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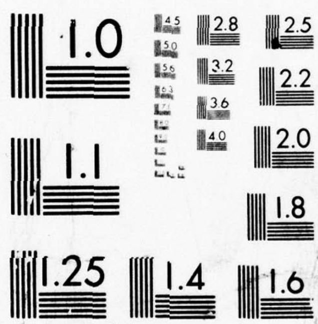

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CONTRACTOR CONSIDERATIONS FOR DEVELOPMENT
TESTING OF ARMY MISSILE SYSTEMS
STUDY REPORT
PMC 73-1

Elmo A. Gallagher
Martin Marietta Corporation

CONTRACTOR CONSIDERATIONS FOR DEVELOPMENT TESTING OF ARMY MISSILE SYSTEMS

STUDY REPORT

Presented to the Faculty

of the

Defense Systems Management School

in Partial Fulfillment of the

Program Management Course

Class 73-1

by

Elmo A. Gallagher
Martin Marietta Corporation

May 1973

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STUDY TITLE: CONTRACTOR CONSIDERATIONS FOR DEVELOPMENT TESTING OF ARMY MISSILE SYSTEMS

STUDY PROBLEM/QUESTION: This paper addresses the considerations a contractor System Test Manager must make during the Conceptual Phase of an Army missile system in order to "tailor" an adequate test program.

STUDENT REPORT ABSTRACT:

The thesis of this paper is that early and comprehensive program test planning is essential to program success and allows the contractor to identify and trade off test elements in order to surface viable test program alternatives.

KEY WORDS: MATERIEL DESIGN AND DEVELOPMENT EVALUATION MISSILE SYSTEMS TEST FACILITIES CONTRACT ADMINISTRATION CONTRACTOR PERSONNEL PROJECT MANAGEMENT CONCEPT FORMULATION

Student, Rank, Service	Class	Date
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An Executive Summary
of a
Study Report
by

Elmo A. Gallagher
Martin Marietta Corporation

May 1973

Defense Systems Management School
Program Management Course
Class 73-1
Fort Belvoir, Virginia 22060

EXECUTIVE SUMMARY

Recent policy changes in the Department of Defense have resulted in new guidelines and considerations to the service components in the area of weapon system developmental testing. It is important for contractor program managers and members of their management team to understand the ramifications of this guidance in order to "tailor" a test program that will be responsive to the intent of this guidance.

Comprehensive and integrated test planning, together with sound test engineering methodology and errorless test operations, are factors a contractor program manager must control in order to assure program success.

This paper addresses the considerations a contractor System Test Manager must make during the Conceptual Phase of an Army missile system in order to "tailor" a test program that will provide meaningful evaluation of deliverable hardware in terms of technical performance within prescribed schedule and cost constraints.

The first chapter identifies the genesis of policy direction regarding Army development testing thru: Department of Defense Directive 5000.1, Acquisition of Major Defense Systems; Department of Defense Directive 5000.3, Test and Evaluation; and in turn, the Army Letter of Instruction, Implementing the New Material Guidelines, and then summarizes the most important aspects of these documents as they apply to developmental testing and contractor participation in such testing.

The second chapter focuses on some of the major considerations a contractor System Test Manager should make during the Conceptual Phase

and recommends a modified Systems Engineering approach be adopted in the test planning process to give the contractor visability to the interactions between test oriented elements and all other program elements thereby introducing a systematic way to identify and control test efforts, cost, and cost estimating.

The third chapter expands the sphere of basic test considerations and explores the test planning that will be required for follow-on phases. Particular emphasis has been placed on Range and Range Support planning for flight test programs.

CONTRACTOR CONSIDERATIONS FOR DEVELOPMENT
TESTING OF ARMY MISSILE SYSTEMS

Introduction

Recent policy changes in the Department of Defense have resulted in new guidelines to the service components in the area of weapon system development testing. It is important for contractor program managers and members of their management teams to understand the ramifications of this guidance in order to "tailor" a test program that will be responsive to the intent of the guidance.

Comprehensive and integrated test planning together with sound test engineering methodology and errorless test operations are factors a contractor program manager must control in order to assure program success.

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CHAPTER I

SURVEY OF ARMY TEST POLICY CHANGES

The genesis of policy direction regarding development testing is found in Department of Defense Directive 5000.1, Acquisition of Major Defense Systems, 13 July 1971, and is amplified in Department of Defense Directive 5000.3, Test and Evaluation, November 1972. In turn, the Army has expanded the direction and passed it to all commands through a Letter of Instruction (LOI), Implementing the New Material Guideline, 23 August 1972.

Understanding the direction and intent of the guidance provided in each of these documents is essential if a contractor is to design a development test program that is responsive to the guidance found in the above documents. The following discussion serves to familiarize the contractor System Test Manager with the most important aspects of these documents as they apply to Army weapon system testing and contractor participation in this activity.

DOD 5000.1 MAJOR ACQUISITION OF DEFENSE SYSTEMS

DOD 5000.1 provides the following overall guidance on weapon system program considerations:

1. Practical tradeoffs shall be made between system capability, cost and schedule.
2. Traceability of cost estimate shall be maintained.
3. Early development shall be devoted to only those parameters necessary to basic design.
4. Programs shall be structured to ensure that demonstration of program objectives is the pacing function.

5. Technical uncertainty shall be continually assessed. Models and the like will be used to increase program confidence.

6. Test and Evaluation shall begin as early as possible making use of the most realistic test environment possible.

7. Cost type prime and subcontractors are preferred where substantial developmental effort is required.

8. Source selection shall be based on the contractor's ability to design, build, and test on a timely and cost effective basis.

9. A realistic work breakdown structure (WBS) shall be established to provide a framework for planning, control, progress reporting, and an estimating base for future costs of the program. (1)

DOD 5000.3 TEST AND EVALUATION

DOD 5000.3 is more specific than DOD 5000.1 in policy for the conduct of development test and evaluation by the DOD components. The following direct quote clearly identifies where the emphasis should be placed during program test planning.

