

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD A 137118

INTEGRATED TEST PROGRAM MANUAL

NAVSEA OD 42282A
1 OCTOBER 1983

100

SDTIC
ELECTE
JAN 17 1984
E



DEPARTMENT OF THE NAVY
STRATEGIC SYSTEMS PROJECT OFFICE
WASHINGTON, D.C. 20376

IN REPLY REFER TO

NAVSEA OD 42282A

1 OCT 1983

NAVSEA OD 42282A

INTEGRATED TEST PROGRAM MANUAL

1. NAVSEA OD 42282A was prepared to provide Strategic Systems Project Office contractors with program guidance for structuring and administering test programs in accordance with the applicable Integrated Test Program requirements of NAVSEA OD 21549A "Technical Program Management Requirements for Navy Strategic Systems Project Office Acquisitions". Originally published in 1973, NAVSEA OD 42282A has been revised to provide additional material relating to management of integrated test programs, to specifically encompass testing of computer software and technical documentation, and to define and cover post-development program testing phases.
2. It is intended that this manual be reviewed periodically to insure its accuracy and currency. Users of the manual are encouraged to report any errors discovered and any recommendations for improvement to Department of the Navy, Strategic Systems Project Office (Attn: SP-2014), Washington, D.C. 20376.
3. Copies of NAVSEA OD 42282A may be obtained from the Defense Technical Information Center, Cameron Station, Alexandria, Virginia, 22314.

ANDREW DEPRETE
By direction

INTEGRATED TEST PROGRAM MANUAL



prepared for

Department of the Navy
Strategic Systems Project Office

Contract

N00030-81-C-0156

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By _____	
Distribution/ _____	
Availability Codes	
Dist	Avail and/or Special
A-1	

FOREWORD

Use of a system is always accompanied by a risk of failure, which may arise from deficiencies of design, manufacture, materials or other essentials. The underlying purpose of any test is to evaluate that risk in whole or in part, to assess the magnitude and acceptability of the risk by qualitative or quantitative means.

Before and after a Strategic Weapons System is deployed, a great many elements of risk must be evaluated by testing. In total, tests may occupy an appreciable part of the facilities and manpower committed to a procurement program and may account for a substantial part of the program's cost.

The objective of this manual is to provide Strategic Systems Project Office (SSPO) contractors with program guidance for structuring and administering test programs in accordance with the applicable requirements of NAVSEA OD21549A, Technical Program Management Requirements for Navy Strategic Systems Project Office Acquisitions. Where inputs are requirements of NAVSEA OD21549A, they are so indicated.

The techniques of this manual have been applied successfully for many years. In particular, the use of a permanent Integrated Test Program Board as a test program management device has been demonstrated by experience in many programs, experience showing that the collective evaluations, judgments and decisions of an Integrated Test Program Board are likely to be better informed and less subject to bias than those made by individuals. On the other hand, when specific actions are required, it has been found more efficient to assign them to individuals rather than to accomplish them through the agency of a board. Operating policies recommended herein embody this basic policy for using the knowledge and experience of a group.

Procedures given herein are compatible with the analytical approach of NAVSEA OD29304B, Reliability And Availability Evaluation Program Manual. With few exceptions the terminology conventions of that document have also been observed.

This revision of NAVSEA OD42282 has been prepared to provide additional material relating to management of test programs, and to extend the coverage of the 1973 edition to encompass testing of computer software and technical documentation, as well as planning for testing in post-development program phases.

TABLE OF CONTENTS

Foreword	iii
Table of Contents	v
List of Figures	vii
Glossary	viii
List of Acronyms and Abbreviations	xi
Documents Referenced in the Text	xiii

SECTION 1 INTRODUCTION

Introduction	1-1
--------------------	-----

SECTION 2 TEST PROGRAM MANAGEMENT CONCEPTS

2.1 Purpose and Scope	2-1
2.2 Integrated Test Program Concept	2-1
2.3 ITPB Organization and Major Activities	2-5

SECTION 3 PREPARATION FOR TEST PLANNING

3.1 Establishing the ITPB and Operating Policies	3-1
3.2 Test Program Constraints	3-1
3.3 ITPB Pre-Evaluation Planning Activities	3-1
3.4 Procedural Instructions	3-2
3.5 ITPB Operation	3-2
3.5.1 Verification Allocation Matrix	3-3
3.5.2 Master Test Planning Summary Chart	3-3
3.5.3 Master Test Schedule and Test Milestone Chart	3-3
3.5.4 Test Status Log	3-3
3.5.5 Status Reports	3-3
3.5.6 Forward Planning for Testing in Later Program Phases	3-6
3.5.7 Indentured System Breakdown	3-6
3.6 Test Program Phases and Objectives	3-6
3.6.1 Development Phase Tests	3-6
3.6.1.1 Development Tests	3-9
3.6.1.2 Engineering Evaluation Tests	3-9
3.6.1.3 Qualification Testing	3-10
3.6.1.4 Software Validation Testing	3-11
3.6.1.5 Software Acceptance Testing	3-12
3.6.1.6 Demonstration Testing	3-12
3.6.2 Production Phase Tests	3-13
3.6.2.1 Technical Documentation Verification Tests	3-13
3.6.2.2 Lowest-Level Item Tests	3-13
3.6.2.3 Production Acceptance Tests	3-14
3.6.2.4 Production Assessment Tests	3-14
3.6.2.5 Aging Test Program	3-14
3.6.2.6 SPALT Test Requirements	3-14

- 3.6.3 Pre-Deployment Phase Tests 3-15
 - 3.6.3.1 Shipyard Installation or Overhaul Test Program 3-15
 - 3.6.3.2 Demonstration and Shakedown Operation Tests 3-15
- 3.6.4 Deployment Phase Tests 3-16
- 3.6.5 Special Operations Phase Tests 3-17

**SECTION 4
TEST PLANNING BY LINE ORGANIZATIONS**

- 4.1 General Considerations 4-1
- 4.2 Test Documentation 4-1
 - 4.2.1 Documents Used by the ITPB 4-1
 - 4.2.1.1 Test Planning Information Form 4-1
 - 4.2.1.2 Delinquent Test Information Notice 4-4
 - 4.2.1.3 Test Program Change Proposal 4-4
 - 4.2.2 Test Documentation Required By Contract/CDRL 4-4
 - 4.2.2.1 Test Plans 4-4
 - 4.2.2.2 Test Procedures 4-7
 - 4.2.2.3 Test Reports 4-7
- 4.3 Planning Software Tests 4-7
 - 4.3.1 Software Module Test Plans and Procedures 4-7
 - 4.3.2 Software System Test Plans and Procedures 4-10
- 4.4 Planning Reliability Demonstration Tests 4-11
- 4.5 Planning Maintainability Demonstration Tests 4-12
- 4.6 Weapon System Tests 4-16
 - 4.6.1 Weapon System Integrated Test Program 4-16
 - 4.6.2 Planning for Weapon System Integrated Test Program 4-19

LIST OF FIGURES

Figure		Page
2-1	Documents of an Integrated Test Program	2-2
2-2	Typical Content of an Integrated Test Program Plan	2-3
2-3	Principal Integrated Test Program Activities	2-4
3-1	Example of Verification Allocation Matrix with Assignment of Test Numbers ...	3-4
3-2	Master Test Plan Summary Chart	3-5
3-3	Typical Content of ITP Status Report	3-6
3-4	Flow of Tests During an Acquisition Program	3-7/3-8
3-5	Content of a Qualification Program Plan	3-11
3-6	Representative Hierarchal Software Structure	3-12
4-1	Example of a Test Planning Information Form	4-2/4-3
4-2	Example of a Test Program Change Proposal	4-5
4-3	Typical Content of a Test Plan	4-6
4-4	Typical Content of a Test Procedure	4-8
4-5	Typical Content of a Test Report	4-9
4-6	Typical Content of a Periodic Test Summary Report	4-14
4-7	Example of Maintainability Demonstration Maintenance Action Log	4-15
4-8	Typical Content of a Maintainability Test Plan	4-17
4-9	Typical Content of a Maintainability Test Procedure	4-17
4-10	Typical Content of a Maintainability Test Report	4-18

GLOSSARY

BASELINE	A description of requirements or configuration defined by specification, to which subsequent changes are related.
COMPONENT	A combination of parts, devices and structure, usually self-contained, which performs a distinct function (acts on one or more inputs to produce an appropriate output) in the operation of an equipment; for example, a converter, gas generator, amplifier.
DEMONSTRATION	Formal measurement of system characteristics with statistical confidence by testing or operation. Both estimation and hypothesis testing approaches are used.
EQUIPMENT	The first assembly level below a subsystem; for example, a Digital Geoballistic Computer.
ERROR RATE	The average rate at which software errors appear in real-time operation under mission conditions. Analogous to hardware failure rate.
ESTIMATION	The use of testing to form estimates of population parameters and to evaluate the precision of those estimates.
FAILURE	Performance below a specified minimum level or outside a specified tolerance interval.
FAILURE RATE	For devices described by the exponential model, the positive constant λ . It is the reciprocal of mean-time-between failures.
FIRMWARE	Programs residing in PROMs, ROMs, etc.
ITEM	General term denoting physical element of a system (any assembly level).
INTEGRATED TEST PROGRAM	A test program in which each test contributes to the timely, cost-effective achievement and verification of product requirements.
MAINTAINABILITY	A measure of the ability of an item to be maintained. Mean preventive maintenance time and mean repair time are commonly-used indices of maintainability. Maintainability is sometimes defined as the probability of repair within a stated time.

MILESTONE	A planned definitive event during a program; for example, the completion of a major work element.
MODULE, HARDWARE	An onboard-replaceable item; for example, a Type 3 Module.
MODULE, SOFTWARE	A unit of the hierarchical organization of a software program, in which a major program function is accomplished. A module has identifiable boundary statements and can be referenced by name from other parts of the program.
PRIME HARDWARE	Hardware manufactured, inspected, tested and handled in full compliance with all specification requirements and all material and process controls applicable to operational hardware.
RELIABILITY	The probability that an item will perform its intended function without failure for a specified interval under stated conditions, given that it is <i>up</i> (operable) at the beginning of the interval.
RISK, CONSUMER'S	The probability that a test will accept by chance a device or lot having a characteristic equal to a specified unacceptable level. A variety of Type-II error.
RISK, PRODUCER'S	The probability that a test will reject by chance a device or lot having a characteristic equal to a specified desired level. A variety of Type-I error.
SCREENING	Tests or inspections applied to 100% of product to precipitate latent defects or to improve the average reliability of outgoing products.
SOFTWARE	Computer programs and data.
SUBCONTRACTOR	A supplier or vendor to a contractor.
SUBSYSTEM	The first indenture level below a system. For example, the Navigation Subsystem or Fire Control Subsystem of the Strategic Weapon System.
SYSTEM	A collection of functionally related items, which together perform one more useful functions; for example, the Strategic Weapon System.
TEST	A procedure for evaluating one or more of the attributes or variables of an item. A test frequently involves operating the device, and usually involves deliberate application of stress, either externally

TEST (Continued)	(e.g., environmental stress) or internally (e.g., self-induced stress). The term test may also include passive examinations or inspections of an item as applicable.
TESTS, ACCEPTANCE	Tests performed to determine the acceptability of outgoing product. Normally applied to 100% of product, but sometimes performed on lot sampling basis when tests are destructive.
TESTS, AGING	Tests performed to detect and track progressive irreversible changes brought about by a.
TESTS, DEVELOPMENT	Tests performed on preliminary or prototype hardware to determine design and performance parameters.
TESTS, ENGINEERING EVALUATION	Functional environmental tests performed to evaluate characteristics of product design and to determine compliance with performance and environmental requirements.
TESTS, QUALIFICATION	Tests performed to demonstrate that prime hardware meets design specification requirements including mission environments.
TESTS, QUALITY ASSURANCE	Tests conducted to verify conformance to quality requirements and to determine acceptability of product.
TESTS, REQUALIFICATION	Tests performed to retain or regain qualified status of a product after any of the following: a) change in hardware design, b) change in source, c) change in manufacturing processes or plant location, d) production interruption for a length of time such that continued validity of previous qualification becomes suspect, e) disqualification of a product, f) major changes in test equipment or test procedures, g) major changes in tooling, dies or fixtures.
TESTS, VALIDATION	Tests performed to assess software compliance with design requirements. Validation tests include module tests, module integration tests and system level tests.
TESTS, VULNERABILITY	Tests designed to demonstrate performance capability after exposure to radiation environments.
VARIABLE	A characteristic or property that is appraised in terms of scalar values.

ACRONYMS AND ABBREVIATIONS

CDRL	Contract Data Requirements List
CPCI	Computer Program Configuration Item
DASO	Demonstration And Shakedown Operation
EET	Engineering Evaluation Tests
FBM	Fleet Ballistic Missile
FMECA	Failure Mode, Effects And Criticality Analysis
FOT	Follow-On Operational Test
GFM	Government Furnished Material
IDS	Integrated Data System
ITP	Integrated Test Program
ITPB	Integrated Test Program Board
ITPP	Integrated Test Program Plan
JCS	Joint Chiefs of Staff
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
OT	Operational Test
PAT	Production Assessment Tests
PROM	Programmable Read-Only Memory
QPP	Qualification Program Plan
RF	Radio Frequency
RM&Q	Reliability, Maintainability And Quality
RMS	Root Mean Square
ROM	Read-Only Memory
SIOP	Single Integrated Operations Plan

SITP	Shipyards Installation Test Program
SOTP	Shipyards Overhaul Test Program
SPALT	Strategic System Projects Alterations
SSPO	Strategic Systems Project Office
SWS	Strategic Weapon System
TVA	Temporary Variance Authorization
WSRT	Weapon System Readiness Test

DOCUMENTS REFERENCED IN THE TEXT

	<i>Referenced Herein In Section</i>
1. NAVSEA OD 21549A, Technical Program Management Requirements For Navy Strategic Systems Project Office Acquisitions.	1., 2.1, 3.5, 3.6, 4.2
2. NAVSEA OD 29304B, Reliability And Availability Evaluation Program Manual.	3.4, 3.6, 4.3, 4.4, 4.5
3. SSPINST P4720.1, SPALT Policies And Procedures For Alteration of FBM Weapon System Equipment.	3.6.2.6
4. SSPINST 4130.7, Configuration Control Of FBM/SWS Computer Program Configuration Items.	3.6.2.6
5. MIL-STD-471A, Military Standard, Maintainability Verification/Demonstration/Evaluation.	3.6, 4.5
6. MIL-STD-781C, Military Standard, Reliability Design Qualification and Production Acceptance Tests: Exponential Distribution.	4.5

Section 1 INTRODUCTION

When the requirements for an overall Strategic Weapon System (SWS) and for the constituent subsystems and equipments have been established, it is essential that every effort be directed at meeting those requirements. NAVSEA OD21549A, Technical Program Management Requirements For Navy Strategic Systems Project Office Acquisitions, requires contractors to establish and maintain an Integrated Test Program (ITP), to assure that system design meets requirements (i.e., adequate design capabilities and design margins).

An ITP should feature planning and management of test activities during system acquisition and later program phases, so that *required system performance confidence* is obtained within schedule and at minimum cost in program resources. Careful planning and day-to-day management is needed, if testing is to be coordinated smoothly with other program activities to permit critical program milestones to be met.

This is particularly true because testing cannot be scheduled rigidly. Flexibility is necessary in the management of a test program because the progress of testing depends on design and development delays, occurrence of failures, facility limitations, and other constraints.

An important element of an integrated test program is coordination with an Integrated Data System (IDS). Data reporting, analysis requirements and formats should be reflected in the Integrated Test Program Plan (ITPP), and in individual test plans, procedures and reports.

The tests required to assure performance of a SWS are complex and extensive. Management concepts are described in this manual for use during the development and produc-

tion, and for planning the pre-deployment, deployment and special operations phases of a program. Three facets of the overall test management task are discussed in this manual—1) management and control, 2) test planning, and 3) test integration.

The contractor is responsible for assuring that all contract requirements are met or exceeded. If any requirements are not met, the contractor is responsible for obtaining contract relief. Pursuant to this objective, the program manager is responsible for the overall management of the test program. His responsibilities include test program direction, changes, policy and budget authorizations, and establishing an ITP approach to meet the *requirements of NAVSEA OD21549A*. This document utilizes the Integrated Test Program Board (ITPB) concept to handle the day-to-day administration of the test program, but the contractor may use a different organizational technique, if desired, to accomplish the planning and control functions this document assigns to the ITPB.

The ITPB is established to provide centralized planning and administration of test programs and to promote optimum use of test resources. It provides a forum for assembling and evaluating test program objectives, plans and problems, for resolving conflicts and inconsistencies in schedules and priorities, for evaluating and reporting progress, and for realigning the tests as program changes occur. The ITPB is responsible for assuring that the tests, as performed, enable continuing evaluation of performance and quality, as well as supporting corrective action decisions and other decisions as necessary.

Responsibility for planning specific tests, performing them and analyzing the resulting data is assigned to various line organizations—

typically design, test, and product assurance engineering. These organizations submit planning information (Figure 4-1) to the ITPB, where it is reviewed, coordinated and approved. Approved plans are summarized in an ITPP.

The test planning function encompasses test integration across the range of program phases in which the contractor has test responsibilities. Integrated test planning consists of two basic tasks, selection of tests for which the need is greatest and assurance that the tests are performed in a way that maximizes the information obtained in return for the resources invested, so that contractual requirements are achieved.

