Space Shuttle Program

FINAL SUBMITTAL

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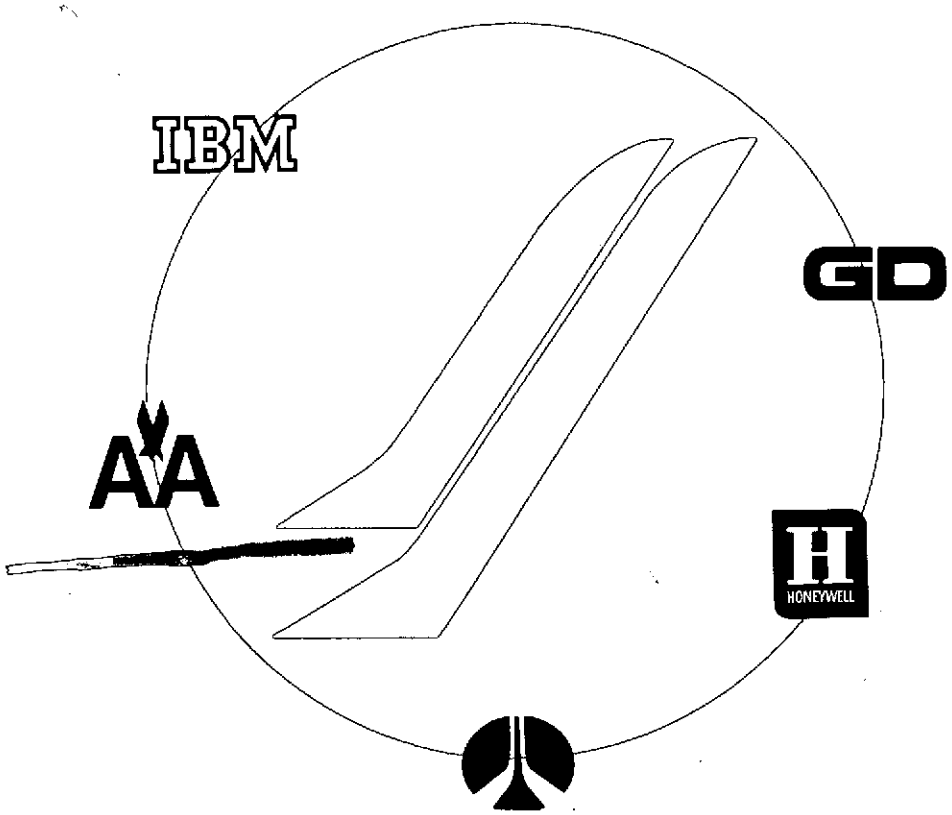

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Preliminary Test Plan for Phase C/D

Volume I. Shuttle System

Contract NAS9-10960
DRL M010, DRL Line Item 17
DRD TM002M
SD 71-105-1
25 June 1971

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SPACE SHUTTLE

PRELIMINARY TEST PLAN for Phase C/D

VOLUME I

Shuttle System

Approved by

B. Hello
Vice President and General Manager
Space Shuttle Program

Contract NAS9-10960
DRL M010, DRL Item 17
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FOREWORD

This plan is one of a family of program plans that establish, as applicable, requirements and prospective implementation approaches for the conduct of Phase C (Design) and Phase D (Development and Operations) of the Space Shuttle Program. With the exception of the cost data, which appear in the Cost and Schedule Estimates Plan only, each plan has been prepared in accordance with the specific contract requirements described in the Contract NAS9-10960 Statement of Work, Paragraph 4.7 and Appendix A, Data Requirements. These plans are as follows:

Title	Volume	SD No.	MSC No.
Program Management Plan for Phase C/D	One volume	SD 71-101	MSC-03308
Engineering and Development Plan for Phase C/D	I. Shuttle System II. Orbiter System III. Booster System	SD 71-102-1 SD 71-102-2 SD 71-102-3	MSC-03309
Operations Plan for Phase C/D	I. Shuttle System II. Orbiter III. Booster	SD 71-103-1 SD 71-103-2 SD 71-103-3	MSC-03310
Facility Utilization and Manufacturing Plan for Phase C/D	I. Orbiter II. Booster	SD 71-104-1 SD 71-104-2	MSC-03311
Preliminary Test Plan for Phase C/D	I. Shuttle System II. Orbiter III. Booster IV. Shuttle Support Equipment V. Shuttle Software	SD 71-105-1 SD 71-105-2 SD 71-105-3 SD 71-105-4 SD 71-105-5	MSC-03312
Logistics and Maintenance Plan for Phase C/D	One volume	SD 71-106	MSC-03313
Program Cost and Schedule Estimates Plan for Phase C/D	One volume	SD 71-107	MSC-03314

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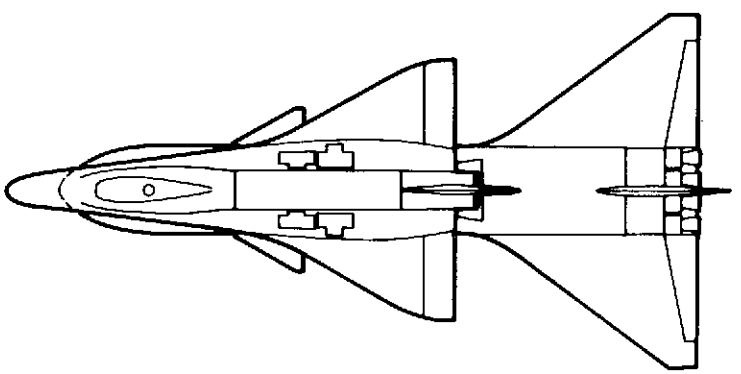
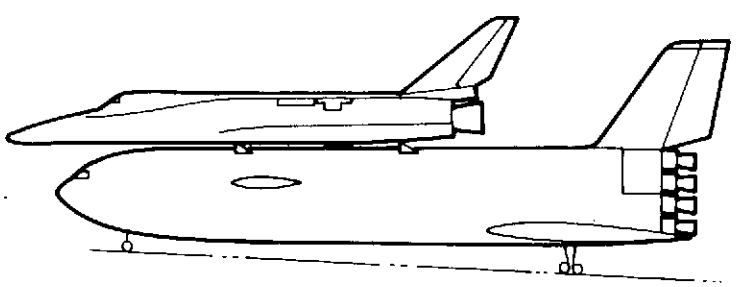
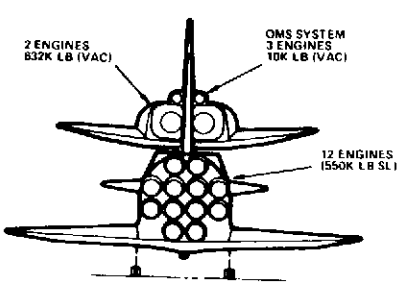
PREFACE

The objective of the Space Shuttle Program is to provide a low-cost space transportation system for placing and retrieving payloads in earth orbit. The first manned orbital flight is scheduled for April 1978. To achieve this goal, a reusable space shuttle system capable of a rapid turnaround, airline-type ground operation has been defined, satisfying as a minimum three basic missions: (1) 100-nautical-mile due-east circular orbit originating from a latitude of 28.5 degrees north, (2) a 55-degree inclination, 270-nautical mile earth orbit, and (3) a 100-nautical mile south polar circular orbit.

To accomplish these missions, a two-stage launch vehicle (shown below) has been defined, which is capable of delivering into orbit one stage with its payload. Each stage is capable of atmospheric entry and return to a designated landing site. The vehicle features moderate acceleration levels, a shirtsleeve cabin environment and quick turnaround capability. Operational facilities and system support equipment complement the flight vehicle.







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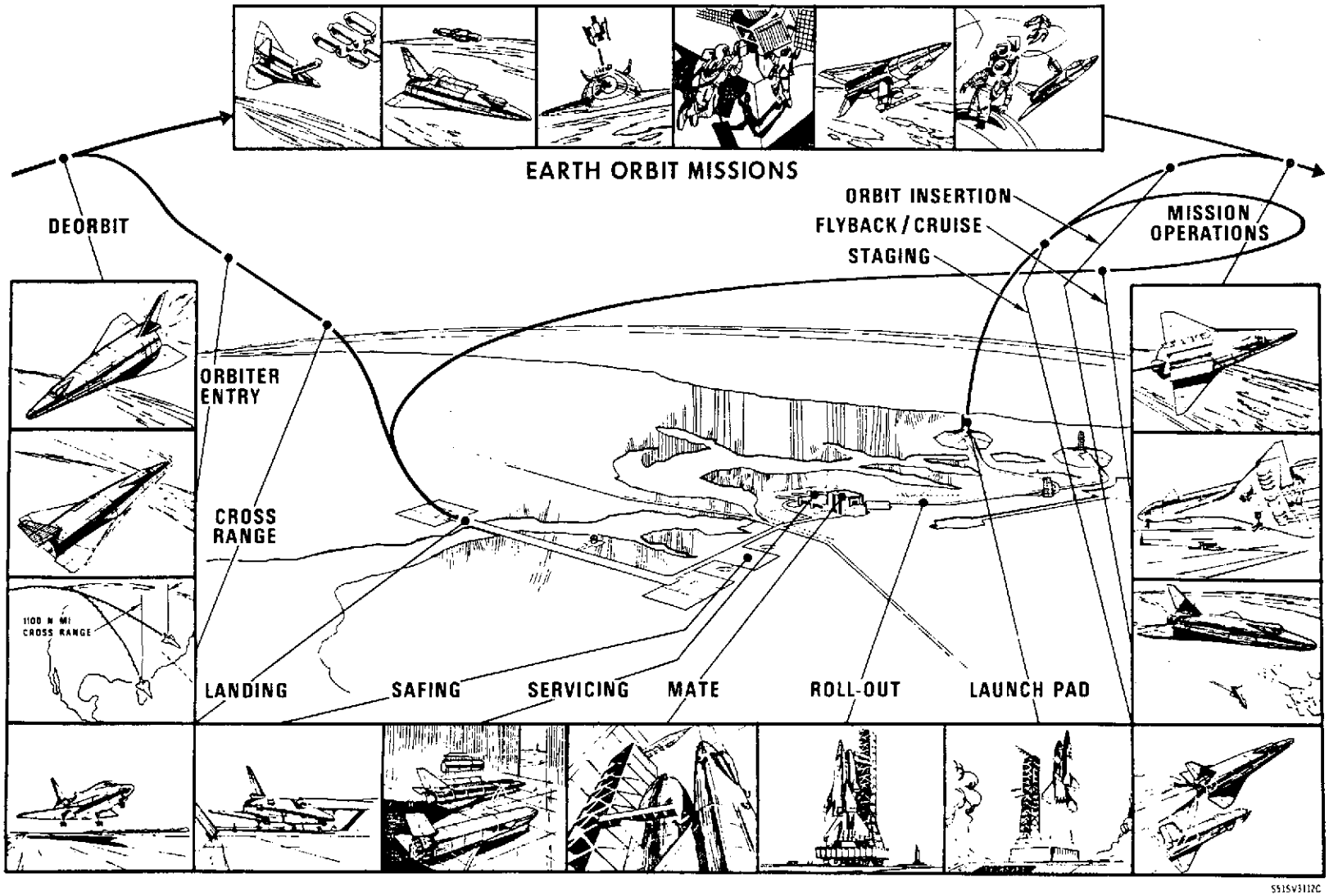
The booster and the orbiter are reusable delta-wing vehicles. The booster is equipped with 12 main rocket engines, an external heat shield to withstand the temperatures of boost and suborbital entry, and deployable airbreathing engines for cruising back to the launch site. The orbiter is equipped with two main rocket engines, orbital maneuvering rocket engines, an external thermal protection system to withstand the temperatures of boost and orbital entry, and deployable air-breathing engines installed for specific missions. The operations facility will provide for preflight readiness checkout, payload installation, and launch control, as well as primary landing sites and facilities for vehicle turnaround and necessary servicing. Shuttle support equipment includes all equipment required to check out, service, handle, and launch the flight vehicles.