1. General

   a. Test and evaluation shall commence as early as possible and be conducted throughout the system acquisition process as necessary to assist in progressively reducing acquisition risks and in assessing military worth.

   b. Acquisition schedules will be based, interalia, upon accomplishing test and evaluation milestones prior to the time that key decisions which would commit significant added resources are to be made.

   c. Before the initiation of development of a new system, test and evaluation using existing systems, or modifications thereto, may be appropriate to help define the military need for the proposed new system and to estimate its military utility. Determination of military worth, need, and utility will be accomplished in accordance with other DOD directives.

d. All test and evaluation activities shall consider environmental issues and provide assessments for review as early as possible in the test planning cycle. (See DOD Directive 6050.1)

2. Development Test and Evaluation (DT&E). DT&E is that test and evaluation conducted to: demonstrate that the engineering design and development process is complete; demonstrate that the design risks have been minimized; demonstrate that the system will meet specifications; and estimate the system's military utility when introduced. DT&E is planned, conducted, and monitored by the developing agency of the DOD Component, and the results thereof are reported by that agency to the responsible Military Service Chief or Defense Agency Director.

a. DT&E shall be started as early in the development cycle as possible and include testing of component(s), subsystem(s), and prototype or preproduction model(s) of the entire system. Compatibility and interoperability with existing or planned equipments and systems shall be tested.

b. During the development phase following the Program Initiation Decision (Milestone I), adequate DT&E shall be accomplished to demonstrate that technical risks have been identified and that solutions are in hand.

c. During the Full-Scale Development phase and prior to the first major production decision, the DT&E accomplished shall be adequate to insure: that engineering is reasonably complete; that all significant design problems (including compatibility, interoperability, reliability, maintainability, and logistical considerations) have been identified; and that solutions to the above problems are in hand.

d. For those systems which have a natural interface with equipment of another Component or may be acquired by two or more Components, joint DT&E may be required. Such joint testing will include participation and support by all affected Components as appropriate. (2)

ARMY LOI IMPLEMENTING THE NEW MATERIAL GUIDANCE

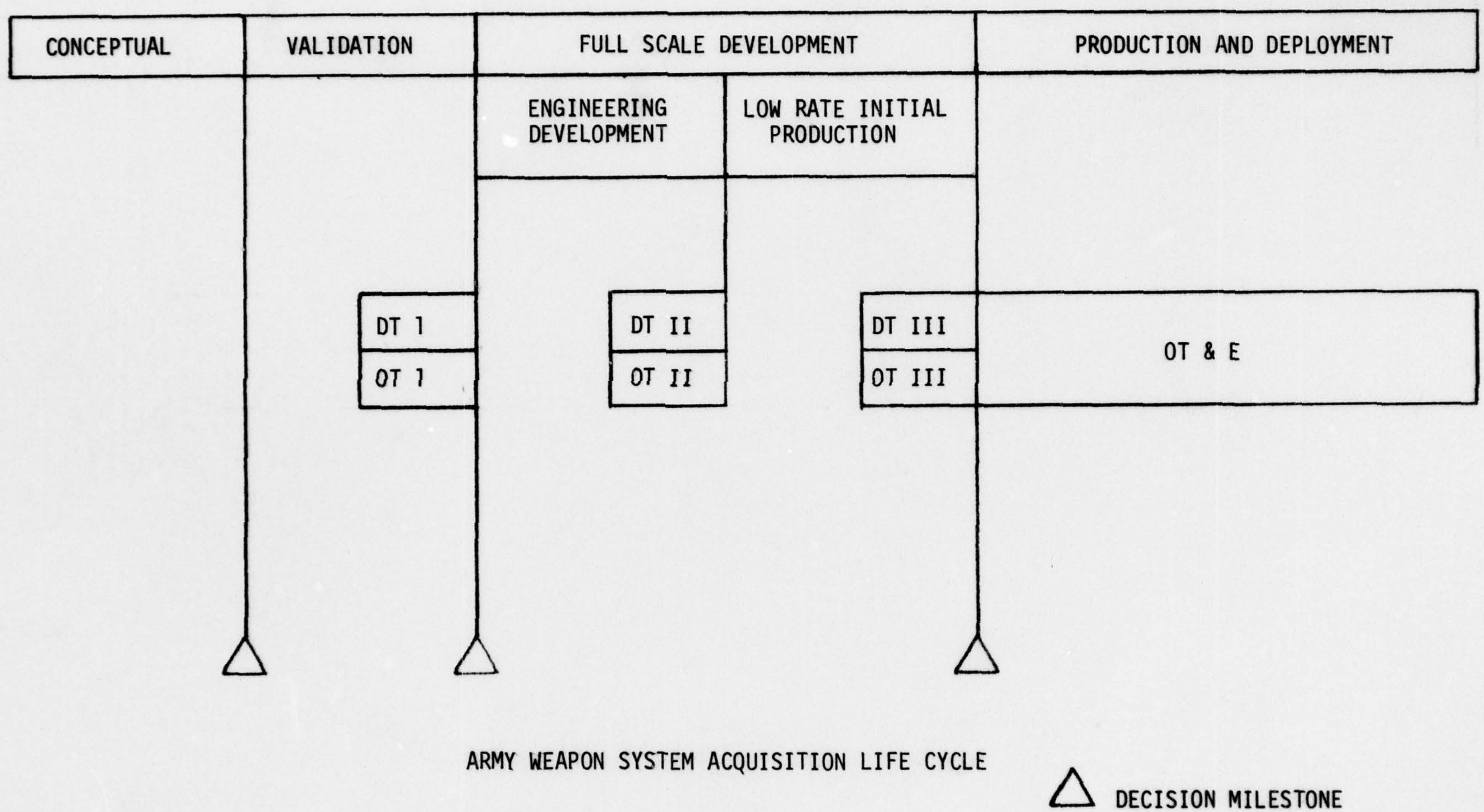
The Army LOI describes Development Testing (DT) and Operational Testing (OT) as a function of the life cycle. Figure 1, Army Weapon Systems Acquisition Life Cycle, depict the relationship the various test categories.

1. Development Testing (DT)

DT is the responsibility of the Army Materiel Command and includes engineering testing and that part of service testing which assesses operability and maintainability of the system by the prospective user. Initial Production Testing (IPT) is now considered as included within the third phase of development testing.

DT is to be started early in the development cycle as possible and should first test components, then subsystems, and finally prototypes or preproduction models of the entire system. Any test data which was previously acquired, regardless of the source, should be used whenever applicable. Representative user personnel should participate in this testing in order to insure "soldier proofing", i.e., assure that human factor considerations have been properly designed into the hardware. The DT test results, reports, and evaluations must be distributed so that review by commands and agencies involved in the decision making process can be accomplished in a timely manner.