Planning is performed iteratively and is refined periodically to accommodate necessary changes after the program is set in motion. Testing progress is evaluated continuously under the administrative direction of

the ITPB, which issues periodic status reports to the program manager.

This document covers development, production, pre-deployment, deployment and special operations test planning. A discussion of software testing in the development phase is provided to emphasize the emergence of software as a major element of systems and as a major source of test program problems, such as schedule slippages and test cost overruns. This document also places special emphasis on reliability and maintainability evaluation and testing. Although reliability and maintainability are performance characteristics, they are afforded special consideration herein, because of the emphasis placed on them in NAVSEA OD21549A.

In this document the term *item* is used to represent any SWS hardware or software element that has performance, design and testing requirements, regardless of assembly level.

Section 2 TEST PROGRAM MANAGEMENT CONCEPTS

2.1 PURPOSE AND SCOPE

NAVSEA OD21549A requires that the contractor establish and maintain an integrated test program at the outset of the development phase. In the development phase the program should cover development tests, engineering evaluation tests, qualification tests, software tests, reliability and maintainability demonstrations, as well as planning for production tests and inspections, pre-deployment and special operations phase tests to the extent of the contractor's responsibilities in those later program phases. Figure 2-1 lists test documents required by NAVSEA OD21549A, with the sections of this document in which they are discussed.

This document describes the integrated test program concept and practices which can be used in the development phase to meet the applicable requirements of NAVSEA OD21549A. It also addresses testing in post-development program phases. Planning, monitoring administration and reporting functions necessary to implement an integrated test program are presented as guidance to aid contractors in planning and executing technically valid cost-effective test programs. This document does not establish contractual requirements. The methods discussed herein are structured to allow continuing visibility of testing activities and program status to contractor management and the Strategic Systems Project Office (SSPO). Contractors should tailor their integrated test programs and supporting activities as appropriate to the needs of their particular programs.

One of the first contractor activities after a contract is finalized is development of an Integrated Test Program Plan. Test program planners should be careful not to change the

scope of contractually specified testing, but to provide specific program definition and details of test design, objectives and procedures consistent with contract requirements. The term *test program* as used herein means all such tests considered collectively.

Preliminary planning for testing during the later program phases of production, pre-deployment, deployment and special operations (e.g., aging and surveillance tests, DASO) for which the contractor may be responsible, should be accomplished during the development phase, and the ITPP should be revised to include any tests planned for execution by the contractor during those later phases.

Figure 2-2 lists typical contents of an ITPP.

2.2 INTEGRATED TEST PROGRAM CONCEPT

In an integrated test program all of the tests contribute without void or unnecessary overlap to the achievement and verification of item requirements within general program goals of schedule and minimum cost. A positive management system is needed to eliminate duplicate tests, make maximum use of test information and assure that relevant resources are used effectively.

The integrated program concept embodies:

- An overall test program philosophy.
- Clear assignment of responsibilities to participating groups.
- Identification of all design requirements, and the sources of those requirements, that require testing to assure compliance with contractual requirements.
- Verification of each such requirement by specific tests.
- Coordinated test program scheduling.
- Decisions on the methods and rationale

Documents Defined By NAVSEA OD21549A	Discussed Herein In Section
Integrated Test Program Plan	2.2
Integrated Test Program Status Reports	3.5.5
Qualification Program Plan	3.6.1.3
Qualification Test Plans	3.6.1.3, 4.2.2.1
Qualification Test Procedures	3.6.1.3, 4.2.2.2
Qualification Test Reports	3.6.1.3, 4.2.2.3
Software Acceptance Test Plans	3.6.1.5, 4.3
Software Acceptance Test Procedures	3.6.1.5, 4.3
Software Acceptance Test Reports	3.6.1.5, 4.3
Software Validation Test Plans	3.6.1.4, 4.3
Software Validation Test Procedures	3.6.1.4, 4.3
Software Validation Test Reports	3.6.1.4, 4.2.2.3
Engineering Evaluation Test Plans	3.6.1.2, 4.2.2.1
Engineering Evaluation Test Procedures	3.6.1.2, 4.2.2.2
Engineering Evaluation Test Reports	3.6.1.2, 4.2.2.3
Reliability Demonstration Test Plan	3.6.1.6, 4.4
Reliability Demonstration Test Procedure	3.6.1.6, 4.4
Reliability Demonstration Report	3.6.1.6, 4.4
Maintainability Demonstration Test Plan	3.6.1.6, 4.5
Maintainability Demonstration Test Procedure	3.6.1.6, 4.5
Maintainability Demonstration Report	3.6.1.6, 4.5
Development Test Procedures*	3.6.1.1, 4.2.2.2
Development Test Reports*	3.6.1.1, 4.2.2.2

*For tests intended to evaluate or verify design capability.

Figure 2-1. Documents Of An Integrated Test Program

TYPICAL CONTENTS OF AN INTEGRATED TEST PROGRAM PLAN	
*1.	Description of the organization and management of the Integrated Test Program.
*2.	Summary of planned tests, including type of test and test objectives.
3.	Samples of standardized data collection forms to be used.
*4.	Identification of tests from which reliability and maintainability assessment data will be obtained.
*5.	Schedules for tests, relating test program milestones to major program milestones.
*6.	Schedules for special test facilities/equipment, test items and test documentation.
7.	Government Furnished Material requirements and impact.
8.	Identification of any approved deviations from contractual requirements.
9.	Identification of applicable operating policies and procedures.

*Required by NAVSEA OD21549A

Figure 2-2. Typical Content Of An Integrated Test Program Plan

that will be used to analyze test data, before beginning the test.

- Standardized data collection forms and methods.
- Regular reporting of test status and results.

The benefits of an integrated test program include:

- A common point of high visibility from which the test program can be managed.
- A test requirements baseline for each functional test used to verify or demonstrate the design.
- Complete uniform collection, analysis and reporting of test data from contractor and sub-tier supplier test sites.
- A master checklist by which the program manager can monitor and evaluate contractual performance.
- Establishment of production, pre-deployment, deployment and special operations phase test requirements at the earliest feasible times.
- Inputs from testing to logistic analysis and evaluation of maintainability, reliability and testability.

Figure 2-3 shows the principal ITP activities and precedence relationships among them. The principal output of the test planning function is the ITPP, prepared in cooperation with the responsible line organizations, whose representatives on the ITPB assure free flow of information among responsible groups. The results of development phase tests contribute to planning for production, pre-deployment, deployment and special operations phase tests. The ITPP evolves throughout the program until it describes tests planned for these later program phases.

The ITPB serves as the overall administrator of the integrated test program. The board monitors and guides test-related activities and the use of test resources throughout the program. In performing this function centrally, the ITPB provides a forum for assembling and evaluating test program objectives, plans, problems, and data, for resolving conflicts among schedules, priorities and interpretations of data, and for documenting and reporting test program progress.

The ITPB should include a representative from each unit having significant test program responsibilities in the contractor's organization. The board begins its work by developing guidelines and instructions, coordinating, reviewing and approving documents that define test requirements, plans, procedures, schedules and costs. Later, the board integrates and optimizes the total test program, monitors performance of the tests and aids in solving a variety of day-to-day operating problems.

Pass/fail criteria are developed prior to initiation of the test. As tests are completed, the ITPB reviews the resulting data (sometimes in reduced form), decides whether the tested item has passed or failed and, in the latter event, specifies the nature and extent of corrective action or retesting necessary before approval can be given. Review of test results is a particularly important function of the board in qualification and requalification tests of hardware and in validation and acceptance tests of software, where the collective experience and judgment of the ITPB members are applied to support important, often difficult, decisions of approval or rejection and retest.

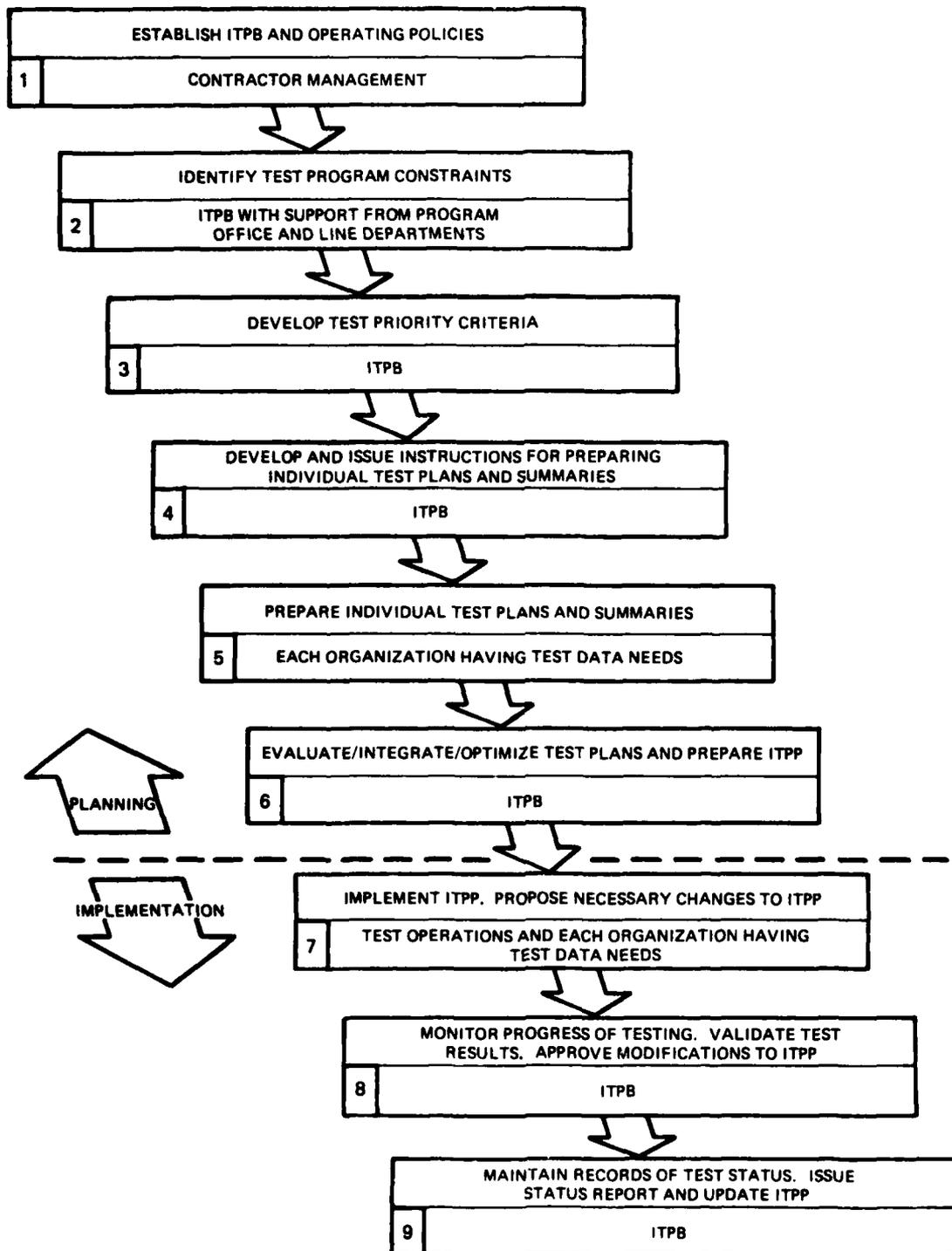


Figure 2-3. Principal Integrated Test Program Activities

Finally, the board maintains essential test-related records and at intervals provides reports of the status of the program to contractor management and operating groups. In discharging these responsibilities during the development phase, the board helps to generate information necessary for planning tests to be conducted later in production and later program phases; for example, the optimum frequency of production assessment tests, baseline parameter statistics against which aging test results will be measured, and telemetry data necessary to evaluate system performance.

When carried out effectively, the ITP concept confers a variety of advantages over decentralized methods of test program management. It helps assure that necessary tests are accomplished and unnecessary tests avoided. Optimum use is made of facilities and other test resources, resulting in reduced program costs. Communication is enhanced by having responsible operating groups participate in the planning and decision processes by means of the ITPB. Data of high quality are acquired, leading to easier and more accurate data analysis, increased confidence in the results of the test program and in the capabilities of the developed product.

2.3 ITPB ORGANIZATION AND MAJOR ACTIVITIES

The ITPB, as established by program management, should include a chairman and supporting staff, permanent members and, as necessary, special members and procuring activity representatives.

The major activities of the ITPB include:

- Initiate analysis of test program requirements and constraints.
- Evaluate program alternatives.
- Issue instructions, forms, procedures and schedules to govern preparation of individual test plans, and the implementation and reporting of the programs.
- Standardize collection of test data.
- Monitor test planning by line groups and resolve questions.
- Assure traceability of test requirements.
- Develop methods for assigning priorities to planned tests.

- Evaluate planned tests and test-defining documents for compliance with program requirements.

- Evaluate test equipment and facilities and recommend optimal approach to resources, schedules and requirements.

- Prepare Integrated Test Program Plan, together with required supporting data.

- Review test data as they are evolved, and monitor the maintenance and storage of test data.

- Verify compliance with test requirements and validate test results for hardware and software testing.

- Administer changes to the ITPP within applicable program constraints and authority delegated by the program manager.

- Issue periodic program status reports and program plan revisions.

The chairman's responsibilities include:

- Preside at meetings and issue minutes.

- Obtain and document board concurrence on all test program direction and subsequent changes.

- Attempt to resolve differences among board members and, where differences cannot be resolved, present alternatives and recommendations to the program manager.

- Issue test program status reports to the program manager.

- Sign all documents requiring ITPB approval or concurrence.

Because of the multiple interfaces and activities of a test program, the ITPB should include permanent members who represent the principal line organizations such as design, system, test, and product assurance. These board members act as liaisons between the test program and their respective organizations.

The permanent members' responsibilities include:

- Integrate test program activities within line groups and act as group representatives on the board.

- Evaluate planned tests for suitability as sources of design, quality, reliability, maintainability and accuracy data.

- Provide alternative solutions to test program problems and conflicts.

- Secure engineering analyses of failures during tests.

In general, permanent members should be senior technical personnel, knowledgeable of performance and test requirements, and able to trade off competing solutions to test problems.

Special representatives to the board serve as limited members on an as-needed basis. Special members may include representatives from various technologies, test laboratories, source inspectors, suppliers or other specialist groups. Special members' responsibilities are to provide expert opinion and advice to the board.

Establishing and managing an ITPB can be more complicated when the contractor is a system design agency, and all or part of the development engineering work is to be done by subcontractors. In these cases the contractor should consider requiring that major subcontractors establish in-house test program boards, so that day-to-day administrative decisions affecting the test program can be made at the lowest appropriate level of responsibility. Alternatively, if subcontractors have limited design responsibility, it may be preferable to have the subcontractors represented on the system design agency's ITPB.

Section 3 PREPARATION FOR TEST PLANNING

3.1 ESTABLISHING THE ITPB AND OPERATING POLICIES

The program manager, in agreement with company line organization, decides early in the program what management tools will be used to assure that the ITP is effectively planned and implemented. The ITPB should be defined in a company procedure, program bulletin or comparable document which outlines the board's operating methods and the responsibilities of the chairman and permanent members. This document should also reflect the policy of the company toward the integrated test program and the use of the ITPB to implement that policy. The policy should establish the authority of the ITPB for planning and implementation to assure an effective ITP.

3.2 TEST PROGRAM CONSTRAINTS

Initial constraints may be imposed on the test program by the contract, by contractor management, or by circumstances. Contractual constraints may include tests that are mandatory under the contract, specified test sample sizes, specified test durations, as well as constraints on performance, cost and schedule. Management constraints might include the level of producer's risk acceptable in the program, the extent of the development effort to be undertaken, and additional restrictions on test costs and schedules. Information on circumstantial constraints, such as limitations on the capacities or capabilities of particular test facilities, is normally supplied by the cognizant line organizations; it is for this reason that effective information exchange between line organizations and the ITPB is of paramount importance throughout the planning process.

Constraints such as those cited above must be identified and documented, because they define the bounds within which the planning process must operate to develop an optimum test program. The test program is then defined by means of analysis and planned choices among discretionary factors.

3.3 ITPB PRE-EVALUATION PLANNING ACTIVITIES

Before requesting individual test plans from line organizations, the ITPB must be prepared to evaluate those plans. In order to evaluate proposed tests, particularly those having verification as a major objective, the board must have available a complete description of the capabilities required of the product, since it is those capabilities that must be verified.

The general nature and scope of test programs must be structured from the beginning to meet the objectives of the various contract phases beginning with development. In development, the ITPB monitors the test and analysis effort to see that all requirements (usually paragraph 3) of the development specification have been verified. This is important as a contractual obligation, and because production tests (to be described in the Production Test And Inspection Plan), will be based upon parameters verified in the development program.

Because some requirements may quite possibly be verifiable by means other than tests (i.e., analysis, simulation, pre-existing data), the overall requirements should be identified by a systematic examination of all applicable verification methods. In particular, the board should evaluate the ability of tests at various assembly levels to provide meaningful verification data. Here the ITPB looks for the most effective test program to verify that

the development specification is met and that production testing will not degrade the developed item.