The significant elements of these missions, as shown in the following figure, are ground operations, launch, and staging of the two vehicles. After staging, the first stage (booster) returns to the launch area while the second stage (orbiter) attains the prescribed insertion orbit after a series of orbital maneuvers. The second stage (orbiter) then delivers or retrieves its payload, enters the atmosphere, acquires the landing site, and completes the approach and landing. Safing operations are completed on each vehicle at the landing area preparatory to the turnaround cycle ground operations. Subsequent to payload installation in the orbiter, the orbiter is mated with the booster, and the mated system is made operationally ready and transported to the launch area for a new mission.



Elements of Space Shuttle Operations

CONTENTS

Section		Page
1.0	PURPOSE	1-1
2.0	SCOPE	2-1
3.0	TEST PROGRAM SUMMARY	3-1
	3.1 Test Program	3-1
	3.2 Test Logic and Schedules	3-2
4.0	TEST PHILOSOPHY AND CRITERIA	4-1
	4.1 Overall Test Program	4-1
	4.2 Mated Orbiter/Booster	4-4
5.0	REQUIREMENTS	5-1
	5.1 Overall Test Program Requirements	5-1
	5.2 Mated Orbiter/Booster Test Requirements	5-2
6.0	APPROACH AND RATIONALE	6-1
	6.1 Overall Test Program	6-1
	6.2 Mated Orbiter/Booster	6-4
7.0	COMMONALITY	7-1
8.0	SUPPORT REQUIREMENTS	8-1
	8.1 Facilities Requirements	8-1
	8.2 Support Equipment Requirements	8-2
	8.3 Range Requirements	8-3
	8.4 Data Requirements	8-3
9.0	GLOSSARY	9-1

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ILLUSTRATIONS

Figure		Page
3-1	Test Logic and Constraint Network	3-3
3-2	Overall Test Schedule	3-4
4-1	Certification Concept	4-5
6-1	Orbiter 2 Detail Test Schedule	6-5
6-2	Booster 2 Detail Test Schedule	6-6
6-3	Mated Test and Operations	6-9

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1.0 PURPOSE

The test program is oriented to demonstrate shuttle mission capability. The program covers the prerequisite testing necessary to develop the vehicles and support systems, and to verify their readiness for operational use.

The preliminary test plan defines the space shuttle test program, and relates the tests to the test requirements delineated in the space shuttle system and end item specifications. The plan also establishes test flows and schedules. The primary function of this plan is to provide the following:

1. A basis for evaluating cost, schedule, and confidence in space shuttle performance.

2. A point of departure to accommodate changes in mission, vehicle configuration, or functional performance requirements as the program moves into Phase C.

This preliminary test plan is prepared in compliance with data requirements list line item 17 for Contract NAS9-10969. (It should be noted, however, that all cost information resulting from this plan is contained in the program cost and schedules estimates plan.)

2.0 SCOPE

The test program, described in the five volumes of this plan, defines the requirements and approach to all levels of testing from engineering design development through acceptance of the production vehicle, including qualification and mission demonstration. In addition to vehicle testing, the program also covers support equipment design development, qualification and acceptance testing, installation checkout, and integration of the support equipment with site facilities and shuttle vehicles. Software development and validation will parallel hardware testing, and are integrated into the test program.

Certification requirements are satisfied by a wide range of analytical methods, supplemented by test only when testing is more practical and/or more cost effective. The method selected to satisfy requirements is delineated in this plan, and will serve as a bridge between specification requirements and test planning until that time during Phase C when a separate certification plan will be prepared.

This preliminary test plan covers Phase C/D testing and provides continuity between the Phase B test plan and the operations plan. The testing for material selection and processing, and the design concept evaluation during Phase B, will extend into the design evaluation and hardware qualification and acceptance testing of Phases C and D. With similar continuity, the ground and flight test program will evolve into mission operations. Facilities, support equipment, personnel, and procedures to be employed during the operational phase will be the same as those used during the mated orbital test flights, with minor updates for the operational configuration and any improvements which may be derived from the test program.

Operational missions overlap a significant portion of the orbital flight-test program. The scope of the preliminary test plan, as it relates to the operations plan in the area of mated orbital launches, is defined as follows:

1. All flight test objectives satisfied by either the flight test program or operational missions are covered in the preliminary test plan.

2. All operational mission objectives satisfied during operational missions or the flight program are covered in the operations plan.

Turnaround activities between test flights will not be included in the preliminary test plan, but will be combined with similar information derived from operational launches and presented in the operational plan to demonstrate program turnaround requirements.

The preliminary test plan format was designed for easy subdivision into a test plan tree, paralleling that of the specification tree. The plan is contained in five volumes as follows:

Volume I - All shuttle system-level and mated orbiter/booster testing

Volume II - Orbiter testing

Volume III - Booster testing

Volume IV - Support equipment testing

Volume V - Software testing

Test information related to each subsystem has been identified by subsystem within each volume, as applicable. This will facilitate the preparation of independent subsystem test plans during Phase C.

3.0 TEST PROGRAM SUMMARY

3.1 TEST PROGRAM

The overall objectives of the test program are (1) to assist in developing design concepts, (2) to certify by analysis and ground test and verify by flight test as required, and (3) to provide data for space shuttle vehicles, support equipment, and software acceptance.

The philosophy and criteria for testing requires making maximum use of the experience gained on previous programs, expanding that knowledge through analysis, combining qualification with development testing where practical, and reducing or eliminating any redundant testing in the checkout of deliverable hardware. This must be accomplished without compromising the performance capability of the delivered end items.

The space shuttle test program is designed to be cost effective, taking advantage of the following: (1) commonality of design to minimize duplication of orbiter/booster testing, (2) subsystem redundancy to minimize downtime during test, and (3) operational vehicle adaptability for use during the flight-test program. Cost effectiveness is further enhanced by using aircraft and space vehicle experience to eliminate or reduce the number of tests required.

Formal requirements for certification and acceptance testing will be derived from the shuttle specification and contract end item specifications. Development test requirements related to design feasibility will be defined when subsystem configuration is further resolved to the component level.

Quality Assurance will verify that all tests have been conducted in conformance with all requirements as established by engineering documentation or specific contract direction. This function encompasses qualification tests as well as final acceptance tests as they apply to the mated shuttle, the booster, the orbiter, and associated support equipment. Validity of software and test setups is established before testing in coordination with Engineering. Detailed Quality Assurance provisions and requirements are delineated in Appendix E of the Program Management Plan under Quality Assurance Program.

3.2 TEST LOGIC AND SCHEDULES

The test program logic and constraint sequence is shown in Figure 3-1. Milestones and major test activity spans are shown in the test schedule (Figure 3-2).

Subsystem development, qualification, and acceptance testing will be conducted at the component through subsystem level, utilizing breadboard setups with prototype through production hardware. Combined subsystem testing (such as cluster static firing) will be performed to integrate the total subsystem and any critical interfaces with other subsystems.

All subsystems will be certified flightworthy before first use in flight. There will be no dedicated test vehicle for integrating the installed subsystems. This will be accomplished through combined subsystem testing and on the first flight-test vehicle for all subsystems, with the exception of the main propulsion subsystem, which will be installed for the first time on the second flight-test vehicle. For those subsystems operable in the assembly and checkout plant, the integration tests will be performed concurrently with the acceptance tests, whereas the APU, fuel cells, jet engines, and other flight-line-operated subsystems will be integrated concurrently with the post-checkout and preflight operations. Taxi, deceleration, and ground handling checks will be included as part of the preflight tests, along with ground runs for the jet engine, fuel cells, and auxiliary power unit. Conventional airplane-type horizontal testing will follow on Orbiter 1 and Booster 1, covering the subsonic flight envelope.

The second flight test vehicle will complement the first by performing a short program of horizontal subsonic testing. A static firing will precede the first manned mated (orbiter/booster) orbital launch. All orbiters and boosters will be static-fired once, prior to their first mated orbital flight.

By means of a series of flights, the orbital flight-test program will verify the operational capability of the vehicle, including its maximum cross range. Both Vehicle 1 and 2 will be reconfigured and included in the operational inventory after completion of their respective roles in the flight-test program. Additional static firings of the main propulsion system of these vehicles will not be a requirement following this reconfiguration.

Integration of the support equipment and software with the shuttle vehicle hardware is an integral part of shuttle vehicle testing and is described in Volumes I, II, and III. Testing of the support equipment is described in Volume IV, and software development, certification, and acceptance testing are discussed in Volume V.

