BY ORDER OF THE
SECRETARY OF THE AIR FORCE

AIR FORCE MANUAL 99-110

3 JULY 1995

Test and Evaluation

AIRFRAME-PROPULSION-AVIONICS TEST AND EVALUATION PROCESS MANUAL

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Director, United States Air Force Test and Evaluation (HQ USAF/TE) directed the development of the generic Air Force Test Process as AFI 99-103. HQ USAF/TE further directed the development of supporting manuals for Electronic Warfare (EW); Armament/Munitions; Space; Command, Control, Communications, Computers, and Intelligence (C4I); and Airframe-Propulsion-Avionics (A-P-A) mission areas. This manual is specific to the A-P-A mission area.

Chapter 1

INTRODUCTION

Section A — Introduction to the A-P-A T&E Process Manual

1.1. General. This Air Force Manual (AFMAN) implements the Air Force (AF) test and evaluation (T&E) process for the Airframe Propulsion and Avionics (A-P-A) mission area systems for aircraft (manned or unmanned) and cruise missiles. It is intended to be universal for use by both the government and contractors during any phase of the acquisition cycle in a wide variety of environments, including government owned/operated test facilities, commercial labs, large open air ranges (OARs), Air Force Test Centers, Product Centers, Air Logistics Centers (ALCs), Air Force Operational Test and Evaluation Center (AFOTEC), and major air commands. It is a guide for use by program managers, test managers, test engineers, test organization personnel, major command headquarters staffs, and others involved in T&E of A-P-A mission area systems. This Air Force Manual (AFMAN) takes the Air Force T&E process described in Air Force Instruction (AFI) 99-103, *Air Force Test and Evaluation Process,* and tailors it for A-P-A mission area systems. This manual, as well as AFI 99-103 and its associated instructions and manuals has application for test items made in the United States or in foreign countries and applies to Developmental T&E (DT&E), Operational' (OT&E), Qualification' (QT&E), Follow-on Operational '(FOT&E), Qualification Opera-tional '(QOT&E), and Initial Operational T&E (IOT&E).

1.1.1. This manual was written assuming that A-P-A mission area systems are part of a larger system, the weapon system which is defined as "A composite of prime operating resources and equipment including aircraft, weapons, weapon racks/launchers, personnel, software, etc., and ancillary resources and equipment including training and support equipment, logistics, etc., used directly by the armed forces to provide an operational combat capability." As such, the A-P-A mission area T&E may require the integration, use, and support of non-A-P-A mission area systems to accomplish A-P-A system test objectives. Other process manuals relating to T&E of aircraft systems include *Electronic Warfare (EW); Command, Control, Communication, Computers, and Intelligence (C4I); Space; and Armament/Munitions* and are contained in AFMANs 99-112, 99-111, 99-113, and 99-104, respectively. See **Attachment 3** for additional T&E related references.

1.2. Scope. This manual covers A-P-A mission areas and systems associated with fixed and rotary wing aircraft, unmanned aerial vehicles (UAV), and cruise missiles. For these air vehicles, related systems and disciplines covered in this A-P-A manual are:

- **Airframe.** Flying qualities, flight controls, structures (airframe itself, inlet design, loads, and flutter), performance, stores integration and separation characteristics, installed engine performance, mechanical systems *(*i.e., hydraulic, electrical, environmental control, landing gear), crew stations (cockpit layout, payload bay, etc.), and mission/auxiliary systems (i.e., airframe mounted auxiliary drives/gearbox, generators.).
- **Propulsion.** Powerplant, inlet effects, nozzle, uninstalled engine performance, and auxiliary power including systems such as jet fuel starter (JFS) and auxiliary power unit(APU).
- **Avionics.** Sensors, communications, navigation, and identification (CNI), guidance, electronic warfare (EW) integration, support/mission systems [includes stores management systems, fire control systems, weapon integration, air-to-air (A/A) and air-to-ground (A/G) delivery accuracy, controls and displays, mission operational flight programs (OFPS), etc.].

1.2.1. Although other necessary specialty disciplines such as: aerial delivery, logistics, human factors, environmental/climatic, instrumentation, software, and safety are not specifically called out in the A-P-A mission area discussions, they are common and of paramount importance to these functional mission areas. Their involvement in the test process is addressed within the templates in section 3.2 of this manual. Also, because most A-P-A system, subsystem, and component hardware is controlled by software, A-P-A related embedded software T&E is also covered in section 3.2 of this manual. Details of software only and hardware only T&E are not included within this manual, instead, software and hardware are treated as merged elements of functional units (i.e., components, subsystems and systems).

1.2.2. A-P-A systems testing that requires the use of stores, missiles, or munitions represent air vehicle/weapon integration tests. Air vehicle/weapon integration testing is common to both the A-P-A T&E process and the Armament/Munitions T&E process. Generally, if the air vehicle is in development or being modified, integration of inventory armament/munitions is tested via the A-P-A T&E process. If the armament/munitions is in develop-ment or being modified and being certified for carriage on a mature platform, the system will generally be tested via the Armament/Munitions T&E process. Integration of new munitions onto a new air vehicle will be tested using a combination of the A-P-A and Armament/Munitions test processes.

1.3. Document Roadmap. This manual is divided into the three separate and distinct areas shown in **Figure 1.1.** The first area, which contains sections 1 and 2, is in narrative format and introduces the A-P-A T&E processes at a high level. The second area, section 3, addresses the application of the A-P-A T&E process which uses a work breakdown structure (WBS), combined with a template format (similar to Willoughby Templates, Department Of Defense (DOD) 4245.7-M, *Transition From Development to Production*) to subdivide the A-P-A mission systems/disciplines into finer details. The template/WBS format allows the reader to quickly gather necessary information at a level of detail controlled by the reader and can easily accommodate changes, updates, and more detailed levels. The third and final area is comprised of the attachments.

Figure 1.1. A-P-A Manual Roadmap.

Sections 1&2	Section 3	Attachments
- Narrative Format	- Template Format	- Narrative Format
- Common to all A-P-A Mission Areas	- A-P-A T&E Process Application	1. Acronyms, Abbreviations, Bibliography, and Glossary of Terms 2. System Development 3. T&E Resources
- Provides Information on: -- General overview (Sec. 1) -- A-P-A T&E Process (Sec.2)	- Uses WBS to Breakdown APA into Details	
	- Provides Details of: -- Test Process -- Mission Req/Integ. -- Documents -- Embedded Software -- Exit Criteria -- Resources	

1.4. Need. The need for implementing a disciplined Air Force T&E process is more critical now than ever before. The complexity of today's highly integrated systems demand the implementation of a process that will enable the efficient use of limited resources, minimize risk during weapon system development and provide an effective, quality product that will satisfy user requirements. The A-P-A T&E process described in this manual has been developed to help guide you through the steps necessary to plan and execute your test effort. By giving proper emphasis to pre-test planning and post-test evaluation, you will minimize the risks and costs hidden within weapon system development and identify deficiencies before the system is operationally tested and fielded. Early involvement of test centers helps to reduce cost and improves the timeliness and effectiveness of testing. The manual is written to provide you, the test planner, guidance on what to do to effectively implement the T&E process, not how to do it. "How to" details are contained in a variety of published guides and handbooks located at test centers, program offices, laboratories, etc.

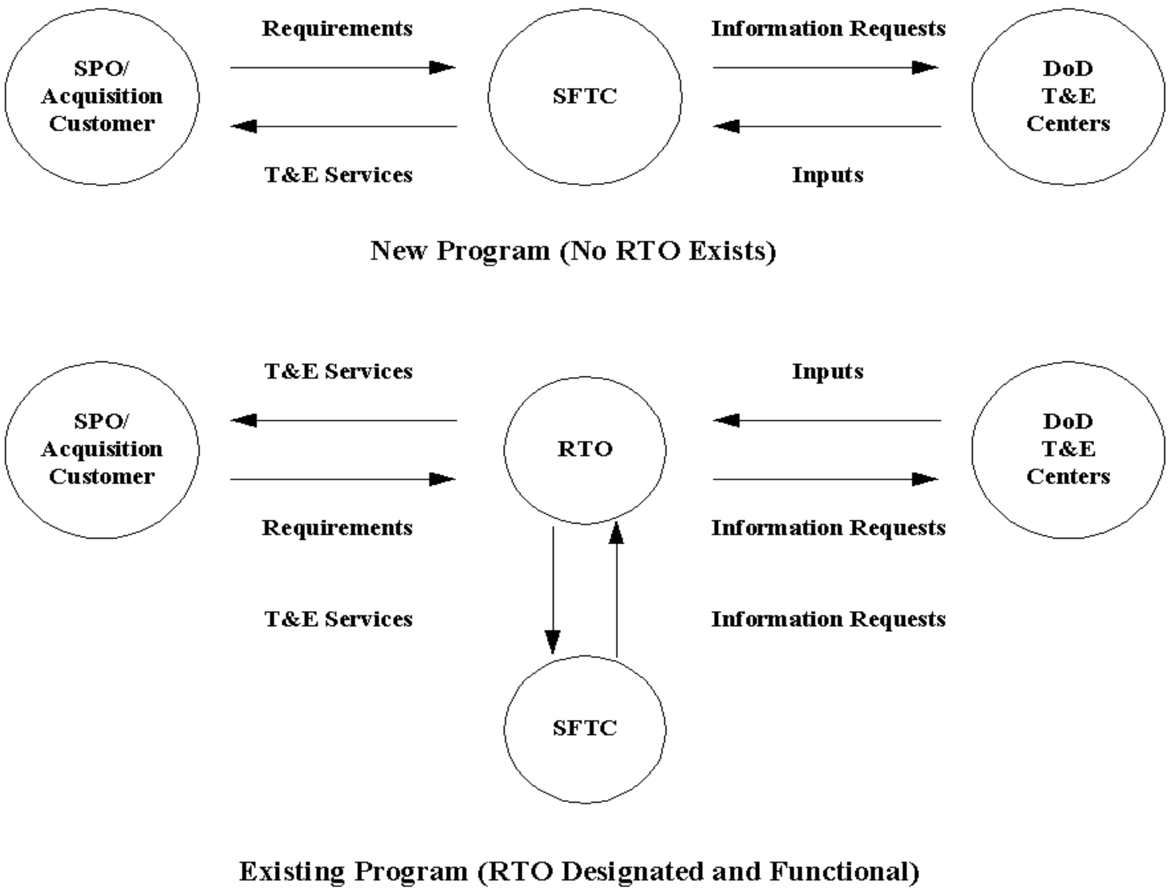
1.4.1. This manual implements the Air Force T&E process for A-P-A mission area systems, and covers items from the operational inventory, developmental or research items, as well as concept evaluations. The manual is a specific application of the generic Air Force T&E process described in AFI 99-103 and covers a wide breadth of airborne weapon system functionalities and specialties, including embedded software which supports A-P-A systems. It is tailored towards personnel not intimately familiar with A-P-A related T&E or how T&E specifically fits into the Department Of Defense (DOD) acquisition process (DOD 5000 series). This includes: experienced acquisition managers with limited T&E experience, inexperienced acquisition managers and personnel, inexperienced testers (both within and not within A-P-A related mission area), and personnel not intimately familiar with the acquisition process. Experienced testers may also find this manual useful as an A-P-A T&E documentation source.

1.5. Direction. HQ USAF/TE defines and directs the use of the Air Force T&E process. The A-P-A Single-Face-To-Customer (SFTC) office is responsible for documenting and advocating the A-P-A T&E process. Stakeholders in the A-P-A T&E process include, but are not limited to: Air Force Materiel Command (AFMC)/DO/XR/EN/LG, AFOTEC, Responsible Test Organizations (RTOs), Participating

Test Organizations (PTOs), Operational Test Agencies (OTAs), Aeronautical Systems Center (ASC), System Program Offices (SPOs), Air Logistics Center (ALC), Electronic Systems Center (ESC), Space and Missile Center (SMC), Laboratories, and Major Range and Test Facility Bases (MRTFBs).

1.6. A-P-A Single-Face-To-Customer Office. The goal of the A-P-A SFTC office is to improve the efficiency and cost effectiveness of A-P-A T&E by assisting customers in early application of the A-P-A T&E process, identifying risks in test options available to the customer, and helping the customer understand the capabilities and test applications of the T&E resources available to them. The SFTC Office brings in the expertise of the above mentioned stakeholders so that the customer understands the capabilities of the available T&E resources. The objective is to reduce the programmatic risks to performance, cost, and schedule. The interfaces used by the SFTC offices to provide services are presented in **Figure 1.2.** and also in the SFTC Mission Needs Statement (MNS)

Figure 1.2. T&E Organization and Customer Interface.



1.6.1. If you plan to conduct a test in one or more of the A-P-A mission areas you should contact the A-P-A SFTC office. This office helped document the A-P-A T&E process, is the custodian of it, and can provide assistance with its implementation for your program. The A-P-A SFTC office also has experienced test planners to help you define cost-effective testing options for consideration by you and your test customer. Further, it has investment planners familiar with current and future test facilities and capabilities of the Air Force. You should take your customer test requirements and test capability needs to the A-P-A SFTC office. They will help you with your initial test planning and any needed test investment guidance.

For assistance, call or write the A-P-A SFTC office as listed below:

A-P-A SFTC Office

(805) 275-9250 or DSN 525-9250

FAX:(805) 275-7135 or DSN 525-7135

AFFTC/XPS

195 E. Popson Ave.

Edwards AFB, CA. 93524-6842

Other SFTC Offices:

Armament/Munitions	AFDT/DRC
C4I	101 W. D Ave, Suite 125
EW	Eglin AFB FL 32542-5495
	DSN 872-9650
	904-882-9650
Space:	SMC/CUC
	160 Skynet St., Suite 1536A
	Los Angeles AFB CA 90245-4683
	DSN 833-2504

1.6.2. Working with the A-P-A SFTC office should save you considerable time and effort and help you get your early test planning started in the right direction. Once a RTO and OTA has been designated for your program, the RTO/OTA will assist you in your test planning and test support needs [per AFI 99-101, *Development Test and Evaluation* [formerly Air Force Regulation (AFR) 80-14], December 1993 and AFI 99-102, *Operational Test and Evaluation,* (formerly AFR 55-43)]. If your A-P-A test program is a new start or modification/Preplanned Product Improvement (P^3I) program and has a Program Management Directive (PMD), per AFI 99-101 and AFI 99-102, you must contact the A-P-A SFTC office and ask for their assistance on early test planning. If you will be writing or revising an A-P-A related Test and Evaluation Master Plan (TEMP) and an RTO has not been designated, you must also contact the A-P-A SFTC office. The three (3) SFTC offices maintain close contact with each other, therefore if you are not sure whether other SFTCs should be involved, contact the A-P-A SFTC office and they will involve other SFTCs if needed.

Chapter 2

A-P-A T&E PROCESS

Section B—Description of the A-P-A T&E Process

2.1. General. Test and Evaluation is conducted throughout the acquisition process. **Figure 2.1.** illustrates at a top-level where and how T&E related subjects and phases relate to the five acquisition phases and milestones. It should be noted that P^3I mods/upgrades typically conducted during the Production & Deployment/Operations & Support phase may include any or all elements of the system maturity from concept to total system integration tests.

2.2. Weapon System Development Flow. The systems, subsystems, and components associated with A-P-A mission areas are developed through a combination of both independent and interrelated design and test activities. During development, various subsystems, components, and functional areas must be integrated to function as a cohesive unit -- the weapon system. The airborne platform associated with the weapon system is the air vehicle and is the A-P-A T&E process's primary focus. **Figure 2.2.** describes the general flow and integration associated with a typical A-P-A system development. The boxes represent a notional flow and can extend over time. A secondary focus of the A-P-A T&E process is to also provide the data required in the development of ground mission simulators, weapons system trainers, etc. An additional focus is on the testing of support equipment being developed for the weapon system already in inventory as well as performing compatibility testing on this equipment with new systems. This testing will require a dedicated effort and should be part of Logistics Test and must occur in concert with the Prime Mission Equipment tests.

2.2.1. During aircraft development, the various functional and specialty disciplines which comprise A-P-A systems must work closely together to ensure adequate integration. The extent of integration largely depends upon the aircraft's system architecture; federated, integrated, or integrated suite, which are described in the following paragraphs and shown in **Figure 2.3.**

2.2.1.1. Federated System. The various subsystems (radar, nav, flight controls, etc.) function autonomously and only interface where data transfer is required (for example, the air data subsystem provides only pressure altitude to the navigation computer for baro damping). In addition, each subsystem interfaces (via displays, scopes, etc.) with the aircrew separately. The F-4, A-10, and KC-135 are examples of a federated architecture.

Figure 2.1. T&E Relationship to the Acquisition Process.

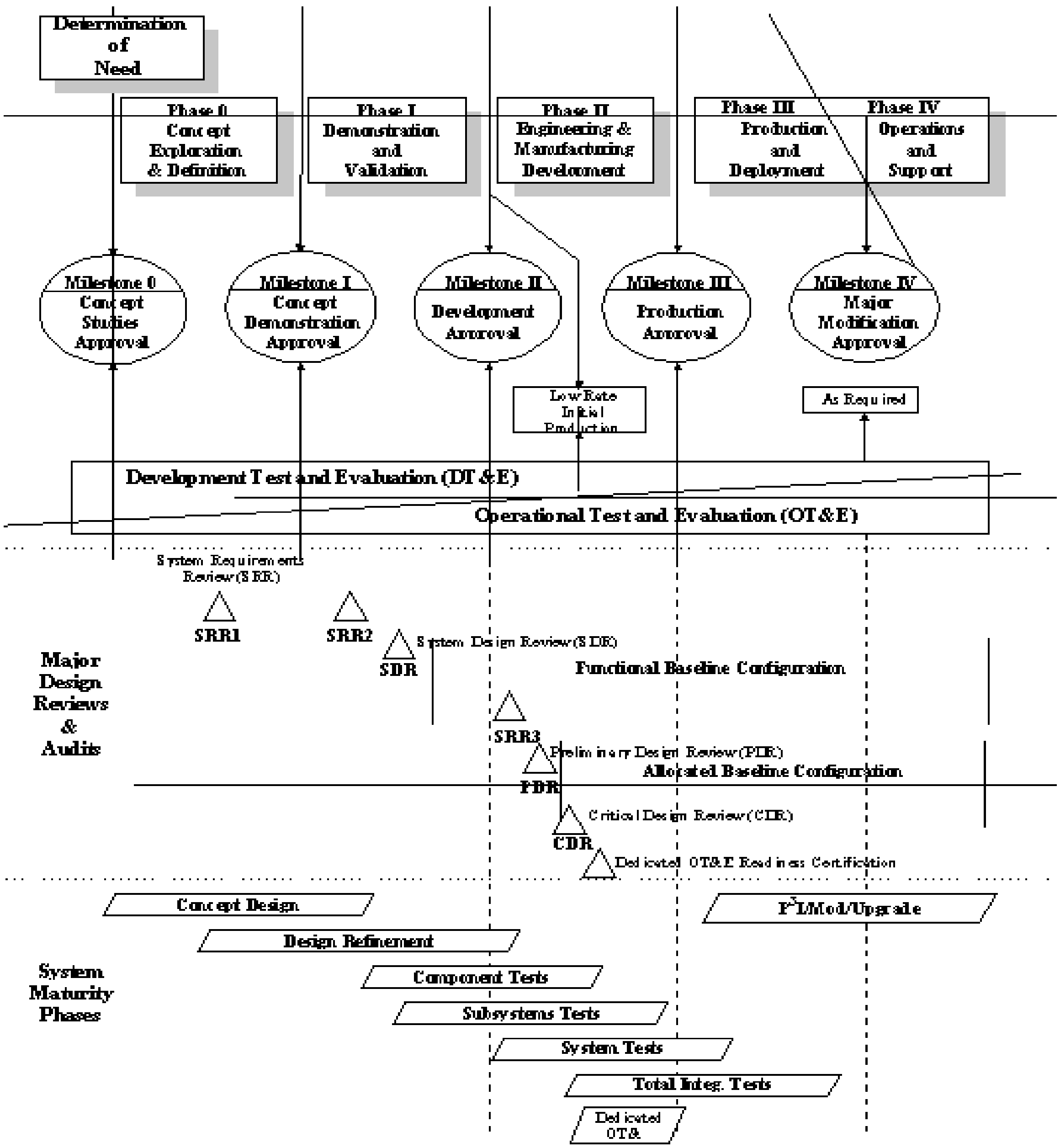
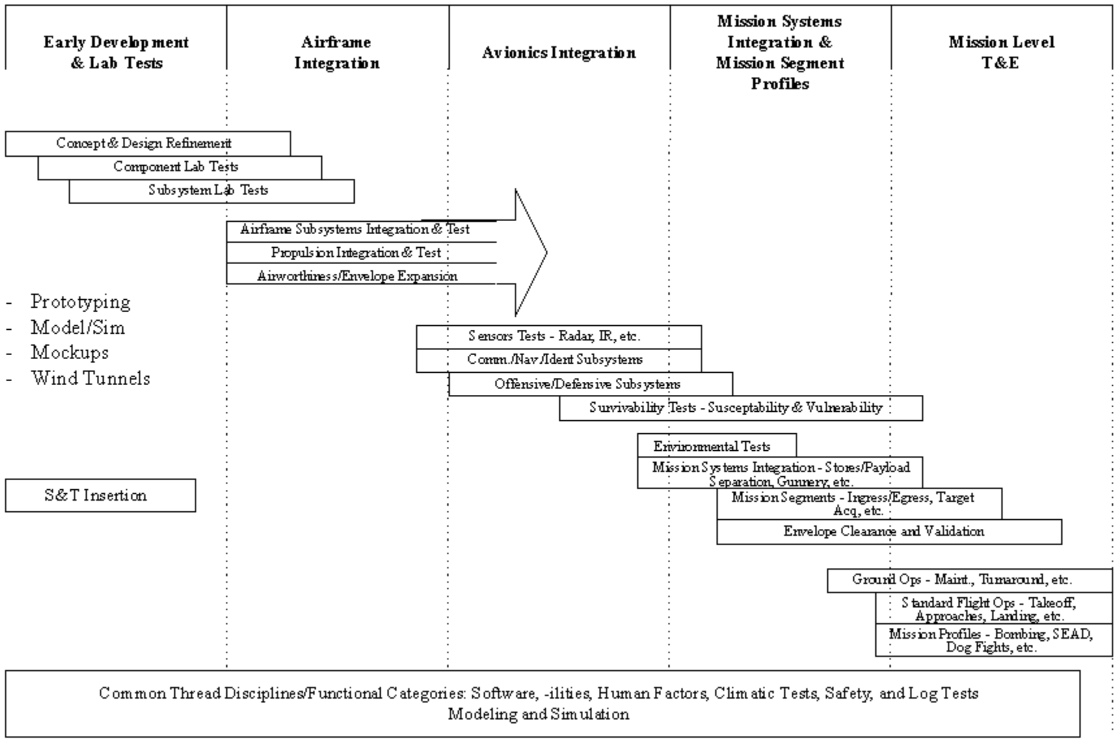


Figure 2.2. A-P-A Weapon System Development T&E Flow.



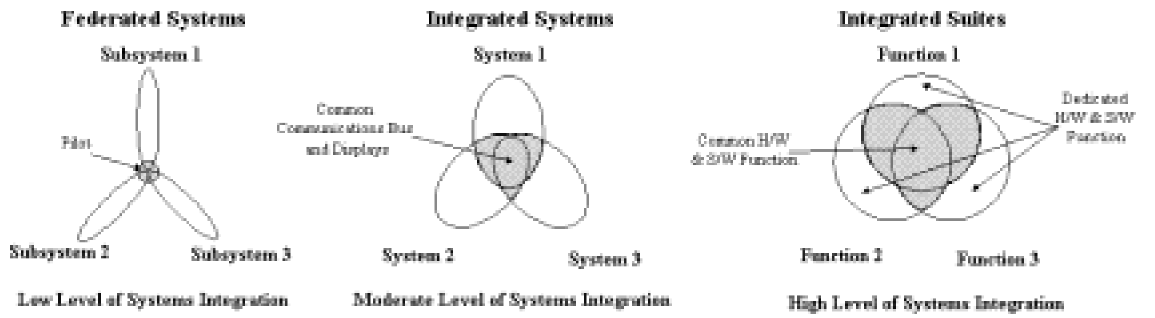
2.2.1.2. Integrated System. A more complex architecture than federated because data are shared between subsystems [usually via Military (MIL)-STD 1553 data buses]. Each subsystem has a central processor which controls the data flow within the subsystem (intra subsystem data flow via subsystem bus) and also communicates with other subsystem data processors (inter subsystem data flow via system bus). Situational awareness is enhanced because data from multiple subsystems can be presented to the aircrew on one display. Systems utilizing integrated system architectures tend to have graceful degradation following a system failure. The F-15E, C-17, and B-2 are examples of integrated systems.

2.2.1.3. Integrated Suite. Integrated suites are charac-terized by common executive control and shared core hardware and software used to implement all required functions. What was referred to as a system in the federated and integrated system architectures is now referred to as a function in the integrated suite. The **system** is now defined as the total hardware and software resources used to implement all required **mission functions**. Integrated suites often use common data processing and signal processing components in a modular, scalable computer architecture. Preprogrammed and collected data is fused in the central processor to provide air vehicle mission management, mission level situational awareness, navigation, targeting, fire control, and defensive functions. The data displayed to the pilot are an amalgamation of the data collected and processed simultaneously by the total system resources. The F-22 avionics are an example of an integrated suite.

2.3. System Maturity. The following is a system maturity discussion which highlights the major events and major aspects which occur during successive stages of an air vehicle's development (also refer to **Fig-**

ure 2.1., **Figure 2.2.**, and **Figure 2.3.**). The division between each of the development phases described below is not discrete. Instead, system development is continuous and requires strong communication between users, designers, testers, etc., in one phase to the designers, tester, etc., in subsequent phases to ensure smooth development transitions. Exit criteria for each of the development phases is provided in the **Exit Criteria** template in this document. References in **Attachment 3** contain information regarding system development and system engineering.

Figure 2.3. System Architecture Types.



2.3.1. Concept Phase. During the system's conceptual design phase, top level documents [Operational Requirements Document (ORD), MNS, Cost and Operational Effectiveness Analysis (COEA), Integrated Logistics Support Plan (ILSP), etc.] create a foundation upon which general A-P-A system requirements are built. Design tradeoffs, primarily using Modeling and Simulation (M&S), occur extensively during this phase. Measurement Facilities (MFs) are the primary tools used to provide data to support high level M&S. See **Figure A2.2.** in **Attachment 2** for a flowchart of the concept/ design refinement process.

2.3.2. Component Phase. Once the initial component and subsystem requirements/designs have been determined from both functional and allocated baselines, component development begins. During this phase, design refinement is most prevalent. The basic thrust of component testing is to ensure the components perform within subsystems as designed. Representative models created in early phases will develop along with the system itself and are updated using test results. Besides M&S, MFs and System Integration Laboratories (SILs) are the primary T&E resources utilized during component development. See **Figure A2.4.** in **Attachment 2** for a flowchart of the component development process.

2.3.3. Subsystem Phase. As a system progresses through the development phases, assessing the tested system's performance against the user's requirements becomes more straightforward. The subsystem phase is the first opportunity to test at a level near the user's requirements without excessive extrapolation of test results. Also during this phase, the number of new models created begins to taper-off, but model sophistication/complexity continues to increase as well as the test sophistication/ complexity. Generally, for a new system, subsystem level testing is conducted in System Integration Laboratories (SILs) and Hardware-In-The Loop (HITL) facilities. See **Figure A2.5.** in **Attachment 2** for a flowchart of the subsystem development process.

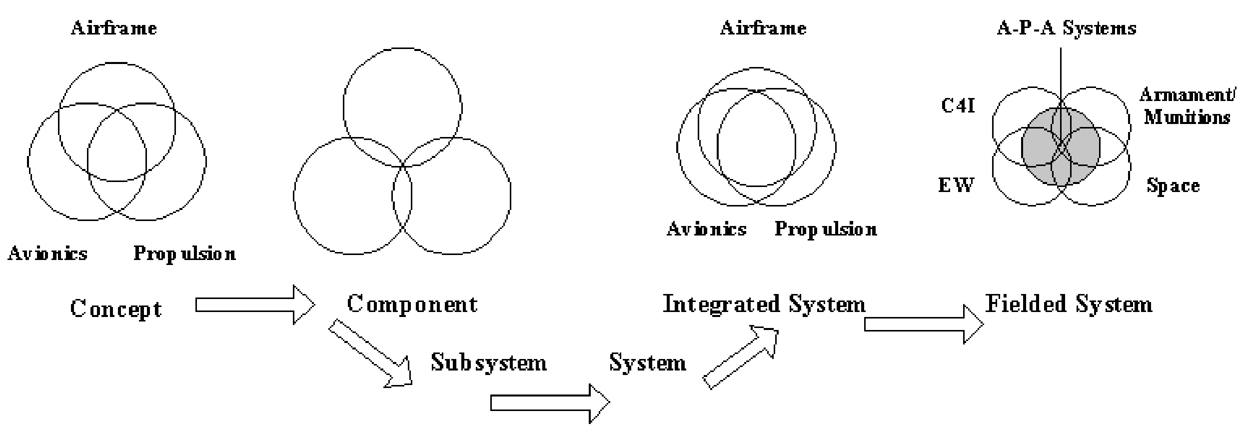
2.3.4. System Development Phase. All of the various subsystems and components associated with the three A-P-A disciplines/systems merge to form the air vehicle. During this phase, operational aspects of T&E become more prevalent than during previous phases, culminating in OT&E certification. For a new system, the DT&E goals are to first ensure the air vehicle is safe, then verify that the air vehicle performs basic functions as designed, establish system limits, resolve anomalies, and finally to obtain a preliminary assessment of the system's operational capabilities, and logistics supportability. During this phase, many of the ORD requirements can be tested directly by DT&E and OT&E testers and test results may also be used to update high level models. Primarily, Installed System Test Facilities (ISTFs) and Open Air Ranges (OARs) are used in this phase. See **Figure A2.7.** in **Attachment 2** for a flowchart of the system level development process.

2.3.5. Integrated System Phase. This phase of a system's development is concerned with testing the weapon system in an environment which as close as practical replicates the environment in which the system is intended to operate. The goal of this phase is to directly test and deliver an effective and suitable weapon system with no operational deficiencies. To accomplish this, realistic suitability and effectiveness testing must be performed using mission-level tasks including maintenance and logistics supportability, aerial delivery, bombing, suppression of enemy air defenses (SEAD), etc. See **Figure A2.9.** in **Attachment 2** for a flowchart of the integrated system development process.

2.3.6. Fielded System. Once the weapon system is fielded, P^3I modifications which are changes to a system still under production and upgrades which are changes to a system no longer under production, require T&E. These P^3I mods/upgrades could range from major to minor, and be performed at either a logistics center, laboratory, or major test center. Obviously, the extent of T&E required and therefore, the resources required, depends upon the exact nature of the mod/upgrade. Unlike a new system development where generally, T&E starts with M&S and ends with OARs, P^3I mod/upgrade programs can start at any T&E resource category level. The six-step T&E process, however, remains the same. Component testing of a P^3I mod/upgrade could be conducted on a flying test bed in an OAR without first going through a SIL, HITL, or ISTF if the test team deems the risk minimal.

2.3.7. Level of Integration Between Mission Areas. An important aspect of system maturity is the level of integration between the three A-P-A mission areas as well as the subsystems/systems associated with each A-P-A mission area required at each phase of a system's maturity. **Figure A2.4.** shows generally the level of integration between A-P-A mission areas as the weapon system development progresses.

Figure 2.4. Notional Level of Integration Between A-P-A Mission Areas.

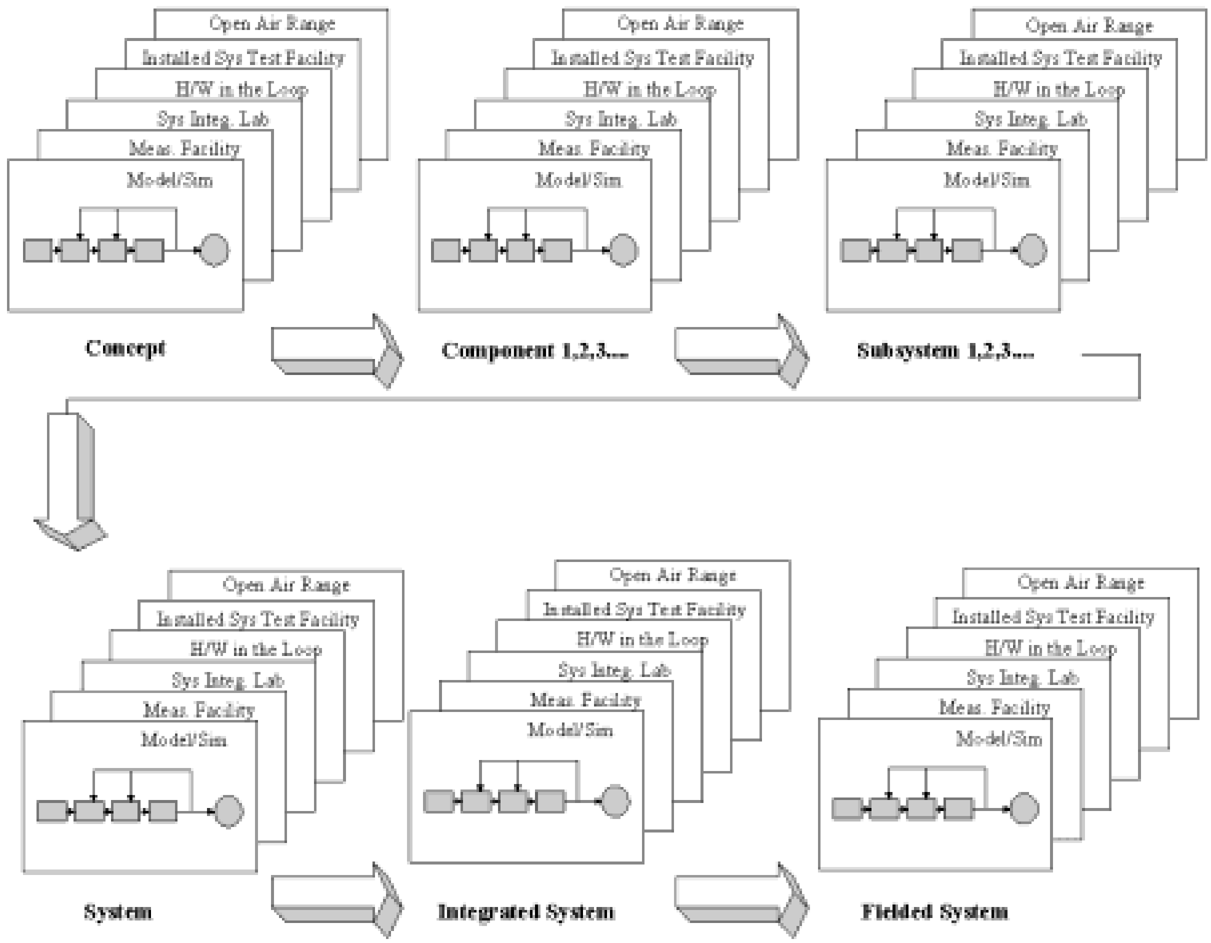


NOTE:

The extent of overlap between the circles represents the relative level of integration

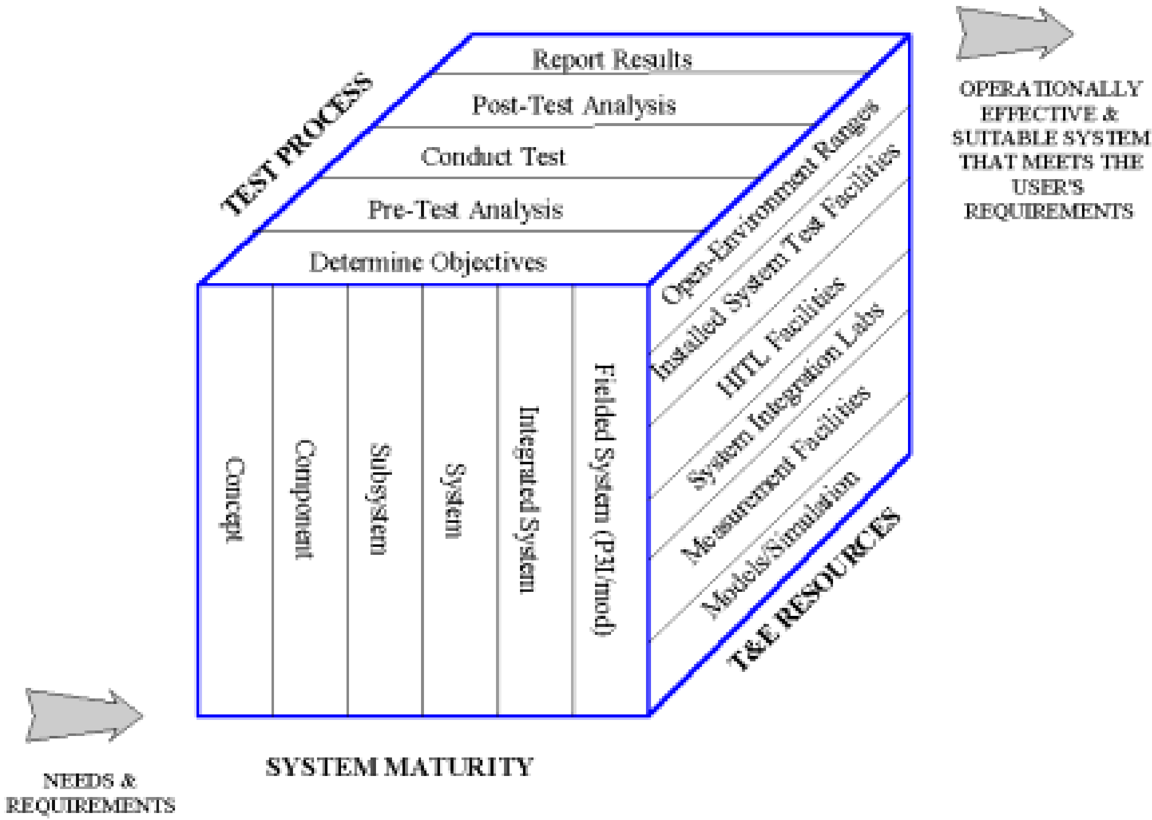
2.4. Test Process. The test process by itself is not the whole story for successfully planning and executing a test. Bringing the right test tools/resources to bear at the right phase in a system's development is also critical. The expertise of the test resources should be exploited as early as possible to aid in controlling programmatic risk. For example, test centers can facilitate early manufacturer's testing by recommending and/or loaning data acquisition equipment or by processing specialized data. **Figure A2.5.** illustrates how the test process relates with test resources and system development maturity.

Figure 2.5. Test Process Expanded to Cover Other Aspects of T&E.



Multi-Dimensional Aspect to the A-P-A T&E Process

Figure 2.6. A-P-A T&E Cube.



2.4.1. A-P-A T&E Process Multi-Dimensionality. The A-P-A system development involves many simultaneous design and test efforts of the A-P-A functional categories/disciplines, each at varying degrees of maturity, merging to form a cohesive integrated weapon system. Various levels of resources are also used during each phase of a system's maturity. To more concisely capture the multi-dimensionality of the A-P-A T&E process, **Figure A2.5.** is modified to form the T&E cube presented in **Figure A2.6.** The main essence of the cube is that the T&E process is performed repeatedly as a system develops. It is performed simultaneously on hundreds and thousands of components, each at varying degrees of maturity and each relying upon various T&E resources/facilities. As the components merge to form subsystems, the test process is again implemented repeatedly on each subsystem, using various T&E resources, and so on through the weapons system's entire development.

2.4.2. Requirement Traceability. As the system develops, fewer tests are performed, but they become more sophisticated and address higher level requirements. During the early phases of a system's development, the test results are compared to low-level requirements which are derived from higher level requirements. As the weapon system evolves and matures, tests are performed which address requirements at higher and higher levels, until finally, test results can be compared directly to the Operational Requirements Document (ORD) and Cost and Operational Effectiveness Analysis (COEA) data. It should be understood that not <u>all</u> parameters will compare on a one-for-one basis due to differences between what is placed in the ORDs and what is placed in the contract. For example, the user's reliability requirements are stated in operational parameters in the ORD whereby the SPO will express their requirements in contractual parameters with proportional (but different) quantitative values.

2.4.3. Generic Air Force T&E Process. The generic Air Force T&E process contained in AFI 99-103 is shown in **Figure A2.7.** To implement the Air Force T&E process for A-P-A mission areas, minor modifications were made to it which further clarify the A-P-A mission area T&E process steps. The A-P-A T&E process is shown in **Figure A2.8.**

Figure 2.7. Air Force T&E Process.

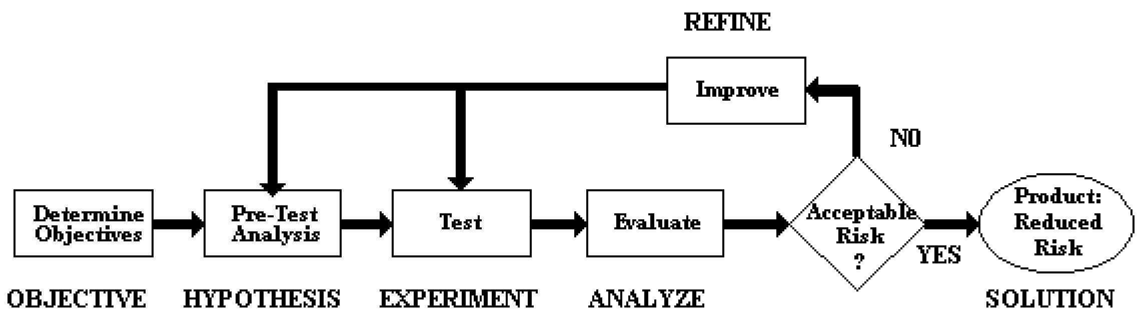


Figure 2.8. A-P-A T&E Process.

