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PROCESS IMPROVEMENTS IN TRAINING DEVICE ACCEPTANCE TESTING,
A STUDY IN TOTAL QUALITY MANAGEMENT

12 December 1990

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TRAINING SYSTEMS SYSTEM PROGRAM OFFICE
AERONAUTICAL SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433-6503

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The development of training device acceptance test improvements have proceeded rapidly and to a successful outcome. To significantly reduce the number of Government test requirements, the joint Air Force/Industry team has formulated 27 complimentary recommendations surrounding the test process rendering improvements estimated to save in excess of 40 percent of Government test time without compromising test objectives.

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LIST OF ACRONYMS

AFSC	Air Force Systems Command
ASD/YW	Aeronautical Systems Division/Training Systems SPO
ATG	Approval Test Guide
ATP	Acceptance Test Procedures
CAO	Contracts Administration Office
CDRL	Contract Data Requirements List
CEVT	Contractor Engineering Verification Test
CFE	Contractor Furnished Equipment
CPSG	Computer Program System Generation (cold start)
CPT	Critical Process Team
CVT	Contractor Verification Test
DCAS	Defense Contracts Administration Service
DCL	Design Criteria List
DoD	Department of Defense
DR	Deficiency Report
ECP	Engineering Change Proposal
FSD	Full Scale Development
GFE	Government Furnished Equipment
I/ITSC	Interservice/Industry Training Systems Conference
LANTIRN	Low Altitude Navigation and Targeting Infrared System for Night
MRP	Material Requirements Planning
MT	Mission Trainer
OFT	Operational Flight Trainer
OT&E	Operational Test and Evaluation
PTT	Part Task Trainer
QDR	Quality Deficiency Report
RDT&E	Research, Development, Test and Evaluation
RFP	Request For Proposal
RFT	Ready For Training
SME	Subject Matter Expert
SPA	System Performance Assessment
SPADE	System Performance And Demonstration Evaluation
SPO	System Program Office
ST 2000	Simulator Test 2000
TD	Test Discrepancy
TQM	Total Quality Management
TRA	Training Readiness Assessment
TRR	Test Readiness Review
WST	Weapons System Trainer

EXECUTIVE SUMMARY

Under the auspices of Total Quality Management, a small group of Government and industry specialists examined the existing training device acceptance test process for potential improvements. The agreed to mission of the Air Force/Industry partnership was to continuously identify and promote implementable approaches to minimize the cost and time required for acceptance testing while ensuring that validated performance supports user training requirements. Application of a Total Quality Process Improvement Model focused on the customers and their requirements, analyzed how work was accomplished, and led to the identification and elimination of several non-value added components in current test practices.

Diverse technical and management approaches were blended into a single improved process known as Simulator Test 2000 (ST 2000). ST 2000 integrates timely, accurate, and streamlined test documentation, provides safeguards for increased confidence in contractor verification testing, and improves on-time test milestone performance via an optimum balance of Government/contractor specification performance validation procedures. The proper mix of Government/contractor responsibilities is highlighted with the creation of Government System Performance and Development Evaluation (SPADE). SPADE eliminates Government repetition of previously conducted contractor tests and emphasizes functional operational checks to determine the ability to satisfy training objectives. This customer oriented approach emphasizes acceptance of documented contractor engineering test results by the Government.

Functional mission testing has been formulated to serve as final Government acceptance. This on-site test philosophy serves to focus final test evaluations on remaining discrepancies and satisfaction of site related test requirements. By testing at a functional level in lieu of detailed testing constructs, it avoids repeating prior Government or contractor tests.

The development of training device acceptance test improvements has proceeded rapidly and to a successful outcome. To significantly reduce the number of Government test requirements, the joint Air Force/Industry team has formulated 27 complimentary recommendations surrounding the test process rendering improvements estimated to save in excess of 40 percent of Government test time without compromising test objectives.

1.0 INTRODUCTION

When late during the summer of 1989 President Bush selected John Betti for nomination as Under Secretary of Defense for Acquisition, Total Quality Management (TQM) was fast becoming more than a household word. In fact, TQM was on a course destined to become an intrinsic management philosophy within the Department of Defense (DoD). Betti was to bring to the DoD from the Ford Motor Company TQM traditions to meet the challenge of providing more defense for the dollar. For the purposes of this report, consider TQM as a leadership philosophy that creates a working environment which promotes trust, teamwork, and the quest for continuous improvement. Other essential elements of TQM require dedication, conviction, and a willingness to bring about change, to do the right things right, the first time, with the ultimate goal being customer satisfaction.

1.1 ACCEPTANCE TESTING AS A CRITICAL PROCESS

At about the same time as Betti's nomination, the Training Systems System Program Office (SPO) at Aeronautical Systems Division (ASD/YW), Wright-Patterson AFB, Ohio was plowing new and fertile ground with contractors from the training system industry. Chartered in August 1989, the YW/Industry Total Quality Steering Group developed a mission "...dedicated to continuous process improvement in the acquisition of training products and services to produce the best trained aircrews and maintenance personnel in the world". Initial membership represented a cross-section from the training systems development industry and included the following companies:

- o CAE-Link Corporation
- o ECC International Corporation
- o FlightSafety Services Corporation
- o General Electric Company
- o Hughes Simulation Systems Incorporated
- o Loral Defense Systems Division
- o McDonnell Douglas Training Systems Incorporated
- o SIMTEC Inc.

Membership from the SPO consisted of five functional experts representing the disciplines of Engineering, Logistics, Contracting, and Program Management. The primary thrust of this Government/industry forum was to identify and provide recommendations for potential areas to improve the training systems acquisition process using the principles of TQM. In October 1989, the Steering Committee completed the identification and ranking of six targets of opportunity:

- o Concurrency
- o Nonvalue added Request For Proposal (RFP) requirements
- o Program Manager protocols
- o Prototype development in a production environment
- o Improved engineering change process
- o Acceptance testing.

The first improvement area selected for action was judged on such considerations as payback potential, direct impact on the user, and benefits of the results to industry. The Steering Committee then used the nominal group technique to identify the opportunity best satisfying the selection criteria. The nominal group technique is a refinement of brainstorming which provides a structured decision making process. The results of this analysis showed development/acceptance testing had twice the improvement potential of any runner-up target of opportunity.

Testing is the primary means by which a training device is evaluated for compliance of the design/product against required characteristics and system performance. Through a process of verification, validation, and authentication, the adequacy of performance characteristics are determined along with identification of deficiencies in system performance. Acceptance testing is defined as any and all contractor and Government activities performed to verify device conformance to specified system/subsystem performance requirements.

The test process provides contract closure and allows training initialization. Yet, despite its importance, the test process and accompanying test documentation has been reported as byzantine at best. Many myths and misinformation abound. There is widespread belief, for example, in the following:

- Acceptance testing contributes to schedule delay
- Testing is rigidly conducted in accordance with the Test Matrix
- The Government must witness all acceptance tests.

Training specialists in industry and Government have long recognized a need for improvements in military acceptance testing of aircrew and maintenance training devices. Over the past years a number of papers have been written on the subject. These works include:

- A comparison of Simulator Procurement/Program Practices: Military vs. Commercial - John Hussar; presented at the 5th Interservice/Industry Training Systems Conference (I/ITSC) 1983
- Commercial Simulator Acquisition: A Three-Way Guide - Arthur Doty, Harold Kottman; presented at the 6th I/ITSC 1984
- A Relook at Determining Simulator Requirements - David Nelson, Stephen Leishman; presented at the Society for Computer Simulation International 1984
- Bridging the Information Gap - J. Shaw, William Lloyd; presented at the 11th I/ITSC 1989.

Despite these efforts, little improvement has been made in the testing process.

1.2 THE ASD COMMANDER'S PERSPECTIVE

Culminating the selection of the device testing process were the remarks of Lieutenant General Mike Loh, then the ASD Commander, as the keynote speaker at the 12th Interservice/Industry Training Systems Conference. In his address to over 3,000 industry and Government training systems executives, Gen Loh cited the YW/ Industry Steering Group as a model of what should be done with every industry involved in defense procurement, "...to establish a workable forum for frank and honest discussion of mutual concerns". He went on to share his belief in the success of the joint Government/industry team formed to study the testing process and prove the worth of this partnership to the skeptics in industry and others, "...this is why I believe the group will succeed; its members own what they are doing. They are building a culture within the industry based on teamwork and trust and have set their sights on continuous improvement. I hope that it is a harbinger of a new attitude within the defense procurement world."

1.3 THE CRITICAL PROCESS TEAM

The Critical Process Team (CPT) was chartered by the Steering Committee to investigate a high level, cross organizational process having a critical impact on satisfying the customer's requirements. The team defined the testing process, identified the owner of the process, and developed a system to recommend action on improving the process.

The Training Systems SPO, in response to the Steering Committee's request, agreed to provide two members with test management/engineering experience previously trained in TQM principles and problem solving techniques. The Steering Committee solicited additional team members from each of its member companies. Industry representatives were asked to be well versed in training device testing, have program management/project engineering experience, and have excellent visibility into their company's operational policies. A time commitment of up to 20% active participation in the CPT was also requested. All team members were required to attend a four day TQM/CPT training workshop. Brief biographies of the CPT members are included in Appendix A.

1.3.1 Team Training

The Cumberland Group, a subsidiary of Armco Steel, conducted an intensive four day workshop to train CPT members how to analyze and improve the process. The Training Systems SPO agreed to fund the training for each CPT member. Team members gained a common understanding of the CPT purpose and were able to come to a consensus on how the acceptance test process is a summation of activities which must be completed in the course providing a product or service.

Effective working relationships were established and the team structure was created. Training provided the beginnings of an understanding of the Cumberland Process Improvement Model methodology. Of particular significance was the judgement of the team that training to define and develop process improvements was essential.

1.4 THE PROCESS IMPROVEMENT MODEL

The Cumberland Process Improvement Model (Figure 1.4-1) consists of five primary steps leading to the elimination of non-value added components. The model stresses that quality problems

CUMBERLAND PROCESS IMPROVEMENT MODEL

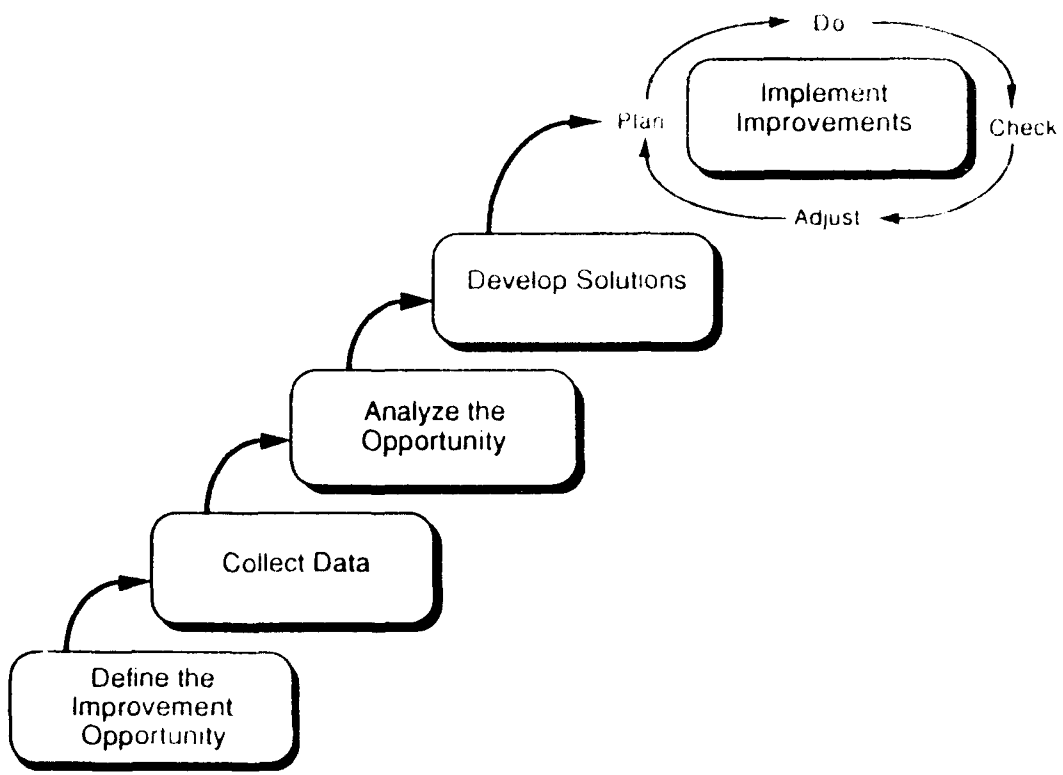


Figure 1.4-1. The Cumberland Process Improvement Model.

are very often rooted in the process that produced them. A change in the process, therefore, is required to achieve meaningful improvement and not just merely eliminate the symptoms. This is the foundation upon which the process management approach to quality improvement is built.

The objective of process management is to focus on the customers of a process, determine what the customer's requirements are, analyze how work will be accomplished, and identify and eliminate the sources of waste in the process.

Define Improvement Opportunity: The purpose of this step is to develop a clear understanding of the team's tasks. Expectations of what was to be accomplished were clarified. Indicators (measures) of improvement and improvement goals used to guide the team as it searched for areas of process adjustments were agreed upon.

Collect Data: The objective of this step is to move from the statement of a problem to a more complete description of the current process. Guidance was received from the Training Systems SPO Program Director, as well as the YW Steering Committee. Performance measures of several completed Government test programs were analyzed to further refine and finalize the process indicators.

Analyze the Opportunity: This step is used to first identify areas of waste in the current process and the associated root causes of each waste area. Waste is defined as any activity that does not add value to the process and was viewed as the primary opportunity for improving the process. Data collected from the previous step was used to identify and prioritize waste and focus efforts on the high payback areas. In the final element of this step, the root causes of each major waste area were identified.

Develop Solutions: The intent of his step is to generate alternative ways to eliminate root causes of waste. The team concentrated on ways to significantly change the process instead of merely making minor adjustments. With no assumed constraints, the team visualized the "perfect" process to form an understanding of what could really be achieved, even if in stages rather than all at once.

Implement Improvements: This final step is designed to improve the process through a series of recommendations resulting from solutions developed during the prior analysis step. Continual improvement is made by planning the modification, engaging the plan, checking the results, and making adjustments based on the results.

For each solution developed, the CPT proposed a recommendation and agreed to advise those assigned to implement each recommendation.

Figure 1.4-2 depicts the action plan that identifies the key events of the process improvement model and when they were to be completed.

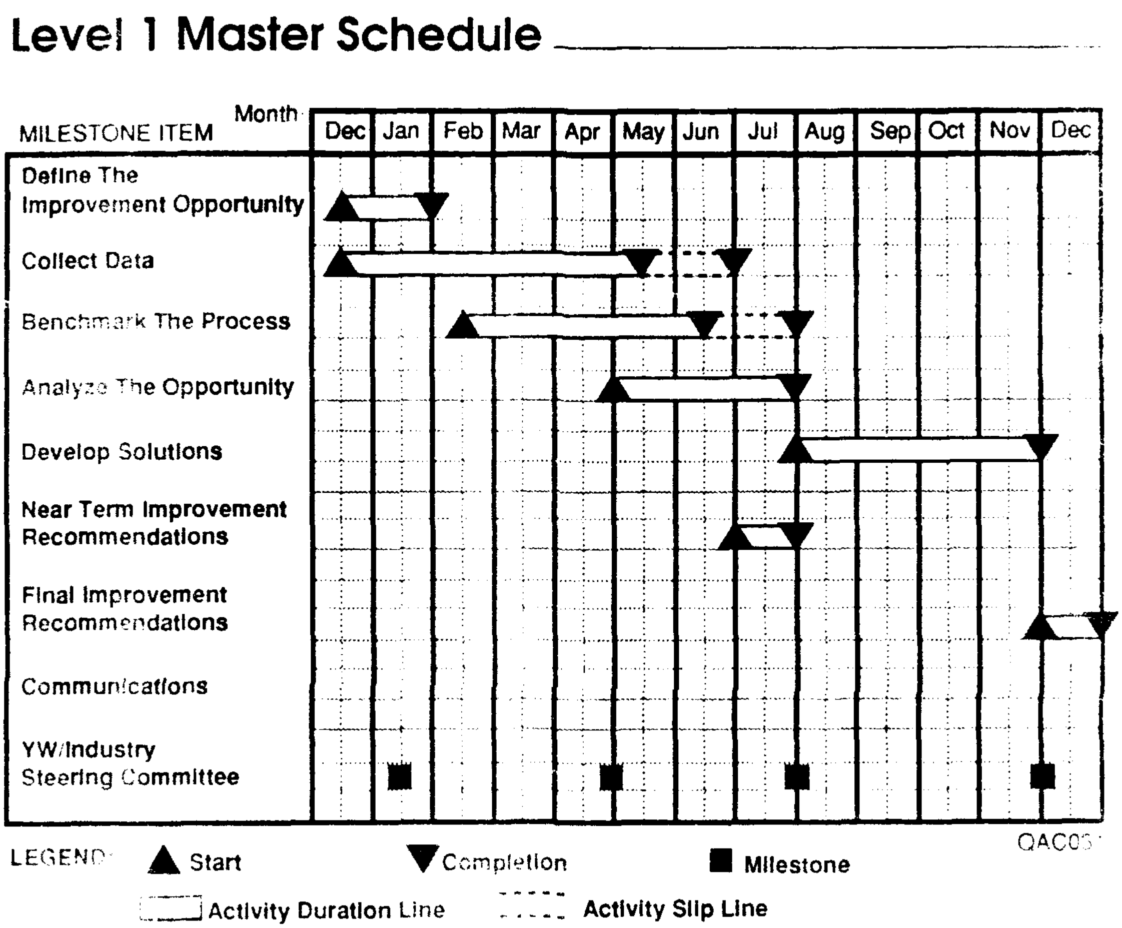


Figure 1.4-2. Master Schedule

2.0 DEFINITION OF THE IMPROVEMENT OPPORTUNITY

The process of developing a clear understanding of the CPT's task and clarifying expectations for improvements in simulator testing was the team's first major assignment. The mission statement that follows was developed in order to clearly define the purpose and reason for existence of the CPT. It was formulated to indicate the partnership between the Air Force and industry in attaining a common goal. The mission statement was coordinated with the owner and approved by the steering committee.

> "We are the YW/Industry Partnership CPT, committed to continuously identify and promote implementable approaches to minimize the cost and time required for acceptance testing of aircrew and maintenance training devices and to insure that these devices support the users' needs."

2.1 PROCESS BOUNDARIES

The CPT clarified the scope of the process to be studied by defining the boundaries of the testing function. There are many relevant decisions pertaining to testing made long before formal tests are conducted. Therefore, the start of the process was considered to be the first time the Government sought responses from industry; namely, the release of the draft RFP. The evolution of test requirements proceeds through contract award, design reviews, manufacture, test, and site acceptance with the signing of the Material Inspection Receiving Report (DD250). The testing process boundaries were then formally defined as the release of the draft RFP until formal sign-off of the DD250 for purposes of constructing the test process flowchart.

2.2 TEST PROCESS FLOWCHART

The test process flowchart was constructed to depict all the acquisition management tasks used to develop and produce a training device. The process was initially defined using the flowchart. Test activities were then further analyzed. The entire flowchart and narrative description is provided in Appendix B. The chart is separated with the top showing those tasks performed by the Air Force and the bottom depicting those of industry.

The flowchart depicts a typical training device development and may vary somewhat depending on a particular program's requirements. Review of the existing process revealed that there were several test repetitions, five different Test Readiness Reviews (TRRs), and seventeen possible delay paths.

2.3 IMPROVEMENT OBJECTIVES

While process improvement is considered ongoing, enduring, and not typically time-related, goals were considered necessary in order to measure progress toward the achievement of the mission objectives. These goals were intended to promote the concept that quality must be enhanced while reducing the cost and time required for acceptance testing of training devices. In this regard, the CPT developed the following improvement goals:

1. Minimize the number of test activities without compromising performance validation

2. Foster timely, accurate, streamlined development of test documents

3. Facilitate Government acceptance of qualified contractor test results

4. Tailor application of Mil-Spec/Std test requirements to emphasize commercial practices

5. Encourage improvement of on-time test milestone performance

6. Refine the test discrepancy generation, tracking and resolution process

7. Promote Government/industry cooperation and partnership for improving aircrew/maintenance training device testing.

3.0 DATA COLLECTION

3.1 PROCESS INDICATORS

Process indicators are used to measure the performance of the acceptance test activities. Two approaches were used to generate the process indicators. The CPT membership produced a list of parameters which measure the performance of the acceptance test effort based on specific testing experiences. The second approach was to define measures relating directly to the delay loops in the process flowchart. Finally, these two lists were evaluated in reference to the following criteria:

a. If the test process is changed, will the proposed indicators be able to measure the improvement?

b. Can the indicator be measured in real terms using objective results?

c. Can data be obtained from the companies, i.e., is the data something likely to be measured and retained as part of the existing testing process?

d. What is the most important data to request?

The total list of process indicators generated is shown in Table 3.1-1.

Using the nominal group technique, the next step was to select from the total list those indicators which would be the "best" measures. This was accomplished by each member selecting the four indicators most meaningful to measure the performance of the acceptance test program. To downselect, the final indicators were based on total points (votes) received as noted in Table 3.1-1. The CPT focused on the four top indicators to be used to collect data for further analysis. These indicators are:

- Test milestones met or delayed
- Number of test discrepancies
- Number of days in test
- Test documentation.

3.1.1 Test Milestones Met or Delayed

The first indicator is based on schedule milestones that are required to conduct a test program. Milestones were chosen to be program/contract schedule events in anticipation that such data would be recorded and could be obtained.

The milestones selected started with TRR and ended with the signing the DD250. The original planned and actual dates were recorded for each event and period of testing. It was to be assumed that the end of one period of testing equaled the start of testing of the next period. The list of milestones evaluated include:

Table 3.1-1. Process Indicators

	Description	Score (Total Points)	Rank
1.	Meeting original contract RFT date	0	
2.	Hours/Days required to test in plant	0	
3.	Number of test documents	11	4
4.	Number of test interruptions	0	
5.	Present Test Matrix which requires analysis/inspect	4	
6.	Less Government/Industry testing issues	1	
7.	Time taken to test specific areas vs. planned time	0	
8.	Number of hours spent in retest	0	
9.	Number of test discrepancies (categorized)	17	2
10.	Number of redundant tests/testing	6	
11.	Number of post-test DRs	0	
12.	Number of tests witnessed by the Government	7	
13.	Number of TDs unresolved on DD250	0	
14.	Reduction in residual problems post DD250	0	
15.	Number and length of work stoppages due to problems discovered in testing	0	
16.	Number of days in test	12	3
17.	Cost overruns of testing	4	
18.	Reduction in the test readiness reviews	0	
19.	Reduced hours/days of on-site testing	0	

Table 3.1-1. Process Indicators -- Continued

	Description	Score (Total Points)	Rank
20.	Time to conduct a test procedure	0	
21.	Timeliness of data delivered	0	
22.	Reduced test force to perform equivalent testing	2	
23.	Number of worked DRs rejected, (Re-submits)	0	
24.	Customer satisfaction, (Using Command)	0	
25.	Reduced hostility between Government/Industry	0	
26.	Numbers of steps in a test procedure	0	
27.	Size of the Government test team	0	
28.	Size of test documentation	0	
29.	Number of man-hours used in redesign	0	
30.	Number of test discrepancies unresolved	0	
31.	Number of unnecessary test requirements	5	
32.	Number out of scope DRs	0	
33.	Number of approval cycles	0	
34.	Test milestones met or delayed	18	1
35.	Number of days lost to manufacturing due to testing	0	
36.	Turnaround time for approval	0	
37.	Number of ECPs inserted in original schedule	0	
38.	CDRLs per commercial practices	3	

- Test Readiness Review
- Computer Program System Generation (CPSG)
- First Article Test Readiness Review
- Development Test
- Operational Evaluation
- Tear down and Pack
- Ship
- On-Site Test Readiness Review
- On-Site Acceptance Test
- On-Site Operational Evaluation
- On-site Sell-off.

3.1.2 Number of Test Discrepancies

The number of Test Discrepancies (TDs) generated during acceptance testing is a measure of the training device quality. To get more insight into the causes of TDs, data was requested to include total number of TDs, number of TD re-submits, number of post sell-off TDs, and number of TDs out-of-scope. Additional TD information such as TDs against the test procedure, number of TD re-submits, total open at start on TRR, and number of internal TD during dry run was not requested as it was known that only the Training System SPO maintains this data.

3.1.3 Number of Days in Test

The purpose of this indicator is to isolate the delay or improvement of schedule once the unit is in test by measuring duration. The acceptance test activity consists of several phases which are shown in the process flowchart. The parameters considered important for this indicator include planned days in test, actual days in test, number of test hours per day, and number of testing days per week.

Data was requested for each phase of testing (duration in days; plan vs. actual). From the results, the CPT selected three phases to measure test duration as a performance indicator. These were in-plant development test, on-site acceptance, and on-site operational/FAA evaluation. While other test phase duration data was available, the phases of tear-down, pack, ship, install, and on-site checkout were not considered actual acceptance testing and thus not used in the final analysis.

3.1.4 Test Documentation

The CPT membership considered test documentation excessive. The size of the test procedures, i.e., number of pages, was the means used to measure this excess. In addition, the detail to which the procedures were written was measured by the number of test steps per page.

The composition of the Test Matrix has significant influence on the size of the test procedures. The data requested for each program was used to identify the number or percent of each Test Matrix category of Inspection, Analysis, Demonstration, and Test used to verify specification performance. A Test Matrix requiring predominantly Demonstration and Test causes lengthy test procedures to be written. In addition, such procedures are usually written at very detailed levels to enable their use by personnel unfamiliar with the trainer systems. Test Matrix category data was not available for commercial airline simulators but was retained for miliary program analysis.

To get an objective measure of the complexity of the system under test, the number of central processing units and lines of code were used as indicators. In addition, the number of subsystems within a trainer could be used to indicate the complexity. With this data it was hoped to determine if a trend exists between the complexity of the trainer and the size of the test procedures.

3.2 PROGRAMS SURVEYED

After settling on which indicators should be used, it was necessary to determine the possible sources of data for the information the CPT needed. In determining the selected programs, the CPT focused on current/recent programs and the likelihood of gathering accurate data.

The following types of trainer programs were included: Maintenance Trainers, Part Task Trainer (PTT), Mission Trainers (MT), Operational Flight Trainer (OFT), and Weapon System Trainer (WST). A brief description of these trainer types is included in Appendix C. The final list of programs selected for data collection is as follows:

- F-16 Air Defense Fighter Cockpit Procedures Trainer (General Dynamics)
- F-15E WST (Loral)
- F-16 LANTIRN PTT (ECC)
- F-15 LANTIRN PTT (ECC)
- GBU-15 PTT (Hughes)
- AV-8B Night Attack WST (McDonnell Douglas)
- C-5B WST (FlightSafety Services Corp)
- EF-111A OFT (AAI)
- F-16 Maintenance Trainers
  - Armament (Hughes)
  - Electrical (ECC)
  - Engine Operation (ECC)
  - Propulsion (ECC)
- F-15 Maintenance Trainers
  - Integrated Avionics System (Hughes)
  - Electrical Power and Lighting (Hughes)
- CH-47D Electrical Systems MX Trainer (Daedalean)
- AH-1S Electrical Systems MX Trainer (Daedalean)

- o UH-1N Basic MX Trainer
  (Daedalean)
- o B-1B WST
  (Boeing)

3.3 QUESTIONNAIRE

The development of the questionnaire focused specifically on the indicators used to gather supporting data. The military questionnaire is shown in Appendix D.

