIVERS

The Deviations/Waivers contained in this section were approved prior to STS–51L. Any of these Deviations/Waivers that apply to future SSP missions must be resubmitted with appropriate rationale for SSP approval and reinstatement.

ARCHIVED DEVIATIONS/WAIVERS AUTHORIZED FOR REQUIREMENTS CONTAINED IN THIS DOCUMENT

1. REQUIREMENT: Paragraph 3.5.14.l.3.(c).(2) specifies as follows:

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

Paragraph 3.6.1.j 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.

DEVIATION: The above requirements shall be implemented on the Orbiter Project as modified by the changes to specific paragraphs in SP–T–0023B as shown below.

A. SPECIFIED REQUIREMENT: Paragraph 3.4.1.1.b Maximum Acceptance Vibration Test Levels – 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.

Paragraph 3.4.1.2 Duration. The acceptance vibration test duration shall be a minimum of 30 seconds per axis. One minute per axis is considered optimum; however, the time shall be sufficient to allow a functional/continuity check on all circuits during the acceptance vibration test, according to Paragraph 3.8.

DEVIATION: 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 acceleration spectral density levels to be equal to 2.2 db (1/1.69 times the qualification test levels) below the qualification level. This deviation, also, allows a minimum of 3 minutes per axis duration for the acceptance vibration 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: Qualification shall be conducted to permit acceptance testing to the revised requirements.

c. STS–1 Installed Hardware: Reacceptance testing will be considered, using the revised requirements, if the hardware is removed for some other reason.

d. Existing Inventory Hardware: Reacceptance test to the revised requirements on a noninterference basis and consistent with guideline 1 above.

e. Follow–on Hardware: Acceptance testing will be accomplished in accordance with the revised requirements, but shall be consistent with guideline 1 above.

NOTE: This Deviation, authorized by PRCBD S02130B, DTD 6/25/77, shall not apply to new or follow–on procurements for Orbiter Project Hardware.

AUTHORITY: Level II PRCBD S02130E, dated 5/1/81.

B. SPECIFIED REQUIREMENT: Paragraph 4.5.2 Thermal Test – 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: 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.

NOTE: This Deviation, authorized by PRCBD S02130B, DTD 6/25/77, shall not apply to new or follow–on procurements for Orbiter Project Hardware.

AUTHORITY: Level II PRCBD S02130C, dated 7/14/80.

C. SPECIFIED REQUIREMENT: Paragraph 3.4.2.1 Temperature Levels. Acceptance thermal tests shall be conducted to levels as severe as possible within the boundaries specified in the following paragraphs:

a. Minimum acceptance thermal test levels – The acceptance thermal test control temperature range shall be a minimum of a 100°F temperature sweep, and tests shall be performed in accordance with the minimum test criteria defined by Figure 2.

b. Maximum acceptance thermal test levels – Components which have expected mission levels greater than a 100°F temperature sweep shall be tested to the greater of the two following levels:

1. Minimum acceptance test thermal levels (100°F temperature sweep) as defined by Figure 2, or

2. Acceptance thermal test levels equal to the temperature sweep resulting from the range limits of 20°F lower than the maximum and 20°F higher than the minimum qualification levels.

The lower temperature limit should be below freezing (30°F) wherever possible. The initial temperature excursion should be in the direction of the expected flight operating temperature of the equipment (hot or cold) so that the specified temperature extreme is achieved at least twice.

Paragraph 3.4.2.2 Duration. The acceptance thermal test duration shall allow a minimum of one and one–half temperature cycles, stabilized at extremes for one hour and allowing a functional/continuity check on all circuits at the temperature extremes as well as during the temperature transition. The optimum number of temperature cycles shall be established on a case–by–case basis for each hardware type selected for environmental acceptance testing.

DEVIATION: This deviation allows a minimum of five temperature cycles (one cycle is denoted on Figure 2). The number of temperature cycles greater than 5 may be established if the history of a hardware type indicates this to be desirable.