During advanced development, adequate DT must be accomplished to demonstrate that the technical risks have been fully



ARMY WEAPON SYSTEM ACQUISITION LIFE CYCLE

FIGURE 1

identified and are manageable.

During engineering development and prior to the first major production decision, the DT accomplished should be adequate to insure that the engineering is reasonably complete; that all significant design problems (including reliability, maintainability and logistical considerations) have been resolved; that manufacturing methods and production engineering data have been generated; and that production planning has been completed to the extent required to provide a realistic basis for estimating costs and delivery schedules.

DT of early production models must be accomplished to assure that the characteristics of the production item meet the prescribed system specifications.

a. DT I is conducted early in the development cycle (Validation Phase). Components, subsystems, or the complete system is tested to determine if the system is ready for Full Scale Development. If this is a test of competing systems, then its purpose is to provide a comparison between the systems being tested. Operational Testing, if appropriate, is conducted concurrently with this test phase.

b. DT II provides the technical data necessary to make a decision if the system is ready for production. It measures the technical performance of the item, its associated tools, test equipment, training package, and maintenance support package. Reliability and maintainability are also evaluated during this test phase. DT II also includes "soldier proofing" by representative user personnel but not necessarily in an operational environment. Operational testing is conducted concurrently by the OT command or agency.

c. DT III is conducted on systems from the initial production to verify that the hardware meets its production specification. This also confirms that any deficiencies previously found have been corrected, and this replaces the Initial Production Test. (3)

2. Operational Testing (OT)

OT, like DT, is started as early as practicable in the development cycle, beginning with early prototypes and continuing through production. OT is accomplished by the user and support personnel of the type and qualifications of those expected to use and maintain the system when deployed. The actual testing will normally be conducted in phases, keyed to the appropriate decision point. The OT test results, reports, and evaluations must be distributed in a very timely manner so that the needed review by the decision makers can be accomplished without delay.

The Army has designated that the Operational Test and Evaluation Agency (OTEA) is responsible for making sure that adequate OT is conducted for all major systems. The OTEA will coordinate with the user in planning for and the conduction of OT. OTEA prepares the independent evaluation of the adequacy of the testing and the validity of the results at the completion of each phase of OT.

a. OT I provides early information as to the operational suitability of the system and also provides a comparison to existing systems. This test phase can identify problems which would be addressed in subsequent testing. If competitive prototypes are being tested, then the testing would be accomplished with DT I using one coordinated test plan.

b. OT II is done just prior to the production decision and it provides a specific assessment of the system's operational suitability and effectiveness. It also provides the data necessary to check on and modify if necessary the training, logistics, organizational, and employment concepts. A small troop is used in this phase to submit the equipment to a realistic operational environment. Data from this phase, together with an independent evaluation, is required by the decision makers to assist them in making a Low Rate Initial Production decision.

c. OT III is accomplished using early production models and provides the following:

   (1) Information pertaining to earlier estimates of operational effectiveness.

   (2) Determines the operational suitability of the production model.

   (3) Optimizes organization and doctrine.

   (4) Validates training and logistic requirements.

(5) Identifies actions that need to be taken before deployment. (4)

WEAPON SYSTEM LIFE CYCLE

As additional background to assist the contractor in test planning activities, it is important that he have an understanding of the evolution of the life cycle of a weapon system. The evolution of a weapon system follows a series of well-defined phases which together form the system life cycle. In each phase there is a sequence of activities, events and specific outputs germane to that phase which must be accomplished before moving to the next phase. The following paragraphs on System Life Cycle define these phases and presents a generalized sequence of engineering activities accomplished in each phase.

1. Conceptual Phase. During this phase, the technical, military, and economic bases for an acquisition program are established through comprehensive systems studies and experimental hardware development and evaluation. The conceptual phase is highly iterative. Its stages overlap rather than occurring sequentially; however, flowing from interacting inputs of operational needs and technology, generally the following stages occur:

   a. Identification and definition of conceptual systems.

   b. Analysis (threat, mission, feasibility, risk, cost, tradeoffs, etc.).

   c. Experimentation and test (of operational requirements, key components, critical subsystems and marginal technology).

   The outputs of the Conceptual Phase are alternative systems (including a preferred system) and their associated program characteristics (costs, schedules, and operational parameters) based on a combination of analyses, experiments and test results.

2. Validation Phase. This is the phase in which the major program characteristics (technical, cost and schedule), through extensive analysis and hardware development, are validated and is often identified with Advanced Development. It is preferred to rely on hardware development and evaluation rather than paper studies, since this provides a better definition of program characteristics, higher confidence that risks have been resolved or minimized and greater confidence in the ultimate outcome. In an idealized case, this phase ends when a representable engineering model has been demonstrated successfully.

3. Full-Scale Development Phase. During this phase, the weapon system including all of the items necessary for its support (training equipment, maintenance equipment, handbooks for operation and maintenance, etc.) is designed, fabricated and tested. The intended output is a "hardware model" whose performance and reliability has been proven experimentally and the documentation needed to produce for inventory use. An essential activity of the development phase is test and evaluation, both that conducted by contractors and that conducted by the Service.

4. Production Phase. During this phase the weapon system, including training equipment, spares, etc., is produced for operational use.

5. Deployment Phase. During this phase the weapon system is provided to and used by operational units. (5)

CHAPTER II

CONSIDERATIONS, GUIDANCE AND APPROACH FOR CONTRACTOR TEST PLANNING DURING THE CONCEPTUAL PHASE

This chapter focuses on the considerations a contractor should make during the Conceptual Phase (CP) of an Army missile system to assure adequate evaluation of technical performance for deliverable hardware within prescribed cost and schedule constraints.