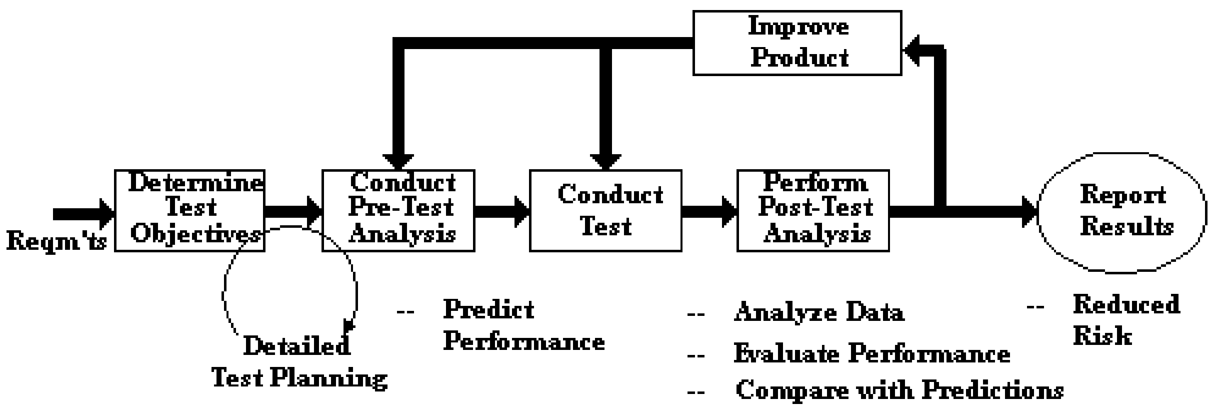
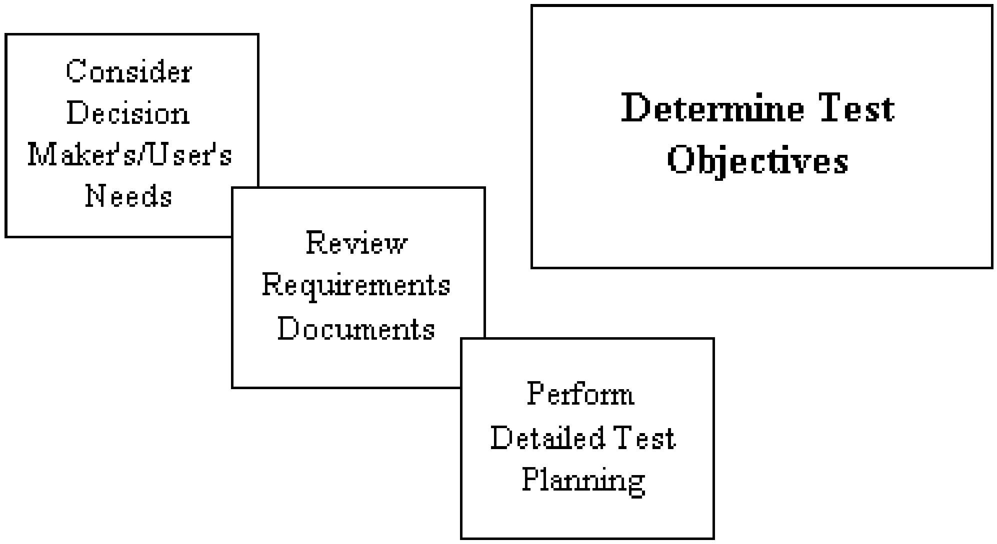


Figure 2.9. Determine Test Objectives.

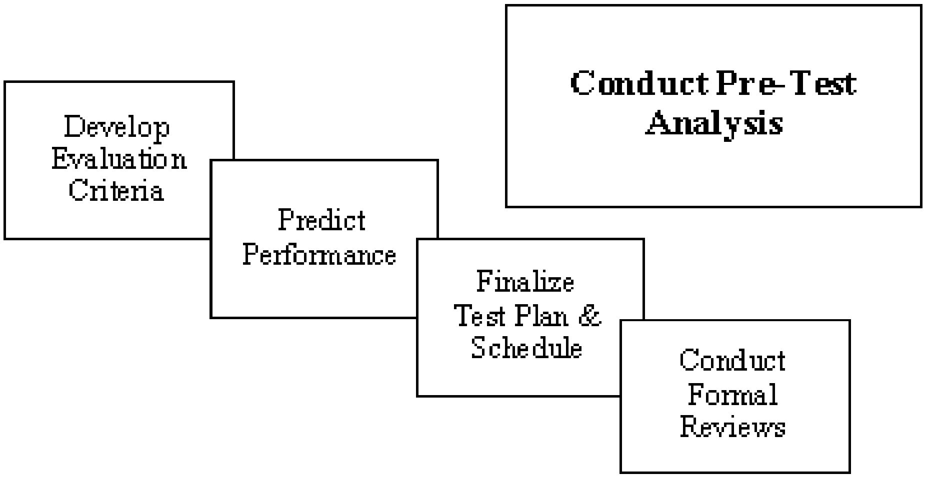


2.4.4. A-P-A T&E Process Steps. The following section is a brief discussion of each A-P-A T&E process step. Additional details are presented in the **Test Process** template in section 3.2.

2.4.4.1. Determine Test Objectives. Clearly defining the test's objectives will bound the test. Use program documents such as the ORD, TEMP, Requirements Correlation Matrix (RCM), Integrated Logistics Support Plan (ILSP), etc., to define requirements and help establish the test objectives. As part of developing the test objectives, ensure the test's success criteria are defined to know when testing is complete. System requirements flow top-down. General requirements, beginning with the MNS, ORD, and COEA, are broken down into more detail in system specifications (type A and type B specifications) and ILSPs. The specifications in turn, then drive the individual aircraft systems/subsystems requirements.

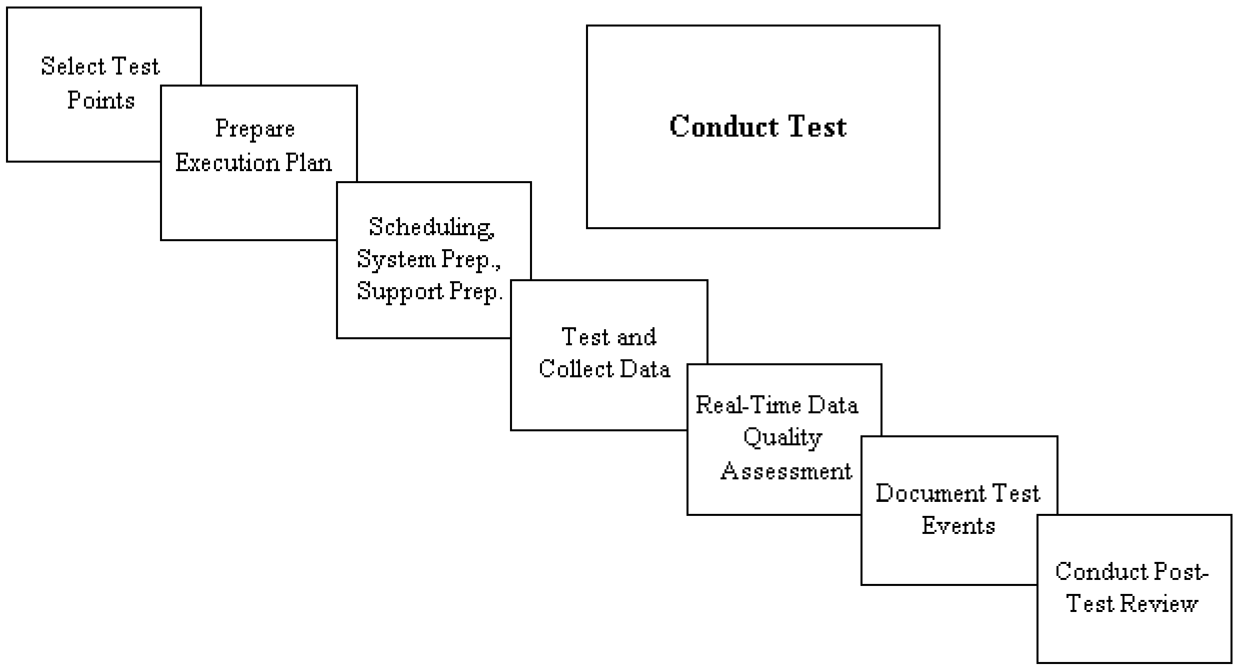
2.4.4.1.1. Detailed Test Planning is normally done by the RTO. The system specification requirements, operational requirements, basic objectives, and pre-test analysis are broken down into manageable elements that allow systematic control of test conditions and system (test article) configuration. Test methods and procedures are developed to limit the number of variables that might influence the result of a test, thereby ensuring repeatability and confidence in the data. The analysis plan is integrated with the detailed objectives in determining statistical requirements for establishing system accuracy and other performance measurements. The detailed objectives, test conditions, test article configurations, and data requirements meld together to yield a matrix of test points or discrete test events. Detailed test planning must also include a strategy for reducing performance risk as quickly as possible while considering system maturity and readiness for any given test. Design engineers often know of potential system weaknesses resulting from tradeoffs made early in engineering, manufacturing, and development (EMD). Design margins are typically reduced during the trade process and if they influence critical performance requirements, they should be tested as soon as possible. Other targets for early risk reduction testing include new technology, software, system interfaces, and component reliability. This part of the test strategy is geared toward developing and maturing the system and it overlaps the second part of the strategy, which should focus on testing as efficiently as possible. Experience is a key factor in laying out an efficient, detailed test event schedule.

Figure 2.10. Conduct Pre-Test Analysis.



2.4.4.2. Conduct Pre-Test Analysis. Use modeling and simulation (M&S), theoretical analysis, previous test results, engineering judgment, etc., to predict the system's performance. These predictions should be developed at every stage of system maturity. Developing the detailed test plan overlaps pre-test analysis and the development of test objectives in the first step. Based on the data requirements in the detailed test plan, a configuration of test instrumentation should be identified. Evaluation criteria should be developed with a basis in the requirements documentation. Specific test resources should also be identified. The matrix of test points should be refined using statistical tools and engineering judgment to minimize the number of test points, resources, and time required to answer the objectives. This is the point where the scope of the test and the overall test schedule are completely defined. Until this point, test managers can use schedule models with historical data from similar programs to develop a preliminary schedule, but a realistic schedule depends on the actual work plan which should be built from the bottom up. The schedule must also be adjusted for expected and unexpected delays due to late delivery of the system, system failure, non availability of support resources, redesign, regression testing, unusable data, poor weather, new safety hazards, etc. A schedule that fails to consider these delays is unrealistic right from the outset. The detailed test plan is formally reviewed by a group of experts, normally referred to as a Technical Review Board and composed of senior engineers external to the project. For flight tests, a similar group of experts reviews the safety analysis to be certain that hazards are minimized to the lowest practical level. This group is normally referred to as a Safety Review Board. The completion of both boards is required before the start of a flight test and may be required to reconvene if new tests are added or new hazards are identified.

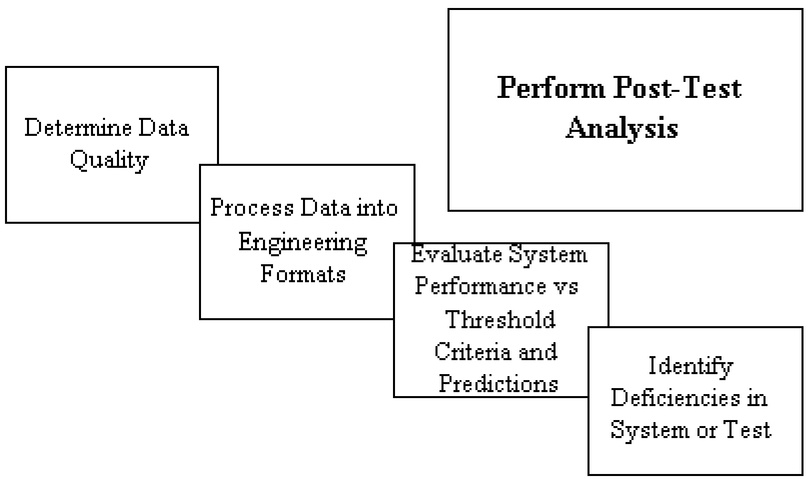
Figure 2.11. Conduct Test.



2.4.4.3. **Conduct Test.** This step in the process may be more complex than it appears, depending on the phase of development. It is usually the most manpower-intensive step because of the number of activities and associated workload that takes place in the short time period prior to and during the test. Before a test can begin, the team must select test events from the overall matrix of test points using a strategy that considers system maturity, risk in system design, and readiness to conduct specific tests at specific conditions. As a minimum, the team must decide on the types of testing so that support activities can proceed. These activities include the scheduling of resources, preparation of the test articles, finalizing support plans, calibrating instrumentation, facility set-up and team briefings. Examples which occur in open air testing are control room set-up and operation, which are normally supported by plans or instructions designed for the specific tests. These activities are so integral to conducting the test that they should be considered part of the test execution itself. In some cases, these preparatory actions are test events in their own right. For example, pre-flight of a test aircraft or weapon is required before flight, but the pre-flight can also be part of the system suitability evaluation. The selected test events are organized according to various planning considerations such as prerequisite actions, test procedures, system loading, build-up in conditions and efficiency. A timeline is normally developed based on the estimated duration of each test event and set-up for each event. This execution plan can be written in various forms depending on the phase of testing. For example, in a System Integration Laboratory (SIL) test, the actual test and system operating procedures can be specified in detail, one after the other, with the test conditions and other requirements for set-up integrated right in with the procedures. In a flight test, the team normally formulates a set of test cards that provide similar information while highlighting limitations and potential hazards. The execution plan is a critical element in the overall test process because it brings everything from prior planning together just before the resources are used. It establishes disciplines and control during test execution, and helps to ensure safety, data repeatability, and error-free testing. The conduct of a test is normally governed by established procedures, practices and techniques that are recognized by technical experts as valid test methodology. Occasionally, new test methods are required to keep pace with advancing technology. When this occurs, the test and engineering communities must join to validate the methodology prior to the test. Whatever methods are used, the testers must be trained or skilled in the procedures, practices, and techniques used. Data can be collected in a variety of ways, from human observation and hand recording, to programmable systems capable of megabit recording. Testing of complex systems usually requires automated instrumentation with speed, resolution, and recording capacity that matches the system under test (SUT). When the performance or functionality of an end-system is tested, data can be gathered manually but tracing the cause of system anomalies usually requires discrete measurements at a subsystem level and precise data.

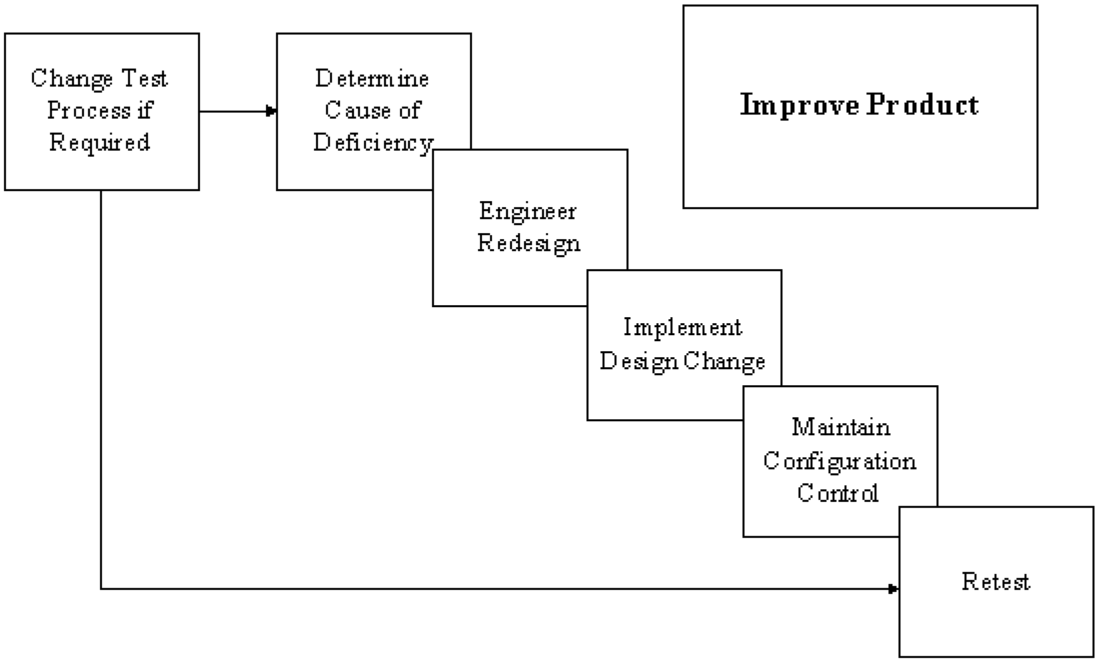
More complicated testing occurs as the system development progresses from early M&S to laboratory brassboard, component, subsystem, and full system testing. Both hardware and software undergo testing. During the early phases of development, they occur relatively independently, then merge to form a system and must then be tested as a unit.

Figure 2.12. Perform Post-Test Analysis.



2.4.4.4. Perform Post-Test Analysis. This step consists of two major substeps: post-test data and system performance evaluation. The data must be converted from raw form to a usable format in engineering units before it can be analyzed. Many programs have found it beneficial to have a "quick-look" data processing capability to determine data quality before sending it forward for more elaborate processing. The quick-look capability should process the data into first-generation engineering units which allow an early view of system performance during specific test points. A Quick-Look capability is very useful when test results are required prior to proceeding to the next event. The development of this capability requires a small investment early in the program and usually pays big dividends in time and money throughout EMD. Data are archived according to a prearranged filing system so that it can be easily recalled. Requirements for preserving data are established during early planning based on the needs of the program. Unusual test results or incidents may add to the basic library requirements. For a flight test, system performance data may be merged with time space positioning information (TSPI), and further processed using analytical program routines to yield data plots, cross-plots, and tables. The system's performance is then evaluated against predicted performance, maturity thresholds, and operational requirements criteria. If the test results do not reasonably match the predicted performance, a check should be made of the predictions, test methodology, adherence to test procedures, data quality, and analytical routines for errors or factors that may have influenced the results, such as weather phenomena or electronic interference. If necessary a retest is conducted. System performance and reliability are qualitatively and quantitatively characterized and deficiencies are identified. System performance and deficiencies should be considered with perspective toward operation requirements and tasks so the effect of a performance feature of deficiency can be understood in terms the user can recognize.

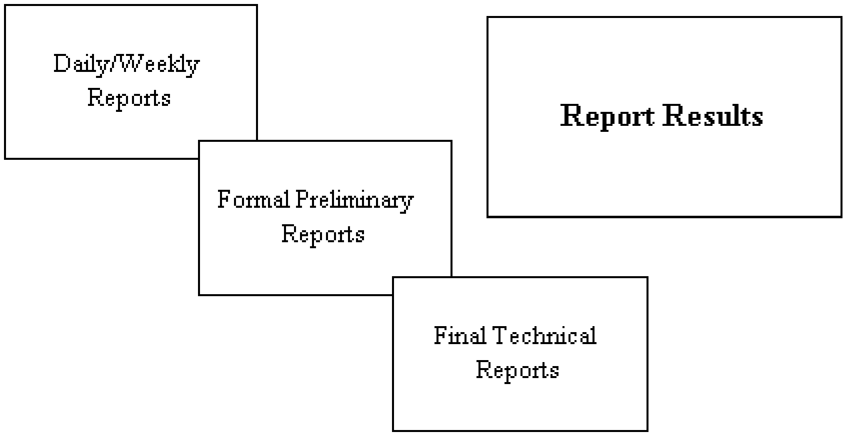
Figure 2.13. Improve Product.



2.4.4.5. Improve Product. If the results of the evaluation indicate a problem exists in system performance or test conduct, action is required. The evaluation should provide sufficient information to determine if the problem resulted from an error in the test process or the SUT. Once understood, problem sources within the test procedures should be eliminated or minimized to prevent future occurrence. This may require changes in models/simulators, test methodology, analytical routines, etc. The system can be retested as soon as the test process is improved.

If a system performance deficiency is identified in the evaluation process, the path will probably be more difficult. System deficiencies normally require design improvements and these improvements take time to implement. For example, a "simple" software change can cause substantial redesign and regression testing. When multiple design changes are made, configuration control becomes critical. Without a structured and disciplined process for configuration control, safety is compromised and cause and effect relationships become impossible to determine. The path for reporting deficiencies should be well established and clear of obstructions. Deficiency reports deserve everyone's full attention throughout the program. The strategy for introducing improvements in the design depends on many factors which could differ on every program. The best technical strategy may not be in line with the best business strategy, and a compromise may be necessary. Only the program manager can decide the best course overall. When design changes are introduced, pre-test analysis should be conducted before conducting more tests.

Figure 2.14. Report Results.

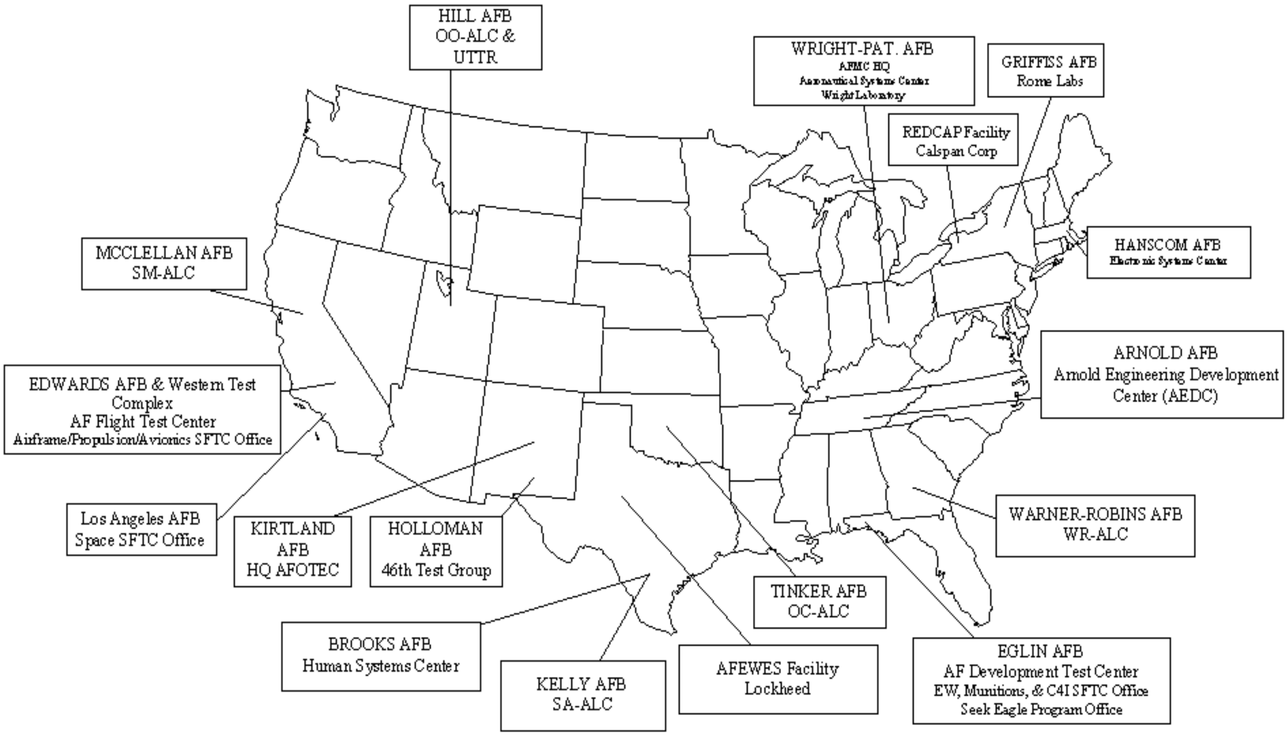


2.4.4.6. Report Results. Test results are used to make decisions. During the system development phase, they help design engineers decide the best course of action for fixing a problem. But the biggest decisions on a program are the milestone decisions. Early in a program, engineers may have to choose between emerging technologies by using the results of experiments that reduce the risks they see for their conceptual system. During a competitive demonstration/validation (Dem/Val), their decision will determine which design receives go-ahead for EMD. When system development has progressed to the point that the system is operationally representative, a decision is required on its readiness to undergo full operational testing. The results of operational testing provide decision makers a basis for their production decisions.

Test results are really just information, which means test results can be communicated in countless ways. Well managed programs determine the type and frequency of reports before a new phase of testing begins. It is not unusual for results to be communicated daily by telephone or facsimile. Major decisions require more formal reporting, such as technical letter reports or preliminary reports of results. The latter is usually given in the form of a briefing. Final technical reports (TRs) provide historical data that can be used by the tester for future tests and by the user to gain an overall insight of their weapon system. The substance of these reports varies with each program, but normally addresses the results associated with each test objective and emphasizes the operational impact for the user.

2.5. T&E Resources. This portion of the manual is a discussion of T&E resources and is one of the three sides of the T&E cube on **Figure A2.6.** Further details are included in the **Resource** templates presented in section 3.2, and also in **Attachment 2**. The map in **Figure A2.9.** shows the location of major Air Force A-P-A related government T&E communities. **Note:** The ALCs are primarily dedicated to operation and sustainment (O&S) testing and are not specific development test assets. The facilities cited are sometimes available to conduct a developmental effort dependent upon the circumstances and level of effort.

Figure 2.15. Airframe-Propulsion-Avionics T&E Community.



2.5.1. The various T&E facilities perform different T&E functions such as: M&S, laboratory work, flight test, etc. Following, is a brief description of the six DOD recognized T&E resource categories. Further information is contained in the **Resource** templates, (paragraphs **3.10.**, **3.11.**, **3.12.**, **Attachment 3**), and the Air Force Test Capability Master Plan (TCMP) and Test Investment Strategic Plan (TISP).

2.5.1.1. Modeling and Simulation (M&S). These resources are used in every stage of a system's develop-ment to help design, predict, and analyze tests. Generally, during the concept phase, M&S form the basis for design tradeoff studies and are at a high level i.e., threat scenarios, and environments. As the system develops from components to the fielded system, M&S can be used to provide generic models for components, interfaces, etc., for use in system design and test. M&S can be very valuable in identifying critical system areas which should be tested, thus reducing the test matrix. Modeling and simulation can be used in real-time during flight test as a system performance comparison tool or used before flights as a platform to rehearse upcoming flights. In either application, it is incumbent upon testers to ensure model assumptions and limitations are clearly understood by decision makers. M&S results can easily be abused if the underlying assumptions and limitations are ignored or unknown. M&S develops with the system by using test results for refinement updates and by progressing from low level/extremely detailed, to more high level, culminating in the ORD/COEA level once again. Increased reliance upon M&S is encouraged during DT&E and OT&E. M&S examples include: real-time pilot-in-the-loop and in-flight simulation capabilities.

2.5.1.2. Measurement Facilities (MF). These resources provide capabilities to measure parameters critical for system design. Generally, they are not test article unique, but do perform a specific function such as signature and navigation accuracy measurements or measurements of aerodynamic forces. A-P-A Examples include: wind tunnels, signature MFs, spin-tunnels, and engine test cells.

2.5.1.3. System Integration Labs (SIL). These re-sources integrate hardware and software components up to the subsystem level using a table-top/spread-bench environment. Usually a specific component is tested in a SIL with the interface components simulated through either hardware or software. These facilities reside at contractor facilities because they are test article specific and are required for integration development. They exist at Air Force test sites for integration testing.

2.5.1.4. Hardware-In-The-Loop (HITL) Facilitles. These resources provide the capability to test actual subsystem level hardware in a closed-loop indoor lab environment such as iron-bird labs and fuel system labs. Generally, they are more sophisticated than SILs and typically reside in contractor facilities. Subsystems and sensors other than the one under test are simulated. A government example is the Integration Facility for Avionic Systems Testing (IFAST) located at the Air Force Flight Test Center (AFFTC), Edwards Air Force Base (AFB) CA.

2.5.1.5. Installed System Test Facilities (ISTF). These resources provide the capability to evaluate systems which are installed on the host platform/airframe while residing within a controlled indoor environment. Examples include: anechoic chambers, limit cycle/ground resonance test stands, structural loads stands and full-scale wind tunnel tests.

2.5.1.6. Open Air Ranges (OAR). This category of T&E resources is divided into two groups, controlled/instrumented ranges and real world environments. Although, the weapon system should be tested in a controlled environment, valuable data may be gathered from real world scenarios which may effect system upgrades/modifications.

2.5.2. **Figure 2.1.** shows the T&E resource type generally utilized for each phase of new system development. T&E resource details are contained in the A-P-A templates (section 3.2) and T&E Resources (**Attachment 3**). It is important to point out that the pace of development of a P^3I program which is already a mature and fielded weapon system is very dependent upon the exact modification/upgrade to be performed. Considerations for program risk, safety risk, program urgency, etc., should also be factored in during the weapon system P^3I development process. Typically, a P^3I program relies upon an abbreviated number of resources as compared to a new program acquisition.

Table 2.1. A-P-A Resource Utilization.

T&E RESOURCE CATEGORIES	Concept Development Phase	Component Development Phase	Subsystem Development Phase	System Development Phase	Integrated System Phase	Fielded System Phase	T&E CONTRIBUTION EXAMPLES
Digital Models & Simulations	+	+	+	+	+	+	- A-P-A Systems Designs - High-level Tradeoff Studies - Mission Rehearsals
Measurement Facilities	+	+	+	+	+	✧	- Aero Forces/moment Meas. - EM Spectrum Measurement - Engine Thrust Measurement - Navigation Performance
System Integration Labs	✧	+	+	✧	✧	✧	- Inter-system Interface Eval. - Intra-System Interface Eval - test item design optimization

T&E RESOURCE CATEGORIES	Concept Development Phase	Component Development Phase	Subsystem Development Phase	System Development Phase	Integrated System Phase	Fielded System Phase	T&E CONTRIBUTION EXAMPLES
Hardware-in-the-Loop Facilities	-	✧	+	+	✧	-	- Failure modes characterization - Multi-Line Replacable Unit (LRU) Integration tests - First-look at test item perf.
Installed Systems Test Facilities	-	✧	✧	+	+	✧	- Installed functionality check - EMI/EMC Eval. -Combat representative scenarios.
Open Air Ranges	-	-	✧	+	+	+	- Airworthiness Evaluation - Systems Functionality in actual - Environment

Table 2.1 Continued

Legend:	Primary Use	+
	Potential Use	✧
	Seldom Used	-

2.6. T&E Planning Considerations. This section is a compilation of information that the reader may find helpful when planning and conducting T&E. The following paragraphs provide insight into some of the more significant program planning issues to consider including major pitfalls to avoid or be aware of during all T&E programs.

2.6.1. Ambiguous Requirements. The foundation for test objectives is assessing how well a system meets requirements. Therefore, if the user does not adequately define the system requirements, the tester's job is extremely difficult or impossible. Testers must ensure the requirements are testable and clearly understood. Ambiguous requirements not identified and corrected early in the acquisition process, will cause problems later. Frequently, testers are caught in a dilemma where a component, subsystem or system test fails because the requirements were not clearly defined or understood. When testers attempt to compensate for or clarify poor requirements, they are viewed as attempting to cut the users out of their operational evaluations or are told that it is too late. This situation can be alleviated during early test planning by ensuring that there is a direct link between MNS, ORD, TEMP and specification requirements to clearly stated test objectives and quantifiable measures of performance. The joint government/contractor team is responsible for the requirements derivation and allocation process to ensure traceability and acceptance. The SFTC offices described previously may assist in correcting deficient requirements prior to RTO designation through early involvement.

2.6.2. T&E Delaying System Development. This is probably one of the most commonly voiced complaints during testing and usually involves many facets which are intertwined and in many cases, outside the tester's control. Obviously, the user would like the needed system delivered as soon as possible and meet the stated requirements documented in the ORD. The developer/contractor and SPO do their best to meet these goals. The tester bridges the sometimes wide gap between the design engineers, the developer, and the users. Non-test related pressures including funding, congressional, or poorly defined requirements and test related pressures such as failed tests, design changes, regression testing, over-testing, etc., force schedule slips during T&E. The schedule may have been unrealistic to begin with due to inadequate T&E input during early program planning, excessive reliance upon a technology which did not materialize or test schedules which did not account for various test efficiency factors. In any event, test schedule compression usually conflicts with one of the tester's main charters --to conduct an adequate system evaluation and provide decision makers with factual, defensible, and repeatable test results. Another facet to the tester induced delay complaint pertains to the real world pressure to fly-fly-fly and demonstrate high sortie rates without adequate regard to useful/productive testing. This also conflicts with the tester's "evaluate" objective. In an attempt to get the aircraft out to the user as quickly as possible, some of the systems may have deficiencies that were not discovered during T&E. Other common sources of test delays are late delivery of Government Furnished Equipment (GFE) items needed to support the test and lack of adequate test instrumentation that precludes fault isolation to a sufficiently low depot level of assembly. It is a well documented fact that fixing system problems late in the acquisition cycle is typically very costly. To minimize these problems, there must be early tester involvement in the acquisition program and structured development testing throughout the acquisition process. Overall program scheduling should provide a more realistic assessment of the test schedule as part of the program executability analysis and during source selection. The schedule must be driven by technical requirements and the capabilities of the various government and contractor agencies to fulfill their respective roles.

2.6.3. Use of Test Results from Immature Systems. This problem surfaces when comparing test results obtained from an immature system against the user's requirements (which assume a mature system) and too much concern is levied against the system when its performance is below the operational requirements. The problem is compounded by the push to conduct operational testing earlier in aircraft development, before the aircraft systems have attained a sufficient level of maturity. AFOTEC uses Operational Assessments (OAs) early in DT&E as described in AFI 99-102 to assess major impacts to operational effectiveness and suitability and to identify major programmatic voids adversely impacting the ability to meet operational requirements. These assessments are intended to evaluate potential areas of concern for operational effectiveness and suitability. The problem is also compounded in software intensive aircraft. By its very nature, software changes (as its name implies), and therefore software intensive systems have a more difficult time achieving maturity and a stable configuration. The configuration must be tightly controlled and closely tracked during T&E to accurately evaluate system performance. Engineering judgment and historical data should be used by testers during DT&E and especially during early operational assessments (EOAs) by AFOTEC to determine whether test results below requirement thresholds are truly a problem. This may be accomplished by plotting the problem parameter (such as reliability) against time to indicate trend and maturity rate. If the parameter is subjective (such as handling qualities) or cannot be plotted, then the tester must use judgment. Ensure competent software development personnel are in place and have a firm understanding of the function and system environment for which they are designing the software. The System Maturity Matrix (SMM), reference Acquisition Policy 92M-001, *System Maturity Matrix*, document may be used to help assess whether the system is maturing at the desired rate.

2.6.4. System Specification vs. User Requirements. This is a common occurrence during DT&E and OT&E and surfaces when system specifications (specs) do not align well with the user's requirements. This also occurs when the user's requirements are ambiguous or always changing (may be due to threat changes). If a system meets a specification, but does not meet an ORD requirement, the government is faced with a contractual dilemma and results in a gap between user requirements and the original system specifications. Disagreements between testers, SPOs, and contractors frequently result which polarize the involved organizations. The tester should submit a deficiency report (DR) which documents the deficiency and assists in resolving the issue through appropriate channels. To alleviate the problem with poor specifications or misalignments with requirements, the tester (RTO, OTA) and user should be given the opportunity and adequate time to review the system's specifications early in the acquisition cycle or when the contract is modified.

2.6.5. Realistic Test Planning. Inadequate resource, schedule, or fiscal planning that does not account for regression testing, realistic test efficiency learning curve, maintenance down time, and unexpected tests can cause significant problems during system acquisition. Care must be exercised by the SPO and test planners to not be overly optimistic during test program planning and also ensure that when pressures are applied to the program, these factors are not eliminated. Too often when this occurs, cost or schedule breaches occur, followed by a continual series of "get well" exercises which rarely succeed. Aircraft are enormously complex machines and when a configuration is changed due to a hardware or software update, modification, or correction of a significant deficiency, some regression testing may be required to ensure it is still safe before proceeding with the originally planned tests. Models and simulations and other ground based resources which have been kept current with test results can assist in regression test planning and reduce the number of test points. The number of regression test points required depends upon factors such as: level of onboard systems integration, safety risk, and extent of system change. The cause and effect relationship involved with software intensive aircraft is complex and requires significant analysis, both intra and inter subsystems. For instance, a seemingly innocent change made to the fuel subsystem may have a drastic effect on other subsystems (avionics, flight controls, etc.). Regression testing should go through the system maturity phases (component, subsystem, etc.), apply the six-step test process, and utilize appropriate T&E resources. The selection of test sequences should be based upon the types of qualification testing planned for qualifying the system, the type of equipment composing the system and other (e.g., safety consideration) to keep the types of retesting of corrective fixes to a minimum.

2.6.5.1. As stated earlier, test planning should account for a real world test efficiency of less than 100 percent. In fact, a good historically derived planning factor for real world test efficiency on a major weapons system is approximately 60 percent. The actual efficiency depends upon many factors some of which include: aircraft type, safety risks, system complexity, and time. Test agencies should use historical data to estimate a realistic test efficiency and utilize this data in TEMPs and other test documents.

2.6.6. Inadequate T&E Interfaces. The lack of a consistent test point of contact (POC) during system development is frustrating to the contractor and SPO because they must interface with numerous test organizations to plan and conduct tests. They need and want a single POC that can resolve test issues without having to go to numerous test agencies to gather the whole story. The A-P-A SFTC office should help mitigate this type of issue prior to RTO and OTA designation. Once an RTO and OTA has been designated, the RTOs and OTAs program test manager [or combined test force (CTF) director, if RTO is organized as such] should serve as this focal point. Another related concern pertains to test support interference. Every effort must be made by the test support organizations to not impinge upon test conduct. Testing should be event-driven resulting in completion of a given test point, test event, or series of tests and not delayed due to a range scheduling conflict or failure of some test support element. Early involvement of the test centers will reduce the delay caused by range scheduling. However, since test support elements sometimes fail, schedule flexibility must be a part of the test plan. This problem is not easily resolved due to increased funding and program priority competitiveness. With limited DOD funds, money allocated towards system development means less money is allocated towards T&E support resources. For example, funding may be required for updating T&E "reference source" measurement systems accuracy to keep abreast with onboard system technology advances. Early test resource planning is critical in ensuring funds are utilized efficiently and where most needed.

2.6.7. T&E of Off-The-Shelf Items. In recent years, the DOD has given greater consideration to procuring systems that are available off-the-shelf (OTS). These systems offer the advantage of immediate availability with no investment required for development. An even greater advantage is that new OTS systems more closely reflect the state-of-the-art with technology than systems that are developed under the government's lengthy acquisition process. But with these advantages come some potential pitfalls which may not be evident to the naked eye. Commercial Off The Shelf (COTS) systems may or may not be suitable for military applications. The best way to determine how suitable they are is to test them in the required mission environment under realistic conditions before deciding to procure them in quantity. Practically all COTS systems that are considered for use on aircraft must interface with the aircraft in some sense. As a minimum, they need electrical power and therefore must be robust enough to handle the small surges, spikes and momentary interruptions that are typical of aircraft electrical systems. The system may be sensitive to background noise, structural vibration or temperature variations that occur in aircraft. The actual mission requirements may overload the system's throughput or service capabilities, or it may not exhibit the robustness and reliability needed in combat conditions. If the system is integrated electronically with other aircraft systems, engineering development work will probably be needed and the integration will need testing. This is particularly true when existing software is changed to host a new system. Human factors may also be important. For example, some commercial communications systems have been installed in aircraft without adequate illumination for night operations. It is easy to overlook a potential problem if a thorough evaluation isn't done up front, including an assessment of what testing should be done with the system fully integrated with the aircraft.

2.6.7.1. Non-development aircraft acquisition can pose greater problems. These aircraft are usually tested by the manufacturer and certified by the Federal Aviation Administration (FAA) or foreign agency for airworthiness. A thorough examination of the test data resulting from these tests almost always shows less than adequate evaluation for military mission purposes. It is not enough to simply look at the aircraft specifications and advertised capabilities without evaluating the existing test data and then testing the airplane as it is intended to be operated in its military mission environment.

2.6.8. Government and Contractor Teaming. The roles government and contractor personnel perform during T&E are important to the success or failure of a test program. Generally, successful government and contractor teaming, especially during DT&E, results in more effective and suitable aircraft being delivered to the user. The level of T&E teaming depends upon what T&E phase the program is in and the associated level of government test involvement. T&E teaming occurs across various facets/tasks: managing, planning, conducting, analyzing, and reporting. The tester's specific duties (and teaming implementation) at a given point in time are dictated by these facets and test phases.

2.6.8.1. In the early phases of program development prior to Responsible Test Organization (RTO) or Operational Test Agency (OTA) designation, government test involvement is primarily limited to the SPO and in some cases, the SFTC offices. During these early phases, besides helping to solidify system requirements and assist with test planning, government testers (primarily SPO engineering or test) should familiarize themselves with the system's design. This occurs through familiarization of system design documents (see **Documents** template in section 3.2), attending various program design reviews [preliminary design review (PDR), critical design review (CDR), system requirements review (SRR), etc.], or if feasible, attending actual tests. Building a strong T&E foundation upon extensive knowledge of the SUT is an important factor in determining the success or failure of a test program.