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: Qualification shall be conducted to permit acceptance testing to the revised requirements.

c. STS–1 Installed Hardware: Reacceptance testing will be considered, using the revised requirements, if the hardware is removed for some other reason.

d. Existing Inventory Hardware: Reacceptance test to the revised requirements on a noninterference basis and consistent with guideline 1 above.

e. Follow–on Hardware: Acceptance testing will be accomplished in accordance with the revised requirements, but shall be consistent with guideline 1 above.

AUTHORITY: Level II PRCBDs S02130E, dated 5/1/81 and S40019–R3, dated 8/26/87.

2. REQUIREMENT: Paragraph 3.5.14.l.3.(c).(2) specifies as follows:

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

Paragraph 3.6.1.j 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.

DEVIATION: The above requirements shall be implemented in the MSFC–SSME, MSFC–ET, and MSFC–SRB Projects as modified by the changes to specific paragraphs in SP–T–0023B as shown below.

A. SPECIFIED REQUIREMENT: Paragraph 3.4.2.1(a)

Minimum acceptance thermal test control temperature range shall be a minimum of a 100°F temperature sweep, and tests shall be performed in accordance with the minimum test criteria defined by Figure 2.

DEVIATION: The following items which are environmentally acceptance tested to a temperature excursion of less than 100°F:

SRB

- PCM MUX
- Flashing Light Assy
- RF Beacon
- Frustrum Location Aid
- Flight Tape Recorder
- Impact Recorder

B. SPECIFIED REQUIREMENT: Paragraph 3.4.2.1.b(2)

Acceptance thermal test levels equal to the temperature sweep resulting from the range limits of 20°F lower than the maximum and 20°F higher than the minimum qualification levels.

DEVIATION: The following items are acceptance tested thermally to the same temperature as qualification and, as noted by asterisk, tested to only one cycle.

ET

- PCM MUX
- Switch Module
- Transducer, Dynamic Press
- Transducer, Press Differential & Absolute, Aero & Press
- Transducer, Press Absolute & Differential Ullage Gas
- Transducer, Acoustic
- Transducer, Calor, Total Heat
- Transducer, Accel., Low Freq.
- Transducer, Accel., High Freq.
- Transducer, Radiometer
- Transducer, Press, Low & Very Low*
- Charge Amplifier*

SSME

- Controller Assembly

C. SPECIFIED REQUIREMENT: Paragraph 3.4.1.1(b)

Maximum acceptance vibration test levels – 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.

DEVIATION: The following items, identified by MSFC as non–flight critical, are acceptance vibration tested to levels and/or spectra which are not compatible with the minimum AVT spectra identified in SP–T–0023B.

<u>SRB</u>

Impact & Flight Recorders
DFI Distributor
Ded. Sig. Conditioner
PCM MUX
SG Signal Cond.
TC Generator
WB Signal Conditioner
FDM Assy
Function Box
Sep. Instrumentation Pkg.
Flashing Light
Beacon
Frustrum Location Aid

<u>External Tank</u>

PCM MUX & Charge Amp
Low Pressure Transducer

AUTHORITY: Level II PRCBD S02130A–R1 dated, 6/29/77.

D. SPECIFIED REQUIREMENT: Paragraph 3.4.1.1 Levels. Acceptance vibration tests shall be conducted to levels as severe as possible within the boundaries specified in the following paragraphs.

a. Minimum acceptance vibration test levels – The acceptance vibration test levels and test spectrum defined by Figure 1 shall be the minimum test criteria.

b. Maximum acceptance vibration tests levels – Components which have 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.

Paragraph 3.4.1.2 Duration. The acceptance vibration test duration shall be a minimum of 30 seconds per axis. One minute per axis is considered optimum; however, the time shall be sufficient to allow a functional/continuity check on all circuits during the acceptance vibration test, according to Paragraph 3.8.

DEVIATION: This deviation allows the acceptance acceleration spectral density levels to be equal to 2.2 db (1/1.69 times the qualification test levels) below the qualification level. This deviation, also, allows a minimum of 3 minutes per axis duration for the acceptance vibration test.