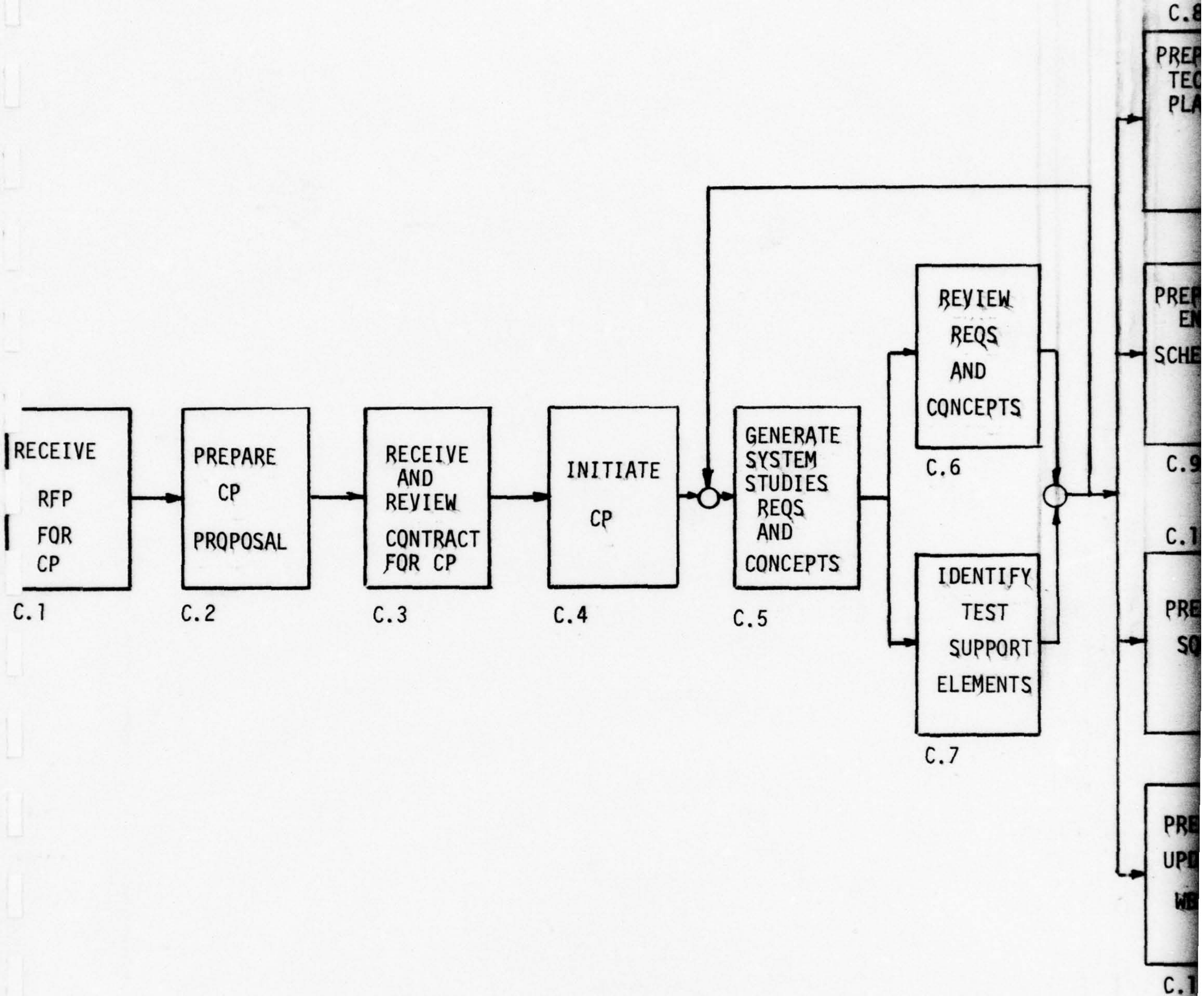
Comprehensive test planning is the tool a contractor has at his disposal to accomplish this task. By and large, test planning is an artform that heretofore has been "fuzzy" and, consequently, costly. New approaches to test planning must be explored if cost effectiveness is ever to be introduced in test process.

In order to give the contractor visibility to the interactions between test oriented program elements and all other program elements in identifying and controlling test efforts, cost and cost estimating, this report recommends that a modified systems engineering approach be adopted in the contractor test planning process. This can be achieved by diagramming the test related program elements and their interactions with other program elements. Figure 2 illustrates the concept. Task oriented block diagrams can be constructed for each phase of the life cycle and can depict the major test related tasks and activities to be accomplished. These tasks and the general sequence in which they are to be accomplished can be displayed on an activity flow diagram. The concept of iterative refinement or "tailoring" can be handled through the use of closed loop notation. Major blocks on the diagram can then be further expanded or described by accompanying text.

In order to demonstrate the approach, this paper addresses test activities associated with a hypothetical Conceptual Phase. The Conceptual Phase was selected due to the amount of strategic test planning and tradeoffs that occur in this phase which establishes a test "benchmark" for follow-on phases.