The ITPB review should confirm the traceability of requirements and assure that the planned test program is not unbalanced, verifying some parameters too often and others not at all or less often than necessary. This activity should be accomplished by the ITPB in direct discussions with the program manager and responsible line managers. Out of this activity the board should develop and document specific policy recommendations to promote uniformity in detailed test planning by line groups. For example, policy statements or recommendations are desirable in answer to test-planning questions such as the following:

- When can engineering analysis or previous data be used in lieu of tests?
- What are the preferable types of test for achieving a given test objective (e.g., if the test objective is to identify failure modes, what types of tests are preferred)?
- What criteria should be used in selecting hardware levels for testing (e.g., at what assembly level will a given type of test be most effective, least costly)?
- What approach should be followed in planning environmental tests? Is the use environment to be simulated exactly? Should overstress testing be used and when? Should environmental stresses be applied sequentially or simultaneously and, if sequentially, in what order? Should the use of outside test facilities be considered?
- What policies are appropriate for planning hazardous types of tests? Tests to failure? Reliability demonstration tests? Maintainability demonstration tests? Accuracy tests?
- What should be the extent of and approach to tests that are destructive, of long duration, or very costly?
- When should multiple-purpose tests be considered (e.g., use of qualification test data for reliability or assessment of accuracy)?
- Can reliability and maintainability demonstrations be completed during development or must they be partially deferred to production?
- Are data system enhancements needed to support the planned test program?

3.4 PROCEDURAL INSTRUCTIONS

The ITPB should issue policies and procedural instructions as necessary to facilitate adequate responses by line organizations in the form of individual test plans. Planners should be apprised of the degree of detail appropriate to various types of test plans. Ideally, the board should furnish sample test plan contents such as those shown in Figures 4-3 and 4-8.

The board should confirm the existence of uniform test data collection procedures that satisfy all data needs of the contractor and SSPO. NAVSEA OD 29304B provides guidelines in these areas. The defining documents should be identified and included by reference in individual test plans. If it is deemed desirable to relax data collection procedures for development tests, minimum data requirements for those tests should be defined.

The board should describe its intended operating policies, procedures and requirements for implementing the test program. It should inform line organizations of test-defining documents the board must review and approve, criteria for deviations, and rules of test program operation, including the latitude of discretionary authority that will be granted to test directors at various sites. The board should define the standards it will apply to evaluate the validity of tests and the effectiveness of corrective actions following test failures.

Guidance for budgetary planning, supporting estimated costs, preparing schedules and establishing program milestones should also be issued, and the board should schedule the initial submission of individual test plans by line organizations.

3.5 ITPB OPERATION

The ITPB's ability to operate depends on a continuous flow of information. For maximum efficiency of operation, the ITPB should have means of standardizing and utilizing the large amount of information a weapon system program can generate. The following are general examples of documents the ITPB can use for these purposes:

- Verification Allocation Matrix
- Master Test Planning Summary Chart
- Master Test Schedule
- Test Milestone Chart
- Test Status Log
- Integrated Test Program Status Report
- Test Planning Information Form
- Test Program Change Proposal

In addition to the information contained in the documents noted above, the ITPB reviews the individual item Test Plans and Test Procedures. With this complete package the ITPB can evaluate the necessity and sufficiency of the proposed tests, to structure a balanced and efficient program and to define the scope of tests needed in production and later program phases.

3.5.1 Verification Allocation Matrix

An initial step in setting-up an integrated test program is to evaluate the item performance requirements. Each performance requirement, as delineated in the overall item specification or sub-tier specification, should be analyzed to determine the best method of verification and the test phase in which verification must be accomplished. Figure 3-1 provides an example of a verification allocation matrix. The board reviews the matrix for completeness, makes or requests corrections and assigns a test number to each test. For complex programs a sequential test numbering system can be established with an identifiable code for each area of design.

The ITPB should review all matrices to detect overlaps, voids and redundancies and to make initial program decisions to combine, add or eliminate tests. Later, as information is received from design and test groups, the program will be reviewed and redirected as necessary. When the initial matrices have been evaluated, the board can initiate its status information system.

3.5.2 Master Test Planning Summary Chart

The Master Test Planning Summary Chart (Figure 3-2) is a key element in detecting test program voids, overlaps and redundancies. Column 1 of the chart can be annotated with the test numbers assigned to the tests on the

verification allocation matrix. The information to be completed on the Master Test Plan Summary Chart is self explanatory and is extracted from test planning information forms discussed in Section 4.

3.5.3 Master Test Schedule And Test Milestone Chart

The Master Test Schedule provides a chronological listing of all planned test dates referenced to the Work Breakdown Structure (WBS) or drawing tree. The ITPB staff can utilize the schedule to monitor test progress and assure that all planned tests are performed. Appropriate annotations are made on the schedule to indicate test completion, deferral, rescheduling, success or failure. The schedule should be capable of highlighting test item problems and test program problems.

The Test Milestone Chart is a pictorial representation of the test program which indicates the interrelationships of all tests. The chart should include all the ITP tests and be based upon program or contract milestones. The primary purpose of the milestone chart is to be able to assess the dependencies of the test program when test slippage and test facility downtimes occur and tests must be rescheduled, or when tests must be added. Once the milestone chart has been drawn, necessary adjustments can be done by attaching overlays to the original chart.

3.5.4 Test Status Log

The ITPB chairman should maintain a current overall Test Status Log. Normally, the ITPB staff provides the chairman with daily information on in-process testing, test progress, failures, test facility problems, etc. to maintain the currency of the log.

3.5.5 Status Reports

The ITPB provides status reports on a periodic basis, usually quarterly, to formally apprise the program manager of test status. These reports form the basis for Integrated Test Program Status Reports which are submitted to SSPO. Figure 3-3 shows the content

VERIFICATION ALLOCATION MATRIX

Test Item Number 123456789
 Test Item Name Black Box

REQUIREMENT		VERIFICATION METHOD				VERIFICATION ALLOCATION				
ITEM SPECIFICATION PARAGRAPH	SUBJECT/ PARAMETER	INSP- TION	ANALYSIS	TEST & DATA REVIEW	ENGINEERING EVALUATION	QUAL TEST	MODULE TEST	ACCEP- TANCE TEST	ETC...	TEST PROCEDURE NO., REMARKS, ETC.
3.3.1.1.1.2	Size Constraints	X			X (E-1)			X (A-1)		
3.3.2	Signal Conversion			X	X (E-2)					
3.4.1.3	Computer Interface		X				X (M-1)			
3.4.1.3.2.3	Output Line Drivers			X						
3.4.2.1	Automatic Search			X						
3.4.3.2.8	Controls & Indicators	X		X	X (E-3)	X (Q-1)		X (A-2)		
3.5	Reliability			X						
3.6.3	Power Consumption		X	X		X (Q-2)				
3.6.4	Internal Temp. Rise		X	X	X (E-4)					

Figure 3-1. Example of Verification Allocation Matrix with Assignment of Test Numbers

MASTER TEST PLAN SUMMARY CHART

1 Line No.	TEST ITEM			SOURCE DOCUMENTS				TEST DESCRIPTION						TEST SCH.				
	2 Dwg. No.	3 Nomenclature	4 Qty	TEST ROMNTS		TEST ALTERNATIVES		10 Cat	11 Name	12 Objects	13 Applied Environ	14 M Data	15 Rel Data	16 Accur Data	17 Priority Data	18 Facil. Used	19 Month Start	20 Month Finish
				6 Perf.	7 Environ	8 Previous Data	9 Analysis											

COLUMN

ENTRY

1. Assign consecutive identification number
2. Tested item drawing number
3. Tested item name
4. Number of items to be tested
5. Origin of tested items (model shop, vendor, etc.)
6. Cite document(s) defining performance requirements
7. Cite document(s) defining environmental requirement(s)
8. Cite document(s) containing previous data usable in lieu of testing
9. Cite document(s) containing analyses usable in lieu of testing
10. Test category (development, qualification, etc.)
11. Title of test (e.g., calibration accuracy and stability test)
12. Concise statement of test objectives
13. Identify applied environment, if any, by reference to spec. paragraph
14. Test valid source of maintainability data (yes, no)
15. Test valid source of reliability data (yes, no). If yes, number of equivalent missions
16. Test valid source of accuracy data (yes, no)
17. Originating organization's assessment of relative priority based on program need
18. Identify facility to be used for test
19. Month and year test scheduled to start
20. Month and year test scheduled to be completed
21. Cost of tested hardware
22. Capital cost of new facilities needed
23. Operating cost of facility for test
24. Cost of instruments, fixtures, procedures and instructions
25. Labor cost to perform test
26. Total cost of test

TEST COST SUMMARY

1 Line No.	TEST COSTS					
	21 Hdw.	22 Invest		24 Fixtures Instrum.	25 Labor	26 Total Cost
		Oper	Software			

Figure 3-2. Master Test Plan Summary Chart

of a status report, with the required content of the NAVSEA OD21549A Integrated Test Program Status Report indicated.

3.5.6 Forward Planning For Testing In Later Program Phases

One of the duties of the ITPB in the development phase is to provide forward planning for testing that will be required in production and later program phases. Proper planning during the development phase will provide a smooth transition to later testing (predeployment, deployment, etc.). The board should identify tests required in production, together with all pertinent information developed in the ITP, such as test parameters, test results, test data and test procedures, which can be used to plan production phase tests. Later, as the program progresses, the ITPB will identify updated ITP information that can be used to support planning for post-production tests.

3.5.7 Indentured System Breakdown

To assure that all items to be tested are accounted for in the integrated test program, the ITPB needs a complete listing of system items. The listing should be by part number, assembly number or software module and higher assembly numbers, so that the ITPB can compare the listing against the Master Test Planning Summary Chart. The board should be on distribution for all subsequent updates of the breakdown, which should also identify design engineers responsible for each item.

3.6 TEST PROGRAM PHASES AND OBJECTIVES

An SSPO system undergoes several categories of tests during phases of its life cycle. Development phase tests support design release, evaluate the limits of system performance, and the adequacy of system design and associated production processes. Tests in the production phase insure that production disciplines are maintained and that RM&Q are not degraded during production. Pre-deployment tests determine the readiness of the complete weapon system for operational deployment. Tests in the deployment phases

CONTENT OF ITP STATUS REPORT

- *1. Description of significant problems, if any, remedial actions taken and schedules for accomplishing planned action.
- *2. Test schedules with current updates.
- *3. Listing of all planned tests completed during the reporting period, with indication of whether test objectives were met.
- *4. A description and status of all failures that occurred during the reporting period.
- *5. Status of open failures and description of corrective actions taken on failures closed during the reporting period.
6. Status of planned capital test facility/equipment procurement.
7. Status of test facility uptime.
8. Status of testing at remote and outside facilities.
9. Status of GFM.

*Required by NAVSEA OD21549A for the Integrated Test Program Status Report.

Figure 3-3. Typical Content Of ITP Status Report

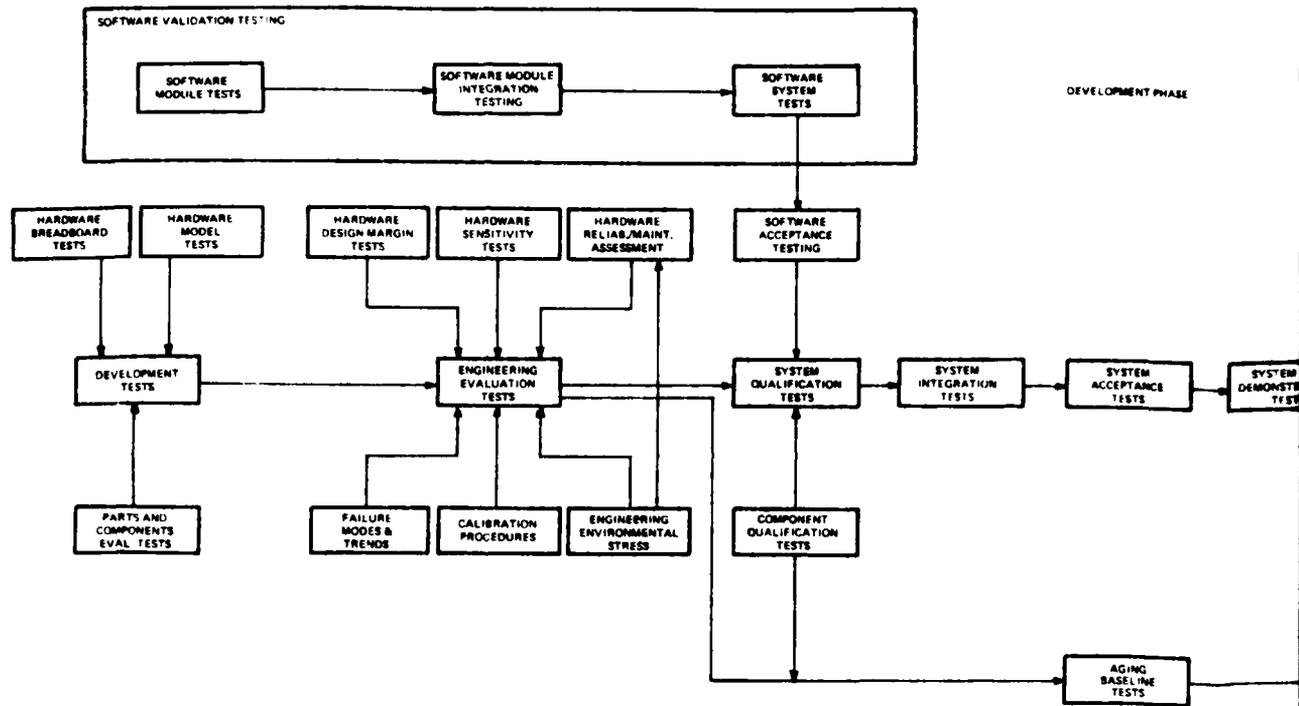
verify weapon system performance under mission conditions, and assess RM&Q during operational life.

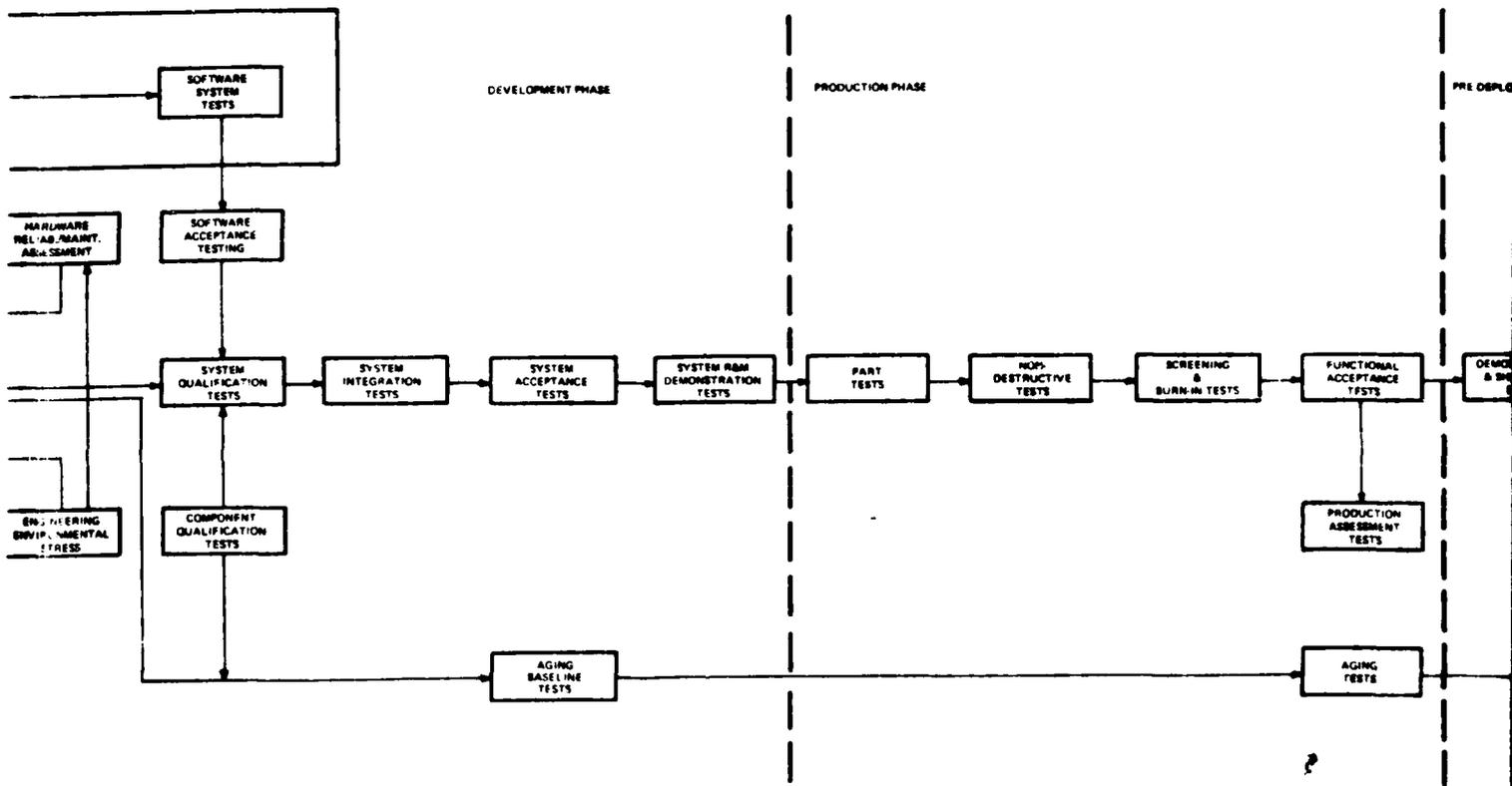
In order to assure uniform terminology for classifying proposed tests, the contractor should standardize the test nomenclature to be used in each program phase. The contractor is encouraged to use his own terminology to identify tests, but these tests should include the general test categories of NAVSEA OD21549A, such as development, qualification, software validation, demonstration, and production assessment tests. Figure 3-4 shows the general flow of testing activities through an acquisition program.