This deviation is to be implemented on the MSFC–SSME, MSFC–ET and MSFC–SRB Projects based on the following guidelines:

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

b. New Equipment Designs: Qualification shall be conducted to permit acceptance testing to the revised requirements.

c. STS–1 Installed Hardware: Reacceptance testing will be considered, using the revised requirements, if the hardware is removed for some other reason.

d. Existing Inventory Hardware: Reacceptance test to the revised requirements on a noninterference basis and consistent with guideline 1 above.

e. Follow–on Hardware: Acceptance testing will be accomplished in accordance with the revised requirements, but shall be consistent with guideline 1 above.

AUTHORITY: Level II PRCBD S02130E, dated 5/1/81.

E. SPECIFIED REQUIREMENT: Paragraph 3.4.2.1 Temperature Levels. Acceptance thermal tests shall be conducted to levels as severe as possible within the boundaries specified in the following paragraphs:

a. Minimum acceptance thermal test levels – The acceptance thermal test control temperature range shall be a minimum of a 100°F temperature sweep, and tests shall be performed in accordance with the minimum test criteria defined by Figure 2.

b. Maximum acceptance thermal test levels – Components which have expected mission levels greater than a 100°F temperature sweep shall be tested to the greater of the two following levels:

1. Minimum acceptance test thermal levels (100°F temperature sweep) as defined by Figure 2, or

2. Acceptance thermal test levels equal to the temperature sweep resulting from the range limits of 20°F lower than the maximum and 20°F higher than the minimum qualification levels.

The lower temperature limit should be below freezing (30°F) wherever possible. The initial temperature excursion should be in the direction of the expected flight operating temperature of the equipment (hot or cold) so that the specified temperature extreme is achieved at least twice.

Paragraph 3.4.2.2 Duration. The acceptance thermal test duration shall allow a minimum of one and one–half temperature cycles, stabilized at extremes for one hour and allowing a functional/continuity check on all circuits at the temperature extremes as well as during the temperature transition. The optimum number of temperature cycles shall be established on a case–by–case basis for each hardware type selected for environmental acceptance testing.

DEVIATION: This deviation allows a minimum of five temperature cycles (one cycle is denoted on Figure 2). The number of temperature cycles greater than 5 may be established if the history of a hardware type indicates this to be desirable.

This deviation is to be implemented on the MSFC–SSME, MSFC–ET and MSFC–SRB Projects based on the following guidelines:

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

b. New Equipment Designs: Qualification shall be conducted to permit acceptance testing to the revised requirements.

c. STS–1 Installed Hardware: Reacceptance testing will be considered, using the revised requirements, if the hardware is removed for some other reason.

d. Existing Inventory Hardware: Reacceptance test to the revised requirements on a noninterference basis and consistent with guideline 1 above.

e. Follow–on Hardware: Acceptance testing will be accomplished in accordance with the revised requirements, but shall be consistent with guideline 1 above.

AUTHORITY: Level II PRCBD S02130E, dated 5/1/81.

3. REQUIREMENT: Paragraph 3.5 Certification, specifies certification planning will assure that necessary data from analyses, development, qualification, major ground test, acceptance, checkout, and flight test are provided with minimum duplication of testing.

WAIVER: For OFT (STS–1 thru STS–4), Paragraph 3.5 requiring certification of the Orbiter hardware for operation at 9 psia for Pre–EVA cabin depressurization is waived.

AUTHORITY: Level II PRCBDs S13443D, dated 3/30/81 and S40019–R3, dated 8/26/87.

4. REQUIREMENT: Paragraph 3.5.4 specifies that certification requirements may be satisfied during development testing in those cases where the following criteria are met.

Predeclaration	The intent to use the test for certification is declared prior to test conduct.

Configuration	Production configuration or approval (where allowed) for differences.
Facilities	Certified
Inspection	Required
Test requirement/ procedures/pass–fail criteria	Formally approved
Acceptance, pre–functional and post–functional test	Required
Documentation	Submittal of configuration description, failure reports, and test results

WAIVER: This requirement is waived for the GH_2 Vent and Relief Valve for ET–1 and subs.

AUTHORITY: Level II PRCBDs S57285, dated 6/11/81 and S40019–R3, dated 8/26/87.