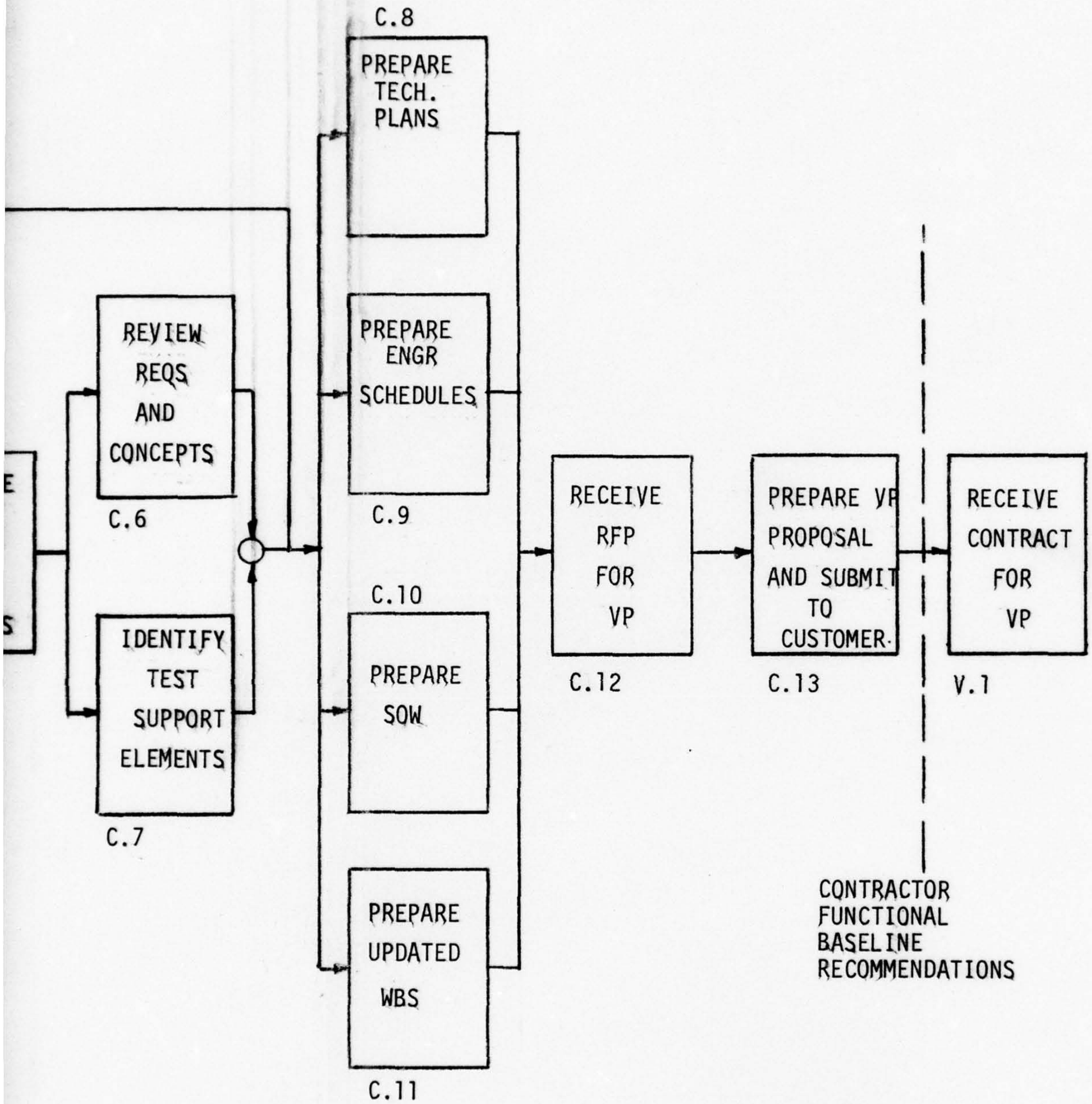
Since discussions will be directed to addressing the test related activities and tradeoff candidates in the Conceptual Phase (CP), an expansion of the contractor responsible efforts during CP is in order.

The efforts during CP are concerned primarily with comprehensive studies leading to the technical, economic and military basis for a decision to develop a new capability. Specifically, it involves the development and selection of the best system approach which will satisfy established mission and performance requirements, and the investigation of feasibility of the approach from a technical, cost, and schedule standpoint. Some of the activities which characterize this period include the preparation of a preliminary system specification, a system development plan, a maintenance support plan, a coordinated test plan, the documentation associated with the prerequisites to contract definition, a plan for conducting contract definition, and a description of the system to be developed (i.e., functional baseline documentation). Near the end of CP, a system review is conducted by both the contractor program office and the government program office to ensure that the necessary preliminary work has been done and that the threat and operational analyses, the tradeoff and cost effectiveness studies, and the development of components and technology provides a firm foundation for engineering development.



CONTRACTOR SYSTEM TEST RELATED ACTIVITIES
CONCEPTUAL PHASE (CP)

FIGURE 2



SYSTEM TEST RELATED ACTIVITIES
NCEPTUAL PHASE (CP)

FIGURE 2

CP ends with a customer decision to pursue the program and to secure the necessary approvals to proceed into validation phase (VP). Most of the major test related events and activities of this phase of the life cycle are described by Figure 2.

The remainder of this chapter's discussion will be centered on describing major test related activities in CP as depicted by the coded blocks in Figure 2. Since system test activities are minimal in blocks C.1 through C.6, the discussion will begin with block C.7.

BLOCK C.7 IDENTIFICATION OF TEST SUPPORT ELEMENTS

The CP RFP will be utilized to define the test support requirements and conduct preliminary design synthesis of hardware, software, computer programs and personnel required for the validation phase test program. The elements engineered will be in support of development, qualification, maintainability, reliability, environmental, field and other required tests. It should be noted that specialized equipment and software developed may be carried over into the FSD phase to support manufacturing operations and flight testing.

This phase will establish firm test support end item and component design requirement sheets for all support elements (including software and computer programs). In addition, detail development, environmental, certification and qualification test programs conducted in the laboratory and the field will be drawn up with the necessary plans to achieve these program efforts. The level of effort accomplished will be to the detail necessary to provide a firm contractor estimate for the price of all testing and support necessary for the validation phase (VP).

BLOCK C.7.1 IDENTIFICATION OF TEST SUPPORT REQUIREMENTS

The test activity requirements and constraints will be identified from CP specifications and also from test plans and descriptions in the RFP. In addition, the requirements, configuration and constraints of existing facilities and equipment that will be utilized by the program will be factored into this process within the appropriate function.

BLOCK C.7.2 PERFORM TEST SUPPORT FUNCTIONAL ANALYSIS

A detailed analysis and survey will be performed to determine the test support functions. The analysis will utilize the preliminary information developed in pre-CP activities and revised for the CP proposal effort. During this phase, the analysis will be revised, refined and significantly expanded to completely describe all test elements. It should be noted that all reasonable alternatives will be developed and included in the analysis. Test support functions to the lowest indentured level of WBS hardware and software functions are required to comprehensively identify the criteria necessary for the development of design requirements and synthesis of elements. The analysis expansion should identify and define all test support elements, and should establish that, as a minimum, the following items have been considered.

1. Functional checkout equipment and consoles
2. Environmental simulation equipment
3. Test fixtures
4. Models and boilerplate operations equipment
5. Facilities (mechanical, civil, electrical, fluid, gaseous, environmental, communications).

6. Operations equipment, instrumentation, telemetry and land line and receiving elements
7. Operation range support (mechanical, civil, communications, electrical, fluid, gaseous, range safety, photographic vehicles, telemetry station, land line instrumentation)
8. Data acquisition and reduction equipment
9. Computer programs
10. Procedures and other software
11. Personnel for test support operation

If necessary, the expansion will be to the level where there is identification and definition of critical and long lead elements. Iteration should be used to accomplish the detail expansion of functions and assignment of each function to a Test Support element. All alternative approaches to accomplish the test support functions necessary for VP shall be resolved prior to the end of CP. Provisions will be built into the analysis to insert added test support functions and element assignments during the VP phase where detail design makes these functions apparent.