3.4 BENCHMARKING

Benchmarking is the concept of "who does it best". The approach was to identify possible candidates for the CPT to evaluate as "best." The benchmark selection criteria included stringent testing, use of commercial practices, and existing measures relating to the TQM process indicators. Candidate benchmark sources were:

- o Airline Simulator Buyers
- o Simulation Industry
- o TQM award winners
- o Other TQM intense companies
- o NASA Simulators
- o Nuclear power plant Simulators.

Searching for highly efficient test methods to benchmark, the team visited the TQM landmark companies, Motorola and IBM. Unfortunately, these firms did not yield the anticipated benchmarks as their processes were invariably on too small a scale to give a comparable measurement. Typical Motorola acceptance tests ran less than twenty-five minutes. This provided an insufficient comparison when measured with the complexity of a modern simulator. IBM tests in a similar manner to the simulator industry, but again the relatively small scale of their devices made comparison difficult. In addition, IBM did not have current data they wished to release.

Other companies investigated by the CPT membership or where a questionnaire was sent are as follows:

- o Walt Disney Imagineering
- o Loral Defense Systems Division
- o CAE Electronics, LTD
- o Link Tactical Simulation Division
- o American Airlines
- o United Airlines Training Center
- o Motorola
- o IBM Owego
- o Xerox Corporation
- o Raymond Corporation
- o Northwest Airlines
- o Martin-Marietta Missile Systems Division
- o NASA
- o Hughes Satellite Division
- o Westinghouse Inc.
- o Boeing Commercial Airplane Co.

o Delta Airlines
o US Air.

The replies to the CPT membership inquiries and questionnaire were extremely poor. Successive follow-ups by team members did little to elicit further responses. Many indicated they felt their testing approach was sufficiently different to make it unsuitable for our purposes. It rapidly became apparent that integration and test of a full flight simulator is a uniquely challenging task not commonly encountered in other industries.

At that point the team decided to focus on the commercial airline simulator industry as the candidate for "best". This was based on the fact that they buy/build a product very similar to the Air Force, use commercial standards, and must pass stringent acceptance testing conducted for/by the FAA. Seven commercial devices provided adequate data for benchmarking. All were true commercial devices with commercial customers, except the C-5B ATS, where United Airlines, using best commercial practices, purchased C-5B WSTs from CAE for that USAF training program. All commercial devices studied were at least FAA Phase II certified high fidelity training devices and equivalent to OFT/WST systems but without tactics simulation. Data was collected from United, Northwest, Delta, US Air, and the Boeing Company and used for subsequent data analysis. The questionnaire used to collect data from the buyers of commercial aircraft simulators is provided in Appendix E.

3.5 DATA SUMMARY

The results of the questionnaire were captured in the Data Tables (Appendix F). The raw data (pages 1 through 8) was analyzed and incorporated into the final summary sheet (pages 9 and 10). Several very important adjustments were made to produce the summary sheet. The first adjustment was to eliminate companies/programs that did not respond to the questionnaire and those who felt their process was different. In addition, programs were dropped if sufficient data was not available. Only limited data was available for maintenance trainer programs due to less stringent test requirements. Comparison data for process indicators was therefore non-existent. The B-1B WST was examined and the data ultimately discarded due to this program's unique difficulties and numerous setbacks which made it a totally atypical measurement point. As a result, six military programs and the seven benchmark commercial programs remained for further evaluation as contained in the final summary sheets. The number of test milestones was reduced from those identified in the questionnaire to get a one-to-one mapping of significant milestones between the military and commercial programs.

4.0 ANALYSIS OF IMPROVEMENT OPPORTUNITIES

There is a fine distinction between a problem and an opportunity. In this phase of the CPT effort, as problems were substantiated, opportunities became apparent. The serious issue then was to focus/select opportunities that satisfied the mission statement.

The raw data, after being reviewed for omissions, was organized for the purpose of identifying waste areas in the test process and subsequently determining their root causes. The data was grouped according to the four process indicators and studied for information and/or conclusions that could be drawn from the data sets. This effort resulted in a series of provocative questions recorded in Appendix G and eight histograms that led to the identification of major waste areas.

Concurrently, the detailed process flowchart was refined, thus creating a clear picture of the current military simulator test process. When evaluated against the datasets, additional waste areas were defined. Each waste area was then decomposed to identify its root causes.

4.1 CHARTS

The data was plotted to obtain a visual representation to assist in the analysis effort. Programs were arranged in order of complexity as judged by the CPT. The analysis consisted of studying each chart to identify relationships, trends, and observations.

4.1.1 Test Program Overview

Chart 1 and Chart 2 depict milestones met or delayed for military and commercial programs. (Figures 4.1.1-1 and 4.1.1-2)

Observations

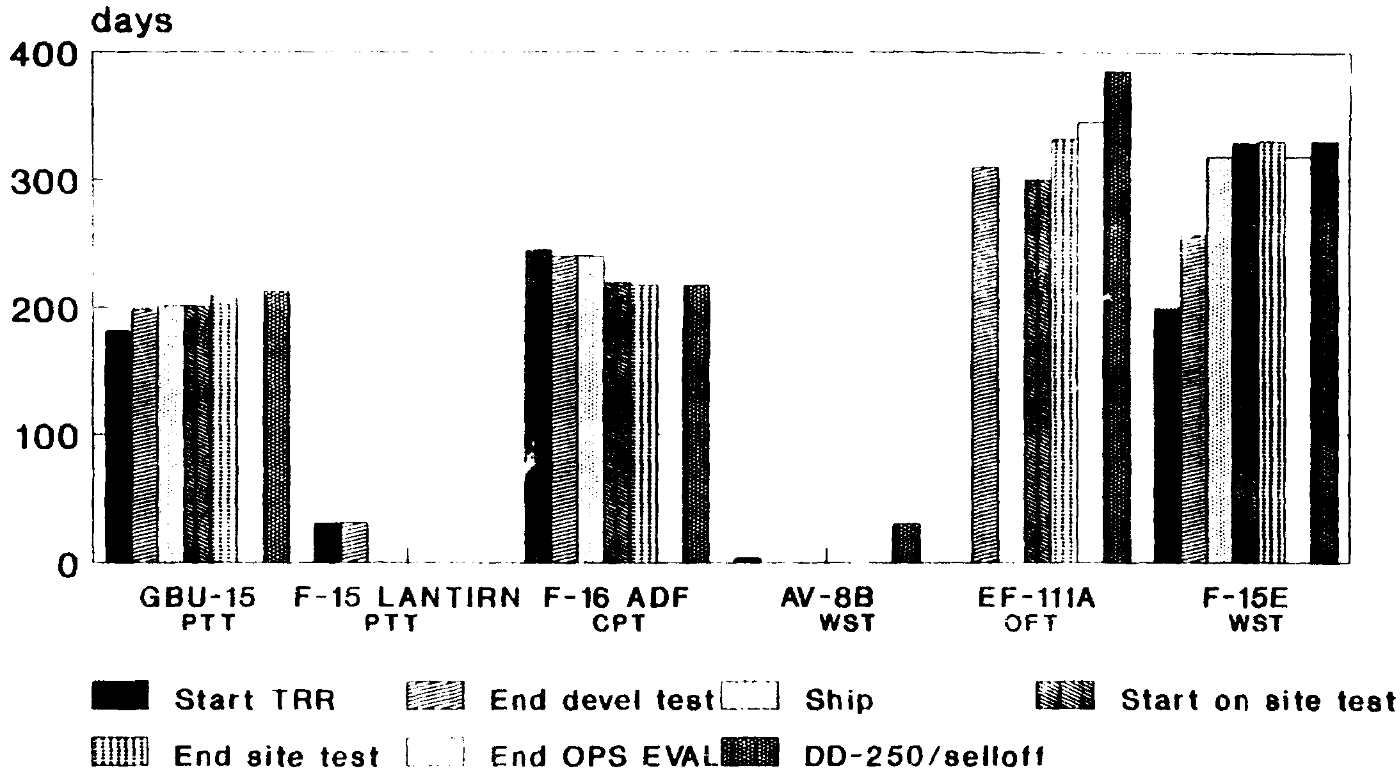
- o Military first article systems are typically late starting test
- o Commercial systems are usually on time starting test
- o Once test starts, it's usually performed according to the planned schedule or the magnitude of delay is held constant
- o Planned tests are realistic in terms of schedule. However, test often starts before the device is completely ready
- o Some programs recover schedule during testing
- o The maximum test schedule adjustment is five to ten percent of that planned
- o Commercial testing appears to finish on schedule.

4.1.2 Test Discrepancies

Chart 3 depicts various categories of discrepancies for both military and commercial programs. (Figure 4.1.2-1)

MILESTONES MET/DELAYED

days late at milestones (military)



LLS 10/01/90

F-15E data is projected

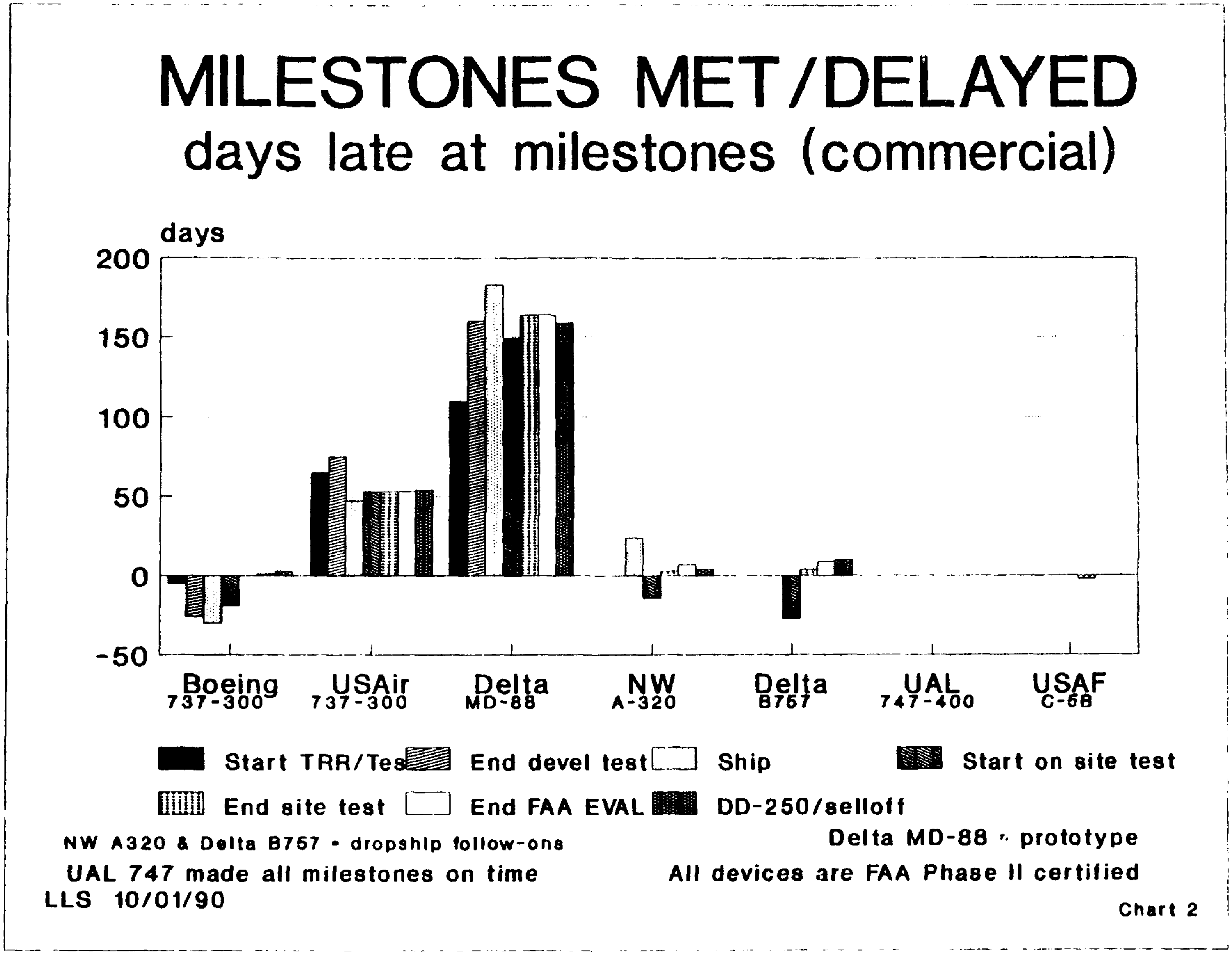
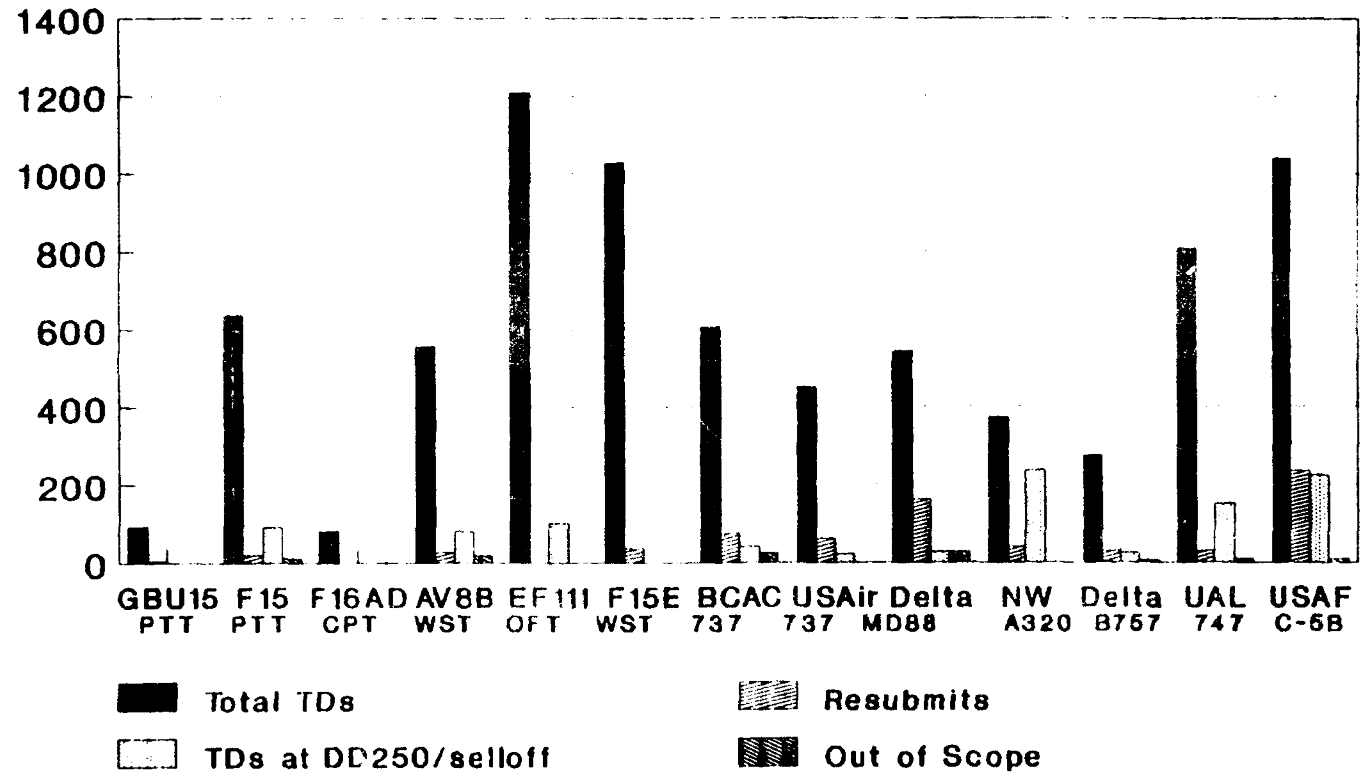


Figure 4.1.1-2. Milestones Met or Delayed (Commercial)

TEST DISCREPANCIES

Military and Commercial



MD-88 and all military are prototypes

F-15E remains in test
LLS 10/01/90

BCAC - Boeing Commercial Aircraft Corp.
NW A320 & Delta B757 - dropship follow-ons

Chart 3

Observations

- o Re-submits do not affect schedule
- o Approximately ninety percent of the TDs are resolved during the testing period
- o The customer accepts the trainer with approximately 10 percent of the TDs remaining
- o Out-of-scope TDs do not affect the test schedule
- o No correlation exists between start of test and the TD count
- o The programs researched had an average of approximately 600 discrepancies
- o Total TD count appears to correlate with device complexity.

4.1.3 Test Days vs. TDs

Chart 4 depicts the number of days in test compared to the quantity of test discrepancies. (Figure 4.1.3-1)

Observations

- o Quantity of TDs appear to correlate to days in test (duration).

4.1.4 Test Phase Duration

Charts 5 and 6 depict planned and actual days for selected test program activities for military and commercial programs. (Figures 4.1.4-1 and 4.1.4-2)

Observations

- o The ratio of military to commercial test phase durations correlates and supports the fact that the military schedule is realistic.
- o Operational/FAA evaluations meet planned duration
- o Typically, both military and commercial programs test ten to twelve hours per day
- o Planned test days correlate well with the actual test days
- o Breaks in the test schedule for redesign activity do not seem to significantly affect days in test
- o Complexity does not appear to affect the planned versus actual test schedule.

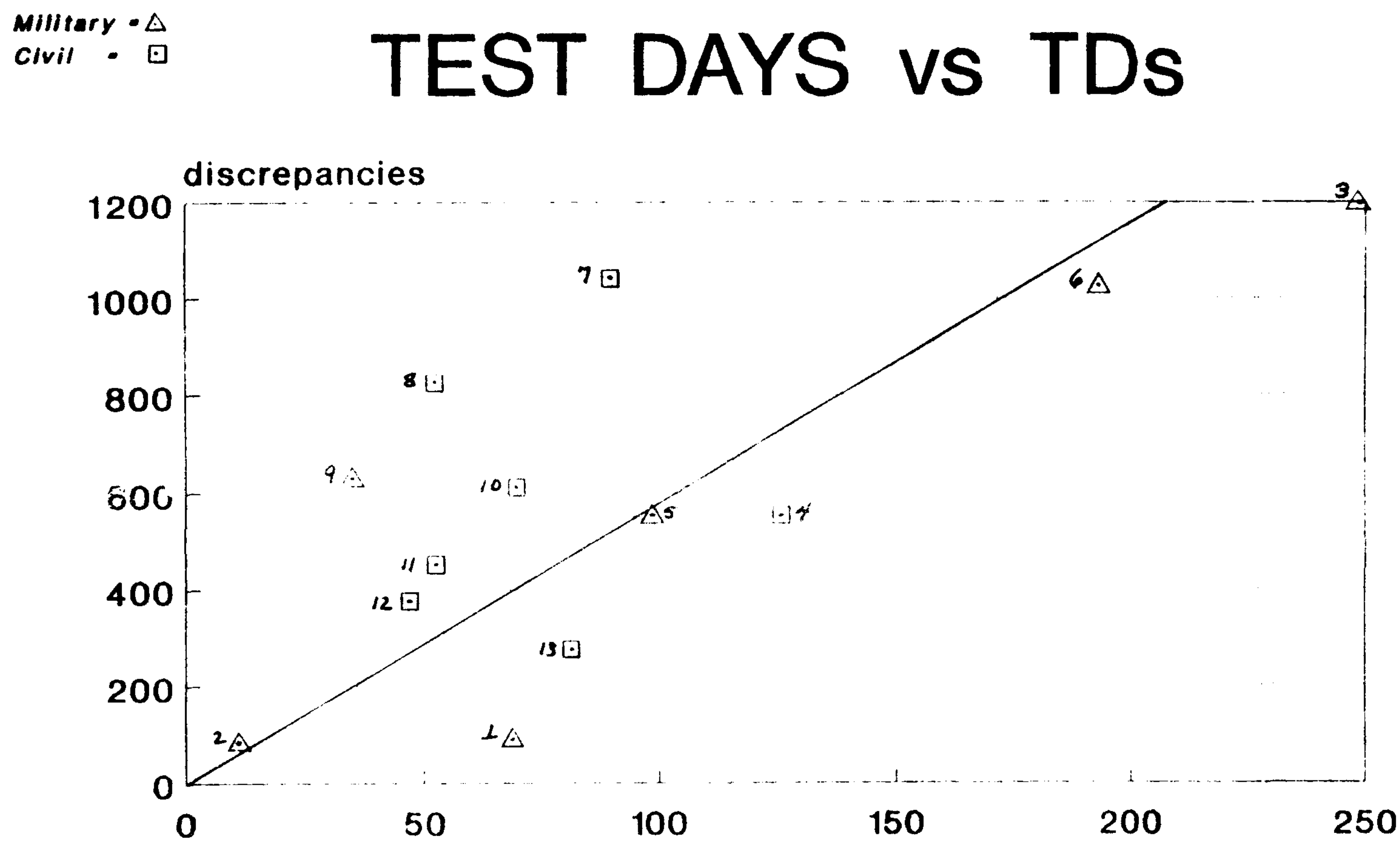
4.1.5 Pages of Test Procedures

Chart 7 depicts the size of test procedures. (Figure 4.1.5-1)

Observations

- o No correlation exists between the number of pages and test duration
- o Allowing for a delta between an FAA Phase II device for military tactics packages found in WSTs, the relative size of military and commercial procedures are the same

TEST DAYS vs TDs



1. GBU-15 PTT
2. F-16 ADF PTT
3. EF-111 OFT est>300 days
4. Delta MD-88
5. AV-8B WST
6. F-15E WST
7. USAF C-5B
8. UAL 747-400
9. F-15 LANTIRN PTT
10. Boeing 737-300
11. USAir 737-300
12. NW A-320
13. Delta B757

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Chart 4

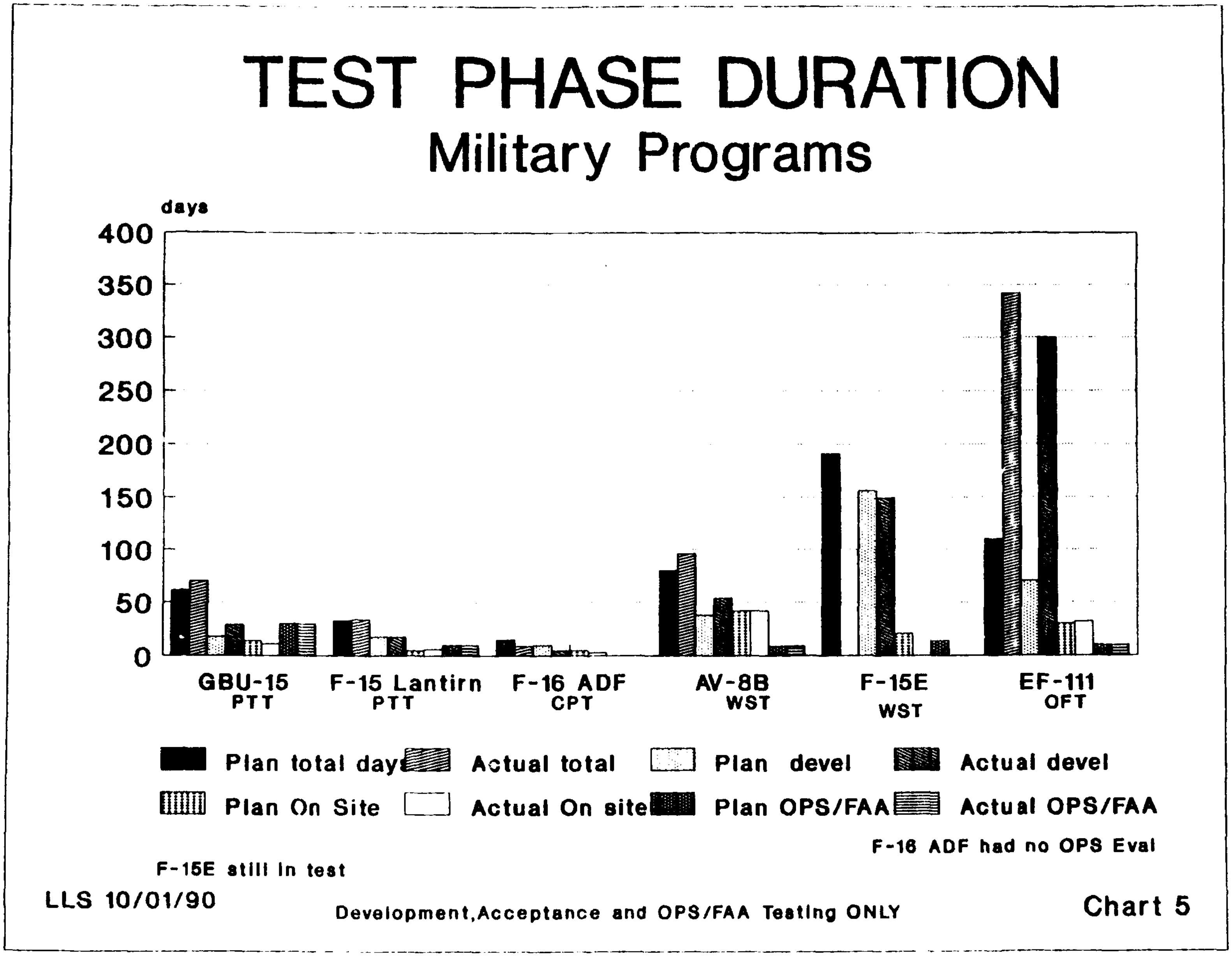
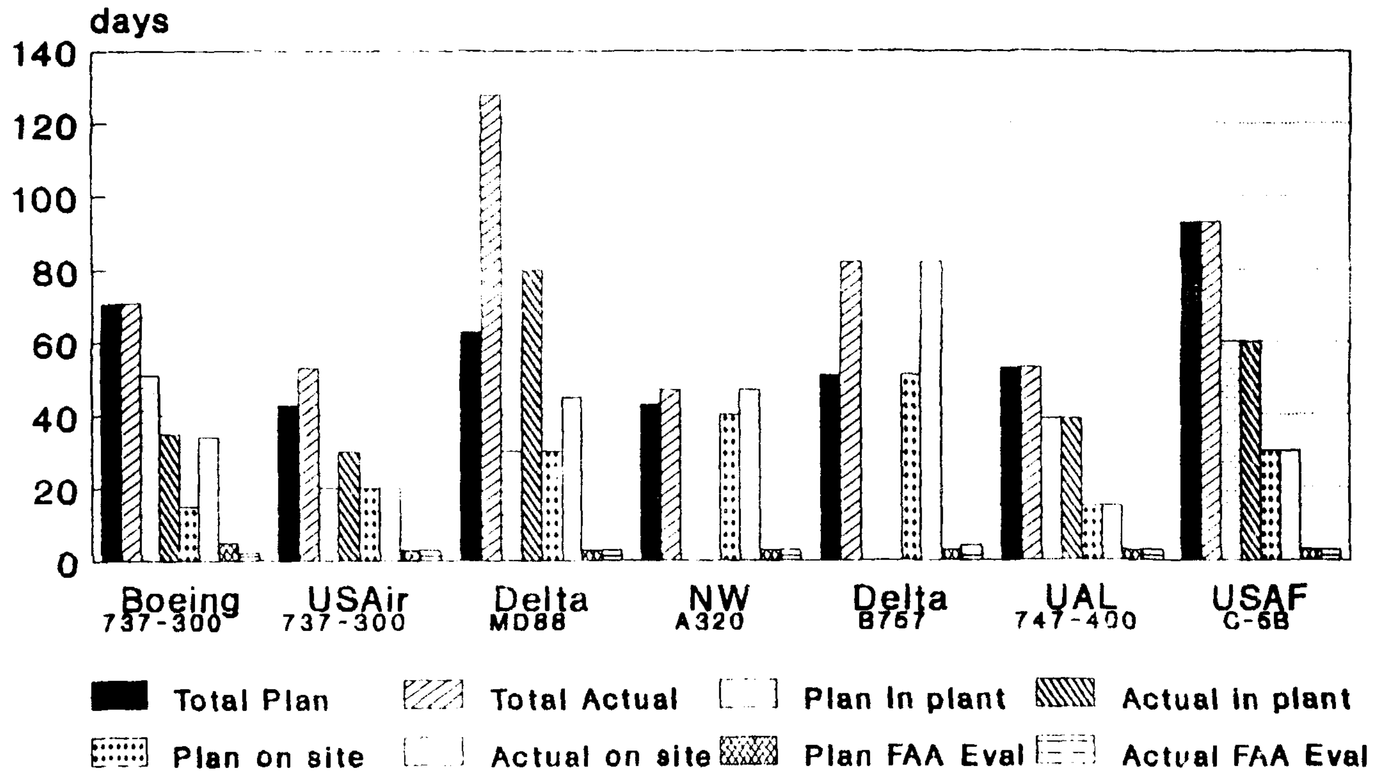