2.6.8.2. Once the RTO and OTA has been designated, the level of T&E participation will increase. A small cadre of experienced test personnel and aircraft maintainers form the core for the initial test force (obviously, the number of people in the small cadre depends upon the test program's size, requirements, and schedule). This small cadre's work experience includes the A-P-A disciplines as well as logistics/maintenance. The government testers bring to the table a wider experience base and operational flavor with which to assist the contractor and ensure the system meets the user's needs. As stated above, this small cadre should familiarize themselves with the system design, establish contacts (in person if feasible) with the SPO and contractor (design engineers, testers, logistics, etc.), and assist in test planning. In line with integrated product development (IPD), the government testers should be included as members of the appropriate integrated product teams (IPTs). In performance of these duties, they should visit the contractor, observe "key" tests, and assist the contractor in test planning. It is vital that participation be constructive and helpful. As such, early in system development, while the system is still under design refinement, government testers should be documenting system deficiencies or problems, primarily through watch items [as outlined in Technical Order (TO) 00-35D-54] and communication to the SPO. The contractor will be much less likely to be up front with the government about problems in subsequent phases if they feel they were "stabbed in the back" during these early phases before the design is solidified. Once the system is developed and nears (or in) engineering, manufacturing, and development (EMD), system deficiencies must be documented using DRs and watch items in accordance with (IAW) TO 00-35D-54. Government and contractor interface and teaming responsibilities must be defined and approved by the Air Force Contracting Officer prior to work initiation, as appropriate.

2.6.8.3. In performance of test planning duties, DT&E and OT&E personnel will ensure they are minimizing duplication by using common data requirements, T&E resources, analysis tools, instrumentation, etc., as much as possible/practical (OT&E data analysis and reporting must be IAW Title 10, United States Code, Section 2399 and Air Force policy). If government and contractor test points are integrated, more efficient and less flight testing results.

2.6.8.4. During test team buildup, as the aircraft development progresses toward first flight, the test force grows and government T&E involvement increases. The government testers (including logistics) should work closely with the contractor in detailed test plan preparation [even if a contract data requirements list (CDRL) item to the government] and become more involved with tests. Again, the Air Force Contracting Officer must approve or concur with such participation. Test involvement examples include observing/participating in: component and subsystem tests, "key" system tests ("key" as determined by tester, such as pilot-in-the-loop simulator tests, surrogate testing, etc.), and pre-flight tests. As with the earlier development phases, the tester will note and document system concerns/problems through watch items, but now also scrutinize them to determine which warrant upgrade to DR status. Contractor participation in teaming is accomplished if the design engineers familiarize themselves with testing (test plans, conduct, and reporting). Design engineer involvement in tests helps ensure a strong feedback between tests and design, which in turn, improves the system's design and performance. In some cases (for example on a large effort, complex system), contractors are encouraged to include design engineers in the test control room during testing.

2.6.8.5. As the aircraft nears first flight, government involvement in safety planning also begins to increase due to increased accountability/responsibility. Since flight testing usually occurs on government ranges, government safety rules must be accounted for. The government has a wide historical base to call upon for planning safe tests and managing risk. The difficult safety planning task for the government is to not overly constrain or hinder the contractor, yet ensure adequate safety precautions and procedures are in place prior to test.

2.6.8.6. The primary method to ensure teaming during flight test at the AFFTC is through the use of CTF. Although other test centers, agencies, etc., may not currently rely upon CTFs to perform T&E, per joint USAF/TE and SAF/AQ policy guidance, CTFs are the recommended approach for T&E as a way to reduce duplications (in data and resources) and costs. CTFs integrate DT&E, OT&E, and contractor T&E requirements and resources (logistics, engineering, support services, etc.) under one organization and the entire test process (from determining test objectives to test reporting) is implemented within one organization. One of the most important aspects of flight test is to provide timely test result feedback in the form of reports, DRs, and briefings to decision makers. If the test team delays this feedback, T&E integrity is reduced or eliminated. Also, independent DT&E, OT&E, and contractor reporting is an essential element of CTFs. The CTF concept may not apply as well to small test programs. In these cases the test organization may tailor the CTF concept or develop a test team approach to best meet their requirements.

Chapter 3

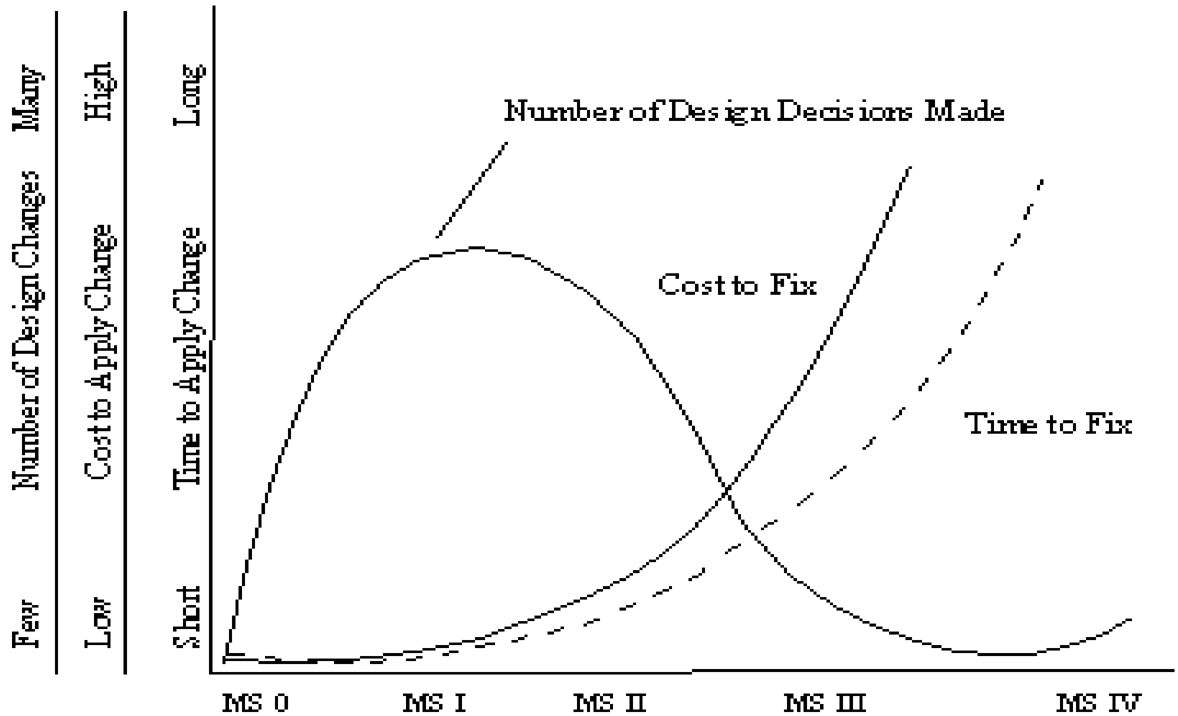
A-P-A T&E PROCESS APPLICATION

SectionC--Application of the A-P-A T&E Process

3.1. General. At each stage of an acquisition program there is considerable pressure to reduce T&E costs and schedule. Test program planning requires trading cost, schedule, and test content such as number of test articles, number and type of T&E resources utilized, instrumentation, etc., against program risks (safety and decision confidence) within an understood environment including security, fiscal atmosphere, political atmosphere, etc. In short, each program must be tailored to minimize cost, schedule, test content, and risks. For example, ISTFs or HITLs should be used instead of more robust and more expensive OARs to gain adequate confidence in a given system if the ISTF or HITL fulfills the T&E requirement. Also see **2.6.1.**, **2.6.8.**, and the templates in section 3.2 for additional discussions of proper test planning.

3.1.1. Not achieving weapon system's performance requirements, within schedule and cost constraints as outlined in program documents and test plans will significantly increase the potential for Congressional oversight and program reductions/cancellation. There are numerous ways to monitor the test portion of the program's cost, schedule, content, and risks. For example, if validated models using test results are utilized in a program development, fewer T&E resources may be required overall because models can more quickly and cheaply explore the test envelope. Also, as discussed previously, sophisticated HITLs and ISTFs may be used in place of more costly and time consuming OARs. Although this approach may reduce some of the system development time, caution should be exercised not to reduce the test schedule. Short, compressed test schedules are rarely ever a panacea, unless the SUT is mature and well understood. Short schedules at first may appear to save money, but usually in the end are more costly. Extra time and money are required which address increased safety and decision risks to mitigate program problems or worse, program cancellation. Therefore, testers should be given adequate time early in a program's acquisition cycle to review and comment upon ORDs and TEMPs. They should review them for adequacy and testability. Correcting an unrealistic schedule, requirement, or test plan early will save a significant amount of money and effort later. Early identification of performance problems also allows fixes to be incorporated into the system before the design is mature. Designing and applying a corrective action early is far less costly in terms of both time and money. **Figure 3.1.** shows the influence of program phase upon life-cycle-cost decisions.

Figure 3.1. Life-Cycle-Cost Decision Impacts. .

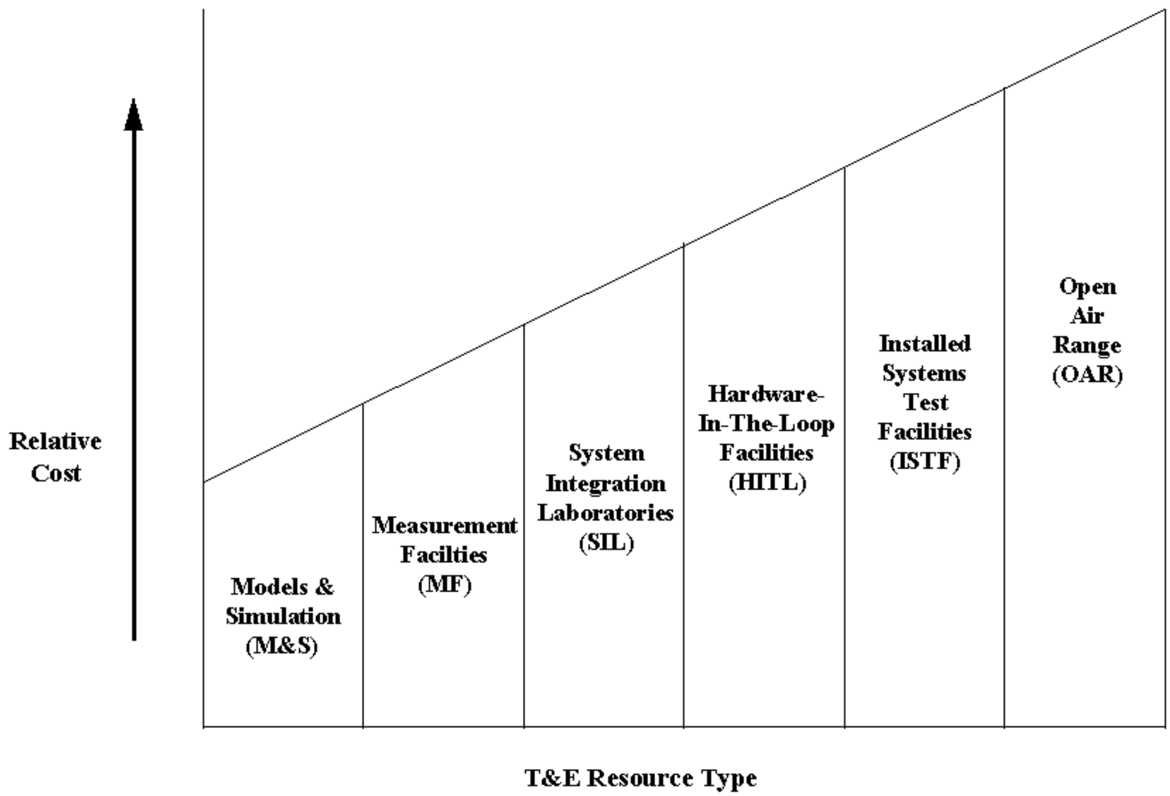


3.1.2. The test planner should develop a robust test strategy that includes numerous fall-back options in the event that undesirable or unpredicted test results occur during testing. The strategy should be designed to support decision maker's needs, identify and correct deficiencies early in development, and include the T&E necessary to support evaluation of: user's key parameters, critical system characteristics, COEA identified sensitive parameters, and parameters considered risky. As part of the test strategy, identify its critical path and also identify options which are dependent upon test results. The critical path links tests which directly support fixed milestone decisions (for example, data which support a fixed schedule budget decision), links programmatic risky tests (schedule, cost, performance, etc.), and links key decision point tests including tests which support acquisition milestones, tests which support choice of one technology implementation versus another, key parameter demonstrations, etc. It is helpful if the tests identified in your test strategy address issues such as conducting a series of small tests designed to obtain results quickly and early, versus one big test late in the acquisition with a limited or no fall-back position.

3.1.3. Properly planning a test program, be it ground/logistics/flight, to optimize the tradeoffs between cost, schedule, test content, and risk is centered around correctly implementing the test process. T&E resource requirements should be smartly tailored during each phase of a system's development. Test results obtained from these T&E resources should be used as building blocks for future tests. The templates presented in section 3.2, as well as other sections of this manual should provide assistance in this effort. Each test should adequately stress the component, subsystem, etc., against its requirements and confidence should be gained that the system's performance is adequate before it progresses to the next development step. The goal of T&E is finding and correcting problems early.

Keep in mind that generally, maximizing the use of M&S (digital pilot-in-the-loop) and in-flight simulation and ground testing (in SILs, HITLs, and ISTFs) prior to and during flight tests reduces overall test costs, since open environment flight tests are the most costly portion per capita of the T&E resource categories. This relationship is shown in **Figure 3.2.**

Figure 3.2. Relative Cost - T&E Resource Utilization.



3.1.4. At ASC, an Integrated Risk Management Process (IRMP) is being developed and implemented for placing emphasis on early definition of program tasks and their interdependencies with more realistic risk assessments, identification of constraints, achievable schedules, and reasonable cost estimates at all stages.

3.1.5. Several key elements in the IRMP include the Integrated Master Plan (IMP), Integrated Master Schedule (IMS), System Maturity Matrix (SMM), and Technical Performance Measurement (TPM).

3.1.6. The IMP, that is developed during the demonstration validation phase, identifies program milestones and success criteria that must be satisfied to complete the program within the defined risk boundaries. The IMS expands the IMP to the work planning level, defining the tasks, their duration and interdependencies required to complete the program. These documents should be expanded for each program phase, used to develop the contract baseline and to task all government and contractor tasks. In parallel with the initial IMP a SMM is developed to capture the technical performance parameters in the requirements correlation matrix, Systems Requirement Document (SRD) and specification. The metrics including Technical Performance Measures (TPMs), used to measure progress are developed in concert with industry. The test planner is an integral part of this entire process. The TEMP is developed and interfaces with the IMP/IMS. Detailed test planning is involved during the entire process at each phase of development. Additional details on integrating T&E with Acquisition Risk Management can be found in **Attachment 1**.

3.1.7. In summary, a well tailored test program should have an auditable building block of T&E results, balance robustness against cost and schedule, strive to identify deficiencies as early as possible, and use validated M&S, where applicable, in place of other more expensive T&E resources to identify the critical high risk issues and also help reduce test matrices. For more details on all three aspects (T&E process, resources, and system maturity) of the A-P-A T&E process, see **3.2.** of this manual. **Attachment 2** of this manual presents a more detailed discussion of weapon system development using the T&E cube to present the multi-dimensional aspects of the T&E process. It includes refinements and details of the test process and resources applied at each stage of a system's development.

3.2. Mission Area Templates. This section presents details of the Airframe-Propulsion-Avionics test and evaluation (T&E) process implementation through application of a work breakdown structure (WBS) type hierarchy, combined with a template type format (similar to Willoughby Templates referenced in **Attachment 1**). Efforts to implement the "Willoughby Templates" approach in documents such as: DOD 4245.7-M, NAVSO P-6071, *Best Practices* (Dept. of the Navy manual), Mar 86, and most recently, Deputy Assistant Secretary of the Air Force Memorandum, *Templates for Certification of Readiness for Dedicated Operational Test and Evaluation (OT&E)*, September 9, 1993, have been very successful. Based on this fact and because the template format is user friendly (it allows the reader to quickly gather necessary information pertaining to the A-P-A T&E process implementation at a level of detail more accessible to the reader), the template format has been applied to this manual. The template format also uses bulletized statements to most efficiently emphasize and capture the important points.

Details of the following subjects are contained within the following templates:

1. A-P-A T&E Process
    - Determine test objectives, pre-test analysis, test, post-test analysis, improve product, report results
2. Mission Requirements and Integration
    - Logistics suitability, interoperability, susceptibility/vulnerability, live fire tests (LFT), climatic tests, human factors, safety, and flight envelope/flight manual development, Aircraft Stores Certified Program
3. Documents
    - Acquisition/requirement documents [Operational Requirements Document (ORD), Cost and Operational Effectiveness Analysis (COEA), SMM, ILSP]
    - System configuration/engineering docu-ments [specifications, Interface Control Documents (ICDs), configuration documents]
    - Test documents [Test and Evaluation Master Plan (TEMP), detailed test plans, DR, analysis reports]
4. Embedded Software
    - Guidance, determine test objectives, pre-test analysis, test, post-test analysis, improve product, report results
5. Exit Criteria (for each development phase)

- Concept, component, subsystem, system, integrated system, and fielded system

6. A-P-A T&E Resources (links tests to resources, however resource/facility details are in **Attachment 3**)

3.2.1. Each template is stand alone. The templates are universal, for use by program managers, testers, decision makers, etc., and therefore, are not easily tailorable to specific functions and personnel. One reader may be a program manager and want information regarding test strategy formulation, in which case he or she may need to review the majority of the templates to collect the big picture. Another reader may be a tester in a laboratory and desire specific information on what to be concerned with in reviewing a TEMP. Although the templates may overlap one another in some areas [for example, the **Test Process** template (test planning section) overlaps with the **Documents** template in the subject of documents review], they do not flow from one to another (i.e., a given template is not a subset of another). **Figure 3.3.** presents an overview of what information is provided within each template and their general format. **Figure 3.4.**, **Figure 3.5.**, and **Figure 3.6.** merely list what disciplines are contained within each A-P-A mission area.

Figure 3.3. A-P-A Templates.

Templates Common to All Three A-P-A Mission Areas

Avionics
Propulsion
Airframe

Test Process

Mission Reqm'ts/Sys Integration

Within these templates, suggestions, helpful hints, guidance, etc., is provided during each of the following T&E steps:

-- Guidance (from DOD, AF, local test agency, etc.)
-- Requirements Review (What documents to review and what to look for in them)
-- Planning
-- Test Conduct
-- Analysis
-- Improve Product
-- Reporting

Documents

Within this template, information, hints, etc., is provided for the following type documents:

-- Reqm'ts/Acquisition
-- Sys Config/Engineering
-- Test Related

Embedded Software

Within this template the Embedded Software test process is outlined with suggestions on items to be considered or included for each step:

-- Guidance
-- Determine Test Objectives
-- Conduct Pre-Test Analysis
-- Conduct Test
-- Perform Post-Test Analysis
-- Improve Product
-- Report Results

Exit Criteria

Within this template, criteria are identified to exit from one development phase to another, i.e.,:

-- Concept
-- Component
-- Subsystem
-- System
-- Integrated System
-- Fielded System

Templates Unique to A-P-A Individual Mission Area

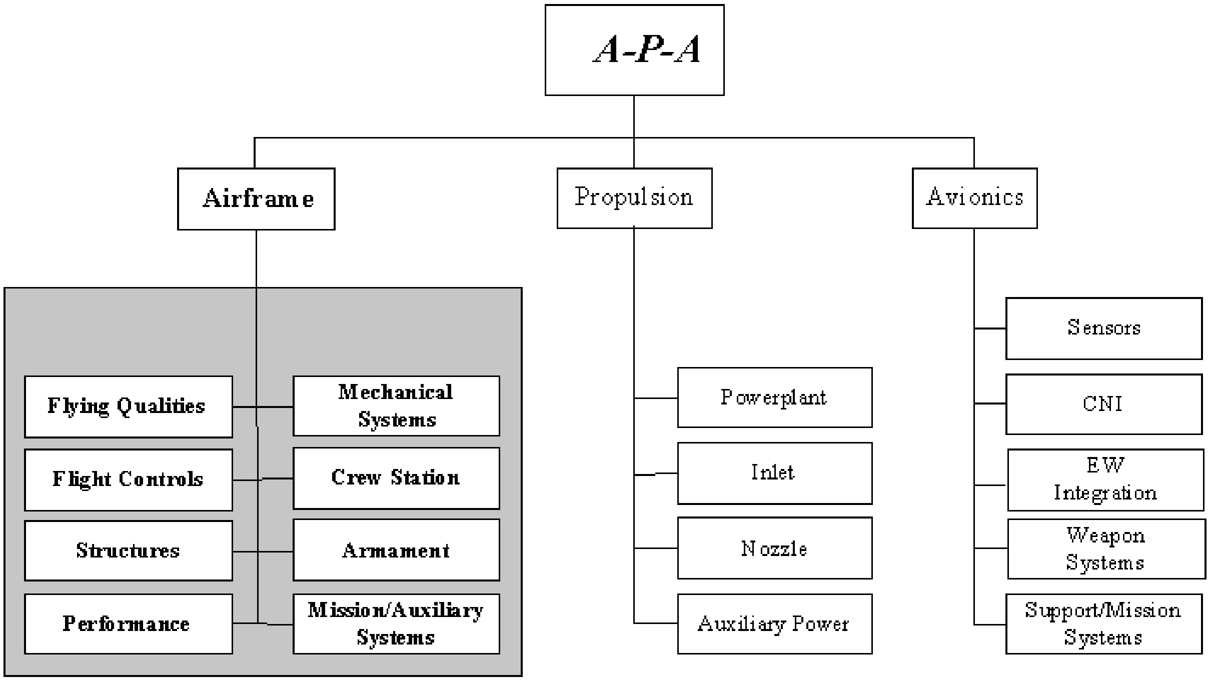
Airframe	Propulsion	Avionics
Resources	Resources	Resources

Within each set of templates, examples are given for types of tests conducted and resources/facilities utilized for each T&E Reliance Category

-- Modeling and Simulation
-- Measurement Facility
-- System Integration Lab
-- Hardware-In-The-Loop Facility
-- Installed System Test Facility
-- Open Air Range

Note: Resource/Facility details, POC, etc., are provided in attachment 3.

Figure 3.4. Airframe Disciplines/Systems.



3.3. Airframe Disciplines/Systems:

3.3.1. Flying Qualities. Static and dynamic stability (longitudinal and lateral-directional), maneuvering flight, high angle-of-attack (AOA), handling qualities and stability derivative identification, and transients between flight control modes.

3.3.2. Flight Controls. Control laws, system stability (gain/phase margins), control surface/fin actuators, air data interface, avionics interface, hydraulics interface, ground collision avoidance systems (GCAS), and flight control portion of automated terrain following/terrain avoidance (TF/TA) and fire control/weapon delivery steering.

3.3.3. Structures. Static and dynamic loads, weight and balance, strength, life, material properties, aeroelasticity, and vibroacoustics

3.3.4. Performance. Range, endurance, speed, payload, thrust/drag measurement, air data corrections, and static aerodynamics

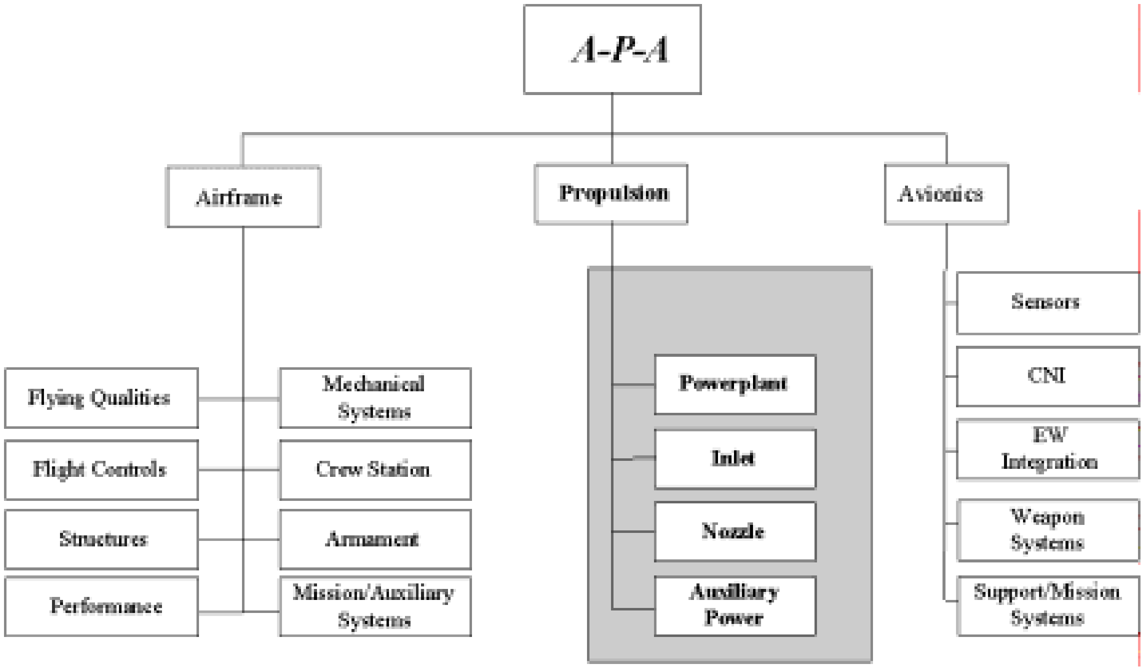
3.3.5. Mechanical Systems. Environmental control and protection, hydraulic, electrical power generation/distribution/regulation, fuel, pneumatic, miscellaneous doors actuation, wings/fins/engine inlet deployment systems, and cooling/heat exchangers, and airframe general interference (engine installation provisions, canopy function and seals, etc.)

3.3.6. Crew Station. Controls and displays, crew station and passenger compartment layout, egress/ejection systems, and life support systems interface

3.3.7. Armament. Weapon captive carry, weapon separation, gunnery, SEEK EAGLE (SE) certification, armament (mechanical/electrical/hydraulic) systems

3.3.8. Mission/Auxiliary Systems. Air refueling, aerial delivery (cargo), parachute recovery systems, accessory drive gearboxes, landing gear, arresting systems (brakes and deceleration devices), and lighting systems

Figure 3.5. Propulsion Disciplines/Systems.



3.4. Propulsion Disciplines/Systems:

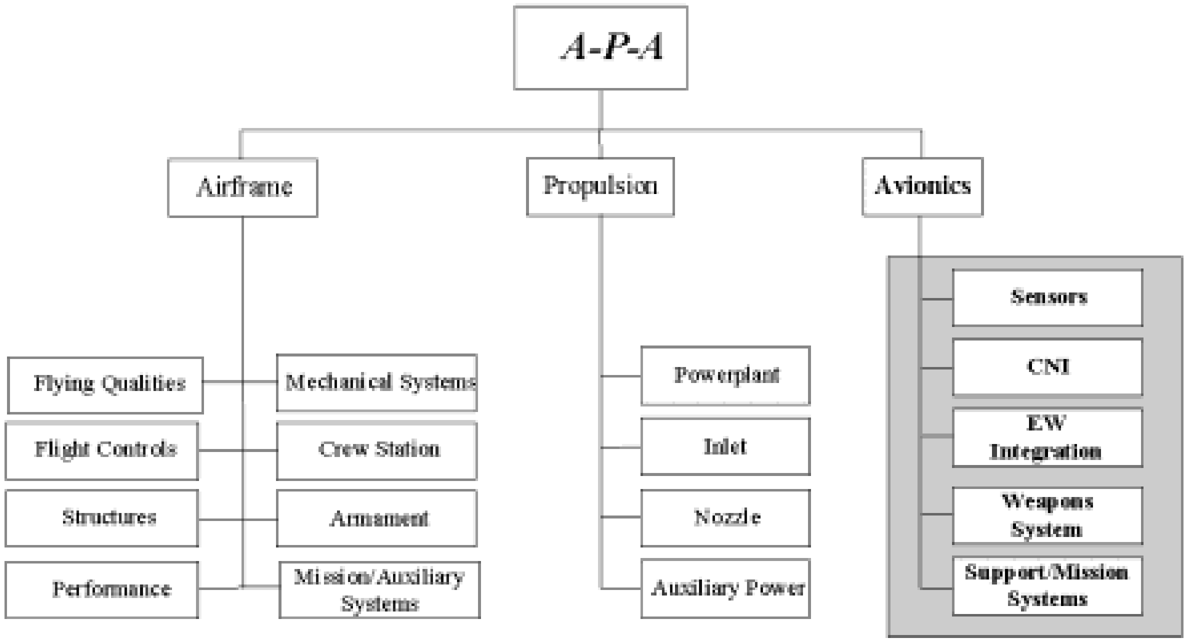
3.4.1. Powerplant. Performance (Thrust, specific fuel consumption, fuel flow determination, etc.) Operability (surge margin, power transients, installation effects, flight envelope, start envelope, component interfaces, etc.), Durability [Low cycle fatigue (LCF), High cycle fatigue (HCF)], ingestion (birds, rain, ice, gun gas, rocket exhaust, steam, foreign objects), and maintainability.

3.4.2. Inlet. Performance (mass flow, pressure recovery, flow distortion, etc.), Operability (starting, unstarting, geometry, bleeds, ingestion, acoustics, etc.). Durability (LCF, HCF, etc.), and Maintainability.

3.4.3. Nozzle. Performance (mass flow, discharge coefficients, etc.), Operability (vectoring, control response, observables, acoustics, etc.), Durability (LCF, HCF, etc.), maintainability, observability, nozzle/afterbody drag, thrust vectoring/reversing and interfacing with airframe.

3.4.4. Auxiliary Power. Auxiliary power unit (APU), jet fuel starter (JFS), starting/operating/interface characteristics, and secondary power systems.

Figure 3.6. Avionics Disciplines/Systems.



3.5. Avionics Disciplines/Systems:

3.5.1. Sensors. Radar, electro-optical (EO) sensors/trackers/designators, infrared (IR) sensors/ trackers/ designators, millimeter wave (MMW) sensors, lasers, ultraviolet (UV) sensors, multi-spectral sensors, reconnaissance sensors, air data systems (airspeed, temp, Mach) and ice detection.

3.5.2. Communications, Navigation, and Identification:

3.5.2.1. Communications/Identification. Radios ultra high frequency/very high frequency/high frequency (UHF/VHF/HF) and data links, Satellite Communication (SATCOM) systems, Identification systems, beacons/transponders, telemetry systems, range safety receivers/decoders.

3.5.2.2. Navigation. Inertial navigation systems (INS), magnetometers, Doppler velocity systems, radar, radar altimetry, Global Positioning Systems (GPS), Tactical Communications and Navigation (TACAN), Long Range Navigation (LORAN), Instrument Landing Systems (ILS) , Digital Terrain Systems, night vision systems.

3.5.2.3. Guidance. Signal/power distribution units, mission control modules, mission management/Operational Flight Program (OFP) systems, mission computer.

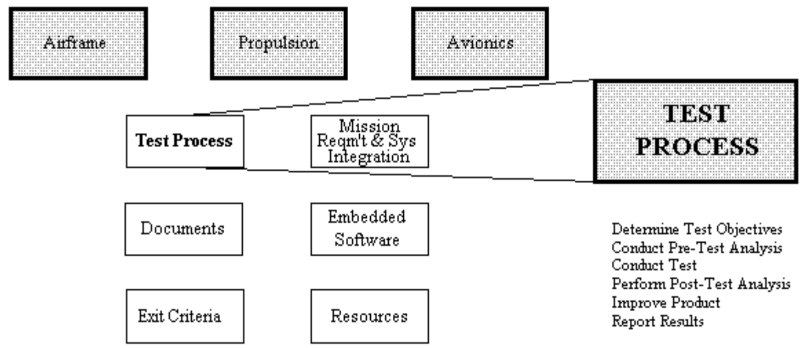
3.5.3. EW Integration. Integration with avionic systems and other aircraft subsystems (for example, flight controls) in support of electronic warfare (EW) mission functions.

3.5.4. Weapon Systems. Weapon delivery, fire control systems, smart weapon/missile integration with avionics systems, stores management systems (SMS)/interfaces, air vehicle/weapon OFP software.

3.5.5. Support/Mission Systems. Controls and displays, mission computers/control modules, electrical power distribution systems, avionics self test/built-in-test (BIT), onboard simulation/training systems, helmet mounted displays (HMDs), offboard support systems usually developed integral with

UAV/cruise missile system operation (ground or airborne launch systems, mission data planning systems and ground or airborne remote flight command/mission control systems).

Figure 3.7. Test Process Template



3.6. Test Process Template: See **Resource** templates for what type of tests are performed during each development phase and what resources are utilized.

3.6.1. Determine Test Objectives:

-Review requirement documents (see **Docu-ments** template)

--Concept phase

---Review ORD, COEA, and MNS

---Identify sensitivity of system performance to key parameters (see DOD Directive 5000.2-M, and AFI 10-601 for definition)

--Component through System Development Phases

---Review functional, allocated, and product specifications, ORD, and COEA

--Integrated and Fielded System Phases

---DT&E should review OT&E test plans and ORD (to ensure realistic operational testing)

---Involve your test center early in the identification of test purpose and test plans.

-Identify the purpose of test and formulate the test plans (see DOD 5000 series guidelines and **Exit Criteria** template for test planning guidance)

--Concept Phase

---Tests primarily support concept tradeoff study models/simulations or demonstrate new technologies being considered for the system's design

--Component through System Development Phases

---Generally, tests are conducted to assess an item's functionality against its design (to ensure airworthiness, assess its performance against specification, preliminary evaluation of operational effectiveness and suitability, etc.)

---Tests become more integrated between disciplines and as such, interfaces (software and hardware) must be evaluated

--Integrated and Fielded System Phases

---DT&E should expand flight and onboard systems envelopes, develop TOs (flight and maintenance), and conduct tests to gain confidence in OT&E certification (assess mission level requirements)

---OT&E evaluates operational effectiveness and suitability

--Identify the test strategy's critical path (path which supports evaluation of user's key parameters, critical system characteristics, COEA identified sensitive parameters, and high program risk areas)

-Identify test success criteria

-Consider decision maker's and user's needs

--Who is going to use the data and what decision will data support?

---Are data for System Program Office (SPO), other testers/designers, Office of the Secretary of Defense (OSD), etc.?

---Are data for final report, milestone (MS) approval, system engineering, etc.?

-Suggestion: Draft a rough outline of test report to help ensure you have answered the mail

3.6.2. Conduct Pre-Test Analysis:

-Confirm that the configuration of the SUT is consistent with test objectives

-Predict System Performance

--Review/use previous test results and similar systems data to help predict system performance

--Use engineering judgment and past experience

--Use requirement documents [ORD, ILSP, Logistics Support Analysis (LSA) and/or specifications] to help focus the test predictions

--Use M&S as a tool to predict system performance

-Identify test conditions and prepare test plan

--Rely upon statistical analysis tools and sound engineering judgment to minimize test matrix

---Use industry accepted method (i.e., Tachuchi) and perform a "Design-of-Experiment" which will define an integrated/efficient test matrix.

--Use M&S to help refine and focus the test conditions

--Identify advanced M&S that will be validated as part of the test process.

--Concentrate test conditions on those areas with high programmatic risks (i.e., those areas with low M&S confidence or where tests results are least predictable)

--Integrate OT&E and DT&E test requirements as much as feasible

--Finalize the detailed test plan and conduct a formal technical review

-Identify safety, environmental, and other test constraints

--See **Safety** section within **Mission Requirements/Systems Integration** template

--Prepare a detailed systems safety analysis with supporting documentation.

--Think through the test step-by-step and look for environmental impacts, possible failure modes, and document them (modify/tailor test plan to account for them)

--Apply for all environmental permits, explosive site plan approvals, waivers, etc.
Note: Ensure all requirements under the National Environmental Protection Act (NEPA) have been satisfied.

-Identify cost and schedule constraints

--Prepare a detailed WBS (identifying tasks, task associated manhour and material costs, and contingencies) and integrated detailed schedule (with tracking capabilities) identifying the critical path and task interactions.

-Identify instrumentation and data requirements as early as possible

--Using the integrated test requirements document and the developed test matrix identify the integrated detailed instrumentation requirements and document.

--Using the integrated detailed instrumentation requirements document identify the integrated detailed data acquisition system requirements document.

--Using the integrated detailed data acquisition system requirements and document identify the integrated detailed data processing, data reduction and data analysis requirements.

---Combine these requirements into a Data Analysis Plan (DAP)

--Suggestion: Draft a rough outline of your test report to help ensure you have planned for adequate instrumentation/data requirements

--Be aware of data sampling considerations (aliasing, data compression, sample rate, nyquist criteria, digital or analog system, etc.)

--Ensure instrumentation system is common airborne instrumentation system (CAIS) compatible as directed by Department of Defense (DOD)

--Identify real-time and post-flight data requirements and cross-check them against safety plan

--Develop post-test and real-time data analysis/reduction algorithms

--Integrate OT&E and DT&E data/instrumentation requirements as much as feasible

-Determine test resources needed to conduct the test and analyze data

--See **Resource** templates and **Attachment 2** for details

--Rely upon statistical analysis tools and sound engineering judgment to minimize test resources

--Integrate OT&E and DT&E resource requirements as much as feasible

3.6.3. Conduct Test:

-Plan test events

--Ensures proposed test sequence complies with 1) the requirements of integrated requirements document, 2) the integrated matrix 3) the integrated detailed instrumentation requirements document, 4) the integrated detailed data acquisition system requirements document, and 5) the integrated detailed data processing, data reduction and data analysis document.

--Select test points from test matrix

--Ensure scheduled resources are in place to support test

--Conduct pre-test briefings

-Perform test and collect data

--Gather the necessary data defined in the test plan within the preplanned test methodology, safety, environmental, etc., constraints

--Integrate OT&E and DT&E testing as much as feasible

-Perform real-time data quality assessment

--Minimizes wasted effort (repeating test points while the test assets are in place and the test is progressing is much more efficient than having to restart the test at a later date)

--Test personnel should have a thorough understanding of the SUT (if feasible, system design engineers could participate in test)

--A quick-look, real-time comparison between predicted system performance and measured performance will help ascertain if test points need repeating

-Document and archive test events

--Maintain a log of anomalies, test points completed, events of interest, etc., for historical purposes (the log helps during post-test analysis)

-Conduct post- test reviews

--Post-test reviews help focus post-test data analysis as well as help scope the next test

3.6.4. Perform Post-Test Analysis:

-Determine data quality

--Utilize a "quick-look" data processing capability to ensure data quality is acceptable before requesting more elaborate processing

--Perform initial assessment of system performance

-Process data into engineering formats

--Focus on those data necessary to answer the test objectives

---Divide data into time slices of interest

--Maintain a log of post-test data which includes parameters such as:

---Time, test point number, test conditions, brief explanation of test points, etc.

-Compare system performance to predictions and system requirements (pre-test analysis)

--If results are different than expected (use engineering judgment and experience) then perform the following (in general order):

---Review test log (from **conduct test** step above) and ensure the test points were valid and proper test procedures were followed

---Verify the data quality/accuracy (instrumentation calibrations, data decompression algorithms)

---Review test methodology and ensure it did not affect data

---Verify data analysis algorithms using data known to be correct

---Ascertain if prediction tools were in error (if data is determined to be valid, but different than predicted, update the prediction tool)

---Ascertain if retest is necessary (perform only as last resort) through engineering judgment and consultation with other personnel

-Identify deficiencies in test item or test procedure

--If test procedure is in error, make corrections and perform retest if necessary

--Provide timely feedback to the appropriate decision makers to assist them in determining the need to go to the Improve Product step.

3.6.5. Improve Product:

-Change test procedure if required

--Eliminate problem sources within the test procedure

--Provide feedback of lessons learned to test personnel

--Perform retest if necessary

-Determine cause of deficiency

--Once identified, provide feedback to appropriate personnel for timely resolution

-Improve design and implement change

--Design changes can take a substantial amount of time to implement and may require a significant amount of regression testing

-Maintain configuration control

--If multiple design changes are imple-mented, a structured configuration control process will be critical to the safe and successful conduct of future tests

3.6.6. Report Results:

-Document test results (also see analysis reports section of **Documents** template)

--Final reports, interim reports, etc.

--Keep in mind that final reports are Historical documents that can significantly benefit the tester for future test programs

-Document test item deficiencies or recommended enhancements

--See DR section of **Documents** template

-Provide timely feedback to decision makers, system design engineers, program managers, other testers, etc.

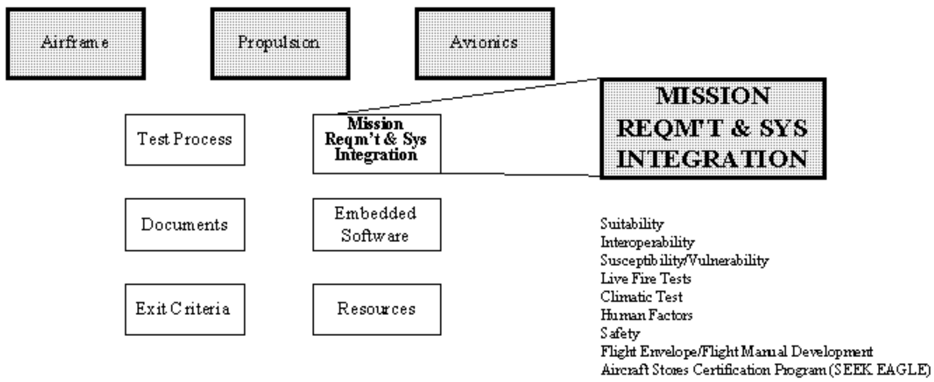
--Use appropriate media (account for coordination time, management oversight, etc.)

---Daily reports, internal memos, E-mail, telecon, DRs, etc.

--Feedback is used to update prediction tools, document deficiencies, make system changes, or plan retests

--Ensure personnel who need the test results receive the test results.