BLOCK C.7.3 ITERATE TEST SUPPORT ANALYSIS

By iterative process and in parallel with the function analysis, Engineering will refine and expand the hardware/software approach including developing alternatives to accomplish the test support function. This will include revising previously developed schematic diagrams, sketches and text descriptions as proposed during the VP proposal effort. In addition to analyzing hardware and facilities, equal emphasis will be placed on identifying procedural data and personnel.

Preliminary design of the equipment, software and facilities will be started and carried to sufficient depth to clearly show the design approach to each element. Studies should be performed to determined man-machine interfaces and establish the personnel required.

BLOCK C.7.4 TEST SUPPORT EVALUATION AND DECISION

Test support elements will be selected primarily by using quantitative measures of effectiveness with no provisions for weighing the various effectiveness parameters. The effectiveness criteria under these conditions are usually described as best performance for lowest cost and best schedules with little attention given to other more or less insignificant variables. Typical examples that fall into this category are:

1. Small test fixtures and jigs
2. Piece part instrumentation both for laboratory and field
3. Calibration equipment and tools
4. Software and computer programs
5. Small test specimens
6. Relatively simple electronic, structural and hydraulic operating equipment

However, with large test support systems containing a multitude of elements the variables such as power, size, weight, reusability, application to other programs, human factors, reliability, safety, etc., become significant as to the determination of the most effective candidate. In this instance, a complete "Systems Effectiveness" model will be assembled, and utilize both quantitative measures of effectiveness and weighting criteria to arrive at the most effective system to satisfy program requirements.

Typical examples to which this will be applied are:

1. Test stand complex (field)
2. System test laboratory
3. Facilities
4. Environmental simulation equipment
5. Data acquisition and reduction equipment.

In effect, all test support elements will be selected by appropriate trade studies that illustrate and verify through proper evaluation the candidate selected is optimum from all alternative candidates studied. It should be noted that no matter how trivial a trade may be, it will always be documented for visibility and traceability of requirements, alternate solution evaluation and selection decision.

The trade studies performed in this phase should identify those elements that show substantial risk due to "state of the art" design, time or cost.

BLOCK C.8 INTEGRATED TEST PLAN

The integrated test plan is designed to show the coordinated and integrated program of all test to adequately demonstrate technical performance of equipment and procedures from piece part through complete systems when implemented in the follow-on phases. The categories of tests that will be planned are Developmental, Certification, Qualification, System and Field Operation Test. Typical items to be included in the plan are schedules; time allocation for procedure development; laboratory equipment usage; field or special test area fixture usage; design, fabrication and procurement of equipment; instrumentation and fixtures; and data acquisition, reduction and analysis.

1. Developmental Tests. These are tests performed to demonstrate the initial design performance of circuits, structures, mechanisms, aerodynamic shape, etc., to show hardware feasibility. These tests include:

   a. Breadboard (electrical, hydraulic, pneumatic)

   b. Mock-up (structure, system and subsystem)

   c. Structural test (static and dynamic)

   d. Limited environmental test on piece parts

   e. Functional test on piece parts and small assemblies

   f. Life test (piece parts)

   g. Model test (aerodynamics, radiation, R.F.).

   These tests assist in evaluating the design and verifying that it is ready for limited developmental production.

2. Certification Tests. These tests are performed to demonstrate that the design is ready for limited field performance test and to demonstrate operational capability. The tests are normally conducted in limited quantities. These tests include:

   a. Environmental (limited)

   b. Assembly level functional

   c. System static and dynamic loads

   d. Subsystem functional

   e. Limited life and fatigue test.

3. System Tests. These tests are to demonstrate systems hardware operating compatibility and its susceptability to external influences. These tests are conducted just prior to first field

operations tests to ensure the system will perform under limited specified operating conditions. The tests include:

a. Laboratory marriage

b. Static firing tests

c. Ground operation tests

d. Limited environmental tests

e. Selected critical field operation tests

f. System instrumentation checkout and verification.

4. Field Operations Test. These tests are conducted using complete prototype systems to demonstrate performance capability under limited field conditions. These tests include:

a. Flight test (limited configuration)

b. Ground test

c. Environmental

d. Operations and maintenance

5. Qualification Tests conclude the testing performed on systems and subsystems by verifying that the hardware will operate at prescribed performance levels under all environmental and service usage conditions. These tests include:

a. Environmental (all hardware levels)

b. Reliability

c. System flight test (full configuration)

d. System ground (functional and environmental)

e. Maintenance verification

f. Operation verification.

BLOCK C.9 PREPARE ENGINEERING SCHEDULES

Schedules will be prepared for the validation phase "cost" package for all operations, maintenance, test support, production and deployment elements. They will be based on the system specification, subsystem requirements, component requirements, preliminary detail design and customer master schedule of activities. The prepared schedules will indicate as a minimum the following elements with their start, significant intermediate and completion dates.

1. Preliminary design
2. Breadboard, mockup and model design and test
3. Basic design
4. Functional and environmental test
5. Certification test
6. Qualification test
7. Field and customer demonstration test
8. Reviews
9. Critical hardware milestones of design, procurement and test
10. Soft and hard tooling design, procurement, fabrication, checkout and availability
11. Software elements for maintenance, production, deployment
12. Test support elements design, procurement, fabrication checkout and availability
13. Test procedures
14. Hardware procurement, fabrication and availability
15. Personnel training and demonstration
16. Facility design, checkout and availability.

All pertinent dates and span times concerning significant events will be included in the schedules, examples of which are: checking, long lead items, data to the customer, customer participation, data from subcontractors, associates and prime, incentive milestones, engineering analysis (stress, weight, circuits, dynamics, system, etc.) wind tunnel, data acquisition from test, computer simulation, etc.

BLOCK C.11 WORK BREAKDOWN STRUCTURE UPDATED

The test support elements identified during CP provide updating information to be used in detailing the Work Breakdown Structure for the validation phase. Initially, the Work Breakdown Structure is furnished by the customer and expanded by him to the summary level. Preliminary design accomplished during CP will expand WBS levels necessary to identify discrete work packages from which a firm price estimate on each detail work package. Accompanying each work package will be a detailed shopping list of assemblies, parts, itemized activities and other program elements that make up a work breakdown package.