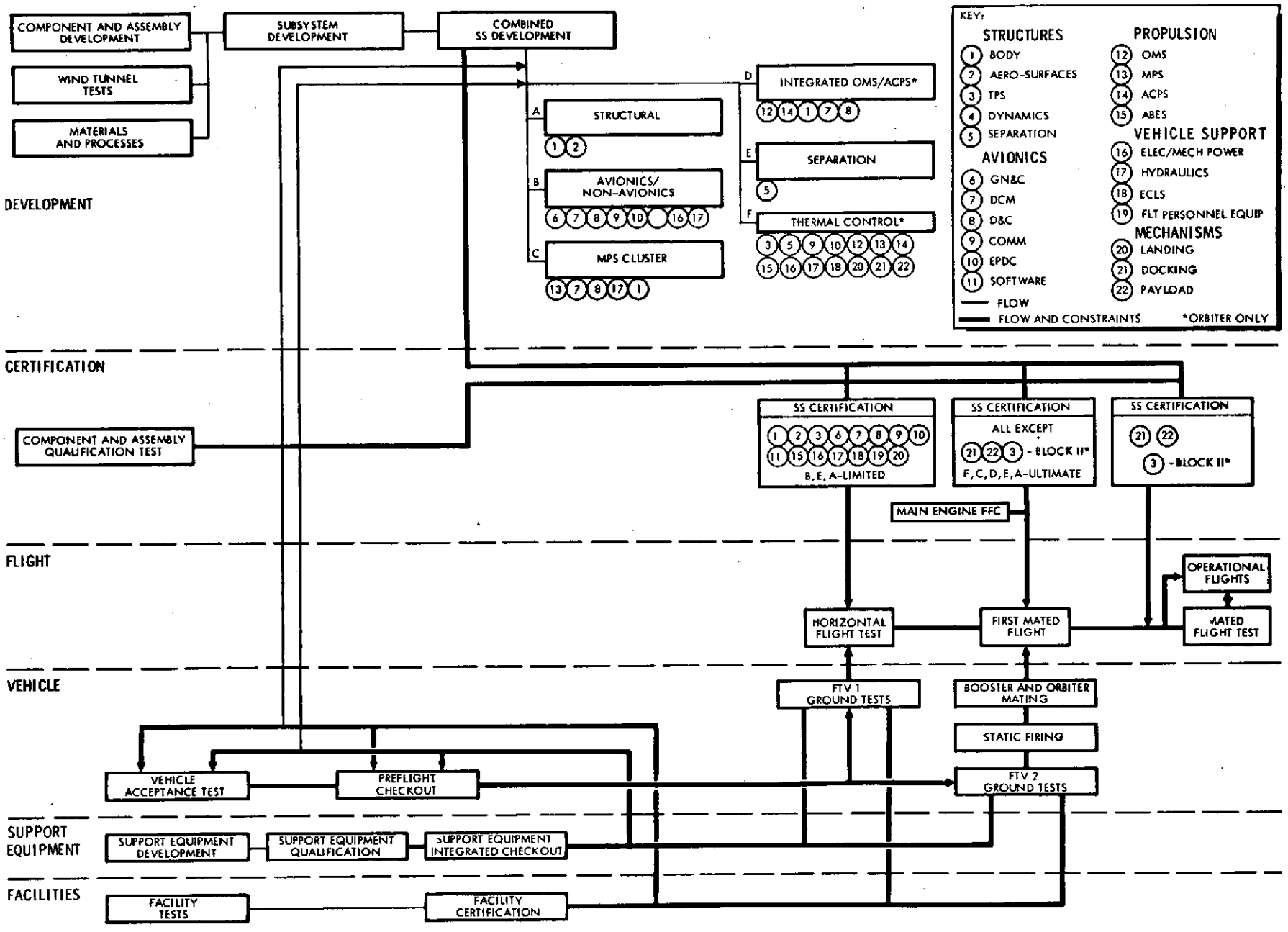


Figure 3-1. Test Logic and Constraint Network

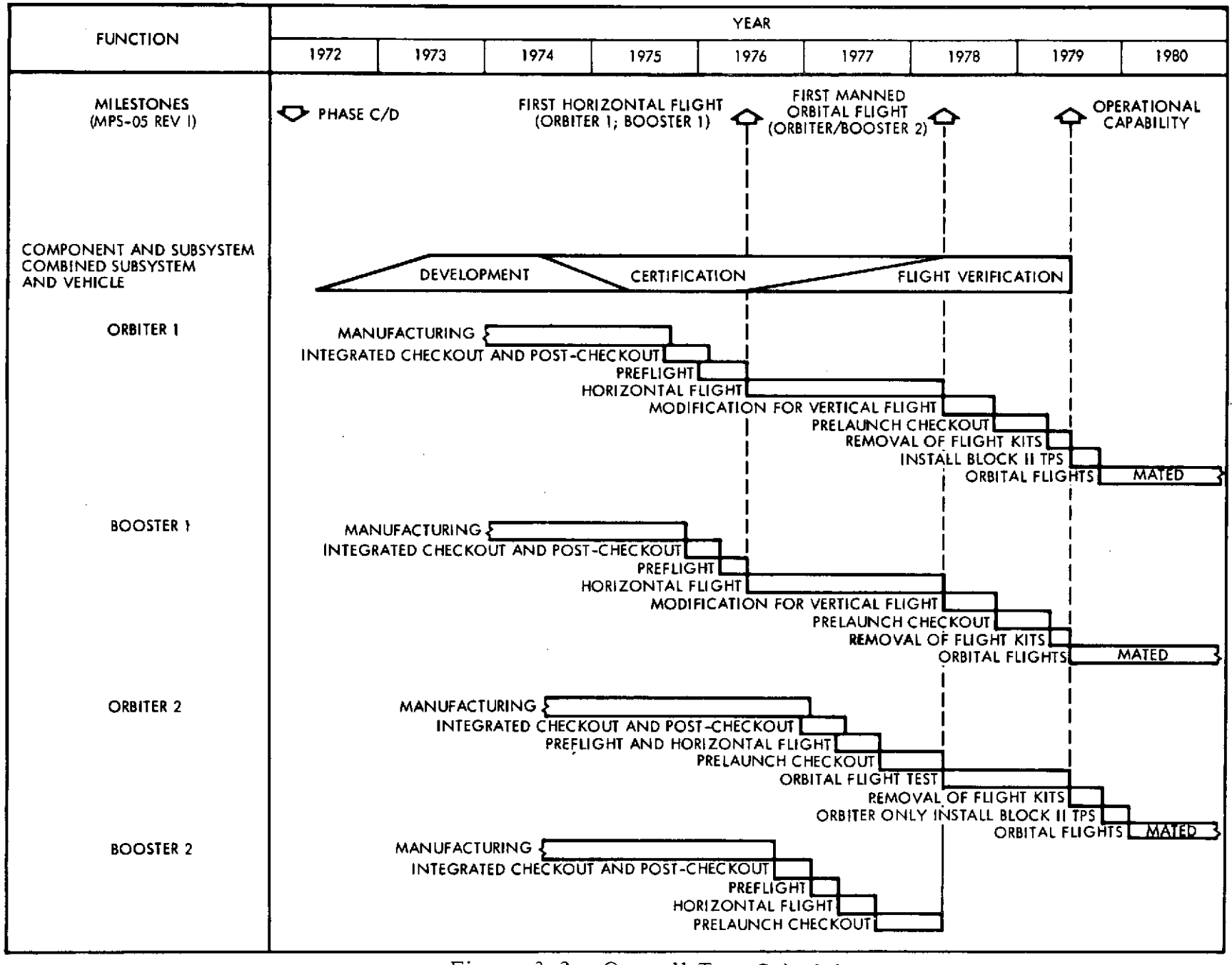


Figure 3-2. Overall Test Schedule

4.0 TEST PHILOSOPHY AND CRITERIA

4.1 OVERALL TEST PROGRAM

The test philosophy for the space shuttle program embodies a set of ground rules and criteria designed to accomplish the following:

1. Provide a basis on which test logic and a test program may be developed to meet the program objectives of low cost, flexibility, reliability, maintainability, and safety.

2. Evaluate test requirements.

3. Assist in formulating design requirements as well as test, checkout, and operational requirements.

The objective of these criteria is to attain the required confidence at each testing level with the minimum expenditure of test hardware and within cost and schedule constraints. Achievement of this goal will require the rigorous evaluation of each design requirement as it relates to test requirements and test program phasing. Redundant testing, and the resulting proliferation of test hardware and facilities, will be eliminated through precise phasing to obtain optimum utilization and maximum test requirements integration. Multiple-purpose test hardware will be used where feasible, and will be identified early to permit consideration of any special configuration requirements during the design phase.

The test philosophy will accommodate various major test categories which have inherently different disciplines and emphasis. For instance, development tests require a highly flexible approach so that systems configurations and operating or checkout procedures may be optimized during the process. Acceptance tests require rigorous application of controls to ensure that all elements of the space shuttle system — including the software, procedures, and support equipment — meet established requirements (specifications).

The philosophy and criteria outlined have been developed to allow maximum use of all test data to satisfy certification requirements. Their aim is to establish an integrated test program which will accomplish

the basic objective of achieving adequate confidence at minimum cost. The philosophy and criteria apply to all system elements, including booster and orbiter, both as single elements and mated, and to support systems unless otherwise noted; they are outlined below:

1. Test requirements will be structured to identify and accumulate data for key components and subsystem parameters throughout all phases of testing. These data will be used in checkout procedure development, trend establishment, and anomaly resolution.

2. The baseline missions and timelines will be used in developing specification requirements. All test requirements will be traceable to the CEI and/or system specifications. Mission requirements updating and changes must, in turn, be reflected in the appropriate specifications and documentation.

3. Functional criticality will be the basis for relating vehicle hardware and test rigors (i.e., items with category of functional Criticality I will require qualification testing).

4. A test logic and constraint network will be used for tracking and control of the test programs. Figure 3-1 is a preliminary top-level logic network showing test constraints.

5. The test approach will be based upon past program experience in order to achieve a cost-effective program.

6. Maximum practical use of commonality will be made for test methods and procedures, test equipment, support equipment, facilities, and operational techniques.

7. All flight tests will be manned operations.

8. The first flight test vehicle will be capable of being configured for use as a fully operational flight vehicle. Subsequent orbiter and booster vehicles will have full operational configuration.

9. Crew safety criteria for the flight-test program will include provisions for crew escape.

10. Flight-test instrumentation will be capable of being installed and removed without significantly impacting the on-board checkout system and data acquisition systems, or without causing extensive rework to put the vehicle in final operational configuration.

11. Test equipment, checkout procedures, and data accumulation will be standardized where practical throughout all phases of testing and between the orbiter and booster. The on-board checkout capability will be utilized to the maximum extent practical.

12. Deliverable support equipment will be used in the test program at the earliest cost-effective time; this includes support of airborne equipment development where practical.

13. A data base with an accompanying retrieval system will be available for engineering evaluation of subsystem performance, and will provide a basis for certification for flight.

14. Special testing for reliability data and performance confidence will be by exception only; the data will be obtained by recording operating time and failure trends data throughout the development, qualification, acceptance, flight, and operational phases of the program and will be retained in the data base.

15. Repetitive testing will be minimized throughout the test cycle, from vendor manufacturing through delivery of end items to the final customer.

16. The tolerance band for requirements will be most stringent (narrow) at the level of acceptance testing for manufacturer's components, or subsystems in order to assure a good screen for workmanship. The tolerance band will be expanded for vehicle checkout and flight testing according to the degree that hardware contributes to total system tolerance limits. Subsequently, the tolerance limits will be expanded, based on flight test and other use experience, for the operational vehicle.