3.6.1 Development Phase Tests

The development phase test program consists of development, engineering evaluation, qualification and/or requalification, software validation and acceptance testing. (Development tests within this section refer to a specific class of tests, not the entire development phase test program).

In general, later categories of tests are more formal than earlier categories. Development tests may be conducted on pre-prototype equipment, such as breadboard circuits or models, or on parts not yet committed for use





2

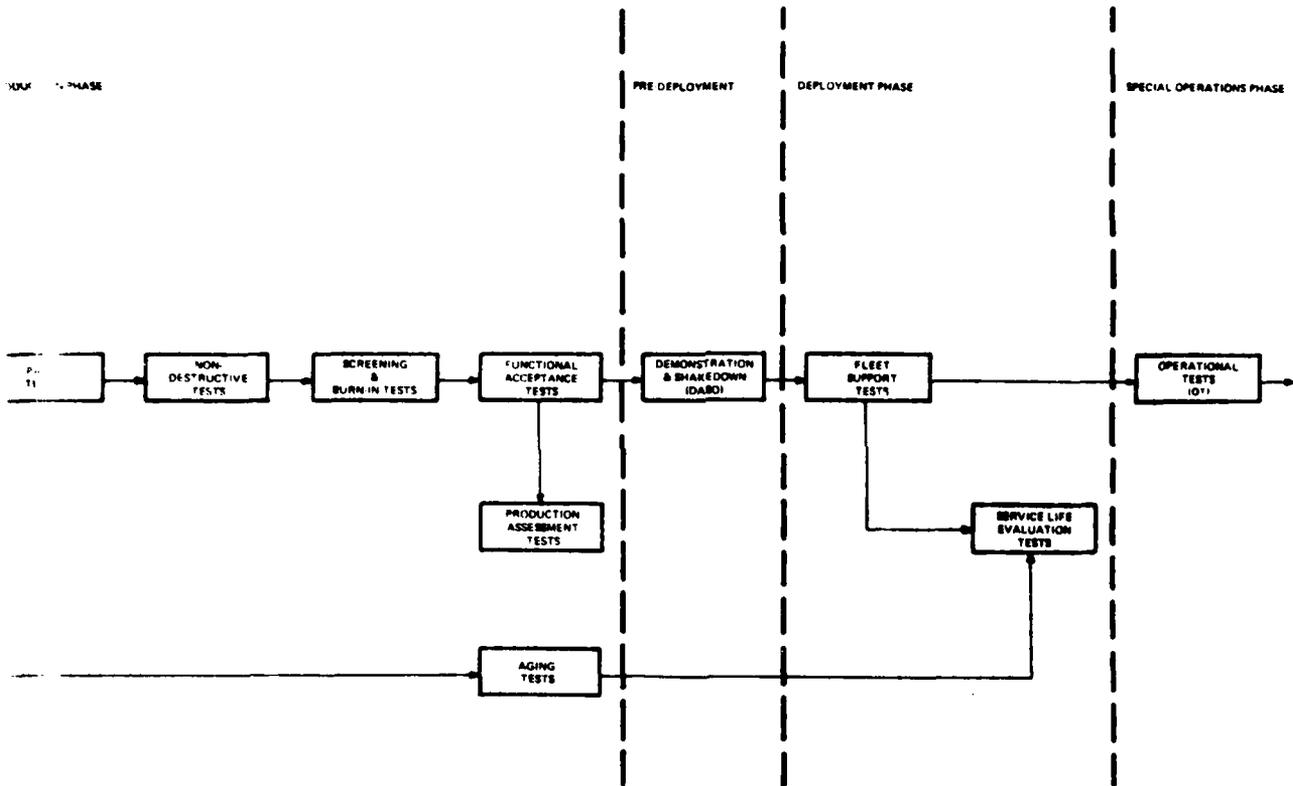


Figure 3-4. Flow of Tests During an Acquisition Program

3

in the system. Development tests may also be applied in areas of design requiring special evaluation. (One objective of Failure Mode, Effects and Criticality Analysis is to identify such areas). Engineering evaluation tests are generally conducted on prototype and pre-production equipment. Qualification tests are conducted on prime hardware, but may be conducted on pre-production hardware conforming to the tactical design and manufactured under all applicable production methods and controls.

While NAVSEA OD21549A generally addresses tactical equipment and tactical support equipment, the contractor may want to consider including in the ITP support items, such as data reduction software and simulation equipments, that are being developed.

3.6.1.1 Development Tests

Development tests are investigatory and are intended to develop concepts, select design solutions, assess the capabilities of vendors, select candidate materials and establish or verify design parameters and specification requirements. Data from development tests are evaluated, to determine whether an acceptable design solution has been reached. Thus, development tests are part of the design activity. They are performed on models, breadboard circuits, parts, components or other elements of the total product.

Development tests differ from tests intended for performance verification in several important ways. Generally, development tests are relatively unstructured and unconstrained by the contract. This is a consequence of the exploratory element common to such tests. Usually, there is a proper emphasis on flexible and informal procedures planned, implemented and evaluated by highly trained engineering personnel.

The principal questions that confront the ITPB when it evaluates development tests typically concern the need for the proposed tests rather than details of their performance. Therefore, it is important that a development test plan answer the question of need. It should cover the intended use of the information to be gained from the tests. And it should assure effective feedback of the information to engineering tasks such as the setting of specification limits. If reasonable alternatives

to the proposed approach exist, or if it is possible to combine the proposed tests with others, those options should be evaluated for cost and effectiveness. In instances when development tests are to be utilized to evaluate or verify design capability, the ITPB should require more formal controls and documentation.

3.6.1.2 Engineering Evaluation Tests

Engineering Evaluation Tests (EET) provide data necessary to verify that the design solutions selected during development can meet specified functional and environmental requirements when the item is fabricated under normal manufacturing processes and controls. They are performed at the highest assembly levels practicable, on prototype and pre-production items representing intended production as closely as possible. EETs are used to assess the degree to which the item meets design intentions, to determine the effects of varying stress levels or combinations and sequences of environments, and to identify failure modes and trends. Data from engineering evaluation and similar verification tests are used to make the milestone decisions that the capabilities of items tested have been successfully verified and that their designs are acceptable for production release. An aging test program (see Section 3.6.2.5) may be begun as part of engineering evaluation, to evaluate the effects of selected long-term environments.

Engineering evaluation tests must be planned in greater detail than development tests. Questions facing the ITPB in its reviewing capacity concern both the need for and implementation of the proposed tests. A variety of questions regarding implementation are of particular interest in EETs and should be answered fully by the plans and procedures submitted to the ITPB: Is the test hardware as nearly prime as practicable? How significant are the remaining differences? Can the tests be conducted at a higher assembly level without excessive loss of sensitivity? Do the planned environmental stress profiles and sequences relate meaningfully to mission requirements? Will the item be operated during or after environmental exposure and will the test exercise the item fully?

EETs may provide data for assessing the accuracy of a tested item (i.e., its contribution to equipment, subsystem and weapon system error). When accuracy is to be evaluated, the ITPB should verify that engineering evaluation test plans define the data necessary to solve the mathematical model that is to be used to estimate error statistics, and that the tests are structured to obtain the data.

EETs may also provide data for the assessment of reliability and maintainability. When utilizing this data for assessment, the validity of the data should be evaluated by the reliability and maintainability line organizations, in accordance with criteria given in NAVSEA OD29304B. Test planners should be conscious of the opportunities presented by EET for extending knowledge of the hardware by applying stress levels that exceed design requirements, while at the same time confirming the item's suitability for program use.

An environmental design requirement may be specified as the maximum mission environment plus a specified margin. Often, however, specifications must be issued before a proper margin has been defined. Environmental extended-limit tests may be performed during development on items for which the weapon specification does not include appropriate design margins. The tests are conducted at levels that exceed the mission environment. The levels are usually increased progressively until failure occurs, in order to determine the limits of the design. However, data from over-stress tests (non-mission environments or extended stress environments) should not be used for reliability measurement.

Definitions of failure may demand special attention when planning EETs. Sometimes the limits of satisfactory component performance in a system are unknown or difficult to determine, or the specified limits may reflect accepted standards of manufacturing quality rather than actual needs of the system (e.g., the common practice of specifying insulation resistance in the megohm region), or the item under test may have been manufactured by other than usual production techniques. Therefore, in determining whether or not a failure in EET is relevant, it may be

meaningful to consider not only the cause of the failure, but also whether the observed anomaly would constitute a failure of the item if it were to occur in service.

3.6.1.3 Qualification Testing

Qualification tests are conducted to demonstrate the ability of prime hardware to meet all specified functional, environmental, and related requirements. Qualification tests are performed on prime items manufactured in conformity with all production processes and quality controls. They usually include performance under simulated mission environments and use conditions, as identified in the item specification. They are formal tests and must be completely documented. Access to qualification test areas should be controlled to the extent necessary to assure proper execution and integrity of the tests. The ITPB should closely monitor the progress of qualification tests. Data from these tests are used to substantiate compliance with specifications before first delivery, so that changes can be made if necessary without adversely affecting production flow. The ITPB should assure that if an item cannot pass qualification, failure analysis and corrective action are initiated immediately. Qualification data may also provide estimates of baseline parameter distributions, which can be compared to future aging test data for use in detecting age degradation.

NAVSEA OD21549A requires the contractor to develop a Qualification Program Plan (QPP), which defines the program that is established and maintained to assure the capability of items to meet specification requirements. Figure 3-5 lists the content of a QPP.

The ITPB should assure that qualification test plans prepared by line organizations reflect compliance with the contract requirements and the approved QPP. The ITPB should have approval authority over qualification test plans. The ITPB should evaluate any proposed modifications or deviations from specified requirements, whether delineated in the plans or separately proposed, prior to submittal to the procuring activity for approval. The ITPB may recommend that certain qualification tests be omitted, if it

believes an item does not require testing based on the item meeting the "qualification by similarity" criteria of NAVSEA OD21549A. The ITPB should exercise caution when recommending an item for deletion from qualification testing, due to the possible cost and schedule impact of having to restore to the program an item which is later found not to meet the similarity criteria. The ITPB should also be alert to the possibility that a previously qualified item may require requalification in accordance with the criteria in NAVSEA OD21549A as, for example, when the item is to be acquired from a second source. When requalification is required, the ITPB should alert the cognizant line organization to begin the process of defining and scheduling the tests.

The ITPB should review qualification test procedures, comparing them with specifications and contractual requirements documents for consistency; any discrepancies should be resolved with the line organization and test facilities personnel. Upon approval, the ITPB chairman should sign or initial the approval sheets of the procedures.

Qualification test reports should also be reviewed by the ITPB to assure that the tests have been conducted in complete compliance with the approved procedures.

3.6.1.4 Software Validation Testing

Software Validation Testing consists of module, module integration and software system tests, to assess the degree to which software modules and systems meet design requirements.

A module is a functional unit of software, generally between 100 and 200 executable statements. Software tests are performed on successively larger units of software, (i.e., modules, combinations of two modules, combinations of these two modules with a third module, etc.) leading ultimately to testing of the complete software system.

There are several approaches to sequencing the testing and merging of modules into larger entities (Figure 3-6). Three of the most successful approaches are designated as Bottom-Up, Top-Down and Modified Top-Down.

In the Bottom-Up approach the program is merged and tested from the bottom to the

CONTENT OF A QUALIFICATION PROGRAM PLAN

1. Describe the organization and management of the qualification program (e.g., applicable policy statements, management directive, etc.).
2. Describe the criteria used to establish qualification test requirements, test locations and criteria for deciding when an item has been successfully qualified.
3. Describe the qualification status of items including: reference documentation and qualification methods for items that require initial qualification, items considered qualified by virtue of previous qualification, including justification; and reasons and extent of required testing for items not considered qualified.
4. Include schedules for preparing qualification test plans and procedures for each hardware item.
5. Delineate the criteria and method for revising and resubmitting the QPP to SSPO.
6. Delineate the criteria and methods to be followed in making decisions concerning the need for requalification.

Figure 3-5. Content Of A Qualification Program Plan

top. The lowest level modules of the software hierarchy are tested and merged with the next higher level. This process is repeated until the top level is reached. Since Bottom-Up testing is initiated at the lower levels of the program, it requires module drivers. A module driver is a method of feeding test case inputs to the interface of the module under test. Bottom-Up testing is most useful when the modules at the bottom of the hierarchy are critically important, as in many real-time systems.

The Top-Down approach to software design and testing is initiated at the highest hierarchical level of the program and proceeds to the lowest level. The components of each hierarchical level are merged and tested with the components of the next lower level. Only the top level of the program is tested in isolation. The Top-Down approach requires the use of stubs, since the module under test may need to pass information to a lower hierarchical level not present in the test configuration. In general, stubs can be less complex than drivers.

In the modified Top-Down testing method, each module to be incorporated into the hierarchy is tested in isolation prior to its integration into the Top-Down testing scheme. This

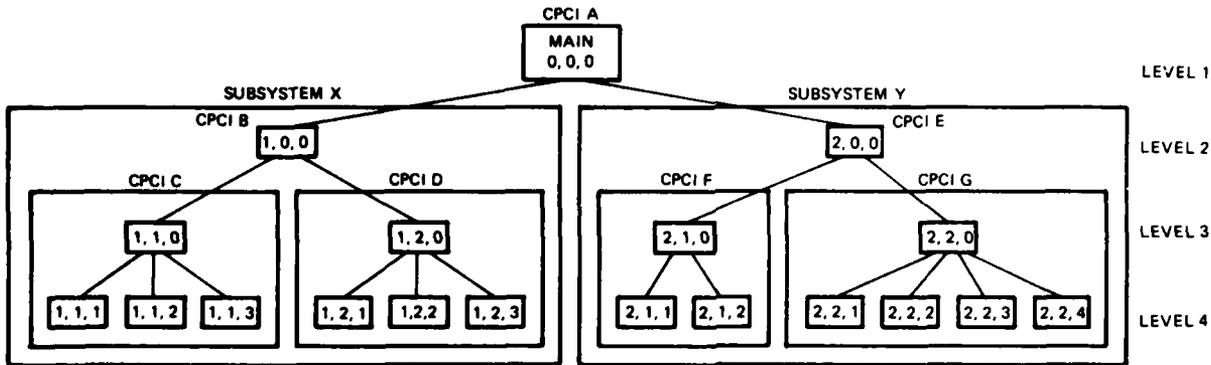


Figure 3-6. Representative Hierarchical Software Structure

method requires module drivers and stubs for each module.

Software validation tests are generally divided into three types: functional, stress and fault tests. Functional tests are performed to assure that modules satisfy performance requirements, that interfaces between modules are error-free, and that the software system performs all its functions. Stress testing is used to test the modules and system by imposing stresses (e.g., illegal inputs, data rates at or exceeding the design limits) to test the reaction of the software. Fault testing assures that self-checking, correcting, performance monitoring and diagnostic design requirements are satisfied. These tests assure that hardware-to-software, software-to-hardware and software-to-software interfaces are compatible. As in hardware testing, use of an independent test team can improve the effectiveness of software validation tests.

Firmware is software residing in (burned into) programmable-read-only memories (PROMs), read-only memories (ROMs), etc. Software developed for delivery as firmware should be tested prior to burn-in of PROMs. This testing is no different from other software validation testing. After burn-in, a verification test should be performed to verify that the burn-in has been done correctly. As a minimum, program listings derived from the burned-in PROMs should be compared with the pre-burn-in listings.

3.6.1.5 Software Acceptance Testing

Software acceptance testing consists of tests at the highest level of integration practicable, consistent with contract and delivery definitions, to demonstrate that design specifications have been met. These tests are performed utilizing intended system hardware and support software (compilers, assemblers, etc.) under actual operating conditions. "Intended system hardware" and "actual operating conditions", as defined by the SSPO subsystem concept, should, as a minimum, be accomplished within the subsystem; however, testing between subsystems should be as defined in the contract. Again, these tests are generally divided into three areas: functional, stress and fault. Acceptance tests demonstrate all man-machine interfaces and verify that documentation is satisfactory. Test effectiveness may be improved by using an independent test team to perform the acceptance tests. Software acceptance tests are also run in later program phases, whenever software modifications are made.

3.6.1.6 Demonstration Testing

Demonstration testing as defined in NAVSEA OD21549A pertains to reliability and maintainability. These tests are formal tests and are performed as required by con-

tract. The purpose of demonstration is to provide evidence that the item meets contractually specified reliability and maintainability. Demonstration should be performed at the highest assembly level practicable and utilizing items that represent the production configuration. Considerations for planning reliability and maintainability demonstrations are presented in Section 4. Guidance for planning reliability and maintainability demonstration tests can be found in NAVSEA OD 29304B and MIL-STD-471A, respectively.