Figure 4.1.4-1. Test Phase Duration (Military)

TEST PHASE DURATION

commercial programs



MD-88 - prototype

NW A320 & Delta B757 - dropship follow-ons

All FAA Phase II certified

LLS 10/01/90

Development, Acceptance and FAA testing ONLY

Chart 6

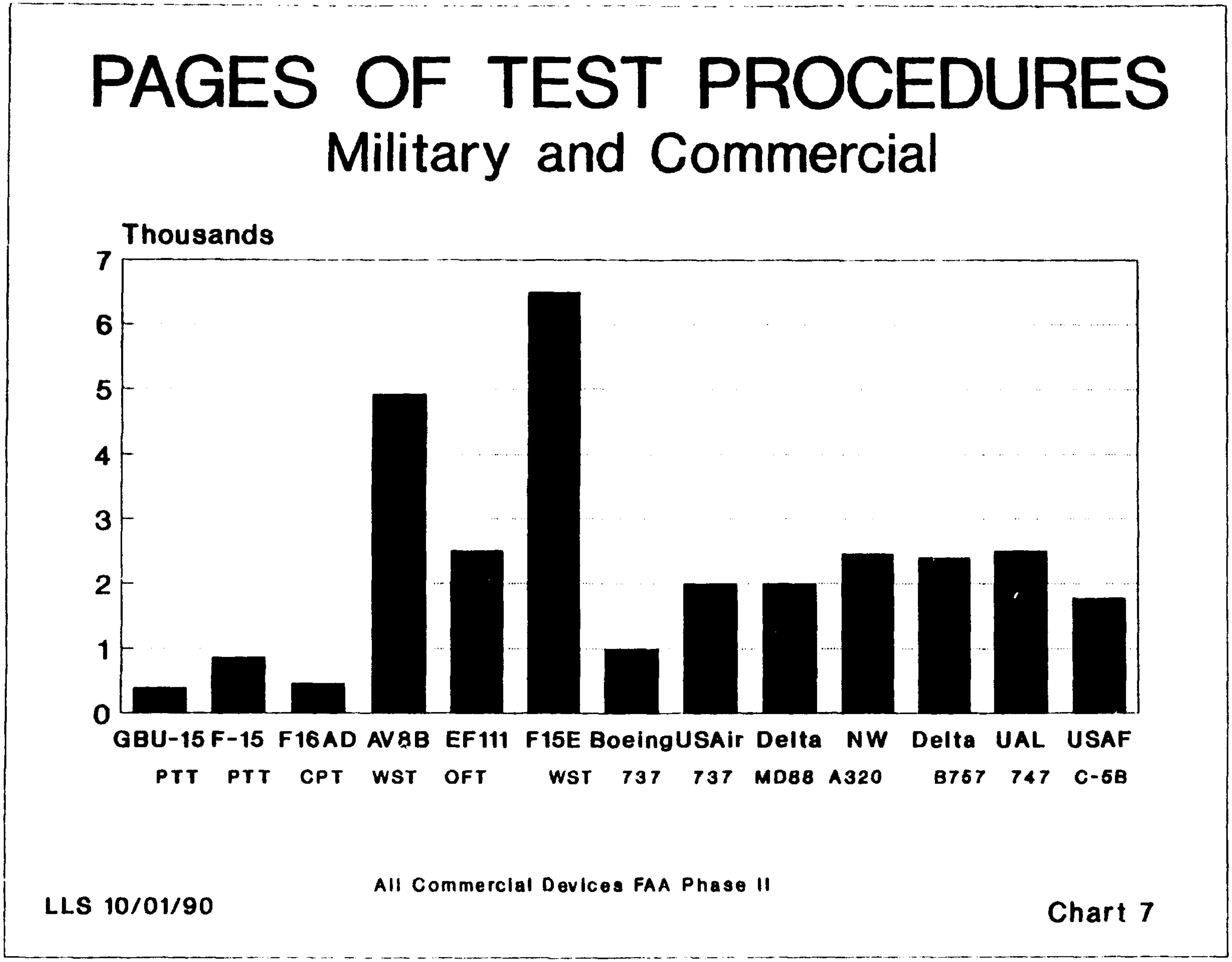


Figure 4.1.5-1. Pages of Test Procedures

- o Size of the test procedures correlates well with trainer complexity.

4.1.6 Test Matrix Factors

Chart 8 depicts a comparison of various test categories for military programs. (Figure 4.1.6-1)

- o Data indicates a low utilization of analysis and a high utilization of test and demonstration to verify specification performance
- o No common application exists from program to program governing the use of inspection, analysis, demonstration, and test.

4.2 IDENTIFICATION OF WASTE AREAS

Each chart was individually reviewed to identify possible waste areas in the test process. Graphical analysis assisted in producing a better definition of the problems. The team used tabular data, histograms, the process macro flow, and comments on the questionnaires to assist and confirm proper identification of critical process indicators and waste areas. Eight waste areas were identified for subsequent root cause analysis.

WASTE AREAS

1. Delay in start of test
2. Redundant testing
3. Detailed customer subsystem performance verification
4. Test Discrepancies
5. Excessive test Documentation
6. Test Interruptions
7. Multiple test readiness reviews
8. Computer Program System Generation (Cold Start).

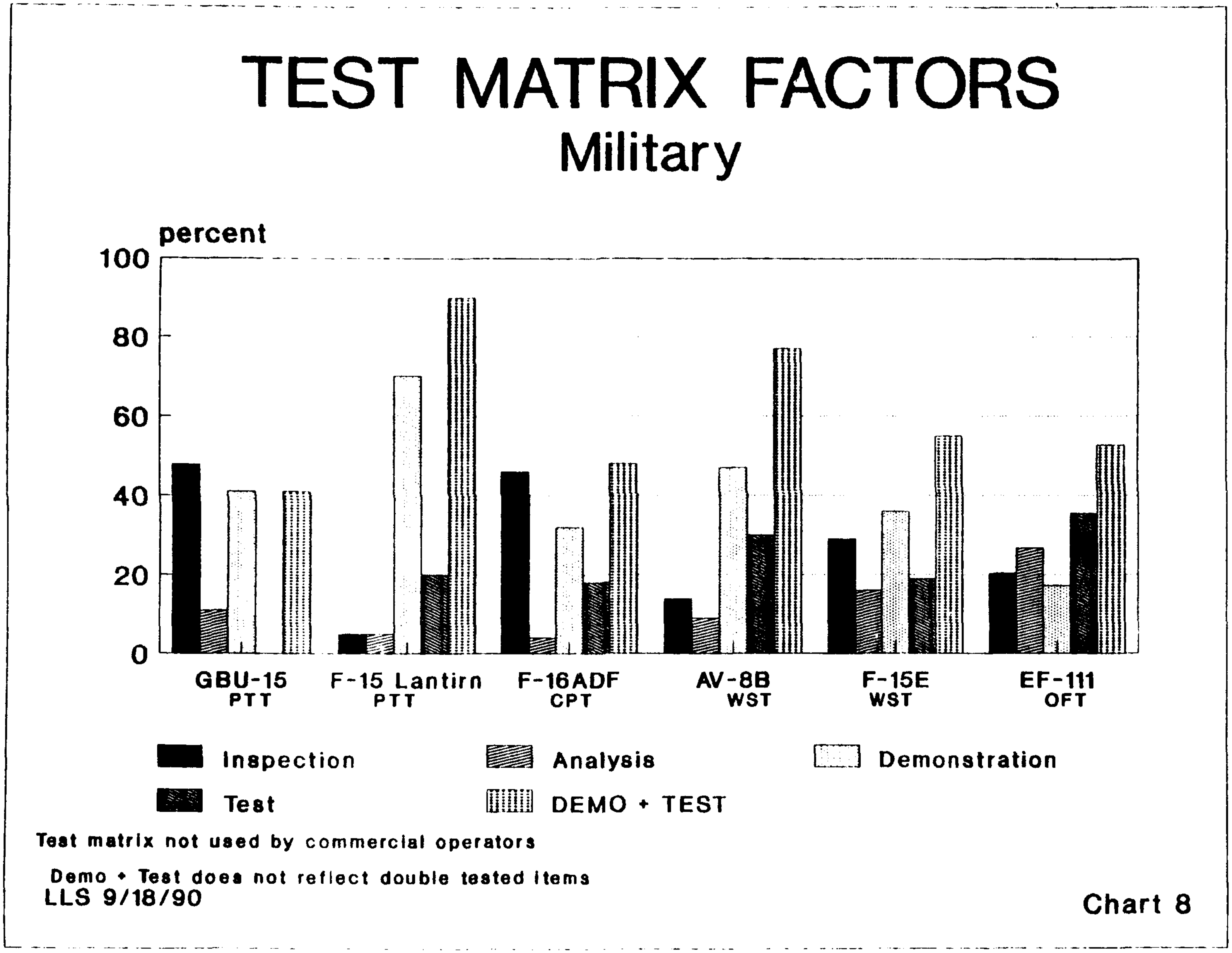


Figure 4.1.6-1. Test Matrix Factors (Military)

5.0 DEVELOPMENT OF SOLUTIONS

The solutions described are based on eleven months of intensive study, data collection, and analysis. With the knowledge obtained to this point, the current test process flowchart was revisited. By removing all constraints, bias, and myths, then applying insight gained from the data, an idealized flowchart was generated to visualize a test process void of identified wastes. This flowchart, in conjunction with the information gained from identifying root causes, provided the basis for developing solutions.

Although the solutions are specific in nature, they are not intended to be perceived as the only solution but rather as the CPT's recommendations based on the research conducted. In a few cases the solution for the root causes of the waste areas identified may require further refinement. For the majority, there are solutions formulated that are easily and readily implementable. It should be noted that all solutions had a consensus of the CPT membership.

5.1 WASTE AREA #1 - DELAY IN START OF TEST

5.1.1 Cause Summary

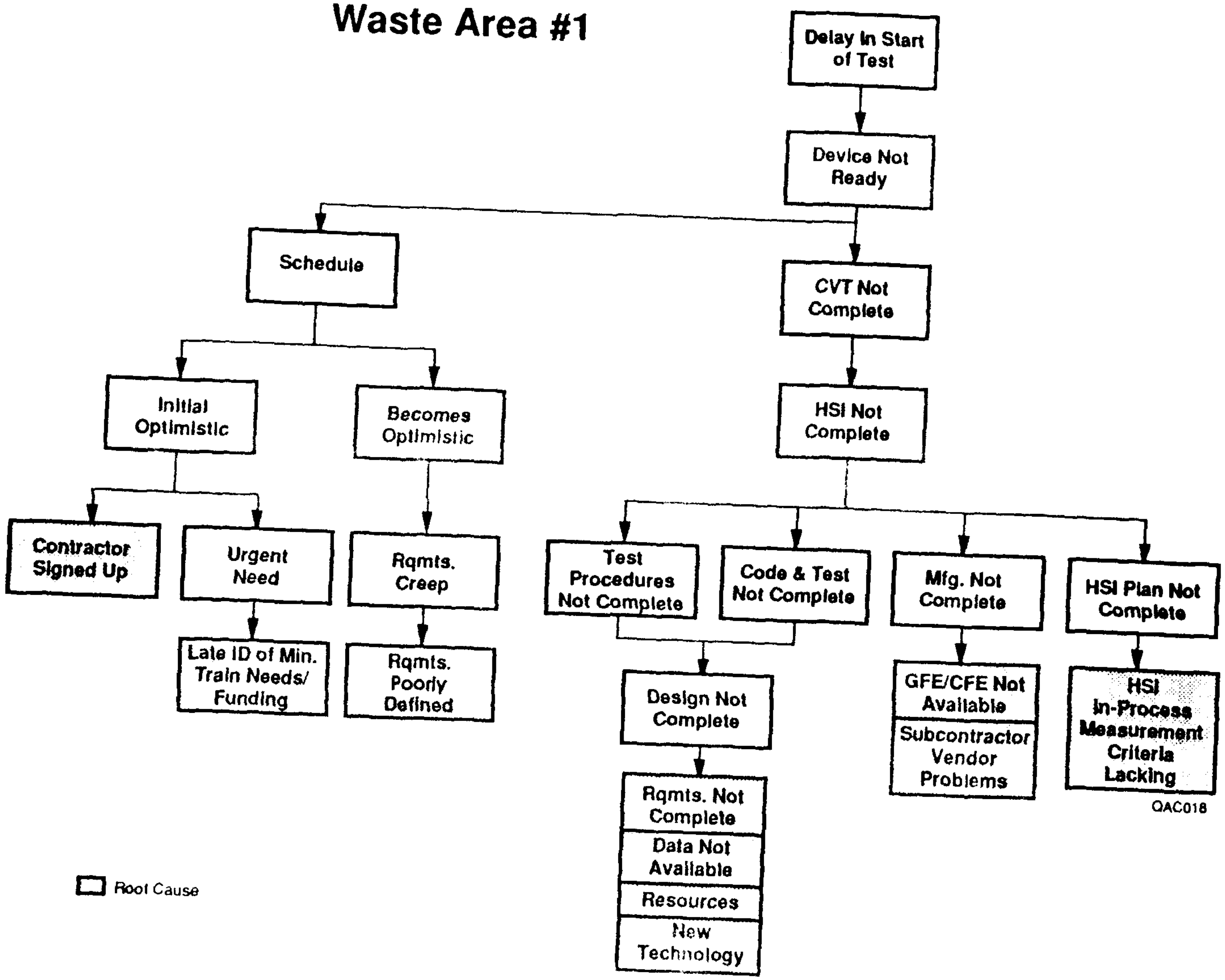
The following factors were identified by this CPT as being directly related to test delays (Figure 5.1.1-1):

- o Late Government identification of minimum training needs/funding
- o Poorly defined requirements
- o Incomplete design
  - Requirements not complete
  - Data not available
  - Resources not available
  - Inefficient implementation of new technology
- o Manufacturing not complete
  - Government Furnished Equipment (GFE)/Contractor Furnished Equipment (CFE) not available
  - Inadequate subcontractor/vendor management
- o Hardware/Software Integration in-process measurement criteria lacking.

5.1.2 Solutions

Program delays due to late Government identification of training needs and inadequate program funding often cause the program planning phase of the procurement process to be incomplete. Inadequate research during this period results in poorly defined requirements. This often results in the requirements "creep" phenomenon during later stages of design development. The problem is further compounded when the contractor accepts these nebulous requirements and consequently fails to perform to Government expectations. Thorough completion of the Training Systems Requirements Analysis prior to the release of the RFP will greatly assist in well-defined, realistic requirements to provide a sound basis for contractor scheduling, pricing, and technical performance.

Waste Area #1


Delay In Start of Test
Device Not Ready
Schedule
CVT Not Complete
Initial Optimistic
Becomes Optimistic
HSI Not Complete
Contractor Signed Up
Urgent Need
Rqmts. Creep
Test Procedures Not Complete
Code & Test Not Complete
Mfg. Not Complete
HSI Plan Not Complete
Late ID of Min. Train Needs/ Funding
Rqmts. Poorly Defined
Design Not Complete
GFE/CFE Not Available
Subcontractor Vendor Problems
HSI In-Process Measurement Criteria Lacking
Rqmts. Not Complete
Data Not Available
Resources
New Technology
Root Cause
QAC018

Problems associated with the contractor's failure to complete the device design prior to testing due to incomplete data may be decreased or eliminated by identifying missing data early during the program and establishing joint contractor/Government interpretation. This interpretation should then be formally included in the Design Criteria List (DCL). Early involvement of Subject Matter Experts (SMEs) will also help alleviate problems associated with a lack of data by providing an "on-line" data source during the design development phase. In addition, implementation of the data generation and management principles identified in the Simulator Data Integrity Program sponsored by the Training System SPO under contract number AF33657-88-C-2168 should be considered to ensure accurate and complete data is provided by the prime weapons system contractor. The Simulator Data Integrity Program serves as a source data process standard and provides the following:

- A tailorable working tool clearly defining the management and technical processes to be applied during the acquisition and implementation of source data
- Processes providing for quality and uniformity among the multiple suppliers of data which support a single training system
- A standard that yields source data products with excellent integrity, quality, and supportability characteristics.

The problem of unavailable resources centers around delays caused by events leading up to and including Hardware/Software Integration which have been determined to be especially significant by this CPT. For example:

- Hardware/Software Integration suffers from poor planning and implementation
- Ability to manage the Hardware/Software Integration process has been lacking
- Start/stop criteria and in-process measurement tools have been non-existent.

The training system industry is encouraged to investigate/solve problems in these areas. It is believed that with the correction of these problems the resources availability issues will be similarly resolved.

Schedule risks associated with utilizing new technology in the device design can be mitigated by developing prototype testing procedures to mature the technology prior to Hardware/Software Integration. These procedures can be reduced on subsequent production quantities as the risk of the technology decreases.

GFE availability problems can be reduced by implementing a system in which the Air Force procures the required training system components from the prime weapons system contractor as soon as GFE requirements are known. An alternative is to have the

Government include in the weapons system contract the requirement to enter into an associate contractor agreement with the simulator contractor to supply the necessary components. Alternatives to using GFE should be explored such as the use of "Olive Drab" commercial components which are essentially equivalent to MIL-SPEC hardware items that have not been sponsored or designed by the Government. The use of equivalent non-military components is yet another option.

Inadequate subcontractor/vendor management problems are not in the Air Force direct line of responsibility; however, the Government can influence the prime contractor to address this area to reduce the risk to testing. Suggestions for industry improvements include:

- o Avoid multi-level, multi-party subcontractor arrangements on major device components where the actual supplier has no direct link to the prime
- o Establish a strong subcontractor/vendor management team to take responsibility for the supplier's performance
- o Use on-site representatives when necessary to closely monitor supplier performance
- o Use Material Requirements Planning (MRP) packages to help schedule vendor delivery
- o Develop reliable second sources for high risk components
- o Insist on monitoring and reviewing major subcontractor performance on a regularly scheduled basis to identify potential problem areas.

5.2 WASTE AREA #2 - REDUNDANT TESTING

5.2.1 Cause Summary

The following factors have been identified as contributing to the problem of redundant testing (Figure 5.2.1-1):

- o No Government recourse after buy-off
- o Improper engineering test procedures
  - Engineering procedures not repeatable
  - Results not documented.

5.2.2 Solutions

The customer views acceptance testing as his "one and only shot" at discovering all system problems. This results in aggressive, excessive testing by the Government to ensure the continued performance of the simulator throughout the required life cycle. The contractors can instill confidence in their product and thus lessen the need for extensive testing by providing a more comprehensive performance warranty package similar in scope to those currently available to commercial airlines.

Redundant testing often occurs as a result of poor contractor testing procedures. The Government does not accept Contractor Verification Testing (CVT) results as valid and usually re-runs the tests in total. Confidence in contractor test results

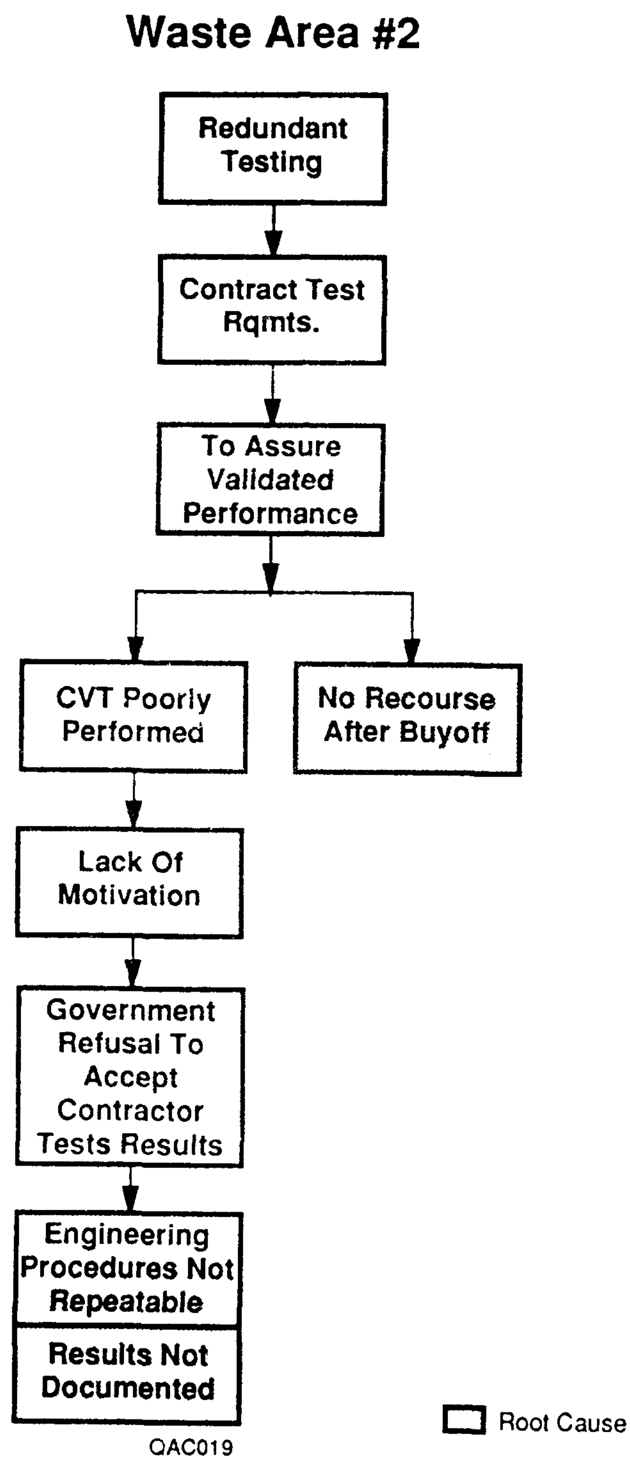


Figure 5.2.1-1. Waste Area #2

can be established by increasing the quality of in-plant testing and including advisory SME involvement during CVT. This solution forces the contractor to conduct in-plant tests which are repeatable and well-documented. Consistent contractor test results will increase the likelihood of Government acceptance of the data generated and eliminate the need for repeating previous contractor testing. Failure to properly perform and document CVT results in jeopardized on-site device performance and reduced profit due to the attending schedule delays and additional contractor resources necessary to upgrade the device to an acceptable condition. With reduced Government in-plant testing, thorough functional mission tests to be conducted by the Government prior to acceptance on-site will become a necessity.

5.3 WASTE AREA #3 - DETAILED CUSTOMER SUBSYSTEM PERFORMANCE VERIFICATION

5.3.1 Cause Summary

The CPT has identified the following factors as contributing to overly detailed performance verification testing (Figure 5.3.1-1):

- Contractor test results not available/documented
- Traditional, bottoms-up test techniques
- Performance risks associated with new technology.

5.3.2 Solutions

The need for detailed Government performance verification to the subsystem level can be eliminated by instituting improved contractor test procedures. Prototype tests should be developed for high risk, new technologies prior to Hardware/Software Integration until a satisfactory confidence level is reached. This compliments the suggestion to mature new technology contained in 5.1.2. Traditional bottoms-up testing should no longer be performed by the Government and will require a modification of the Test Matrix for inclusion in the MIL-PRIME Air Force Guidance specifications 87241 for flight simulators and 87228 for maintenance training devices. Instead, these procedures should be completed during CVT. The procedures and test results should be thoroughly documented for Government review, thus allowing one time cost effective and efficient system level acceptance testing.

5.4 WASTE AREA #4 - TEST DEFICIENCIES

5.4.1 Cause Summary

The CPT has identified the following problem areas which contribute to TDs (Figure 5.4.1-1):

- Lack of trained resources
- Invalid test procedures
- Poorly defined operational performance
- Data shortfalls
- Incomplete contractor testing.