Figure 3.8. Mission Requirements and Systems Integration.



3.7. Mission Requirements and Systems Integration Template:

3.7.1. Suitability. (includes reliability, maintainability, logistics test, availability, supportability, compatibility, transportability, and training) is the degree to which a system can be satisfactorily placed in field use to accomplish its peacetime and wartime mission

-Guidance contained in DODI 5000.2, Parts 6&7, AFI 10-602, *Determining Logistics Supportability and Readiness Requirements* (formerly AFR 57-9), AFI 20-101, *Instructions for Logistics Strategic Planning* (formerly AFR 400-1), AFI 21-101, *Air Force Aircraft And Equipment Maintenance* (formerly AFR 66-1), AFR 800-8, *Integrated Logistic Support (ILS) Program*, MIL-STD 1388-1A, *Logistic Support Analysis*, and Defense Systems Management College (DSMC) Handbook, *Integrated Logistics Support Guide*, 1st Edition, May 1986

-Planning

--Suitability is as important as system effectiveness (range, speed, survivability, etc.)

--Test programs must implement integrated logistics support (ILS) and Logisitics Test (LOG TEST) methodology IAW AFI 99-101 and -102)

--Suitability must be designed into the weapon system early in acquisition/ development cycle and cannot be "added" as an after the fact

--Weapon system "maintainers" should be involved as early as possible in the weapon system's acquisition/development to influence the design

--Ensure software suitability is tested

-Requirements Review

--Review ORD to ensure suitability related ORD requirements are complete (for example, clearly define the downtime assumptions when stating availability requirements)

--Review ORD to ensure measurable terms are used when stating suitability requirements (mean-time between critical failures for reliability, not just 99 percent reliable)

--Ensure software suitability is sufficiently addressed in requirements

--Ensure requirements are testable (for example, 99 percent reliability with 90 percent confidence and with one failure would require 400 test trials)

-Test Conduct

--The ALCs depot maintenance infrastructure resources are intended to support sustainment activities on fielded systems not development or acquisition programs. These capabilities can and should be utilized when available to support test efforts if T&E facilities are not available or adequate to meet certain requirements.

--"Piggy-back" testing as much as possible (use onboard BIT data if available as well as routine ground maintenance data), but time and resources (test articles, manpower, etc.) must also be dedicated for suitability testing (for example, LOG TEST)

--Use DR system IAW TO 00-35D-54 to not only document deficiencies, but to propose improvements/enhancements to the system (including software)

--Implement a shared reliability, maintainability, and availability (RM&A) database controlled by Joint Reliability and Maintainability Evaluation Team (JRMET) - see AFI 99-101 and -102

-Data Analysis

--Data are reviewed/"authenticated" by JRMET - consists of DT&E, OT&E, SPO, user, and contractor representatives

--System effectiveness data system (SEDS) is used to facilitate the JRMET process by storing and processing failure and maintenance data generated during flight test

--Should be interaction between JRMET and DR Review Board (see TO 00-35D-54, *USAF Deficiency Reporting and Investigating System*, for DR Review Board details)

--OT&E data must be gathered/analyzed in accordance with (IAW) OT&E policy (see AFI 99-102) and Public law

3.7.2. Interoperability. The ability of weapon systems and their onboard systems to transmit information/data or receive information/data effectively from other weapon systems/onboard systems

-Guidance

--Department of Defense Directive (DODD) 4630.5, *Compatibility/Interoperability/and Integration of C3I Systems*, Department of Defense Instruction (DODI)e 4630.8, *Procedures for Compatibility/Interopera-biity/and Integration of C3I Systems*, and Joint Chiefs of Staff/Special Instruction (JCS/SI) 6212.01 direct what, when, and how systems must perform interoperability T&E

---Interoperability T&E must be accomplished prior to MS III

---The Joint Effectiveness and Interoperability Office (JEIO) within Defense Information Systems Agency (DISA) is responsible for interoperability testing (see JEIO Circular 9002, *Requirements Assessments and Integration Certification of C3I and AIS Equipment and Systems* for guidelines)

---The Joint Interoperability Test Center (JITC), Ft. Huachuca AZ is the DOD Executive Agent for interoperability testing and certification of C4I systems and equipment. JITC observes DT&E and OT&E interoperability test events or conducts inoperability testing when services are unable to address interoperability in DT&E and OT&E.

--Interoperability is a Tri-Service requirement

-Planning

--Primarily a C4I function, however because of the strong linkage between C4I and avionics, interoperability requirements and T&E must be accounted for in joint A-P-A and C4I related T&E

--Contact C4I SFTC Office, Air Force Development Test Center (AFDTC)/XRC, Eglin AFB FL (DSN 872-2853) for further information

--SPO must ensure resources for interoperability T&E are included in program planning and documented in TEMP

3.7.3. Susceptibility/Vulnerability Concerns. Survivability is a composite of susceptibility (probability of being hit) and vulnerability (probability of being downed by a hit). Mathematically, Survivability = 1 - (Susceptibility ¥ Vulnerability).

-Guidance

--For assistance in implementing a survivability program for your weapon system contact AFMC rep. for Joint Technical Coordinating Group on Aircraft Survivability (JTCG/AS) Office at DSN 222-2120

--DODI 5000.2, Part 6, sec. F, AFI 62-201, *Systems Survivability*, and MIL-STD 1799, *Survivability, Aeronautical Systems* contain survivability guidance

-Requirements Review

--Review ORD, and system threat assessment report (STAR) to ensure survivability assumptions/scenarios are adequately defined

-Planning

--Ensure TEMP has planned for resources (threat surrogates, targets, etc.) and their availability to conduct survivability testing

--Ensure testing will verify and validate survivability models

-Testing

--Survivability is not **one number** (much like there is no such thing as a single radar cross section (RCS) for an aircraft because it is dependent upon frequency, look angle, polarization, etc.), but instead, survivability is dependent upon many factors, including: weapon system's concept of operations (CONOPS), threat type/density, and combat scenario

---Therefore because of the large number of tests which would have to be conducted to assess survivability, modeling and simulation (M&S) must be used to assess survivability (unless very narrow constraints/assumptions are placed on survivability requirement, thereby drastically reducing the test matrix)

--Susceptibility and Vulnerability tests are used to verify M&S assumptions and results, and can also be used to directly demonstrate a system's survivability under a given scenario

--Individual component and subsystem vulnerabilities (data are stored in a vulnerability database/budget code) are aggregated using statistical analysis and combined with shot-line analysis (results obtained form a computer model of aircraft) to calculate an aircraft's vulnerability to a given hit

---Component and subsystem failure modes must be well understood

---Historical data from similar systems live fire test and evaluation (LFT&E) should supplement your aircraft's vulnerability data

---Testers must update database/budget code using LFT data

--The susceptibility of a weapon system is derived through combining a series of probabilities (i.e., probability of being detected, times probability once detected of being acquired, times probability of being targeted/lock-on by weapon, times probability of weapon detonating in vicinity of target and a fragment striking aircraft)

3.7.4. Live Fire Test. Title 10, United States Code, Chapter 139, Section 2366, et seq., Congressionally directs live fire testing and further guidance is contained in Secretary of Defense Memorandum, *Live Fire Test and Evaluation Guidelines,* 27 Jan 94, Department of Defense Manual (DODM) 5000.2-M, Parts 10 & 11, and AFI 99-105, *Live Fire Test*. Purpose of test is to provide timely and reasonable assessment of the vulnerability/lethality of a system.

-Guidance

--Per Section 2366 of 10 U.S.C. 139, LFT&E must be accomplished sufficiently early in a program to identify and assess possible design deficiencies to the system before MS III

--Typical point of contention is whether specific weapon system is "covered" under the law for LFT&E (covered system is defined in above listed documents, but open to interpretation. Note: may include preplanned product improvement (P^3I) programs)

--**Do Not** assume you are exempt (i.e., not a covered system), instead a waiver must be granted before MS II, and procedures are also contained in above listed documents)

--Beginning with component level T&E, vulnerability T&E (may include live fire) continues through EMD with additional component/system level T&E, and progresses to LFT&E of production representative items before proceeding beyond low-rate initial production (LRIP)

--By MS I, a decision should be made whether the system is "covered" and initial draft LFT&E and vulnerability/susceptibility strategy formulated. By MS II, the TEMP should contain a mature strategy (waiver, or full-up LFT&E). If applicable, entire LFT&E (including reporting) must be completed by MS III

-Planning

--Contact Wright Laboratories/FIV for assistance in developing the LFT&E strategy

--Perform survivability assessment and vulnerability risk versus cost assessment to ascertain LFT&E cost effectiveness and level of vulnerability testing (for example, a weapon system with an extremely low susceptibility may not warrant full-up LFT&E)

--Rely extensively on modeling and simulation to assess survivability (composite of susceptibility and vulnerability) and for planning vulnerability testing shot-line selection/test matrix (could include live fire)

--Where feasible, use component, sub scale, or partial system live fire tests to update models, demonstrate vulnerability without full-up LFT&E, or in buildup to full-up LFT&E

-Requirements Review

--Review MNS, ORD, STAR, and COEA to plan realistic vulnerability T&E including LFT&E against realistic threats

--Include LFT&E and/or survivability assessment strategy (including resources) in TEMP IAW DODM 5000.2-M, Part 7

-Test Reporting

--Document LFT&E results and submit to OSD no later than (NLT) 120 days after test completion see DODM 5000.2-M, Part 10)

3.7.5. Climatic Tests. (Tests conducted in the following environments: icing, extreme hot-weather/cold-weather, blowing sand/dust, humidity, vibration, and acoustic to assess system functionality and suitability)

-Guidance and requirements are contained in MIL-STD 210, *Climatic Extremes for Military Systems,* MIL-STD 810, *Environmental Test Methods,* and *AFR 80-31 "All-weather Qualification Program for Aircraft Systems & Material"*

-Planning

--Ensure climatic T&E is included in TEMP (allocate time, manpower, and resources)

--Indoor climatic labs (for example, the McKinley Climatic Lab at Eglin AFB - see **Attachment 2** for information regarding climatic labs) allow full-scale weapon system testing to be conducted in a controlled environment (therefore more efficient T&E than in open-environment), however the aircraft must be stationary (engines, APUs, etc., may be running)

--Plan and conduct climatic tests during deployment to extreme weather sites.

--Controlled in-flight icing may be conducted using an instrumented KC-135 aircraft (contact 412 TW/TSSS, Edwards AFB CA, DSN 525-9090 for information) or for slow speed in-flight icing using an instrumented CH-47 helicopter (Contact US Army, STEAT/AQ-CE, Edwards AFB CA, DSN 527-3901)

--Ensure support equipment is included in climatic test planning

--Ensure maintenance related tasks are evaluated during extreme environment testing

--Component climatic requirement T&E are performed during acceptance and/or qualification tests (typically at contractor facilities, but oversighted by government quality assurance personnel)

--Incorporate degraded modes into climatic test plan (perform risk versus probability of occurrence analysis to assist with test matrix planning)

-Requirements Review

--Review component, subsystem, and system specifications and ORD for climatic requirements for adequacy and testability

-Test Conduct

--Document deficiencies using DRs IAW TO 00-35D-54

--Verify and Validate TO maintenance procedures

--Assess human factor related tasks in realistic climatic conditions (for example, maintenance tasks with cold weather gloves on)

3.7.6. Human Factors:

-Guidance

--Guidance is contained in DODI 5000.2, Part 7-B, and DODM 5000.2-M, Part 6-H

--As with logistics tests, weapon systems must have good human factors designed into them and not added as afterthought

--Human factors have a significant impact on mission effectiveness and suitability

--Human factors have a strong influence on crew station layout (member of cockpit working group per AFI 63-112), crew visual and aural annunciation, and mission systems (air refueling, cargo delivery, night vision, ingress/egress systems, etc.), but must also be involved with systems which interface with personnel (maintenance, flying qualities, etc.)

-Planning

--Utilize simulators (with required fidelity) as much as possible to help reduce/focus more expensive tests

--Test Performance Assessment and Evaluation System (Test PAES) is a networked computer system available for assistance in human factors T&E. Contact 412 TW/OG/DOEH, DSN 525-9092 for information

-Test Conduct

--Human factors tests typically piggy-back on systems tests

--Data gathered through questionnaires, video, debrief comments, aircraft instrumentation, and aircrew flight reports

--Document deficiencies with DRs IAW TO 00-35D-54

3.7.7. Safety. The time invested into a well planned, well thought out safety plan is worth the effort.

-Guidance is contained in AFI 91-402, *USAF Mishap Prevention Program* and AFI 91-404

-Planning

--Refer to your individual center's, lab's, agency's, etc., safety office for detailed safety planning process guidelines

--Rely upon past history/lessons learned for effective safety planning (each center, lab, etc., should have a safety archive)

--Use failure modes and effects analysis (FMEA) and similar system documents to aid in safety planning

--Conduct risk versus hazard probability assessment and if applicable, include in safety plan

--Allow adequate time for safety plan approval cycle in test scheduling

--It is essential for effective safety planning that the tester **know** the SUT

--Ensure appropriate real-time instrumen-tation required for safety monitoring is included in the test plan

--Ensure appropriate safety related memo-randum of agreements (MOAs), treaties, legal documents, etc., are in place prior to test

--Ensure the test plan uses a risk build approach to testing (i.e., progress from low risk tests to progressively higher risk tests and use data obtained from previous tests to help assess risk)

-Test Conduct

--Test prebrief should be mandatory prior to all tests

---Brief safety constraints

---Ensure necessary instrumentation is functioning

---Gets test participants focused on the test

--Ensure safety plan/constraints are adhered to during test

---If a test team is conducting the test, assign a test director with safety responsibility

---Minimize deviations from well thought-out safety plan

--Follow mandated safety procedures in the event of a mishap or accident

3.7.8. Flight Envelope and Flight Manual Development:

-Testers, SPO, users, and contractor must work together to determine the flight envelopes (permissible, operational, etc.)

--Review ORD, MNS, Specifications, and flight manuals from previous aircraft models (i.e. for F-15E flight envelope/manual development, use F-15 C/D data) to assess envelope requirements

--M&S should be the primary tool to assist in envelope determination, however the data must be validated by flight test and flight test envelope "corners" should be flight test demonstrated if feasible

--If your program involves a new munitions or new loading on existing aircraft, contact the Armament/Munitions Single Face To Customer (SFTC) office and/or SEEK EAGLE office at DSN 872-4190.

-The SPO is responsible for the TO-001, *Aircraft Flight Manual* development, however responsibility may be delegated to the contractor and Responsible Test Organization (RTO)

--For a new aircraft, use FMEA and flight safety related documents (for example, the test force should develop a "what-if" document prior to first flight which is a paper analysis of possible aircraft problems and procedures for in-flight trouble shooting, aircrew and ground emergency procedures, and recovery procedures) to form the basis for preliminary flight manual emergency procedures

--Use the test force's/contractor's aircraft flight operating limitations document to assist in-flight manual development

3.7.9. Aircraft-Stores Certification Program (SEEK EAGLE). The process by which aircraft-store configurations are certified on aircraft to meet operational requirements specified by the using command. This process assures aircraft-store compatibility (store loading, safe carriage and separation), and weapon delivery accuracy verification.

-Guidance

--AFI 63-104, *The SEEK EAGLE Program*, defines the SEEK EAGLE (SE) process and *the SEEK EAGLE Engineering/Test Capabilities Handbook* (Aug 1992) identifies the location, primary mission, and major aircraft-store certification test resources available at government test and analysis facilities. *Program Management Directive for Aircraft-Stores Certification (SEEK EAGLE), PMD 5077*, provides direction and funding for certification projects.

-Process

--Begins with SE Request (SER) submitted by the using command or the Directorate of International Programs (SAF/IAY) for Foreign Military Sales International programs and ends with the publication of related technical orders and user acceptance of the Operational Flight Program accuracy, as shown in **Figure 3.7.**

--Each SER made into one or more projects designed to include activities required to complete certification process. Each project tailored from a standard template which considers program requirements, performance, schedule, cost and constraints.

--SE Management Support System (SEMSS) used to track status [Office of Primary Responsibility (OPR, schedule, cost, etc.)] for each activity.

-Planning

--SE activities integrated with acquisition programs early in life cycle (not later than Demonstration/Validation phase) to ensure timely consideration of realistic operational configurations and to integrate SE to maximum extent possible during DT&E and IOT&E.

--Certification of baseline aircraft-store configurations completed applying Integrated Weapon System Management (IWSM) guidelines: follow-on certifications accomplished by the Air Force Seek Eagle Office (AFSEO).

-Aircraft/Store Integration

--SE not responsible for development or modification of aircraft or store to achieve actual aircraft-store configurations requested for certification. This includes avionics, electrical and mechanical integration or associated modification to the aircraft/store to provide required operational interfaces.

--Systems integration and hardware modification are the responsibility of the store and/or aircraft System Program Offices.

Figure 3.9. SEEK EAGLE Process.

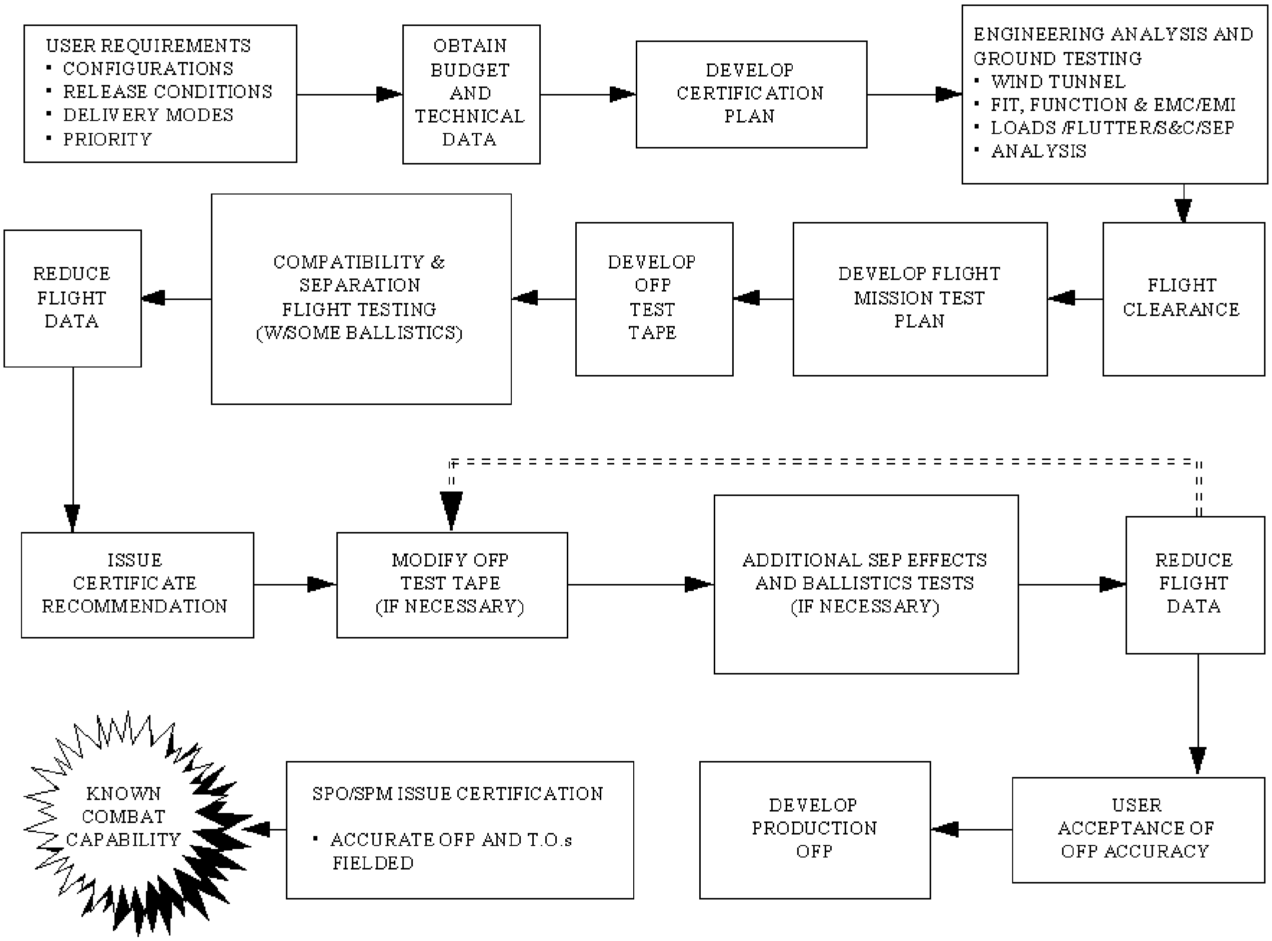
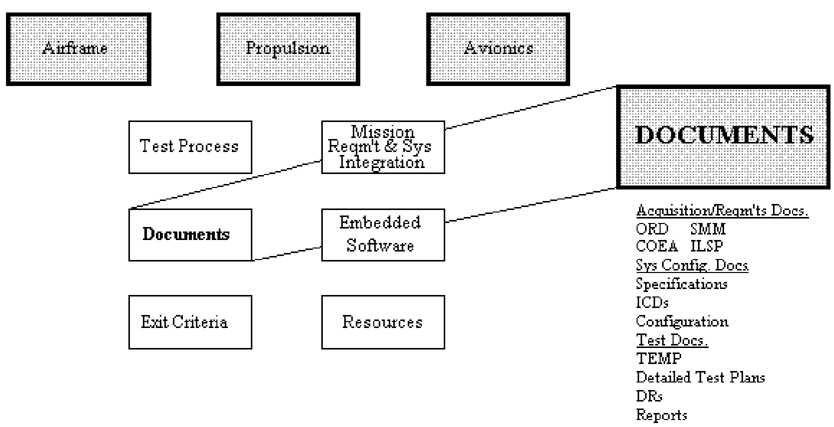


Figure 3.10. Documents.



3.8. Documents Template:

3.8.1. Acquisition/Requirements Documents:

-The Operational Requirements Document (ORD) is the responsibility of the user and documents how a system will be operated, deployed, employed, and supported

--ORD format/content guidance is contained in DODM 5000.2-M, Part 3, and AFI 10-601

--Ensure the requirements are realistic, testable and are expressed in measurable terms (range, endurance, functionality, reliability, etc.)

--Provides tester with system CONOPS and summarizes the threats (details in STAR)

--Testers should use it for planning operationally realistic tests (including DT&E)

-Cost and operational effectiveness analysis (COEA) is the responsibility of the user and is a quantitative analysis which identifies the preferred system

--Guidance is contained in DODI 5000.2, Part 4-E and DODM 5000.2-M, Part 8

--Documents the Measure of Effectiveness (MOE) for determining whether the system meets the users needs and as such, should be reviewed for testability and to determine whether assumptions and models are valid

--Provides testers (OT&E and DT&E) with the critical operational issues (COIs), their MOE, and costs (should be used when making T&E resource planning decisions)

--If the COIs or MOE are not directly testable, lower level test criteria, Measure of Performance (MOP) - speed, range, handling qualities, etc., must be developed

--Assesses sensitivity of critical performance alternatives

--Testers should ensure COEA key assumptions and estimates are testable

-System Maturity Matrix (SMM) is the responsibility of the SPO and is an acquisition management tool used for evaluating weapon system capability versus time and defines criteria for risk management and analysis

--See OSD Policy 92M-001 for guidance regarding SMM application

--Time-phased comparison of the user's system requirements and contractual specifications which lead to maturity

--Includes significant parameters necessary to measure progress towards meeting the user's needs

--Ensure requirement criteria traceability to the ORD

--Establishes system development exit criteria (see **Exit Criteria** template for additional information)

-Integrated logistics support plan (ILSP) is the responsibility of the SPO (Logistics Manager) and provides ILS information used to develop and define supportability design factors and develop integrated system support structure. Identify and establish requirements for: maintenance concept, manpower (skills, numbers of, etc.), supply support, support equipment, training, packaging-handling-storage-and transportation, technical data (TOs), and system support facilities

--Guidance contained in DODI 5000.2, Part 7, AFI 10-602, AFI 20-101, AFI 21-101, AFR 800-8, MIL-STD 1388-1A, and DSMC Handbook, *Integrated Logistics Support Guide*, 1st Edition, May 1986

--Documents the Integrated Weapon System Management (IWSM) approach to system fielding

--Integrity Program documents are Military Standards that provide general requirements and specific tasks to achieve software, aircraft structural, engine structural, avionics and mechanical integrity during the development and deployment of systems and equipment. These documents impose a requirement for a Development Integrity Program with an objective to assure that operational needs are met, the system is supportable and can be developed within schedule and resource constraints of the acquisition program. The test requirements to verify the design and performance are generated as Section 4 requirements in these documents. The integrity documents include:

--MIL-STD 1803 Software Development Integrity Program

--MIL-STD 1530 Aircraft Structural Integrity Program

--MIL-STD 1783 Engine Structural Integrity Program

--MIL-STD 1796 Avionics Integrity Program

--MIL-STD 1798 Mechanical Equipment and Subsystem Integrity Program

3.8.2. System Configuration/Engineering Documents:

-Baseline documentation (functional, allocated, product, process baselines)/(A, B, C, D, or E type specifications). These documents identify system requirements at progressively lower levels and contractually bind the contractor

--Guidance contained in DODI 5000.2, Part 9-A, MIL-STD 480, MIL-STD 483, AFR 800-60, and DSMC Handbook, *Systems Engineering Management Guide*, 2nd Edition, 1990

--The various specification levels provide a clear audit trail beginning with user requirements to product/item requirements

--Formally reviewed at various government reviews [preliminary design review (PDR), critical design review (CDR), system requirements review (SRR), etc.] dependent upon acquisition phase

--Ensure the specifications are relevant and do not just "gold plate" the user's requirements

--Ensure the requirements are testable

-Interface Control Documents (ICDs) control interfaces between various components, subsystems, or systems by documenting interface agreements, architecture, and requirements (timing, bit-map, protocol, etc.)

--Written by system designer(s) (usually the contractor)

--Essential document to control software-to-software interfaces as well as software-to-hardware interfaces

--Critical document during problem troubleshooting

-Configuration documents are constantly changing documents which evolve with the system. They document the exact functional and physical characteristics of the system versus time. The documents are at various levels depending upon the level of detail needed to identify a configuration and contain information such as component (hardware and software) serial numbers, versions, modifications, maintenance write-ups, and instrumentation configuration

--System detailed characteristics are documented by the designer (usually the contractor)

--The system configuration is controlled through the Configuration Control Board (CCB) made up of representatives from DT&E, OT&E, contractor, SPO, and sometimes the user

--These are essential documents to the tester in that they define exactly what configuration is/has been tested

--Tester must ensure the configuration is valid for the test to be performed

3.8.3. Test Documents:

-The TEMP is the responsibility of SPO and is prepared as early in the acquisition process as possible. Identifies and integrates high level T&E objectives, responsibilities, resources, and schedules in support of key program decision points

--Guidance is contained in DODI 5000.2, Part 8, and DODM 5000.2-M, Part 7

--Written through Test Plan Working Group (TPWG) forum and is a product of the T&E planning process

--Top-level summary of the program's T&E process implementation

--Used to generate lower-level detailed T&E plans

--Required at milestone I and updated at each major milestone or significant change in the status of the acquisition program

--Ensure the plan is executable, defendable, and uses a building block approach for test progression (see **2.6.8.** for further details)

--Ensure traceability to requirements documents (ORD, COEA, STAR, ILSP, etc.)

--Tailor each version to support appropriate milestone decision

--Include both hardware and software test information

-Detailed test plans flow top-down from TEMP and document test planning to a level detailed enough to perform a specific test and gather required information. Guidance is contained in AFI 99-101

--The format and content for detailed test plans vary and are usually directed by individual centers, agencies, and labs

--Detailed test plans should be written and coordinated among all test participants (DT&E, OT&E, contractor, and SPO) to maximize test efficiency (for example DT&E and OT&E should strive to use the same instrumentation, data, test points, etc.)

--Ensure tests can be conducted within safety, environmental, etc.

--Perform any necessary hazard (safety, environmental, etc.) analysis prior to conducting test and ensure results are utilized in detailed test planning

-Deficiency Reports (DRs) [formerly service reports (SRs)] are government written and controlled documents which identify system (hardware and software) deficiencies

--Of paramount importance to testers and decision makers by providing feedback into the system engineering process to make corrections

--Essential for correcting deficiencies early (recommend being implemented during contractor DT&E using watch items in conjunction with formal DRs- see TO 00-35D-54)

--Directed and Implemented IAW TO 00-35D-54 during government testing

--Prior to government conducted testing, a contractor-owned and - based DR system must be established

--DRs/watch items are reviewed, approved, and prioritized through DR Review Boards chaired by testers

--Resolution of DRs is accomplished through material improvement project (MIP) chaired by SPO

-Analysis Reports (interim, final, daily, etc.) take-on many forms dependent upon the time span covered for a given (or set of) test, the testing agency/command, and the report recipient

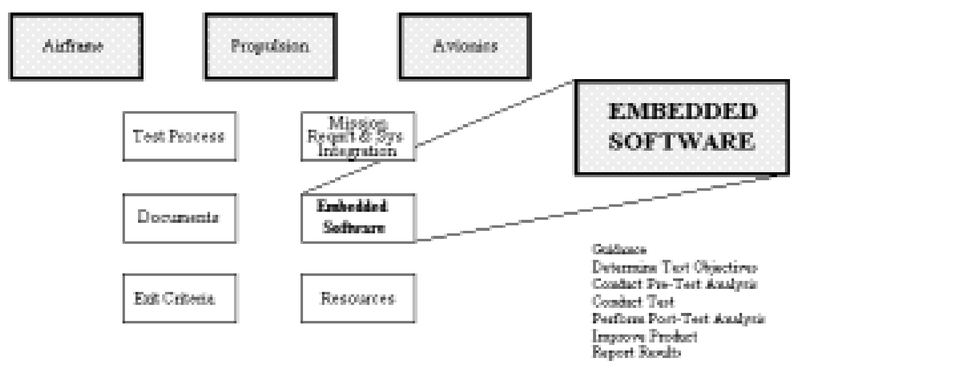
--Ensure reports are timely for decision makers and "answer the mail"

--Formats, content, etc. are directed by individual centers, agencies, etc.

--It is helpful to outline the test reports prior to testing to ensure necessary data is gathered for decision makers

--Keep in mind that final reports are historical documents and therefore, must adequately describe the system configuration, data analysis, assumptions, etc.

Figure 3.11. Embedded Software.



3.9. Embedded Software Template:

3.9.1. Guidance:

-Embedded software testing encompasses a wide range of complex areas from initial software testing at the module level (DOD-Std-2167, *Defense System Software Development*) to integrated DT&E and OT&E testing. For the purposes of this manual it is impossible to cover all aspects of the embedded software testing process. Therefore, the generic concept of testing embedded software will be covered with the following documents recommended as sources of information on the software development and testing processes.

-Embedded software guidance is contained in Secretary of the Air Force Memorandum, *Guidance for the Successful Acquisition of Computer Dominated Systems and Major Software Development*, DOD-STD-2167, DOD-STD-2168, *Defense System Software Quality Program*, AFR 800-14, *Life Cycle Management of Computer Resources in Systems*, AFLCR 800-21, AFMC Pamphlet 800-45, *Risk Abate-*

ment, AFMC Pamphlet 800-60, *IWSM Guide,* AFMC *Embedded Software Management Plan,* 1 Sep 93, and MIL-STD-1803, *Software Development Integrity Program,* 15 Dec 1988.

-The extent of embedded software testing is determined by the level of testing required. Test team involvement should start at the earliest possible stage of the project. Ideally the test team would define the high level test criteria during the concept exploration phase, participate in generating the TEMP and participate with the Computer Resources Working Group (CRWG).

-Software testing starts at the computer software unit (CSU) level followed by the computer software component (CSC) and computer software configuration item (CSCI) testing. Normally this testing ensures that the intended software functionality has been achieved. The next level (normally a system level test) tests the CSCIs integration with the hardware and other CSCIs in an operational environment. This test is intended to "drive out" possible operational problems. Each level is increasingly complex and requires understanding of the software and software environment being tested. The level at which the embedded software is being tested determines which of the steps into this template will be used. This determination is made by the test team who is ultimately responsible for defining and conducting the test.

3.9.2. Determine Test Objectives:

-Review requirements to ensure that each section 3 (specification) requirement has a corresponding section 4 paragraph stating how that requirement will be tested

-Review Requirements Document

--Appropriate DOD-Std-2167A documents [System Requirements Specification (SRS), System/Segment Specification (SSS), System/Segment Design Document (SSDD), System Design Document (SDD), Software Test Plan (STP), Standard (STD), Interface Design Document (IDD)]

--Operational Requirements Document (ORD), Mission Needs Statement (MNS)

-Identify purpose of test

--To test functionality, basic or expanded

--To write or verify documentation (TOs, manuals)

-Formulate test plan (see DOD 5000 series and the **Exit Criteria** template for guidance)

-Identify test completion criteria

--How will you know when the test is complete?

--What is success? What will mean re-test is required?

-Identify test result reporting requirements

--Who will need the results?

--What data formats and media are required?

---Prototype the results: draft a rough outline of the test report early and verify with the intended receivers that the proposed data and formats will meet their needs

3.9.3. Conduct Pre-Test Analysis:

-Predict software performance

--Review previous test, if any, or similar software systems data to help predict software performance

--Use engineering judgment or past experience

--Use modeling and simulation to help predict performance

--Using software listings and documentation to guide you, determine software design limits and predict performance at and beyond those limits

-Identify test conditions

--Where will testing occur? In isolation or attached to the rest of the system?

--On the ground, in the air, local or remote, special facility?

--Develop test matrix, using modeling and simulation, statistical analysis and good judgment to focus the test on areas where confidence is low or risk of failure is high

--Test matrix should exceed software design limits as determined by examination of code listings and software documentation

--Test to find errors, and also show what works; each bug found and eliminated increases the value of the software

-Identify safety and environmental test con-straints

--Identify local safety hazards caused by test and incidental to test

---High or low temperatures, wet, slippery, freezing, caustic, poisonous

---Know what other software, systems or subsystems could be affected or activated by the test, and possible safety hazards as a result: e.g., testing fire detection subsystem could activate fire suppression subsystem

---Identify environmental requirements, such as anechoic or thermal

--Identify possible environmental hazards

---Explosion, fire, poisonous gas

-Determine instrumentation and data require-ments early

--What do you want to report? What do you need to measure?

--Review the prototype results report (see **Determine Test Objectives**, on this template to ensure that the expected results are linked to the necessary instrumentation)

--Make sure you know what you are **really** measuring

--Will you need and will the software provide "diagnostics" if requested?

-Determine Test Resources needed to conduct test and analyze data

--People, fixtures, facilities, analysis software

3.9.4. Conduct Test:

-Collect data

--Follow test plan and collect data

--Testing should be scripted, then follow the script

--Integrate OT&E and DT&E testing whenever possible

-Perform real-time data quality assessment

--Use quick-look capabilities where available, devise your own when not

--Much cheaper to repeat a test point on the spot, when everything is in place, rather than having to set it all up again later

--Compare predicted with actual to determine if test points ought to be repeated

--Test personnel should have good understanding of the embedded software in the SUT. If possible, involve software designers/developers in the testing

-Document test events

--Testing should be scripted, and a log updated as each test point is completed

--Note all anomalies and anything interesting, especially unexpected events

--More is better; good documentation will help the post-test analysis

-Conduct pre- and post-test reviews

--Pre-test briefings will help focus personnel on the task at hand

---Use check-off list to ensure nothing is missing

--Refreshes testers on safety, test and environmental constraints, hazards

--Post-test reviews help focus analysis and help scope the next test

3.9.5. Perform Post-Test Analysis:

-Compare measured data to predicted data and software requirements (pre-test analysis)

-If different more than expected (use engineering judgment and experience) then perform the following (in general order)

--Review test log and ensure the test point was valid

--Verify the data quality/accuracy

--Review test methodology and ensure that it did not affect the data

--Verify data analysis algorithms using data known to be correct

--Ascertain if prediction tools were in error

-Ascertain if retest is necessary

-Identify deficiencies in the software or procedure

--If test procedure is in error, make corrections and perform retest if necessary

3.9.6. Improve Product:

-Change test procedure if required

--Correct problem sources within the test procedure

--Perform retest if necessary

-Determine cause of deficiency

--Identify and correct problems as early as possible during the software development process

--Correcting a software error during the design phase is substantially less costly than discovering an error in the production system

-Improve design and implement change

--Before proceeding through the test process steps, it may be necessary to access and possibly revise the system test objectives

--Modification of the system architecture may require a significant amount of regression testing

-Maintain configuration control

--A structured, well defined configuration control process will significantly reduce both software and system risks during development

3.9.7. Report Results:

-Document the software deficiencies and/or recommended enhancements

--See DR section of the **Documents** template

-Provide timely feedback to decision makers, system designers, program managers, other testers, etc.

--Use appropriate media (account for coordination time, management oversight, etc.

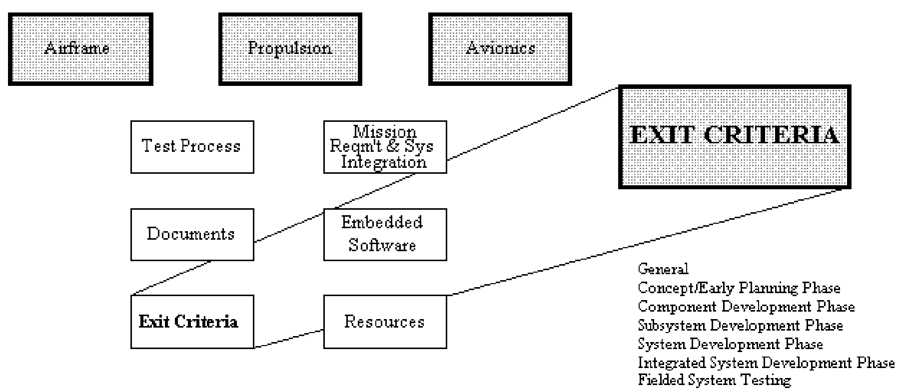
---Daily reports, internal memos, E-mail, telecon, DRs, etc.

--Feedback is used to update prediction tools, document deficiencies, make software changes, or plan retests

-Document test results

--Final reports, interim reports, etc.

Figure 3.12. Exit Criteria.



3.10. Exit Criteria Template:

In planning and executing a test program, it is important to understand and define criteria which identify the successful completion of test phases and individual tests. The following templates are suggestions/ things to consider when identifying exit criteria during the various stages of a weapon system's development.

3.10.1. General:

-The weapon system's System Maturity Matrix (SMM) is a tool used to track technical progress against the program's critical system characteristics (see DODI 5000.2 for definition), allocated requirements (system specifications) and Air Force Acquisition Policy 92M-001

--The SMM also defines exit criteria for completing each acquisition phase/MS

--See **Documents** template for additional information regarding SMMs and system specifications

-The tester should develop criteria which identify the completion/success criteria for critical aspects of the development process

--For example, delivery of a specific set of ICDs may be critical before proceeding through a given subsystem's development

-In short, the testers in conjunction with the SPO, should identify the critical events, system performance, test prerequisites, documents, data, and resources needed to minimize risks and proceed efficiently through each stage of a test program

3.10.2. Concept/Early Planning

-Test program planning

--Good planning is always the key to good testing and good planning always starts with reviewing requirements

---See **Documents** template for suggestions on reviewing requirement documents

---The results of COEA and models should be reviewed to identify the key drivers in system performance and identify sensitive parameters

---Review the various baselines (functional, allocated, etc.) to identify desired component, sub-system, and system performance

---Review development schedules, deliverables, and contract data requirements list (CDRL) items to ensure prerequisite tests, data, support equipment, and test articles are properly identified and can be delivered within the contract constraints

--Develop a test program built upon answering the mail on all the requirements discussed above

---The TEMP, SMM, program introduction document (PID)/statement of capability (SOC), detailed test plans, etc., should document a clear audit trail from weapon system requirements, to test objectives, to individual test success criteria

---The TEMP, SMM, PID/SOC, detailed test plans, etc. should also baseline an executable test pro-gram with measurable exit criteria

---Ensure test strategies have flowcharts which identify exit criteria and include adequate (numbers of and timing of) program reviews

---Develop a program which allows early identification and correction of problems on those areas identified above to be risky

---Review USAF/TE's *Certification of Readiness for Dedicated OT&E* Templates and ensure the test program will give DT&E enough data and sufficient confidence when the time comes to certify readiness for dedicated OT&E

--Failure to meet a given exit criteria will require either additional testing and/or a reassessment of the risk and performance requirements.

3.10.3. Component Development Phase:

-Testing is conducted to evaluate how well the components perform within their respective subsystems as designed and whether they meet specifications/baselines (generally component testing is too low level to assess against user requirements)

--Typically, the component under test is stimulated using inputs derived from an external simulation (hardware and/or software)

--Ensure the component's software is adequately exercised (adequately depends upon the code's size, complexity, number of interfaces, etc.)

-Typical component exit criteria include: Meeting environmental requirements (strength, life, weight, temperature,vibration, etc.), airworthiness certification, component level software module performs as required, subsystem simulation in which component is installed meets requirements, updating a model from component test results, or verifying a design change

-Usually for a new weapon system program, component level testing is conducted primarily using Measurement Facilities (MFs), System Integration Laboratories (SILs), and M&S facilities

--See **Resource** templates and **Attachment 3** for additional information

3.10.4. Subsystem Development Phase:

-Testing is conducted to evaluate how well a given subsystem performs against design requirements internal to its respective system and how well it interfaces with other subsystems (internal and external to its system)

--Subsystem testing is typically the first opportunity to test at a level near the user requirements level without excessive extrapolation

--Ensure component and subsystem ICDs are written and adhered to before proceeding too far into system level development ("too far" depends upon risk, adequate schedule allowance to correct problems, resource availability, etc.)