3.6.2 Production Phase Tests

Test programs during production are performed under controlled production conditions on a continuing basis. They are intended to assure quality by verifying the acceptability of delivered hardware, therefore they are conducted on prime hardware suitable for service use. Data from production tests are used to confirm that the items being produced continue to conform to the standards established by the design disclosure documentation. Inherent in the production test planning process is the need for a smooth transition from development to production.

3.6.2.1 Technical Documentation Verification Tests

Testing to verify operational technical documents, including manuals and procedures for installation, operation, diagnosis and maintenance, which are delivered under contract, should be covered by the integrated test program plan. The responsible line organizations should plan in-process reviews of such documents during their production, to detect editorial or technical problems or deficiencies, and to verify corrective actions. Readability reviews are conducted on completed documents. Procedures presented in the documents are tested under operational conditions, to demonstrate their accuracy, completeness and adequacy.

3.6.2.2 Lowest-Level Item Tests

Production testing of items at the lowest indenture level includes both acceptance and assessment tests. These items are functionally tested with environmental conditions applied, to verify acceptability of functional performance. The tests are also designed to detect subtle construction, manufacturing and process changes. Where functional tests are destructive to an item, such as propulsion or pyrotechnic items, a combination of non-destructive testing and functional testing should be performed.

Acceptance tests usually take place at the source and are run by the supplier. Assessment tests are performed by the contractor to verify the supplier's data, by repeating measurements on the same sample of items, supplemented by data from additional items accepted by receiving inspection based on incoming acceptance tests.

A small number of item samples, as determined by shipping lot size or number of sublots, is subjected to visual and physical analysis to detect construction, workmanship, material or process changes that might degrade part quality or reliability. Physical analysis should include dissection and inspection by scanning electron microscope.

Non-destructive tests are quality tests that apply a variety of chemical, magnetic, sonic, radiographic and other evaluation techniques to the selected items to detect degradation, while maintaining the performance integrity of the items. Non-destructive testing is usually performed on 100 percent of items, where functional testing would be destructive. Functional testing of such items is done on a sampling basis. Environmental conditions include temperature, vibration, shock, humidity, electromagnetic, etc., which establish the suitability of the item for use. Vulnerability (nuclear) testing in reactors and surface effects environments are performed on selected items (such as semiconductors), based on mission analysis, to assure that the items meet degraded characteristics requirements.

3.6.2.3 Production Acceptance Tests

Production acceptance tests are performed on end items, including spares, and on lower level items intended for use in end items, to verify compliance to specification requirements and to weed out latent defects. Acceptance tests should reflect performance requirements and tolerance limits defined during development phase testing. These tests should be under conditions that simulate end use of the item to the highest degree practicable.

Production acceptance tests are applied to 100 percent of production items which can be tested non-destructively; most screening and burn-in tests fall into this category. Where test changes are needed or tests need to be developed, the tests should be designed based on the criticality of the item and to assure that the impact of undetected faults is acceptably small. As a minimum, the test should expose faults that could materially reduce mission capability. Beyond that, it may be necessary to test for less severe faults when warranted by their cumulative effect on system readiness and logistic cost. The extent of tests to reduce less severe faults should be a trade-off against incentives, or the cost of testing against the cost and manpower required to correct failures later in service. The planning process for these tests utilizes the information and results of the development phase integrated test program.

3.6.2.4 Production Assessment Tests

Production Assessment Tests (PAT) assess the ability of production controls to preclude problems having potential impact on the quality, safety and reliability of hardware delivered to the fleet. Periodic tests and inspections are conducted on random samples of selected functional and structural items that have already passed acceptance requirements. The nature of the tests, number of test samples selected for each assessment, and frequency of the tests should be in accordance with approved plans compatible with the complexity of the production process and its controls. Production assessment tests apply

a range of functional and environmental tests (some at degrading levels) to random samples of production items. If an item is produced on more than one production line, or procured from more than one source, sample selection should include all lines and sources. Typically, the tests are run on a lot basis, or quarterly when production is continuous and not readily divided into lots. PAT tests are similar to those used originally to qualify the design and manufacturing process.

3.6.2.5 Aging Test Program

An aging test program is a surveillance program which evaluates the effects of selected long term (real time) environmental stresses on items in use or storage. An aging test program, if initiated early in the development program, can indicate parameter degradation rates prior to system deployment. Aging tests are intended to make visible any degradation due to service environments, handling and repeated operation. An aging test program plan should include the approaches, practices and technology used to identify failure modes, detect item degradation modes and measure rates of degradation. The selection of items for the aging tests should be based on established criteria: e.g., item criticality, known storage, handling or operational limitations, unknown long term performance (stability) of an item, and intended operation, storage or handling in uncontrolled or undesirable environments.

The Service Life Evaluation Test Program is a form of aging test program; it is a coordinated hardware fleet return program, to provide early detection of item deterioration.

3.6.2.6 SPALT Test Requirements

The Strategic System Projects Alteration (SPALT) Program governs the necessary tasks for configuration control and status accounting of configuration changes to SWS hardware and software. The SPALT program is a controlled system requiring testing of configuration changes; it is defined by and required to be in accordance with SSPINST P4720.1 and SSPINST 4130.7.

3.6.3 Pre-Deployment Phase Tests

Test programs during the pre-deployment phase provide an assessment of the Strategic Weapon System as it is installed in the submarine.

3.6.3.1 Shipyard Installation Or Overhaul Test Program

As the SWS is installed aboard each submarine during new construction, conversion or overhaul, the SWS undergoes pre-deployment testing in accordance with the Shipyard Installation Test Program (SITP) or Shipyard Overhaul Test Program (SOTP). The objective of these tests is to demonstrate weapon system operability and performance, in as nearly a tactical closed-loop configuration as possible, at dockside and at sea. This program tests the SWS, including ship support systems, with the aid of an Active Inert Missile. The responsibilities of all activities concerned with SITP/SOTP, as well as the specific test requirements, are delineated in an Integrated Test Program Outline.

SITP/SOTP is divided into six phases; inspection, static, grooming, subsystem operation, system interface and system operation tests. Inspection includes visual checks of all subsystems for damage, arrangement, orientation, clearances, accessibilities, installation in accordance with applicable drawings, and tests of cable continuity. Trident Measurement Program tests, to verify that critical coordinated features/parameters (e.g., access door alignment, support group height) have been fulfilled, are also included. Static tests are integrity tests for submarine electrical power supplies and piping systems; they include energizing electrical power supply circuits to check for isolation to ground, proper voltage, frequency and phase rotation, and piping systems to check for strength. Grooming tests insure satisfactory operation of all equipment and circuits within a subsystem, including controls, displays, sequencing, alarms and instrumentation. Subsystem operation tests demonstrate that the subsystems perform within specified tolerances in normal casualty and test modes. System interface tests demonstrate that proper mechanical,

electrical, fluid and optical interconnection and transmission exists between subsystems. System operation tests demonstrate system operability and performance.

3.6.3.2 Demonstration And Shakedown Operation Tests

Demonstration and Shakedown Operation (DASO) Tests, consisting of test missile launches, are intended to demonstrate the readiness of the complete weapon system for deployment. They evaluate the complete weapon system, including crew performance, all system interfaces, shore-based support capability and missile accuracy and reliability under operational conditions. DASO tests are performed after initial installation of the strategic weapon system in a newly constructed submarine and after each submarine overhaul cycle or conversion, to verify readiness of production systems and crews.

DASO is the earliest of the fleet test programs employed by SSPO to evaluate the SWS in service. DASO tests provide baseline performance data in operational environments. They also provide crew training and aid the development and evaluation of tactical operating procedures and related documentation. They serve to certify both the weapon system and crews for deployment.

DASO demonstrates the safety and serviceability of the weapon system, tests the adequacy of modifications and improvements, and enables crews to determine and demonstrate weapon system performance in new missions or new modes of operation. DASO operations furnish preliminary missile flight reliability and accuracy data to support recommendations for Single Integrated Operations Plan (SIOP) planning factors. DASO tests are specially instrumented and monitored and are designed to be as nearly representative of tactical situations as possible.

DASO (TRIDENT II) consists of seven phases of test operations:

- 1) Loadout loading and alignment, missile acceptance tests and inspections.
- 2) Navigation Operations (NAVOPS) testing and calibration of the navigation subsystem.
- 3) In-tube Conversion (ITC) convert to test-missile configuration.

4) Preparation and Readiness Evaluations (PREPs) – installation, checkout and acceptance tests of instrumentation.

5) Tactical Exercise demonstrate: (a) readiness of equipment, crew and documentation, (b) interface and performance capability, (c) countdown procedures.

6) Launcher Operations – test firings with impact location.

7) Post-DASO Operations – restore SWS to tactical configuration.

The navigation subsystem is evaluated during DASO relative to routine upkeep and patrol operations. This includes the crew's ability to conduct standard monitoring and calibration, and the subsystem's ability to support tactical mission accuracy and reliability objectives. Estimates are made of navigation functional errors and uncertainties at launch, and the adequacy and accuracy of applicable documentation is evaluated.

The fire control subsystem is self-tested using the keyboard and test operating panel. The subsystem's contribution to dynamic errors (position, velocity, heading) are estimated, as is the reliability of the subsystem and its constituent equipments.

A variety of missile evaluations are made, including guidance alignment and readiness tests. Performance of the guidance servo-loop, attitude and acceleration control, computer, instrumentation and other guidance components is measured.

Overall functional performance of the missile and guidance subsystems in flight is determined by missile, submarine and support ship instrumentation, and by range instrumentation, which continuously measures and records missile performance and down-range, cross-range and height-of-burst miss distances.

The launcher subsystem is evaluated for performance of missile gas system, ejection, in-tube and underwater flight, closure detonation and event timing. The ship's hovering and compensation functions are also evaluated.

Sonar evaluation, communications readiness exercises and special tests for hardware proofing and other purposes may also be conducted in conjunction with DASO operations.

All hardware and software failures, repair actions, and anomalous conditions are tabulated during DASO. Statistical measures of reliability, accuracy and performance are

calculated for comparison with expected performance. Design defects or deficiencies, performance abnormalities, documentation deficiencies and similar problems are identified and corrective action recommendations are made. SPALTS/TVAs are evaluated to verify that they have no adverse effects on performance.

Upon SSPO direction, contractor personnel may be requested to participate in DASO tests, to provide information concerning operation and status of equipment furnished by their company, and advice and support on problems that may arise during DASO.

3.6.4 Deployment Phase Tests

Fleet test programs during the deployment phase provide a continuing assessment of the functional status of items in the logistic flow and on station, and the effects of long term operational environments on items at various logistic locations.

These tests support the fleet inventory and deployment program. They include field testing of production items in the logistic flow. The tests range from comprehensive system tests at shore-based facilities to limited system tests aboard submarines. Their primary objective is to assure satisfactory functioning of tactical systems throughout the operational cycle. Tests are conducted at maintenance levels 1, 2, and 3.

Level 1 tests (Patrol Tests) conducted aboard the submarine verify operational readiness of the system. Level 2 tests (Recertification Tests), at the refit facility and at the tender, assure continued operational readiness of the complete weapon system. These tests, conducted during selected refit periods, are similar to Level 1 tests. A capability exists on tenders to perform package surveillance, prior-to-issue tests and package failure verifications. Level 3 tests conducted at shore-based facilities include non-destructive testing of ordnance and propulsion items. They validate and certify factory produced items for deployment and inventory.

Tests are conducted at all three maintenance levels with support equipment that has been certified for use in the production test program. Deployment phase tests are conducted by government and contractor person-

nel. Testing criteria and techniques are based on information developed by the integrated test program during development and production phases. Test results are transmitted to the contractor for use in tracking product quality trends.

Tests during patrols include routine maintenance, operability and checkout tests and Weapon System Readiness Tests (WSRT). Data from patrol tests are integrated with DASO and Operational Test/Follow-On Operational Test (OT/FOT) data to assess the accuracy and reliability of the deployed fleet. After the patrol, the SSBN crew prepares a data package, which includes handwritten logs, Fire Control and Navigation hardcopy printouts, failure and problem reports, data and performance tapes (audio and digital). All equipment downtimes and repair times during patrol are recorded, system and subsystem readiness indices are calculated. "Quick look" evaluations are prepared for each subsystem.

Patrol testing analysis has several objectives:

- 1) To provide information based on performance of the SWS under actual patrol conditions, to derive SIOP planning factors.
- 2) To provide operational commanders with evaluations of individual SSBNs and classes of SSBNs on patrol.
- 3) To provide crews with analyses of their ship's performance, to enable them to improve operating and maintenance procedures and to compare their ship's performance with others of the same class.
- 4) To provide the subsystem branches at SSPO with analyses of the performance of their subsystems and constituent equipments in the tactical environment.
- 5) To supplement crew reports relative to equipment problem areas.

Reports and other source data from patrol performance analyses may be made available to contractors for independent evaluation of their equipment.

3.6.5 Special Operations Phase Tests

Periodically, submarines are ordered off patrol to perform an Operational Test (OT) or Follow-On Operational Test (FOT).

Operational tests and, at reduced frequency, Follow-On Tests are performed to:

- 1) Obtain reliability, performance, and accuracy data and SIOP planning factors for the weapon system and its constituent subsystems under representative tactical conditions.
- 2) Verify that reliability, performance, accuracy and planning factors do not significantly degrade during the life of the weapon system.
- 3) Determine the adequacy of tactical software, procedures and technical support documentation.

Operational tests involve launches of test missiles into areas monitored by reentry impact location systems. The tests are conducted in as operationally realistic a manner as possible, with nontactical operations held to a minimum. Testing is structured to span the range of mission variables (e.g., range, loft angle, reentry velocity). Unplanned deviations are evaluated on a case by case basis, so that statistical "outliers" can be treated properly. For example, data from tests representing unreliable performance or other deviations from normal performance is usually excluded from accuracy calculations. The effects of system modifications are evaluated, and estimates of the weapon system's performance factors and reliability are adjusted accordingly.

The accuracy with which the reentry body is delivered to the target area is evaluated. Accuracy data are used to establish sufficient impact and burst-height error statistics to make valid estimates of accuracy under expected tactical conditions, and to determine, to the extent permitted by available instrumentation, error sources within the system on a subsystem and flight phase basis.

Operational tests (OT) are used to establish performance factors based on a statistically significant sample of representative tactical missiles for use by the Joint Chiefs of Staff (JCS) in the SIOP. Follow-on operational tests (FOT) are conducted to verify that system performance has not changed with service life.

Section 4

TEST PLANNING BY LINE ORGANIZATIONS

This section sets forth guidance for line organizations to support an Integrated Test Program. Techniques, considerations and precautions that should be utilized or observed when planning tests are presented and discussed.

4.1 GENERAL CONSIDERATIONS

The requirements, guidelines and instructions discussed previously to manage and control the test program must be made available to affected line groups. Training sessions should be held to familiarize line personnel with the intent, structure and operation of the ITP. Attention should be directed toward defining the types of tests as cited in Section 3, completing information forms, preparing test plans, procedures and reports, maintaining the integrity of the tests, identifying test requirements, consolidating tests where possible, and using standardized data recording forms.

4.2 TEST DOCUMENTATION

Test documents, such as information forms, plans and procedures, are the means for formally disseminating test needs, and for planning, performing and reporting tests. These documents fall into two categories: test documents used as tools by the ITPB and documents required by contract.

4.2.1 Documents Used By The ITPB

To plan and administer an integrated test program, the ITPB requires test information to be supplied by the line organizations. The timeliness of that information is extremely important. The following paragraphs discuss

documents line organizations can provide to aid the ITPB and the operation of the ITP.

4.2.1.1 Test Planning Information Form

Test planning information is completed and submitted to the ITPB, via the test facilities manager, as soon as possible after the need for a test has been identified. Figure 4-1 is an example of an information form. It includes areas for evaluation by the test facilities manager and the ITPB. Areas of concern or disagreement should be resolved as soon as possible. Among information items that should be provided are:

Independent Test Facilities – Independent test facilities provide alternatives or supplements to in-house testing; they may provide certain advantages over in-house facilities:

- a. Relief of high demand on in-house facilities.
- b. Experienced testing personnel having technical expertise that may not be available in-house.
- c. Existing test plans and procedures that may be reused or modified.
- d. High-cost sophisticated test systems, which can reduce test labor and automate production of required verification documentation.
- e. Greater flexibility in implementing an ITP, by contractors with limited testing capabilities.