Waste Area #3

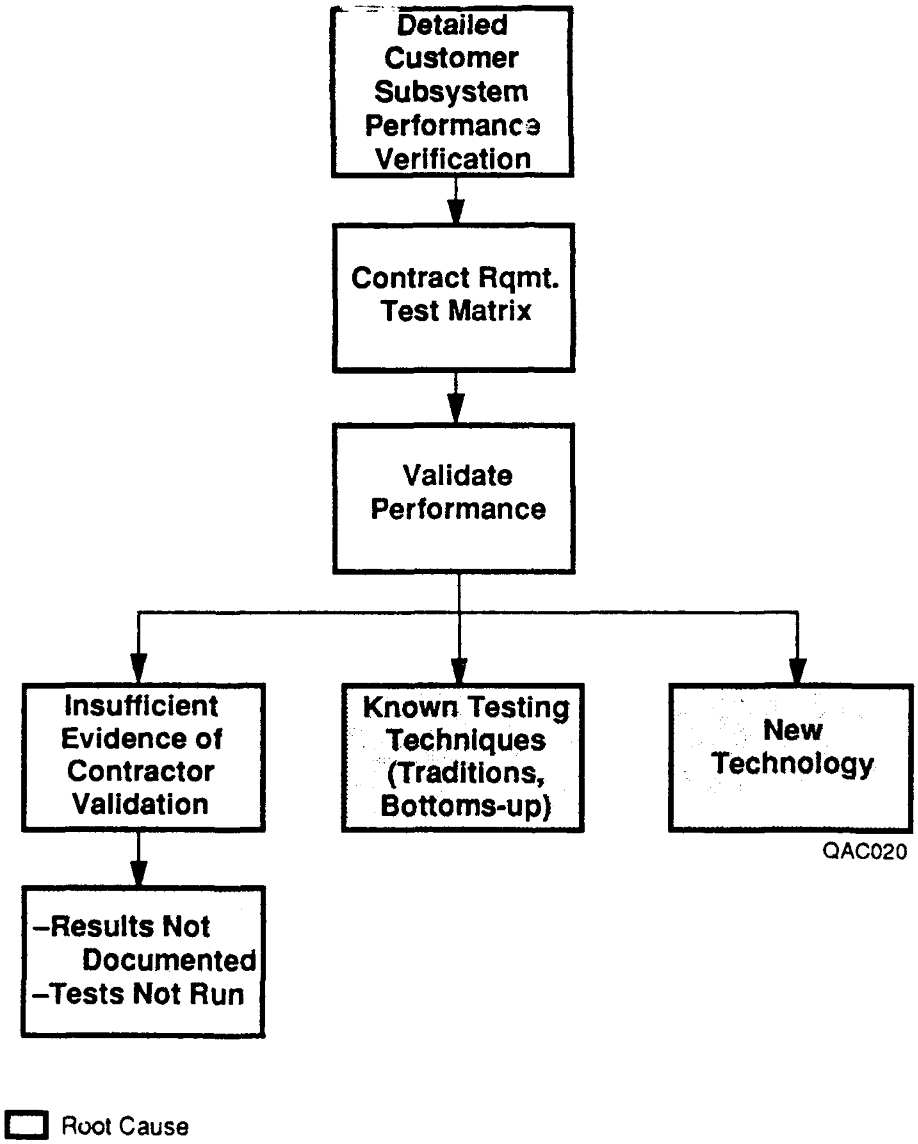


Figure 5.3.1-1. Waste Area #3

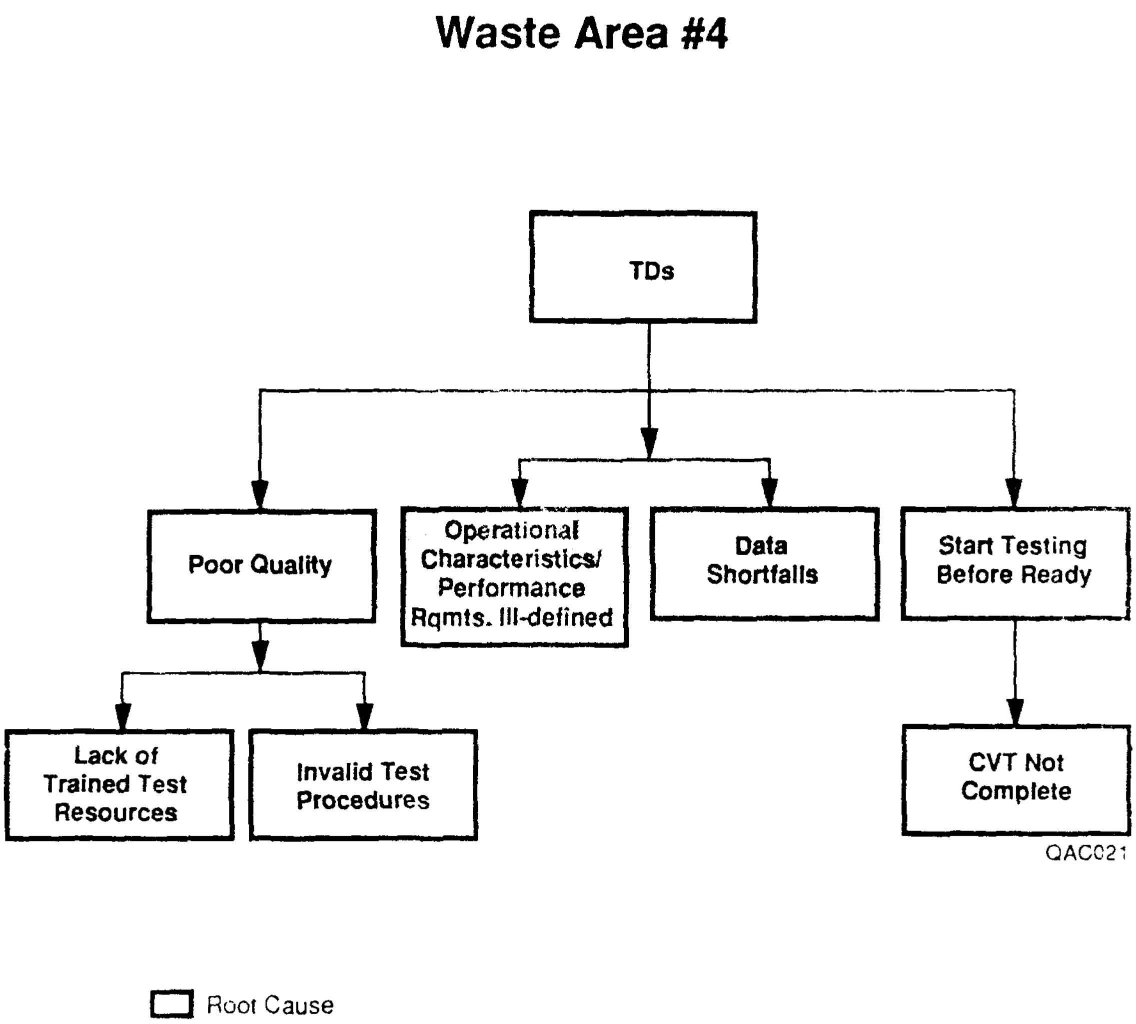


Figure 5.4.1-1. Waste Area #4

5.4.2 Solutions

TDs are often a result of poor quality in the areas of:

- o Workmanship
- o Configuration Management
- o Software Design
- o Hardware Design
- o Corrective Action.

Proper training of test personnel in these areas is essential in limiting the number of TDs written against a given device. Proper training ensures that test procedures are properly generated and performed and test personnel are able to sufficiently measure device performance against performance criteria. Implementing in-house training programs based on the principles of TQM to create a climate of pride, teamwork, and ownership has great potential to alleviate excessive TDs and increase overall quality.

Poorly defined performance requirements also contribute to unnecessary TDs. This problem relates back to a failure of the Government to identify training needs early in the program and complete the Training Requirements Analysis Report and Operator and Maintenance Analysis Report as discussed in section 5.1.2, Waste Area 1. Once identified, the contractor must interpret test requirements correctly and obtain Government concurrence.

A closely related problem is a lack of performance data. Data shortages can be alleviated by making SMEs available throughout the design, development, and CVT testing phases of the program. SME involvement in design reviews is especially encouraged to clarify design data assumptions and resolve ambiguities with the results then formally documented. Also, implementing the Simulator Data Integrity Study recommendations will help ensure effective data flow between the prime airframe/avionics developer and training system manufacturers as previously outlined in Waste Area #1.

The final area identified as contributing to TDs is testing prior to satisfactory completion of CVT. The many factors involved in this problem and the CPT's recommended solutions have been previously discussed in Waste Area #1.

It should be noted that TDs are symptoms, not causes. Root causes which give rise to TDs have been identified and solutions discussed in each of the other waste areas.

5.5 WASTE AREA #5 - EXCESSIVE TEST DOCUMENTATION

5.5.1 Cause Summary

The following factors contribute to the problem of excessive documentation (Figure 5.5.1-1):

- o Documentation is overly complex and detailed providing for
  - Repeatability
  - Skill level

Waste Area #5

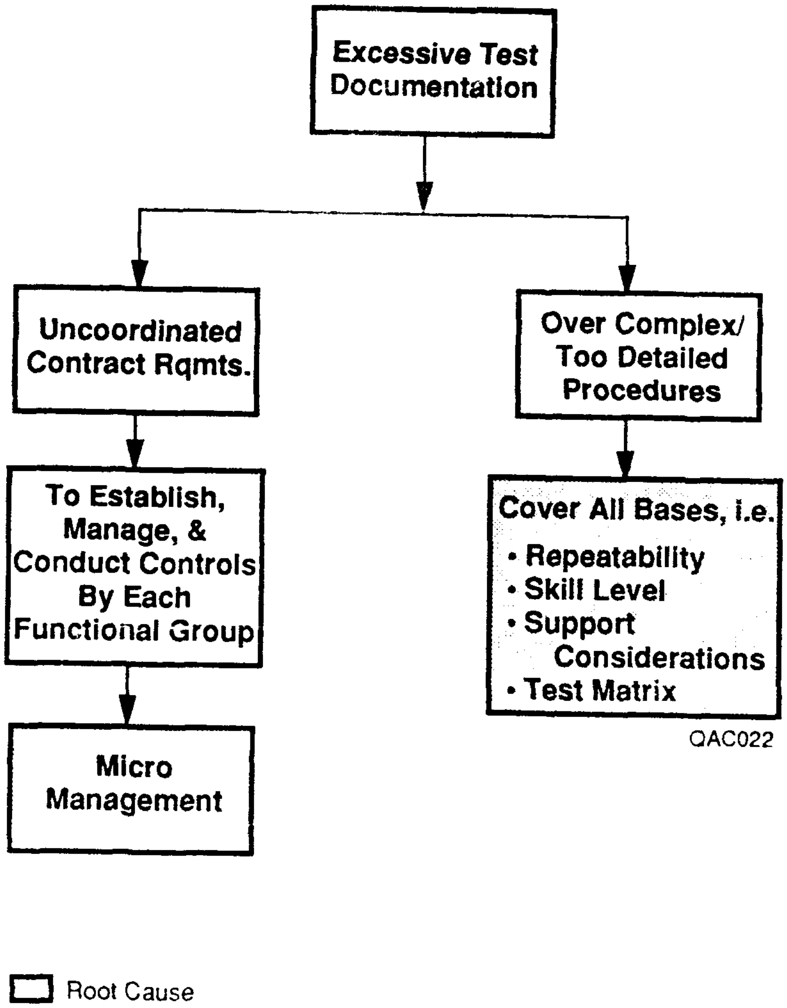


Figure 5.5.1-1. Waste Area #5

- Support considerations
  - Test Matrix requirements
- o Documentation is not coordinated across contract requirements
  - Micro management.

5.5.2 **Solutions**

Overly complex and detailed documentation can be alleviated by writing engineering tests at the functional level. CDRL items should be changed to allow submittal in contractor's format. Greater emphasis should be placed in the SOW requirements for contractor development of automated test procedures for such areas as aero and performance tests, initial conditions, avionics, nav-aids, diagnostics, etc. A further solution is to have Government testing at the mission level which eliminates the need for step by step procedures. Support considerations no longer dictate excessive test documentation as Contractor Logistics Support has been implemented for all programs. Another solution is to examine the Test Matrix at design reviews to minimize the requirements for tests and demonstrations based on systems design.

Documentation which is uncoordinated across contract requirements can be avoided by centralizing the responsibility and authority for data requirements with the Government lead engineer to eliminate duplication. In addition, pre-approved plans for Systems Engineering Management, Systems Test, Quality Assurance, Configuration Management, Software Development, etc., should be used wherever possible to eliminate the need for separate plans for each program.

5.6 WASTE AREA #6 - TEST INTERRUPTIONS

5.6.1 **Cause Summary**

The following factors were identified as causing schedule interruptions (Figure 5.6.1-1):

- o GFE/CFE spares not available
- o Schedule pressure
  - Acceptable risk
- o Poor systems analysis/solutions unsatisfactory
- o Customer facility not ready
  - Lack of control of the construction program
  - Lack of contractor design
- o Software update process errors.

5.6.2 **Solutions**

Test interruptions due to schedule pressure often result from allowing known problems to exist unresolved. The contractor should monitor these problems through the use of established risk management procedures, resolve TDs as quickly as possible, and ensure trained personnel are available in each specific program area. The determination of acceptable risk to enter into Government testing with known problems occurs during TRR. A more comprehensive analysis effort should be made at this time prior to entering test to avoid delays, disruptions, and waste.

Waste Area #6

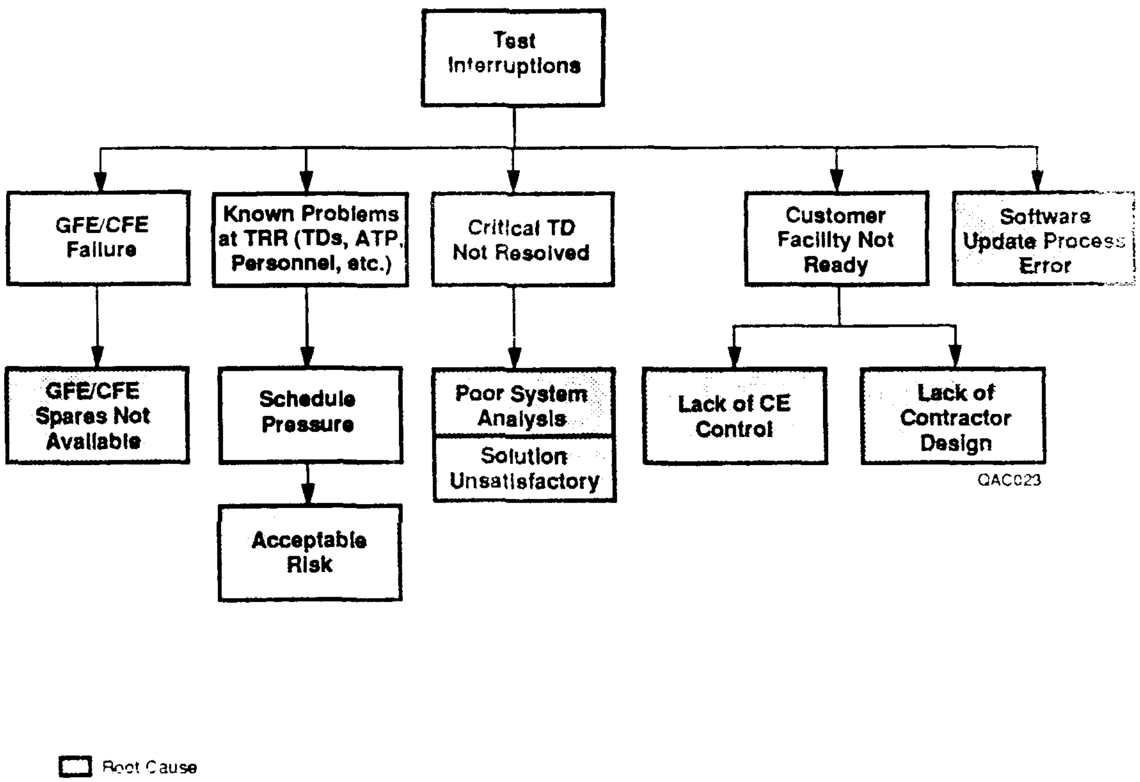


Figure 5.6.1-1. Waste Area #6

A lack of GFE/CFE spares is often responsible for test interruptions. The Government can solve this problem by considering spares requirements when ordering components from the weapons system manufacturer. For CFE, the contractor should establish a repair pipeline with the original equipment manufacturer and have the system in place prior to testing. Additionally, the solution for early acquisition of GFE by the Government should be implemented as discussed previously in paragraph 5.1.2.

Poor system analysis is the root cause of many test interruptions as unresolved critical TDs often result. An ad hoc team should be established to resolve "show stopper" TDs utilizing both contractor and Air Force resources as required.

Automated error detection methods should be explored to reduce interruptions due to software update process errors.

Modification or new construction of a facility is most often accomplished via the Military Construction route (3300 appropriation funding). However, the ability to use RDT&E (3600 appropriation funding) should be exploited where new facility construction is a requirement. AFR 80-22 states that RDT&E funds may be used to acquire industrial and RDT&E facilities needed by contractors to fulfill R&D contracts as authorized by 10 USC 2353. This has been interpreted to mean that where a facility is needed by a contractor in order to perform tasks required by a R&D contract, that facility may be provided through this funding.

5.7 WASTE AREA #7 - MULTIPLE TEST READINESS REVIEWS

5.7.1 Cause Summary

The following item has been identified as causing multiple TRRs (Figure 5.7.1-1):

- o Failure of the contractor to be ready for test.

5.7.2 Solution

Multiple TRRs are costly to both the Government and contractor, contribute to the length of the test schedule, and constitute a non-productive expenditure of test team resources. Data indicates that the contractor historically is not ready at TRR. Multiple Government TRRs can be avoided by placing the burden of test readiness solely on the contractor. The need for multiple TRRs should be re-evaluated and contract requirements written to reduce the number of TRRs accordingly.

5.8 WASTE AREA #8 - COMPUTER PROGRAM SYSTEM GENERATION

5.8.1 Cause Summary

The following factor has been identified as contributing to CPSG requirements (Figure 5.8.1-1):

- o Lack of or weak contractor software tools
- o The need to accommodate changes.

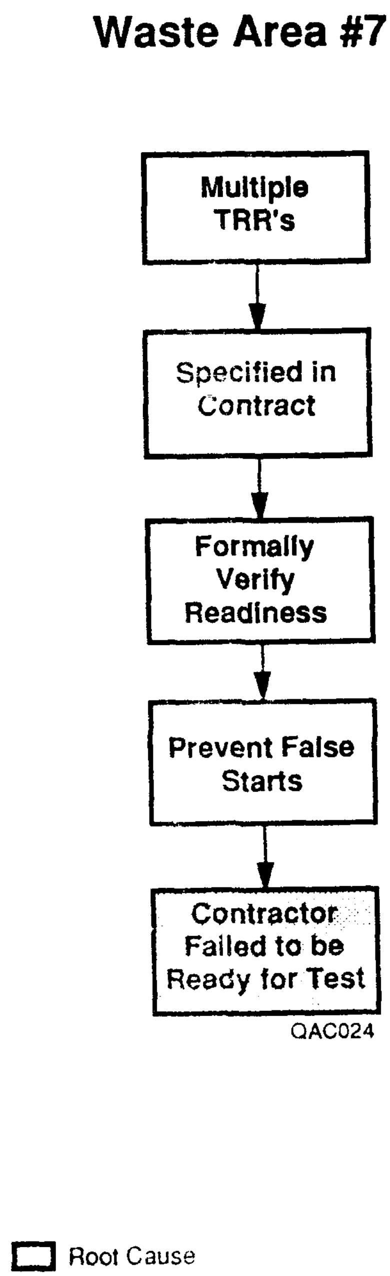


Figure 5.7.1-1. Waste Area #7

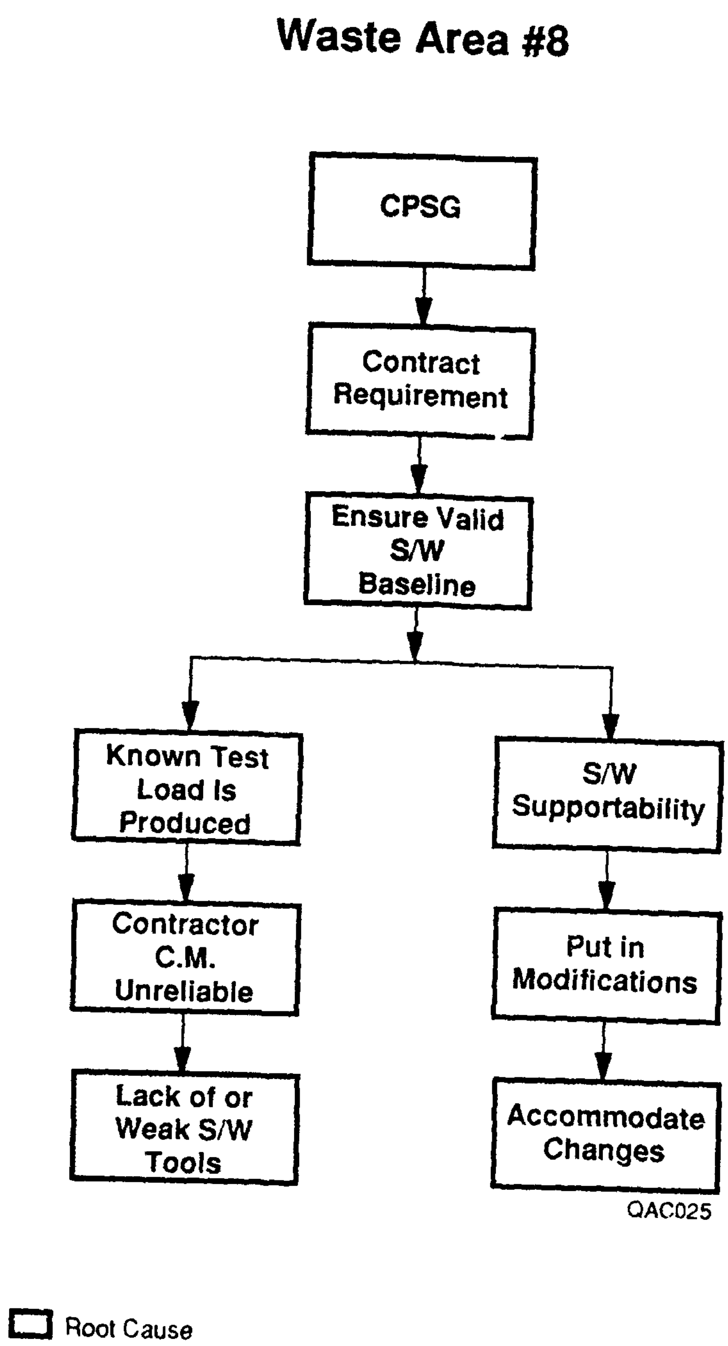


Figure 5.8.1-1. Waste Area #8

5.8.2 Solution

CPSG requirements constitute a lengthy and unnecessary waste of resources when large scale, complex devices are involved. Software tools and processes are available which provide the same level of confidence in the integrity of the software as CPSG. This is particularly true for those programs requiring Ada software language. Government certification of contractor software tools and processes for software configuration management and the capability to support changes should be accomplished prior to test. The procedures for certification should be included in the Configuration Management Plan. Certification would then allow for the elimination of CPSG requirements.

6.0 IMPROVEMENT RECOMMENDATIONS

The CPT is recommending fundamental changes to the acceptance test process and supporting activities of that process. These recommendations are based on analysis of the current test methodolgy and solutions formulated by the team to eliminate the root causes for identified wastes. Accountability will be improved by better aligning authority with responsibility for both the Government and contractor development test teams. Unnecessary and redundant testing will be eliminated, test documentation will be minimized, and the level and type of testing will be more focused on satisfying training requirements. In addition, a comprehensive and more effective test assessment will be realized without extensive TRRs. Test procedures will be elevated to the functional level and Air Force SMEs will be made available to assist the contractor during the development phase. Test functionality will not be reduced nor will test integrity be compromised as a result of these recommendations.

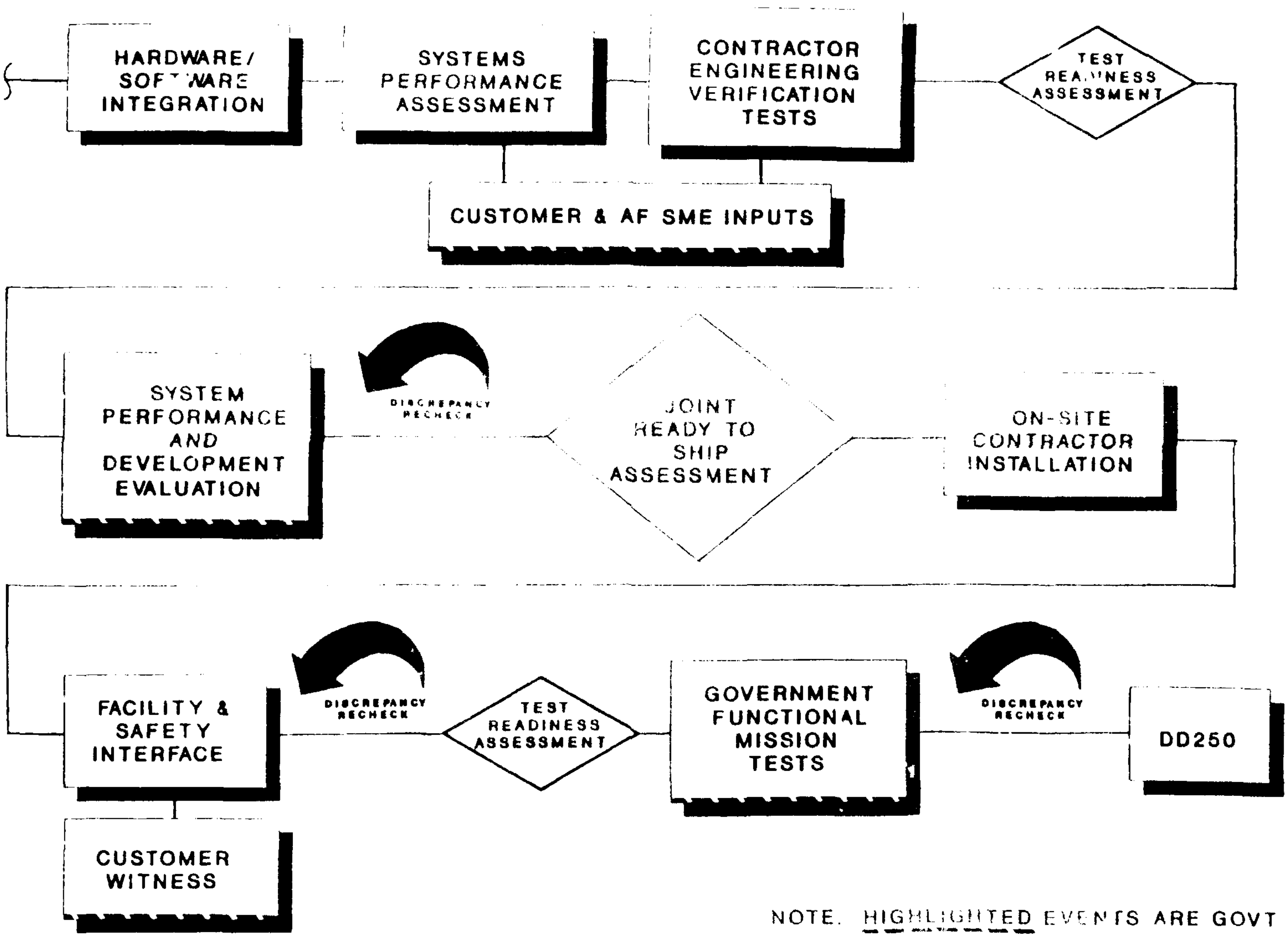
The CPT concentrated on the task of improving the efficiency of acceptance testing. However, "testing" encompasses and is influenced by a much broader span of activity outside the formal test program. Program development tasks prior to acceptance testing were suspected by the CPT membership of masking problems subsequently appearing during or delaying the start of acceptance testing. The data collected supports prior suspicions. CPT findings show a major cause for delay in fielding acceptable training devices is due to activity that precedes the start of acceptance testing. In particular, recommendations made in the areas of design data, aircraft components, and Hardware/Software Integration are emphasized because of their known historical impact on the test program. Correction of these problems will largely avoid significant delays experienced on past programs. Further, in the era of software driven glass cockpits, these problems will assume even larger proportions if not contained.

The CPT, through the efforts of identifying areas of waste, has formed additional recommendations viewed as critical. Three general recommendations are made to improve Government and contractor test program efficiency through contract provisions relating to contractor performance and are strongly recommended. To determine ideas for further improvements, a letter was sent by the Training Systems SPO Program Director to canvas the training systems industry. The correlation of the comments with the team's recommendations was excellent. Virtually all companies proposed ideas similar to those advanced by the CPT. This can be interpreted as a very high order of confirmation of the team's analysis. The supporting inputs received from industry, the success on programs (where applied), and the judgement of the CPT were virtually unanimous in citing these improvement recommendations.

6.1 THE SIMULATOR TEST 2000 PROCESS

The recommended new process known as Simulator Test 2000 (ST 2000) is shown in Figure 6.1-1. When contrasted against the current test process (Appendix B), the elimination of redundant Government CPSG testing, in-plant performance tests, and on site

SIMULATOR TEST 2000 (PROPOSED)



NOTE. HIGHLIGHTED EVENTS ARE GOVT TEST ACTIVITIES acceptance tests, plus a reduction in TRRs, becomes obvious. To convey these improvements, the substance of the ST 2000 process is described along with the ensuing recommendations.

6.1.1 Systems Performance Assessment

A need exists early in the test program to assess the performance of the devices. The CPT recognizes that even with a comprehensive set of data, it is often incomplete and does not always cover abnormal conditions, malfunctions, all weather effects, or flight conditions outside normal envelopes. The System Performance Assessment (SPA) fulfills this need by providing SMEs to assist the contractor development process. In implementation, the contractor will provide a menu of areas to be assessed by Air Force SME's. SME inputs are considered vital and are expected to be incorporated by the contractor. Upon SME evaluation, subjective inputs are quantified and incorporated in the DCL, thus establishing an agreed to basis for their incorporation. Incorporating SPA within the ST-2000 process allows the contractor more time in-plant to resolve training related deficiencies. Improvements forecasted include a reduced test program schedule and fewer deficiencies in training devices being fielded.

6.1.2 Contractor Engineering Verification Tests

This segment of the ST-2000 process represents a significant improvement in the time to accomplish acceptance testing by incorporating the following improvements:

- o Contractor performance of engineering development tests with results completely documented
- o Test procedures written at a higher functional level
- o Greater emphasis on automated testing
- o Automated error detection in the software compile/load build process
- o Elimination of Government CPSG tests.

Contractor Engineering Verification Tests (CEVT) are all engineering tests, including automated Approval Test Guides (ATGs) similar to those required by FAA Advisory Circular 120-40, required by the Test Matrix. The tests are conducted by engineering and witnessed by appropriate Quality Assurance personnel. As requested by the contractor, Air Force SMEs will be made available to confirm correct systems operation.