--Ascertain what capability is needed and demonstrated from the subsystem before progressing too far into system level development

-Typical exit criteria include: updating a system or subsystem level model from subsystem test results, demonstrating redundancy requirements, demonstrate the subsystem's functional requirements, meeting life-cycle endurance requirements (x number of cycles before failure), etc.

-Usually for a new weapon system program, subsystem testing is conducted primarily using SILs, Hardware-In-The-Loop (HITL), and M&S

--See **Resource** templates and **Attachment 3** for additional information

3.10.5. System Development Phase:

-Testing is conducted to ensure the air vehicle is safe, evaluate how well the system performs against design requirements, and obtain a preliminary assessment of the weapon system's operational effectiveness and suitability (to support certification of readiness for dedicated OT&E) before proceeding into the integrated system testing phase

--Ascertain air vehicle's airworthiness prior to first flight

---Verify installed component, subsystem, and system structural integrity and functionality

---Assess performance capability

---Verify system stability

---Verify subsystem/system compatibility [Electromagnetic Interference (EMI), Electromagnetic Compatibility (EMC), etc.)

---If sufficient flight risk, perform taxi tests

--Identify test point success criteria required for safe envelope expansion

---Ensure test points adequately test system functionality and gain confidence before proceeding to successive test points

--Once the system is mature enough (SPO, DT&E, and OT&E discretion), ensure DT&E tests are operationally realistic and adequately address operational requirements (COIs, MOE, and MOPs)

---Refer to USAF/TE's *Certification of Readiness For Dedicated OT&E* Templates for details

-Typical exit criteria include: demonstrating basic airworthiness tasks (takeoff, landing, navigating, refueling, etc.), demonstrating preliminary mission level tasks (bombing, aerial delivery, SEAD, etc.), evaluating maintenance tasks, technical order validation, developing the flight manual to a pre-determined level, Certification of Readiness for Dedicated OT&E, etc.

-System level testing is primarily conducted in ISTFs and OARs

--See **Resource** templates and **Attachment 3** for additional information

3.10.6. Integrated System Development Phase:

-Testing is conducted to evaluate the weapon system's operational effectiveness and suitability in an environment which as close as practical replicates the weapons system's intended operational environment

--DT&E test objectives should concentrate on conducting operationally realistic tests which adequately stimulate and evaluate the weapon system in support of dedicated OT&E certification (if not completed in previous phase)

--OT&E testers must ensure adequate data is gathered to perform system evaluation to answer all COIs (require MOE and MOP evaluation/rollup)

--Ensure DRs are closed or in MIP process (see TO 00-35D-54 for details) prior to fielding

-Typical exit criteria include: demonstrating key parameter thresholds in ORD (see AFI 10-601 and DODM 5000.2-M, Part 3), answering COI, MOP criteria, providing OT&E final report to OSD, collecting data for high level model verification, validation and accreditation (VV& A), etc.

-System level testing is primarily conducted in OARs and is supported by M&S

--See **Resource** templates and **Attachment 3** for further information

3.10.7. Fielded System Testing:

-P^{3}I and upgrade programs (weapon system is out of production) require some level of T&E. The level required is very dependent upon the exact nature of the mod/upgrade. Some may require only FOT&E, but others may require a full blown DT&E/OT&E (in which case the acquisition and development cycle starts over)

--Testing is conducted to ensure the mod/upgrade meet requirements (user and in some cases, detailed specifications)

-Typical exit criteria include: verifying weapon system increased suitability and/or effectiveness (OT&E exit criteria), evaluating changes to system for effects on safety, flight characteristics for flight manual changes, increased system performance

-Fielded system testing is primarily conducted on OARs or ALCs (see resource templates and **Attachment 3** for further information).

3.11. Airframe Mission Area Template:

Test Resources (Also see **Attachment 3**, **T&E Resources**, for details)

3.12. Propulsion Mission Area Template:

Propulsion Test Resources (Also see **Attachment 3**, **T&E Resources**, for details)

3.13. Avionics Mission Area Template:

Avionics Test Resources (Also see **Attachment 3**, **T&E Resources**, for details)

Figure 3.13. Airframe Mission Area.

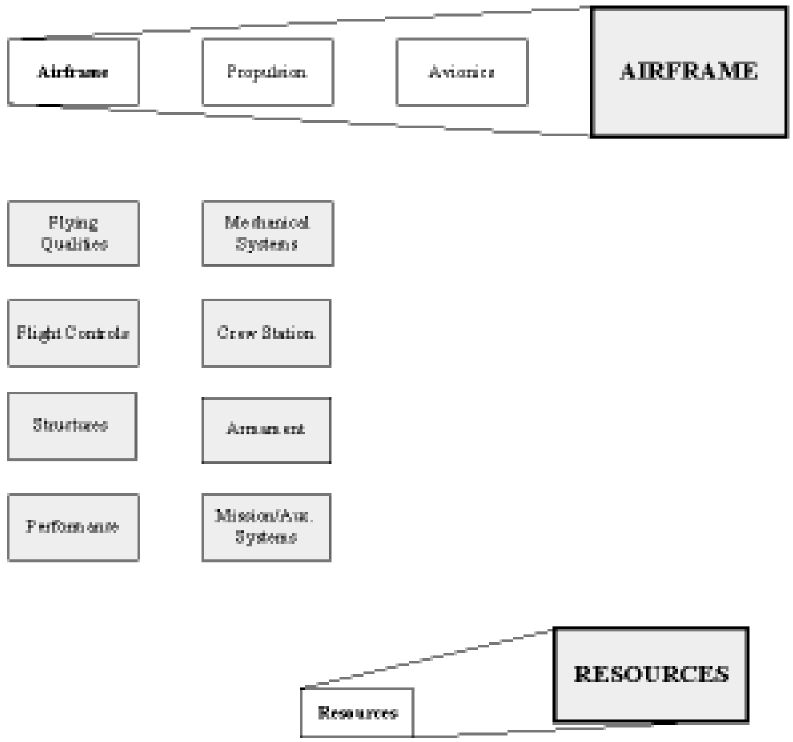


Table 3.1. Airframe Modeling and Simulation (M&S).

Typical Models	Purpose
Ballistic Accuracy Models	Provide flow field effects coefficients for OFP for initial SEEK EAGLE tests
Control systems block diagrams (flight control, mechanical subsystems, etc.)	System stability analysis
System architecture models (flight control, mechanical subsystems, etc.)	Inter-item requirements determination, Intra-system (hardware/software) requirements determination, failure mode analysis, RM&A analysis
Structural Models	Loads, strength, life, aeroelastic, weight and balance, vibroacoustic.
Aerodynamic Models	Digital and piloted simulation, aircraft performance analysis, flight control development, flutter analysis, air data computation development, determine forces and moments, inlet performance and airframe/engine compatability.
Specialty Models (models with very specific purpose used during systems engineering)	Simulate items (components, subsystems, systems) functionality during systems engineering

Typical Models	Purpose
Component/subsystem vulnerability models	Assess test item vulnerability. Contact Wright Labs/FIV for further information
In-flight simulators and instrumented flying test beds	Variable in-flight stability training aircraft (VISTA), total in-flight simulator (TIFS) (both Calspan Co. operated), and contractor owned/ operated aircraft

Table 3.2. Airframe Measurement Facilities (MF).

Typical Tests	Resource
	(these facilities are usually not specific to test item .i.e., independent of test item size, shape architecture, etc.)
Conceptual design wind tunnel tests (platform shaping, new technologies experiments, preliminary aerodynamics, etc.)	Contractor and government (gov't). Wind Tunnels [Arnold Engineering Development Center (AEDC), Wright Lab, etc.]
Gather detailed wind tunnel data for aerodynamic databases (performance and flight control data, and spin recovery data)	Contractor and gov't. Wind Tunnels (AEDC, Wright Lab, etc.)
Wind tunnel flutter tests	Contractor and gov't. Wind Tunnels (AEDC, Wright Lab, etc.)
Structural strength, life, and stiffness tests	Primarily contractor owned/operated test stands, Wright Labs Structural Test Facility
Component-level Environmental Tests (strength, life, functionality and acceptance tests)	Acceptance testing is typically performed in contractor facilities/chambers. Gov't Facilities: Erosion control measurement facilities, component climatic chambers Central Inertial Guidance Test Facility (CIGTF) at Holloman AFB, large climatic chamber at Eglin AFB, Environment Test Faclities at WPAFBHypersonic ranges at AEDC
Birdstrike Effects	Birdstrike Impact Facilities at AEDC and Wright Labs
Ballistic Accuracy Wind Tunnel Tests	Government wind tunnels, AEDC Aerodynamic Wind Tunnel 4T and Propulsion Wind Tunnel 16T
Safe Separation Weapon Integration Tests	Government wind tunnels, AEDC Aerodynamic Wind Tunnel 4T and Propulsion Wind Tunnel 16T.
Vectored Nozzle Performance Testing	AEDC Propulsion Wind Tunnel 16T

Table 3.3. Airframe System Integration Labs (SIL).

Typical Tests	Resource
	(hardware is typically modeled in software or is prototype and the resources are usually specific to the test items)
Bench-Top component lab tests (for example, actuator bench tests, control surface load test, software modules tests, etc.)	Usually performed in contractor facilities or in Air Logistics Center (ALC) facilities for P^3I programs
Subsystem lab tests (for example, software based flight control/avionics integration tests, piloted flying qualities/flight controls simulation, prototype mechanical subsystems tests)	Primarily performed in contractor facilities for new system acquisition or in ALC facilities for P^3I programs
Preliminary logistics related tests (gather preliminary maintenance task related data using full-scale mockups)	Mockups are usually built in contractor facilities for new system acquisition
Preliminary (software based) failure modes and effects criticality tests	Contractor hosted computer models
Fielded OFP Support/Mod	Applicable ALC (type aircraft dependent)
New Technology demonstrations - Ground based: high pressure hydraulics, virtual cockpit, human factors/life support, etc.	Wright Labs (materials lab, flight control lab, etc.), Human Systems Center (HSC) labs (human factor labs, centrifuge, etc.), and contractor labs
Ballistic Accuracy Mods to OFP	Air Force SEEK EAGLE Office (AFSEO)

Table 3.4. Airframe Hardware-In-The-Loop (HITL) Facilities.

Typical Tests	Resource
	(these facilities test uninstalled hardware and are typically test item specific)
Flight control/hydraulic integration tests (iron bird tests)	Usually performed in contractor facilities (hardware specific)
Pre-installed structural loads tests	Usually performed in contractor facilities (hardware specific)
Gyro/attitude control system tests	Usually performed in contractor facilities (hardware specific)
HITL piloted simulations (to assess system stability)	Usually performed in contractor facilities (hardware specific)
Mechanical systems functionality tests (fuel system tilt tests, electrical power load tests, etc.)	Usually performed in contractor facilities (hardware specific)
Component/subsystem life-cycle endurance tests/ Qualification Tests	Usually performed in contractor facilities (hardware specific)

Typical Tests	Resource
Failure Modes and Effects Analysis Testing	Usually performed in contractor facilities (hardware specific)
Fielded OFP Support/Mod	Applicable ALC

Table 3.5. Airframe Installed System Test Facilities (ISTF).

Typical Tests	Resource
	(these facilities test items as installed in the air vehicle)
Ground vibration tests (GVT) - (determine structural mode/freq.)	Limited gov't facilities (Edwards AFB,), usually conducted using contractor facilities
Limit cycle/ground resonance test (GRT) - (evaluate open and closed loop stability of flight controls, mechanical subsystems, etc.)	Limited gov't facilities (Edwards AFB), usually conducted using contractor facilities
EMI/EMC tests	AFDTC Pre-flight Integration of Munitions and Electronic Systems (PRIMES) and Large shielded Benefield anechoic facility (BAF) at AFFTC
Aircraft ground load tests (drop tests, structural failure tests (100%, 200% load tests)	Usually conducted at Contractor facilities (Lockheed facility at Plant 42, Palmdale, Ca. and Wright Labs
Live Fire Tests	Wright Labs/FIV (up to 30mm), high speed test track at Holloman AFB
Full-scale climatic tests	McKinley Climatic Lab, Eglin AFB
System functional/acceptance tests	Conducted at manufacturing site
Prototype Ejection/Egress Systems Tests (hypersonic and crew module ejection systems)	high speed test track (Holloman AFB)
Cruise Missile T&E	Full scale captive flight testing in AEDC Propulsion Wind Tunnel 16T
Electronic Countermeasures (ECM) and Electronic Counter-Countermeasures (ECCM) tests (flare dispensing, decoys, chaff, etc.)	High speed test track (Holloman AFB)
Ground Gun Tests	Gun Test Facility at Edwards AFB and Eglin AFB

Table 3.6. Open Air Ranges (OAR) - Airframe related T&E (Typical Ground/Pre-flight Tests).

Typical Ground/Pre-flight Tests	Resource
	(see **Attachment 3** for list and description of major test locations/ranges)
Suitability Ground Tests (Reliability, Maintainability, etc.)	Conducted at test locations

Typical Ground/Pre-flight Tests	Resource
Pre-flight taxi tests (assess handling qualities, systems functionality with system in motion, etc.)	Conducted at weapon system manufacturing site
Ground Operations Tests (turn radius, handling qualities, external lighting, etc.)	Conducted at weapon system manufacturing site prior to delivery then at test site during gov't T&E
UAV/Cruise Missile "IRON BIRD" Ground Launch tests	Utah Test and Training Range (UTTR)
Braking, RTO tests, arresting systems tests	These are usually high risk tests, and are typically conducted at Edwards AFB (emergency options)
EMI/EMC test	PRIMES Test Facility at Eglin, BAF at AFFTC

Table 3.7. Open Air Ranges (OAR) - Airframe related T&E (Typical Flight Tests).

Typical Flight Tests	Resources
Envelope expansion - Flight controls, flutter, mechanical systems, 80/100% loads, flying qualities, air data, high AOA, etc.	- New aircraft/major P^3I/high risk programs - Edwards AFB, Eglin AFB
Aero/Performance Data Base Verification	Edwards AFB
Mission Systems: - Air refueling qualification - In-flight icing and rain - Aerial cargo delivery development and OT&E - Initial weapon separation & delivery (not certification or weapon development) - Terrain following/terrain avoidance (TF/TA) development (flyup command checkout, ride quality, auto let down, etc. Also see Avionics templates -TF/TA)	Instrumented KC-135 and KC-10 aircraft -412 TW, Edwards AFB Instrumented KC-135aircraft -412 TW, Edwards AFB Edwards AFB, , Eglin AFB Edwards AFB, Eglin AFB, UTTR Edwards AFB
UAV/Cruise Missile captive carriage testing	UTTR, Edwards AFB
UAV testing	UTTR, Eglin, White Sands Missile Range (WSMR)
Cruise Missile T&E	UTTR, Eglin, Vandenburg Test Range
Fielded OFP Support/Mod	Applicable OFP

Figure 3.14. Propulsion Mission Area.

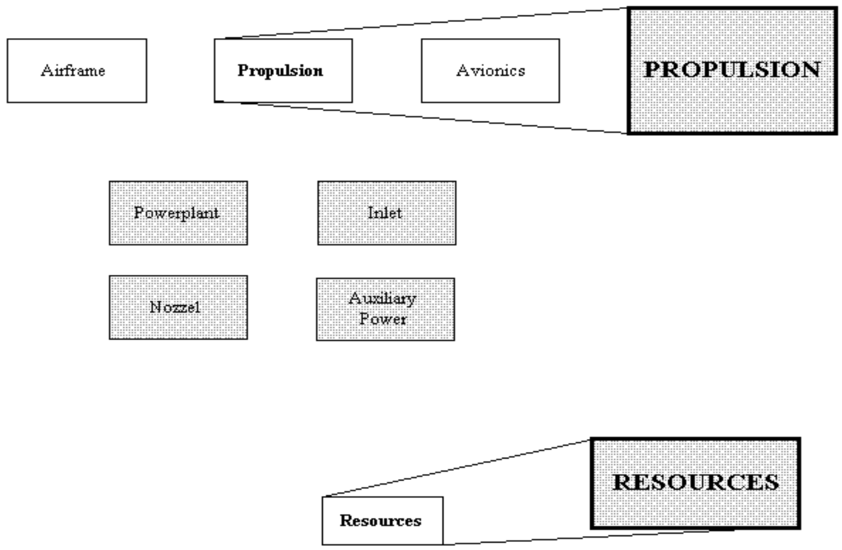


Table 3.8. Propulsion Modeling and Simulation (M&S).

Typical Models	Purpose
Performance Deck: steady-state engine and components	Engine, component, and Aircraft performance analysis, first order usage analysis
Specification Deck: steady state engine & components as baselined in the specification	Acceptance testing, Technical Order (TO) preparation analysis
Transient Deck: transient engine/component performance	Engine component, control system, ancillary systems, thermo, maintenance, and structural performance; second order usage analysis
Aerodynamic Models (May interface with airframe aero model)	Assess thermal and structural effects and help perform durability predictions
Structural Models (may interface with airframe structural models)	loads, deflections, stress/strain analysis and durability predictions
Inlet Performance Model	Engine face distortion (static and dynamic pressure)
Scram Jet Performance	Combustion chemistry and internal flow Modeling
External burning afterbody	Surface conditions and thrust

Table 3.9. Propulsion Measurement Facilities (MF).

Typical Tests	Resource
	(these facilities are usually not specific to test item i.e., independent of test item size, shape architecture, etc.)
Material properties development and T&E	Material vendor/subcontractor facilities, engine manufacturer and gov't material Lab (Wright Lab for example)
Airfoil cascade performance	Engine manufacturer facilities, gov't labs and cascade rigs (Wright Lab for example),
Component performance and durability tests	Usually contractor but some gov't rigs (Wright Labs, AEDC, and NASA-Lewis) to test: bearings, cascades, combustors, pumps, and seals.
Component performance, stability, and structural integrity	Usually contractor, but some gov't component rigs for fans, compressors, and nozzles. (Wright Labs and AEDC).
Inlet distortion testing using Air Jet Distortion Generator or scale models	AEDC engine test cells or wind tunnels
Engine inlet icing, deicing	AEDC engine test cells
Supersonic flow inlets	AEDC Aerospace Propulsion Systems Test Facility (ASTF), Tunnels B, C, and APTU
Transonic Performance of Scramjet Engine	AEDC ASTF
Flight Test Engine Calibration	AEDC altitude cells

Table 3.10. Propulsion System Integration Labs (SIL).

Typical Tests	Resource
	(hardware is typically modeled in software or is prototype and the resources are usually specific to the test items)
Bench-Top tests for pumps, actuators, heat exchangers, and engine controls	Usually performed in contractor facilities or in ALC facilities for P^3I programs
Aero-propulsion labs for developing leading-edge technologies	Aero-Propulsion Directorate, Wright Labs
Preliminary (software based) failure modes and effects criticality tests	Contractor hosted, with interfaces computer modeled

Table 3.11. Propulsion Hardware-In-The-Loop (HITL) Facilities.

Typical Tests	Resource
	(these facilities test uninstalled hardware and are typically test item specific)
Integrated control system tests (with flight controls/avionics), engine control tests, sensor and effectors T&E	Usually performed in contractor facilities (hardware specific).
Uninstalled engine sea-level testing: performance, operability, durability, and failure mode/ effects (vulnerability/containment tests)	Usually performed in contractor facilities (hardware specific). Gov't facilities include AEDC.
Uninstalled engine altitude testing: performance, operability, stability, inlet/nozzle compatibility	AEDC. Limited engine contractor facilities
Uninstalled engine anti-icing/de-icing qualification	AEDC
Altitude chamber testing performance and operability of full-up inlet/engine combination at varieties of sideslips and angles-of-attack	AEDC-Aerospace Propulsion Systems Test Facility (ASTF)
Sea level tests of uninstalled engines at extreme temperatures	McKinley Labs (Eglin AFB) engine test cells
Uninstalled test at extreme pressures and temperatures	AEDC, and NASA-Lewis

Table 3.12. Propulsion Installed System Test Facilities (ISTF).

Typical Tests	Resources
	(these facilities test items as installed in the air vehicle)
Installed engine tests (ground level, ambient conditions) of steady-state and transient performance thrust characteristics	Horizontal Thrust Stand, Edwards AFB
Installed engine ground tests at climatic extremes	McKinley Climatic Lab (Eglin AFB)
Live Fire Vulnerability Tests with operating engine (stationary and/or with blown air)	Wright Labs/FIV.
Accelerated mission testing; emission testing; fuel evaluation testing; endurance testing; and component testing for future sea-level standard engine test requirements	OC-ALC
System functional/acceptance tests	Performed at aircraft/engine mating location

Table 3.13. Open Air Ranges (OAR) - Propulsion T&E (Typical Ground/Pre-flight Tests).

Typical Ground/Pre-flight Tests	Resource
	(see **Attachment 3** for list and description of major test locations/ranges)
Suitability Ground Tests (Reliability, Maintainability, etc.)	Conducted at test locations - Major Range and Test Facility Bases (MRTFB), ALCs, and other Department of Defense (DOD) & contractor ranges
Ground Engine starts in various wind conditions and ambient temperatures	Conducted at test locations - MRTFBs, ALCs, and other DOD & contractor ranges
Pre-flight/functional checks: steady-state, transient, and back-up control operation	Conducted at test locations - MRTFBs, ALCs, and other DOD & contractor ranges
Ground Acoustics (danger areas, noise levels, etc.) and engine exhaust blast zones	Conducted at test locations - MRTFBs, ALCs, and other DOD & contractor ranges if appropriate equip. available.
Thrust reverser operations in various X-winds. Ground operations (ops) using thrust reverse	Conducted at test locations - MRTFBs, ALCs, and other DOD & contractor ranges

Table 3.14. Open Air Ranges (OAR) - Propulsion T&E (Typical Flight Tests).

Typical Flight Tests	Resources
Envelope Expansion - steady-state and transient engine ops throughout flight envelope, afterburner operation, back-up control testing, in-flight thrust reversing, airstarts, thrust vectoring, High AOA, and departed flight.	Conducted at test locations - MRTFBs, ALCs, and other DOD ranges. Typically next generation engines in single engine aircraft and high AOA testing is conducted at the AFFTC (emergency landing options on lakebeds).
Propulsion Performance - aircraft accelerations, climbs, descents, cruise, and turns	Conducted at test locations - MRTFBs, ALCs, and other DOD ranges.
Engine armament gases compatibility (gun gas ingestion, missile firing, etc.)	Conducted at test locations - MRTFBs, ALCs, and other DOD ranges.
Alternate fuels T&E (Jp-5, JetA, etc.)	Conducted at test locations - MRTFBs, ALCs, and other DOD ranges.

Figure 3.15. Avionics Mission Area.

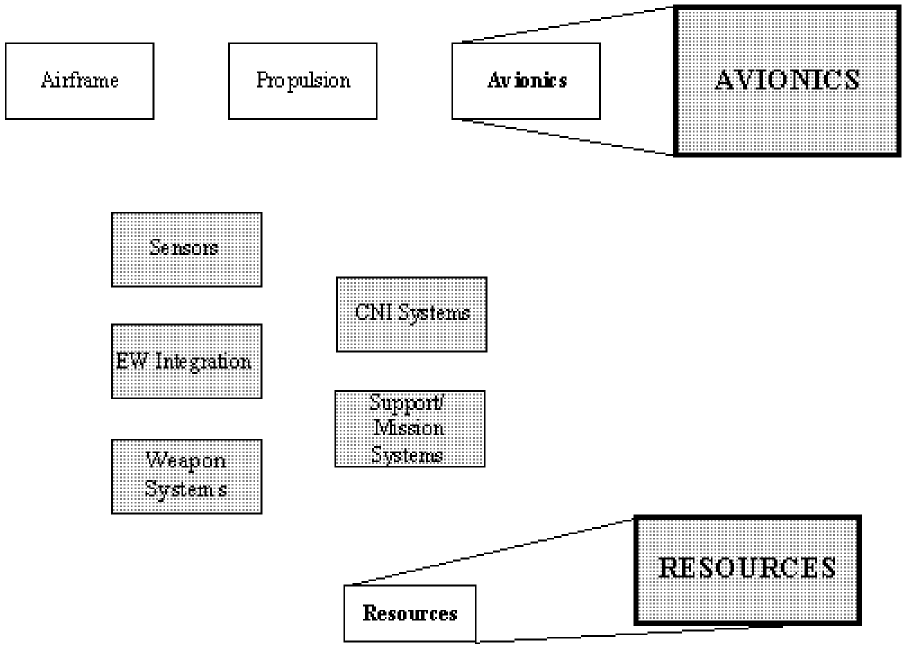


Table 3.15. Avionics Modeling and Simulation (M&S).

Typical Models	Purpose
Mission Level Survivability/Threat Models	Mission level analysis to support COEAs, ORDs, and Electronic Combat (EC) system performance. These models are usually VV&A'd by National Air Intelligence Center (NAIC)/TANV, Wright-Patterson AFB
Indoor EC threat simulators	Assess the effectiveness of EC systems/integration in an indoor, controlled environment. Typical simulators include Real-time Electronic Digitally Controlled Analyzer Processor (REDCAP)- 46th TW, Buffalo NY. and various Wright Labs/AAWA.

Typical Models	Purpose
Avionics Models	Digital system models or digital system description of avionics on selected aircraft. The IFAST facility has avionics models of selected systems on B-1B, F-15, F-16. When hardware is not available, then models are substituted to provide system integration test capability.
Navigation Models	Simulate nav. system inputs to assess performance. These models are typically contractor developed, but Central Inertial Guidance Test Facility (CIGTF), Holloman AFB may also provide assistance.
Specialty Models (models with very specific purpose used during systems engineering)	Simulate items (sensor, CNI, components, subsystems, systems) functionality during systems engineering
Component/subsystem vulnerability models	Assess test item vulnerability. Contact Wright Labs/FIV for further information
In-flight simulators and instrumented flying test beds	Evaluate avionic subsystem and component performance in instrumented flying test beds in **Flying Test Beds**, section of **Attachment 2**, VII.C. Example includes Advanced Radar Test Bed. Also see Support Aircraft Test Capability Master Plan (TCMP).

Table 3.16. Avionics Measurement Facilities (MF).

Typical Tests	Resource
	(these facilities are usually not specific to test item i.e., independent of test item size, shape architecture, etc.)
Sensor characterization facilities (antenna pattern, EO test facility, etc.)	Various Rome Lab Facilities (Griffiss AFB, NY) and contractor facilities.
Signature measurement	Contractor and gov't. **ground** ranges. Examples include Radar Target Scatter Facility (RATSCAT)/RATSCAT Advanced Measurement Facility (RAMS) (Holloman AFB) and infrared (IR) measurement labs In-flight measurement (Radar, IR, acoustic, etc.): see special access required (SAR) facilities in **Attachment 3** for POC #s.
Guidance and Navigation system characterization and certification	CIGTF - 46TG/TGG, Holloman AFB.(Guidance and navigation component and system laboratory and field tests).

Table 3.17. Avionics System Integration Labs (SIL).

Typical Tests	Resource
	(hardware is typically modeled in software or is prototype and the resources are usually specific to the test items)
Bench-Top component lab tests (for example, evaluate gyro accuracy, assess sensor resolution, etc.). These are end-to-end tests of components.	Usually performed in contractor facilities or in ALC facilities for P^3I programs, but gov't examples include Electronic Warfare Avionics Integration Support Facility (EWAISF) (WR-ALC/LN), IFAST (412 TW, Edwards AFB), and CIGTF (Holloman AFB)
Subsystem level lab tests. These tests evaluate intra and inter subsystem integration using primarily computer simulation of inputs/outputs. Examples include evaluating display interface with radar system, ensuring EC subsystem interfaces with avionics, and software module tests	Primarily performed in contractor facilities for new system acquisition or in ALC facilities for P^3I programs. Gov't examples include EWAISF (WR-ALC/LN), IFAST (412 TW, Edwards AFB), CIGTF (Holloman AFB), and PRIMES (Eglin AFB).
Preliminary logistics related tests (gather preliminary maintenance task related data using full-scale mockups)	Mockups are usually built in contractor facilities for new system acquisition
Preliminary (software based) failure modes and effects criticality tests	Contractor hosted computer models
Fielded OFP Support/Mod	Applicable ALC
New Technology demonstrations/research (ring laser advancement, GPS enhancement, radar advancements, etc.)	ASC/Wright Labs (avionics directorate), HSC labs (human factor labs, and contractor labs

Table 3.18. Avionics Hardware-In-The-Loop (HITL) Facilities.

Typical Tests	Resource
	(these facilities test uninstalled hardware and are typically test item specific)
Assess Avionics Interface with non-avionics subsystems (similar to SIL tests but using actual hardware). Examples are avionics-to weapon delivery interface, avionics to flight controls, avionics to BIT, and EC integration.	Usually performed in contractor facilities (hardware specific). Gov't example is the Guided Weapon Evaluation Facility (GWEF)-Eglin AFB), REDCAP (Calspan/Buffalo), Air Force Electronic Warfare Evaluation Simulator (AFEWES) (46TW/Fort Worth) and IFAST (412TW/Edwards AFB) and PRIMES Test Facility (Eglin AFB)
Navigation subsystem tests	Usually performed in contractor facilities (hardware specific). Gov't facility is CIGTF at Holloman AFB

Typical Tests	Resource
Sensor functional tests	Usually performed in contractor facilities (hardware specific)
Cockpit systems end-to-end tests (helmet mounted displays, night vision system test, mission management system tests.	Usually performed in contractor facilities (hardware specific)
Component/subsystem life-cycle endurance tests/ Qualification Tests	Usually performed in contractor facilities (hardware specific)
Failure Modes and Effects Analysis Testing	Usually performed in contractor facilities (hardware specific)
Fielded OFP Support/Mod	Applicable ALC

Table 3.19. Avionics Installed System Test Facilities (ISTF).

Typical Tests	Resource
	(these facilities test items as installed in the air vehicle)
Onboard Offensive/Defensive suite evaluation, antenna radiation coverage measurements, systems sensitivity measurements.	Benefield Anechoic Facility (BAF- Edw ards AFB) PRIMES Test Facility (Eglin AFB)
Onboard simulation (simulates air-to-air (A/A) engagements, air-to-ground (A/G) missions, etc., through onboard displays [heads-up display (HUD), cathode ray tubes (CRT), etc.)	Typically performed at RTO facility/program test location. PRIMES Test Facility (Eglin AFB)
EMI/EMC tests	Limited test capability at some test centers [BAF, Pre-flight Integration of Munitions and Electronic Systems (PRIMES)] and contractor facilities.
System functional/acceptance tests	Performed at manufacturing plant
Live Fire Tests	Wright Labs/FIV (up to 30mm), & rocket sled test track at Holloman AFB
Full-scale climatic tests	McKinley Climatic Lab, Eglin AFB

Table 3.20. Open Air Ranges (OAR) - Avionics T&E (Typical Ground/Pre-flight Tests).

Typical Ground/Pre-flight Tests	Resource
	(see **Attachment 3** for list and description of major test locations/ranges)
Suitability Ground Tests (Reliability, Maintainability, etc.)	Conducted at test locations - MRTFBs, ALCs, and other DOD ranges
Weapon system harmonization tests (gun system/sensor boresighting, HUD/ windscreen parallax/light transmissivity tests, etc.)	Conducted at test location utilizing local resources (gun butt, theodolites, etc.)

Typical Ground/Pre-flight Tests	Resource
Weapon/stores drop tests (into sand box or similar fixture)	Conducted at test location - MRTFBs, ALCs, and other DOD ranges
BIT pre-flight	Conducted at test location - MRTFBs, ALCs, and other DOD ranges

Table 3.21. Open Air Ranges (OAR) - Avionics T&E (Typical Flight Tests).

Typical Flight Tests	Resources
Sensor development (test radar modes, EO/IR performance, etc.)	AFFTC, AFDTC, Utah Test and Training Range (UTTR), and ALCs (and their local area ranges - for example, including China Lake for AFFTC airspace)
Navigation /Guidance development (box routes, radar/star tracker/etc., integration with nav. subsystem)	CIGTF 46 TG/TGG (Holloman AFB, NM). Box Routes may vary from small race-track type patterns within DOD airspace or could also include routes across thousands of miles.
Comm and Ident T&E (max. functional range, azimuth characterization, etc.)	Conducted at test locations (if part of larger T&E) and MRTFBs.
Antenna pattern tests	Owens Valley Range
Mission/Support Systems development (night vision, GCAS, BIT, HMD, onboard simulation, etc.)	AFFTC
In-flight signature measurement	See MFs and SAR resources (see **Attachment 2**, Avionics OARs)
Avionics/EC suite integration T&E	Areas with surrogate, simulated, or actual threat assets - Examples are: AFFTC, AFDTC, and SAR resources
TF/TA development (radar/flight control integration, ground plane clearance, mission OFP integration. Also see Airframe templates-TF/TA)	Ranges with various terrain, topography, etc. AFFTC usually performs early development using instrumented routes (see Airframe resources in **Attachment 3**)
Weapon System Integration T&E (weapon separation T&E, nav. integration w/smart weapons, sensor/guided weapon integration, avionics/weapon integration, etc., gun harmonization)	AFFTC, UTTR, and Air Force Development Test Center (AFDTC) ranges (also see Airframe resources in **Attachment 3**).
Preliminary Survivability T&E [Minimum (Min)Resolvable Temp.(MRT), detection, etc.]	AFFTC, AFDTC, and SAR resources
Interoperability T&E	JITC (also see **interoperability** section of Mission Reqm'ts template)
Avionics OT&E (survivability, SEAD, weapon delivery, etc.).	AFFTC, AFDTC, and SAR resources
Fielded OFP Support/Mod	Applicable ALC, AFFTC, and AFDTC

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Attachment 1

GLOSSARY OF REFERENCES, ACRONYMS, ABBREVIATIONS, AND TERMS

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Abbreviations and Acronyms

A/A—Air-to-Air

A/G—Air-to-Ground

AEDC—Arnold Engineering Development Center

Aero—Aerodynamic

AF—Air Force

AFAM—Air Force Acquisition Model

AFB—Air Force Base

AFDTC—Air Force Development Test Center

AFEWES—Air Force Electronic Warfare Evaluation Simulator

AFFTC—Air Force Flight Test Center

AFI—Air Force Instruction

AFMAN—Air Force Manual

AFMC—Air Force Materiel Command

AFOTEC—Air Force Operational Test and Evaluation Center

AFR—Air Force Regulation

AFSEC—Air Force Sensor Evaluation Center

AFSEO—Air Force SEEK EAGLE Office

AFTB—Avionic Flying Test Bed

AFTI—Advanced Fighter Technology Integration

AI—Air Intercept

AIRADE—Airborne Radar Detection

AIRS—ACM Imaging Radar System

AIS—Automated Information System

AISF—Avionics Integration Support Facility

ALC—Air Logistics Center

AMT—Accelerated Mission Testing

AOA—Angle-of-Arrival

AOA—Angle-of-Attack

A-P-A—Airframe-Propulsion-Avionics

APU—Auxiliary Power Unit

ARTB—Advanced Radar Test Bed

ASC—Aeronautical Systems Center

ASETS—Airborne Seeker Evaluation Test System

ASTF—Aeropropulsion Systems Test Facility

ATRIS—Automated Test Resources Information System

ATIC—Avionics Test and Integration Complex

BAF—Benefield Anechoic Chamber

BIT—Built-In-Test

BLM—Bureau of Land Management

c.g—Center of Gravity

C4I—Command, Control, Communications, Computers and Intelligence

CAIS—Common Airborne Instrumentation System

CCB—Configuration Control Board

CDR—Critical Design Review

CDRL—Contract Data Requirements List

CFD—Computational Fluid Dynamics

CIGTF—Central Inertial Guidance Test Facility

CIRIS—Completely Integrated Reference Instrumentation System

CM—Cruise Missile

CNI—Communications, Navigation, and Identification

COEA—Cost and Operational Effectiveness Analysis

COI—Critical Operational Issue

CONOPS—Concept of Operations

COTS—Commercial-Off-The-Shelf

CRT—Cathode Ray Tube

CRWG—Computer Resources Working Group

CSC—Computer Software Component

CSCI—Computer Software Configuration Item

CSEL—Communications Systems Evaluation Lab

CSU—Computer Software Unit

CTF—Combined Test Force

DAOA—Dynamic Angle Of Arrival

DAP—Data Analysis Plan

DEES/CEESIM—Dynamic/Combat Electromagnetic Environment Simulator

Dem/Val—Demonstration/Validation

DIME—Dynamic Infrared Missile Evaluator

DISA—Defense Information Systems Agency

DOD—Department Of Defense

DODD—Department Of Defense Directive

DODI—Department Of Defense Instruction

DODM—Department Of Defense Manual

DR—Deficiency Report (replaced Service Report)

DSMC—Defense Systems Management College

DT&E—Developmental Test and Evaluation

DTIC—Defense Technical Information Center

EC—Electronic Combat

ECCM—Electronic Counter-Countermeasures

ECIT—Electronic Combat Integrated Test

ECM—Electronic Countermeasures

ECS—Environmental Control System

ECSRL—Electronic Combat Simulation Research Laboratory

EISF—Extendible Integration Support Facility

EM—Electromagnetic

EMC—Electromagnetic Compatibility

EMD—Engineering, Manufacturing, and Development

EMI—Electromagnetic Interference

EO—Electro-Optical

EOA—Early Operational Assessment

EOSIM—Electro-Optical Simulation

ESC—Electronic Systems Center

ESS—Electromagnetic System Simulator

ETF—Engine Test Facility

EW—Electronic Warfare

EWAISF—Electronic Warfare Avionics Integration Support Facility

FAA—Federal Aviation Administration

FICSIM—Fire Control Simulation

FLIR—Forward Looking Infrared

FMEA—Failure Modes and Effects Analysis

FOT&E—Follow-on Operational Test and Evaluation

FOV—Field-of-View

GCAS—Ground Collision Avoidance System

GENESIS—GENeralized Environment for the Simulation of Integrated Systems

GFE—Government Furnished Equipment

GHz—Giga Hertz

Gov't—Government

GPS—Global Positioning System

GRT—Ground Resonance Test

GVT—Ground Vibration Test

GWEF—Guided Weapons Evaluation Facility

HCF—High Cycle Fatigue

HF—High Frequency

HITL—Hardware-In-The-Loop

HMD—Helmet Mounted Display

HSC—Human Systems Center

HUD—Heads-Up Display

I&GTC—Infrastructure and Generic Test Capability

IADS—Integrated Air Defense Systems

IAL—Integrated Avionics Laboratory

IAW—In Accordance With

ICD—Interface Control Document

ICNIA—Integrated Communications, Navigation, and Identification Avionics

IDAL—Integrated Defensive Avionics Lab

IDD—Interface Design Document

Ident—Identification

IESS—Integrated Electromagnetic System Simulator

IFAST—Integration Facility for Avionic Systems Testing

ILS—Instrument Landing System

ILS—Integrated Logistics Support

ILSP—Integrated Logistics Support Plan

IMP—Integrated Master Plan

IMS—Integrated Master Schedule

INS—Inertial Navigation System

IOT&E—Initial Operational Test and Evaluation

IPD—Integrated Product Development

IPT—Integrated Product Team

IR—Infrared

IRCM—Infrared Counter Measures

IRMP—Integrated Risk Management Process

ISTF—Installed Systems Test Facility

ITB—Integrated Test Bed

IV&V—Installation Verification and Validation

IWSM—Integrated Weapon System Management

J-STARS—Joint Surveillance Target Attack Radar System

JCS/SI—Joint Chiefs of Staff/Special Instruction

JEIO—Joint Effectiveness and Interoperability Office

JFS—Jet Fuel Starter

JITC—Joint Interoperability Test Center

JMASS—Joint Modeling and Simulation System

JRMET—Joint Reliability and Maintainability Evaluation Team

JTCG/AS—Joint Technical Coordinating Group on Aircraft Survivability

JTIDS—Joint Tactical Information Distribution System

KVA—Kilovolt Amp

LAPES—Low Altitude Parachute Extraction System

lbs—Pounds

LCF—Low Cycle Fatigue

LCL—Laser Communications Laboratory

LFT—Live Fire Test

LFT&E—Live Fire Test and Evaluation

LID—Laser IRCM Development

LOG TEST—Logisitics Test

LORAN—Long Range Navigation

LRIP—Low-Rate Initial Production

LRU—Line Replaceable Unit

LSA—Logistics Support Analysis

LWT—Two Foot Water Tunnel

M&S—Modeling and Simulation

MF—Measurement Facility

MIL—Military

Min—Minimum

MIP—Material Improvement Program

MMW—Millimeter Wave

MNS—Mission Needs Statement

MOA—Memorandum of Agreement

Mod—Modification

MOE—Measure of Effectiveness

MOP—Measure of Performance

MRT—Minimum Resolvable Temp

MRTFB—Major Range and Test Facility Base

MS—Milestone

NAIC—National Air Intelligence Center

NASTRAN—NASA Structural Analysis

nav—Navigation

NEPA—National Environmental Protection Act

NLT—No Later Than

O&S—Operation and Sustainment

OA—Operational Assessment

OAR—Open Air Range

OFP—Operational Flight Program

OPR—Office of Primary Responsibility

ops—Operations

ORD—Operational Requirements Document

OSD—Office of Secretary of Defense

OT&E—Operational Test and Evaluation

OTA—Operational Test Agency

OTP—Operational Test Program

OTS—Off-The-Shelf

P3I—Preplanned Product Improvement

PAES—Performance Assessment and Evaluation System

PAMS—Precision Antenna Measurement System

PDR—Preliminary Design Review

PI—Program Introduction

PID—Program Introduction Document

PIRA—Precision Impact Range Area

PMD—Program Management Directive

POC—Point of Contact

PRIMES—Pre-flight Integration of Munitions and Electronic Systems (Facility)

PTO—Participating Test Organization

PWT—Propulsion Wind Tunnel

QOT&E—Qualification Operational Test and Evaluation

QT&E—Qualification Test and Evaluation

RAMS—RATSCAT Advanced Measurement Facility

RASPL—Radar Analysis and Signal Processing Laboratory

RATSCAT—Radar Target Scatter Facility

RCM—Requirements Correlation Matrix

RCS—Radar Cross Section

REDCAP—Real-time Electronic Digitally Controlled Analyzer Processor

RF—Radio Frequency

RM&A—Reliability, Maintainability, and Availability

RMCC—Ridley Mission Control Center

RTF—Radar Test Facility

RTG—Radar Target Generator

RTO—Responsible Test Organization

RTS—Radar Test Station

SAR—Special Access Required

SAR—Synthetic Aperture Radar

SARL—Subsonic Aerodynamic Research Laboratory

SATCOM—Satellite Communication

SCLP—Surrogate Carrier Launch Platform

SDD—System Design Document

SE—SEEK EAGLE

SEAD—Suppression of Enemy Air Defenses

SEDS—System Effectiveness Data System

SEMSS—SE Management Support System

SER—SEEK EAGLE Request

SFTC—Single-Face-To-Customer

SIL—System Integration Laboratory

Sim—Simulation

SM—Single Manager

SMC—Space and Missile Center

SMM—System Maturity Matrix

SMS—Stores Management System

SOC—Statement of Capability

Spec—Specification

SPO—System Program Office

SR—Service Report (replaced by DR)

SRD—System Requirements Document

SRR—System Requirements Review

SRS—System Requirements Specification

SSDD—System/Segment Design Document

SSE—Simulation Support Environment

SSS—System/Segment Specification

STAR—System Threat Assessment Report

STD—Standard

STP—Software Test Plan

SURVIAC—Survivability/Vulnerability Information Analysis Center

SUT—System Under Test

SWIS—Stores/Weight/and Inertia System

Sys—System

T&E—Test and Evaluation

TACAN—Tactical Communications and Navigation

TCMP—Test Capability Master Plan

TECNET—Test and Evaluation Computer Network

TEMP—Test and Evaluation Master Plan

TEMS—Test and Evaluation Mission Simulator

TERCOM—Terrain Contour Matching

TF—Terrain Following

TF/TA—Terrain Following/Terrain Avoidance

TGF—Trisonic Gasdynamics Facility

TIFS—Total In-flight Simulator

TIMP—Test Investment Master Plan

TISP—Test Investment Strategic Plan

TM—Telemetry

TPM—Technical Performance Measurement

TO—Technical Order

TOV&V—Technical Order Validation and Verification

TPWG—Test Plan Working Group

TR—Technical Report

TRMP—Test Resource Master Plan

TSPI—Time Space Positioning Information

TW—Test Wing

U.S.C.—United States Code

UAV—Unmanned Aerial Vehicle

UHF—Ultra High Frequency

USAF—United States Air Force

UTTR—Utah Test and Training Range

UV—Ultraviolet

VHF—Very High Frequency

VISTA—Variable In-flight Stability Training Aircraft

VV&A—Verification, Validation, and Accreditation

VWT—Vertical Wind Tunnel

WBS—Work Breakdown Structure

WSMR—White Sands Missile Range

Terms

Refer to AFI 99-103 Air Force Test Process, as well as AFM 11-1, Air Force Glossary of Standardized Terms and DOD Glossary of Defense Acronyms and Terms for definitions of common terms used is this manual.