In analyzing the need for and constraints on the use of independent test facilities, the ITPB should evaluate the capability and reputation of the facility proposed. Areas of concern are schedule availability, logistic complexities and costs, required on-site test surveillance by witnessing personnel, metrology capabilities, expertise in the area of the

FROM: Item Designer
 TO: ITPB
 VIA: Test Facilities Manager

TEST PLANNING INFORMATION FORM

Item No. _____ Form No. _____ Rev: _____ Date _____

Item Name _____ Length of Test _____

No. of Items Required Per Supplier _____ No. of Suppliers _____ Total Cost of Test _____

- Item on hand at present time.
- Item on order, expected receipt date _____
- Item produced in-house, expected receipt date _____

Location of Test Facility

- In-house _____ Source _____
- Independent Facility _____ Availability Date _____ Contracted? Yes No

Test Number _____ Test Type _____

Test Name _____

Test is for corrective action verification? Yes No

Test Objective _____

Test is Non-destructive Destructive Ability of design to pass test. Low Medium High

Environmental Requirements	ITPB Evaluation			
	Satisfactory?		Status	Remarks
	Yes	No		
<input type="checkbox"/> Humidity _____				
<input type="checkbox"/> Shock _____				
<input type="checkbox"/> Acceleration _____				
<input type="checkbox"/> Vibration _____				
<input type="checkbox"/> Temperature _____				
<input type="checkbox"/> Altitude _____				
<input type="checkbox"/> User (For Software) _____				
<input type="checkbox"/> Other _____				

Test Plan Available: Preliminary _____ Date _____ Final _____ Date _____

Test Procedure Available: Preliminary _____ Date _____ Final _____ Date _____

Pre-test conditioning required? No Yes Describe: _____

GFM Required? No Yes Requested? Yes No Date needed? _____

GFM Description _____

GFM Present Action _____

Can obtain Reliability Evaluation Data from test? Yes No If No, what test changes are necessary to obtain Reliability Data? _____

Can obtain Maintainability Evaluation Data from test? Yes No If No, what test changes are necessary to obtain Maintainability Data? _____

Can obtain Accuracy Data from tests? Yes No If No, what test changes are necessary to obtain Accuracy Data? _____

Can data for the evaluation of the maintenance package be obtained from test? Yes No If No, what changes are necessary to obtain data? _____

Disposition of test items at completion of test? _____

Figure 4-1. Example Of A Test Planning Information Form

Traceability of Test Requirement			
Test Parameter or Functions	Test Type	Requirement Specification	Requirement Specification Paragraph
			Comments

Test Support Requirement		Test Facility Evaluation				ITPB Remarks					
Type of Hardware/Fixtures/Software	Measurement Parameter	Data		Interval Between Calibrations	Equipment Availability						
		Attribute	Variables		Accuracy	Date Available	Alternate Date Available	Purchase Yes	Rent Yes		

Signatures: Item Engineer _____ Date _____ Test Facility Engineer _____ Date _____
 Supervisor _____ Date _____ Supervisor _____ Date _____
 ITPB _____ Date _____

- Completed Copies to:
- Item Engineer
 - Systems Engineer
 - Test Facilities Engineer
 - Product Assurance Engineer
 - Project Engineer
 - Safety Engineer

Figure 4-1. Example Of A Test Planning Information Form (Continued)

required type of test, and the ability to test at the necessary assembly level.

Environmental Requirements – The line organization provides the planned environmental and test limits for each specific environment. The ITPB must be completely familiar with the program requirements to assure that the planned limits are correct. Any discrepancies should be resolved immediately.

Government Furnished Material (GFM) – Government furnished material is usually required early by the contractor, and made available as part of the contract. This area of the planning information form is used to verify that needed GFM has been placed under contract. If this is not the case, steps should be taken to modify the contract or ITP.

Reliability, Maintainability Or Accuracy Assessment Data – The line organization, working with the cognizant specialist groups, should review the intended test for usability of results to assess reliability, maintainability or accuracy. The ITPB may recommend changes to the proposed test to make the test results more useful for assessment of reliability, maintainability or accuracy, diagnostic programs or documentation.

Traceability Of Test Requirement – The line organization should provide enough detail in this section so that the test requirement can be traced. More columns may be necessary to reflect subtier specifications and paragraphs. If the planned test is an extensive verification of item requirements, a separate attachment may be added to provide the traceability of each requirement (parameter or function) to be verified.

Evaluations – Evaluations of planned tests by the ITPB and by test facility personnel are most critical early in a program. Planning errors may be difficult to correct due to the length of time required to contract for services, purchase capital equipment or rerun tests. The ITPB chairman should assure that all organizations affected are aware of evaluations made by the board and of actions being taken to resolve differences.

Planning information provided to the ITPB should be as accurate as possible, but submission of planning forms should not be delayed because certain information is not yet avail-

able. Status updates can be provided by later revisions of the planning form.

4.2.1.2 Delinquent Test Information Notice

When it is difficult to get the required test inputs from a line group, the ITPB should issue a delinquent test information notice to encourage the submission of test information. Efforts should be made, however, to resolve delinquencies by direct contacts whenever possible. Once the notice is issued, a response period of not more than two weeks should be allowed. If the delinquency is not resolved within that time period, action should be initiated at the program manager level.

4.2.1.3 Test Program Change Proposal

A Test Program Change Proposal, such as Figure 4-2, can be initiated by anyone in the program. The intent of a proposal may be to reduce test cost, facility burden, manpower requirements, or time constraints. A proposal should relate to one or more specific tests; it should show how the present test position can be improved by, for example, combining tests to achieve the required test program objectives. Supporting data to show that previous requirements will be met by the new proposal must be included on the form. Each responsible evaluation activity (e.g., item designer, ITPB, test facilities manager) reviews the proposal. The approved proposal is then distributed.

4.2.2 Test Documentation Required By Contract/CDRL

Contract data requirements are specified in NAVSEA OD21549A and contracted for by inclusion on the Contract Data Requirements List (CDRL). Figure 2-1 contains a listing of the NAVSEA OD21549A required documents. Contractual test documentation includes test plans, procedures and reports. These documents are generally prepared by line organizations.

4.2.2.1 Test Plans

A copy of each test plan is submitted to the ITPB for approval. Test plans are needed

FROM:

TO:

VIA:

PROGRAM TEST CHANGE PROPOSAL

Form No. _____ Date _____ Sheet ____ of _____

Item No. _____ Item Name _____ Test # _____

Item No. _____ Item Name _____ Test # _____

Item No. _____ Item Name _____ Test # _____

Present Plan, Status or Problem	
Proposal Change or Solution	
Supporting Analysis	
Documentation Affected	
<input type="checkbox"/> Approval <input type="checkbox"/> Disapproval <input type="checkbox"/> Response Attached	<input type="checkbox"/> Approval <input type="checkbox"/> Disapproval <input type="checkbox"/> Response Attached
Evaluation Activity _____	Authorizing Activity _____

Copies to:

Figure 4-2. Example Of A Test Program Change Proposal

TEST PLAN

The test plan shall identify and describe planned contractor activities for implementation of test requirements. As a minimum, the test plan should include the following:

- a. Type of test; e.g., Hardware-EET, Software-Validation.
- b. Applicable documents.
- *c. Test objectives and requirements of each test, to include why the test is necessary, what the test will achieve, traceability of requirement.
- *d. Test item configuration description and number of items to be tested (if more than one supplier, identify all suppliers and quantity from each which will be tested).
- e. Limited life item identification.
- f. Conditions to be met before testing begins, e.g., item design maturity, pre-test conditioning, approvals, etc.
- *g. Test conditions, environmental, operational (definition of each operating mode) and performance profiles, and duty cycle.
- h. Order in which elements of the test will be performed.
- *i. Test conduct ground rules, failure criteria, analysis techniques for interface boundaries (between test set-up and item under test) for assignment of failure.
- *j. Parameters to be measured and required accuracy.
- *k. Data collection, analysis and corrective action system to be used, including failure occurrence control.
- *l. Test duration.
- m. Criteria for continuing test in the event a failure or stoppage occurs.
- n. Samples of data collection forms.
- o. Suitability of the test for reliability, maintainability and/or accuracy assessment.
- p. Any planned maintenance to test item(s) or test facility during test.
- *q. Test facility and equipment descriptions and requirements, including safety monitoring for electrical, mechanical and environmental interfaces.
- r. Government Furnished Material requirements.
- *s. Test schedules and milestones.
- t. Disposition of tested items upon completion of test.
- u. Contractor and procuring activity participation:
 - (1) specific responsibilities,
 - (2) access to test area and item under test,
 - (3) training or familiarity requirements.
- v. List of test procedures required.
- w. List of test reports to be issued.

*Required By NAVSEA OD21549A

Figure 4-3. Typical Content Of A Test Plan

for each item of hardware and software that is to be tested. Planning should be performed in sufficient detail to enable the ITPB to evaluate the adequacy of each test, and to determine whether and how individual plans can be modified for an optimum overall program. Test plans for items that are to receive similar testing may be consolidated to the extent that information common to them is not repeated, but is cited by reference. Figure 4-3 lists the content requirements of a test plan.

4.2.2.2 Test Procedures

A test procedure should be prepared for each test, to serve as a step-by-step guide for the test personnel who will perform the test and to enable others to monitor conduct of the test. Test procedures should be tailored to the technical level of the personnel who will perform the test. Thus, style and degree of detail may range from "insert probe A at point B" to "run gain and insertion loss checks using a model 4200 RF microwattmeter". When there is a question as to the training level of the test personnel who will perform a test, it is better to error on the side of too much detail in the test procedure.

An adequate procedure enables a properly trained user to conduct the test correctly without reference to other documents. Necessary test equipment and instruments are specified, the test set-up is shown schematically, all required measurements and tolerances are listed. The data sheets to be used to record item performance in the test are included as part of the procedure. Figure 4-4 lists typical items of information that should be contained in a test procedure.

4.2.2.3 Test Reports

A test report is a formal document reporting and interpreting the performance of one or more tests. The ITPB will usually be asked to confer approval on test results, or to direct corrective action and retesting, without waiting for a test report to be produced. Review of the test procedure, test data sheets, failure reports, failure analysis reports, memos or other documents evidencing compliance with

required corrective actions, generally comprises a sound basis for timely ITPB action. The ITPB should require however, that all tests be documented by means of test reports within a few weeks of completion. A copy of each report is filed by the ITPB as part of the item test data package. Tests stretching over several months or more should be reported at intervals, to keep the ITPB and management aware of status and progress against program milestones.

Figure 4-5 lists the typical information content of a test report.

4.3 PLANNING SOFTWARE TESTS

4.3.1 Software Module Test Plans And Procedures

The content of software module test plans and procedures is basically similar to that indicated for hardware tests in Figure 4-3 and 4-4, modified to meet the special needs of software tests. Modifications include:

- a. When identifying support facilities and equipment, include support software requirements such as simulation, data recording, data reduction, data analysis programs, known test cases or test case libraries.
- b. All outputs, at each evaluation point, should be specified with tolerances for the defined inputs. Outputs should be verified for limits, accuracies and timing.
- c. Meaningfulness of outputs, ease of interpretation, failure/error diagnostics, consistency and uniformity of syntax, conventions, semantics, format, style and abbreviations.
- d. Acknowledgement of all human inputs at the user interface.
- e. Verification of the software security provisions.
- f. Test inputs should include both legal and illegal inputs and should be provided at a rate able to stress the module(s) under

TEST PROCEDURE

Test procedures provide detailed technical directions for implementing the required test. Procedures contain step-by-step instructions of how the test will be set-up, initiated and performed. The test procedure should, as a minimum, include the following:

- a. Applicable documents, including specifications, instructions, procedures, handbooks, manuals, military specifications, software program listings, etc.
- b. A brief description of all units comprising the item(s) under test and a specific listing of those units/items which will be placed on test and the up-to-date configuration (drawing list including approved changes, waivers and deviations).
- c. Test and monitoring equipment to be used, including manufacturer, model number, serial number and calibration requirements.
- *d. Interconnecting cable diagrams of complete test set-up including item under test and test monitoring equipment.
- *e. Special equipment or facilities required, such as fixtures, etc.
- f. Any computer software used in the test.
- g. List of any Government Furnished Materials to be used during test.
- h. Assumptions concerning test or deviations from specifications.
- i. Pre-test conditioning.
- *j. Electrical, mechanical and environmental stress levels.
- *k. Normal checkout procedures for item(s) under test.
- *l. Verification of test set-up, including power-up sequence.
- m. Allowable adjustments during test.
- n. Preventive maintenance measures to be performed, if allowable by specification, during test.
- *o. Performance parameters to be measured, accuracy, frequency of measurement, and method. Where visual observation is to be used, sufficient criteria for evaluation must be provided.
- *p. Data to be recorded during tests and samples of reports or log forms to be used; e.g., Test Log and Data Record, Failure Record, Failure Tag, Failure Report.
- *q. Performance parameter limits beyond which a failure has occurred.
- *r. Pass/fail criteria.
- s. Action to be taken in event of failure (or software error).
- t. Action to be taken if a reject decision is reached, including corrective action plan and retest provisions.
- *u. Action to be taken in the event of test interruption.
- *v. Whether testing will be continuous or interrupted by work shifts.
- *w. Applicable safety precautions for personnel and facility protection.

*Required by NAVSEA OD21549A.

Figure 4-4. Typical Content Of A Test Procedure

TEST REPORT

The test report is the formal record of the results of an item(s) test. The test should, as a minimum, include the following:

- *a. A reference to the applicable test plan and procedures.
- b. Test article identification and full description of test specimens utilized, including any deviations from the configurations specified in the applicable test plan.
- c. Date and geographical location of test.
- d. Statement of test objectives; including type, unit of measure, and quantitative goals/requirements.
- e. Discussion of methods and conditions of the test, including environmental levels, test profile, methods of evaluating the data obtained and comparison of the conditions with those anticipated in ultimate deployment and use of the contract item.
- f. Results obtained, including identification and discussion of objectives demonstrated satisfactorily and those not demonstrated satisfactorily.
- *g. Identification of significant events, problems and any departures from the test procedure.
- h. Pre-conditioning results.
- i. Corrective action planned or taken.
- *j. Results of data analysis, failure diagnosis, conclusions and recommendations.
- k. Requirement for retest.
- l. Results of retest.
- m. Copy of all test data, e.g., test logs and data records.
- *n. Copies of waivers, deviations and failure reports pertaining to the test.

*Required by NAVSEA OD21549A.

Figure 4-5. Typical Content Of A Test Report

- | | |
|---|---|
| <p>test at or above their design limits. Real data is preferable to synthetic data.</p> <p>g. Incorporation of error corrections and verification of error corrections should remain within the control of the configuration management system, to reduce the probability of the error correction process introducing new errors into the software.</p> <p>h. Step-by-step instructions should address the man-machine interface and include:</p> | <p>(1) Any extensive manipulation of controls and settings.</p> <p>(2) Each step of testing, listed as an individual instruction.</p> <p>(3) Evaluation criteria for any step where evaluation is required</p> <p>(4) The evaluation technique, such as templates for use on hard copy outputs.</p> |
|---|---|

- i. Failure/error determination, to generally include any stoppage of the test.
- j. Identification of government furnished material including support software (tools, service aids, etc.).
- k. Testing should provide data to analyze the error rate of the software, classify errors, and measure the rate of reliability growth (error rate reduction).

4.3.2 Software System Test Plans And Procedures

Software system test plans and procedures should include content as indicated in Figures 4-3 and 4-4 modified by the previous considerations for module tests and the following:

- a. Testing the total man-machine interface using the actual system hardware and support software in, as nearly as practicable, actual operating conditions to provide certification.
- b. Testing of the system as prescribed by the system specification, to include use of actual operational manuals to load and initiate program(s) and operate the system; demonstrate control of the system from all local and remote modes of operation, capability of performance monitoring, diagnostic, degraded and casualty mode techniques.
- c. Testing of system internal and external software interfaces (in SSPO terminology, these are all internal subsystem interfaces and, to the extent practicable or allowable by contract, external interfaces with other subsystems) utilizing actual hardware, system software, and operational manuals; includes all performance monitoring, failure detection and isolation, degraded and casualty mode techniques (reaction to missing, illegal, and "significantly different to previous" inputs, internal and external computer communications).
- d. Testing of software system's ability to perform under stress (proper reactions

and response times) as a result of data rate saturation with legal and illegal inputs, data transfer overload, simultaneously (maximum use of data input/output ports) exercising all sections of the program, by overloading main and secondary storage (i.e., mass and scratch memories, tables, buffers), simultaneous operation and scenario-operation of all hardware.

- e. Interconnecting control and data path diagrams should appear in test documents.

f. Conduct of the test should include:

(1) Failure definition generally based on specified performance, with no stoppages or interruptions due to software errors. (Use of self-recovery features frequently reflects an underlying software failure and should be treated as a program stop).

(2) Length of test based upon: continuous or less than continuous operating programs, saturation testing, reduced capability testing (shutting off equipments), manual and automatic operation testing, scenario testing (modes of operation), failure compensation testing (including failures).

(3) Recording of all events (see NAVSEA OD29304B for example of form), failures/errors, response capability, shutdown, restart and recovery techniques, degraded and casualty capabilities, etc.

(4) Corrective action plan of action to isolate failure to hardware or software, steps to be followed to determine, initiate and verify corrective action, while avoiding inducement of other errors.

- g. Demonstration that the software program(s) can be modified as may be required in service, i.e., use of latest revisions of all documentation, procedures adequate to implement program

modifications (i.e., error correction responding to changes in requirements or the operational environment), procedures in place to verify modification and that all other impacted software has been analyzed and corrected.

4.4 PLANNING RELIABILITY DEMONSTRATION TESTS

Reliability demonstration testing has a specific meaning in a test program. It is a formal test, of significant duration and sample size, to demonstrate a specification requirement statistically. Reliability tests should be performed over the complete range of design environments, utilizing extreme or worst case operational stress levels in the sequence encountered in the mission. Items under test should be representative of production items, manufactured by the same manufacturing techniques that will be used for the production items, receiving the same burn-in or conditioning that production items will receive, and containing all approved design modifications.