17. The contractor will be responsible for maintaining documentation upon which flight suitability is based.

18. Maximum use will be made of existing contractor and government test facilities where practical and cost effective.

19. Interchangeability will be maintained such that any orbiter will be capable of mating with any booster.

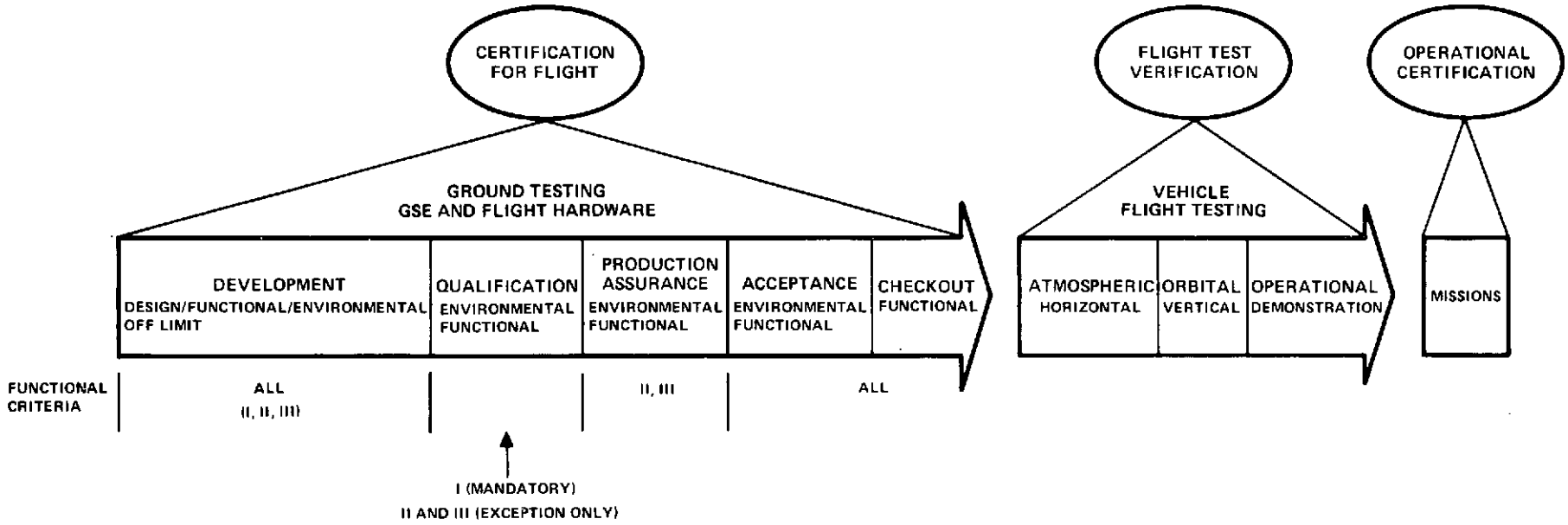
Certification Testing - Verification of the engineering and development requirements will be met through certification testing and analysis. The test categories for certification are development, qualification, acceptance, production assurance, checkout, and flight tests. The concept and terminology for certification and all testing are shown in Figure 4-1. These tests will be performed on orbiter/booster subsystems, on orbiter/booster vehicles during ground and flight tests, and on facilities and ground support equipment as certification tests. The requirements for these tests are based on the test philosophy and criteria presented in this test plan.

4.2 MATED ORBITER/BOOSTER

In addition to the test philosophy and criteria applicable to the total shuttle system, the following items are oriented to the mated orbiter/booster ground and flight tests.

1. The first orbital flight test for the mated vehicle will have a mission duration of up to seven days.

2. Main-engine-out capability will not be included as a part of the flight test program, but will be demonstrated during propulsion ground tests.



NOTES:

1. CERTIFICATION FOR FLIGHT—THAT ACCUMULATION OF TEST DATA AND ANALYSIS, FROM ALL SOURCES, WHICH ESTABLISHES THE FLIGHT SUITABILITY OF SUBSYSTEMS.
2. SUBSYSTEM TEST REQUIREMENT—CERTIFICATION FOR FLIGHT WILL BE COMPLETED BEFORE FIRST ACTIVE USE IN MANNED FLIGHT. CERTIFICATION MAY BE SATISFIED BY TEST OR ANALYSIS, OR A COMBINATION OF TEST AND ANALYSIS.

Figure 4-1. Certification Concept

5.0 REQUIREMENTS

5.1 OVERALL TEST PROGRAM REQUIREMENTS

The following general requirements have been identified and are consistent with the shuttle system and the contract end item specification:

1. Materials, processes, and nondestructive testing techniques will be determined to be adequate for fabrication, maintenance, and reconfiguration of shuttle system elements.

2. Wind tunnel, thermal-vacuum, and structures laboratory test results will support technology trades for shuttle system configuration resolution and design optimization.

3. Subcontractor-supplied and inplant-fabricated hardware will be subjected to subcontractor and/or in-process testing, installed subsystem testing, and integrated system testing, including mission simulation.

4. Shuttle space hardware will be certified flightworthy before its first use for manned flight.

5. Hardware common to the orbiter and booster will be certified to the more severe functional and environmental requirement, and testing will not be repeated for orbiter and booster.

6. Support equipment, software, facilities, personnel, and procedures will be compatible with subsystems, orbiter, booster, and shuttle system hardware.

7. An adequate and accurate on-board checkout capability, ground data station, and supporting software will be required to support flight test and vehicle operations.

8. Test support requirements, including facilities, support equipment, and software, will be defined and developed during early Phase C activities.

9. All program elements (vehicle, support equipment, and facilities) will exhibit electromagnetic compatibility.

10. Training for crew and ground test and operations personnel will be integrated with the test program requirements. This will allow cost-effective sharing of mockups, breadboards, and trainers, and ensure continuity between test and operations activities.

11. Only those payloads compatible with support equipment, facilities, and vehicle will be included in the test program.

12. The main propulsion engine will satisfactorily meet interface requirements with all elements of the Space Shuttle Program.

13. A flight-test program will be performed to demonstrate and verify that mission objectives can be obtained and to mature the vehicle subsystems before operational status.

5.2 MATED ORBITER/BOOSTER TEST REQUIREMENTS

All requirements for testing will originate in the shuttle system and end item specifications. Section 4.0 of the Shuttle System Specification delineates certification requirements for the mated vehicle in conjunction with other shuttle system elements. Of the requirements identified for shuttle level certification, those allocated for test are summarized as follows: The basic shuttle mission, including the orbiter to payload and space station compatibility will be demonstrated; and the operational site interfaces of the support equipment and facilities with the vehicle will be verified.

The testing described in this volume is designed to satisfy the shuttle system test requirements described above. The requirements are limited to those for (1) mated orbiter/booster ground dyanmics tests, (2) orbiter or booster checkout in preparation for mated launch, (3) mated shuttle boost through orbiter and booster reentry to jet-powered cruise flight, and (4) integration of the support equipment and software with the vehicles in support of these tests.

Mated orbiter/booster test requirements are limited to those requirements satisfied by the mated orbiter/booster test activities. These requirements will be satisfactorily performed and achieved, and are listed as follows:

1. Vibration modes of the mated orbiter/booster will be measured in the horizontal position to verify dynamic predictions.

2. Satisfactory orbiter/booster mating capability will be demonstrated.

3. Tanking and detanking procedures will be demonstrated for both vehicles while they are mated on the launch pad.

4. The mated configuration will demonstrate the capability of meeting launch countdown sequence procedures.

5. Launch and boost environment will be measured to verify vehicle design parameters.

6. The booster main propulsion performance will be demonstrated.

7. Orbiter/booster performance and stability and control during boost will be demonstrated.

8. The orbiter/booster separation sequence will be performed to demonstrate adequate orbiter-to-booster clearance, separation mechanism operation, thrust buildup and decay timing, and effects of orbiter exhaust plume impingement on the booster.

9. Orbiter main propulsion and guidance, navigation, and control performance will be demonstrated during orbit injection.

10. Orbit maneuvering subsystem (OMS) thermal-vent system, propellant orientation capability, and zero-gravity gauging system on the orbiter will be demonstrated.

11. Subject to the availability of the space station, orbiter rendezvous, payload deployment, docking, cargo and crew transfer, undocking, and deorbit will be demonstrated.

12. Orbiter on-station performance will be demonstrated for maximum mission orbit duration.

13. Orbiter and booster handling characteristics in the unmated configuration will be evaluated during ACPS control, aerodynamic surfaces control, and the transition from ACPS to aero-surfaces control.

14. The orbiter thermal protection and control subsystem will be demonstrated; predicted heat rate and fluxes during boost and reentry, and orbiter heat balance as experienced during orbital on-station dwell will be verified.

15. The booster thermal protection subsystem during boost and entry will be demonstrated.

16. Orbiter and booster structural static and dynamic loads will be verified, particularly during launch, separation, and entry maneuvers.

17. Orbiter and booster data and control management (DCM) subsystems and related software will provide specified management and data storage for the respective vehicle subsystems.

18. Orbiter and booster power generation subsystems, including orbiter fuel cell, will provide prescribed electrical and hydraulic power during mission demonstrations.

19. Orbiter environmental control and life support subsystem (ECLSS) performance will be evaluated, including the O_2 and N_2 partial pressure regulation system.

20. The orbiter ECLSS radiator will be deployed and retracted.

21. Orbiter and booster ECLSS subsystems cooling loops will be demonstrated, including the transition to and from ground support equipment.

22. Orbiter and booster flight crew and passenger ingress and egress will be demonstrated and emergency backout procedures in safety critical tests such as off-loading of propellants.

23. The support equipment, software, and facilities will interface, in accordance with specifications, with the orbiter and booster at the operational launch site areas.

24. Verification requirements for abort, rescue, and additional missions will be incorporated when these areas are further defined.

6.0 APPROACH AND RATIONALE

The scope of the test program is determined primarily by test requirements, whereas the approach and rationale are shaped by test philosophy and criteria. This section describes, in general terms, the approach and rationale for the overall test program and, in more detail, the mated orbiter/booster test activities. The approach and rationale for testing subsystems, combined subsystems, and the orbiter and booster vehicle may be found in Volumes II and III. Volumes IV and V cover support equipment and software.

6.1 OVERALL TEST PROGRAM

The test program meets the major milestones identified on the Space Shuttle Phase C/D Master Program Schedule (MPS-05 Revision 1) and reflects the program requirement for cost effectiveness.

When compared with previous space programs, the space shuttle test program has (1) combined tasks to eliminate the need for several of the major test articles; (2) designed to minimize the requirements for development testing; (3) approached qualification on the basis of functional criticality of hardware; (4) minimized duplication of support equipment; and (5) selected an adequate but minimal flight test program.

Dual use of vehicles to satisfy development test program requirements and later operational requirements has eliminated the need for dedicated test vehicles in cluster static firing, facility fit check, integration of the installed subsystems, and flight testing.