5. **REQUIREMENT:** Paragraph 3.2 GENERAL GUIDELINES, 0. ICD verification, specifies that functional interfaces will be verified by major integrated ground tests combined with hardware acceptance and checkout, 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 OMRSDs). 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.

WAIVER: The requirement for a verification demonstration of ICD requirements as related to transients and ripple for the SRB power buses is waived for STS–3 and subs.

AUTHORITY: Level I PRCBDs H20755, dated 3/16/82 and S40019–R3, dated 8/26/87.

6. REQUIREMENT: Paragraph 3.5 CERTIFICATION, specifies certification planning will assure that necessary data from analyses, development, qualification, major ground test, acceptance, checkout, and flight test are provided with minimum duplication of testing.

WAIVER: For STS–5 through STS–8, STS–11, STS–41C and subsequent EVA operations, excluding Spacelab Missions, Paragraph 3.5 requiring certification of the Orbiter and payload hardware in the crew cabin for operation at 10.2 psia for pre–EVA cabin depressurization is waived.

AUTHORITY: Level II PRCBDs S13442AR6, dated 8/24/82; S1344AR12, dated 1/23/84; S13442JR1, dated 7/6/84 and S40019R3, dated 8/26/87.

1.2 RETIRED DEVIATIONS/WAIVERS

The Deviations/Waivers contained in this section have been removed from the list of active Deviations/Waivers because of expiration of effectivity.

7. REQUIREMENT: Paragraph 2.7 GROUND SYSTEM VERIFICATION. The overall objectives of the Ground Support System Verification Program will be 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 NSTS. In addition to acceptance testing, each element project office and launch and landing site shall identify the test and/or analysis required for the certification of GSE and ground systems. Each element project office will identify and approve that GSE for certification which requires additional testing or analysis required in addition to acceptance testing. Certification 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 X) and/or have Safety Critical functions or characteristics shall be certified. Verification of the launch and landing site ground system is described in Master Verification Plan, Volume VIII (Launch and Landing Site Verification Plan – KSC). Launch and landing site verification status shall be maintained and reported for each flight until all applicable requirements are either verified, revised, waived, or have their applicability changed. Contingency landing site equipment design and verification requirements are the same as primary landing site ground equipment.

WAIVER: The above requirement is waived for HPU servicing carts, S77–0150, S/N #1 and #3 in support of STS–29, STS–28 and STS–30 processing prior to DCR verification completion.

AUTHORITY: Level II PRCBDs S41230Z, dated 7/6/88; S41230ZR1, dated 11/30/88; S41230ZR2, dated 2/10/89 and S41230ZR3, dated 3/27/89.

8. REQUIREMENT: Paragraph 3.6 CERTIFICATION PROGRAM. Certification planning will assure that necessary data from analysis, development, (predeclared) qualification, major ground test, acceptance, checkout, and flight test are provided with minimum duplication of testing.

WAIVER: Paragraph 3.6 requiring certification of the Orbiter and payload hardware in the crew cabin for operation at 10.2 psia for EVA activities is waived for STS–26, STS–27 and STS–29 only.

RATIONALE: Qualification Site Approval (QSA) has been approved for STS–30 to certify Orbiter cabin for 10.2 psia EVA Support Operations. Rockwell will be directed to complete 10.2 psia cabin certification documentation for STS–28 and subs.

AUTHORITY: Level II PRCBDs S60154R8, dated 9/22/88 and S60154R9, dated 4/27/89.

9. **REQUIREMENT:** Paragraph 3.6.1 Application of Certification. All flight hardware and software shall be certified....

WAIVER: The above requirement is waived for the overall Side Hatch Crew Escape System (SHCES, P/N V070–553411–001), the thruster assembly (P/N MC325–0041–0001) and the cartridge assembly (MC325–0041–0002) for STS–26 thru STS–32, and STS–36 and STS–31.

AUTHORITY: Level II PRCBDs S76233, dated 9/10/88; S076233R2, dated 3/16/90 and S076233R3, dated 3/26/90.

10. **REQUIREMENT:** Paragraph 3.6.21 Recertification. Hardware and/or software recertification will be required:

a. When design or manufacturing process changes have been made which affect form, fit, function safety and/or reliability.

b. When the manufacturing source is changed.

c. When changes are made in specifications, manufacturing processes or procurement source for any fluids or other materials used in processing or operating the hardware.