The design of an item is based on requirements defined in one or more specification documents. A reliability test should provide confidence that the item can meet the reliability requirements, either by testing for an extended length of time (or number of cycles) or by testing a statistically determined quantity of items. Tear-down and visual inspection may be needed after the tests to verify the item condition. This length of time or quantity of items is the major difference between reliability tests and general qualification tests. Design constraints generally encompass the normal operating conditions an item is expected to see. For example, an item which is designed to operate over the temperature range of 0-50°C, but will normally operate between 25 and 30°C, should be tested to provide assurance that the item can operate over the 0-50°C range. This will assure that the item can operate in the normal temperature range, while also assuring that the item will operate when the temperature conditions are outside the normal range but within the design range. When items are designed to meet combinations of environmental conditions, such as vibration, humidity, temperature, etc.,

the reliability test should be performed under these combinations of conditions. The sequence of the environments and the sequence of combinations of environments should follow the mission profile.

When the test is time or cycle oriented, trade-offs have to be made as to the number of items to be placed under test. Trade-off considerations include: contract requirements, military standard requirements, program schedule, items available, facilities to simultaneously handle multiple items, number of test hours or cycles required to be accumulated, reliability prediction results, etc. The number of items tested should also depend on the duration of testing applied to a specific item. The longer an item is on test, the more knowledge is accumulated about the long term effects of environmental conditions, interfaces, and operation of the item. A larger sample, however, gives more information about the manufacturing process that produced the item, and the performance of the item population.

When tests are destructive in nature, which is the case for use-expended (one-shot) items, cost must be considered in the trade-off analysis.

When considering applying operational interfaces to the item(s) under test, simulation and stimulation techniques should be completely analyzed. Caution should be exercised because these techniques tend to provide "pure" or "perfect" inputs and outputs. As an example, a real functioning synchro, providing real signals, will contain transients which the input of a signal converter must be designed to handle, however an input signal by simulation techniques would not contain these transients. A test without real synchro signals may not be a representative test.

Appropriate measures must be taken to insure limited access to reliability test areas, to detect tampering with items under test (e.g., by use of detection stickers) and to inform test personnel about requirements to be adhered to in the test area. Test equipment should not be tampered with or removed from the area. Adjustments and maintenance not allowed by test procedure must be prevented and every test event must be com-

pletely recorded. Understanding of the test requirements is essential when designing test facilities. To prevent environmental stresses from exceeding the design range, a facilities safety design should be incorporated to ensure the shut-down of any malfunctioning item. For example, limit switches which can shut off a malfunctioning vibration table not only save manpower, but in conjunction with vibration chart recorders, can maintain the integrity of the test.

Use of existing or temporary facilities can reduce costs. Rather than purchasing an additional environmental chamber for one-time use, scheduling changes can be made or consideration given to building a generic test set-up able to meet requirements. As an example, to provide a high temperature test, a temporary structure of wood, insulation, circulation and exhaust fans, heating elements and temperature monitoring sensors might be used in place of a new environmental chamber. Use of independent test facilities may also provide a significant cost savings.

Test equipment used for inputs, outputs and test monitoring must meet accuracy, calibration and data requirements. Whether the equipment is mechanical, hydraulic, electronic or electromechanical, the requirements must be adhered to and addressed in the test procedures. Where software programs are utilized for performance monitoring, verification is needed prior to the start of the tests, to assure that the software program will reliably detect degradations or failures.

Digital readout or automated recording equipment, as opposed to instruments requiring visual interpretation of readings, are to be preferred if available.

Reliability tests should be performed at the highest assembly levels practicable. An advantage of higher level tests is that they improve the validity of the tests: the equipment is operated close to its mission mode. A disadvantage is that the tests must occur later in the program than would lower level tests, and some internal component states may be difficult to observe.

Throughout an ITP, test data are generated which may be of use in evaluating reliability. When Figure 4-1 is completed, the ITPB

should evaluate the proposed test for use as reliability data. If the test data generated are not usable for reliability demonstration, it may be possible to modify the test (see Sheet 1 of Figure 4-1) so that the data will be suitable. To be considered for use as reliability data, the test must be controlled per approved procedures, be witnessed by the responsible organizations, use the proper test items and meet the interface and environmental requirements.

Figure 4-1 should be completed by the line organization and submitted to the ITPB and the facilities manager, providing all the details of the proposed reliability test. Any differences or variations between the details on this figure and the specification requirements should be fully identified and addressed during the ITPB review meetings, and any remaining variations evaluated for expected effects on the item's demonstrated reliability. NAVSEA OD29304B provides technical guidance for planning reliability demonstration tests.

Reliability test plans and procedures are necessary to govern the performance of the tests. The test plan should specify the statistical test plan chosen, values for risk, lower and upper test parameters (e.g., MTBF), cite applicable military specifications and satisfy the content requirements of Figure 4-3. Test procedures should satisfy the content requirements of Figure 4-4.

Reliability test reports should be prepared reporting the results of the tests. A test report should satisfy the content requirements of Figure 4-5. For lengthy tests, periodic interim reports should be submitted to the ITPB. Periodic summary reports should satisfy the content requirements of Figure 4-6.

4.5 PLANNING MAINTAINABILITY DEMONSTRATION TESTS

Maintainability demonstration testing is formal testing to verify achievement of contractual maintainability requirements. Maintainability tests should be performed on items representative of the production item (i.e., containing all approved design modifications), with proven performance monitoring and

diagnostic software programs, with verified and validated item documentation (i.e., operation manual, technical manual), with actual tools and test equipment to be used in service, by personnel trained in the service training program and in environments (i.e., temperature, spatial constraints) simulating those which will be found aboard the submarine. MIL-STD-471A provides technical guidance for planning maintainability demonstration tests. The following discusses some of the more general aspects of maintainability testing.

The results of a maintainability test should provide statistical confidence in the maintainability design of the item and a qualitative assessment of the item maintainability approach. Figure 4-7 is an example of a log for recording qualitative and quantitative data during a maintainability test.

The maintainability design criteria of an item is derived from quantitative requirements and design practices. The requirements/design practices are based on:

- a. Types of repairs and replacements allowed (and sparing concept) at each maintenance level.
- b. Manpower skills.
- c. Quantity of manpower that will be available to maintain the item.
- d. Maintenance time limitations.
- e. Restrictions on special tools and support equipment.
- f. Soldering/unsoldering limitations.
- g. Testability provisions.
- h. Test point provisions.
- i. Spares provisions - transportation, packaging, handling, preservation.
- j. Accessibility provisions.
- k. Safety - handling constraints (weight, etc.), hazard conditions/warnings, finished product maturity (sharp edges, etc.).
- l. Preventive/planned/scheduled maintenance constraints.
- m. Mounting/attachment provisions.
- n. Built-in-test provisions and requirements - modularity, automation, failure detection and isolation constraints, functionality, testability, fail safe constraints, diagnostic programs, performance monitoring programs.
- o. Adjustment/Alignment/Calibration provisions.

A checklist should be utilized to assess all of the maintainability characteristics as each maintenance task is performed. The analysis should also evaluate the adequacy of personnel training, supporting documentation, tools, maintenance aids, support equipment and manufacturing techniques.

Test maintenance personnel should be Navy technicians, having the proper rating or Navy Enlisted Classification, and of the lowest rate authorized to perform the item maintenance. The technicians should be trained in the approved training program and, preferably, have completed it several weeks before the test. This places the burden of the maintenance action on the maintenance documents and aids, as it should. If Navy technicians are not available, contractor personnel may perform the tests with the following precautions: 1) these personnel should not be at an advantage or disadvantage when performing the test, 2) the test team should verify that the technicians follow the maintenance manual procedures step by step.

Documentation and maintenance aids must be in versions that have been verified and validated. When developing the documentation, certain basic premises must be met, i.e., material must be sufficiently detailed, must be written for the proper level of technician training, and must have been written by personnel knowledgeable in the operation and maintenance of the item. Support equipment should be that equipment called for in the maintenance manuals. Support equipment should be assessed for capability, proper maintenance and calibration. Tools should include only those called for in the maintenance manuals. Spares should be supplied to the maintenance technician as they would be supplied on the submarine.

The item under test should be as similar to the production item as possible. All known modifications and corrective actions should be incorporated into the test item. Software programs should be patch free, verified and validated.

The ITPB should assure a pretest evaluation of the complete maintenance package. Areas of concern are: When simulating or inducing faults (such as prefaulted modules) into the

PERIODIC TEST SUMMARY REPORT

The Periodic Test Summary Report should, as a minimum, include the following:

- a. Type and number of items on test and type of test.
- b. Total elapsed item hours (cycles), test hours (cycles) during the period covered in the report and the total accrued item hours (cycles) of testing at the report date.
- c. Total number of item failures for each operational mode specified in the duty cycle.
- d. Description of each failure problem area, related failure analysis, and corrective action.
- e. Test conditions and analysis of any variation from specified conditions.
- f. Present reject/accept status and estimated test time (cycles) for completion and date.
- g. A chart showing a plot of the observed reliability characteristic from start of test through the report period and the predicted value for comparison.
- h. A detailed chart depicting the history of every item under test by serial number and with time (meter readings) or cycles recorded. This history traces all activities from and including pre-conditioning to delivery.
- i. All pre-conditioning time and failures by item serial number on *all* items delivered.
- j. Cumulative results of previous and present month's testing under present contract.
- k. The status and/or disposition of each corrective action.

Figure 4-6. Typical Content Of A Periodic Test Summary Report

test item, the technique should actually be checked out for "proper" operation of the fault, and the maintenance documentation should be verified against the test item. Since the total document package should have been verified previously, the impact of an error found in this portion of pretest should be carefully considered, leading to a complete review of the document. The test program should make allowances for time to perfect and verify corrective actions of problems found during the pretest evaluation. The performance of the pretest evaluation, and the verification of corrective action implementation, should assure that when maintainability tests are performed, valid test data are obtained, within reasonable time constraints and without the constant test interruptions so

often associated with maintainability testing. Some other areas to be considered are:

- a. What happens if a test does not include enough events to be statistically valid? As an example, as items are designed to require less preventive maintenance tasks, it is not always practical or reasonable to test statistically the design of these tasks. However, during a test the design of and adequacy of the maintenance package for these tasks should be assessed. Generally, what should be done is to perform the maintenance on the task(s) enough times to assure the test team that the design is satisfactory and that all documentation, training, etc. is adequate. When repeating the same task, allowances must be made for the learning curve of the maintenance technician.

MAINTAINABILITY DEMONSTRATION MAINTENANCE ACTION LOG

SYSTEM: _____ S/N _____ TEST SITE: _____ DATE: _____
 PERSON INSERTING SIMULATED MALFUNCTION _____ MAINT. CREW: 1) _____ 2) _____ 3) _____
 SIMULATED MALFUNCTION: _____

LOCAL TIMES TO NEAREST MINUTE (IN MILITARY TIME NOTATION) ELAPSED TIMES TO NEAREST MINUTE

1. START DEMONSTRATION (LOCAL TIME) _____
2. FIRST INDICATION OF FAILURE _____ OBSERVED SYMPTOM(S) _____
3. ACTIVE TIME TO LOCALIZE TO EQUIPMENT _____ REMARKS _____
4. ACTIVE TIME TO ISOLATE MALFUNCTION _____ REMARKS _____
5. ACTIVE TIME TO DISASSEMBLE _____ REMARKS _____
6. ACTIVE TIME TO INTERCHANGE _____ REMARKS _____
7. ACTIVE TIME TO REASSEMBLE _____ REMARKS _____
8. ACTIVE TIME TO ALIGN _____ REMARKS _____
9. ACTIVE TIME TO CHECKOUT _____ REMARKS _____
10. TOTAL ACTIVE MAINTENANCE TIME (SUM OF 3 THRU 9) _____
11. INACTIVE TIME FOR SPECIAL INSTRUCTIONS _____ REMARKS _____
12. OTHER ADMINISTRATIVE TIME _____ REMARKS _____
13. DELAY TIME FOR PARTS, TEST EQUIPMENT _____ REMARKS _____
14. OTHER DELAY TIME _____ REMARKS _____
15. TOTAL INACTIVE TIME (SUM OF 11 THRU 14) _____

16. RECOVERY COMPLETED (LOCAL TIME) _____ (NOTE: 16 MINUS 2 SHOULD EQUAL SUM OF 10 AND 15. IF NOT, EXPLAIN)

17. SUPPORT ADEQUATE

	YES	NO	REMARKS
SPARES	<input type="checkbox"/>	<input type="checkbox"/>	_____
MAINTENANCE PERSONNEL TRAINING	<input type="checkbox"/>	<input type="checkbox"/>	_____
FAULT ISOLATION SOFTWARE	<input type="checkbox"/>	<input type="checkbox"/>	_____
TOOLS	<input type="checkbox"/>	<input type="checkbox"/>	_____
TEST EQUIPMENT	<input type="checkbox"/>	<input type="checkbox"/>	_____
DOCUMENTATION, MAINTENANCE	<input type="checkbox"/>	<input type="checkbox"/>	_____
DOCUMENTATION, OPERATIONAL	<input type="checkbox"/>	<input type="checkbox"/>	_____

MAINTENANCE ACTION(S) TAKEN: _____

PROBLEMS: _____

SPARES INSTALLED: _____

PERSON RECORDING MAINTENANCE TIMES: _____ ORGANIZATION _____

(SIGNATURE)

Figure 4-7. Example of Main: nability Demonstration Maintenance Action Log

b. As in all formal testing, the integrity of the test must be maintained, procedures strictly adhered to, the area restricted to the test team, and distractions and noise beyond normal levels kept to a minimum.

c. Qualitative, and to some extent quantitative, deficiencies discovered during the test should be corrected as they are found. This is not always possible, but every effort should be made to make and verify the corrections. If the deficiencies become too numerous, then it is the obligation of the test team to terminate the test and perform corrective actions. The complete maintenance package should again be verified prior to retesting or restarting the test.

d. Environmental constraints and conditions during the maintainability test should be consistent with operational conditions. Areas to be considered include confinement of maneuvering space, accessibility to the item, and orientation of the item, as well as temperature, vibration, pressure and noise environments that would present problems to the normal work effort or require extra or special clothing.

Planning for a maintainability test begins with the submittal of test details to the ITPB by the line organization, using Figure 4-1. Any differences or variations between the details on this figure and the specification requirements should be fully identified and addressed during the ITPB review meetings; any remaining variations should be evaluated for expected impact on the item's demonstrated maintainability.

Maintainability test planning must consider not only the demonstration of a maintainability requirement, such as mean time to repair (MTTR), but also the verification of the appropriate testability requirements, which have an impact on operational availability and maintainability. The testability parameters which are usually specified include fault coverage, false alarm rate, and fault isolation. The requirements for fault coverage and false alarm rate are often written in a form such as: "The system shall detect 98% of operational faults with a false alarm rate not to exceed 2%. The system shall isolate a fault to a single module 90% of the time, and

to an ambiguity group of not more than 5 modules 99% of the time."

The first two parameters, fault coverage and false alarm rate, are usually verified by analysis of the circuitry, including Failure Mode, Effects and Criticality Analysis (FMECA). NAVSEA OD29304B provides technical guidance for FMECA. If false alarm rate is specified in time e.g., mean time between false alarms, a MIL-STD-781 procedure (where a false alarm is considered a failure) can be employed to demonstrate the requirement.

Verification of the fault isolation requirement is a joint analysis and test function. The testability or maintainability analysis assures that the hardware/software design allows for the proper number and placement of test points to isolate the detected fault. This analysis is a major input to the critical design review and should be used when preparing software element and integration test specifications.

The actual demonstration of the isolation capability of the design with respect to the requirements occurs during the maintainability demonstration. Here the selection of faults plays an important role in determining if the test will exercise the diagnostic software adequately. The faults must be selected so that modules which will fail most often are faulted most often. However, it is necessary to avoid faulting a module in an identical manner if the module is selected again. This modification to the selection process allows wider exercise of diagnostic programs and maintenance manuals.

Maintainability test plans and procedures are needed to govern the performance of the test. Test plans and procedures should satisfy the content requirements of Figures 4-8 and 4-9, respectively. Maintainability test reports should satisfy the content requirements of Figure 4-10.

4.6 WEAPON SYSTEM TESTS

4.6.1 Weapon System Integrated Test Program

A Weapon System Integrated Test Program is performed under SSPO direction. Tests cov-

MAINTAINABILITY TEST PLAN

The Maintainability Test Plan should identify and describe planned contractor activities for implementation of test requirements. The plan should, as a minimum, include the following, as appropriate:

- a. The content of Figure 4-3.
- b. A description of the maintenance concept.
- c. Identification of the level(s) of maintenance to be demonstrated.
- d. A description of the adequacy/inadequacies of maintenance support elements (documentation, tools, spares, etc.).
- e. The qualifications and training (experience resumé) of operator and maintenance personnel performing the tests.
- f. Discussion of test team personnel indoctrination.
- g. The procedure for selection of maintenance tasks.
- h. The identification of "Special" maintenance tasks.

Figure 4-8. Typical Content Of A Maintainability Test Plan

MAINTAINABILITY TEST PROCEDURE

The Maintainability Test Procedure should provide technical directions for implementing the required test. Procedures contain step-by-step instructions of how the test will be set up, initiated, performed, and secured. The test procedure should as a minimum, include the following, as appropriate:

- a. The content of Figure 4-4.
- b. The method of handling outstanding pretest problems.
- c. The number of hours the maintenance technician(s) will work each day.
- d. The method of handling test interruption (i.e., deficient documentation, training, software programs, etc.).