The cluster static-firing vehicles are operational vehicles with limited subsystems installed to satisfy certification testing requirements. In addition to the primary purpose of main propulsion subsystem integration and interfacing of the main propulsion with support structure, power, control, and instrumentation subsystems, the test vehicle interfaces and functional compatibility with the operational ground support equipment and facilities will be demonstrated where applicable. Booster 4 and Orbiter 5 are scheduled for use in the static-firing program. Upon completion of the cluster static firing, each vehicle will be reconfigured, completed, and reassigned to the operational inventory.

Facility fit checks will be performed initially using the cluster static firing vehicles. These checks will be supplemented later by a demonstration of the fully configured orbiter and booster in the mated configuration. Orbiter 2 and Booster 2 will be at the operational site and will be used for the mated vehicle facility fit checks. A dedicated fit check vehicle will not be required.

Installed subsystem integration tests will also be performed using a flight test vehicle. Orbiter 1 and Booster 1 will provide the means for the first end-to-end checks on a total vehicle. Previous combined subsystem tests of the avionics and propulsion subsystems, in conjunction with subsystem level tests of hydraulics, ECLSS, and deployment mechanisms, will provide the assurance that major discrepancies will not be uncovered for the first time on the flight vehicle during these integrated subsystem tests.

The two flight-test vehicles, Orbiters 1 and 2 and Boosters 1 and 2, will also be reconfigured and reassigned to the operational inventory upon completion of the flight-test program. Of the major ground-test and flight-test vehicles and articles delineated on the MPS-05 Revision 1 schedule, only the structural test articles used for static and fatigue tests will not be reusable as operational vehicles.

In addition to making use of major test vehicles, the design approach of selecting previously developed hardware and employing proven concepts will further enhance the cost effectiveness of the test program by minimizing development testing. This is particularly applicable to landing gear, hydraulics, environmental control and life support, communications, and other avionics subsystems. Selection of common components for use on the orbiter and booster and common support equipment will further reduce the development test requirements.

Qualification testing is required on all Functional Criticality I items (those items, the functional capability of which could be lost as a result of a single stress or environment, and upon which the safety of the crew or vehicle depends). Certification of Functional Criticality II items will be accomplished by the accumulation of test data from development tests, acceptance, and other areas of checkout. Functional Criticality II includes those items, the loss of which could cause the launch to be delayed, the mission safely terminated, or primary or secondary objectives lost. Limiting qualification testing to Functional Criticality I and only selected items of Functional Criticality II with management approval will minimize the qualification program without introducing hazards to the crew or vehicle.

The test program documentation will consist of plans, procedures, and reports. Certification, flight verification, and acceptance requirements are delineated in the shuttle system and end item specifications. These requirements, combined with failure mode effects and analysis and functional criticality level of hardware items, are the primary factors in establishing the test logic and constraint networks. The certification and flight verification plan will incorporate these networks, the justification for analysis or test, and the rationale for the hardware level selected for those tests. Test plans will define the approach and rationale for implementing the tests. They are tiered in a test plan tree covering the following: general shuttle system; end item (orbiter, booster, support equipment, and software); subsystem development and qualification; ground test; flight-test; and acceptance. Support requirements will be identified for each test or test series in their respective plans. In addition, lists of facility, support equipment, and software requirements will be compiled into separate documents; these will identify need dates, total requirements, and shared or common usage items.

Any additional development testing will be initiated based upon development test requests. All development, qualification, and acceptance test and checkout will be performed to standardized test and checkout procedures prepared in consonance with quality assurance and safety ground rules. Quick-look and engineering-analysis reports will be prepared on all development tests and those qualification tests where anomalies occur. Final reports will be prepared on development and qualification testing of (1) subsystems, (2) major combined subsystems, and (3) flight testing.

A data base will be compiled for ready retrieval of test data. The base will include test-article configuration, test results, mean time between failure, and any anomalies which may have occurred during test.

Components and subassemblies are accepted by process and procurement specifications. Orbiter, booster, and other end items (support equipment and software) will be accepted according to test procedures, which when approved will become a part of the customer acceptance data package. Services and support agreements and/or program requirement documents will be prepared delineating all base and range support for the horizontal and vertical flight-test programs. Prior to use of checkout stations at the test sites, the facilities with support equipment installed will be verified by site certification checkout procedures.

Manufacturing checkout is comprised of in-process and acceptance checkout functions starting with acceptance of a component at a subcontractor facility and ending with integrated vehicle checkout and delivery to flight test. In-process checkout is performed as a function of the vehicle major assembly build cycle. It includes structural integrity and cleanliness verification of the tube systems. It also included wire harness and limited subsystem functional checks, to the extent necessary to verify correct installation of the subsystem elements peculiar to that major assembly under test. The major assemblies are delivered to final assembly for mating and integrated acceptance checkout. Acceptance checkout will be accomplished on the assembled vehicle to demonstrate that the product complies with specifications, is capable of performing in conformance with contractual requirements, and is free from manufacturing defects.

Ground tests will be performed in preparation for the subsonic test program. These tests will include APU and fuel cell operations, jet engine runups, taxi, steering, and deceleration tests. Upon completion of the ground tests and ferry of the orbiter to the flight test station, the subsonic flight test program will be initiated.

The subsonic flight testing of an orbiter and booster will allow an evaluation to be made of (1) takeoff and landing, steering, and deceleration devices; (2) the low-speed performance, handling, stability, and control characteristics; and (3) the nonorbital operation of the subsystems. Initial flight testing will be conducted with manual approach and landings. The development and optimization of the automatic landing system will be phased in later during the subsonic flight test program.

A single orbiter and booster are assigned to the subsonic test program, and the second orbiter and booster are designated primarily for mated orbital test launches. A detailed description of the mated orbiter/booster test approach and rationale is presented in the following section.

6.2 MATED ORBITER/BOOSTER

The mated orbiter/booster test activities are defined as those ground and flight tests performed in the mated configuration, orbiter and booster tests performed in preparation for a mated launch, and flight tests of orbiter and booster individual elements initiated by a mated launch. The ground tests shown in Figures 6-1 and 6-2 include: low-frequency dynamic tests of the mated orbiter/booster; static firings of the orbiter and booster individual elements; interface checks of the orbiter, booster, and the mated configuration with the operational site facilities and support equipment; and prelaunch checkout of the orbiter and booster. The flight tests include those for mated launches, orbiter activities while performing on-orbit demonstration tests, and atmospheric entry of the orbiter and booster through jet engine deployment and ignition.