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.

WAIVER: The above is waived to allow use of Extravehicular Mobility Unit (EMU) arm bearing secondary restraint brackets made by non–certified manufacturer.

AUTHORITY: Level II PRCBD S76349, dated 11/15/88.

11. REQUIREMENT: Paragraph 3.7.1q Acceptance Criteria. The following minimum reverification criteria will apply during turnaround operations:

1. Preflight checkout/inspection will be performed to verify satisfactory performance/operation of all systems/subsystems/components required to assure flight safety and mission success.

2. The philosophy shall be to verify two failure tolerance (fail op–fail safe) for all critical functions wherever possible. The "Critical Function" is that function for which the criticality of the failure mode was assigned. Whenever a critical function is two–failure tolerant or less because of design, that function and all existing functional redundancy shall be verified prior to each flight. All other critical functions which are greater than two failure tolerant shall be verified to the three level, but the remaining functional paths are candidates for periodic checkout.

   Two–failure tolerance of critical function shall be interpreted to mean three independent redundant paths to perform the critical function. No more than one of the three paths considered may be an emergency system, unlike backup system, or approved emergency crew procedure. At least two of the paths must be primary redundant systems designed to perform the function nominally. An independent functional path is intended to mean one success path from the critical function level, down through all subtiers of the subsystems to the component level. While it is not intended to require checkout of all subtier support redundancy in the functional path prior to each flight, it is intended that periodic checkout strategy be planned to verify all subtier and component level redundancy at reasonable intervals.

(a) All Criticality 1 functions and all Criticality 1R functions which are two–failure tolerant or less shall be verified prior to each flight except when rationale to avoid invasive or illogical test procedures as defined in Paragraph 5 below applies.

(b) OMRS requirements intended to verify redundant function beyond the three level shall be performed each flight except when rationale to avoid invasive or illogical test procedures as defined in Paragraph 5 below applies, or unless periodic interval is specified under the provisions of Paragraph 3 and 4 below.

(c) All Criticality 2 functions which could result in an in–flight abort, contingency deorbit, or emergency crew procedure shall be verified prior to each flight except when rationale to avoid invasive or illogical test procedures as defined in Paragraph 5 below applies. Invocation of Priority Missions rules or other controlled abbreviation of the mission does not constitute an aborted mission for this purpose.

3. A periodic maintenance interval may be specified for any of the following requirements:

   (a) Requirements to verify redundancy of functions beyond two–failure tolerance in Criticality 1R functions.

   (b) Requirements to verify Criticality 2 or 2R functions which could not result in an abort, contingency, or emergency crew procedure.

   (c) Requirements relating to Criticality 3 functions.

4. A periodic maintenance interval may be specified for those requirements in Paragraph 3 above subject to the following constraints.

   (a) In all cases, the decision to perform a requirement on a periodic basis rather than each flight as well as the interval to be used will be based on good engineering judgment and shall be consistent with safety of flight considerations. Rationale for establishing periodic maintenance intervals shall be approved by the OMRS/SIR and documented in the OMRSD.

(b) The maintenance interval specified may be on a number of flights or cycles basis but in the case of an Orbiter, may also specify the maximum calendar time interval. Effectivity for first flight of a new vehicle shall also be considered.

(c) In addition to the foregoing general constraints, at least one of the following specified rationale must apply before any requirement may be reduced from each flight effectivity to periodic.

1. System/function/component certification and failure history established beyond any reasonable doubt that reliability is sufficiently high to justify the reduction.

2. System/function/component performance history is well enough established to show that no significant degradation can be projected within the next maintenance interval.

3. System/function/component is static, (i.e., static seals) and is not disturbed and certification program has demonstrated design life at least two times accumulated life at end of next mission.