6.1.3 Test Readiness Assessment - In Plant

A single in-plant TRA supports the CPT recommendation to reduce the number of TRRs in the current process. The TRA provides the opportunity to review prior contractor test activity using engineering and ATG test results as documented evidence of specification compliance. This information, in conjunction with the status of contractor deficiencies, establish the review criteria for readiness of the device to begin Government functional and operational tests.

6.1.4 System Performance And Demonstration Evaluation

The elimination of redundant testing was a major objective of the CPT. In the process of gaining feedback from military and commercial simulator programs, a strong emphasis was made to assure that the device was capable of supporting the training syllabus prior to shipment from the contractor's plant. The System Performance and Demonstration Evaluation (SPADE) satisfies the above intentions by performing functional check flights or free play using ATGs and/or predefined mission scenarios for aircrew trainers and selective stand-alone malfunction tests for maintenance trainers. This testing, conducted by the Government and supported by the contractor, is the first opportunity for the Government test team to generate discrepancies. It provides a trainer evaluation in which discrepancies that impact training on the device are identified and resolved. In no case is a repetition of prior CEVT advocated.

6.1.5 Joint Ready To Ship Assessment

The objective is to determine readiness to ship after joint contractor/Government review of all previous test results and evaluations. Criteria should include the following:

- o Documented evidence of specification compliance is acceptable
- o Previous contractor discrepancies have been dispositioned
- o SPADE is successful and discrepancies affecting training have been resolved/corrected, or their disposition has been agreed upon
- o Site planning has been accomplished.

6.1.6 On-Site Contractor Installation

This activity is similar to that conducted in the current acceptance process. The contractor, upon teardown, pack, and ship, proceeds with on-site installation and checks the device to insure:

- o Equipment operation is restored to pre-ship condition
- o Facility related installations are functioning properly
- o Any contractor deficiencies which can be corrected at that time are accomplished.

6.1.7 Facility and Safety Interface

These tests are conducted by the contractor and witnessed by the Government. The tests include applicable CEVT, facility installation and interface tests plus safety tests that can only be conducted as part of final installation. Since these tests form part of formal device acceptance, TDs may be generated. In addition, the contractor can submit previous open contractor discrepancies that require recheck.

6.1.8 Test Readiness Assessment On-Site

During this TRA, the Government reviews the results of contractor on-site test activity including installation and checkout, CEVT, facility, safety, and discrepancy status. The final assessment that the training device is ready for Government functional mission acceptance tests is ultimately the Government's decision.

6.1.9 <u>Government Functional Mission Tests</u>

The CPT recognized that the level and type of testing should be focused on the device's viability for training. The CEVT validated the soundness of the design through engineering and automated ATG tests. A similar site related contractor engineering test activity satisfied facility related requirements. The purpose of Government mission acceptance test is to perform final acceptance tests with emphasis on training capability and closure of discrepancies.

Mission testing uses pre-defined scenarios and free play. Operational procedures and characteristics are further evaluated within the context of conducting the mission. The Government conducts these tests with contractor support. TDs are written with closure authority and decision of acceptability of results resting with the Government.

6.2 RECOMMENDATIONS

The following represents the list of recommendations made by the CPT.

1. Implement the Simulator Test 2000 process by forming a Government Corrective Action Team to draft a generic SOW and data/contract provisions and insert Physical Configuration Audit requirements (if any) at the appropriate point in the process. (Source: Process Analysis)

    a. Engineering development tests should be performed and results submitted to the Government for acceptance to eliminate redundant testing. (Source: Waste Areas 2 and 3)
    b. To minimize ambiguous design requirements and avoid the tendency to redesign during both contractor and Government test phases, the Government will make SMEs available to assist in subjective evaluations. Subjective data will be quantified and incorporated in the DCL. (Source: Waste Areas 1, 2, and 4)
    c. Greater emphasis should be placed in the SOW to automate test routines similar to FAA Advisory Circular 120-40 requirements for commercial airlines to produce reliable, repeatable, and well-documented results and alleviate the need for redundant Government tests. (Source: Waste Areas 2 and 5)
    d. Government test procedures should be written at a functional level to facilitate SPADE and on-site mission testing. (Source: Waste Area 5)
    e. The training system developer should manage a single discrepancy status accounting system to eliminate duplicative and often disparate systems. During test, an ad-hoc team to

identify and manage the resolution of "show stopper" TDs should be established. (Source: Waste Area 6)

f. The SOW should emphasize automated error detection in the software compile/load build process to drastically reduce software generation errors. (Source: Waste Area 6)

g. Reduce the number of TRRs to minimize delays in the test schedule by shifting the burden of test readiness to the contractor. (Source: Waste Area 7)

h. Provide the training system contractor the opportunity to eliminate Government CPSG and realize schedule and resource economics through advanced Government certification of software configuration management systems. (Source: Waste Area 8)

2. A well defined and realistic Training Systems Requirement Analysis should be developed and released prior to release of the RFP to establish and bound training tasks as early as possible in program development. (Source: Waste Area 1)

3. Make SMEs available to the training device contractor early in the program to help resolve data deficiency problems and establish consensus on interpretation and application. (Source: Waste Areas 1, 2, and 4)

4. Implement the Simulator Data Integrity Program study recommendations to ensure timely, accurate, and complete data availability to the training device developer from the weapons system design contractor. (Source: Waste Area 1)

5. Establish a CPT to investigate solutions to incomplete Hardware/Software Integration planning including start, stop, and in-process measurement criteria to assure improved management of this important development step which is critical to CEVT. (Source: Waste Area 1)

6. Mitigate technical performance and schedule risks by using prototype testing to mature new technology applications prior to attempted insertion into Hardware/Software Integration. (Source: Waste Areas 1 and 3)

7. To relieve the schedule delays attributable to unavailable/late aircraft components, early identification of requirements (including spares) followed by obtaining sufficient priority for timely acquisition from the weapons system contractor is considered essential. Components could be manufactured or alternately provided by the training system developer via an associate contract agreement with the weapons system developer. The use of equivalent, non-military

components (i.e., commercial standards, designed for foreign governments) should be allowed and encouraged. (Source: Waste Areas 1 and 6)

8. **Prime contractors must strengthen subcontractor/vendor management processes to improve delivery performance and reduce the impact on device readiness. (Source: Waste Area 1)**

9. Require more aggressive, comprehensive performance warranties to crystalize contractor liability and bolster Government confidence in contractor assertions to "meet the specification." This will radically reduce contract test requirements. (Source: Waste Area 2)

10. Contract specification test requirement definitions must be clarified to assure current application of test techniques for performance validation. Traditional bottoms-up testing would virtually be eliminated. Test application should be determined at design reviews. Additionally, MIL-PRIME Air Force Guidance specifications 87241 for flight simulators and 87228 for maintenance training devices requires revisions to include test definitions. (Source: Waste Areas 3 and 5)

11. Training of contractor test personnel in the principles of TQM would greatly improve product quality. Reduction in discrepancies and a more thorough accomplishment of procedures would practically be guaranteed. (Source: Waste Areas 4, 5, and 6)

12. CDRL responsibilities should be centralized with the Government lead engineer to avoid duplication and unnecessary/uncoordinated test documentation requirements. (Source: Waste Area 5)

13. Institute a program to allow pre-approval of contractor plans required for Government oversight to eliminate the need for separate plans for each program. (Source: Waste Area 5)

14. To abate the impact of test interruptions, risk management programs must be developed and implemented to anticipate and manage possible causes. (Source: Waste Area 6)

15. A repair pipeline should be negotiated with the original equipment manufacturer prior to testing to insure the availability of spares during the test program. (Source: Waste Area 6)

16. Training device development programs requiring new/modified facilities should consider tasking the development contractor as authorized by 10 USC 2353 to

centralize contract engineering responsibilities. (Source: Waste Area 6)

17. Remove test duplication that exists in software at the Computer Program Component and Computer Program Configuration Item level (between 2167A and acceptance test requirements) by revising 2167A criteria. (Source: Waste Area 2)

18. As a factor in the procurement selection process, develop a Blue Ribbon Contractor List based upon the contractors test track record. (Source: CPT expertise. See paragraph 6.3.1)

19. Test incentive awards should be applied to contracts and structured as a strong motivator as in other critical performance areas. (Source: CPT expertise. See paragraph 6.3.2)

20. Minimize the value associated with the contractual milestone for shipment to reduce conflict between test completion and ship milestones. (Source: CPT expertise. See paragraph 6.3.3)

6.3 CPT GENERATED RECOMMENDATIONS

6.3.1 Test Blue Ribbon Contractor Program

The CPT endorses development of an additional contract provision to reward superior contractor test performance. The purpose is to formalize waiving test program past performance assessment requirements once a contractor demonstrated exceptional compliance to contract requirements. This provision recognizes that among responsible contractors, varying degrees of quality and test programs exist.

An integral part of this program is the development of a Blue Ribbon Contractor list for simulation and training device manufacturers participating in either firm fixed pricing or cost plus FSD contracts. Membership on this list indicates a contractor has demonstrated dependable quality and test program performance on AFSC contracts during the past year. The Blue Ribbon Contractor List will be a major factor in the evaluation of past quality and test program performance.

The suggested criteria for membership on a Blue Ribbon Contractor List are as follows:

1. The contractor has been awarded and/or delivered items on at least one Air Force Systems Command (AFSC) FSD contract worth an aggregate total of $10M or more during the past three years, and,

2. The contractor has demonstrated 90 percent or higher on-time delivery (total quantity delivered on-time divided by total quantity due) of all test related data items of exceptional quality (first time

submittal gained Government approval with only minor correction required).

3. The contractor demonstrated quality performance on AFSC contracts measured as follows:
   - Resolution and rapid correction of priority TDs must have been accomplished within 45 calendar days or less. This includes completion of all Government in-plant testing through total correction (to the Government's satisfaction) of all Priority 1 and 2 TDs. For purposes of discussion, the 45 day duration is measured from the day of discovery and submittal ("Day 1") through successful recheck of all Priority 1 and 2 TDs ("Day 45 or less"). The various TD priorities are defined as follows:
     Priority 1: Those TDs involving safety, which require immediate correction in order to prevent injury to test personnel or to prevent damage to equipment.
     Priority 2: Those TDs, other than safety, which if not corrected could result in an extension of the planned test schedule or which may impact training.

4. No known in-plant Quality Deficiency Reports (QDRs) (i.e., unresolved method C, D, or E) are permitted. A QDR is defined as a report generated due to a defect which is found during acceptance or visual inspection or during functional test or checkout which indicates a failure or that failure is imminent, and is attributable to errors in workmanship or nonconforming material. QDRs are generated from field activities (i.e., DCAS).

Membership on the Test Blue Ribbon Contractor List is by application only. Any contractor that meets the criteria described above may apply for membership by providing the following information to ASD/YWK.

The number of AFSC contracts received in the past three years to include the following information:

a. Contract number.

b. Date of award.

c. Total contract price.

d. Type of testing accomplished and duration.

e. Significant test accomplishments.

At least semi-annually The Training Systems SPO will convene a panel to review contractor applications for membership on the Test Blue Ribbon Contractor List. The panel will use

Government data to validate a contractor's application. Data will include, but not be limited to: TD Management System, Data Item Tracking System, and Contract Administration Office maintained data, including the Quality Assurance Representative's documented records of a contractor's in-plant Quality Program. Those contractors meeting or exceeding the membership criteria will be placed on the Test Blue Ribbon Contractor List.

Contractors on a Blue Ribbon Contractor List will be reviewed semi-annually to ascertain whether or not their quality and test program performance still meet the criteria for Blue Ribbon membership. One year's worth of data will be reviewed. Contractors who no longer meet the criteria will be deleted from the Test Blue Ribbon Contractors List. The contractor will be notified in writing of the deletion and the reasoning of the panel.

Contractors whose names appear on the Blue Ribbon Contractor List do not need to submit past performance data with any proposals responding to RFPs. In addition, Contractor Performance Assessment Reports as required by AFSC regulation 800-54 will require no evaluation in the test and evaluation area for those qualified contractors. Simply inserting "Test Blue Ribbon Contractor" will suffice. The CPT urges this be implemented at the earliest possible opportunity with concurrence of the Training Systems SPO Program Director.

6.4.2 Contractor Test Performance Incentives

The CPT recognized that the contractor currently has every incentive to start Government test to see if he can "sell-off" the device and save schedule. If testing fails to achieve the desired result, the contractor may find it more economical to resist corrections, attempt short term solutions, and hope test schedule concerns will cause the Government to weaken its position.

The CPT believes that exceptional contractor test performance should be rewarded. Conduct of an effective, well planned test program is a worthwhile objective. The creation of contract incentives to accomplish this, however, is dependent upon several variables including the basic nature of the testing (development vs. production), the type of contract (cost vs. fixed price), and the type of incentive (i.e., objective performance incentive versus subjective award fee incentive). Each of these factors, along with other pertinent facts, must be weighed when trying to assess the ability to create a "real" contract motivator. The ultimate question to be satisfied is "What motivates the contractor?" Is it profit, sales, cash flow, etc.? The answer lies in the contract type which is what inspires motivation.

- o Development Testing - Cost Type Contract - Award Fee Because of the very nature of a development program, it would be extremely difficult to structure a performance incentive which would be meaningful. Development testing by its very nature is intended to surface problems before the design is frozen and moved into a production and deployment environment. The key is solid test planning and analysis in order to minimize surprises. These tend to be much more subjective areas when attempting to establish measurement criteria. Additionally, if work is being performed under a cost type contract, the need to get the hardware bought off in order to liquidate cost and gain profit is nonexistent. Award fee provisions would allow tailoring of the incentive from period to period as the program progresses and provides multiple opportunities to comment/reward performance

- Production Acceptance Testing - Fixed Price Type Contract
  - Performance Incentive

  In a production/deployment environment, test requirements have been defined. Because of this, the Government's ability to write a meaningful incentive at the time of contract award is much greater. A concern remains that the incentive being structured is sufficient in terms of dollars or corporate visibility to be an effective motivator and is in balance with the remainder of the program. From a cash flow/liquidation standpoint, the contractor is still motivated to push for contract buy off in order to claim progress payments and profit. Additionally, the incentive must be justifiable in terms of overall savings to the Government (i.e., reduced Temporary Duty, more efficient use of personnel, reduced paperwork, etc.).

The CPT recommends that initiatives begun by The Training Systems SPO should be continued and applied to all new acquisition programs. It is extremely important to monitor results of programs where incentives have been applied to ensure the level of value is worthwhile to the contractor, that they remain realistic and achievable, and experience gained through their application is reinvested in future programs.

6.4.3 Milestone Funding

Existing Firm Fixed Price contract funding/billing milestone schedules may influence acceptance test performance. Too much financial value is associated with the shipment of training devices from the contractor's facility. This places significant pressure on the test organization to start Government acceptance as soon as possible and ship before all problems have been corrected and re-tested in order to capitalize on contract milestone payment provisions. It causes the contractor to be willing to "take the risk" that problems can be solved during second shift, in the period of equipment tear down, pack, and ship, or during site installation and checkout.

Having the contractor revenue events place less emphasis on the ship milestone could improve overall test performance. The contractor would keep the equipment in plant to complete problem resolution and re-test. This approach enables the contractor to conduct testing in-plant which is much more cost effective to both the contractor and Government. The contractor can solve problems quicker by having all his resources available rather than using "tiger teams" on-site.

The CPT recommendation is to reduce the size of the dollar value associated with training device shipment from the contractors facility. The decision to start acceptance testing should not be influenced by a large contractor revenue event. The final contract funding profile should place more emphasis on final acceptance testing on-site. The contractor would still be motivated to finish as soon as possible but is not incentivized to prematurely ship the device.

6.4 PROCESS IMPROVEMENT BENEFITS

For any recommended process change to be considered for implementation, a measurable improvement must be expected. If there is a significant anticipated benefit as a result of the new process, a high degree of motivation to adopt the new process will be present. The consensus of this CPT is that with the adoption and implementation of ST-2000 process, a significant savings in resources can be achieved. Additionally, if the recommendations and other categories of suggested changes which are not directly part of the formal simulator test phase are also implemented, additional efficiency in each training device acquisition program can be achieved.

A comparison of the total contractor and Government test effort, referred to as the "Idealized WST Test Program", can be made to the ST-2000 process test program. The Idealized WST Test Program assumes that once testing begins, it progresses and is completed without delays or interruptions. This test program includes CVT, Performance/Acceptance Tests, and in-plant as well as on-site Operational Evaluations as depicted below:

Idealized WST Test Program

		IN-PLANT		ON-SITE		
TESTS:	CVT	Performance Test	OPS EVAL	Acceptance Test	OPS EVAL	TOTAL
WEEKS:	20	18	2	6	2	48

The total test effort of forty-eight (48) weeks required by the idealized WST test program can now be compared to estimates for WST testing using the ST-2000 process.

ST 2000 PROCESS

	IN-PLANT			ON-SITE	
TESTS:	SYSTEM ASSESSMENT	CEVT	SPADE	FUNCTIONAL & MISSION TESTS	TOTAL
WEEKS:	1.5	20	6	3	30.5

The reduction of the total test effort from forty-eight (48) weeks to thirty and one half (30.5) weeks represents a savings of approximately thirty-seven (37) percent. The CPT members' consensus is that this amount of savings can be realistically expected if all elements of ST-2000 process are implemented.

The CPT also made several recommendations and other observations which pertain to the total training device acquisition program. These are not within the formal test phase, but directly affect the start or progress of testing. The potential savings to cost and schedule which can be achieved by implementing these changes are not overlooked. The largest waste in most military training device development programs occurs, for a variety of reasons, prior to the device being ready for testing. A review of the Test Program Overview, Days Late At Milestones (Military), data shows that on average military programs are 158 days (32 work weeks) late prior to beginning of test. The elimination of this waste would result in cost and schedule overrun savings of approximately twenty (20) percent over the life of a planned thirty-six (36) month program.

7.0 CONCLUSION

The YW/Industry CPT spent one year engaged in the analysis of the current training device acceptance test process and the development of improvements. Using the Cumberland Group's Process Improvement Model to structure the team's activities, monthly working sessions were used to manage the effort. A conservative estimate of time expended by each team member is in excess of 400 man hours.

With the completion of the team's assignment, the resulting improvement recommendations clearly indicate that success was achieved. Time was indeed well spent, resources were adequate, and the potential payback without any compromise to training device performance is substantial.

To measure success, the CPT reviewed accomplishments with respect to the improvement goals established at the commencement of the effort as discussed in Section 2.0, Definition of the Improvement Opportunity. In formulating these goals, the CPT focused on several fundamental principles considered essential to whatever process changes might be recommended to improve acceptance testing of aircrew and maintenance trainers. These principles generally promote the concept that quality must be enhanced while time required for testing is reduced. The following paragraphs highlight the relationship between study goals and the most prominent recommendations.

GOAL #1. **MINIMIZE THE NUMBER OF TEST ACTIVITIES WITHOUT COMPROMISING PERFORMANCE VALIDATION**. While reviewing the present acceptance test process, the CPT identified a number of contractually required test activities that seemed to add little value, were redundant, or that could be accomplished jointly by the contractors and Government. Several areas of contractor testing repeated by the Government, multiple TRRs, and numerous delay paths were identified through process analysis. Held sacrosanct was that reduction in test activity could only be recommended provided that performance validation could not be bargained for any reductions in test activity. The customer was to be assured that the training device has been adequately tested to guarantee the quality and performance required by specification. Predominate recommendations for improvements include the ST 2000 Test Process, waiving CPSG, prototype testing of new technology, and the expanded use of contract warranty and incentive provisions.

GOAL #2. **FOSTER TIMELY, ACCURATE, STREAMLINED DEVELOPMENT OF TEST DOCUMENTS**. The data collected showed a wide diversity of test procedures written at various levels of comprehension and detail that do not correlate with the complexity of individual training devices. The team's concern that the development of test documents may be delayed due to the Government review and approval process and that the documents are written to a level of detail necessary only for inexperienced test personnel was reinforced. If test document development could be streamlined and standardized, the possibility of reducing the number of formal test days could be a realistic achievement. Centralized data responsibilities, improved test requirement (matrix), automated test routines, and test procedures written at the functional level are major enhancements toward satisfying this goal. Certification of certain contractor test processes by implementing a system for pre-approved plans also goes a long way to sort out the test document quagmire.

GOAL #3. **FACILITATE GOVERNMENT ACCEPTANCE OF QUALIFIED CONTRACTOR TEST RESULTS.** Few would question that schedules are extended when tests are repeated by the Government even when qualified contractor test results may be available. Major trainer systems are often retested and subsystem engineering tests repeated due to mistrust and a lack of documented test results. This typifies the "business-as-usual" syndrome in the well established process and illustrates the traditional mindset of bottoms-up testing. To break this cycle, allocating clear test and reporting responsibilities to the contractor is essential. Agreements on format, content, and other issues relating to acceptability of results must be negotiated between training system contractors and the Government. Major improvement recommendations to require the contractor to conduct engineering development tests, write and resolve discrepancies, and revamp the Hardware/Software Integration phase of program development are all essential to strengthen the Government's belief in contractor results.

GOAL #4. **TAILOR APPLICATION OF MIL-SPEC/STD TEST REQUIREMENTS TO EMPHASIZE COMMERCIAL PRACTICES.** The fundamental concept is to test only what needs to be tested at the level which will insure specification compliance. This is often difficult to describe because there is no single, universally accepted definition of what constitutes "Best Commercial Practices". For the purpose of this study, the CPT agreed that commercial practices were simply methods of doing business used by commercial operators that made sense. Primary commercial practices recommended include the implementation of performance warranties to relax the need to accomplish detailed subsystem testing and the development of standards for obtaining accurate performance data packages for use by the system developer. Commercial facility construction practices should be pursued to simplify matching facility design and schedule considerations with those of the training device development. Yet another recommendation towards satisfying this all important objective is to use ATGs similar to those required by the FAA in their certification of flight simulators for aircrew training. Tailoring MIL-STD-2167 requirements to eliminate repetitive testing is also strongly advocated and can be accomplished now by the buying agency.

GOAL #5. **ENCOURAGE IMPROVEMENT OF ON-TIME TEST MILESTONE PERFORMANCE.** Strong evidence of waste is clearly obvious from the available data serving to underscore the appropriateness of this goal. The capability of the contractor to meet schedule commitments during the development (pre-test) phase is vital in the overall improvement of on-time test milestone performance. The data suggests that testing, even when begun late, tends to follow the planned schedule. Recommendations to eliminate roadblocks to on-time testing are numerous. Timely availability of products, documenting training requirements, integration of Government SMEs in the development process, resolution of subjective data areas, identification and ordering of aircraft components, and a genuine test management risk abatement plan comprise a sample of those available. Possibly more significant are those incentive/award improvements which include financial considerations for exceptional contractor test performance.

GOAL #6. **REFINE THE TEST DISCREPANCY GENERATION, TRACKING, AND RESOLUTION PROCESS.** TDs are generated during acceptance testing because of a variety of reasons. Notwithstanding, TDs constitute waste by definition (failure to do it right the first time). The late receipt of data and the correct interpretation of data both seem to be factors which create conditions causing the generation of many TDs. Inadequate contractor testing and test procedures, often due to a lack of system knowledge, create problems late in the development cycle and their resolution usually affects the test schedule. Recommendations to moderate the impact of deficiencies include the use of SMEs early in the development program to interpret and clarify data, ad-hoc teams to prioritize TDs for resolution, and automated software error detection tools in the compile/load build process. A related recommendation for the training of contractor test personnel in the principles of TQM to improve product quality would as a natural consequence reduce discrepancies.

GOAL #7. **PROMOTE GOVERNMENT/INDUSTRY COOPERATION AND PARTNERSHIP FOR IMPROVING AIRCREW/MAINTENANCE TRAINING DEVICE TESTING.** One of the best ways to solve problems and thereby improve processes is to motivate all parties to be involved and work together. The YW/Industry Total Quality Executive Steering Committee, formed in July, 1989, by Col. Wayne Lobbestael, Training Systems SPO Program Director and his staff, certainly is the genesis for the type of Government/industry partnership that will be effective in solving mutual problems to the benefit of both partners. The Critical Process Team was chartered by the Steering Committee to search for opportunities to improve aircrew/maintenance training device testing. All recommendations give everyone a stake in the outcome and each demands a climate of pride, professionalism, excellence, and trust to make them work.

The premier improvement to simulator and maintenance trainer test process has been identified as Simulator Test 2000. Reforms to reduce Government test, strengthen and reallocate contractor test responsibilities, refine test documentation, and discrepancy management encompass eight major CPT recommendations.

The most significant process change is the customer's agreement to accept the test results from CEVT. Repetition of these tests by the Government is no longer a requirement. This commitment eliminates the single largest cycle of testing from the current acceptance test process.

In point of fact, ST 2000 places the responsibility to thoroughly execute CEVT squarely on the contractor. It must be conducted to the same level as required for developmental performance testing previously conducted by the Government. This means that test results must be documented, verifiable and repeatable. Failure to execute stringent, valid testing with documented results will motivate the customer to demand a repeat of previously run tests and will again require 100% witnessing of CEVT. If the contractors do not perform their part, the customer has no alternative but to revert back to the existing test philosophy. The customer has extended the opportunity, the contractor must aggressively respond for ST-2000 to be viable.

APPENDIX A

CPT MEMBER BIOGRAPHIES

WILLIAM J. ADAMS BIOGRAPHICAL DATA

William J. Adams is presently the Associated Director of Systems Engineering for Hughes Simulation Systems, Inc. Mr. Adams is responsible for Visuals, Operator Trainers, Maintenance Trainers and Naval Combat Systems. Mr. Adams has direct experience in development and sell-off testing in each of these product areas.

Design and development of the Torpedo Handling System for the DD 963 Spruance Class Ship was the first exposure to the Acceptance test process. This activity covered development testing through sell-off aboard ship. Test sell-off included both a Prime and the U.S. Navy. This was followed by the assignment to develop the Modular Combat System which is a fully distributed computing Fire Control System. As part of this responsibility Mr. Adams not only directed total System acceptance but also lead the Acceptance Teams for major subcontractor equipment; HR-76 Track Radar, SPS-58 Surveillance Radar; UPA-62 Display Systems, totaling in excess of $50 million. Recent assignments include the management of the F-15 and F-16 maintenance Trainers and hands on Acceptance test of the GBU-15 Part Task Trainer, (Visuals and Database).

Mr. Adams graduated from Loyola University of Los Angeles in January 1967 with a Bachelor of Science degree in Mechanical Engineering. He has an MBA in Finance from University of Southern California, 1971 and Masters in Computer Science from West Coast University, 1978.

A.F. EMERSON BIOGRAPHICAL DATA

Mr. Emerson is presently the Vice President of Quality for ECC International Corp. where he has been employed since 1973. Since that time he has established and managed the Integrated Logistic Support, Reliability and Maintainability Engineering, Customer Service, Technical Publications and Training Departments.

Prior to joining ECC, Mr. Emerson had extensive experience in Electrical Engineering - University of Maryland; Reliability Engineering - General Electric Co.; Quality Control Engineering - Spartan Electronics; Quality Management - Marine Resources; Reliability and Quality Management - Fourdee Inc.

GERALD KOSYDAR BIOGRAPHICAL DATA

Gerald M. Kosydar has over 26 years of experience in all aspects of simulation and training systems. He currently is Director - Advanced Engineering and Technology for Systems and Products at CAE-Link Corporation's Link Flight Simulation Division.

Prior to this assignment, Mr. Kosydar was Director Engineering - Special Programs, which included directing the engineering effort for the Link B-2 Training Systems Program. Other prior assignments include Director - Air Force Advanced Simulation Technology and Director - Commercial Engineering Technology where he directed engineering development, including the Micro-Simulation Technology program that introduced microprocessor and VLSI technology into the Link simulation product line.

Mr. Kosydar also directed, managed, and was responsible for the Advanced Simulation Technology program which introduced Large Scale Integration and Advanced Integrated Technology into both Link's military and commercial product lines.