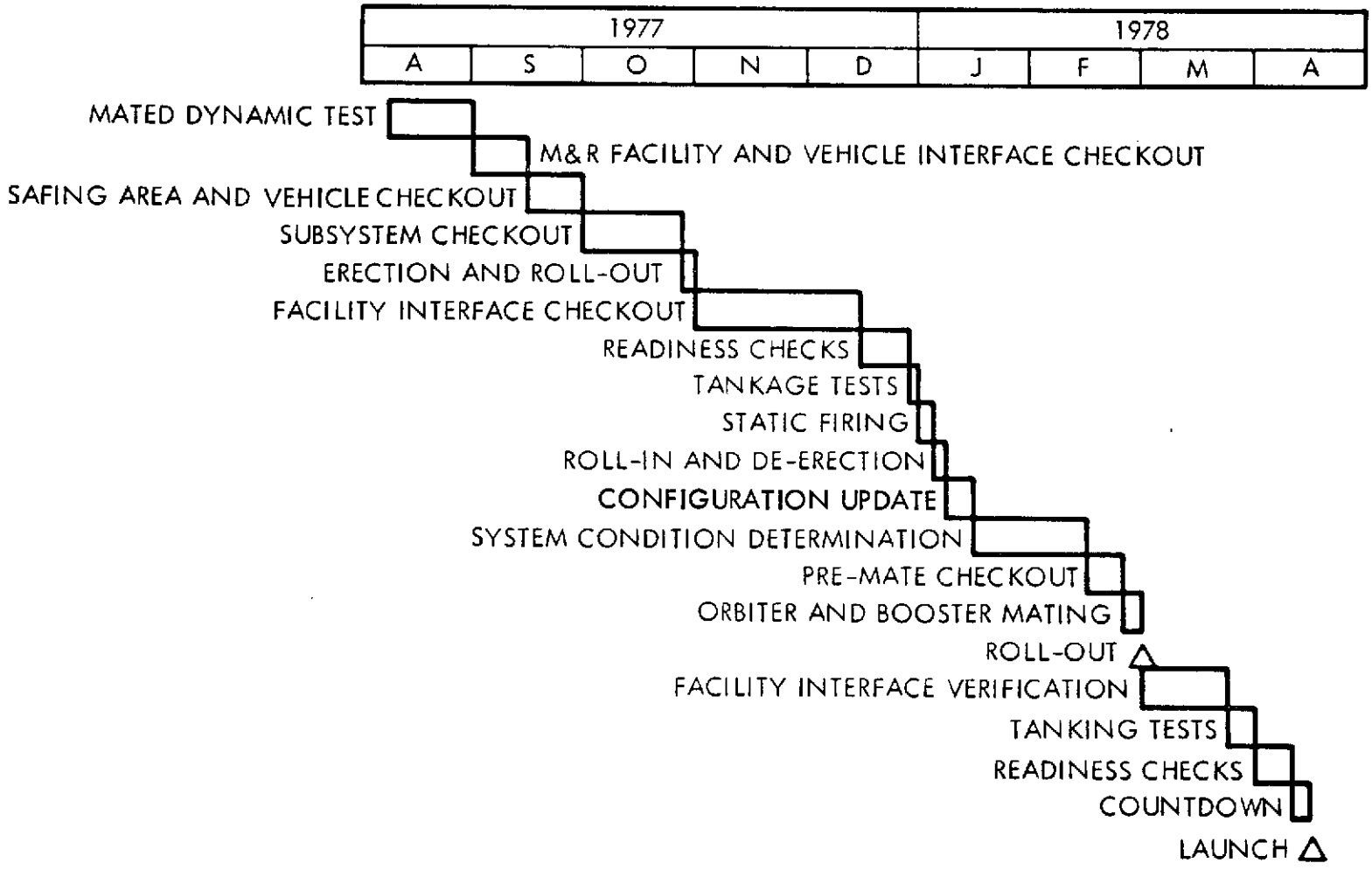


Figure 6-1. Orbiter 2 Detail Test Schedule

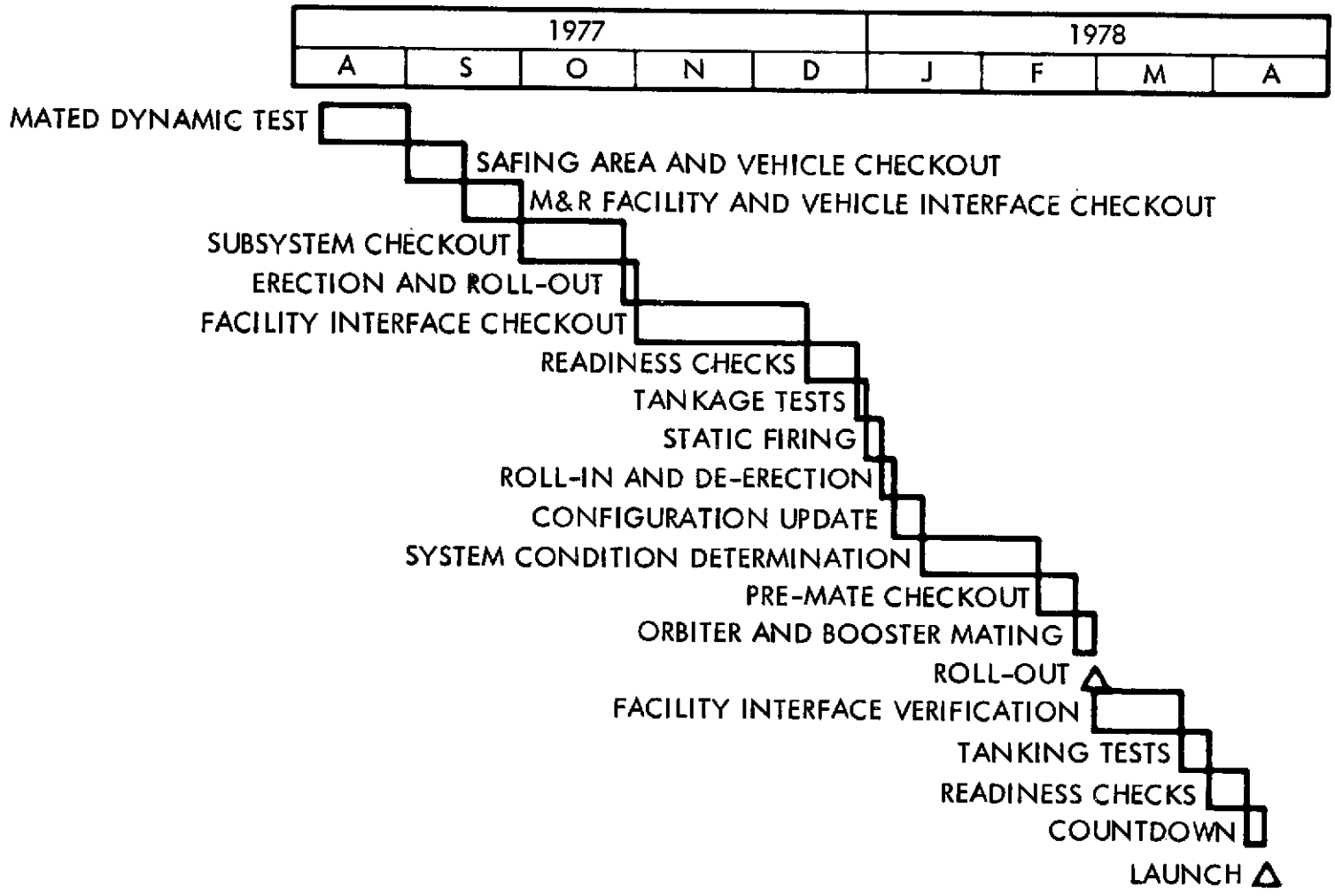


Figure 6-2. Booster 2 Detail Test Schedule

The ground vibration test is planned to obtain bending and torsion modes and damping characteristics. It is similar to the tests conducted independently on the booster and orbiter. The mated vehicle will be in the horizontal position, supported by a low-frequency suspension system, and will be stimulated by low force-level inputs. These measured responses will provide a basis for analytically extrapolating orbiter and booster measurements to the mated boost configuration.

Cluster static firing of Orbiter 2 and Booster 2 on separate launch pads at the operational site is planned as a flight-readiness demonstration of the main propulsion subsystem. This static firing is not unique to the flight test vehicle performing the first manned orbital launch, but is scheduled to be conducted once on each orbiter and booster.

Interface checks with the support equipment and facility at each launch site checkout area will be required for both the orbiter and booster. These areas include maintenance and repair, launch pads used for individual static firing, mated vehicle launch complex, and post-mission safing areas. At each checkout area, the support equipment/facility interfaces will be checked and the support equipment functionally verified before connecting with the vehicle for interface checks. These checks will be repeated as each new orbiter or booster is cycled through the checkout areas for the first time. Subsequent cycles of the same vehicle will require only a support equipment hookup verification check.

Prelaunch checkout of the first orbiter and booster at the launch site includes subsystem tests in the maintenance and repair (M&R) checkout stations. The orbiter and booster are then independently erected and relocated to the respective launch pads for static firing. Prestatic firing checks include tanking, propellant gauging calibration, detanking, and vehicle safing. Subsequent to static firing, the vehicles are returned to the M&R checkout area where a subsystem check is made to provide a pre- and post-static firing subsystem status comparison. An integrated subsystems test, including a mission simulation, will precede the move to the mating area where the orbiter and booster will be erected, mated, and readied for transport to the launch complex. Support equipment hookup and interface checks will be conducted prior to tanking tests, which will then be accomplished for the first time in the mated configuration. Vehicle subsystems will be verified ready for launch, including interface with range tracking and communication systems. Upon verification that all shuttle system elements are ready for launch, the countdown will be initiated.

The mated orbiter/booster flight test program shown in Figure 6-3 consists of a series of orbital flights extending over a period of 14-1/2 months. Test requirements for this program are defined in Section 5.0; however, the key areas of concern are reiterated as they relate to the approach and rationale. They are: demonstration of the boost performance and separation; on-orbit

subsystem performance and thermal balance under space environment; and demonstration that the thermal protection system (TPS) can withstand atmospheric entry environment.

The first launch of the mated configuration will demonstrate booster main propulsion subsystem performance, orbiter/booster controllability, and will provide measurements to verify static and dynamic load predictions in the areas of ignition shock, acoustics, and separation. Aerodynamic interference and boost heating parameters will be measured to verify analytical estimates and wind tunnel measurements. Separation performance will be evaluated based on sequence of events, orbiter thrust buildup and booster thrust decay, and separation linkage loads for nominal conditions. There is currently no requirement for demonstrating separation at other than nominal conditions.

The orbiter thermal protection will be evaluated by exposing the TPS to an increasingly severe environment on each flight. This will be accomplished by judiciously selecting the proper combination of payload weight, orbit ephemeris, cross-range, and entry trajectory. It is anticipated that three orbital flights will be required to build up to maximum flight operational conditions. These tests will be performed with Block I TPS. Based on the similarity of the Block I and Block II TPS and the information derived from the Block I flights, demonstration of the Block II TPS will be performed as the first operational missions of flight test vehicles 1 and 2.

Demonstration of missions requiring payload deployment will be limited on the early flights to payload size buildup consistent with TPS demonstration requirements.

The availability of the space station will also influence the first demonstration of docking, space station/orbiter compatibility, and cargo and passenger transfer. Cargo deployment will be exercised with each incremental increase of payload. Subsequent to payload deployment demonstration, satellite implacement and retrieval methods and techniques will be demonstrated. Rendezvous will be demonstrated with the space station or, in the event the space station is not yet available, with a substitute satellite. Other orbital tasks such as evaluating orbiter subsystems on-station, undocking, and deorbit will be satisfied on the early flights; however, maximum on-station dwell time will require the addition of a specific objective to the primary objectives defining a later launch. Maximum cross-range capability is a primary objective which will be initially demonstrated during orbital testing with Block I TPS.

Based upon the approach and rationale presented previously, the schedule of MPS-05 Revision 1 mated orbital launches is depicted in Figure 6-3. The mid-1979 operational capability milestone is identified and coincides with the completion of Orbiter 2 and Booster 2 testing. Five mated orbital test launches

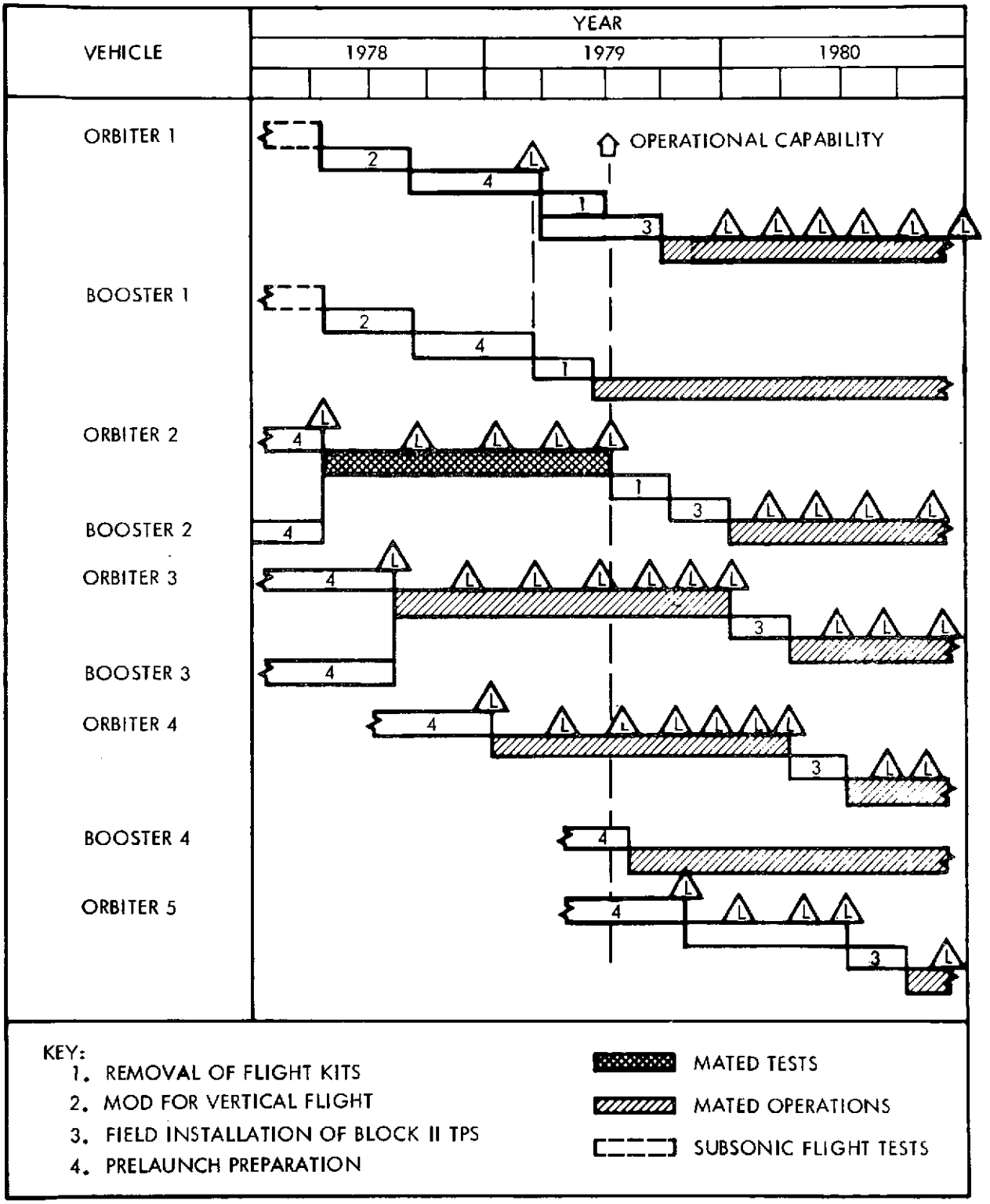


Figure 6-3. Mated Test and Operations

on this vehicle will be supplemented by a single, mated, orbital test launch on Orbiter 1 and on Booster 1. During this same time span, six operational launches will be performed. The only difference between the test launches and the operational launches is that Orbiters 1 and 2 and Boosters 1 and 2 will incorporate development flight instrumentation (DFI). The first of the operational flights is scheduled for Orbiter 3/Booster 3, 3-1/2 months after the first test launch of Orbiter 2/Booster 2. These operational missions will be limited to trajectories previously demonstrated by a test vehicle or to trajectories with less severe environment or functional rigor. If operational instrumentation is adequate for obtaining the required information, operational vehicles may be interchangeably used with test vehicles in accomplishing the test program. To obtain maximum utilization of the available launches, an instrumentation kit is under consideration and study. If acceptable, the instrumentation kit may be used as a limited DFI substitute on those launches of operational vehicles with flight test objectives.