4. Other rationale approved on a case–by–case basis by the OMRS/SIR.

5. In many cases, periodic or zonal inspections are preferable to performing a particular test prior to each flight because the test procedures may be so invasive that the potential for damage and system degradation is greater than the potential for increased reliability. In such cases, sufficient verification of the function may be determined by indirect means. In other cases, the structural/mechanical requirements of OMRSD will provide adequate

assurance of reliability. In any case, invasive test procedures which may damage, degrade, or present an increased risk of failure because of equipment removal, limited access, or abnormal operations shall be avoided. Additionally, there may be cases where hardware design prohibits preflight verification or for some reason such verification is illogical. Under no circumstances should tests be performed which place the flight at risk or reduces redundancy or reliability. In these cases, the test and checkout requirements and/or periodic requirements shall be made consistent with the retention rationale in the CIL. Justification for relaxation of the checkout philosophy in these cases, and in the cases of invasive tests described above, shall be approved at the OMRS/SIR and documented in the OMRSD.

6. An in–flight check (previous flight) may be substituted for a ground check subject to the following constraints.

   (a) The in–flight check is at least as comprehensive in meeting the objectives of the test and the intent of the retention rationale as the ground test.

   (b) Any failure mode for which the check applies is not sensitive to on/off cycles, or will not result in loss of primary function.

   (c) Whenever an in–flight check is proposed in lieu of ground test, the rationale shall be approved by the OMRS/SIR and documented in the OMRSD. In these cases, any additional ground maintenance intended to compliment the in–flight check should be described. Additionally, a maximum calendar interval should be specified in the rationale during which the check is valid as well as any other constraints deemed appropriate for that particular test.

   (d) In–flight check does not apply to Criticality 1 functions.

7. In addition, the following guidelines apply to vehicle test and checkout:

(a) Hardware which has been removed, replaced, disconnected, or modified since the last usage shall be verified.

(b) Periodic inspection requirements shall be performed to assure all systems structural integrity is maintained.

(c) TPS will be verified by inspection, test, or analysis prior to each flight to assure ascent and entry capability. Required preflight verification/inspection by the launch operations center shall be documented in the OMRSD.

(d) Primary structures shall be inspected periodically to assure that the vehicle retains its structural integrity. Required preflight verification/inspection by the launch operations center shall be documented in the OMRSD.

(e) Connectors and all associated functions shall be verified when invalidated.

(f) Wire harnesses shall be inspected when disturbed. Accessible wire harnesses shall be inspected prior to area closeout. Required preflight verification/inspection by the launch operations center shall be documented in the OMRSD.

(g) Test, pretest, post test, and special storage environments and conditions will be defined as required to prevent compromising the quality and/or reliability of the article (e.g., cleanliness requirements for MPS or Star Tracker cavity).

(h) Flight hardware to be used with the payload for the next flight shall be checked prior to that flight.

8. LRUs removed from the vehicle for field maintenance must be reverified prior to reinstallation in the vehicle. Functional verification of the affected paths within the LRU will suffice when the repair involves replacement of plug–in modules (SRUs) only. Repair involving more than module replacement (e.g., soldering, potting) will

necessitate complete acceptance testing of the LRU, including environmental acceptance testing when applicable.

WAIVER: The above is waived for the Ground Test OMRSD requirements (V42BA0.010, V42CA0.010 and V61AM0.010) imposed on KSC for STS–29 (Flight 8 of OV–103).

AUTHORITY: Level II PRCBDs S41623, dated 11/10/88 and S50751, dated 8/15/89.

20. REQUIREMENT: Paragraph 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.

WAIVER: The above requirement is waived for the cup assembly and (3) attach bolts (G070–540328–0070) on the right–hand aft sling attach point for STS–31.

RATIONALE: Due to the discovery of a loose nutplate receptacle at the lower forward cup attach point it was determined that any further removal/installation of fasteners would require nutplate replacement. Access is impossible at KSC during demate operations, thus the cup assembly and (3) attach bolts will replace the nutplate.

EFFECTIVITY: STS–31

AUTHORITY: Level II PRCBD S061531L, dated 5/3/90.

33. REQUIREMENT: Paragraph 3.6.14.l.3(c).(2) Acceptance test – The requirements and tolerances on acceleration spectral density shall be as defined in Johnson Space Center document SP–T–0023, Environmental Acceptance Testing.