Attachment 2

SYSTEM DEVELOPMENT

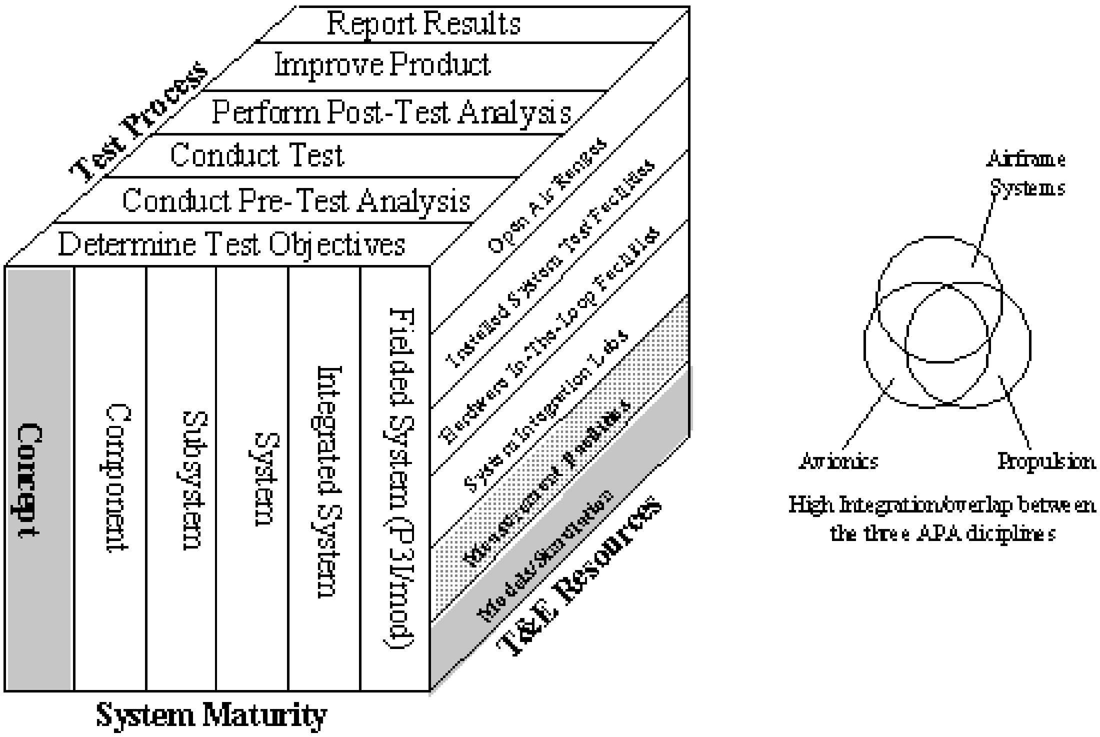
A complete and detailed discussion of test and evaluation (T&E) and systems development is contained in Test and Evaluation Management Guide, Defense Technical Information Center (DTIC). This attachment tailors systems T&E/development discussions as they pertain to the Airframe-Propulsion-Avionics (A-P-A) T&E process.

A2.1. Concept Phase. During the system's conceptual design phase, the Mission Needs Statement (MNS) and Operational Requirements Document (ORD) (typically under development at this stage) lay a design foundation upon which the general aerodynamic shape, size, weight, and system architecture of the air vehicle can be tailored. Most design tradeoffs within and between functional categories/disciplines occur at this early stage of a system's development (Acquisition Phase 0). Examples of tradeoffs include: inlet location, platform shape [aerodynamics vs. radar cross section (RCS)], internal vs. external weapons carriage, and wide dispersion of components/many access panels (for low vulnerability) vs. few access panels/close placement of components (high maintainability). **The basis for these early concept design tradeoff studies are models/simulations**. They are used to assess proposed designs against the user's requirements. Logistics requirements, based on the ORD and Logistics Support Analysis (LSA) are included in tradeoff decisions using high level logistic models. These models are based upon past experience with similar systems. The level of logistic tradeoff (as with other disciplines tradeoffs) depends upon a risk analysis performed against the system specification. The other cross-functional disciplines (safety, human factors, and climatic) may also be included in tradeoffs, but to a lesser extent during this early phase.

A2.1.1. Primarily, the type of **testing** required during the conceptual design phase for a new system is measurement testing (primarily wind tunnel testing, materials testing, propulsion concept testing, and observability testing) - to provide data for high level aero models, not to validate the models (not enough of the proposed system's hardware is available to test). A test matrix must be developed which ensures data will be gathered at the necessary conditions (Mach number, density, azimuth and elevation, etc.) and can be scaled to the necessary conditions with the required confidence.

A2.1.2. **Figure A2.1.** shows the primary test resources used during the concept phase and the level of integration (overlap) between the three A-P-A functional categories/disciplines. The 6-step test process introduced in the main body of this manual is followed regardless of what resource is utilized or what phase of system maturity the aircraft is in. The contractor performs nearly all the testing during conceptual design with government review. The contractor may utilize their own facilities or government facilities, depending upon availability and capabilities.

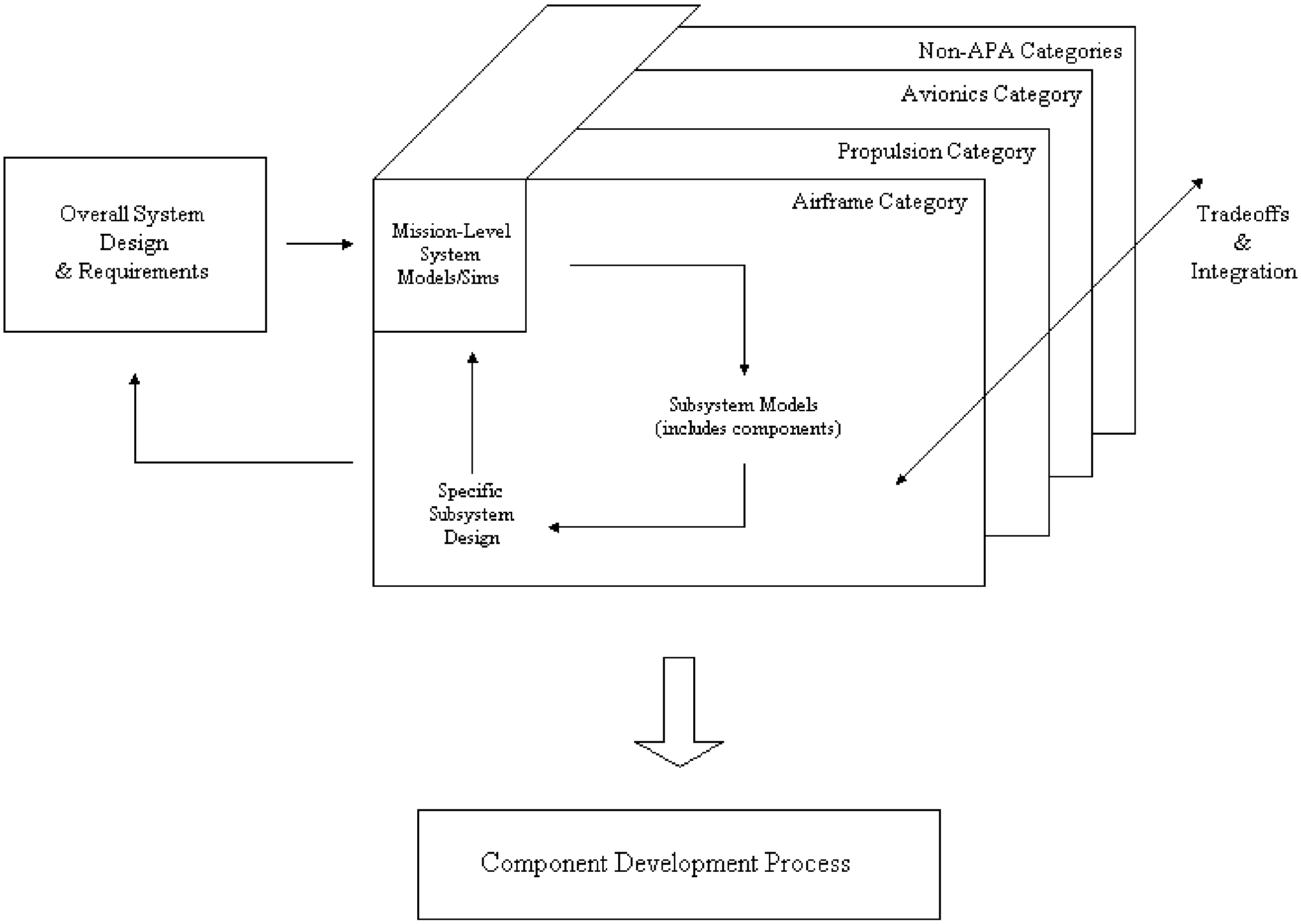
Figure A2.1. Primary Test Resources & Integration Level During Concept Development.



A2.2. Design Refinement (pre-component). Once the aircraft's overall design has been determined, the next step is to develop the components. However, before components can be designed, the system/subsystem in which they function must be designed to determine the individual component's detailed performance requirements. Therefore, between the high level concept design and the component development phase, an enormous design effort is undertaken by the contractor to solidify and refine the aircraft's systems/subsystems conceptual designs. This design refinement process is very complex and the details are outside the scope of this document and may be found in system engineering documents (such as MIL-STD 973, *Configuration Management*). For the purposes of this manual, the design refinement process follows a work breakdown type structure and dissects the weapon system's general requirements to lower, more detailed requirements (accomplished through functional and allocated baseline - see **Figure 2.1.** and refer to acquisition course documents such as DOD 5000.52-M for details).

A2.2.1. Design refinement is achieved by implementing the test process using a mix of prototype testing and modeling/simulation to provide feedback to the designers (primarily modeling/simulation). **Figure A2.2.** illustrates this point. As during the previous section (concept), during this early phase of the system's maturity, numerous tradeoffs occur within and between functional categories/disciplines.

Figure A2.2. Design Refinement Process.



A2.2.2. During design refinement its important the government single manager (SM)/System Program Office (SPO) manager and contractor keep logistics, safety, and human factors concerns in mind. System attributes such as reliability, maintainability, human interfacing, etc., must be designed into the system (from the ORD and carried through to system specifications, Integrated Logistics Support Plan (ILSP), etc.) and cannot be added after manufacturing without great cost, time, and risk to the program.

A2.2.3. Although more testing (in wind tunnels and/or labs) is conducted during design refinement than during concept exploration, the majority of work still involves developing and utilizing models/simulation to develop the system. Details and examples of models/sims used by each A-P-A discipline are included within each specific A-P-A discipline's template in section 3.2. The tests conducted in labs normally involve testing new technologies (using prototypes) which have been proposed in the system's design. These labs could either be contractor or government operated.

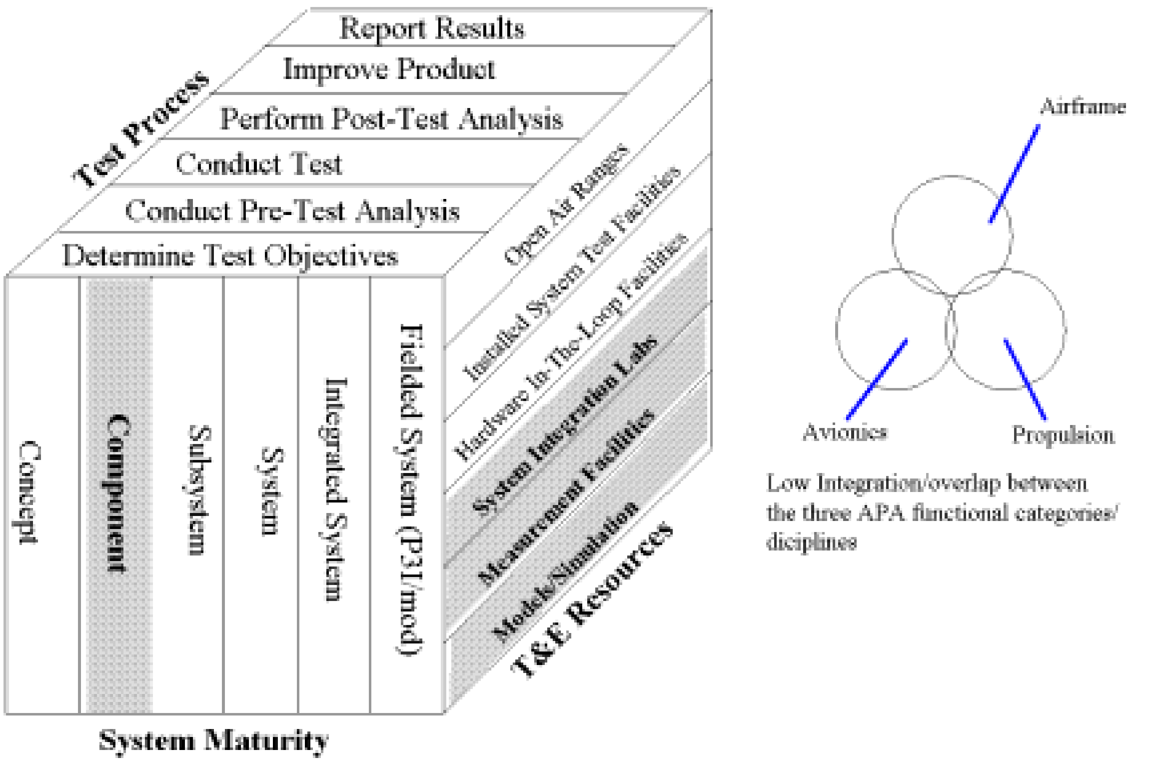
A2.2.4. By the conclusion of acquisition phase 0 and at milestone 1, the basic air vehicle shape, size, and weight has been determined, as well as the overall system's architecture (federated, integrated, or integrated suite). The A-P-A disciplines begin to solidify their system's/subsystem's design and architectures based on the aero foundation and the overall system architecture. Preliminary failure modes and effects analysis (FMEA) is performed to assess system failure degradation modes and failure probabilities against the ORD, specifications, and MIL-STDs. Preliminary Live Fire/vulnerability assessments are performed using models and contribute to design tradeoff decisions.

A2.2.5. The A-P-A disciplines develop more models/simulations and build upon existing ones to create more elaborate models/simulations as the system develops (i.e., models are rarely discarded as the system matures, instead, they mature with the system). Besides being used to refine the design, these early models/simulations also serve as a core set to be used in successive phases of the weapon system's maturity to predict test results (used during application of the test process during component, subsystem, and system testing).

A2.2.6. In this early phase of a system's development, prior to testing, only limited model verification can be achieved (exploring leading-edge technologies with limited test data). Fortunately A-P-A models are largely (though not exclusively) based upon scientific first principles and laws of physics and therefore, the core equations are fairly common throughout industry. Avionics models however, are based more on a mix between physics and logic equations. The differences between various models arise from the values used for the variables and constants contained in the equations because these are normally derived from tests. So at this early stage of model development, best guesses and past experience data are used to choose the variable/parameter values.

A2.3. Component Development Phase. Once the initial A-P-A component and subsystem requirements/de-signs have been determined (from functional and allocated baselines), component development begins. The basic thrust of component testing is to ensure the components perform within subsystems as designed. The test process is applied to prototype components and actual components using various levels of test resources (models/simulations through open-air testing). **Figure A2.3.** shows the primary test resources used during component development and level of integration/interfacing between the three A-P-A functional categories/disciplines.

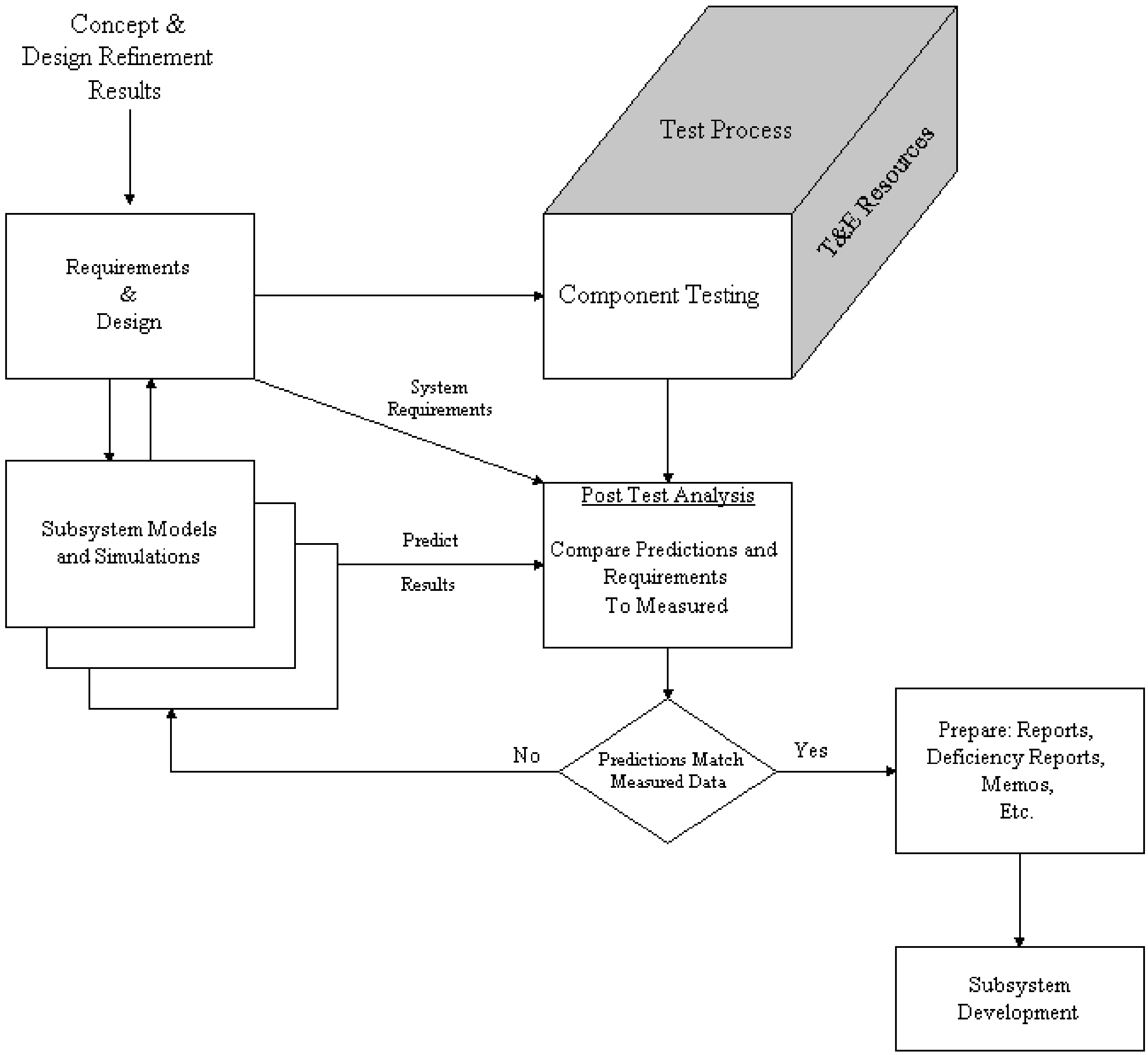
Figure A2.3. Primary Test Resources & Integration Level During Component Development.



A2.3.1. Little integration and tradeoff occurs between A-P-A disciplines during component development because the majority of components do not interface with subsystems outside the subsystem in which they reside. During component development close coordination must occur within the functional categories/disciplines to refine the systems/subsystems designs in which the components reside. Thus ensuring the components and associated subsystems form an integrated design occurred during the design refinement process.

A2.3.2. The test resources chosen for a given component depends upon factors such as cost, design risk, integration requirements, maturity of system in which it is embedded, simulation fidelity/variables, and schedule. Component test results are compared with expected results from system and subsystem models which were also used to refine the overall design. **Figure A2.4.** shows how the test process is applied during component development.

Figure A2.4. Component Development Process.



A2.3.3. Generally component development is subcontracted out by the prime contractor. Obviously both the prime and subcontractors must work closely to establish component requirements, design components, and test the components to ensure they function correctly as a unit (the subsystem). A goal for all concerned parties (government, and contractors) is to use off-the-shelf components or slight modifications, in which case, component testing is dramatically reduced. For state-of-the-art technologies or designs with stringent requirements, the components must be developed from scratch.

A2.3.4. Primarily, the models used during component development are the same subsystem models used to refine the design. Components are modeled within these subsystem models and represent component performance to the required fidelity. Normally, the A-P-A components are modeled within subsystem and system models and do not have their own unique models because the performance requirements for an A-P-A component can usually be ascertained directly from these higher level models. Stand alone component models are created if the component requirements push the available state-of-the-art (high risk) or must very accurately represent the component. For stand alone models, comprehensive component testing is needed to ensure high model fidelity.

A2.3.5. As part of post-test analysis, test results are compared to predicted results (from models) to ensure components function as designed and meet requirements. In those cases where the component does not meet requirements or the design does not meet requirements, corrective action is required. What corrective action is required is dependent upon the discrepancy, the system contract, and system maturity. As stated previously, the contractor conducts the majority of testing for acquisition phases 0-I. Therefore, during early stages of system development, the government should keep a log of noted problems (using the watch-items described in Air Force Technical Order (TO) 00-35D-54) and not submit formal deficiency reports (DR) unless determined by government to be crucial. To adequately document and correct the deficiency/discrepancy, a formal deficiency/discrepancy is required. Per AFI 99-101 and AFI 99-102, the government SM shall ensure the contractor has an adequate discrepancy reporting system established prior to contractor performed component testing (which can easily transfer data or directly interface with the government DR system) and the government has a DR system established in accordance with (IAW) TO 00-35D-54 prior to government performed testing.

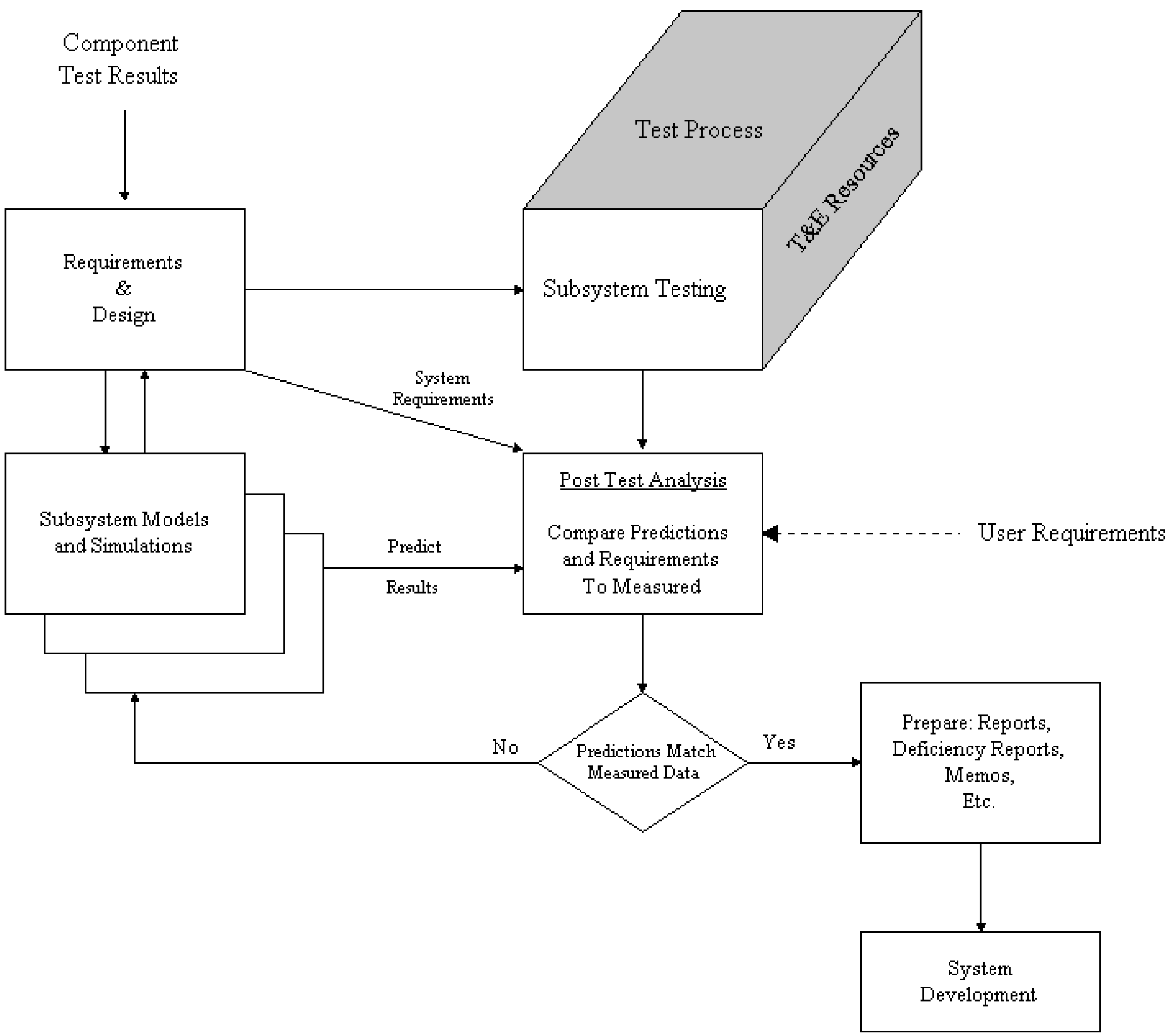
A2.3.6. As stated earlier and in **Figure A2.3.**, the facilities used to conduct component testing for the A-P-A disciplines depends upon many factors, but generally component testing for a new total system development is conducted with models and simulations Measurement Facilities (MF), System Integration Laboratories (SIL), and limited testing in Hardware-In-The-Loop (HITL) facilities. Generally, many of these types of facilities are owned and operated by contractors/subcontractors and the actual tests are conducted by the contractor/subcontractors with government oversight and review of test results. Details regarding the various facility types used for the three A-P-A disciplines are included in section 3.2 and **Attachment 3** of this manual.

A2.3.7. During component development, the common thread disciplines (logistics, human factors, safety, etc.) must ensure the components meet their requirements. Just like the A-P-A system disciplines, they must compare component test results against models and either update the best guess models, or influence a design change. The level of influence the common thread disciplines have on the design engineers depends largely upon the requirements (i.e., high reliability, maintainability, and availability (RM&A) ORD requirements have a stronger influence than relatively trivial requirements). These common thread disciplines generally "piggy-back" their testing during SIL and HITL tests. In some cases these common thread disciplines shall conduct dedicated tests against ORD derived requirements which have been flowed down to allocated baseline requirements and verify model predictions (i.e., a component durability test to assess how many times the component cycles before failure - these results are aggregated with other component RM&A results to compare to system level ORD requirements). Mock-ups and prototypes for the flight control subsystem, structure, airframe systems, avionics package, and powerplant are built as precursors to actual hardware labs. Human factors and safety problems tend to surface when tasks (either crew tasks or maintenance tasks) are performed using the mock-ups (which then influence a design change).

A2.3.8. The culmination of all the tests conducted on a given component (functional tests, durability tests, etc.) "qualifies" the component for the next phase of system maturity, subsystem development.

A2.4. Subsystem Development Phase. As a system progresses through the development phases, assessing the actual system performance against the users requirements becomes more straightforward. The assessments become more straightforward and more confidence is gained in the design (assuming the assessment is positive) as the system development progresses from components to total system. The test objectives are elevated from specification levels to higher levels - levels approaching the ORD requirements (i.e., a user's aircraft range requirement in the ORD can only be **directly** assessed after the aircraft is built and flight tested). The subsystem phase is a critical phase to assess how well the overall design compares to the user's requirements because it is the first opportunity to test at a level near the user's requirements without excessive component extrapolation/aggregation. Also, subsystem models have been updated to reflect the component test results which increases the models fidelities (and confidence in their predictions). **Figure A2.5.** shows the subsystem development process. Note that this is very similar to the component development process (**Figure A2.4.**), but includes more direct comparison of test results to user requirements (not just model predictions).

Figure A2.5. Subsystem Development Process.

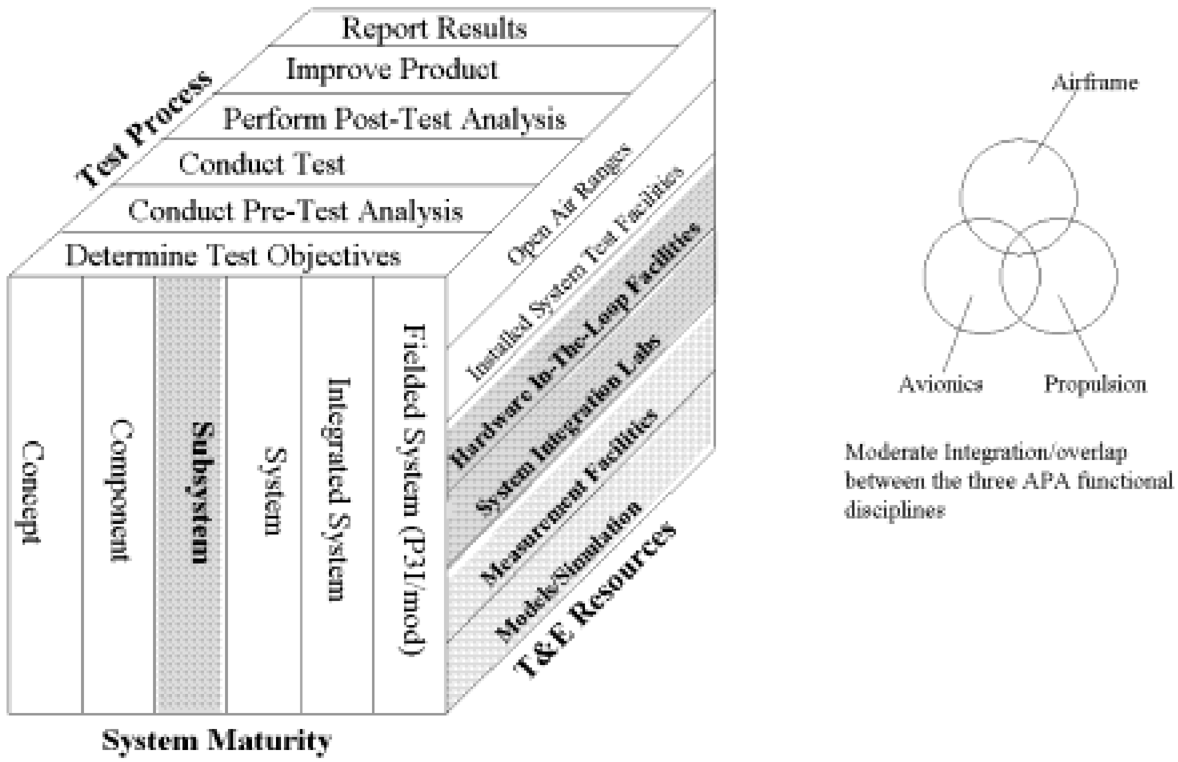


A2.4.1. By this phase in a system's development, the overall system design and the LSA database should be fairly well solidified. Preliminary TOs drafting begins in support of early DT&E. Subsystem design changes may be required to fix problems or implement improvements discovered during component and/or subsystem testing, but these changes must account for resulting schedule and cost impacts. Care must be taken to not be overly optimistic regarding cost and schedule impacts. It is better to fix **and retest** early, than believe analysis alone without test verification and find out further in development that the fix did not work or was not possible.

A2.4.2. Along these same lines, LFT of components and subsystems (using prototype or production representative components) should occur no later than this stage of development to ensure adequate time to make a design change if required and to budget for the cost of such testing. The LFT Law, Title 10, United States Code (U.S.C.), Chapter 139, Section 2366, et.seq., states LFT must occur sufficiently early in the development phase to allow for any LFT design deficiency to be corrected before proceeding beyond low-rate initial production (LRIP). Also at this point in a systems development, the general LFT strategy should be developed (i.e., is the system "a covered system" under the definition of the law and will full-up LFT occur or will the Air Force seek a waiver to the law). Vulnerability models are used to develop the LFT matrix, form the basis for the LFT strategy, reduce the number of shots, and help analyze/understand test results. For further Air Force guidance regarding LFT, see AFI 99-105.

A2.4.3. During the subsystem development phase, the number of new models created begins to taper-off, but model sophistication/complexity continues to increase as a system develops. Similarly, test sophistication/complex-ity has increased from that during component development. Generally speaking, subsystem testing is primarily conducted in SILs and HITLs as shown in **Figure A2.6.** These facilities assess how well a given subsystem (and components) function against design requirements and also how well it integrates with other subsystems. Detailed FMEA is typically performed during this phase and the system development phase using these facilities. This is accomplished by inducing a set of test matrix failures (either through hardware or software) and observing the effect on the subsystem/system. The type of induced failures ranges from single input/output signals within a component, single component failures, to multiple component failures. The effect these failures have on the overall system is very dependent upon the system architecture. Generally, integrated suite designs (F-22) are more robust than federated designs (F-4), but the FMEA and system integration is more complex for integrated suites.

Figure A2.6. Primary Test Resources & Integration During Subsystem Development.



A2.4.4. During subsystem development, integration/interfacing becomes testable to a limited extent. Similar to extrapolating component test results to assess how well they meet user requirements, subsystems testing is the first opportunity to directly assess systems integration without excessive extrapolation. The government must ensure the contractor produces and uses Interface Control Documents (ICD) as a vehicle to ensure the system designers adequately account for subsystem integration/interfacing.

A2.4.5. Usually subsystem testing is planned and conducted by the contractors, with limited government involvement (over the shoulder or reviewing test results). By this point in a system acquisition [i.e., demonstration/validation (Dem/Val) or engineering, manufacturing, and development (EMD) acquisition phase], the government RTO should have been designated. The Responsible Test Organization (RTO) should assist the SPO in observing and reviewing tests. This gets the testers involved early, which results in more effective testing (and a more effective system) in subsequent maturity and acquisition phases.

A2.5. System Development Phase. The goals for this system development phase are to first ensure the air vehicle is safe, then verify the air vehicle performs basic functions as designed, and finally to obtain a preliminary assessment of the system's effectiveness and suitability. If problems regarding effectiveness and suitability are discovered during this test phase, corrective action will be taken, but a comprehensive assessment of the user's requirements is made during the next phase of the weapon system's development - Integrated System testing.

A2.5.1. Usually during this phase, issues regarding the air vehicle's instrumentation system surface. Well before this phase, the end-to-end instrumentation system (measurement, to telemetry, to data storage) should have been designed and incorporated. Typically, instrumentation is a large effort and may involve dedicated test air vehicles which may or may not be retro-fitted after test completion to match production specifications. Regardless, sufficient allowances must be made in the Test and Evaluation Master Plan (TEMP) budget design to account for instrumentation requirements. Things to keep in mind include: data sampling rates (to ensure necessary data are not aliased), mux-bus interference problems, telemetry bandwidth, data compression algorithms, and onboard data tape operation. Most current aircraft programs rely upon collecting data via the aircraft's own MIL-STD-1553 buses.

A2.5.2. During the system development phase various subsystems and components come together to form the air vehicle. Actual subsystem components are installed within and on aircraft structural components, which are then mated to form the air vehicle. At each step of assembly, the component installation is formally verified and validated against drawings by inspectors (contractor and government qualification engineers). Then are rigorously tested against functional test procedures written by the design engineers for functionality using special test equipment (voltmeters, pressure sensors, torque wrenches, theodolites, computer interfaces, etc.). Once components are linked (in hardware or software) to form subsystems, the subsystem functionalities are formally tested, again, through highly controlled and regulated procedures. The above assembly tests are commonly referred to as installation verification and validation (IV&V) and will not be addressed to further extent in this document (a separate process outside the scope of this document).

A2.5.3. A-P-A system testing is divided into distinct phases: pre-flight testing and flight testing. The pre-flight testing is specific, rigorous tests to ensure subsystem functionality and safety prior to delivery of the aircraft to the government. The "flight" testing phase is all the ground and flight testing performed to evaluate the capability of the aircraft. Ground tests are typically conducted after pre-flight tests during the flight test phase - examples include braking tests, ground handling, and logistics tests. Data from both the pre-flight and flight phases are used to verify and update the system models.

A2.5.4. **Figure A2.7.** shows the system-level test process. The system is assessed against the user's requirements during flight test, during actual flights or during ground tests. Pre-flight tests do not have strong ties to the user's requirements and are mainly conducted to ensure the aircraft is "ready" for flight. As shown in **Figure A2.8.**, system-level testing is conducted primarily using Installed System Test Facility (ISTF) and open-air ranges (OAR). All the various subsystems function within, and are tested onboard, an integrated environment - the air vehicle. However, to reduce the number of test variables, the individual subsystems tests are conducted somewhat independently (i.e., flight controls has a series of unique tests, avionics has a series of unique tests, propulsion, etc.). Not until the next phase of system maturity/development: Integrated System, is the system tested using integrated/mission level tasks. The "common-thread" disciplines (logistics, human factors, etc.) can be realistically validated on the air vehicle during the integrated system phase. This testing is identified in the TEMP as part of the required ground tests which update the LSA database predictions and identify RM&A achievements or shortfalls. System testing is usually conducted as a team effort involving the contractor(s) and the government (DT&E and OT&E), although Air Force Operational Test and Evaluation Center's (AFOTEC) use of contractor data and support (the system under test contractor, not AFOTEC support contractor) is restricted per 10 U.S.C. 2399.

Figure A2.7. System Level Test Process.