Other Engineering assignments included: Manager - Systems and Integration, Manager - Computer and Instructional Systems, Manager - Advanced Tactics Development, and Manager - Special Products, which included motion systems, visual systems, and computer interface and I/O development.

Earlier Mr. Kosydar was the Lead Engineer for the tactics portion of F-4 simulators, and designed radar and tactical simulations for the F-111, J-35, and development designs for new programs.

Before joining Link, Mr. Kosydar was responsible for advanced development engineering in the ASN/USW field and design engineering of the test facility for the F-111A inertial reference system for General Dynamics.

Mr. Kosydar spent three years in the Navy specializing in Radar Electronics. He holds a B.S. degree in Physics from the University of Scranton.

ROBERT A. LILLIE BIOGRAPHICAL DATA

Mr. Lillie is presently the Chief Engineer for the Tactical/ Trainers Programs, Training Systems SPO. His responsibilities include supervising program development, training requirements definition, design, acquisition, and testing of simulators and training systems for Tactical and Air Training Commands.

EXPERIENCE:

Nov 1979 - Dec 1989: Lead Engineer for the F-16 Weapons System Trainer (WST). Responsible for the technical efforts associated with the design and test of the flight simulator and visual, EW, and DRLMS subsystems. Planned and conducted testing on all F-16 WST configurations and integration testing. Tested all Foreign Military Sales versions of the F-16 WST.

Jun 1973 - Nov 1979: Aerospace Engineer. Provided functional engineering support to various simulator programs. Analyzed aerodynamic data requirements, worked with flight test organizations, monitored aerodynamic modeling, and performed qualification and acceptance testing of T-37, T-38, C-130, B-52, and KC-135 simulators.

SAM MALENE BIOGRAPHICAL DATA

Mr. Malene is employed at Loral Defense Systems Division in Akron, Ohio. He has been with the company for 15 years working in various simulator engineering capacities. Prior to that, he served in the U.S. Navy flying patrol aircraft. His present position is Deputy Program Director for the F-15E Weapon Systems Trainer. In this capacity, he has overseen the test and checkout of three highly complex and sophisticated training devices. Prior to this assignment, he was the project engineer for two F-15J Flight Simulators for the Japanese. He has worked as a development and test engineer and was involved with system checkout and test on six F-15 Operational Flight Trainers for the U.S. Air Force. He also has helped install several simulators and numerous modifications to field sites. He has additional experience working with automatic test equipment to check electronic circuit cards used in simulation.

Mr. Malene has a B.S. in Electrical Engineering from the University of Dayton, and M.B.A. from the University of Akron and is a graduate of the Program Management Course at Defense Systems Management College at Ft. Belvoir, VA.

LAWRENCE L. STEWART BIOGRAPHICAL DATA

Lawrence L. Stewart is Manager of Systems Test at the Link Flight Simulation Division (LFSD) of CAE-Link, Binghampton, New York. Mr. Stewart has been continuously employed within the LFSD integration and test organization where he currently manages test and delivery of helicopter and fixed wing systems including F-4, C-130, UH-60, AH-64, and software support centers.

Mr. Stewart is a 1965 graduate of the U.S. Naval Academy, with a MS in Industrial Management from Rensselaer Polytechnic Institute. His Navy training included Naval Flight Training and graduation from the Naval War College, Newport, Rhode Island. Mr. Stewart's twenty year Naval Aviation career included fleet and training tours in P3 Patrol Aircraft, training aircraft, and the USS LEXINGTON. Overseas duty extended from Vietnam to the Mediterranean, North and South Atlantic, and Central America. He has extensive training experience in Navy primary aircraft and simulation, including assignment as a Quality Assurance Representative and Contracting Officer's Technical Representative during his last three year tour of duty. During that same period, he was the Chief of Naval Training UC-12B and C-131 NATOPS evaluator.

Throughout Mr. Stewart's Navy career he was responsible for increased training efficiency initiatives including radical downward manpower restructuring of Navy Training Squadrons in the wake of contractor maintenance programs and significant increases in the use of simulator training time within Navy primary and advanced propeller training.

JOHN M. THORN BIOGRAPHICAL DATA

Mr. Thorn possesses twenty-six years of simulation experience and has held a variety of positions in all areas of the simulation/ simulator environment including maintenance, design, integration, and test.

Currently, Mr. Thorn is Manager of the Test Engineering Department of McDonnell Douglas Training Systems, St. Louis. Past positions include:

o **Manager - Test Engineering Section -**	**Reflectone**	1986-89
o Group Leader - Avionic	Reflectone	1982-86
o Avionics Lead Engineer A310/B747 Simulators	Reflectone	1981-82
o Project Engineer CH-46D	Reflectone	1979-81
o Project Engineer (R & D) at Crew Station Design Facilities Wright Patterson AFB	LINK	1971-79
o Site Manager - Mather AFB FB-111 Nav/Bomb Training Device	LINK	1969-70
o Test Engineer - F111 Program	LINK	1968-69
o Radar Training Device Specialist	USAF	1964-68

PUBLICATIONS:

Simulate versus Stimulate: Avionic Nov, 1984

FLOYD WEAVER BIOGRAPHICAL DATA

Floyd W. Weaver is presently the Lead Simulator Test Pilot for FlightSafety Services Corporation's C-5B Aircrew Training System located at Altus Air Force Base, Oklahoma. Mr. Weaver's association with Services Corporation began on March 31, 1986 when he was selected to perform acceptance testing of six new C-5B FAA Phase II Weapons System Trainers and four redesigned Crew Procedure Trainers built by CAE-Montreal for United States Air Force aircrew training.

Mr. Weaver graduated from Memphis State University at Memphis, Tennessee, with a Bachelor of Science in Industrial Psychology. He was then commissioned in the United States Air Force and selected for Undergraduate Pilot Training, completing qualifications as an Air Force pilot in November, 1960. Additional educational studies include Professional Military Education and graduate courses in business management.

Mr. Weaver's career in the Air Force spanned a period of over twenty-six years. His interest in simulator devices and aircraft testing began in 1970, when he accomplished in-plant and on-site acceptance testing of the original C-5A Mission Flight Simulator. During his remaining Air Force career, he was the Military Airlift Command's Test Pilot to test and accept several new C-5 systems, including the Ground Proximity Warning System, Triple Inertial Navigation System, and the Fuel Savings Advisory System. He also conducted the initial flight tests to verify the compatibility of the C-5 aircraft to air refuel with the KC-10 aircraft, with emphasis on structural as well as operational requirements.

As part of his current duties with Services Corporation, Mr. Weaver flies the C-5 airplane on a regular basis to compare the simulator performance with the actual aircraft and to test system modifications. Mr. Weaver is an FAA Certified Flight Instructor with over 11,400 flight hours as a pilot.

F.J. "CHIP" WINTER BIOGRAPHICAL DATA

Mr. Winter has technical and managerial experience with both the Federal Government and industry. He was employed as a flight test engineer by General Dynamics in Fort Worth, Texas, responsible for conducting tests on advanced aircraft weapon systems. As a senior systems design engineer for Northwest Airlines in Minneapolis, Minnesota, he was responsible for implementing system improvements to the commercial aircraft fleet.

Employed by the Aeronautical Systems Division (ASD) at Wright-Patterson AFB Ohio since 1964, he has held various positions on key Air Force programs. He was assigned to the Air Force Flight Dynamics Laboratory, Flight Research and Test Branch, where he was project engineer for refined flight control and display investigations. He also managed and conducted the Federal Aviation Administration sponsored Phase II microwave landing system research simulation.

Mr. Winter is currently assigned to the ASD Training Systems SPO as the Director of Acquisition Management. He is responsible for the test and deployment planning and implementation for each of several strategic, tactical and airlift programs. He has written and presented several articles and technical reports and he has been a member of the American Helicopter Society, the Society of Flight Test Engineers, and the American Institute of Aeronautics and Astronautics. He is currently a member of the Air Force Association and the Interservice Industry Training Systems Conference steering committee. He holds a Bachelor of Science degree in Aeronautics and a Master of Arts degree in Psychology.

APPENDIX B

CURRENT TEST PROCESS FLOWCHART

DESCRIPTION OF THE CURRENT TEST PROCESS FLOWCHART

Page 1 of the flowchart shows the RFP/Proposal/Contract Award process where the test requirements are first addressed and agreed to. The system requirements are then reviewed and design data is requested.

Page 2 describes the preliminary system design and design review processes where specific requests for action (RFAs) are answered causing delays or worse...rejecting the PDR.

Page 3 describes the Critical Design Review (CDR) and the hardware/software design processes. Generation of test procedures, hardware drawing release, and software coding all follow CDR approval.

Page 4 depicts how testing is begun with subsystem or unit testing and then continued with hardware/software integration. Any problems encountered require redesign and rewrite of test procedures.

Page 5 shows the contractor verification test cycle and results in a statement of test readiness to the Air Force. Test Readiness Review (TRR) #1 is conducted prior to a Computer Program System Generation (CPSG) test or "cold start".

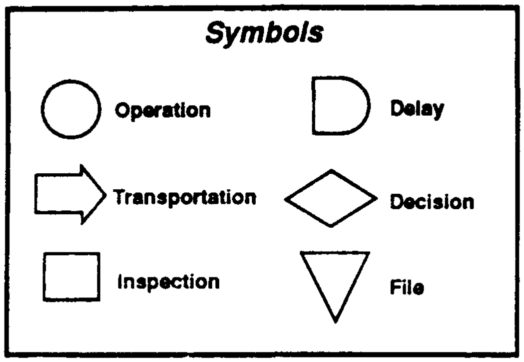
Page 6 shows the cold start process and the functional check of the device that determines operational status of the software load prior to the second TRR.

Page 7 describes the Government in-plant performance test and operational evaluation processes including TD resolution.

Page 8 shows TRR #4 to determine if the device is ready to ship. The contractor on-site installation and verification tests are also shown prior to on-site Government acceptance testing.

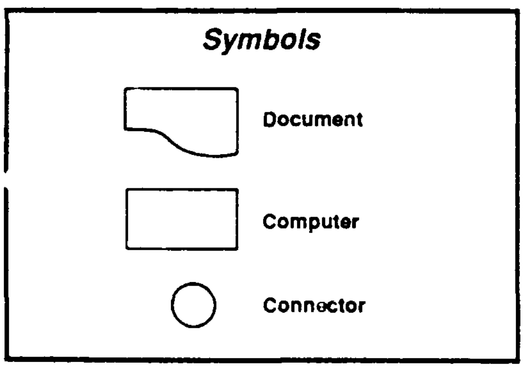
Page 9 shows the last test cycle, operational evaluation, and TD recheck, prior to the final acceptance.

PROCESS ANALYSIS



Symbols are the language of Process Analysis. There are nine symbols, six of which represent different types of tasks. They are:

Operation - means to create or change something.
Transportation - denotes physical movement.
Inspection - used when something is checked or verified.
Delay - represents any temporary stoppage in work.
Decision - used whenever a decision causes the workflow to split; for example, into separate "o.k." and "not o.k." paths.
File - used to represent the filing of documents.



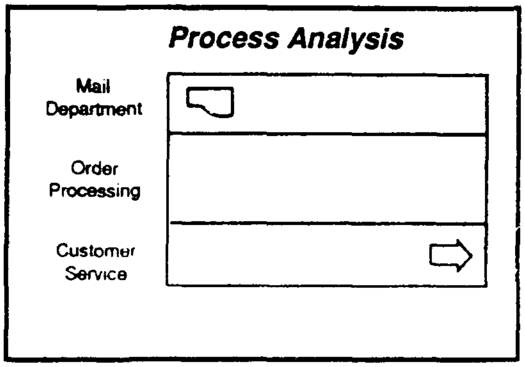
There are three others which are useful:

Document - used for any piece of paper.
Computer - represents any computer or computer system.
Connector - used to link different parts of the diagram whenever drawing flow lines is confusing or impractical.

The PA kit contains hundreds of each of these symbols. A description of each task or activity in the workflow can be written directly on the symbol and the symbol can be applied to the charting paper.

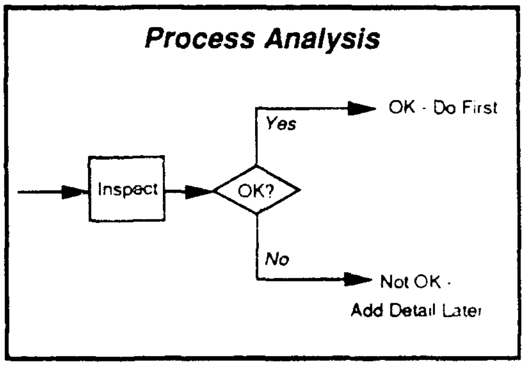
QAC033

PROCESS ANALYSIS



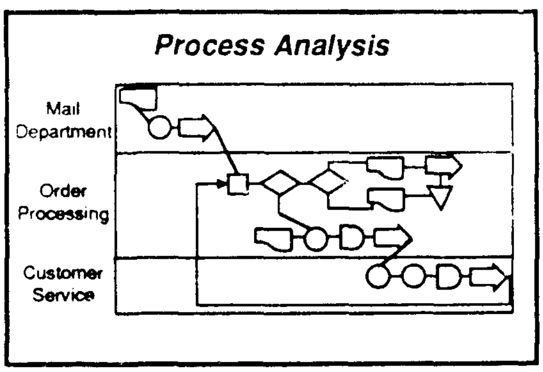
To construct the chart, the charting paper is attached to the wall. The team identifies the different departments or groups involved in the process and assigns a horizontal section of the chart to each. Then, symbols are added to the chart to represent the beginning and ending of the process. The task remaining is to fill in the blank space.

As the team continually asks, "What happens next?" appropriate symbols are added with descriptions and connecting flow lines.



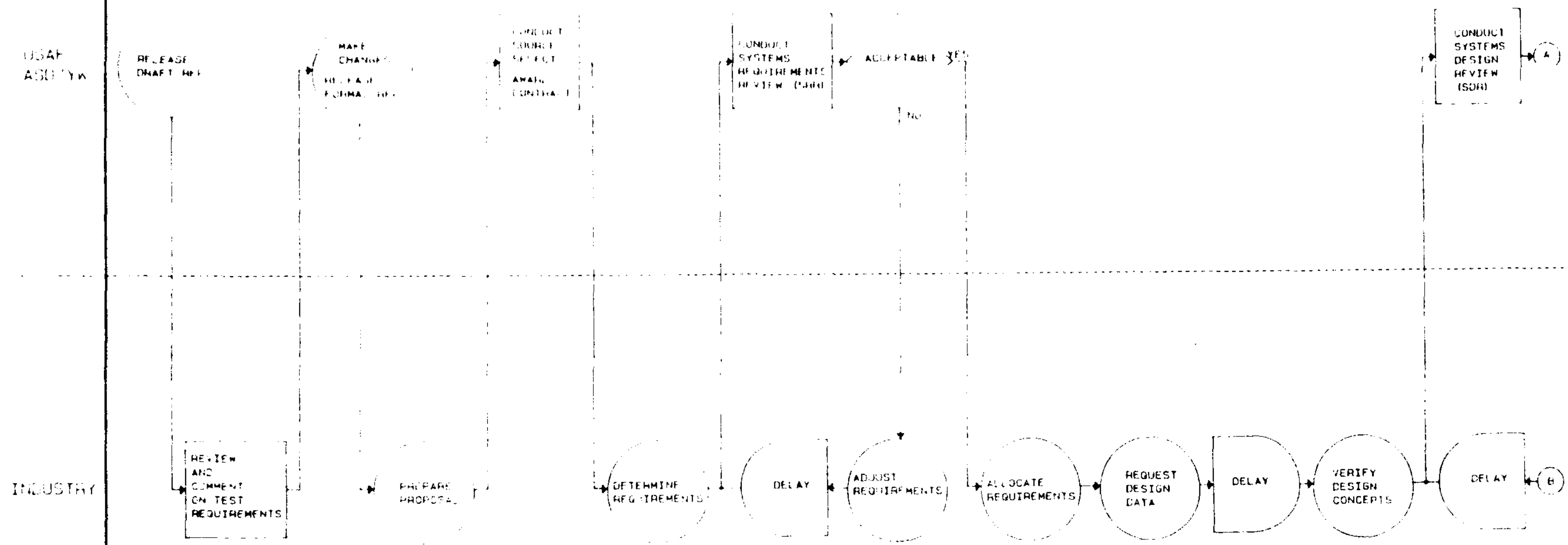
A good flowcharting tip is not to get immediately lost in the detail of what happens when an error occurs.

The first time though, the team should note the decision points and assume everything is "o.k." Then, the detail for the "not o.k." paths can be added. The resulting chart will be much more readable.



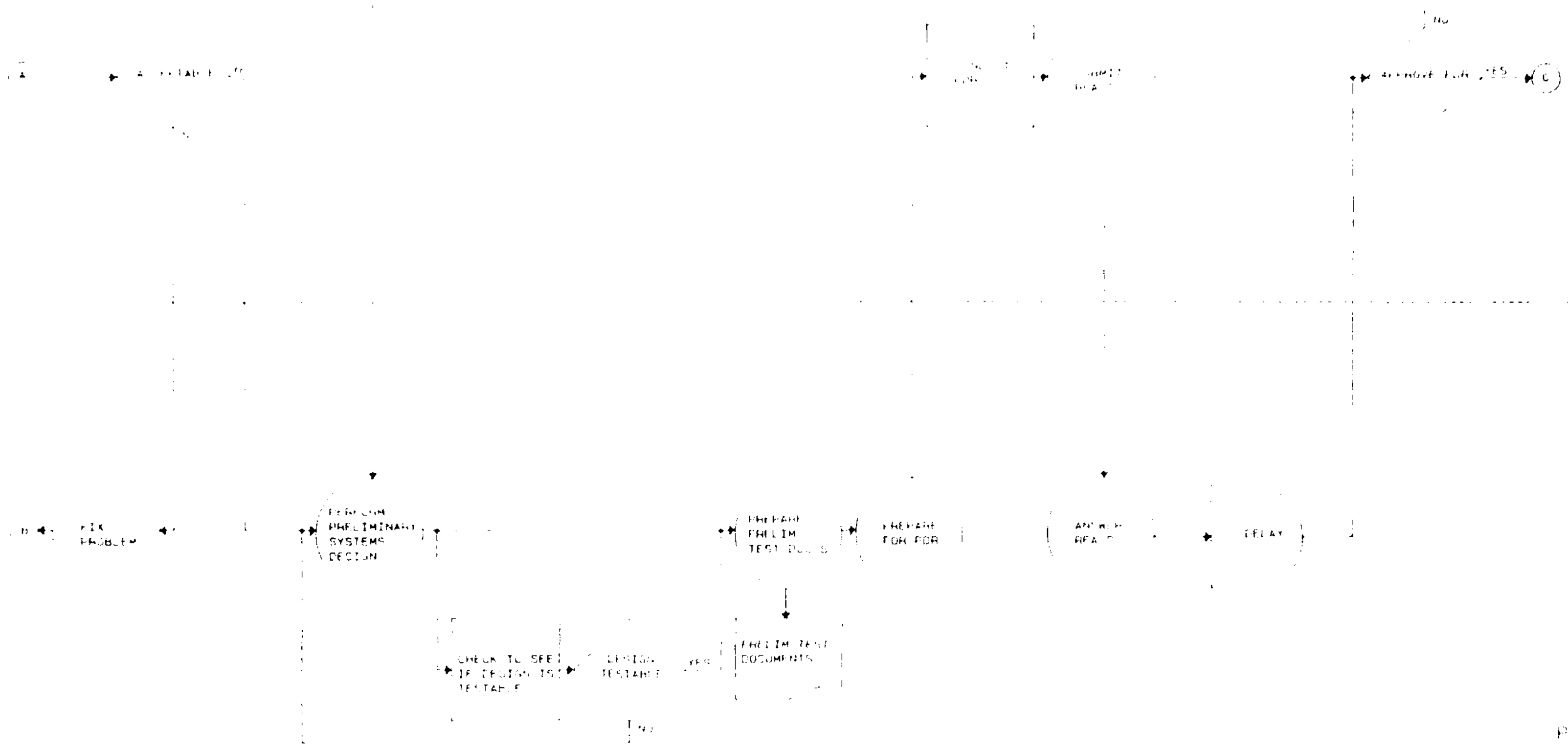
A flowchart for a cross-functional process might look like this when completed.