BLOCK C.13 REVIEW VP PROPOSAL

The validation phase proposal package will be carefully reviewed and critiqued through a series of technical and management reviews culminating in a final contractor "in-house" management review. Test participation in these reviews is mandatory. The purpose of these reviews is to assure correctness of all technical and management data; depth, completeness and clarity of presentation; and that proper emphasis has been placed on all areas considered critical to winning validation phase contract. The reviews must be conducted early enough to allow for corrections and modifications.

CHAPTER III

ADDITIONAL TEST PLANNING CONSIDERATIONS

The previous chapter presented a generalized approach for planning program test activities during the Conceptual Phase. As a result, a "shopping list" of possible test elements was identified for potential tradeoff candidates that could be used in "tailoring" the development test program.

The purpose of this chapter is to expand the sphere of considerations and provide the contractor with additional insight as to the level of detail that will be required for test planning during follow-on phases. The approach used is to consider a few test elements common to all Army missile systems; such as environmental tests, marriage tests, qualification tests, and flight tests. Particular emphasis has been placed on Range and Range Support planning for flight test programs. It has been the author's experience that unless thorough planning and coordination is effected, program costs are likely to increase and schedules will be jeopardized.

PLANNING ENVIRONMENTAL TESTS

Selected environmental test (often called preflight certification test) will be planned to assure the system and subsystem elements can sustain the rigors of field operation and demonstration without degradation of designed performance. These tests usually include most severe dynamic, static, and thermal environments as well as radiation (nuclear and electromagnetic) susceptability tests. Specific test may be, but are not limited to, shock, vibration, acceleration, temperature, static load, RFI-EMI susceptability, gammaneutron radiation and other environments that cause significantly high level mechanical stress or electronic circuit disturbance.

If there is low confidence that section level hardware does not process adequate repeatability of performance under the influence of environments resulting from manufacturing processes and workmanship, engineering design problems, etc., there will be a Production Environmental Test (PET) program set up and conducted on the critical items on either a sample or an each item basis. These tests will be performed using selected critical environments and at selected levels which will not degrade performance, but will show up deficiencies, problems or malfunctions that would seriously jeopardize engineering and qualification testing.

The sequence of environmental tests will be governed by predetermined test requirements and incorporated in an applicable test plan. The plan will be updated as prototype design progresses. Procedures for conducting the tests, and the necessary support equipment used in the performance of the tests will begin with the establishment of preliminary design updated as required. The results of the tests will be documented in reports that fully described the tests as to conduct, objectives, acceptance criteria, failure criteria, events, observables, data results and conclusions. Procedures and test support documents will be referenced in the report and corrected as necessary to reflect test amendments, corrections and deviations. The documentation developed and published will be placed on file to provide a method of rapid retrieval for future reference.

PLANNING MARRIAGE TESTS

The marriage tests (also called System Tests) are generally planned to be conducted on two or more assembled units of a complex subsystem, the subsystem itself or the complete system to determine functional compatibility, interface compatibility, dynamic range of all functions and other systems test to verify design, fabrication and specified operational characteristics. This test can be used for "proofing" factory acceptance test procedures. Emphasis of these tests will shift from gaining laboratory engineering knowledge to assuring each system manufactured is ready for flight test. It is mandatory that all flight units, including the instrumentation packages and test support equipment, be assembled and checked out in this manner to achieve a high confidence level in attaining demonstration test goals.

The test plans, for the sequence and control of the test, procedure preparation, design and fabrication of test support equipment, and documentation preparation, control and retrieval, should be taken into consideration.

PLANNING QUALIFICATION TESTS

Qualification tests are planned to demonstrate that the developed system/subsystem will operate as specified and there is no out-of-tolerance performance due to environmental influence. These tests are conducted on the lowest indentured identifiable assembly or component on the WBS that is performance critical to the system and on all subsystems as required to show proof of performance. The types of test that may be performed are:

1. Laboratory environmental test on components, assemblies, subsystem and system.
2. Field Test on complete system.

Laboratory Environmental Test: These tests will subject qualification hardware to simulated environmental stress, corrosion and erosion levels. The object of these tests are to perform parametric performance studies under the influence of the specified environmental extremes, including those particular levels that critically disturb the test specimen performance. All design or functional deficiencies observed will be corrected by an appropriate change and the unit retested. The test results of each test specimen will be published in a report that contains all pertinent test information such as:

a. Specimen configuration
b. Specimen hardware changes required
c. Support equipment and configuration
d. Procedures and deviations
e. Data (raw and reduced)
f. Design and performance irregularities observed
g. Results and analysis
h. Conclusions and recommendations
i. Test configuration and deviations
j. Acceptance and failure criteria.

PLANNING FLIGHT TESTS

These tests require operation of the system under actual field environments to determine the system performance and functional capability within specified design tolerances and requirements.

The test results of each system test will be published in a report that contains all the pertinent data described in the laboratory environmental test paragraph.

At the end of the Development Testing, an overall report will be published which summarized the equipment tested, equipment major changes, confidence level of the test, overall test results, overall conclusions and recommendations.

Another salient feature of field test is that it provides an excellent opportunity to verify and also gather valuable background material on the logistic elements (technical publications, personnel utilization, maintenance procedures, material allocation, equipment utilization, training required, test and checkout of field located equipment, etc.).

Structuring the flight test program is a delicate balance of art, science and political procedures. It is at the focal point of leverage for program cost, schedule and performance considerations. The number of missiles to be fired, the intended mission, the success or failure criteria, the types of targets, etc., all play an important role in flight test planning.

RANGE FACILITIES PLANNING

Most flight test programs are conducted at off site locations due to hazardous nature of missile launch operations. Generally these off-site locations are test ranges operated by the government or in a few instances, by private contracts.

The program using these ranges will require facilities ranging from limited office and work spaces to elaborate launch complexes. The modifying, designing, building, and operating these facilities must be included during the early planning efforts.