Figure 4-9. Typical Content Of A Maintainability Test Procedure

MAINTAINABILITY TEST REPORT

The Maintainability Test Report is the formal record of the results of an item's maintainability test. The test report should, as a minimum, include the following, as appropriate:

- a. The content of Figure 4-5.
- b. The results of the pretest evaluation.
- c. An analysis of qualitative observations made during the test (such as a matrix of deficiencies against item design, item manufacture, documentation, training, software programs, etc.).
- d. The intended action and time frame to rectify all deficiencies (i.e., "will be redesigned", "will be redesigned during production", "pen and ink changes will be proposed", etc.).

Figure 4-10. Typical Content Of A Maintainability Test Report

ered by the Weapon System Integrated Test Program include missile flight tests (which actually begin in the development phase), DASO tests, patrol tests, OT/FOT tests and surveillance tests, including those of the Fleet Return Evaluation Program.

The general purpose of the system level test program is to:

- 1) Determine the weapon system's readiness for operational deployment.
- 2) Verify processes within the weapon system that determine its performance capabilities and to enable valid extrapolation of performance observed under test conditions to performance expected under operational conditions.
- 3) Provide for the Commander-in-Chief's estimates of performance planning factors under operational patrol conditions, and to make this information available to the JCS at the earliest possible date for use in SIOP planning.
- 4) Provide continuing evaluations of sources of inaccuracy, unreliability and maintenance burden within the weapon system, and to guide improvement efforts.

Documents developed for the test program include:

- 1) A Weapon System Integrated Test Program Plan.
- 2) A Weapon System Analysis Plan.
- 3) A DASO Test Plan.

- 4) A DASO Analysis Plan.
- 5) DASO Test Reports.
- 6) A OT Test Plan.
- 7) A OT Analysis Plan.
- 8) OT/FOT Performance Reports.
- 9) A Patrol Test Plan.
- 10) A Patrol Analysis Plan.
- 11) Patrol Performance Reports.
- 12) Flight Trajectory Reports.

The Weapon System Integrated Test Program Plan describes the planned weapon system tests and indicates how test results will be used. The Weapon System Integrated Test Program Plan describes all system evaluations to be performed as a result of the planned tests, addresses range safety and takes into consideration requirements for test facilities, including any new facilities that may be needed to support the tests.

The measures of deployed system performance evaluated during these tests are reliability, accuracy, communications and reaction time, firing rate and the envelope of performance (flight range and loft and footprint capability). Test data acquired are analyzed to determine estimates of each of the constituent elements of weapon system reliability and contributors to inaccuracy during the test. Errors are grouped by type and combined using a mathematical system error model to propagate them through the system to reentry body impact. Sensitivity coefficients are used

to calculate the miss-distance contributions of subsystems and components. Three types of errors predominate:

1) Measurement (Input) Errors - Errors in determining or stating quantities used in generating control functions.

2) Scheme (Formulation Model) Errors - Errors resulting from use of imperfect relationships or equations in generating control functions.

3) Variation (Output) Errors - Errors that occur when control functions generated by the system are not identical each time they are replicated using the same input functions.

Subsystem Accuracy is evaluated as follows:

1) Navigation subsystem accuracy is evaluated in terms of discrete launch errors, individual equipment accuracy statistics and long-term RMS errors. Navigation errors include latitude and longitude errors, heading and velocity errors, and time of day errors.

2) Fire control subsystem accuracy is measured in terms of errors in guidance platform position, velocity, orientation at launch, time of flight, stored coefficients, guidance system alignment within the tube and with respect to optical navigation reference.

3) Missile subsystem errors relate to guidance components, separation velocity and gas dynamics variations, drag coefficients, weather parameters during reentry and errors of arming and fuzing components.

4.6.2 Planning for Weapon System Integrated Test Program

The subsystem contractor's major responsibility for contributing to the Weapon System

Integrated Test Program is to participate in SSPO's Data Requirements Working Group and supply information documentation giving subsystem description and functional performance, to the extent required by contract. Numerous inputs to DASO, patrol and OT/FOT planning tasks may originate with subsystem contractors. These inputs include subsystem accuracy and reliability models, the specific function measurements required to evaluate subsystem performance, as well as the degree of measurement accuracy, precision and repetition rate required. Data elements the subsystem contractor should plan to provide include: each function to be measured, tests in which the function is to be measured, source/pickoff, update rate, accuracy (μ , σ , RMS), precision/resolution, bandwidth, range, sample rate, maximum rate of change, data time correlation, and time interval.

Also to the extent required by the contract, the subsystem contractor will perform evaluation of data from the weapon system tests.

Many decisions on inputs to the Weapon System Integrated Test Plan and evaluation of weapon system test results are aided by data from the development and production test program. Planning includes:

1) Assuring that all essential performance parameters that have been definitized are verified.

2) Assuring that models are defined in terms of observables.

3) Assuring that enough development and production test data is available to evaluate the results of weapon system tests.

INDEX

- Acceptance tests 3-13
- Acceptance tests, software 3-12
- Accuracy 3-17, 4-4, 4-18, 4-19
- Accuracy, errors affecting 4-19
- Active inert missile 3-15
- Aging tests 3-14
- Analysis in lieu of testing 3-2
- Approval of tests by ITPB 4-5

- Baseline, definition viii
- Bottom-up testing of software 3-11
- Breadboard circuits, use in development testing 3-9
- Burn-in, firmware 3-12
- Burn-in, hardware 3-14

- Change proposal 4-5
- Component, definition viii
- Contractor program manager's responsibilities 1-1
- Contractor responsibilities 1-1
- Contractor responsibility in weapon system test program 4-18
- Cost planning 3-2

- Data system 1-1
- Definitions of terms viii, ix, x
- Delinquent test information notice 4-4
- Demonstration viii
- Demonstration and shakedown operations 3-15, 3-16
- Demonstration, maintainability 3-12
- Demonstration, reliability 3-12
- Deployment phase 1-1, 3-6, 3-16
- Deployment phase tests 3-16
- Destructive tests 4-11
- Development phase tests 2-1, 3-6
- Development tests x, 2-1, 3-7
- Documentation for maintainability testing 4-13
- Documentation readability 3-13
- Documentation, verification of 3-13
- Documents, test 4-1
- Documents used by the ITPB 4-1

- Engineering evaluation tests 3-9
- Environmental requirements 4-4
- Environmental tests 3-2
- Environments, design requirement 3-8
- Environments, non-destructive 3-13

- Equipment, definition viii
- Errors affecting missile accuracy 4-19
- Exercise, tactical 3-16

- Facilities, independent test 4-1
- Facilities, temporary 4-11
- Failure criteria 2-3
- Failure, definition viii, 3-8
- Failure rate, definition viii
- Fire control subsystem, self test 3-16
- Firmware viii, 3-12
- Follow-on operational tests 3-17
- Form, Maintenance Action Log 4-15
- Form, Master Test Plan Summary 3-5
- Form, Test Planning Information 4-1, 4-2, 4-3
- Form, Test Program Change Proposal 4-5
- Form, Verification Allocation Matrix 3-4
- Forms, data collection 2-3

- Government furnished material 4-4
- Grooming tests 3-15
- Guidance subsystem, evaluation of 3-16

- Hierarchical structure of software 3-12

- Indented system breakdown 3-6
- Inspection included in term "test" ix, x
- Inspection part of SIOP/SOTP 3-15
- Installation tests at shipyards 3-15
- Instructions issued by ITPB 3-2
- Integrated data system 1-1
- Integrated test program vii, 1-1, 2-1
- Integrated test program activities 2-4
- Integrated test program administration 2-4
- Integrated test program board, activities 2-5
- Integrated test program board, chairman's duties 2-5
- Integrated test program board, concept 1-1
- Integrated test program board, establishment of 3-1
- Integrated test program board, evaluation of planning documents 4-1
- Integrated test program board, evaluation of test reports 4-5
- Integrated test program board, instructions 3-2
- Integrated test program board, membership 2-3
- Integrated test program board, members' duties 2-5
- Integrated test program boards, of subcontractors 2-5
- Integrated test program board, of system design agency 2-5

NAVSEA OD 42282A

- Integrated test program board, organization of 2-5
- Integrated test program board, operation of 3-2
- Integrated test program board, preevaluation planning by 3-1
- Integrated test program board, purpose 1-1
- Integrated test program board, reports 2-5
- Integrated test program board, responsibilities 1-1
- Integrated test program board, special representatives' duties 2-5
- Integrated test program concept 2-1
- Integrated test program constraints 3-1
- Integrated test program documents 2-2, 3-3
- Integrated test program objectives 3-6
- Integrated test program phases 3-6
- Integrated test program plan 3-8
- Integrated test program plan, content of 2-3
- Integrated test program status report 2-2, 3-6
- In-tube conversion 3-15
- Item, definition 1-2

- Joint Chiefs of Staff, SIOP planning factors 3-17

- Keyboard, of fire control subsystem 3-16

- Launcher operations 3-16
- Launcher subsystem, evaluation 3-16
- Life, evaluation 3-16
- Life, performance stability during 3-17
- Line organizations, responsibility for planning tests 1-2
- Loadout, part of DASO 3-15
- Log, maintenance action 4-15
- Lot sampling 3-14
- Lowest-level item tests 3-13

- Maintainability viii
- Maintainability demonstration 1-2, 4-12
- Maintainability demonstration by simulation of malfunctions 4-12
- Maintainability demonstration checklist 4-13
- Maintainability demonstration documentation 4-13
- Maintainability demonstration, inadequate sample size 4-13
- Maintainability demonstration maintenance action log 4-15
- Maintainability demonstration test personnel 4-17
- Maintainability documentation test plan 4-17
- Maintainability demonstration test procedure 4-17
- Management of integrated test program 1-1, 2-1, 2-5, 3-1
- Master test planning summary chart 3-3
- Master test schedule 3-3
- Mean time between failures 4-12

- Mean time to repair 4-16
- Milestone, definition ix
- Milestone chart 3-3
- Missile launches in DASO 3-16
- Missile launches in OT/FOT 3-17
- Missile subsystem, evaluation 3-16
- Module, hardware ix
- Module, software ix
- Navigation operations 3-15
- Navigation subsystem, evaluation 3-16
- NAVSEA OD 21549A 1-1, 3-7, 3-8, 3-12
- NAVSEA OD 21549A, documents defined by 2-2
- NAVSEA OD 21549A, test categories of 3-6
- NAVSEA OD 29304B 3-13, 4-12, 4-16
- Non-destructive testing 3-13, 3-16
- Notice, delinquent test information 4-4
- Nuclear environments in vulnerability testing 3-13

- One-shot items, testing of 4-11
- Operational tests 3-17
- Organization of ITPB 2-3
- Overhaul tests at shipyards 3-15

- Pass/fail criteria 2-3
- Patrol analysis plan 4-18
- Patrol test plan 4-18
- Planning factors, SIOP 3-17
- Planning, test (See test planning)
- Plans, test (See test plans)
- Pre-deployment phase 1-1
- Pre-evaluation planning 3-1
- Preparation and readiness evaluations 3-16
- Pre-test evaluation of maintenance package 4-13
- Prime hardware, definition ix
- Priorities of tests 2-4
- Procedural instructions 3-2
- Procedures, test (See test procedures)
- Production acceptance tests 3-14
- Production assessment tests 2-5, 3-14
- Production phase 1-1, 3-13
- Production test and inspection plan 3-1
- Program phases 1-1
- Post-DASO operations 3-16

- Qualification program plan 3-10
- Qualification testing 3-10

- Readability of documents 3-13
- Readiness, weapon system 3-17
- Reliability, definition ix
- Reliability testing 1-2, 3-12, 4-11
- Reliability testing environments 4-11

- Reliability testing of use-expended items 4-11
 - Reliability testing, preferred assembly level 4-12
 - Reliability test plans 4-12
 - Reliability test procedures 4-12
 - Report, ITP status 2-2, 3-6
 - Report, periodic test summary 4-14
 - Reports, test (See test reports)
 - Requalification testing 3-11
 - Requirements, test (See test requirements)
 - Risk ix
- Sampling 3-14
 - Schedule planning 3-2
 - Schedules 2-3
 - Screening ix
 - Selection of test 1-2
 - Selective deletion of qualifications tests 3-11, 3-16
 - Service life evaluation test program 3-14
 - Ship support system 3-15
 - Shipyards installation or overhaul test program 3-15
 - Software, definition ix
 - Software, testing 3-11, 3-12, 4-5, 4-7, 4-10
 - Software testing, duration 4-10
 - Software testing, failure definition 4-10
 - Software testing, interfaces 4-10
 - Sonar evaluation 3-16
 - SPALT test requirements 3-14
 - SPALTs/TVAs, evaluation of 3-16
 - Special operations phase 1-1, 3-17
 - Special operations phase tests 3-12
 - Status report, ITP 2-2, 3-6
 - Strategic planning factors,
 - determination of 3-15, 3-17, 4-18
 - Strategic Systems Project Office 2-1
 - Strategic weapon system 1-1, 4-16
 - Subsystem, definition ix
 - Subsystem operations in DASO 3-15, 3-16
 - Success criteria 2-3
 - System, definition ix
- Tactical exercise 3-16
 - Testability 4-14
 - Test areas, access to 4-11, 4-13
 - Test data, use for reliability demonstration 4-12
 - Test documentation 4-1
 - Test equipment 4-11, 4-12
 - Test facilities, independent 4-1
 - Test facilities, temporary 4-11
 - Test integration 1-1
 - Testing, bottom-up, of software 3-11
 - Testing, ITPB approval of 4-5
 - Testing, top-down, of software 3-11
 - Test management 1-1, 2-1
 - Test planning 1-1, 1-2
 - Test planning for post-development phases 3-4
 - Test planning outputs 2-3
 - Test plans 4-4
 - Test plans, control of 4-7
 - Test plans, development 3-7
 - Test plans, maintainability demonstration 4-12, 4-17
 - Test plans, qualification 2-2, 3-8
 - Test plans, reliability demonstration 2-2, 4-10
 - Test plans, software acceptance 3-12
 - Test plans, software module 4-7
 - Test plans, software system 4-10
 - Test plans, software validation 2-2, 3-11
 - Test priorities 2-4
 - Test procedures 2-2, 4-8
 - Test procedures, content of 4-8
 - Test procedures, development 2-2, 4-7
 - Test procedures, engineering evaluation 2-2, 3-9
 - Test procedures, maintainability
 - demonstration 4-10, 4-11
 - Test procedures, qualification 3-10
 - Test procedures, reliability demonstration 4-10, 4-11
 - Test procedures, software acceptance 2-2, 3-12
 - Test procedures, software module 4-7
 - Test procedures, software system 4-10
 - Test procedures, software validation 2-2, 3-4
 - Test program change proposal 4-4, 4-6
 - Test program evaluation 1-2
 - Test reports 4-5
 - Test reports, content of 4-9
 - Test reports, development 2-2
 - Test reports, engineering evaluation 2-2
 - Test reports, ITP status 2-2, 3-6
 - Test reports, maintainability
 - demonstration 2-2, 4-12, 4-8
 - Test reports, periodic summary 4-14
 - Test reports, qualification 2-2
 - Test reports, reliability demonstration 2-2
 - Test reports, software acceptance 2-2
 - Test reports, software validation 2-2
 - Test requirements for SPALTs 3-14
 - Test requirements, traceability of 3-2, 4-4
 - Test selection 1-2
 - Test status log 3-3
 - Test summary 2-3
 - Tests, acceptance x, 3-13
 - Tests, aging x, 3-14
 - Tests, categories per NAVORD OD 21549A 3-6
 - Tests, DASO 3-15
 - Tests, development x, 2-1, 3-7
 - Tests, development phase 2-1, 3-6, 3-16

Tests, engineering evaluation x, 3-9
Tests, environmental 3-2
Tests, firmware 3-12
Tests, flow of, during acquisition 3-9
Tests, grooming 3-15
Tests, ITPB approval of 4-5
Tests, lot sampling 3-14
Tests, lowest-level item 3-13
Tests, maintainability 2-1, 3-12, 3-13, 4-12
Tests, multipurpose 3-2
Tests, non-destructive 3-13, 3-16
Tests, OT/FOT 3-17
Tests, patrol 3-16, 3-17
Tests, pre-deployment 2-1, 3-15
Tests, production 2-1, 3-13
Tests, production acceptance 3-14
Tests, production assessment 2-5, 3-14
Tests, qualification x, 2-1, 3-8
Tests, quality assurance, definition x
Tests, screening 3-14
Tests, software acceptance 3-12
Tests, software validation 3-11
Tests, special operations 2-1, 3-17
Tests, static 3-15
Tests, system interface 3-15
Tests, system operation 3-15
Tests, technical documentation verification 3-13

Tests, Trident measurement program 3-14
Tests, use-expended items 4-11
Tests, validation, definition x
Tests, vulnerability x, 3-13
Tests, weapon system readiness 3-17
Traceability of test requirements 3-2, 4-4
Trident measurement program 3-14

Use-expended items 4-11

Validation of software 3-11
Variable, definition x
Verification allocation matrix 3-3
Verification of documentation 3-13
Verification of fault isolation capability 4-16
Vulnerability testing 3-13

Weapon system integrated test program 4-16
Weapon system integrated test program,
planning for 4-18
Weapon system integrated test program,
plans required 4-16
Weapon system integrated test program, purpose 4-16
Weapon system readiness,
evaluation of 3-15, 3-17, 4-18
Weapon system, strategic 1-1
Work breakdown structure 3-3

END

FILMED

02 - 84

DTIC