SPECIFIED REQUIREMENT: SP–T–0023, Paragraph 3.4.1 Acceptance Vibration Test

Paragraph 3.4.1.1 Levels. Acceptance vibration tests shall be conducted to levels as severe as possible within the boundaries specified in the following paragraphs:

a. Minimum acceptance vibration test levels – The acceptance vibration test levels and test spectrum defined by Figure 1 shall be the minimum test criteria.

WAIVER: The above requirement is waived to allow SRB Range Safety Distributor (RSD) acceptance testing at 6 dB below the maximum qualification vibration level for a duration of three minutes per axis.

RATIONALE: The RSD is presently acceptance tested to the 6.1 Gravity Root–Mean–Square (GRMS) spectrum. Verification test levels (6 dB below qualification) have been used for post–flight recertification when no major repair is required. The verification levels are equal to or higher than the acceptance criteria at most frequencies and the Power Spectral Density (PSD) is higher for all axes. The 45th Space Wing requested that the verification criteria be used for acceptance testing because the PSDs are higher than the present acceptance criteria.

Secondly, the RSD is only qualified for five acceptance tests at 6.1 GRMS. Additional acceptance testing reduces the qualified operating life of the component. The verification test levels alleviate this problem since they are 6 dB below qualification levels.

The SRB project recommends that all future acceptance testing of the RSD be performed 6 dB below the maximum qualification environment.

EFFECTIVITY: Non–flight Specific

AUTHORITY: Space Shuttle PRCBD S082290, dated 12/17/93.

34. REQUIREMENT: Paragraph 3.7.1 Acceptance Test Requirements

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.

SPECIFIED REQUIREMENT: SP–T–0023, Paragraph 3.4.1 Acceptance Vibration Test

Paragraph 3.4.1.1 Levels. Acceptance vibration tests shall be conducted to levels as severe as possible within the boundaries specified in the following paragraphs:

a. Minimum acceptance vibration test levels – The acceptance vibration test levels and test spectrum defined by Figure 1 shall be the minimum test criteria.

WAIVER: The above requirement is waived to allow SRB RSD acceptance testing at 6 dB below the maximum qualification vibration level for a duration of three minutes per axis.

RATIONALE: The RSD is presently acceptance tested to the 6.1 GRMS spectrum. Verification test levels (6 dB below qualification) have been used for post–flight recertification when no major repair is required. The verification levels are equal to or higher than the acceptance criteria at most frequencies and the PSD is higher for all axes. The 45th Space Wing requested that the verification criteria be used for acceptance testing because the PSDs are higher than the present acceptance criteria.

Secondly, the RSD is only qualified for five acceptance tests at 6.1 GRMS. Additional acceptance testing reduces the qualified operating life of the component. The verification test levels alleviate this problem since they are 6 dB below qualification levels.

The SRB project recommends that all future acceptance testing of the RSD be performed 6 dB below the maximum qualification environment.

EFFECTIVITY: Non–flight Specific

AUTHORITY: Space Shuttle PRCBD S082290, dated 12/17/93.

35. REQUIREMENT: Paragraph 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.

WAIVER: The above requirement is waived to allow the use of a self–contained Data Acquisition System (DAS).

RATIONALE: The SRB project has identified an urgent need to collect SRB water impact and slapdown loads and has designed and manufactured a self–contained DAS which has been analyzed and a hazard assessment made which verifies that the DAS containment system (the SRB parachute camera cannister) will contain any and all possible DAS anomalies within the cannister, thereby precluding any detrimental effects to the capability of the SRB to perform successfully all mission phases including launch, ascent, separation, descent, splashdown, and tow back.

EFFECTIVITY: STS–72 and STS–75 thru STS–999

AUTHORITY: Space Shuttle PRCBD S074070A, dated 1/9/96.

36. REQUIREMENT: Paragraph 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.

WAIVER: The above requirement is waived to allow the use of the SRB salt water–activated parachute release device which has not been flight certified.