In most cases the test range to be used will be specified by the contracting agency. In some cases, however, it is necessary to conduct a survey of available ranges to determine which best satisfies the objectives of the test program at minimum cost to the overall program. Selection of a facility site on a given range is a function of several variables. These include the availability of existing facilities which may be suitably modified; constraints on location due to some hazardous nature of the system during ground handling or in flight; system performance characteristics such as range, field or fire or flight envelope; and a test design requirement such as maximizing the effectiveness of available instrumentation. Once the range is chosen and a site selected, the required test facilities to support the program must be identified. Generally flight test facilities fall into the following categories:

1. Launch complexes
2. Assembly areas
3. Office and shop work areas
4. Storage facilities (warehouse and stockroom)
5. Special utility requirements

The test facilities may be supplied by the contractor, range, or by various sub and/or associated contractors or by a mixture of all of these. Extensive liaison is required to coordinate these agencies and the coordination effort must be included in planning considerations for the flight test program. The successful preparation of a flight test facility prior to the first launch includes the following type of activities:

1. Preparation of interface specifications and design criteria.
2. Preparation of layout, installation, and detail design drawings.
3. Review of designs by associated contractors.
4. Construction (generally through subcontracts), or
5. Construction surveillance if actual construction responsibility rests with the Corps of Engineers or another agency.
6. Activation - the installation of system peculiar hardware.
7. Test and checkout of the facility to insure adequacy prior to first launch attempt.
8. Selection, training and deployment of field personnel.

Since the preparation of a test site is generally a long lead time item, early identification of test objectives, philosophies, system hardware, and auxiliary equipment (instrumentation, test and checkout equipment, and special test tools) will materially aid in test facility planning.

RANGE SAFETY PLANNING

There is a tendency in planning a missile system flight test program to neglect or attempt to ignore the requirement for a range safety system. This generally occurs because of one or a combination of the following reasons:

1. All early effort is concentrated on the tactical system design;
2. A range safety system complicates, and sometimes compromises the "tactical design"; and
3. They are costly.

Nevertheless, because most test ranges contain large numbers of complex instrumentation, extensive facilities, numerous personnel, and are sometimes located too near large population centers; the test program will not be allowed to operate without range safety provisions. The initial step is to contact the designated test range and determine the established range safety criteria. Based on this determination the requirements for a range safety system should be developed and processed. The activities required include some or all of the following:

1. Failure mode studies.
2. Flight envelope or "footprints" studies for various malfunctions.
3. Conceptual design studies to evaluate methods of meeting the range requirements.
4. System design and documentation. This should include sequence formal reports.
5. System verification, test, and demonstration including test hardware.

Most range safety systems will require not only on-board provisions, but also special test and checkout equipment on the ground to insure operational readiness before launch.

RANGE INSTRUMENTATION PLANNING

Data measurements necessary for system performance evaluation must be determined in the initial program planning phase. Subsequently, a determination is made of the measurement and data retrieval systems available.

Sources for data measurement and retrieval will generally fall into three areas:

1. Government operated national test ranges.
2. Privately operated industrial test facilities.
3. Self-furnished by the program contractor (prime or sub).

An overall data acquisition plan should be formulated by the system test planner to take full advantage of test capability documentation that are available from range agencies and test facilities.

Most of the government operated test ranges (orbital missions excepted) operate under the National Range Documentation (NRD) system and will provide upon request NRD publications which detail the facility capabilities for supporting program data requirements. Most data involving vehicle tracking and position, meteorology, reception of airborne radio frequency data including telemetry and radar safety surveillance must be obtained directly from National Ranges due to excessive cost to publish the document and security restrictions.

Under certain conditions, "state of the art" hardware may be required for the collection of some data. Seldom, if ever, is such hardware available at government test hanger or facilities. The planner must consider furnishing additional funding for the Range agency to purchase and operate program peculiar equipment. (e.g., laser trackers, IR devices, advanced camera installation, etc.)

TEST RANGE COORDINATION

The official method of coordination between a contractor system test planner and a government test range is by way of the National Range Documentation system. Two important documents that must be completed prior to range commitment to accommodate a missile test program are the Program Introduction (PI) Document and the Range Statement of Capability (RSC) document.

The PI includes a definition of program time phased activities and is a request to the Range to supply specified range resources to support the test program. In addition, it contains that level of detail on the weapon system characteristics to allow the Range agency to determine the amount of support required.

The RSC is the Range response to the Users PI submittal. It outlines the support services to be furnished to the user. The PI and approved RSC forms a basic agreement between the user and Range guides subsequent detailed planning documents for both User and Range.

CONCLUSIONS

This report afforded the author an opportunity to research and survey recent changes in Department of Defense and Army policies in the area of weapon system development testing. The benefits of this effort are reflected in the reorientation of the author's thoughts on "tailoring" a test program away from one of total performance consideration and toward one with balanced considerations of cost, schedules, and performance.

Early and comprehensive program test planning during the Conceptual Phase is essential to program success in that it allows the contractor to identify and tradeoff test elements in order to surface viable test program alternatives and then select a test program that will adequately evaluate the technical performance of deliverable hardware within prescribed cost, schedule and performance constraints.

It is feasible to adopt a modified systems engineering approach as a test planning tool for examining the interactions between program test elements and all other program efforts and, thereby, give the contractor visability in identifying and controlling test efforts, test costs, and test cost estimates. This technique was demonstrated by applying it to a hypothetical Conceptual Phase (in chapter 2); however, its utility in other life cycle phases is obvious.

The potential problems that face the contractor System Test Manager as a result of the new policy changes on developmental changes are many. One problem is the decrease in flexibility to implement alternatives for conducting integrated test activities. Traditionally, test cost accounts have been the repository for management reserve funds. Consequently, funding of test activities has been relatively unencumbered so long as a sound technical test approach was followed. This cornucopia has been turned upside down now that cost has replaced technical performance as the prime consideration in the weapon acquisition process. The System Test Manager must be vigilant in his efforts to assure that the PM is not overcome by enthusiasm to comply with cost objectives to the extent that the test program neither provides an adequate basis for uncovering latent technical risks nor confirms hardware performance to specified requirements. The solution to this problem can be accomplished through close coordination among the System Test Manager, the Program Manager and other managers of the program team.

Another - and in the author's opinion the biggest - problem facing the contractor System Test Manager lies within his test team and subordinates. By and large, test planners and test engineers sense the change in emphasis of program objectives; but are not totally conscious of the impact these new policy changes will have on their day-to-day activities. The System Test Manager must make a concerted effort to educate his team in new program cost techniques as they apply to the test area without destroying or discouraging their diligence toward technical excellence. He must teach them that cost and technical performance objectives are not dichotomous entities, but rather, are elements that must be blended in proper proportions to assure program success.

ANNEX A

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ANNEX B

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