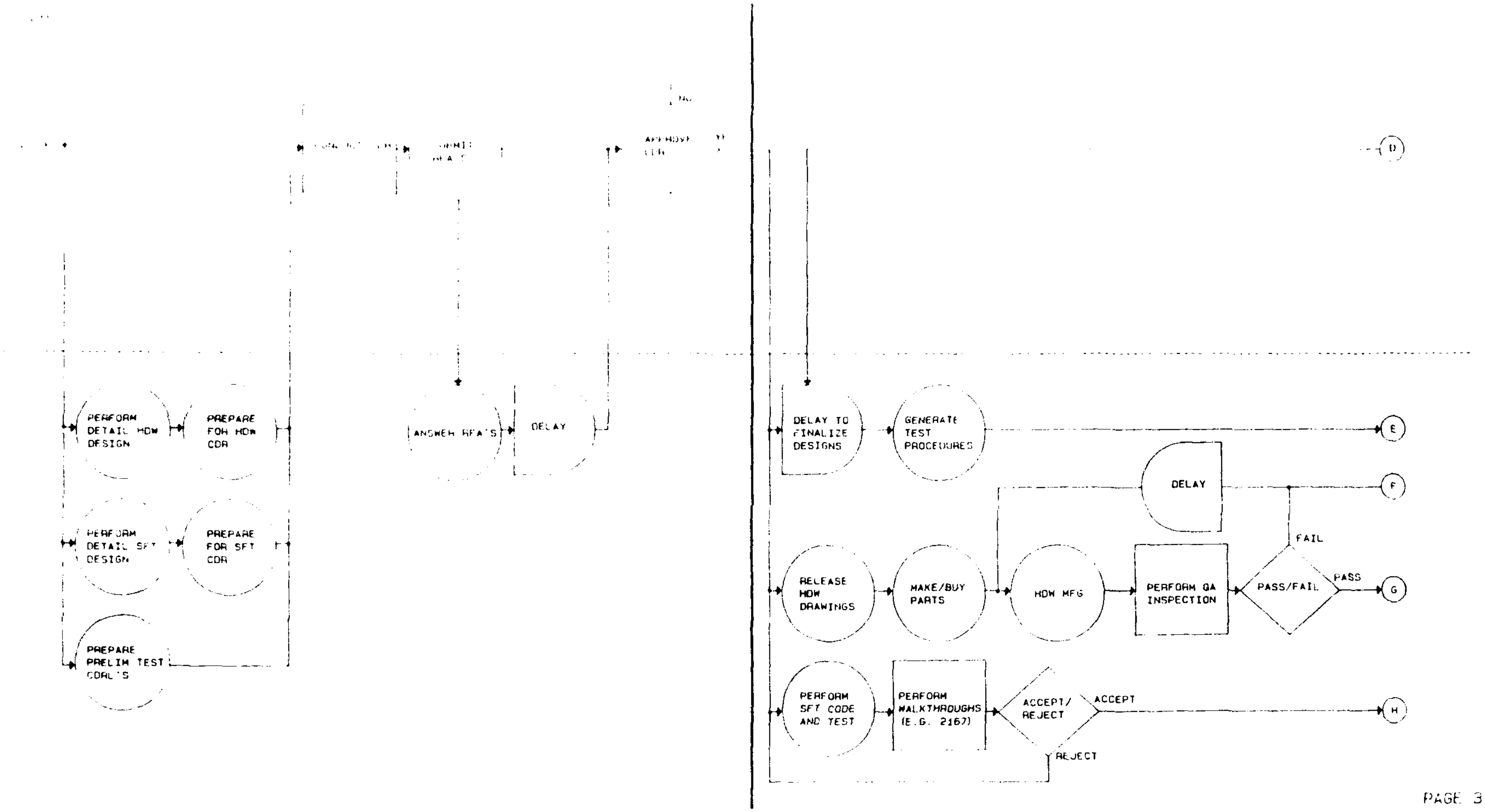
QAC032

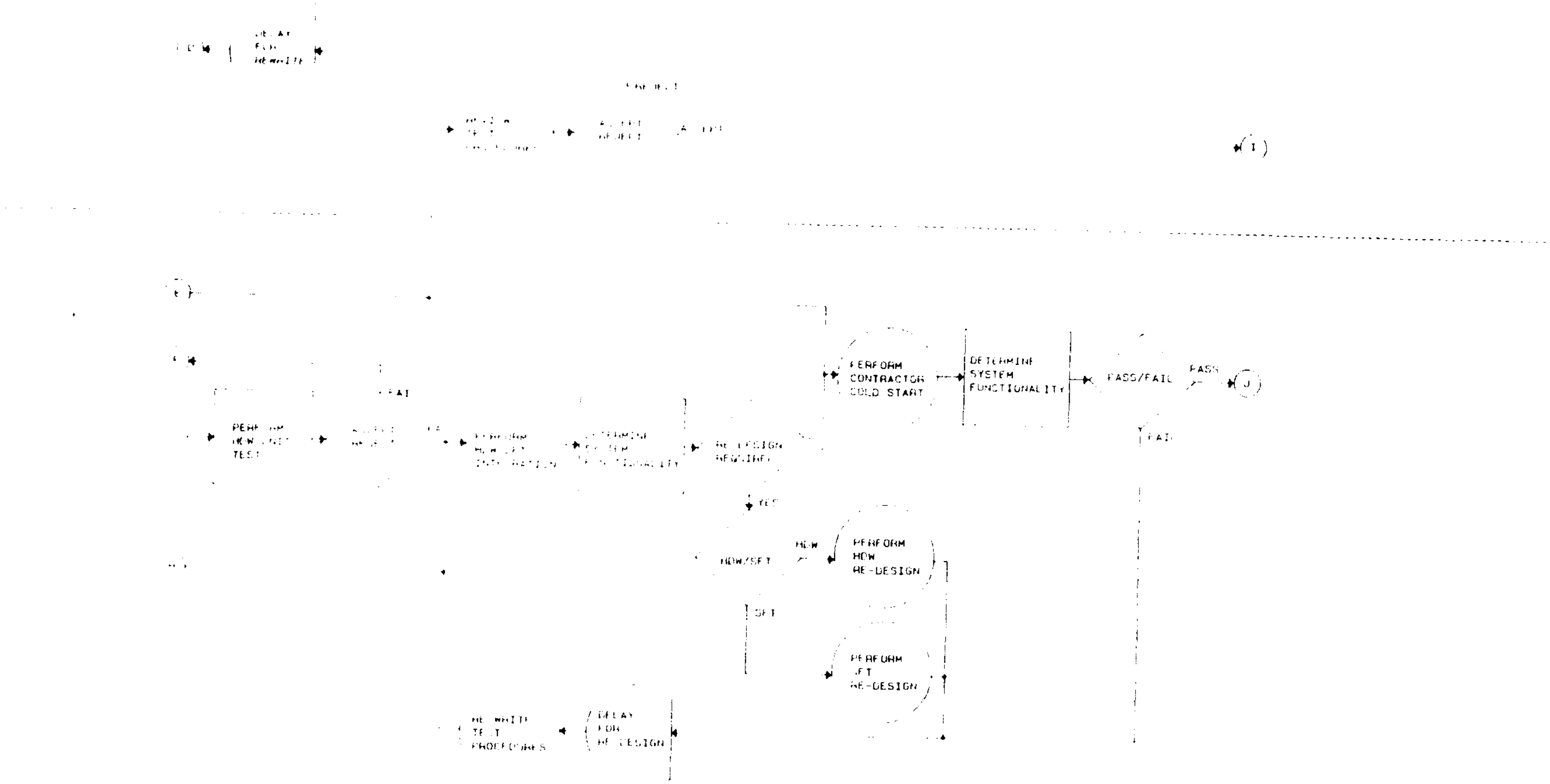


NOTE REFLECTS TYPICAL ACQUISITION PROCESS EMPHASIS BY CPT IS ON TESTING

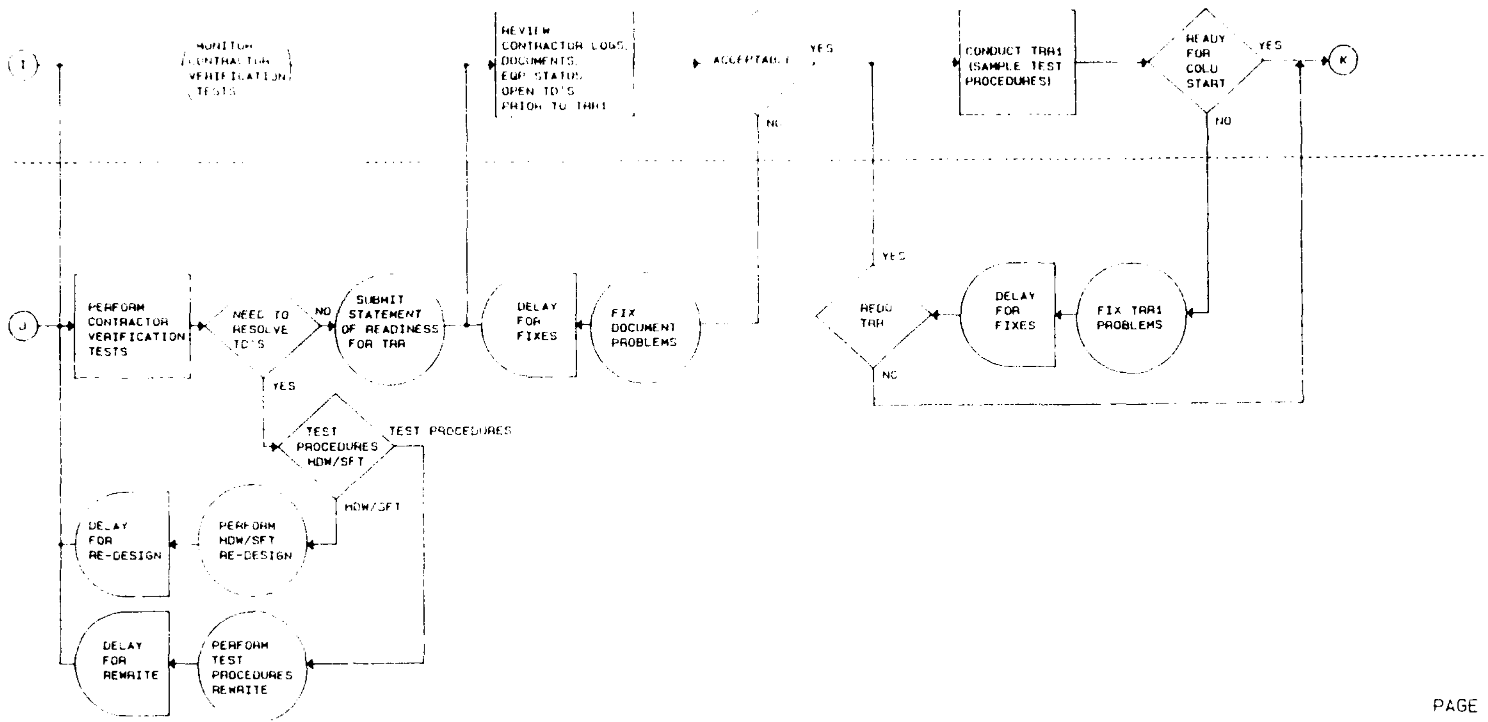
SIMULATOR TESTING MAIN FLOW (REV A

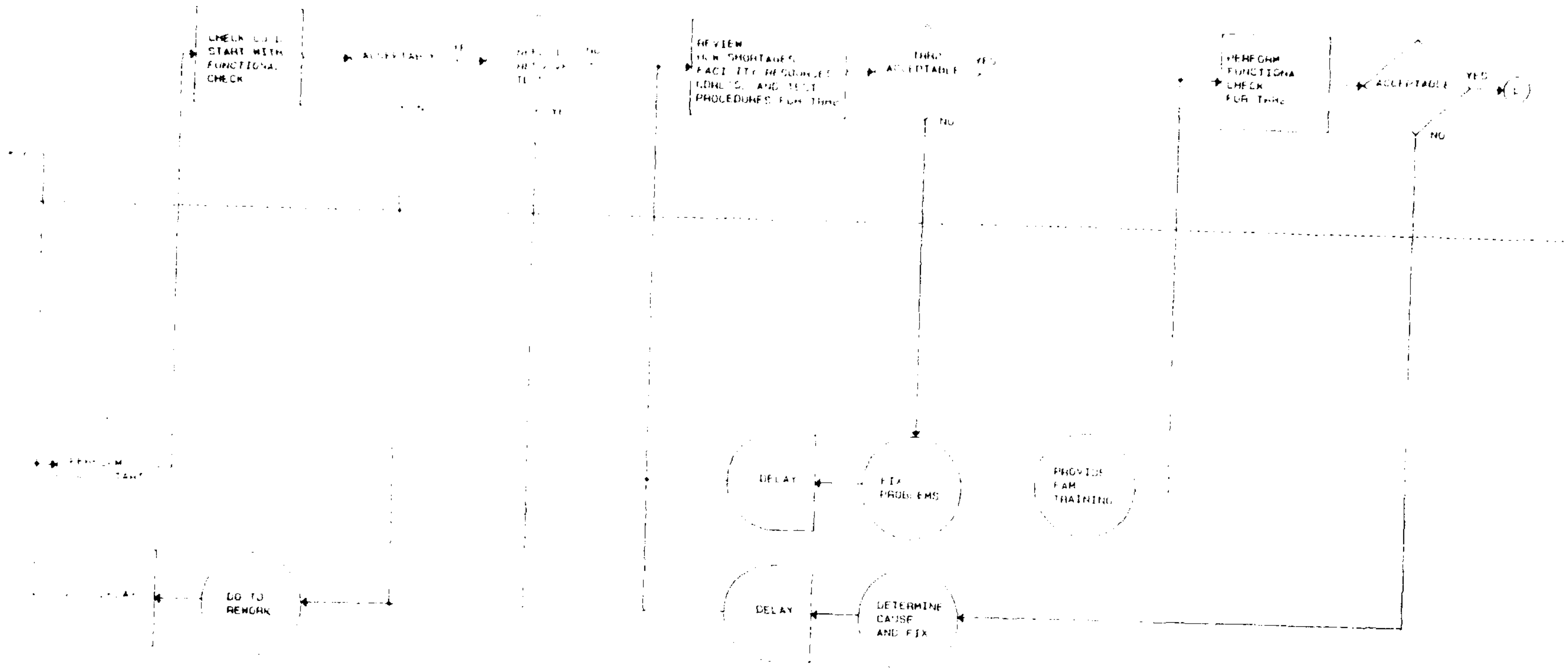

FIX PROBLEM
PERFORM PRELIMINARY SYSTEMS DESIGN
CHECK TO SEE IF DESIGN IS TESTABLE
DESIGN TESTABLE
YES
NO
PRELIM TEST DOCUMENTS
PREPARE PRELIM
PREPARE FOR PDR
DELAY
C

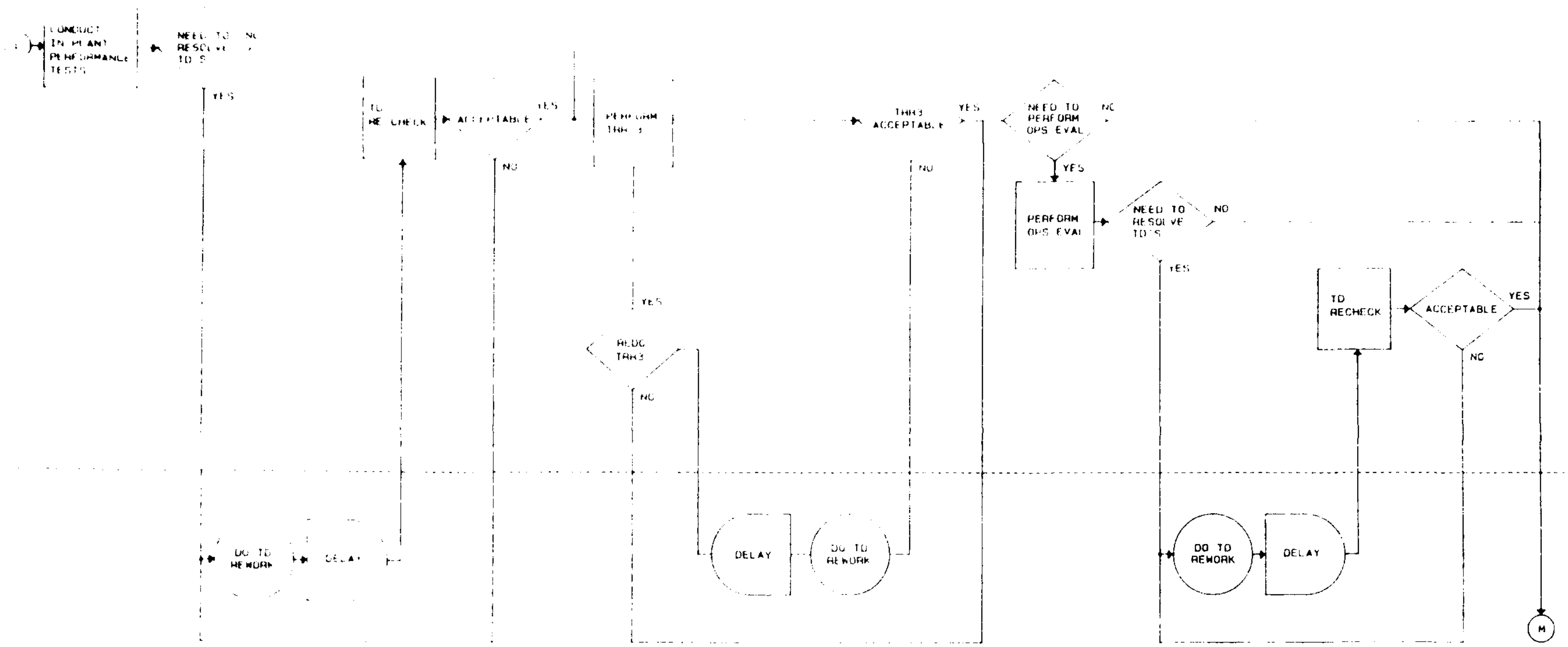

PERFORM DETAIL HDW DESIGN
PREPARE FOR HDW CDR
PERFORM DETAIL SFT DESIGN
PREPARE FOR SFT CDR
PREPARE PRELIM TEST COAL'S
ANSWER RFA'S
DELAY
DELAY TO FINALIZE DESIGNS
GENERATE TEST PROCEDURES
E
DELAY
F
RELEASE HDW DRAWINGS
MAKE/BUY PARTS
HDW MFG
PERFORM QA INSPECTION
PASS/FAIL
FAIL
PASS
G
PERFORM SFT CODE AND TEST
PERFORM WALKTHROUGHS (E.G. 2167)
ACCEPT/ REJECT
ACCEPT
REJECT
H
D

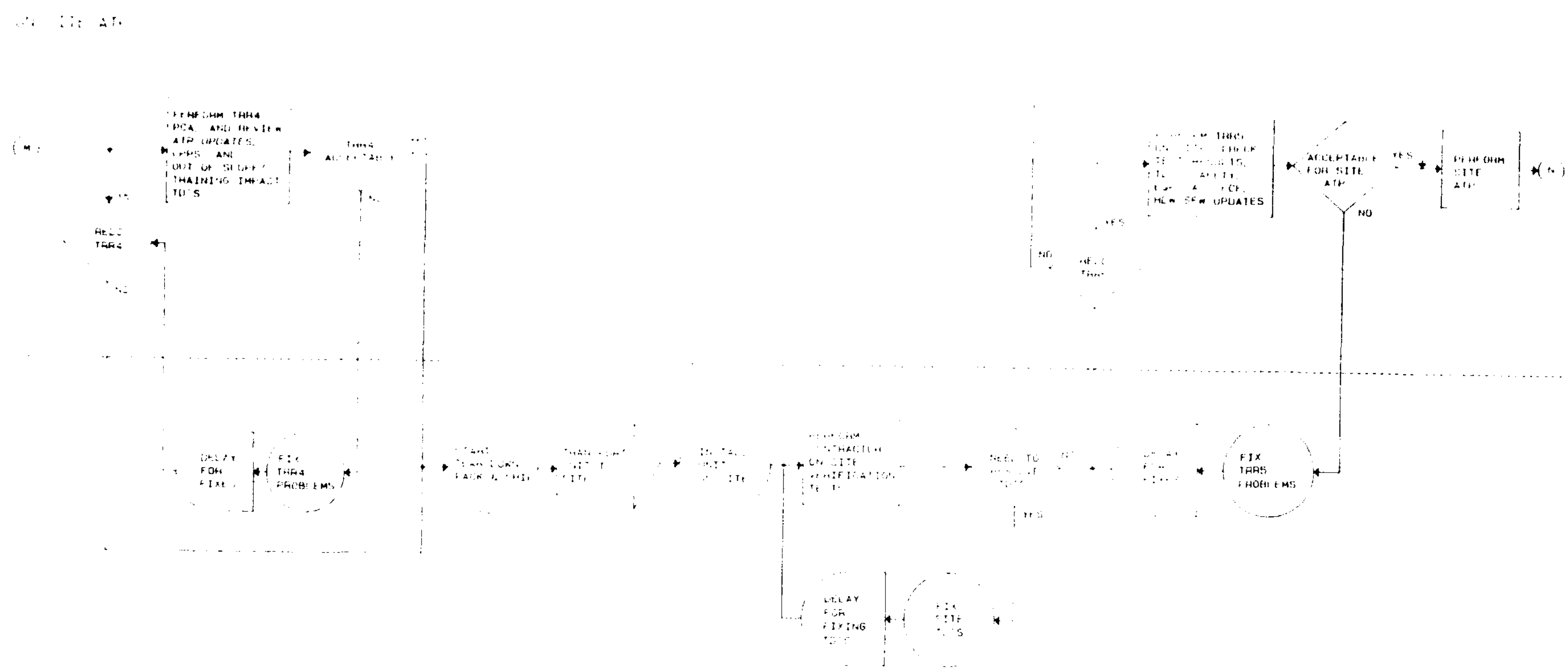

PERFORM
CONTRACTOR
COLD START
DETERMINE
SYSTEM
FUNCTIONALITY
PASS/FAIL
PASS
FAIL
J
I
PERFORM
HDW
RE-DESIGN
PERFORM
SFT
RE-DESIGN
HDW/SFT
HDW
SFT
YES
DELAY
FOR
RE-DESIGN

PAGE 4


I
MONITOR CONTRACTOR VERIFICATION TESTS
REVIEW CONTRACTOR LOGS, DOCUMENTS, EQP STATUS, OPEN TO'S PRIOR TO TRR1
ACCEPTABLE
YES
NO
CONDUCT TRR1 (SAMPLE TEST PROCEDURES)
READY FOR COLD START
YES
NO
K
J
PERFORM CONTRACTOR VERIFICATION TESTS
NEED TO RESOLVE TO'S
NO
YES
SUBMIT STATEMENT OF READINESS FOR TRR
DELAY FOR FIXES
FIX DOCUMENT PROBLEMS
REDO TRR
YES
NO
DELAY FOR FIXES
FIX TRR1 PROBLEMS
TEST PROCEDURES HDW/SFT
TEST PROCEDURES
HDW/SFT
DELAY FOR RE-DESIGN
PERFORM HDW/SFT RE-DESIGN
DELAY FOR REWRITE
PERFORM TEST PROCEDURES REWRITE

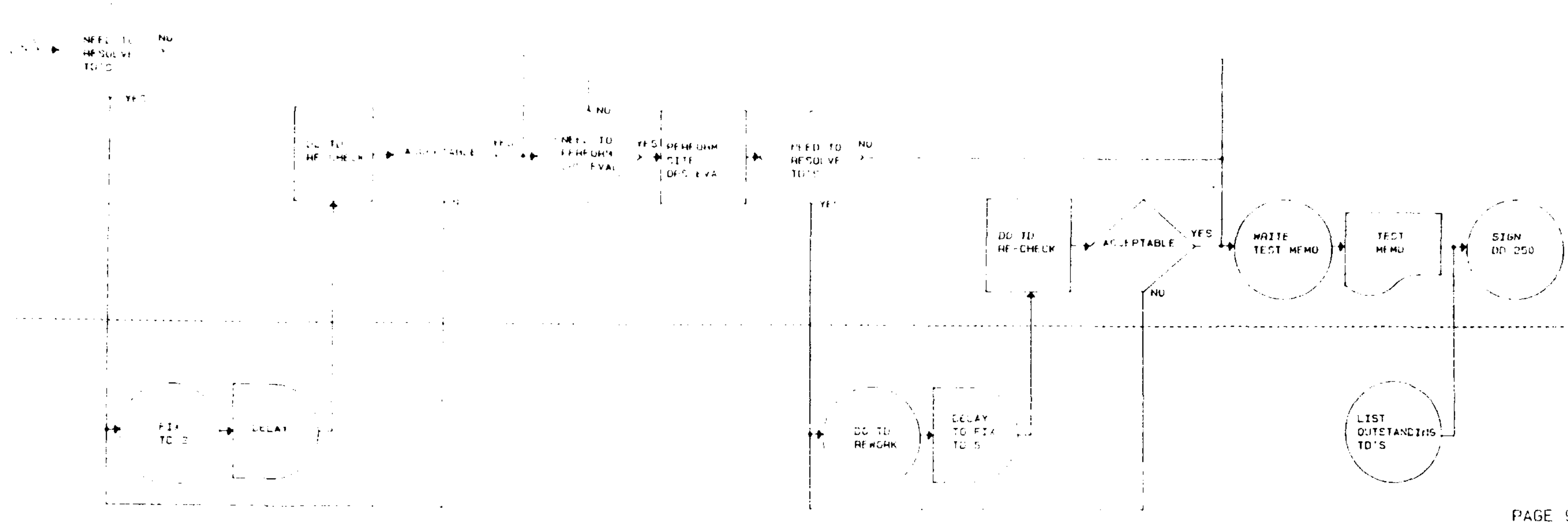

CHECK
START WITH
FUNCTIONAL
CHECK
REVIEW
SHORTAGES
PROCEDURES FOR
ACCEPTABLE
YES
NO
PERFORM
FUNCTIONA
CHECK
FOR
ACCEPTABLE
YES
NO
DELAY
FIX
PROBLEMS
PROVIDE
FAM
TRAINING
DELAY
DETERMINE
CAUSE
AND FIX
GO TO
REWORK


CONDUCT IN-PLANT PERFORMANCE TESTS
NEED TO RESOLVE TD'S
YES
NO
DO TO REWORK
DELAY
TO RECHECK
ACCEPTABLE
YES
NO
PERFORM THR 3
YES
REDO THR3
NO
DELAY
DO TO REWORK
THR3 ACCEPTABLE
YES
NO
NEED TO PERFORM OPS EVAL
YES
NO
PERFORM OPS EVAL
NEED TO RESOLVE TD'S
YES
NO
DO TO REWORK
DELAY
TO RECHECK
ACCEPTABLE
YES
NO
M



PERFORM TRR4
RELC TRR4
THR4 ACCEPTABLE
DELAY FOR FIXES
FIX TRR4 PROBLEMS
ACCEPTABLE FOR SITE ATP
YES
NO
PERFORM SITE ATP
NEW SFW UPDATES
FIX TRR5 PROBLEMS
DELAY FOR FIXING

PAGE 8



NO
YES
NO
YES
PERFORM
SITE
NEED TO
RESOLVE
NO
YES
DO TD
RE-CHECK
ACCEPTABLE
YES
NO
WRITE
TEST MEMO
TEST
MEMO
SIGN
DD 250
DO TD
REWORK
DELAY
TO FIX
LIST
OUTSTANDINGS
TD'S

PAGE 9

APPENDIX C

TRAINING SYSTEM TYPES

TRAINING SYSTEM TYPES

- MAINTENANCE TRAINER
  - SPECIFIC SYSTEM/SUBSYSTEM TASKS
- PART TASK TRAINER (PTT) - AIRCREW & MAINTENANCE
  - DISCRETE TASKS
- OPERATIONAL FLIGHT TRAINER (OFT)
  - DYNAMICALLY SIMULATES ACTUAL FLIGHT CHARACTERISTICS
  - LIMITED MISSION EXECUTION
- MISSION TRAINER (MT)
  - MISSION ORIENTED WARFARE ENVIRONMENT FOR WEAPON SYSTEMS OPERATIONS
- WEAPON SYSTEM TRAINER (WST)
  - FLIGHT AND SYSTEMS OPERATION
  - MISSION REHEARSAL

APPENDIX D

DATA COLLECTION QUESTIONNAIRE

(MILITARY PROGRAMS)

QUESTIONNAIRE

PURPOSE

To gather and analyze performance parameters associated with formal customer test acceptance. The objective is to streamline the test effort without compromising the confidence in the test program. The customer is not to assume any additional risk due to streamlining efforts.

RESULTS

Your participation will assure you of obtaining the findings determined by the CPT and any recommendations being proposed.

I. Data will be collected in four primary areas:

- Test Milestones
- Test Discrepancies
- Test Duration
- Test Documentations

Note: Only data for the development unit (first article) is solicited.

II. Name of program: ______________________________

1. Test Milestones:

Dates requested are those dates met or missed with respect to planned or actual schedules at concract award. Comment on differences.

Data requested for the following specific start and completion date if applicable/available.

	Original Date	Actual
Customer Test Readiness Review	________	________
Customer Coldstart	________	________
Customer in-plant First Article Test Readiness Review	________	________
Customer in-plant First Article Development	________	________
Operational Evaluation	________	________
Teardown/Pack	________	________
Ship	________	________
Customer on-site First Article Test Readiness Review	________	________

	Original Date	Actual
Customer on-site First Article Tests		
Acceptance		
Operational Evaluation		
Sell off (customer acceptance)		

2. Test Duration (Actual test days):

	Plan Days	Actual Days	Hours /Day	Days/ Week	Comments
Customer cold start					
Customer in-plant development					
Customer in-plant operational evaluation					
Contractor on-site installation and test					
Customer on-site acceptance					
Customer on-site operational evaluation					

3. Test Discrepancies:

Number of contractor discrepancies open at TRR ______________

Number of contractor discrepancies at start of tests ______________

Total number of customer discrepancies (first unit) ______________

Number of customer discrepancies resubmitted ______________
(A discrepancy resubmitted four times would count as four)

Number of contractor discrepancies from internal Dry Run ______________

Number of customer discrepancies post sell-off ______________

Number of customer discrepancies judged out-of-scope ______________

Number of customer discrepancies against test procedures ______________

4. Test Documents:

Development test procedures.

Number of pages ________

Number of steps/page ________

Number of steps for major subsystems (i.e., radar, visual aero, powerplant, motion, etc.) ________ ________ ________ ______

Test Matrix

Total number of inspections ________

Total number of analysis ________

Total number of demonstrations ________

Total number of tests ________

5. Engineering change activity

CDR through start of customer tests. Comment with respect to impact on the test process. Qualify if possible, i.e., ECN, SLR's, etc.

- o CDR to start of Hardware/Software Integration ________________
- o Hardware/Software Integration to TRR ________________________
- o TRR to sell ____

Range the type of change activity that most impacts test.

- o Internal/Engineering activity ______________________________
- o Changes to close customer DR's ____________________________
- o Incorporation of late data, configuration/performance change etc. ____________________

6. Program Complexity Indicators:

a. Lines of Code ________

b. Number of CPU's ________

c. Major subfunctions ________

d. Other significant characteristics

7 Provide any specific comments or/and recommendations which would in your opinion make the formal Customer Test phase more cost effective.

APPENDIX E

DATA COLLECTION QUESTIONNAIRE

(COMMERCIAL AIRLINES)

QUESTIONNAIRE

PURPOSE

To gather and analyze performance parameters associated with formal customer test acceptance. The objective is to streamline the test effort without compromising the confidence in the test program. The customer is not to assume any additional risk due to streamlining efforts.

RESULTS

Your participation will assure you of obtaining the findings determined by the CPT (Critical Process Team) and any recommendations being proposed.

I. Data will be collected in four primary areas:

- Test Schedules
- Test Discrepancies
- Test Duration
- Test Documentations

II. Name of program: ______________________________

1. Test Schedule:

   Dates requested are those dates met or missed with respect to planned or actual schedules at contract award. Comment on differences.

   Data requested for the following specific start and completion date if applicable/available.

	Original Date	Actual
Customer in-plant Engineering Test	________	________
Customer in-plant FAA Evaluation	________	________
Teardown/Pack	________	________
Ship	________	________
Contractor on-site installation and test	________	________
First Readiness Review	________	________
Acceptance Testing	________	________
FAA Evaluation	________	________
Sell off (customer acceptance)	________	________

(BACPT2) Date: 3/13/90

2. Test Discrepancies:

Number of customer discrepancies ____________________

Number of open customer discrepancies post sell-off ____________

Number of customer discrepancies judged out-of-scope ____________

Number of customer discrepancies resubmitted ______________
(A discrepancy resubmitted four times would count as four)

3. Test Duration (Actual test days):

	Plan Days	Actual Days	Hours /Day	Days/ Week	Comments
Customer in-plant engineering tests	____	____	____	____	________
Contractor in-plant FAA test	____	____	____	____	________
Contractor on-site installation and test	____	____	____	____	________
Customer on-site tests	____	____	____	____	________
FAA Evaluation	____	____	____	____	________

4. Test Documents:

Engineering test procedures.

Number of pages ______

Number of steps/page ______

Number of steps for major subsystems (i.e., radar, visual aero, powerplant, motion, etc.) ______ ______ ______ ______

5. Comment as appriopriate for those activities that preceeded the stant of in-plant customer acceptance tests. Describe impact on the test process.