RATIONALE: The device will be designed and manufactured to USBI Specification 10SPC–0236. The specification requires a qualification test to include a proof load, vibration, 40–foot and 6–foot drop, low and high temperature functional, and ultimate load. As part of the overall certification program, the devices will be used to release one parachute on each booster for six flights (developmental). At the completion of the third flight, a formal Certification of Qualification (COQ) will be submitted for the seventh flight. All parachutes will be released with these devices on the seventh flight. A hazard analysis has been performed and is documented in SAR 2–96–SWAL, SRB Main Parachute Salt Water Activated Disconnect Link, August 1.

This device performs a Criticality 3 function and is contained within the parachute pack.

EFFECTIVITY: BI-090 thru BI-094 and BI-096

AUTHORITY: Space Shuttle PRCBDs S074058D, dated 8/30/96; S074058DR1, dated 9/2/97 and S074058DR2, dated 10/1/98.

37. **REQUIREMENT:** Paragraph 3.6.21 Recertification.

Hardware and/or software recertification will be required:

b. When the manufacturing source is changed

WAIVER: The above requirement is waived to allow the use of polysulfide sealant from unqualified facility (Mojave) on internal nozzle joint bolts and leak check plugs on STS-82 (BI-085) and BI-086 thru BI-091 for external, seawater intrusion protection, reuse issue only.

RATIONALE: Polysulfide material from unqualified facility meets all lot acceptance test criteria. Nozzle plugs on STS-82 will be replaced due to uncertainties surrounding the effect of the new material on pocketing erosion. There are no performance issues with other applications.

STS-82 (BI-085) and BI-086 thru BI-091 are safe to fly.

EFFECTIVITY: STS-82 (BI-085) and BI-086 thru BI-091

AUTHORITY: Space Shuttle PRCBDs S074848, dated 2/7/97 and S074848R1, dated 2/18/97.

38. **REQUIREMENT:** Paragraph 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.

WAIVER: The above requirement is waived for use of a non-GSE hydraulic hoist for Orbiter brake handling.

RATIONALE: MCR #21163 is in work to obtain two new HM-2000 hydraulic hoists to be used for the handling of Orbiter carbon brake assemblies. Those new hoists will become a part of the A70-0768 GSE end item. Upon implementation of the new hoists the currently used HM-4000 non-GSE hydraulic hoist will be removed from use for purposes of handling flight hardware.

The non-GSE hydraulic hoist will be effective for all Orbiters, as required, to support scheduled operations until such time.

EFFECTIVITY: STS-84 thru STS-90

AUTHORITY: Space Shuttle PRCBD S060810A, dated 3/18/97.

40. REQUIREMENT: Paragraph 3.6.21 Recertification.

Hardware and/or software recertification will be required:

c. When changes are made in specifications, manufacturing processes or procurement source for any fluids or other materials used in processing or operating the hardware.

WAIVER: The above requirement is waived to allow new Mobil Jet II Oil Formulation Number RM 286A and Qualification Number 0-1K as acceptable for servicing the Orbiter and SRB APUs.

RATIONALE: Significant testing performed by the Department of Navy, Navy Air Propulsion Center (Report NAPC-LR-88-6) shows that the lubricating oil meets or exceeds all performance requirements. Based on an assessment involving Mobil Oil Company representatives, the minimal chemistry differences between qualification 0-1E and the new 0-1K oil will result in no significant differences between the reactivity of oils with hydrazine or ammonia.

EFFECTIVITY: STS-83, STS-84 and STS-85

AUTHORITY: Space Shuttle PRCBD S040975E, dated 4/4/97.

41. REQUIREMENT: Paragraph 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.

WAIVER: The above requirement is waived to allow the use of non-certified ground test equipment to measure APU Speed Sensor Circuit Magnetic Pickup (MPU) voltage during APU confidence run.

RATIONALE: The ability to perform in-vehicle replacement/retest of a damaged APU Speed Sensor at KSC significantly improves processing safety by deleting requirements for multiple hazardous scape operations and reduces program costs associated with APU replacement/retest operations and Logistic's spares inventory.

The non-certified ground test equipment is built in accordance with the applicable specifications and has passed all required acceptance tests.

EFFECTIVITY: STS–83

AUTHORITY: Space Shuttle PRCBD S011583K, dated 3/7/97.

THIS PAGE INTENTIONALLY LEFT BLANK