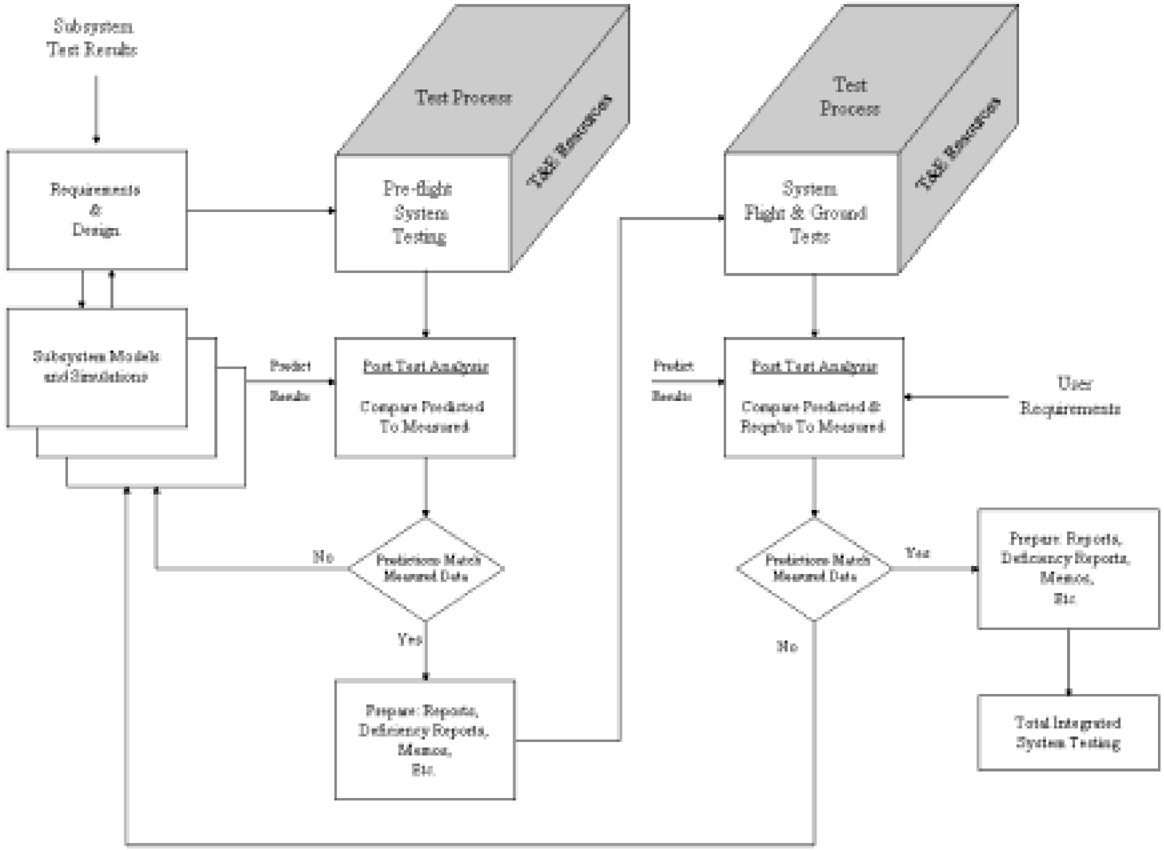
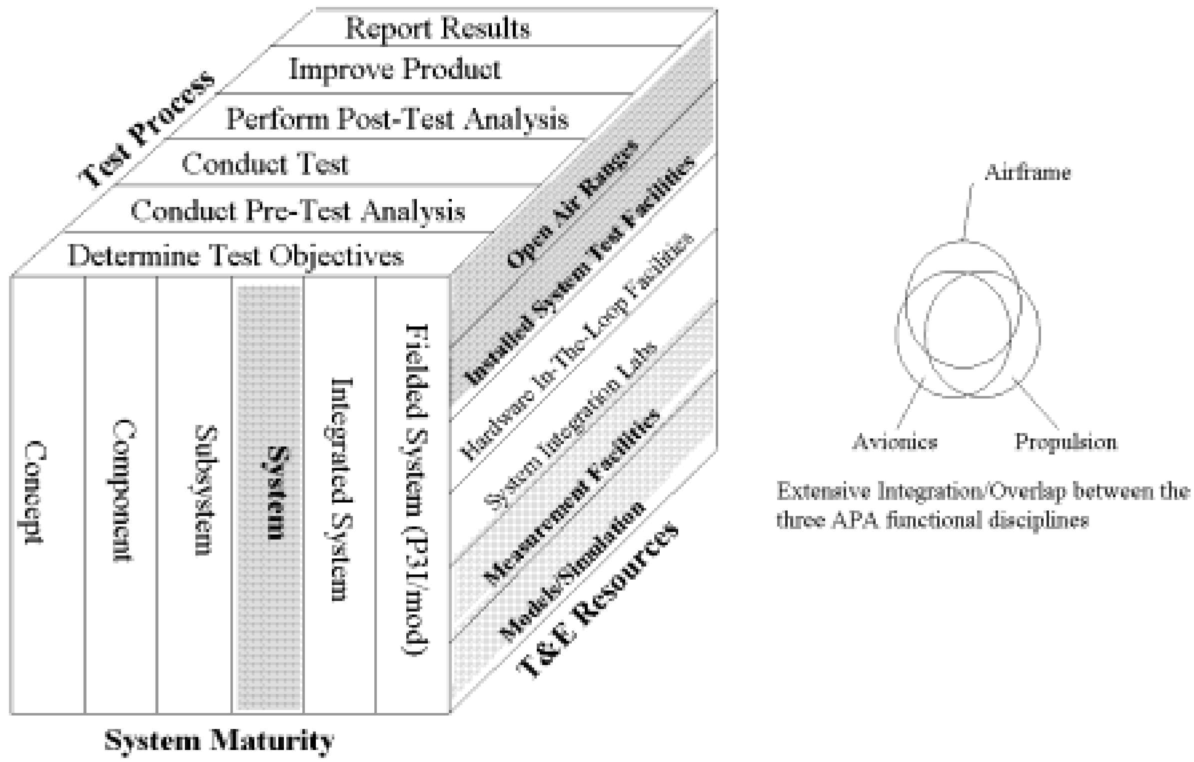


Figure A2.8. Primary Test Resources & Integration Level During System Development.



A2.5.5. As stated in the previous paragraph, once the air vehicle has been assembled and IV&V'd, a significant number of pre-flight tests must be conducted to ensure the aircraft is flight safe and "critical" systems (those necessary to sustain flight) function properly. These pre-flight tests are not large scale IV&V, but instead, assess whether the various subsystems function as an integrated/cohesive unit as designed - the air vehicle. These tests are usually conducted by the contractor in ISTFs or on the assembly floor using special test equipment and are monitored by the government (details of these tests are in the specific A-P-A disciplines sections later in this document). A representative (though not exclusive) series of pre-flight tests is shown in **Table A2.1.**

Table A2.1. Pre-Flight Test Phase Examples.

	Ground Test	Purpose
1.	Functional tests of A-P-A subsystems: hydraulic, environmental control system (ECS), flight controls, engines, auxiliary power units (APU), etc.	Verify installed subsystems function and interface properly within installed environment.
2.	Structural ground vibration test (GVT)	Verify structural modes of the air vehicle while configured in various mass property conditions [center of gravity (c.g.) & Fuel]. Requires "soft supporting" air vehicle off gear to simulate flight configuration.
3.	Ground resonance tests (GRT) and limit cycle tests	Verify adequate control system gain and phase margins (open and closed loop). Verify interaction between structural modes, aerodynamics and flight control system. As with GVT, air vehicle must be "soft supported".
4.	Electromagnetic interference (EMI)/electromagnetic compatibility (EMC) Tests	Avionics and electrical equipment on the air vehicle are operated to ensure no incompatibilities exist that would affect flight safety.
5.	Taxi Tests (Beginning with low speed and progressing to near lift-off speed)	Last series of ground tests to verify system is ready for flight. Exercise system while aircraft is in motion.

A2.5.6. Finally, after all the years of planning and preparation the real heart of system-level testing is conducted - open-air flight test. Open Air Ranges (OAR) allow flight testing under a controlled environment (to reduce number of test variables and risk) in natural climatic conditions. ISTFs are still used during open air testing to assist with mission planning and/or to investigate problems discovered during open air testing.

A2.5.7. Flight testing begins in the heart of the flight envelope (altitude and airspeed) and the heart of individual subsystems functional design envelopes. Along the way, as more confidence is gained in-flight safety and subsystem functionality, the envelopes are expanded. Not all subsystems mature at the same rate and subsystem upgrades occur at different times. Regression testing is often required when these upgrades are performed. This all adds significant complexity to system-level testing. Management systems must be created to track the air vehicle's configuration vs. time, flight no., etc., and systems must be created to track the various subsystem envelopes. Further details regarding A-P-A system flight testing may be found within each specific A-P-A discipline's section in this document.

A2.5.8. As shown in **Figure A2.7.**, many of the user's requirements (range, RM&A, etc.) will be directly tested during system testing. For instance, logistics test (LOG TEST as defined in AFI 99-101) will be the process adopted for validating RM&A requirements. Requirements in which mission level assets are integrated with the test air vehicle (for example: assessing those requirements which integrate Joint Surveillance Target Attack Radar System (J-STARS) with the test aircraft's weapon delivery) are assessed during the next total integrated system phase. In instances where the air vehicle does not meet the user's needs or problems need to be documented and solutions found, a formal government DR will be written as required by AF TO 00-35D-54. The SPO will then work with the contractor as required to resolve the deficiency.

A2.5.9. Included in the system development phase (as part of LOG TEST) is preliminary TO validation and verification (TOV&V). These documents mature with the air vehicle and testing is conducted IAW the currently verified/validated TO and recommended corrections or enhancements submitted IAW applicable directives. Maintenance actions should be performed IAW draft TOs and recommended corrections or enhancements be explored/incorporated into final versions.

A2.5.10. An important step during system testing is OT&E certification. This occurs when the SM (in consultation with DT&E and OT&E representatives and HQ USAF) believes the system is ready to transition from DT&E to dedicated OT&E (and is confident the weapon system will pass OT&E testing). Details of this process/step may be found in AFI 99-101, AFI 99-102, and USAF/TE's OT&E Certification Templates.

A2.5.11. To ensure system suitability is adequately addressed, structured suitability tests will be conducted. Logistics tests will be identified in the TEMP and dedicated time and resources (manpower, test articles, support equipment, etc.) identified. In the past, the disciplines typically associated with suitability testing (logistics, "ilities", human factors, safety, etc.) had to plan their test in a piggy-back fashion. This may be called for in some instances (to save time and money), but not all. Dedicated time and assets must be set aside to conduct suitability tests and ensure the delivered air vehicle meets all the user's requirements - both effectiveness AND suitability. As stated in previous maturity test phase sections of this document, these common thread disciplines have been involved with the air vehicle's development from the beginning, therefore adequate suitability testing should be conducted and tied closely with effectiveness testing.

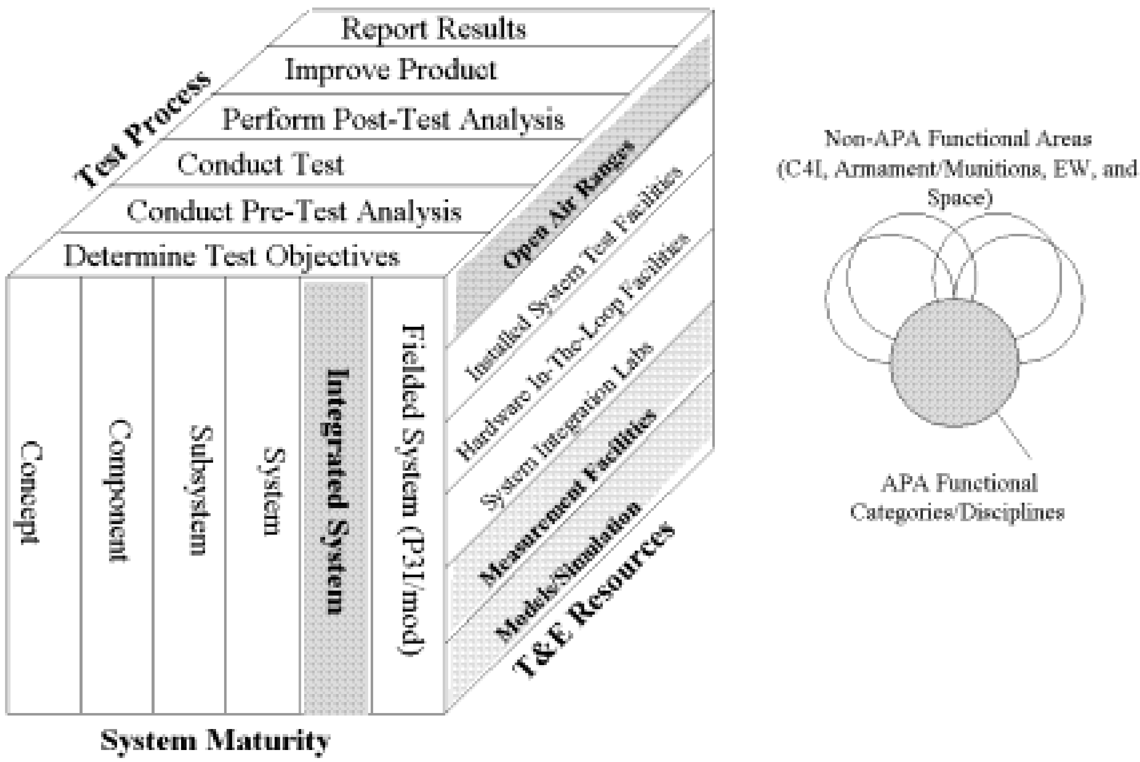
A2.5.12. By this point in system development (pre LRIP decision), either full-up LFT must have occurred [refer to LFT Law, Office of Secretary of Defense (OSD) guidance, and Air Force guidance for details] or a waiver granted.

A2.6. Integrated System Test Phase. This phase of system development is concerned with testing the weapon system in an environment which as close as practical replicates the environment in which the weapon system will operate. **Figure A2.9.** shows the integrated system development process. The goal for this phase of system development is to deliver an effective and suitable weapon system to the user with no "gotchas" or "by the ways......". To accomplish this, realistic suitability testing must be performed in addition to realistic effectiveness testing. Examples include, but are not limited to: exercising the ILSP, conducting TOV&V, conducting survivability testing in simulated threat environments using operational tactics, performing various maintenance tasks (to verify LSA predictions), and exercising subsystems while in realistic environmental conditions. Suitability testing evaluates integration/interfaces with outside systems (C3I network, ground-based targeting system), and conducting mission level tasks (bombing after navigating ingress route, live-fire weapon against drones, etc.). This testing is a combination of OT&E and DT&E with the majority of the testing being OT&E.

Figure A2.9. Total Integrated System Development Process.

A2.6.1. **Figure A2.10.** shows the resources used and the level of system integration required during integrated system testing. Similar to the previous development phase (system testing), integrated system testing is conducted almost exclusively in OARs (with less reliance upon ISTFs than during system-level testing) and primarily by AFOTEC (after OT&E test readiness certification). This usually requires conducting the tests at ranges (or within special designated areas) which approximate operational environments. These ranges include threats and threat surrogates, operational representative targets, and are usually instrumented for test purposes.

Figure A2.10. Primary Test Resources & Integration Level During Total Integrated System Testing.



A2.6.2. Obviously, now the system is performing tasks which require high levels of system integration/interfacing and the test objectives are aimed toward mission-level tasks [aerial delivery, bombing, suppression of enemy air defenses (SEAD), etc.]. Therefore, the corresponding models used during this phase of development are mission-level models similar to those during concept exploration. Note the development cycle has gone full circle by the fact that the integrated system development focus (mission-level tasks) is aligned very closely with the concept development focus (mission level tasks) and the corresponding high-level ORD requirements (mission-level tasks). Also note that the level of integration required during development and testing during the various system maturity phases has gone full circle. Close cooperation/coordination between and with subsystems was required during concept development and then again during integrated system development.

A2.7. P^{3}I Major Modification. A "modification" is a change to a system (whether for safety, to correct a deficiency, or to improve program performance) that is still being produced. An "upgrade" is a change to a system (whether for safety, to correct a deficiency, or to improve program performance) to a system that is out of production. A "major modification" to a program is defined as a modification that in and of itself meets the criteria of acquisition category I or II or is designated as such by the milestone decision authority. Major modifications require a Milestone IV decision unless the decision to modify results from one of the alternatives considered as part of the Milestone I decision process. Upgrades are part of the milestone 0 decision process.

A2.7.1. As with all the system maturity phases (concept through fielding), the level of testing is dependent upon the specific P^3I/mod. The test resources, analysis, and the T&E pace is very dependent upon the exact P^3I/mod requirement. For a P^3I/mod, tradeoff studies are more straightforward than with a new systems design because there is already an existing system with which to assess the proposed designs against (the number of unknowns and test variables is drastically reduced) and the integration requirements are more clearly understood early in the study.

A2.7.2. If the P^3I/mod is focused toward one of the three A-P-A functional categories/disciplines, airframe for example, then the majority of development and testing will occur within that functional category/discipline. For example, an upgrade to an airframe system, such as a wing upgrade or change to outer mold line, would require significantly more aerodynamic testing than avionics testing. Other airframe category tests may be required (system closed-loop stability), as well as some other functional category/discipline development and testing (change to systems within the wing). However, this may not always be the case and depends on factors such as interface requirements, safety, and design risk. Nonetheless, the test process side of the T&E cube always applies.

A2.7.3. As stated earlier, the test resources utilized during the P^3I/mod program is dependent upon the exact nature of the P^3I/mod. Unlike a new systems development where generally, T&E starts with modeling and simulation measurement facilities and ends with open-air ranges, P^3I/mod programs can start at any facility level. Component testing of a P^3I/mod could be conducted on a flying test bed without going through SILs, HITLs, etc., if the test team (SPO, contractor, and RTO) deem the impact and risk is minimal. System-level testing a P^3I/mod generally is conducted similar to new system testing described above. However, pre-flight tests are less extensive and less problems are encountered with tracking multiple envelopes and configurations. Like new system testing, P^3I/modification testing primarily occurs in OARs and ISTFs. These OARs may either be ranges designed specifically for flight test (for example, Edwards AFB CA) or ranges utilized by the Air Logistics Centers (ALC).

Attachment 3

T&E RESOURCES

Introduction

The following attachment provides brief descriptions and points of contact (POC) for government test and evaluation (T&E) facilities, laboratory facilities used for research and Air Logistics Center Depot maintenance infrastructure resources [associated with Airframe-Propulsion-Avionics (A-P-A) related T&E]. The laboratory and ALC resources are listed as potential capabilities to support development and acquisition programs if T&E facilities are not available or adequate to meet requirements. The facilities are categorized using the Reliance T&E Resource Categories (Measurement Facilities (MF), System Integration Labs (SIL), etc.). Also see the Test and Evaluation Computer Network (TECNET) (computer hosted list), Automated Test Resources Information System (ATRIS) Air Force Acquisition Model (AFAM), Test Investment Master Plan (TIMP), Test Capability Master Plan (TCMP), and Test Resource Master Plan (TRMP) for additional information regarding Department of Defense (DOD) T&E resources.

Note: Facilities which are listed in T&E resource related documents (TISP, TCMPs, and TRMP) are categorized using the common reliance categories and may be very specific to a given Major Range and Test Facility Base (MRTFB). For the purposes of this document however, many small/very specific facilities are not listed, but instead, are captured under their MRTFBs reliance category. For example, the weight and balance facility located at Edwards Air Force Base (AFB), CA is a MF and is not specifically listed in this attachment, however its function is associated with the flight test category under open-environment testing -- (the facility measures parameters associated with flight testing of air vehicles).

Detailed facility descriptions for selected T&E organizations can be found in the following documents. This information can be used to supplement the resource summary data provided in this attachment.

--Arnold Engineering Development Center (AEDC) , Test Facilities Handbook (Thirteenth Edition) May 1992. Contact: AEDC/DOCS, Arnold AFB TN 37389-5000, DSN: 340-6653.

--Wright Laboratory (WL), Research and Development Facilities Handbook, WL-TR-92-0004, Aug 1992. Contact: WL/DOT, Wright Patterson AFB OH 45433-6523, DSN: 785-4404.

--Air Logistics Centers (ALCs), Ground Test and Evaluation Capabilities, 1 June 1994. Contact: AFDTC/XRM, Eglin AFB FL, DSN: 872-4190.

--84th Test Squadron, Radar Test Facility User's Guide, Tyndall AFB FL. Contact: 84TS/DOR, Tyndall AFB FL 82403-5435, DSN: 523-3376.

--Rome Laboratory, Facilities Register, RL-TR-93-91, April 1993. Contact: RL/ERPE, Griffiss AFB NY 13441-4505. DSN: 587-3282.

--AFFTC Range User's Guide, Edwards AFB CA. Contact: 412TW/TSR, DSN: 527-3050.

--AFDTC Technical Facilities Manuals - Vol I, II, III (Class). Contact: 46 TW/XP, DSN: 872-5307

It is recommended that the user first contact the SFTC office for assistance in test planning and obtaining recommendations for T&E resources. The specific facility points of contact listed in this attachment are provided to assist the user in obtaining detailed data on test capabilities.

Modeling and Simulation

These resources are used in every stage of a system's development to help design, predict, and analyze tests. Generally, during the concept phase, modeling and simulation (M&S) form the basis for design tradeoff studies and are at a high level (for example, threat scenarios, and environments). As the system develops from components to the fielded system, M&S can be used to provide generic models for components, interfaces, etc., for use in system design and test. M&S develops with the system (using test results to update and refine) and progresses from low level/extremely detailed, to more high level, culminating in the Operational Requirements Document (ORD)/Cost and Operational Effectiveness Analysis (COEA) level once again (Note: the requirements have gone full cycle from high level, to low level, then back to high level). Increased reliance upon M&S is encouraged during developmental test and evaluation (DT&E) and operational test and evaluation (OT&E).

A3.1. Airframe:

A3.1.1. Aerodynamics and Performance Models. [Including computational fluid dynamics (CFD)]

A3.1.1.1. AEDC - External Flow Field Models of Aircraft with and without external stores or stores in internal bays. Contact: AEDC/DOF, DSN: 340-7721.

A3.1.1.2. ASC - Provides air vehicle Aero/Performance estimates including external aero (e.g., lift and drag), internal aero (e.g., installed engine performance and airframe/engine compatibility, and air vehicle performance (e.g., mission and point performance). Contact: ASC/ENFT, Flight Mechanics Branch, DSN: 785-5503.

A3.1.1.3. AEDC - Inlet ducting flow field models. Contact: AEDC/DOF, DSN: 340-7721.

A3.1.1.4. Wright Lab - CFD methodology development with emphasis on increased computational speed while remaining robust with reasonable accuracy. Contact: WL/FIMC, DSN: 785-4305.

A3.1.2. Structural and Finite Element Modeling:

A3.1.2.1. AEDC - General Purpose: ANSYS (mainframe), NASA Structural Analysis (NASTRAN) experience, ALGOR (PC), Specialty: FLOMODL (PC based steady state or transient flow network code). Contact: AEDC/DOF, DSN: 340-5305.

A3.1.2.2. ASC - Provides air vehicle structural analysis and evaluation. Contact: ASC/ENFS, Structures Branch, DSN: 785-3330.

A3.1.2.3. Wright Lab - Structural Modeling Tools & Analysis. Contact: WL/FIB, DSN: 785-5200.

A3.1.2.4. AFDTC - Structural and Finite Element Modeling. Contact: 46OG/OGME DSN: 872-3017.

A3.1.2.5. Seiler Lab - Numerical Modeling and experiments on unsteady aerodynamics including 3-D unsteady vortex dynamics, unsteady boundary layer transition/separation, and active flow control and free shear layer instability analysis. Contact: Seiler Lab DSN: 259-3120.

A3.1.3. Ground-Based Piloted Simulation:

A3.1.3.1. AFFTC - T&E Mission Simulator (TEMS). Provides flight test programs with real-time piloted (fixed and motion) simulation of flight dynamics and aircraft systems. Contact: 412 TW/EWW, DSN: 527-0840.

A3.1.3.2. Wright Lab - Flight simulation lab provides multi-aircraft full mission level (avionics, control weapon, threat) piloted simulation in 40' dome, 20' moving base dome, and multiple manned combat stations with 360 degrees field-of-view (FOV) --threat or friendly. Contact: WL/FIGD, DSN: 785-4690.

A3.1.4. In-flight Simulation:

A3.1.4.1. Wright Lab - Total In-flight Simulator (TIFS). A modified NC-131H aircraft owned by Wright Labs and operated by Calspan Corp. which is configured with simulation cockpit (can be customized to match test aircraft) in addition to flight cockpit. Onboard digital computers allow 6 degree-of-freedom rigid body simulation of an aircraft's control system/flying qualities. In-flight simulation give pilots cues not available in ground based simulations. Contact: WL/Flight Dynamics Directorate, DSN: 785-3853. The TIFS can also be configured with a radome, in place of the evaluation cockpit, to house a variety of radar and Forward Looking Infrared (FLIR) systems for flight testing. In this configuration, the aircraft can be flown from a pilot station in the cargo compartment of the aircraft. Contact: WL/FIGD DSN: 785-3853.

A3.1.4.2. Wright Lab - Variable Stability In-flight Simulator Test Aircraft (VISTA). A modified F-16D Block 30, Peace Marble configuration owned by AF and operated by Calspan Corp. The onboard digital computers make the aircraft capable of simulating the flying characteristics of high performance aircraft. Contact: WL/Flight Dynamics Directorate, DSN: 785-3853.

A3.1.5. Survivability/Vulnerability Models:

A3.1.5.1. Wright Lab - The Survivability/Vulnerability Information Analysis Center (SURVIAC) has models that address engagement functions such as exposure, detection, tracks, launch and guidance, damage assessment and failure analysis. Contact: WL/FIVS/SURVIAC, DSN: 785-4840.

A3.1.5.2. ASC - The Joint Modeling and Simulation System (J-MASS) provides a simulation support environment (SSE) and modeling library. The SSE enables the user to create models, configure scenarios, execute simulations and analyze results. The library contains models of weapon systems/components, threats, and environments. Contact: ASC/RWWW, DSN: 785-3969.

A3.1.6. Weapons Integration:

A3.1.6.1. AEDC - Safe Separation Models. Contact: AEDC/DOFA, DSN: 340-7721.

A3.1.6.2. AEDC - Ballistic accuracy, bombing algorithm and separation coefficients. Contact: AEDC/DOFA, DSN: 340-7721.

A3.1.6.3. AFFTC - System Accuracy Evaluation Software System. Contact: 412TW/TSVW, DSN: 525-9094.

A3.1.6.4. ASC/SK - The SEEK EAGLE Office at Eglin AFB has safe separation models. Contact: AFSEO/TA DSN: 872-9052.

A3.1.6.5. AFDTC - PRIMES and the GWEF-PRIMES Links have weapons integration capability. Contact: 46TW/TSWW DSN: 872-9354.

A3.1.7. Air Vehicle Subsystem Models:

A3.1.7.1. ASC - Provides subsystems integration/performance estimates [e.g., environmental control system (ECS), fuel, and landing gear]. Contact: ASC/ENFA, Air Vehicle Subsystem Branch, DSN: 785-5178.

A3.2. Propulsion:

A3.2.1. Performance, Specification, and Transient Decks: (computer models of engine)

A3.2.1.1. AEDC - Models are used in aircraft performance predictions (calculates thrust at given ambient/flight condition), and used in engine development/design. The models are developed by and are hosted at engine contractors in conjunction with DOD test organizations. For decks used during flight test. Contact: AFFTC/DOEF, DSN: 525-9017. For decks used during development. Contact: AEDC/DOP, DSN: 340-5305.

A3.2.1.2. AEDC - Developed propulsion modeling software called "ATEST". Uses thermodynamic cycle equations to simulate steady-state engine performance. If dynamic control system information is available, it can also model dynamic performance for throttle motions and airstarts. Contact: AEDC/DOP, DSN: 340-5305.

A3.2.1.3. Wright Lab - Conducts engine thermodynamics, turbine performance, and compressor analysis modeling in support of research and conceptual propulsion systems. Contact: WL/POT, DSN: 785-2331.

A3.2.1.4. ASC - Provides engine performance stability estimates. Contract: ASC/ENFP, Propulsion Systems Branch, DSN: 785-9595.

A3.2.1.5. AEDC developed propulsion modeling software, “DYNTECC” is a one-dimensional, stage-by-stage compression system mathematical model which is able to analyze any generic system. It has the capability to analyze post-stall behavior as well as predict the onset of compression system instability. Stability limit analysis can be conducted for single-spool and dual-spool systems with and without distortion. Contact: AEDC/DOP DSN: 340-5305.

A3.2.1.6. AEDC supported propulsion modeling software “NPARC” Navier-Stokes flow simulation program is used to calculate the properties of a fluid flow, based on specific boundary surfaces and flow conditions. It has been used on aerospace propulsive applications as diverse as supersonic and hypersonic inlet design, rocket nozzle failure analysis, turbine engine exhaust mixer design, missile nose cone analysis, instrumentation probe design, and ducted flow analysis. Contact: AEDC/DOP DSN: 340-5305.

A3.2.1.7. AEDC supported integrated modeling software based on the GENeralized Environment for the Simulation of Integrated Systems (GENESIS) for the prediction of overall integrated vehicle performance. Integrated vehicle performance is based on sub-models of the airframe, propulsion, and control system performance. Specific vehicle simulations (i.e., F-16, F-15/SMTD, Mark-80 Bomb) are implemented at AEDC. Contact AEDC/DOP DSN: 340-5305.

A3.2.2. Aerodynamic Models: (also see Airframe M&S in this attachment)

A3.2.2.1. AEDC - Stage stacking, cascade, quasi 3D modeling. Contact: AEDC/DOP, DSN: 340-5305.

A3.2.2.2. Wright Lab - Propulsion system aerodynamic modeling for research and conceptual designs. Contact: WL/POT, DSN: 785-2331.

A3.2.2.3. ASC - Provides engine performance and airframe/engine integration and compatibility analyses. Contact: ASC/ENFP, Propulsion Systems Branch, DSN: 785-9595.

A3.2.3. Structural Models: (also see Airframe M&S in this attachment)

A3.2.3.1. AEDC - Finite element models on mainframe or PC. Contact: AEDC/DOP, DSN: 340-5305.

A3.2.3.2. ASC - Provides engine structural analyses. Contact: ASC/ENFP, Propulsion Systems Branch, DSN: 785-9595.

A3.2.3.3. Wright Lab - Turbine Engine Structural Analysis Center for Research and Conceptual Design. Contact: WL/POT, DSN: 785-2331.

A3.2.4. Simulation of Inlets, Ducts, and Nozzle Afterbodies:

A3.2.4.1. AEDC - CFD Simulation of inlets, ducts, and nozzle afterbodies. Contact: AEDC/DOFA, DSN: 340-7721.

A3.2.5. Piping Networks:

A3.2.5.1. AEDC - Mainframe (ANSYS) or PC (FLOMODL) steady state or transient capability. Contact: AEDC/DOP, DSN: 340-5305.

A3.2.6. IR Models:

A3.2.6.1. AEDC - Infrared (IR) subroutines appended to performance models. Contact: AEDC/DOP, DSN: 340-5305.

A3.2.6.2. AFDTC - Airframe and engine signature and scene data reduction and repositories are maintained for use in countermeasure modeling. Contact: 96CCSG/SCW DSN: 872-2180.

A3.3. Avionics:

A3.3.1. In-flight Simulations: (see Avionics Flying Test Beds at end of this attachment)

A3.3.2. Integrated Avionics Simulations:

A3.3.2.1. Wright Lab - The Integrated Avionics Laboratory (IAL) is a combined avionics research, development, modeling and simulation facility that provides the ability to accomplish research and independent verification of avionics concepts and systems. Its purpose is to conduct real-time/non-real-time, multi-spectral, multi-disciplinary experiments and analysis in the areas of integrated avionics, core processing architecture, information processing, communication, navigation, identification, software, life cycle support and machine intelligence. Contact: WL/AAA, DSN: 785-5218.

A3.3.2.2. Wright Lab - The Electronic Combat Simulation Research Lab (ECSRL) provides expertise and digital tools for supporting studies, COEAs and technology insertion development for the J-MASS. Contact: WL/AAWA-1, DSN: 785-4429.

A3.3.3. CNI Related M&S:

A3.3.3.1. AFDTC - Central Inertial Guidance Test Facility (CIGTF), Holloman AFB NM. This facility performs T&E measurement of guidance systems (missiles and aircraft) and has extensive knowledge in related M&S. Contact: 46TG/GD, DSN: 349-2123.

A3.3.3.2. Wright Lab - The Communications Systems Evaluation Lab (CSEL) provides a dynamic evaluation of state-of-the-art communications, navigation and identification (CNI) systems in the integrated electromagnetic system simulator (ESS) and provides computer controlled threat interference signals. Contact: WL/AAAI, DSN: 785-2766.

A3.3.3.3. Wright Lab - The Integrated Test Bed (ITB) provides a real-time simulation of aircraft performing an operational mission allowing evaluation of advanced avionic systems, architecture and components across a broad spectrum of performance requirements. Contact: WL/AAAS, DSN: 785-4827.

A3.3.4. Embedded Software:

A3.3.4.1. Wright Lab - Embedded Computer Resources Support Improvement Facility provides a capability to develop, test and evaluate new technologies designed to improve support capability of avionics embedded system software. Contact: WL/AAAF, DSN: 785-3826.

A3.3.4.2. ASC - Embedded Computer Resources - Integrated Engineering and Technical Management data. Contact: ASC/EN (CR), DSN: 785-3656.

A3.3.5. Airborne Radar and Fire Control Modeling:

A3.3.5.1. Wright Lab - The Radar Analysis and Signal Processing Lab (RASPL) provides state-of-the-art modeling, analysis, simulation and signal processing environment for conducting air-to-air (A/A) and air-to-ground (A/G) radar system studies. Contact: WL/AARM, DSN: 785-6071.

A3.3.5.2. Wright Lab - The Fire Control Simulation (FICSIM) Facility provides analysis of fire control system performance in A/A arena, and A/G arena. Detailed modeling of radar sensor with airborne radar detection (AIRADE) model and electro-optic sensors in the Electro-Optical Simulation (EOSIM) model. Contact: WL/AART, DSN: 785-3215.

Measurement Facilities (MF)

These provide capabilities to measure parameters critical for system design. Generally, they are not test article unique, but do perform a specific function (for example, signature measurement or aerodynamic forces). A-P-A examples include: wind tunnels, radar cross section (RCS) ranges, spin-tunnels, and the electromagnetic interference (EMI)/electromagnetic compatibility (EMC).

A3.4. Airframe:

A3.4.1. Wind Tunnels:

A3.4.1.1. AEDC - The Propulsion Wind Tunnel (PWT) Facility includes 16 ft. tunnels for testing the aerodynamic performance of full-scale engine installation, large aircraft models or large and full-scale missiles for transonic (16T) and supersonic (16S) operating regimes. A 4 ft. transonic tunnel (4T) is used primarily for store separation testing. Contact: AEDC/DOFA, DSN: 340-7721.

A3.4.1.2. AEDC - The Von Karman Gas Dynamics Facility is comprised of aerodynamic test units to permit testing of relatively large-scale models of high speed aircraft and missiles in a Mach number range extending from 1.5 to 10. Tunnel A is supersonic with a 40x40 inch test section and a Mach number range of 1.5 to 5.5. Tunnel B is hypersonic with a 50 inch diameter and a Mach number range of 6 or 8. Tunnel C is hypersonic with a 50 inch diameter and a Mach number 10 and supersonic aerothermal with a 25 inch diameter and Mach number 4 or 8. Contact: AEDC/DOFA, DSN 340-7721.

A3.4.1.3. Wright Lab - The Flight Dynamics Laboratory has seven research, development and test wind tunnels capable of providing measurement facilities for airframe T&E.

--Subsonic Aerodynamic Research Laboratory (SARL). This is a 10 by 7 ft. subsonic wind tunnel able to produce a flow speed to 0.5 Mach number. The SARL provides high quality subsonic flow for design and for analytical methods validation purposes.

--Vertical Wind Tunnel (VWT). This facility is a 12 ft. diameter open jet test section wind tunnel capable of speeds to 125 ft./sec to test parachutes, ejection seats, free falling bodies, and to study low speed aerodynamics. The tunnel has even been utilized to train paratroopers. It is projected that the VWT will have a rotary balance support to allow dynamic testing in FY96.

--Two Foot Water Tunnel (LWT). A low cost test facility to provide a vivid depiction of the flow field about air vehicles for design and analysis purposes.

--Two Foot Trisonic Gasdynamics Facility (TGF). A variable density wind tunnel providing a test Mach number range of subsonic through Mach 3, for design and analysis purposes. The density can be varied from 0.25 to 1.5 atmosphere.

--Mach 3 High Reynolds Number Facility (M3). This blow down facility simulates flight at Mach 3 over an altitude range from sea level to 30,000 ft. in closed 8 inch test section.

--Mach 6 High Reynolds Number Facility (M6). This blow down facility simulates flight at Mach 6 over an altitude range from 30,000 ft. to 130,000 ft. and test flow temperatures to 1000 degrees R in an open jet test section with a 13 inch diameter exit.

--Twenty Inch Hypersonic Wind Tunnel. This blow down facility simulates flight at Mach 12 and Mach 14 over an altitude range from 120,000 ft. to 150,000 ft. and test flow temperatures to 2000 degrees R in an open jet test section with a 20 inch exit diameter.

Contact: WL/FIME, DSN: 785-2139.

A3.4.2. Structural Test Facilities: (Government facilities and facilities owned and operated by aerospace contractors)

A3.4.2.1. Wright Lab - Structures Test Facility. Large-scale combined elevated temperature static and dynamic testing of aerospace vehicles. Contact: WL/FIBT, DSN: 785-5059.

A3.4.3. Aero-Thermodynamic Heating Indoor-Facilities:

A3.4.3.1. AEDC - Tunnels B&C for aerothermal testing. Contact: AEDC/DOFA, DSN: 340-7721.

A3.4.3.2. Wright Lab - Radiant heat facility/convection heat facility. Thermal simulation wing radiant heat - 55MW maximum power. Contact: WL/FIBT, DSN: 785-5059.

A3.4.4. Birdstrike Testing:

A3.4.4.1. AEDC - Birdstrike Impact Measurement Facility. Contact: AEDC/DOFA, DSN: 340-5599.

A3.4.5. Component Size Environment/Climatic Test Chambers: (also see Installed System Test Facilities - section A3.13.)

A3.4.5.1. Wright Lab - Structures Test Environmental Simulation/Fatigue and Fracture Lab. Contact: WL/FIBT, DSN: 785-5059.

A3.4.6. Stability and Control Testing:

A3.4.6.1. Wright Lab - Flight control simulation lab (fixed, motion, and in-flight) at Wright Lab. Contact: WL/FIGD, DSN: 785-4690.

A3.4.7. Combined Environments/Acoustic Test Chamber:

A3.4.7.1. Wright Lab - High temperature, high intensity acoustic testing facility. Contact: WL/FIBT, DSN: 785-5059.

A3.4.8. Operations and Support Facilities: (detailed descriptions are contained in ALCs Ground T&E Capability Report, dated 01 June 1994)

A3.4.8.1. OC-ALC - The Engineering Test Support Facility supports the component level hydraulics pneumatics, material, vibration, and environmental measurements. Contact: OC-ALC/TIESS, DSN: 336-5498,

A3.4.8.2. SA - ALC - The Physical Science Lab consists of five (5) laboratory sections: Chemical Science Section, Metallurgical Science Section, Nondestructive Inspection and Testing Section, Process Control Section, and Quality Verification Section. Contact: SA-ALC/FM1, DSN: 945-4664.

A3.4.8.3. SM - ALC - The Science and Engineering Lab, F-111 cold proof load facility, non-destructive inspection facility, Pneudraulic/Hydraulic test and advanced composites facility have the capability to test F-111, A-10, F-117 and other airframe components. Contact: SM - ALC/TIEE, DSN: 633-3147.

A3.4.8.4. WR - ALC - The Corrosion and Environmental Test Facility, Environmental Test Facility, and Science and Engineering Lab have the capability to test airframe components for F-15, C-130, and C-141. Contact: WR - ALC/TIECE, DSN: 468-3238.

A3.4.8.5. OO - ALC - The Non-Destructive Test Facility and Science and Engineering Lab have the capability to test airframe components for F-16 and C-130s. Contact: OO - ALC/LIWB4, DSN: 458-4217.

A3.5. Propulsion:

A3.5.1. Uninstalled Engine Test Cells:

A3.5.1.1. AEDC - The Engine Test Facility (ETF) has several air-breathing test cells capable of simulating flight operational conditions over a wide range of Mach numbers and altitudes. Measurements can be made under precisely controlled conditions required to determine operational characteristics of major subassemblies (cascades, fans, and compressors). Contact: AEDC/DOP, DSN: 340-5305.

A3.5.1.2. Wright Lab - Advanced Turbine Engine and Compressor Research Facility. Contact: WL/POT, DSN: 785-2331. Combustion Research Facility: Contact: WL/POS/POP, DSN: 785-9991.

A3.5.2. Wind Tunnels:

A3.5.2.1. AEDC - Propulsion wind tunnels 16T and 16S. (See Airframe for measuring aerodynamic performance of full-scale engine installation, section II.A.1.a.) Contact: AEDC/DOFA, DSN: 340-7721.

A3.5.3. Engine Material Properties Labs:

A3.5.3.1. Wright Labs - Evaluate bearing materials and lubricants at high speed and high temperature. Contact: WL/POSL, DSN: 785-1286.

A3.5.4. Engine Component Test Rigs:

A3.5.4.1. AEDC - Engine test cells may be modified to support core engine and combustor testing. Contact: AEDC/DOP, DSN: 340-5305.

A3.5.4.2. AEDC - Component icing and de-icing Research and Test Facilities. Contact: AEDC/DOP, DSN: 340-5305.

A3.5.5. Engine Operations and Support Facilities:

A3.5.5.1. OC - ALC - The First Article Testing Unit, Jet Engine Test Facility and Cruise Missile Engine Test Cells, provide the capability for turbine engine tests. Contact: OC - ALC/TIESS, DSN: 336-5498.

A3.5.5.2. SA - ALC - The Engine NDI Facilities, Cryogenic SPIN Test Facility and Jet Engine Test Facility. These capabilities are dedicated to the repair and production of fielded engine systems. T&E usage would have to be based on availability and feasibility. Contact: SA - ALC/FM-1, DSN: 945-4664.