The transition from those orbital flights which share flight test and operational objectives to totally operational missions is described in more detail in Section 2.8 of Volume 1 of the Operations Plan (SD 71-103-1; MSC-03310).

7.0 COMMONALITY

Commonality refers to those items, including hardware, materials, software, and services that are common to the orbiter/booster or associated ground systems that can be developed, procured, and/or performed in a common manner during Phase C/D activity in order to minimize overall program costs.

Commonality is not limited to orbiter and booster components or subsystems, but applies to all shuttle system hardware and software including common support equipment for both test and operations, and extends even to the use of common test facilities.

Designing for commonality is a technique employed after considering many independent factors including development and certification test costs. Commonality analysis, common hardware identification, and requirement-and-constraint definition will continue with particular emphasis during the Phase C design phase. It will utilize the techniques established during Phase B in which commonality is evaluated between design feasibility evaluation, definition of specifications, definition of verification and test requirements and definition of approaches for satisfying these requirements.

8.0 SUPPORT REQUIREMENTS

Support requirements unique to the mated orbiter/booster test activities are discussed in this section. Support requirements common to operations and tests are called out in Volume I, Appendixes C and D, of the Operations Plan. This section defines only those additional requirements unique to tests.

8.1 FACILITIES REQUIREMENTS

8.1.1 Facilities Requirements - Mated Dynamic Tests

Mated structural dynamic tests will be accomplished in the vertical assembly building at the operational site with the empty orbiter and booster mated in the horizontal position. Facilities required are as follows: hangar space adequate to mate the orbiter and booster horizontally and overhead cranes to lift the orbiter. Mated dynamic tests are discussed in Section 6.0 of this volume.

8.1.2 Static Firing - Flight Readiness

All five orbiters and four boosters will be flight-readiness static fired before their first mated mission. They will not be subsequently static fired.

Static Firing - Orbiter

Static firing of the orbiter will require a modified launch pad with the following:

Modified umbilical arms
Modified booster erector
Water-jacketed exhaust system
Modified water deluge system
Modified fluid distribution and electrical lines

Static Firing - Booster

Static firing of the boosters will require special hold-down arms and a modified-water-deluge system. The facilities listed above are not new requirements but are the same as required for the booster cluster static firing test program.

8.2 SUPPORT EQUIPMENT REQUIREMENTS

8.2.1 Support Equipment - Mated Dynamic Tests

The following equipment will be required to conduct mated orbiter/booster dynamic tests:

External electrical power (mated)
External hydraulic power (mated)
Dynamic shakers and mounting stands
External acceleration sensors
Shaker frequency and amplitude control console
Acceleration sensor recording equipment
Flotation gear for booster vehicle mounting
Intercommunications

8.2.2 Support Equipment Static Firing - Flight Readiness

Static Firing - Orbiters

Static firing of the orbiters will require the following support equipment:

Boat-tail fire detection, extinguishing and purge system (H_2O and GN_2)
Hazardous gas detection system
Emergency engine shutdown system
Emergency tank vent system
High response rate acoustic and vibration data-acquisition instrumentation

Static Firing - Boosters

Static firing of the boosters will require the following support equipment:

Boat-tail fire detection, extinguishing, and purge system (H_2O and GN_2)
Hazardous gas detection system
Emergency engine shutdown system
Emergency tank vent system
High response rate acoustic and vibration data-acquisition instrumentation

The support equipment listed above are not new requirements but the same as required for the cluster static firing test program.

8.3 RANGE REQUIREMENTS

Normal range support for hazardous operations will be required.

8.3.1 Range Requirements - Mated Dynamic Tests

No range requirements are anticipated for the mated structural dynamic tests.

8.3.2 Range Requirements - Static Firing

1. Range requirements - orbiters static firing - flight readiness.

   The range requirements, communications and test control station, apply to the orbiters static firing tests.

2. Range requirements - boosters static firing - flight readiness.

   The range requirements, communications and test control station, apply to the boosters static firing tests.

The range requirements listed above are not new requirements but the same as required for the cluster static firing test program.

8.4 DATA REQUIREMENTS

8.4.1 Data Requirements - Mated Dynamic Tests

For the mated dynamic tests, engineering units of data are to be recorded and reduced to define the dynamic characteristics of the mated vehicles through the following:

External

Shaker frequency and amplitude
Accelerometer frequency and amplitude

Onboard development flight instrumentation (DFI)

Accelerometer frequency and amplitude
Stress and strain frequency and load

8.4.2 Data Requirements - Static Firing - Flight Readiness

Static Firing - Orbiters

Data requirements for the orbiter's flight readiness static firing are as follows:

Acoustic and vibration data
Main propulsion subsystem (MPS) engine performance data (DFI)
MPS propellant tankage and feed system performance data (DFI)
Subsystem performance data (DFI)

Static Firing - Boosters

Data requirements for the booster's flight readiness static firing are as follows:

Acoustic and vibration data
MPS engine performance data (DFI)
MPS propellant tankage and feed system performance data (DFI)
Subsystem performance data (DFI)

The data requirements listed above are not new requirements but the same as those required for the booster cluster static firing test program.

9.0 GLOSSARY

The following definitions are applicable to the test plan. They are subject to change with the completion of other acquisition plans.

ABES	Air-breathing-engine subsystem.
acceptance	The act by which the customer approves specific services rendered or acknowledges that certain specific articles or end items are in conformity with the contract and/or with applicable Class I documents.
acceptance tests	Tests to verify that the end-item hardware conforms to the applicable specification for performance as a basis for acceptance. Also, where applicable, tests to confirm that the end-item performance and configuration is equivalent to a previously certified end item.
ACPS	Attitude control propulsion subsystem.
ACT	Acquisition, control, and test.
aerodynamics	The branch of dynamics which treats (1) the motion of air and other gaseous fluids and (2) the forces acting on solids in motion relative to such fluids.
aeronautics	The science and art pertaining to the flight of aircraft.
airfoil	Any surface, such as an airplane wing, aileron, or rudder, designed to obtain reaction from the air through which it moves.

air speed	The speed of an aircraft relative to the air. Its symbol is "V".
alternate landing site	A secondary landing site selected for the orbiter or booster for landing from the atmospheric flight mode when the primary landing site is not available.
angle, critical	An angle of attack at which the flow about an airfoil changes abruptly, with corresponding abrupt changes in the lift and drag.
angle, gliding	The angle between the flight path during a glide and the horizontal axis.
angle, ground	The acute angle between the wing chord and the horizontal when the airplane is resting on level ground in its normal position.
angle of attack	The angle between the reference line in a body and the line of the relative wind direction projected on a plane containing the reference line and parallel to the plane of symmetry. In a wing, this is the angle between the chord of the wing and the relative wind. The symbol is "α".
anthropometric	Ascribing human measurements and movements to nonhuman things on a comparative basis.
ASIL	Avionics Subsystems Integration Laboratory.
APS	Auxiliary propulsion subsystem.
atmosphere, standard	An arbitrary atmosphere used in comparing the performance of aircraft. The standard atmosphere in use in the U. S. at present represents very nearly the average ground conditions at latitude 40 degrees.

breadboard	A subsystem, a functional portion of a subsystem, or substitute hardware assembled schematically correct but not packaged in the final configuration and not necessarily using qualified components. Used during development testing to ascertain the feasibility of a design approach.
certification	The process (analysis, test, checkout, inspection, etc.) by which component, subsystem, or vehicle acceptability for flight or operational use is established.
checkout	A sequence of visual inspection, functional, operational, or calibration tests to determine the condition and status of system equipment or element thereof.
chord	An arbitrary datum line from which the ordinates and angles of an airfoil are measured. It is usually the straight line joining the ends of the meanline.
climb, rate of	See rate of climb.
COFI	Checkout and fault isolation.
combined subsystems tests	Any test that involves the operation and interdependence of two or more subsystems through a common interface (or interfaces).
common data base	A collection of diverse data gathered and stored in a compatible format with a minimum of redundancy and structured in such a manner that permits timely data correlation and retrieval, as required.
common use	The use of an item in, or in conjunction with, multiple program support applications.
commonality	Any item of hardware, materials, software, or any services common to or having equal usage with two or more shuttle system prime elements (i.e., orbiter, booster, payload module, or associated ground systems) that can be developed, procured, or performed in a common manner.
component	Any self-contained part or unit which performs a distinctive function necessary to the operation of a subsystem.

constraint network	See test logic and constraint network.
contract end item (CEI)	A contract end item is defined in the contract and normally is an item which has a functional entity capable of being controlled through a separate part number and serial number.
controllability	The quality of an aircraft that determines the ease of operating its controls and the effectiveness of controls displacement in producing change in flight attitude.
controls	A general term applied to the means provided to enable the pilot to control the speed and direction of flight, attitude, power, etc., of an aircraft.
Criticality I	A measure of the critical nature of a function which, if a failure were to preclude satisfactory performance of that function, the loss of crew members' life and/or loss of vehicle are imminent.
Criticality II	A measure of the critical nature of a function which, if a failure were to preclude satisfactory performance of that function, one or more of the following conditions would occur, depending on the particular time in the mission of the failure: (1) immediate (safe) mission-flight termination, (2) unscheduled termination at the next planned earth landing area, and (3) loss of primary and/or secondary mission objectives.
Criticality III	Other than Criticality I or II.
D&C	Flight crew displays and controls subsystem.
DCM	Data and control management subsystem.