A3.6. Avionics:

A3.6.1. Special Access Facilities:

A3.6.1.1. AFFTC - Other special test capabilities may exist that can be applied to specific programs. Contact the Single-Face-To-Customer (SFTC) office with your requirements so an assessment can be made on special test facility applicability. Contact: AFFTC/XPS, DSN: 525-9250.

A3.6.2. RF Antenna Characterization Facilities:

A3.6.2.1. Rome Lab - Newport Research Facility evaluates antenna systems in "farfield" environment. Capability to pedestal mount F-16, B-1B, F-15, etc., airframe and measure radiation patterns. Contact: RL/ERS, DSN: 587-4217.

A3.6.2.2. Rome Lab - Stockbridge Research Facility evaluates antenna systems and ECM threat responses much like Newport Research Facility, but on large airframes (C-130, C-135, B-52, etc.). Contact: RL/ERS, DSN: 587-4217.

A3.6.2.3. Rome Lab - Precision Antenna Measurement System (PAMS), Verona Research Facility, Rome Labs, NY. An airborne dynamic radio frequency (RF) antenna measurement facility used to test antenna patterns from airborne aircraft. Ground based data collection receivers gather in-flight emission data and analyze data. Contact: RL/ERS, DSN: 587-4217.

A3.6.2.4. AEDC - Focal Plane Characterization Chamber, characterization by flood source and point source for focal plane arrays. Contact: AEDC/DOS, DSN: 340-5599.

A3.6.3. Signature Measurement Facilities:

A3.6.3.1. AFDTC - Radar Target Scatter (RATSCAT) Facility, at Holloman AFB NM provides the capability to make laboratory quality monostatic and bistatic RCS pole measurements [test article weights up to 100,000 pounds (lbs.)] including imaging. RCS measurements range from 150 MHz to 36 Giga Hertz (GHz) using co- and cross-polarization. Additional capabilities include high fidelity RCS model fabrication, and RCS prediction and analysis. Contact: 46TG/TGR, DSN: 349-3365.

A3.6.3.2. AFDTC - RATSCAT Advanced Measurement Facility (RAMS), at Holloman AFB NM provides similar function as the RATSCAT Facility, but a much lower RCS levels (very low observable). Contact: 46TG/TGR, DSN: 349-3365.

A3.6.3.3. AEDC - SDIO/Plume Data Center - Engine plume measurements in tests cells and in-flight. Contact: AEDC/DOC, DSN: 340-5599.

A3.6.3.4. Wright Lab - Radar Cross Section (RCS) Measurement Labs. Contact: WL/XPN, DSN: 785-5076.

A3.6.3.5. OO - ALC - The ACM Imaging Radar System (AIRS) is used to diagnose degradations of the cruise missile RCS. Contact: OO - ALC/LIWGE, DSN: 458-7351.

A3.6.4. Guidance and Navigation Measurement Facilities:

A3.6.4.1. AFDTC - Central Inertial Guidance Test Facility (CIGTF) at Holloman AFB, NM performs characterization verification of navigation and guidance components and systems including jamming/spooling vulnerability testing. Facilities contain the largest collection of precision test tables in the US and state-of-the-art GPS jamming/spooling systems. Conducts the full gamut of field testing including aircraft, ground and rocket sled testing. Contact: 46TG/TGG, DSN: 349-2123.

A3.6.5. Weapons Integration Measurement Facility:

A3.6.5.1. AFFTC - Stores/Weight/and Inertia System (SWIS) Facility, at Edwards AFB CA precisely measures store weight and inertia prior to aircraft loading (guided, unguided, and missiles). Contact: 412TW/TSVW , DSN: 525-9094.

A3.6.5.2. AEDC - Store Carriage Loads and Safety of Flight Clearance Tunnels 4T, 16T, and Tunnel A. Contact: AEDC/DOFA, DSN: 340-7721.

A3.6.5.3. AFDTC - Fixed and mobile facilities for measuring store mass and physical properties. Contact: AF SEO, Eglin AFB, DSN: 872-9052.

A3.6.5.4. AFDTC - Using the GWEF-PRIMES Link, parametrics of full-scale munitions in the GWEF connected to aircraft in the PRIMES can be measured for Captive-Carry, midcourse, and terminal phases of weapon system employment. Contact: 46TW/OGM, Eglin AFB, DSN: 872-4257.

A3.6.6. RF Receiver/Processor Measurement Facilities:

A3.6.6.1. Wright Lab - The RF Receiver/Processor Laboratory has developed special test equipment to automate receiver measurements using common test criteria. Contact: WL/AAWP, DSN: 785-6131.

A3.6.6.2. Wright Lab - Dynamic/Combat Electromagnetic Environment Simulator (DEES/CEESIM) Facility to simulate realistic signal environments and evaluate receiver performance. Contact: WL/AAWA, DSN: 785-4264.

A3.6.7. Electro-Optical Measurement Facilities:

A3.6.7.1. Wright Lab - The Electro-Optical Receiver Lab is a development, test and evaluation facility designed to perform automatic measurements and evaluations. Most optical receiver types have been tested in this facility. Contact: WL/AAWP, DSN: 785-2471.

A3.6.7.2. Wright Lab - The Optical Research Lab provides the capability for test, characterization and development of novel optical components and devices for use in laser radar systems. Unique capability for testing and evaluating the rapidly maturing technology of agile beam steering using liquid crystal phased arrays. Contact: WL/AARI-2, DSN: 785-9614.

A3.6.7.3. Wright Lab - The Laser Radar Research Lab provides analysis and testing capability for improved electro-optical (EO) targeting and weapon delivery laser radar technologies. Unique capability or 2 micro meter Laser Technology. Contact WL/AARI-2, DSN 785-9614

A3.6.8. Communication Avionics:

A3.6.8.1. Wright Lab - The Integrated Electromagnetic System Simulator (IESS) provides real-time dynamic testing of advanced integrated communications, navigation, and identification avionics (ICNIA). Contact: WL/AAAI, DSN: 785-2766.

A3.6.9. Radar Measurement Facilities:

A3.6.9.1. AFFTC - The Integration Facility For Avionic System Testing (IFAST) provides radar spread benches with bays on side of building to allow radar clear FOV transmission/receive (see HITL Facilities). Contact: AFFTC/412TW/EWW, DSN: 527-5404.

A3.6.9.2. AFFTC - A Radar Target Generator (RTG) and Dynamic Angle of Arrival (DAOA) Facility is currently in the preliminary design phase with an interim capability planned for GFY 96. This will allow installed airborne radar testing over controlled ranges of operational conditions. This part of the Electronic Combat Integrated Test (ECIT) Installed System Test Facility (ISTF) currently under development (see ISTF). Contact: AFFTC/412TW/EWD, DSN: 525-9426.

A3.6.9.3. AFFTC - Advanced Radar Test Bed (ARTB) is a modified C-141 capable of testing various airborne interceptor radars (see Flying Test Beds). Contact: AFFTC/418TW/DOE, DSN: 527-4009.

A3.6.9.4. 84th TS - The Radar Test Facility (RTF) can provide DT&E capability for Air Intercept (AI) radars, electronic counter measures (ECM), and electronic counter countermeasures (ECCM) in a controlled repeatable test environment [see Hardware-In-The-Loop (HITL)]. Contact: 84TS/DOR, DSN: 523-3376.

A3.6.9.5. Rome Lab - Newport Antenna Range for testing advanced surveillance radars. Contact: RL/ERS, DSN: 587-4217.

A3.6.10. Avionics Operations and Support Facilities:

A3.6.10.1. OC - ALC - The Avionics Reliability Center has the ability to test aircraft inertial navigation systems, altitude heading reference systems and automatic flight control systems. Contact: OC - ALC/LIIRU, DSN: 336-5064.

A3.6.10.2. OO - ALC - The Nose Radome and Radar Antenna Test Facilities, Avionics/Electronic Support Facilities, and Optic and Photonic System Facilities offer T&E capabilities for F-16 and other platforms. Contact: OO - ALC/LIRP, DSN: 458-8080.

A3.6.10.3. SM - ALC - The Electro-Optics Test Facility, near field test range, in-flight display systems and avionics test stands offer T&E capabilities for F-111, F-117, and A-10. Contact: SM-ALC/TIEE, DSN: 633-3147.

A3.6.10.4. WR - ALC - The Indoor Doppler Antenna Test Range, Microwave Antenna Test Facility, and Electronic Failure Analysis Lab provide avionics test capabilities. Contact: WR - ALC/LYPCA, DSN: 468-4157.

System Integration Laboratories (SIL)

These facilities integrate hardware and software components up to the subsystem level using a table-top/spread-bench environment. Usually a specific component is tested in a SIL with the interface components simulated (either through hardware or software). These facilities usually reside at contractor facilities because they are test article specific.

A3.7. Airframe:

A3.7.1. Aerodynamic/Flight Control Related Labs: (developing leading-edge technologies)

A3.7.1.1. AEDC - Tunnel 16T full-scale captive flight cruise missile testing, functional testing of wing deployment, inlet deployment, engine start and engine operation. Contact: AEDC/DOFA, DSN: 340-7721.

A3.7.1.2. Wright Lab - Real-Time Piloted engineering Flight Simulation Lab to develop flight vehicle and flight control technology. Flight Simulation Lab provides multi aircraft full mission level (avionics, controls, weapon, threat) piloted simulation in 49 foot dome, 20 foot moving base dome, and multiple manned control stations with 360 degrees field-of-view (FOV) threat and friendly. Contact: WL/FIGD, DSN: 785-4690.

A3.7.1.3. Wright Lab - Flight Control Activation and Hydraulics Systems Labs. Contact: WL/FIGS DSN: 785-2831

A3.7.2. Materials and Structures Labs: (developing leading-edge technologies)

A3.7.2.1. AEDC - Aerothermal Tunnel C, material performance in interference flows. Contact: AEDC/DOS, DSN: 340-5599.

A3.7.2.2. Wright Lab - Aircraft Structures Test Facility. Contact: WL/FIBT, DSN: 785-5723.

A3.7.3. Vehicle Subsystem Labs: (developing leading-edge technologies)

A3.7.3.1. Wright Lab - Landing Gear Development Facility to perform functional and qualification test on landing gear assemblies and component hardware. Contact: WL/FIVM, DSN: 785-2663.

A3.7.4. Human Factors/Cockpit Integration Related Labs: (developing leading-edge technologies)

A3.7.4.1. Wright Lab - Cockpit and Crew Simulation Lab. Contact: WL/FIP, DSN: 785-2260.

A3.7.4.2. HSC Labs, Brooks AFB, TX. Contact: HSC/YA DSN: 240-2345.

A3.7.5. Life Support Labs: (developing leading-edge technologies)

A3.7.5.1. HSC, Brooks AFB, TX. Contact: HSC/YA DSN: 240-2345.

A3.7.6. Airframe Operations and Support Facilities: (see discussion in Measurement Facilities)

A3.8. Propulsion:

A3.8.1. Propulsion Integration Facilities:

A3.8.1.1. AEDC - Engine inlet compatibility at ASTF and 16T/16S wind tunnels. Contact: AEDC/DOFA, DSN: 340-7721. ASTF Contact: AEDC/DOP, DSN: 340-5305.

A3.8.1.2. AEDC - Engine performance, operability, inlet distortion and aeromechanical; all with airframe interfacing simulated as required in turbine engine altitude cells. Contact: AEDC/DOP, DSN: 340-5305.

A3.8.1.3. Wright Lab - Aero-Propulsion Directorate. Contact: WL/POMX, DSN: 785-2131.

A3.8.2. Engine Operations and Support Facilities: (see discussion in Measurement Facilities, II.B.5.)

A3.9. Avionics:

A3.9.1. Avionics/Electronics Related Labs: (for developing leading-edge technologies)

A3.9.1.1. Wright Lab - Avionics Directorate. Contact: WL/AA, DSN: 785-2620.

A3.9.1.2. Wright Lab - Solid State Electronics Directorate. Contact: WL/EL, DSN: 785-2911.

A3.9.1.3. Wright Lab - Integrated Defensive Avionics Lab (IDAL), is an evolving development/evaluation center for radar warning receiver technology, real-time J-MASS technology, mission rehearsal simulation and integrated defensive avionics. Supports both open and closed loop simulation with man/HITL evaluations. Contact: WL/AAWA-2, DSN: 785-4264.

A3.9.2. Facilities used for Testing Avionics/EC Flight Hardware/Software:

A3.9.2.1. AFFTC - Integration Facility for Avionic System Testing (IFAST). This facility supports flight test programs with avionics spread benches for functional verification, anomaly characterization, integration testing, regression testing, software evaluation, and aircrew familiarization (including weapons/munitions/armament and sensors). Radar bays on side of building allow radar clear FOV transmission/receiving. Contact: 412TW/EWW, DSN: 527-5404.

A3.9.2.2. WR - ALC - Electronic Warfare Avionics Integration Support Facility (EWAISF). Provide engineering and platform support Air Force airborne electronic warfare (EW) systems (ALQ, ALE, and ALR series). Contact: WR -ALC/LNEV, DSN: 468-3691.

A3.9.2.3. AFDTC - Pre-flight Integration of Munitions and Electronics Systems (PRIMES) Facility provides a subsystem/system hot bench avionics test capability. Contact: 46TW/TSWW DSN: 872-9354.

A3.9.3. Facilities for Testing Weapons Hardware/Software Integration:

A3.9.3.1. AFFTC - Stores Buildup/Integration Facility at Edwards AFB CA. DOD explosive certified facility used to evaluate weapon integration with aircraft stores management systems. Has capability to evaluate cruise missile integration. Contact: AFFTC/412 TW/TSVW, DSN: 525-9094.

A3.9.4. Avionics Operations and Support Facilities:

A3.9.4.1. OC - ALC - Avionics Integrated Support Facilities are used to conduct maintenance and integration testing to verify and analyze software problems, to design code and test changes to correct identified problems and to test new software versions. Avionics Integration Support Facility (AISF) facilities include: E-3 AISF; E-4B SIL; B-52 AISF; B-1B AISF; and CM AISF. Contact: OC - ALC/TIESS, DSN: 336-5498.

A3.9.4.2. OO - ALC - F-16 Software Development and Engineering Test Station and Software Technology Support Center supports avionics integrated support testing. Contact: OO - ALC/ LIWB4, DSN: 458-4217.

A3.9.4.3. SA - ALC - C-17 Avionics Integrated Support Facility(currently under construction). Contact: SA - ALC/LC, DSN: 945-3495.

A3.9.4.4. SM - ALC - The Advanced Electronics Center, Extendible Integration Support Facility (EISF), System Technology Insertion Facility, F-111 AISF, A-10 ISF, and the Operational Test Program (OTP) provides software integration testing capabilities. Contact: SM - ALC/TIEE, DSN: 633-3147.

A3.9.4.5. WR - ALC - Avionics Integrated Support Facilities include the following capabilities: GPS ISF; C-130 Self Contained NAV SYS ISF; Joint Stars ISF; EW AISF; F-15 AISF; Pave Tack AISF; and SOF AISF. Contact: WR-ALC/LNEV, DSN: 468-3691.

Hardware In-The-Loop (HITL) Facilities

These facilities provide the capability to test actual subsystem level hardware in a closed-loop indoor lab environment (for example, iron-bird labs and fuel system labs). Generally, they are more sophisticated than SILs and typically reside in contractor facilities. Subsystems and sensors other than the one under test are simulated. A government example is the Integration Facility For Avionic System Testing (IFAST) located at the Air Force Flight Test Center, Edwards AFB CA.

A3.10. Airframe:

A3.10.1. Subsystems Test Facilities:

A3.10.1.1. Wright Lab - Tire and Brake Dynamometers. Contact: WL/DOR, DSN: 785-4404.

A3.10.1.2. Wright Lab - Hydraulics System Simulator. Contact: WL/DOR, DSN: 785-4404.

A3.10.1.3. Wright Lab - Structures Test Facility. Contact: WL/FIBT, DSN: 785-5059.

A3.10.1.4. AFDTC - Climatic Laboratory for Airframe Testing . Contact: 46TW/TSWL, DSN: 872-4610.

A3.10.1.5. Wright Lab - Vibroacoustics Test Facilities . Contact: WL/F1BG, DSN: 785-2544

A3.10.2. Operations and Support Facilities (see ALC capabilities in Measurement and SIL Testing Section)

A3.11. Propulsion:

A3.11.1. Uninstalled Engine Sea -Level T&E:

A3.11.1.1. AEDC - Sea Level Test Stand (SLT-1). Contact: AEDC/DOP, DSN: 340-5305.

A3.11.1.2. AEDC - APTU, T_t, up to 2000 degrees R. Contact: AEDC/DOF, DSN: 340-7721.

A3.11.2. Uninstalled Engine Altitude T&E:

A3.11.2.1. AEDC - Engine Test Facility (ETF), and Aeropropulsion Systems Test Facility (ASTF) are used for the evaluation of air-breathing engine performance, engine/inlet dynamics, engine operability transients, engine aeromechanical behavior, engine mission simulations, engine/inlet and components/missile mission simulation, engine durability [Ram Accelerated Mission Testing(AMT)], and nozzle vectoring and development. Contact: AEDC/DOP DSN: 340-5305

A3.11.3. High AOA/Sideslip T&E:

A3.11.3.1. AEDC - Aeropropulsion Systems Test Facility (ASTF), provides one test cell with "free jet" capability to perform altitude testing for performance and operability with full-up inlet/engine combination at varieties of sideslips and angles-of-attack. Contact: AEDC/DOP DSN: 340-5305.

A3.11.3.2. AEDC - Propulsion Wind Tunnels 16T and 16S engine inlet compatibility. Contact: AEDC/DOFA, DSN: 340-7721.

A3.11.4. Uninstalled Engine Icing/de-icing/anti-icing Qualification T&E:

A3.11.4.1. AEDC Engine Test Facility (ETF) and Aeropropulsion System Test Facility (ASTF) provide test cells with the capability to perform inlet/engine or uninstalled engine anti-icing/de-icing qualification testing at various altitude/Mach No. and rain cloud conditions. Contact: AEDC/DOP DSN: 340-5305.

A3.11.5. Climatic Testing of Engine/Components:

A3.11.5.1. McKinley Climatic Laboratory Engine Test Cells, provides the capability to test functioning engines in extreme temperature conditions. Contact: Eglin AFB, DSN: 872-4601.

A3.11.5.2. AEDC Engine Test Facility (ETF) and Aeropropulsion Test Facility (ASTF) provide test cells with the capability of thermally soaking and operationally testing of engines at extreme temperatures ranging from -100×F to +1080×F. Contact: AEDC/DOP DSN: 340-5305.

A3.11.6. Operations and Support Facilities: (see ALC capabilities in Measurement and SIL testing section)

A3.12. Avionics:

A3.12.1. Navigation:

A3.12.1.1. AFDTC - Central Inertial Guidance Test Facility (CIGTF). Contact: 746th Test Squadron, DSN: 349-2123.

A3.12.2. Facilities used for Testing Avionics and EC Integration Flight Hardware/ Software:

A3.12.2.1. AFFTC - Integra*tion* Facility for Avionic Support Testing (IFAST). This facility supports flight test programs with avionics spread benches for functional verification, anomaly characterization, integration testing, software evaluation, and aircrew familiarization. Radar bays on side of building allow radar clear FOV transmission/receiving. Contact: FFTC/412TW/EWW, DSN: 527-5404.

A3.12.2.2. Air Force Electronic Warfare Evaluation Simulator (AFEWES). Provides high density signal environment to test ECM techniques using manned threat simulators. Can test components and subsystems in either open or closed loop mode. Contact: 46 TW/TSWW, DSN: 872-3410.

A3.12.2.3. Real-time Electromagnetic Digitally Controlled Analyzer Processor (REDCAP). Provides real-time man-in-the-loop hybrid simulation of Integrated Air Defense Systems (IADS) to test component performance and simulated aircraft survivability. Contact: 46TW/TSWG, DSN: 872-3410.

A3.12.2.4. AFDTC - PRIMES Facility at Eglin AFB. Contact: AFDTC/DRC DSN: 872-9650

A3.12.3. Weapons Integration HITL Facilities:

A3.12.3.1. AFFTC - Stores Buildup/Integration Facility. DOD explosive certified facility used to evaluate weapon integration with aircraft stores management systems. Has capability to evaluate cruise missile integration. Contact: 412 TW/TSVW DSN: 525-9094.

A3.12.3.2. AFDTC - Guided Weapons Evaluation Facility (GWEF). Provides weapon system and subsystem T&E using digital, HITL, and ECM simulation. Using the GWEF-PRIMES link, HITL testing of full scale munitions in the GWEF, connected to aircraft in the PRIMES, is provided for captive-carry, midcourse, and terminal phases of weapon system employment. Contact: 46 TW/TSWG, DSN: 872-9988.

A3.12.3.3. AEDC - IR Guided Weapons, Direct Write Scene Generator Facility. Contact: AEDC/DOC, DSN: 340-5599.

A3.12.4. Avionics/Electronics Labs for HITL Testing:

A3.12.4.1. Wright Lab - The Dynamic Infrared Missile Evaluator (DIME) facility provides testing capability in the areas of IR guided weapon exploitation and infrared countermeasures (IRCM) technique development. Provides a range of capabilities from aircraft signature studies in the visible and IR portion of the spectrum to real-time HITL flyout simulation. EO/IRCM techniques can be developed using both digital modeling and hardware tests. Contact: WL/AAWW, DSN: 785-4174.

A3.12.4.2. Wright Lab - The Optical Collimator Facility provides research, test and analysis capability for tactical and strategic EO and laser radar systems under simulated environmental conditions. Contains a 100 inch diameter optical collimating mirror housed in a vacuum chamber which can be evacuated to simulate a 270,000 ft altitude. Contact: WL/AARI-2, DSN: 785-9614.

A3.12.4.3. Wright Lab - Infrared Laboratory capable of characterizing and supporting the development of EO imaging sensor systems. Contact: WL/AARI-2, DSN: 785-9614.

A3.12.4.4. Wright Lab - Air Force Sensor Evaluation Center (AFSEC) provides capability for T&E and development imaging sensor system. Capable of emulating actual flight environments with equipment installed in aircraft section. Contact: WL/AARF, DSN: 785-5406.

A3.12.4.5. Wright Lab - Extremely broad bandwidth anechoic facility to perform exploitation of foreign missile system and develop countermeasures against the missiles. Contact: WL/AAWW-2, DSN: 785-6504.

A3.12.5. Operations and Support Facilities: (see ALC capabilities in the Measurement and SIL testing section)

A3.12.6. Radar Test Facilities:

A3.12.6.1. AFFTC - The IFAST Radar Test Station (RTS) provides a radar ground test facility that is configurable to several different avionics configurations. The RTS can operate the radar using airborne targets or simulated targets via a signal generator. The F-15 avionics laboratory also located in the IFAST provides a core avionics and radar ground test facility reconfigurable to support avionics flight tests. Contact: 412TW/EWW DSN: 527-5404.

A3.12.6.2. 84th Test Squadron - The Radar Test Facility (RTF) conducts operational test and evaluation (OT&E) and developmental test and evaluation (DT&E) on airborne interceptor radars, electroinc countermeasures (ECM), and electronic counter-countermeasures (ECCM). The RTF provides F-15, F-16, and AIM-7F/M/H integrated weapon system testing in a controlled, repeatable test environment. Contact: 84TS/DOR, DSN: 523-3376.

Installed System Test Facilities (ISTF)

These facilities provide the capability to evaluate systems which are installed on the host platform/airframe while residing within a controlled indoor environment. Examples include, anechoic chambers, limit cycle/ground resonance test stands, structural loads stands and full-scale wind tunnel tests.

A3.13. Airframe:

A3.13.1. Ground Resonance/Vibration/Limit Cycle Test (GRT/GVT) Systems. Predominantly conducted in aerospace contractor owned and operated facilities

A3.13.1.1. AFFTC - Limit Cycle/GRT system. Contact: AFFTC/XPS, DSN: 525-9266.

A3.13.1.2. Wright Lab - Ground Vibration Tests. Contact: WL/FTBG, DSN: 785-5200

A3.13.2. Egress/Ejection Systems T&E: 1High Speed Test Track. Contact: AFDTC/Holloman, DSN: 349-2133.

A3.13.3. Vulnerability/Live Fire T&E:

A3.13.3.1. Wright Labs - Live Fire capability up to 30mm rounds. Contact: WL/FIV, DSN: 785-4840.

A3.13.3.2. High Speed Test Track. Contact: AFDTC/Holloman, DSN: 349-2133.

A3.13.4. MI/EMC/Lightning Effects T&E:

A3.13.5. Climatic Testing: (see **A3.4.4.** for component testing)

A3.13.5.1. McKinley Climatic Lab, AFDTC, Eglin AFB, FL. Info (size, temp ranges, etc.). Contact: AFDTC/Eglin, DSN: 872-4601.

A3.13.6. Structural Load T&E: (see Measurement Facilities)

A3.13.7. ECM/ECCM Testing. High speed test track. Contact: 846th Test Squadron, DSN: 349-2133

A3.14. Propulsion:

A3.14.1. Installed Engine Test Facilities:

A3.14.1.1. AFFTC - Horizontal Thrust Stand. Provides direct measurement of thrust at ground level (approx. 2200 ft altitude) at ambient conditions. Can accommodate 1 Mlb aircraft and asymmetric thrust. Contact: AFFTC/DOEF, DSN: 525-9017.

A3.14.2. Climatic T&E: (see Airframe Installed System Test Facilities, **A3.13.**)

A3.14.3. Live Fire/Vulnerability T&E: (see Airframe Installed System Test Facilities, **A3.13.**)

A3.15. Avionics:

A3.15.1. EC and Avionics Integration:

A3.15.1.1. AFFTC - Benefield Anechoic Chamber (BAF) 412TW/EWWA, Edwards AFB, CA Supports flight and ground test programs with a large (264x250x70 ft.) anechoic chamber, the largest in the world. Attenuation/isolation ranges from 120 to 200 dB within the chamber's RF quiet zone. A turntable and hoist located near the center of the chamber allows testing to be accomplished at multiple azimuths and elevations using free-space RF techniques. Signal generation system provides an extensive emitter library capable of simulating land-based, sea-based, air-to-air red, blue, and gray systems primarily with the frequency range of 0.5 to 18.0 GHz. Test environments are possible well outside this frequency range. Contact: 412TW/EWWA, DSN: 527-0840.

A3.15.1.2. AFFTC - Electronic Combat Integrated Test (ECIT) Development Program. The ECIT Program will provide the Avionics Test and Integration Complex (ATIC) with a secure ground test environment to test and evaluate current avionics systems and future complex, highly-integrated software, intensive avionics suites installed on the combat aircraft. Avionics suites include radar, electronic warfare, communications, navigation and identification (CNI), Infrared (IR), weapon management, sensor management and other functions. The ECIT will create realistic multispectral, multiple player, and synthetic environments so that integrated avionics can be tested. The initial development phase, infrastructure and generic test capability (I&GTC) is planned for development start in GFY95. Contact: 412TW/EWD DSN: 525-9426.

A3.15.2. Weapons Integration:

A3.15.2.1. 46TW/TSWW - Pre-flight Integration of Munitions and Electronics Systems (PRIMES). Provides an RF environment in 108x78x30 ft. anechoic chamber to stimulate the weapon/aircraft. The facility has a 0.5 to 18 GHz dynamic threat signal simulator, as well a subsystem/system hot bench test room and data analysis package. Using the GWEF-PRIMES Link, integrated performance testing of full scale munitions in the GWEF, connected to aircraft in the

PRIMES, is provided for captive-carry, midcourse and terminal phases of weapon system employment. Contact: 46 TW/TSWW, DSN: 872-9354.

A3.15.3. EMI/EMC, Climatic, and Vulnerability T&E: (see Airframe **A3.13.**)

A3.15.3.1. AFDTC - PRIMES EMI/EMC capability. Contact: 46TW/TSWW DSN: 872-9354.

A3.15.4. Threat Exploitation Facilities:

A3.15.4.1. Wright Lab - Hangar 4 anechoic facility capable of performing threat radar and missile technical exploitation. Allows development of ECM techniques against actual threat hardware and test of operational ECM systems under controlled conditions. Exacts data from damaged components and complex printed circuit boards. Contact: WL/AAWP-2, DSN: 785-2471.

Open Air Ranges (OAR)

This category of T&E resources is divided into two groups, controlled/instrumented ranges and real-world environments. Although, the weapon system should be tested in a controlled environment, valuable data may be gathered from real-world scenarios which may effect system upgrades/modifications.

A3.16. Airframe:

A3.16.1. Basic Airworthiness: (performance and flying qualities)

A3.16.1.1. AFFTC - Besides fully instrumented ranges [with global positioning system (GPS), visual, or radar tracking] for conducting Airworthiness T&E (flying qualities, performance, high AOA, structural tests, etc.), the AFFTC has unique airworthiness related facilities for: air data calibration (tower and pacer), aircraft weight and balance (up to 1M lbs), gun harmonization (30mm gun butt), large lakebed (multiple emergency landing options), instrumentation lab (Class II capable). Contact: 412 TW/TSF, DSN: 525-9089.

A3.16.1.2. System Effectiveness Data System (SEDS) - Used to store and process failure and maintenance. Generates reliability and maintainability parameters during a development test program. Contact: 412 TW/TSSR DSN: 525-9128

A3.16.2. TF/TA Development:

A3.16.2.1. AFFTC - Haystack Butte Route. This is a 5 X 26 mi. fully instrumented and surveyed route (to 2 ft elevation resolution). It contains a smooth gradual incline over desert terrain with an abrupt terrain change at Haystack Butte for fly-up command checkout and is ideal for initial TF/TA development. Contact: 412 TW/TSR, DSN: 525-3050.

A3.16.2.2. AFFTC - R-2508 airspace terrain following/terrain avoidance (TF/TA) training routes. Multiple routes over varying terrain (desert and mountainous) with sited navigation waypoints. Contact: 412 TW/TSR, DSN: 525-3050.

A3.16.2.3. AFFTC - Utah Test and Training Range (UTTR) Hill AFB UT. Land areas beneath the 17,000 square nautical mile UTTR airspace contains some 30 different DMA Terrain Contour Matching (TERCOM) maps in all four categories of Landfall, Midcourse, Enroute, and Terminal. Additionally, all categories of land surface roughness are available from Very Smooth to Very Rough. Airspace vertical limits allow aircraft, cruise missile, or UAV TF/TA flight operations down to 100 feet AGL throughout the range, and down to the surface over DOD owned land areas. Contact: 545TG/XRP, DSN: 458-7852.

A3.16.3. Aerial Delivery:

A3.16.3.1. AFFTC - In addition to in-flight aerial delivery T&E (AFFTC is DOD center of expertise for aerial delivery) including low altitude parachute extraction system (LAPES) (lakebed is ideal for initial LAPES T&E), the AFFTC has facilities which support aerial delivery (parachute drying tower, parachute rigging facility, load buildup facility, and fully instrumented drop ranges). Contact: 417 TS/EN, DSN: 527-6404.

A3.16.4. Structural Flight Test: (loads, aeroelasticity, weight and balance, and vibroacoustics)

A3.16.4.1. AFFTC - Real-time (near) system is available in mission control rooms to provide structural damping, frequency, and structural response of air vehicles. Contact: 412TW/TSFS DSN: 525-9091.

A3.16.5. Initial Weapons Separation T&E: (also see **A3.18.**)

A3.16.5.1. AFFTC - Precision Impact Range Area (PIRA) A 75 sq. mi. precision instrumented Class-B range (with supersonic capability) for overland dropping inert stores. For weapon system development, the range is used for weapon separation T&E (less than 1 ft resolution) and preliminary weapons integration T&E. Contact: 412 TW/TSR, DSN: 525-3050.

A3.16.5.2. AFDTC, Eglin AFB has capability for weapon separation T&E - Contact: 46OG/OGMD DSN: 872-9551.

A3.16.5.3. Weapon/Avionics Integration T&E (see **A3.18.1.**).

A3.16.6. Air Refueling Certification and Development:

A3.16.6.1. AFFTC - Instrumented KC-135 and KC-10. Contact: 412TW/TSSS, DSN: 525-9090.

A3.16.7. In-flight Icing and Rain:

A3.16.7.1. AFFTC - Instrumented KC-135. The aircraft uses bleed air and water nozzles to control droplet size, density, etc. for producing artificial icing cloud (4-6 ft diameter). Contact: 412TW/TSSS, DSN: 525-9090.

A3.16.7.2. AFFTC - Instrumented CH-53. Contact: US Army STEAT/AQ CE, DSN: 527-3901.

A3.16.8. Aircraft Braking and Mechanical Systems T&E:

A3.16.8.1. AFFTC - Aircraft braking performance is evaluated. 15,000 ft runway plus lakebed overrun minimize risks. Contact: 412TW/TSSS DSN: 525-9090.

A3.16.8.2. AFFTC - Mechanical Systems T&E (deceleration devices). Contact: 412TW/TSVI, DSN: 525-4820.

A3.16.9. Unmanned Air Vehicle (UAV) Flight Test:

A3.16.9.1. AFFTC - Utah Test and Training Range (UTTR) Hill AFB UT. A 17,000 square nautical mile airspace, overland, test range consisting of Restricted Areas and MOAs overlying DOD and Bureau of Land Management (BLM) government lands. Has UAV launch and recovery areas/facilities, including 13,000 foot runway adjacent to administrative and maintenance support facilities at Dugway Proving Ground. Complete range instrumentation services are provided for

TSPI, TM, data processing and display, including remote command/control and range safety flight termination capabilities. Contact: 545TG/XRP, DSN: 458-7852.

A3.16.10. Cruise Missile (CM) Flight Test:

A3.16.10.1. AFFTC - Utah Test and Training Range (UTTR) Hill AFB UT. A 17,000 square nautical mile airspace, overland, test range with all variations of terrain (very smooth to very rough) and categories of TERCOM maps for TF/TA cruise missile operations. All test terrains and maps are contained within the range boundaries. Range has complete TSPI, TM, and command/control/termination capabilities and airburst or ground impact scoring. An instrumented TF route/corridor (IR-200) links the UTTR with Nellis-Tonapah, Edwards-China Lake, and Vandenburg-Pt. Mugu Ranges for testing realistic range/endurance and navigational accuracy. Contact: AFFTC 412TW/TSR, DSN: 525-3050, or Contact: UTTR 545TG/XRP, DSN: 458-7852.

A3.16.10.2. AFDTC - Eglin AFB has a Cruise Missile Test Capability. Contact: 46TW/TSWW DSN: 872-9354.

A3.17. Propulsion:

A3.17.1. Propulsion Flight Test. Instrumentation telemetry available in real-time

A3.17.1.1. AFFTC - 20,000 sq. mi. of airspace, with GPS, radar, optical tracking capability. Real-time and/or post-flight data TM available using Ridley Mission Control Center (RMCC). Contact: 412 TW/TSR, DSN: 525-3050.

A3.17.1.2. ALCs (WR, OO, and SM) - Contact Appropriate Center

A3.17.2. Propulsion Flight Test. Hazardous propulsion T&E (new single-engine aircraft T&E, high AOA, very high speed (hypersonic, etc.)

A3.17.2.1. AFFTC - Provides numerous emergency landing options on 5x12 mile lakebed and/or 15,000 ft runway. Contact: 412 TW/TSR DSN: 525-3050.

A3.17.3. UAV and Cruise Missile Propulsion-related T&E: (see **A3.16.**)

A3.18. Avionics:

A3.18.1. Weapons Integration: (weapon/stores separation T&E is in **A3.16.5.**)

A3.18.1.1. AFFTC - The Dual Air-To-Ground Range (DAGRAG) is a continual low altitude air-to-surface gunnery, bombing, and rocket range. Contact: 412 TW/DOEA, DSN: 525-9060.

A3.18.1.2. UTTR for very large footprint weapons. Contact: AFFTC/XPS, DSN: 525-9266.

A3.18.2. EC Integration/Survivability T&E:

A3.18.2.1. AFFTC/EW Directorate - EW Integration and Effectiveness Flight Testing at specific ranges. Contact 412TW/EW DSN: 525-7772.

A3.18.2.2. AFDTC/EW SFTC Office - EW Integration and Effectiveness Flight Testing at specific ranges. Contact: AFDTC/DRC DSN: 872-9650.

A3.18.3. Special Access Facilities:

A3.18.3.1. AFFTC - Other special test capabilities may exist that can be applied to specific programs. Contact the SFTC office with your requirements so an assessment can be made on special test facility applicability. Contact: AFFTC/XPS, DSN: 525-9250.

A3.18.4. Cruise Missile Flight Test: (see **A3.16.10.**)

A3.18.5. Laboratory Open Ranges:

A3.18.5.1. Wright Lab - The Laser Communications Lab (LCL) provides a capability for development and test of next generation Laser and RF communications systems. Provides line-of-sight access to remote locations for propagation and data collection/recording. Contact: WL/AAAI-2, DSN: 785-3455.

A3.18.5.2. Wright Lab - Laser IRCM Development (LID) range for short range, closed loop IRCM development testing. Provides robust measurement of IR or effectiveness. Contact: WL/AAWD, DSN: 785-3489.

A3.18.5.3. Wright Lab - EO sensor evaluation range is capable of evaluation EO sensors, obtaining target and background signatures, and determining effect of camouflage on sensor performance. Contact: WL/AARI, DSN: 785-9609.

Flying Test Beds

A3.19. Airframe:

A3.19.1. In-flight Simulators:

A3.19.1.1. Wright Lab - Total In-flight Simulator (TIFS) - A modified NC-131H aircraft owned by Wright Labs and operated by Calspan Corp. which is configured with simulation cockpit (can be customized to match test aircraft) in addition to flight cockpit. Onboard digital computers allow 6 degree-of-freedom rigid body simulation of an aircraft's control system/flying qualities. In-flight simulation give pilots cues not available in ground based simulations. Contact: WL/FIGD, DSN: 785-3853.

A3.19.1.2. Wright Lab - Variable Stability In-flight Simulator Test Aircraft (VISTA). A modified F-16D Block 30, Peace Marble owned by AF and operated by Calspan Corp. The onboard digital computers make the aircraft capable of simulating the flying characteristics of high performance aircraft. Contact: WL/FIGD, DSN: 785-3853.

A3.19.2. Captive Carriage Platforms:

A3.19.2.1. AFFTC - Surrogate Carrier Launch Platform (SCLP) at Utah Test and Training Range (UTTR) Hill AFB UT. A modified C-130 aircraft for externally carrying and operating developmental cruise missiles, UAVs, or precision munitions (up to 10,000 lbs gross weight) for captive flight tests or developmental launches. Onboard equipment allows receiving, processing, recording, and reradiating of test/TM data to range mission control centers. Installed airframe, propulsion, and avionic subsystems can be tested and evaluated for risk reduction prior to first flights of new vehicles. Contact: 545TG/XRP, DSN: 458-7852.

A3.20. Propulsion:

A3.21. Avionics:

A3.21.1. Radar/Sensors:

A3.21.1.1. AFFTC - Advanced Radar Test Bed (ARTB). A modified/highly instrumented C-141. Various airborne fire control radar (APG-63/70, APG-66/68, etc.) hardware/software can be installed (in modified radomes) and data recorded and/or real-time monitored from stations in rear of aircraft. Contact: 412 TW/OG, DSN: 527-2410.

A3.21.1.2. AFDTC - Airborne Seeker Evaluation Test System (ASETS). A modified/instrumented C-130 with 54 in. turret mounted on belly of aircraft to house test seekers (IR, millimeter wave, laser, etc.). Instrumentation/data recorders are in racks in cargo-hold of aircraft. Contact: 46 TW/AFDTC, DSN: 872-6414.

A3.21.2. CNI:

A3.21.2.1. Joint Tactical Information Distribution System (JTIDS). A modified/instrumented T-39B with F-15 JTIDS terminal installed. JTIDS is a joint service program to design, develop, secure, jam-resistant, digital information distribution system with relative navigation and positive identification capabilities. Contact: AFDTC/XRC, DSN: 872-2853.

A3.21.2.2. AFFTC - Satellite Communication (SATCOM). A modified/instrumented C-135 for developing and testing SATCOM systems. Modifications included addition of numerous antennas, 25 in. satellite dish under tri-band radome, and data/instrumentation racks. Contact: 452 FLTS/DOOB DSN: 527-8456.

A3.21.2.3. AFDTC - Completely Integrated Reference Instrumentation System (CIRIS). A modified/instrumented C-141 which contains a palletized data baseline accurate inertial reference system for flight test of inertial navigation systems (INS). Contact: 46TW/AFDTC, DSN: 787-3991.

A3.21.3. Support/Mission Systems:

A3.21.3.1. AFFTC - Advanced Fighter Technology Integrator (AFTI/F-16), Wright Labs but located at AFFTC, Edwards AFB, Ca. A highly modified F-16 which tests assortments of advanced avionics/weapon delivery systems including: Ground Collision Avoidance, Digital Map Navigation, and Night Attack Systems (advanced sensors and helmet-mounted sights/displays). Contact: 412 Test Wing (TW)/OGRN, Phone: (805) 258-3437.

A3.21.3.2. AFFTC - Avionic Flying Test Bed (AFTB). A highly modified/instrumented C-135A used for development and test of advanced navigation, radar, and avionic integration. Currently utilized for B-2 avionics/radar development. Modification include four 70/90 kilovolt amp (KVA) generators, upgraded cooling, sensor window, GPS antennas, and modified radome. Contact: 420 FLTS/ENV, DSN: 525-8993.

A3.21.3.3. AFFTC - Speckled Trout. Highly modified C-135C to test advanced cockpit avionic systems. Modifications are numerous and include: GPS, MIL-STD 1553 data bus, Barry Research (BR) communications chirpsounder [high frequency (HF) tuner], advanced navigation systems (Lasernav II and Litton 92 systems), and flight instrumentation system. Contact: 412 FLTS/CC, DSN: 527-7791.