development	The process of advancing from one state or condition to an improved condition and/or the achievement of improved capability as an outgrowth or derivative of a previous capability.
development flight instrumentation (DFI)	Special instrumentation equipment installed in the flight test vehicle(s) during the development phase to collect data necessary to verify design predictions but not required for operational vehicles.
development tests	Tests employed as a part of the development process to determine the feasibility of the design approach, to verify design predictions, to develop test and checkout procedures, to ascertain the responses to stimuli or combination of stimuli that are difficult to predict accurately, and to provide confidence in the ability of the hardware to pass qualification tests, if required.
drag	The component of the total air force on an aircraft or airfoil parallel to the relative wind. Its symbol is "D".
ECLSS	Environmental control and life support subsystem.
elevon	A hinged movable airfoil, usually part of the trailing edge of a wing, which performs the dual function to impress both a rolling and a pitching movement on the aircraft.
end item	A complete functional item of equipment, a separate entity normally capable of being controlled through a separate part number and serial number; prime item.
facility	A permanent or semipermanent functional capability that is built, installed, or established to perform a particular function or to serve a particular purpose.
failure mode and effect analysis (FMEA)	A systematic evaluation of a system or subsystem design, analyzed to the component level, to find the possible modes of failure and determine their effect on the system.

ferry	To fly the orbiter or the booster from one point to another under its own power in an atmospheric, conventional-type-aircraft flight mode.
flap	A hinged or pivoted airfoil forming the rear portion of an airfoil used to vary the effective camber.
flight path	The path of the center of gravity of an aircraft with reference to the earth.
flight test	Testing of a flight vehicle or its subsystems by actual flight such that the parameters under examination are operated, stressed, or exercised in a prescribed manner and under specified flight conditions.
fuselage	The structure of approximately streamline form to which are attached the wings and tail unit of an airplane. In general, it contains the power plant, passengers, cargo, etc.
glide	A descent with reference to the horizontal at a normal angle of attack and without engine power sufficient for level flight in still air.
ground tests	Any tests performed on the ground as opposed to tests performed on a vehicle in free flight. Includes wind tunnel tests, subsystem development and qualification tests, simulation tests, etc.
GN&C	Guidance, navigation, and control
horizontal flight test	Flight tests of the orbiter or booster when flying as a conventional aircraft in the atmospheric flight mode.
horizontal flight-test facility	A facility specifically equipped to support the conventional aircraft atmospheric flight mode of the orbiter and/or booster.
in-process test	A test performed during the fabrication of an end item at various stages in the process of assembly to verify that an item or subsystem, as assembled to that point, functions properly.

integrated systems test	A test of the prime item involving multiple subsystem operations to verify the overall capability of the flight subsystems to meet the mission performance requirements as a total or integrated system and are physically, functionally, and operationally compatible with each other, with required software and with mating ground support functions.
interface simulator	A device used to simulate or substitute for the interface of a system or subsystem when that system or subsystem is not available.
intermediate ferry-landing site	A landing site selected for use by the orbiter and/or booster for reservicing when a ferry mission spans a longer distance than the flight range of the vehicle.
landing area	That portion of the landing site or landing facility specifically reserved for landing the orbiter or booster.
landing site, alternate	See alternate landing site.
landing speed	See speed, landing.
launch complex	A collection of facilities, support equipment, communication equipment, and all related services required at the launch site to perform the countdown and launch of the shuttle vehicle.
LRU	Line replaceable unit.
M&R building	A building at the launch site specifically dedicated to the maintenance and repair of prime items as a part of turnaround operations; maintenance and repair building.
maintainability demonstration	Tests to verify that the maintainability requirements, as established in applicable end item specification, have been achieved.
maintenance area	A specific area set aside for performing maintenance operations on shuttle system equipment.
maneuverability	That quality of an aircraft which determines the rate at which its attitude and direction of flight can be changed.

mating area	A specific area at the launch facility set aside and properly equipped for the operation of mating the orbiter and booster prior to launch.
mission-critical	A function or hardware item, the successful operation of which is essential to the satisfactory execution of the intended mission.
multilateration	See precision ranging.
MPS	Main propulsion subsystem.
OMS	Orbit maneuvering subsystem.
operational facility	A facility devoted to performing all or part of the functions associated with the operational aspects of the shuttle vehicle.
operational turnaround capability	The minimum time required for the orbiter and booster to receive necessary maintenance, repair, and servicing after returning from an orbital mission or launch in order to be ready for commitment to the next orbital mission.
operations plan	Document which describes the requirements and sequence of tasks for operation and maintenance of the shuttle system to ensure capability to perform a variety of orbital missions.
precision ranging	Radio ranging which provides distance (range) and velocity (range rate) of the vehicle with respect to a transponder for rendezvous and multiple transponders for navigation, approach, and landing.
Pogo	An interaction among fuel-pressure pulsations, chamber-pressure fluctuations, engine-thrust variations, vehicle structural deflections, and line/tank volume changes producing a longitudinal oscillatory coupling.
Preferry	Pertaining to those activities necessary to prepare the orbiter and/or booster vehicles for a ferry mission.

prime item	A major element of the shuttle system; i.e., orbiter, booster, payload module or ground systems, as defined in the contract. A prime item will normally have a functional entity capable of being controlled through a separate part number and serial number.
PRSD	Power reactant supply and distribution.
qualification	The determination, performed with appropriate rigor, that an item of hardware meets its specified design and performance requirements throughout the predicted environments or combination of environments with designated margin.
qualification test	A test performed with appropriate rigor on selected hardware of production configuration and manufactured by production processes to verify that the item meets the design and performance requirements while being subjected to the worst-case predicted environment or combination of environments with specified margin as defined in applicable specifications. The tests are conducted as a formal demonstration of design and performance adequacy.
rate of climb	The vertical component of the air speed of an aircraft; i.e., its vertical velocity usually expressed in feet per minute.
reliability test	Any test performed with the primary objective of collecting statistical data necessary to establish the required level of confidence and/or failure rates.
Reynolds number	A nondimensional coefficient used as a measure of the dynamic scale of a flow. Its usual form is the fraction $\frac{\rho V \ell}{\mu}$ in which ρ is the density of the fluid, V is the velocity of the fluid, ℓ is a linear dimension of a body in the fluid, and μ is the coefficient of viscosity of the fluid.

safing area	An area of, or adjacent to, the prime landing site specifically dedicated to and equipped for rendering the orbiter or booster safe (1) for personnel ingress and egress and (2) with respect to the functional integrity of the vehicle after returning from a mission.
scale	The change in any aerodynamic coefficient, such as the drag, due to a change in the value of the Reynolds number.
shuttle system	Reusable prime system elements (orbiter, booster, payload module and ground systems) and related supporting hardware, software, personnel, and consumables which provide a capability for the delivery and/or retrieval of payloads in a variety of earth orbit operations.
software	Punched cards, punched or magnetic tapes, etc., used to control the operation of semiautomatic or automatic devices.
span	The maximum distance, measured parallel to the lateral axis, from tip to tip of an airfoil, of an airplane wing inclusive of ailerons, or of a stabilizer inclusive of elevator. For a wing its symbol is "b".
specification tree	A list of specifications starting with the shuttle system specification and showing all subordinate specifications indentured in such a manner as to show their relationship to each other and to the top-level shuttle system specification.
speed, landing	The minimum speed of an airplane at the instant of contact with the landing area in a normal landing.
speed, minimum flying	The lowest steady speed that can be maintained, with any throttle setting whatsoever, by an airplane in level flight at an altitude above the ground greater than the span of the wings.

stability	That property of a body which causes it, when disturbed from a condition of equilibrium or steady motion, to develop forces or moments which tend to restore the body to its original condition.
stability, directional	Stability with reference to disturbances about the normal axis of an aircraft; i. e., an airplane possesses directional stability in its simplest form if a restoring moment comes into action when it is given a small angle of yaw.
stability, dynamic	That property of an aircraft which causes it, when its state of steady flight is disturbed, to damp the oscillations set up by the restoring forces and moments and gradually return to its original state.
stability, inherent	Stability of an aircraft due solely to the disposition and arrangement of its fixed parts; i. e., that property which causes it, when disturbed, to return to its normal attitude of flight without the use of the controls or the interposition of any mechanical device.
stability, lateral	Stability with reference to disturbances about the longitudinal axis; i. e., disturbances involving rolling or sideslipping. The term lateral stability is sometimes used to involve both directional and lateral stability, since these cannot be entirely separated in flight.
stability, longitudinal	Stability with reference to disturbances in the plane of symmetry; i. e., disturbance causing airplane pitching and variation of the longitudinal and normal velocities.
stability, static	That property of an aircraft which causes it, when its state of steady flight is disturbed, to develop forces and moments tending to restore its original condition.
stall	The condition of an airfoil or airplane in which it is operating at an angle of attack of maximum lift. Beyond the angle the airplane loses the necessary lift for support and control.

subsystem	A major functional part of a Space Shuttle System which is essential to the operational completeness of the system.
support equipment	All equipment required to support the test, operation, and maintenance of the vehicle and all its airborne equipment.
surface, control	A movable airfoil designed to be rotated or otherwise moved by the pilot in order to change the attitude of the aircraft.
system	A composite of equipment, skills, and techniques (including all related facilities, equipment, material, services, and personnel) which are capable of performing a clearly defined function in the accomplishment of an objective within a subsystem.
System	Integrated Space Shuttle System (booster, orbiter, support equipment and software).
test, acceptance	See acceptance test.
test, combined systems	See combined systems test.
test flows	A diagram showing the sequence of tests to be performed on one or more items of hardware.
test, horizontal flight	See horizontal flight test.
test, in-process	See in-process test.
test, integrated systems	See integrated systems test.
test logic	The rationale for performing a series of tests in a particular sequence.
test logic and constraint network	A portrayal of the certification and flight verification requirements showing the sequence of operations and the appropriate rationale for each component/subsystem. The network also depicts the prerequisites and the constraints that require a prescribed level of verification by one

	component/subsystem before being operated with another item or performing more rigorous functional operations.
test plan tree	A list of test plans starting with the shuttle system test plan and showing all subordinate test plans indentured in such a manner as to show their relationship to each other and to the top-level shuttle system test plan.
test, qualification	See qualification test.
test, reliability	See reliability test.
turnaround	Those activities associated with maintenance, reconfiguration, and servicing of an orbiter or booster after performing a mission up to the point of being ready for commitment to the next orbital mission.
wind tunnel	An apparatus producing an artificial wind or air stream, in which objects are placed for investigating the air flow about them and the aerodynamic forces exerted on them.
wing	A general term applied to an airfoil, designed to develop the major part of the lift of a heavier-than-air craft. The wing axis is the locus of the aerodynamic centers of all the wing sections.