APPENDIX F

DATA TABLES

REVISED PAGE 1

OCT 26, 1990

		PROGRAM	TRR ORGINAL	TRR ACTUAL	TRR DUR	COLD START ORGINAL	COLD START ACTUAL	COLD START DUR	1st ART TRR ORGINAL	1st ART TRR ACTUAL	1st ART TRR DUR
1	HUGHES	PTT GBU-15 PTT	02-Feb-88	02-Aug-88	-182	02-Aug-88	03-Aug-88	-183	N.A.	N.A.	-182
2	ECC	PTT F-15E LANTRIN	29-Mar-88	29-Apr-88	-31	02-May-88	02-May-88	-31	29-Apr-88	29-Apr-88	-31
3	ASD	CPT F-16 AIR DEFENSE COCKPIT	27-Mar-89	27-Nov-89	-245	28-Mar-89	28-Nov-89	-490	N.A.	N.A.	-245
4	MDAC	WST AV8B NAWST DEVICE 2F150	25-May-89	29-May-89	-4	22-May-89	22-May-89	-4	N.A.	N.A.	-4
5	ASD	OFT EF-111	11-Mar-85	11-Mar-85	0	15-Mar-85	13-Apr-85	-29	15-Apr-85	15-Apr-85	0
6	LORAL	WST F-15E WST E3	01-Aug-89	16-Feb-90	-199	19-Jan-90	12-Mar-90	-251	29-Jan-90	27-Mar-90	-256
7	ECC	MT F-16C ELEC MAINT TR	???	???	0	???	???	0	???	???	0
8	ECC	PTT F-16C LANTRIN	27-Nov-88	27-Jan-89	-61	27-Jan-89	27-Jan-89	-61	27-Jan-89	27-Jan-89	-61
9	ECC	MT F-16C PROP MAINT TR	???	???	0	???	???	0	???	???	0
10	ECC	MT F-16C ENG OPS MAINT TR	???	???	0	???	???	0	???	???	0
11	HUGHES	MT F-16 TFE-19 ARMAMENT	09-Jan-89	03-Apr-89	-84	09-Mar-89	03-Apr-89	-109	N.A.	N.A.	-84
12	HUGHES	MT F-15 MSIP TFE-15	15-May-88	01-Aug-88	-78	01-Aug-88	01-Aug-88	-78	N.A.	N.A.	-78
13	HUGHES	MT F-15 MSIP TFE-16	16-Apr-88	01-Sep-88	-138	01-Sep-88	01-Sep-88	-138	N.A.	N.A.	-138
14	ASD	MT CH-47 EL SYS	N.A.	N.A.	0	N.A.	N.A.	0	N.A.	N.A.	0
15	ASD	MT AH-1S EL SYS	N.A.	N.A.	0	N.A.	N.A.	0	N.A.	N.A.	0
16	ASD	MT UH-1N BASIC	N.A.	N.A.	0	N.A.	N.A.	0	N.A.	N.A.	0
17	ASD	WST B-1B SIMULATOR SYSTEM	18-Oct-88	18-Oct-88	0	24-Oct-88	10-Nov-88	-17	15-Nov-88	10-Mar-89	-115

	BENCHMARK	PROGRAMS	START ENGINEERING TEST ORGINAL	START ENGINEERING TEST ACTUAL	START ENGINEERING TEST DUR	NOT APPLICABLE COLD START ORGINAL	NOT APPLICABLE COLD START ACTUAL	NOT APPLICABLE COLD START DUR	NOT APPLICABLE 1st ART TRR ORGINAL	NOT APPLICABLE 1st ART TRR ACTUAL	NOT APPLICABLE 1st ART TRR DUR
1	BCAC	737-300 STD #1	01-Feb-86	27-Jan-86	5			5			5
2	USAir	737-300 #4 Phase II	10-Oct-89	26-Jan-90	-108			-108			-108
3	DELTA	MD88 #1 PHASE II SIMUL'R	18-Sep-87	06-Jan-88	-110			-110			-110
4	NW	AIRBUS A320 SIMULATOR #3			0			0			0
5	DELTA	757 #2 AST PHASE II SIM			0			0			0
6	UAL	747-400	19-Sep-88	19-Sep-88	0			0			0
7	FS	AST C-5B WST-1	28-Apr-86	28-Apr-86	0	27-Jun-86	27-Jun-86	0	N.A.	N.A.	0
8	CAE	NUCLEAR POWER PLANT SIM			0			0			0
9	ASD	HS601 TEST EQ'T (SAT)	01-Mar-90	01-Apr-90	-31	N.A.	N.A.	-31	01-Mar-90	01-Apr-90	62

		PROGRAM	DEVELOPMENT ORGINAL	DEVELOPMENT ACTUAL	DEVELOPMENT DUR	OP EVAL ORGINAL	OP EVAL ACTUAL	OP EVAL DUR	TEARDOWN/PACK ORGINAL	TEARDOWN/PACK ACTUAL	TEARDOWN/PACK DUR
1	HUGHES	PTT GBU-15 PTT	04-Aug-88	20-Aug-88	-198	22-Aug-88	02-Sep-88	-193	06-Feb-89	09-Feb-89	[illegible]
2	ECC	PTT F-15E LANTRIN	02-May-88	02-May-88	-31	16-May-88	16-May-88	-31	03-Jun-88	03-Jun-88	[illegible]
3	ASD	CPT F-16 AIR DEFENSE COCKPIT	05-Apr-89	05-Dec-89	-489	N.A.	N.A.	-245	???	???	[illegible]
4	MDAC	WST AV8B NAWST DEVICE 2F150	30-Jun-89	30-Jun-89	-4	N.A.	N.A.	-4	10-Jul-89	18-Jul-89	[illegible]
5	ASD	OFT EF-111	30-Apr-85	15-Apr-85	15	20-Mar-86	15-Aug-86	-148	???	???	[illegible]
6	LORAL	WST F-15E WST E3	29-Jan-90	28-Mar-90	-257	01-Jul-90	15-Sep-90	-275	23-Jul-90	15-Oct-90	[illegible]
7	ECC	MT F-16C ELEC MAINT TR	???	???	0	???	???	0	???	???	[illegible]
8	ECC	PTT F-16C LANTRIN	30-Jan-89	30-Jan-89	-61	13-Feb-89	13-Feb-89	-61	25-Feb-89	25-Feb-89	[illegible]
9	ECC	MT F-16C PROP MAINT TR	???	???	0	???	???	0	???	???	[illegible]
10	ECC	MT F-16C ENG OPS MAINT TR	???	???	0	???	???	0	???	???	[illegible]
11	HUGHES	MT F-16 TFE-19 ARMAMENT	17-May-89	17-May-89	-84	17-May-89	17-May-89	-84	02-Jun-89	02-Jun-89	[illegible]
12	HUGHES	MT F-15 MSIP TFE-15	16-Oct-88	22-Nov-88	-115	16-Oct-88	22-Nov-88	-115	25-Nov-88	25-Nov-88	[illegible]
13	HUGHES	MT F-15 MSIP TFE-16	01-Oct-88	22-Nov-88	-190	01-Oct-88	22-Nov-88	-190	25-Nov-88	25-Nov-88	[illegible]
14	ASD	MT CH-47 EL SYS	N.A.	N.A.	0	10-Jun-85	10-Jun-85	0	13-Jun-85	13-Jun-85	[illegible]
15	ASD	MT AH-1S EL SYS	N.A.	N.A.	0	30-Jan-86	30-Jan-86	0	20-Feb-86	20-Feb-86	[illegible]
16	ASD	MT UH-1N BASIC	N.A.	N.A.	0	29-Oct-86	29-Oct-86	0	05-Nov-86	05-Nov-86	[illegible]
17	ASD	WST B-1B SIMULATOR SYSTEM	02-Dec-88	20-Mar-89	-108	14-Mar-89	12-Jan-90	-304	N.A.		

		PROGRAM	ENGINEERING TEST ORGINAL	ENGINEERING TEST ACTUAL	ENGINEERING TEST DUR	FAA EVALUATION ORGINAL	FAA EVALUATION ACTUAL	FAA EVALUATION DUR	TEARDOWN/PACK ORGINAL	TEARDOWN/PACK ACTUAL	TEARDOWN/PACK DUR
1	BCAC	737-300 STD #1	04-Apr-86	14-Mar-86	26	NONE	NONE	5	25-Apr-86	31-Mar-8[illegible]	[illegible]
2	USAir	737-300 #4 Phase II	10-Nov-89	24-Jan-90	-183	N/A		-108			[illegible]
3	DELTA	MD88 #1 PHASE II SIMUL'R	18-Sep-87	06-Jan-88	-220	N/A	N/A	-110	09-Oct-87	11-Apr-88	[illegible]
4	NW	AIRBUS A320 SIMULATOR #3	N/A	N/A	0	N/A	N/A	0	15-Oct-89	02-Nov-89	[illegible]
5	DELTA	757 #2 AST PHASE II SIM	NONE	NONE	0	NONE	NONE	0	???	30-Mar-88	*****
6	CAE	UAL 747-400	19-Sep-88	19-Sep-88	0	N/A		0	28-Nov-88	28-Nov-88	[illegible]
7	FS	AST C-5B WST-1	24-Jun-86	24-Jun-86	0	24-Jun-86	24-Jun-86	0	11-Jul-86	11-Jul-86	[illegible]
8	CAE	NUCLEAR POWER PLANT SIM	22-Jan-88	23-Oct-87	91	N/A		0	07-Apr-88	21-May-8[illegible]	[illegible]
9		HS601 TEST EQUIPMENT	01-May-89	01-May-89	-31	01-Feb-90	01-Feb-90	-31	15-Mar-90	22-Apr-9[illegible]	[illegible]

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	PROGRAM	SHIP ORGINAL	SHIP ACTUAL	SHIP DUR	ON-SITE TRR ORGINAL	ON-SITE TRR ACTUAL	ON-SITE TRR DUR	ON-SITE ACCEPTANCE ORGINAL	ON-SITE ACCEPTANCE ACTUAL	ON-SITE ACCEPTANCE DUR
1	PTT GBU-15 PTT	06-Feb-89	09-Feb-89	-185	05-Jun-89	05-Jun-89	-182	06-Jun-89	16-Jun-89	-192
2	PTT F-15E LANTRIN	03-Jun-88	03-Jun-88	-31	19-Jun-88	19-Jun-88	-31	20-Jun-88	20-Jun-88	-31
3	CPT F-16 AIR DEFENSE COCKPIT	24-Jul-89	25-Jan-90	-430	05-Jun-89	05-Feb-90	-490	12-Jan-90	08-Feb-90	-272
4	WST AV8B NAWST DEVICE 2F150	24-Jul-89	24-Jul-89	-4	N.A.	N.A.	-4	06-Nov-89	06-Nov-89	-4
5	OFT EF-111	???	???	0	01-Nov-86	01-Nov-86	0	13-Nov-86	15-Dec-86	-32
6	WST F-15E WST E3	15-Aug-90	30-Oct-90	-275	15-Oct-90	02-Jan-91	-278	19-Nov-90	07-Feb-91	-279
7	MT F-16C ELEC MAINT TR	???	???	0	???	???	0	???	???	0
8	PTT F-16C LANTRIN	25-Feb-89	25-Feb-89	-61	04-Mar-89	04-Mar-89	-61	06-Mar-89	06-Mar-89	-61
9	MT F-16C PROP MAINT TR	???	???	0	???	???	0	???	???	0
10	MT F-16C ENG OPS MAINT TR	???	???	0	???	???	0	???	???	0
11	MT F-16 TFE-19 ARMAMENT	02-Jun-89	02-Jun-89	-84	N.A.	N.A.	-84	N.A.	N.A.	-84
12	MT F-15 MSIP TFE-15	25-Nov-88	25-Nov-88	-78	28-Nov-88	28-Nov-88	-78	22-Dec-88	22-Dec-88	-78
13	MT F-15 MSIP TFE-16	25-Nov-88	25-Nov-88	-138	29-Nov-88	29-Nov-88	-138	13-Dec-88	13-Dec-88	-138
14	MT CH-47 EL SYS	14-Jun-85	14-Jun-85	0	N.A.	N.A.	0	20-Jun-85	16-Feb-90	*****
15	MT AH-1S EL SYS	21-Feb-86	21-Feb-86	0	N.A.	N.A.	0	24-Feb-86	24-Feb-86	0
16	MT UH-1N BASIC	15-Nov-86	15-Nov-86	0	N.A.	N.A.	0	19-Nov-86	19-Nov-86	0
17	WST B-1B SIMULATOR SYSTEM	N.A.		0	N.A.		0	N.A.		0

	PROGRAM	SHIP ORGINAL	SHIP ACTUAL	SHIP DUR	FIRST READINESS REVIEW ON-SITE TRR ORGINAL	ACTUAL	DUR	ACCEPTANCE TESTING ON-SITE ACCEPTANCE ORGINAL	ACTUAL	DUR
1	737-300 STD #1	02-May-86	07-Apr-86	30	26-May-86	12-May-86	19	13-Jun-86	18-Jun-86	0
2	737-300 #4 Phase II	11-Dec-89	27-Jan-90	-155	N.A.	N.A.	-108	02-Feb-90	27-Mar-90	-161
3	MD88 #1 PHASE II SIMUL'R	16-Oct-87	16-Apr-88	-293			-110	18-Dec-87	15-May-88	-259
4	AIRBUS A320 SIMULATOR #3	15-Oct-89	08-Nov-89	-24	N.A.	N.A.	0	10-Mar-90	13-Mar-90	-3
5	757 #2 AST PHASE II SIM		04-Apr-89	*****			0	[illegible]	04-Jul-89	[illegible]
6	UAL 747-400	29-Nov-88	29-Nov-88	0	N.A.	N.A.	0	23-Jan-89	23-Jan-89	0
7	AST C-5B WST-1	11-Jul-86	11-Jul-86	0	26-Jul-86	26-Jul-86	0	03-Oct-86	01-Oct-86	2
8	NUCLEAR POWER PLANT SIM	14-May-88	16-Jun-88	-33	N.A.	N.A.	0	14-Aug-88	22-Sep-88	39
9	HS601 TEST EQUIPMENT	16-Mar-90	23-Apr-90	-69	20-Mar-90	01-May-90	-73	27-Mar-90	08-May-90	-73

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#			PROGRAM	ON-SITE OPS EVAL ORGINAL	ON-SITE OPS EVAL ACTUAL	ON-SITE OPS EVAL DUR	ON-SITE SELL-OFF ORGINAL	ON-SITE SELL-OFF ACTUAL	ON-SITE SELL-OFF DUR
1	HUGHES	PTT	GBU-15 PTT	18-Sep-89	20-Sep-89	-184	21-Sep-89	21-Sep-89	-182
2	ECC	PTT	F-15E LANTRIN	27-Jun-88	27-Jun-88	-31	13-Jul-88	13-Jul-88	-31
3	ASD	CPT	F-16 AIR DEFENSE COCKKPIT	N.A.	N.A.	-245	06-Jul-89	08-Feb-90	-462
4	MDAC	WST	AV8B NAWST DEVICE 2F150	15-Nov-89	15-Nov-89	-4	15-Nov-89	15-Dec-89	-34
5	ASD	OFT	EF-111	27-Oct-86	09-Nov-86	-13	31-Jan-86	20-Feb-87	-385
6	LORAL	WST	F-15E WST E3	01-Nov-90	16-Jan-91	-275	19-Nov-90	07-Feb-91	-279
7	ECC	MT	F-16C ELEC MAINT TR	???	???	0	???	???	0
8	ECC	PTT	F-16C LANTRIN	13-Mar-89	13-Mar-89	-61	25-Mar-89	25-Mar-89	-61
9	ECC	MT	F-16C PROP MAINT TR	???	???	0	???	???	0
10	ECC	MT	F-16C ENG OPS MAINT TR	???	???	0	???	???	0
11	HUGHES	MT	F-16 TFE-19 ARMAMENT	N.A.	N.A.	-84	19-May-89	01-Jun-89	-97
12	HUGHES	MT	F-15 MSIP TFE-15	22-Dec-88	22-Dec-88	-78	22-Dec-88	22-Dec-88	-78
13	HUGHES	MT	F-15 MSIP TFE-16	13-Dec-88	13-Dec-88	-138	13-Dec-88	13-Dec-88	-138
14	ASD	MT	CH-47 EL SYS	N.A.	N.A.	0	N.A.	N.A.	0
15	ASD	MT	AH-1S EL SYS	N.A.	N.A.	0	N.A.	N.A.	0
16	ASD	MT	UH-1N BASIC	N.A.	N.A.	0	N.A.	N.A.	0
17	ASD	WST	B-1B SIMULATOR SYSTEM	26-Apr-89	12-Jun-90	-412	30-Apr-89	28-Jun-90	-424

#			PROGRAM	FAA EVALUATION ORGINAL	FAA EVALUATION ACTUAL	FAA EVALUATION DUR	CUSTOMER ACCEPTANCE SELL-OFF ORGINAL	CUSTOMER ACCEPTANCE SELL-OFF ACTUAL	CUSTOMER ACCEPTANCE SELL-OFF DUR
1	BCAC		737-300 STD #1	20-Jun-86	24-Jun-86	1	23-Jun-86	25-Jun-86	3
2	USAir		737-300 #4 Phase II	N.A.	10-May-90	*****	02-Feb-90	28-Mar-90	-162
3	DELTA		MD88 #1 PHASE II SIMUL'R	22-Jan-88	01-Jul-88	-271	29-Jan-88	01-Jul-88	[illegible]
4	NW		AIRBUS A320 SIMULATOR #3	15-Mar-90	22-Mar-90	-7			0
5	DELTA		757 #2 AST PHASE II SIM	01-Jul-89	10-Jul-89	-9	01-Jul-89	11-Jul-89	-10
6	CAE		UAL 747-400	26-Jan-89	26-Jan-89	0	27-Jan-89	27-Jan-89	0
7	FS	AST	C-5B WST-1	17-Oct-86	17-Oct-86	0	03-Oct-86	03-Oct-86	0
8	CAE		NUCLEAR POWER PLANT SIM	N.A.	N.A.	0	14-Aug-88	22-Sep-88	-39
9			HS601 TEST EQUIPMENT	31-Mar-90	IN-WORK	*****	31-Mar-90	12-May-90	-73

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		PROGRAM	COLD START				IN-PLANT DEVEL				IN-PLANT OPS EVAL			
			PL	ACT	HRS PER DAY	DAYS PER WK	PL	ACT	HRS PER DAY	DAYS PER WK	PL	ACT	HRS PER DAY	DAYS PER WK
1	PTT	GBU-15 PTT	5	2	8	5	18	29	12	5	30	15	8	5
2	PTT	F-15E LANTRIN	2	2	10	5	18	18	10	5	30	30	10	5
3	CPT	F-16 AIR DEFENSE COCKPIT	?	?	?	?	8	5	?	?	N/A	N/A	N/A	N/A
4	WST	AV88 NAWST DEVICE 2F150	3	3	10	6	38	54	10	6	1	1	8	5
5	OFT	EF-111												
6	WST	F-15E WST E3	12	10	16	6	156		12	5	14			
7	MT	F-16C ELEC MAINT TR	?	?	?	?	32	32	10	5	?	?	?	?
8	PTT	F-16C LANTRIN	2	2	10	5	18	18	10	5	20	20	10	5
9	MT	F-16C PROP MAINT TR	?	?	?	?	35	35	10	5	?	?	?	?
10	MT	F-16C ENG OPS MAINT TR	?	?	?	?	27	27	10	5	?	?	?	?
11	MT	F-16 TFE-19 ARMAMENT	1	1	8	5	32	32	12	6	N/A	N/A	N/A	N/A
12	MT	F-15 MSIP TFE-15	2	2	8	5	33	33	12	6	N/A	N/A	N/A	N/A
13	MT	F-15 MSIP TFE-16	1	1	8	5	30	52	12	5	N/A	N/A	N/A	N/A
14	MT	CH-47 EL SYS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	10	10	?	?
15	MT	AH-1S EL SYS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	3	?	?
16	MT	UH-1N BASIC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	3	?	?
17	WST	B-18 SIMULATOR SYSTEM	21	21	16	7	50	52	12	5	14		24	7

		PROGRAM	COLD START				IN-PLANT DEVEL				IN-PLANT OPS EVAL			
			PL	ACT	HRS PER DAY	DAYS PER WK	PL	ACT	HRS PER DAY	DAYS PER WK	PL	ACT	HRS PER DAY	DAYS PER WK
1		737-300 STD #1	N/A	N/A	N/A	N/A	45	35	8	5	N/A	N/A	N/A	N/A
2		737-300 #4 Phase II					20	30	10	5	N/A	N/A	N/A	N/A
3		MD88 #1 PHASE II SIMUL'R					30	80	12	7	5	10	12	7
4		AIRBUS A320 SIMULATOR #3					0	0			0	0		
5		757 #2 AST PHASE II SIM					N/A	N/A	N/A	N/A	I/U	I/U	I/U	I/U
6		UAL 747-400					39	39	12	7	N/A	N/A	N/A	N/A
7	AST	C-58 WST-1	N/A	N/A	N/A	N/A								
8		NUCLEAR POWER PLANT SIM					54	135	8	5	N/A	N/A	N/A	N/A
9		HS601 TEST EQUIPMENT	N/A				198	220	8	5	8	15	8	5

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	PROGRAM	ON-SITE INSTALL/TEST PL	ACT	HRS PER DAY	DAYS PER WK	ON-SITE ACCEPT PL	ACT	HRS PER DAY	DAYS PER WK	ON-SITE OPS EVAL PL	ACT	HRS PER DAY	DAYS PER WK
1	PTT GBU- 5 PTT	5	3	12	5	14	11	10	5	30	30	8	5
2	PTT F-15E LANTRIN	5	5	8	5	5	5	8	5	10	10	8	5
3	CPT F-16 AIR DEFENSE COCKPIT	5	3	?	?	5	3	?	?	N/A	N/A	N/A	N/A
4	WST AV8B NAWST DEVICE 2F150	60	104	16	6	42	42	12	6	9	9	8	5
5	OFT EF-111												
6	WST F-15E WST E3	60				21				14			
7	MT F-16C ELEC MAINT TR	N/A	?	?	?	N/A				N.A.			
8	PTT F-16C LANTRIN	4	4	10	5	3	3	10	5	13	13	10	5
9	MT F-16C PROP MAINT TR	N/A	?	?	?	N/A				N.A.			
10	MT F-16C ENG OPS MAINT TR	?	?	?	?	?	?	?	?	?	?	?	?
11	MT F-16 TFE-19 ARMAMENT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12	MT F-15 MSIP TFE-15	1	1	12	5	26	26	12	6	N/A	N/A	N/A	N/A
13	MT F-15 MSIP TFE-16	1	1	12	5	15	15	12	5	N/A	N/A	N/A	N/A
14	MT CH-47 EL SYS	2	2	?	?	4	4	?	?	N/A	N/A	N/A	N/A
15	MT AH-1S EL SYS	1	1	?	?	3	3	?	?	N/A	N/A	N/A	N/A
16	MT UH-1N BASIC	2	2	?	?	2	2	?	?	N/A	N/A	N/A	N/A
17	WST B-1B SIMULATOR SYSTEM	14	0	12	7	20	0	10	5	7		16	7

	PROGRAM	CONTRACTOR ON-SITE INST'L/TEST PL	ACT	HRS PER DAY	DAYS PER WK	CUSTOMER ON-SITE ACCEPT PL	ACT	HRS PER DAY	DAYS PER WK	FAA EVALUATION PL	ACT	HRS PER DAY	DAYS PER WK
1	737-300 STD #1	24	35	24	7	15	34	5	5	5	2	8	2
2	737-300 #4 Phase II	20	27	8	7	20	20	10	5	3	3	9	3
3	MD88 #1 PHASE II SIMUL'R	50	30	24	7	30	45	12	7	3	2.5	8	N/A
4	AIRBUS A320 SIMULATOR #3	75	50	8	5	40	44	17	5	3	3	8	5
5	757 #2 AST PHASE II SIM	50	35	24	6	48	61	13	6				
6	UAL 747-400	39	39	24	7	15	15	12	7	8	8	8	5
7	AST C-5B WST-1												
8	NUCLEAR POWER PLANT SIM	25	30	8	8	40	40	8	5	N/A	N/A	N/A	N/A
9	HS601 TEST EQUIPMENT	10	???	8	5	2	???	8	5	10	???	8	5

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	PROGRAM	TD OPEN TRR	TD CONTR START TEST	TD TOTAL	TD RE-SUBMIT	TD INTERN DRY RUN	TD POST SELL OFF	TD OUT OF SCOPE	TD TEST PROC	NO. OF PAGES	STEPS PER PAGES	STEPS PER SUBSYS RADAR	STEPS PER SUBSYS ENGINE	STEPS PER SUBSYS WPN	STEPS PER SUBSYS IOS
1	PTT GBU-15 PTT	5	UNK	94	5	UNK	0	0	UNK	400	2.5	109			
2	PTT F-15E LANTRIN	UNK	UNK	638	20	UNK	92	13	42	862	9	1038			
3	CPT F-16 AIR DEFENSE COCKPIT	???	TBD	83	TBD	TBD	TBD	3	TBD	461	7	???	???	???	???
4	WST AV8B NAWST DEVICE 2F150	???	???	557	28	???	81	20	53	2272	5	924			
5	OFT EF-111	UNK	UNK	1209	?	?	102	UNK	?	2400	7	759		281	
6	WST F-15E WST E3	93	894	1028	37	894	0	0	500	6500	7	1500	900	600	700
7	MT F-16C ELEC MAINT TR	N.A.	UNK	70	UNK	UNK	0	UNK	1	270	3.5	467			
8	PTT F-16C LANTRIN	UNK	UNK	727	UNK	UNK	UNK	UNK	28	519	5	844			
9	MT F-16C PROP MAINT TR	N.A.	UNK	33	UNK	UNK	0	UNK	0	711	4	2259			
10	MT F-16C ENG OPS MAINT TR	N.A.	UNK	8	UNK	UNK	0	UNK	1	188	3	272			
11	MT F-16 TFE-19 ARMAMENT	UNK	UNK	114	45	UNK	1	3	UNK	967	2	64			
12	MT F-15 MSIP TFE-15	UNK	UNK	2000	500	UNK	2	1000	UNK	1180	2.5	75			
13	MT F-15 MSIP TFE-16	UNK	UNK	300	150	UNK	1	150	UNK	548	3	50			
14	MT CH-47 EL SYS	UNK	UNK	40	?	?	0	10	?	150	5	?	?		
15	MT AH-1S EL SYS	UNK	UNK	31	?	?	0	6	?	150	8	?	?		
16	MT UH-1N BASIC	UNK	UNK	8	?	?	0	0	?	100	8	?	?		
17	WST B-1B SIMULATOR SYSTEM	125	125	1378	184	3423	N/A	32		21600	18				

	PROGRAM	TD OPEN TRR	TD CONTR START TEST	TD TOTAL	TD RE-SUBMIT	TD INTERN DRY RUN	TD POST SELL OFF	TD OUT OF SCOPE	TD TEST PROC	NO. OF PAGES	STEPS PER PAGES	STEPS PER SUBSYS RADAR	STEPS PER SUBSYS ENGINE	STEPS PER SUBSYS WPN	STEPS PER SUBSYS IOS
1	737-300 STD #1			607	75		42	24		1000	10				
2	737-300 #4 Phase II			451	62		21	UNK		2000	4				
3	MD88 #1 PHASE II SIMUL'R			544	162		27	27		2000	2				
4	AIRBUS A320 SIMULATOR #3	374	237	374	40	UNK	237	0		2453	6	288	910	408	84
5	757 #2 AST PHASE II SIM			275	30		25	7		2400	6				
6	UAL 747-400			810	30		150	10		UNK	UNK				
7	AST C-5B WST-1	390	1040	1040	236	UNK	224	10	71	1774	6	36			
8	NUCLEAR POWER PLANT SIM			196	104		115	0		1800	7				
9	HS601 TEST EQUIPMENT	134	20	134	0	UNK	OPEN	6	12	750	5	750	750	1500	750

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	PROGRAM	INSPECT	ANALY	DEMO	TEST		1 CDR TO HSI HW	2 CDR TO HSI SW	3 HSI TO TRP HW	4 HSI TO TRR SW	5 TRR TO SELL	6 INTERNAL	7 CLOSE DR	8 LATE DATA	
1	PTT GBU-15 PTT	250	55	210	0	515	???	???	???	???	???	???	???	???	2503[illegible]
2	PTT F-15E LANTRIN	39	43	590	167	839	1005 TOTAL					1	3	2	8483[illegible]
3	CPT F-16 AIR DEFENSE COCKPIT	???	???	???	???	0	???	???	???	???	???	???	???	???	[illegible]
4	WST AV8B NAWST DEVICE 2F150	???	???	???	???	0	???	???	???	???	???	???	???	???	???
5	OFT EF-111	98	128	83	170	479	???	???	???	???	???	???	???	???	???
6	WST F-15E WST E3	240	135	300	145	820	4900	300	1400	670	???	???	???	???	3361[illegible]
7	MT F-16C ELEC MAINT TR	105	35	82	NONE	222	500 TOTAL					1	3	2	2500[illegible]
8	PTT F-16C LANTRIN	28	37	775	273	1113	571 TOTAL					1	3	2	991[illegible]
9	MT F-16C PROP MAINT TR	105	35	82	NONE	222	1100 TOTAL					1	3	2	30[illegible]
10	MT F-16C ENG OPS MAINT TR	107	35	83	NONE	225	400 TOTAL					1	3	2	22[illegible]
11	MT F-16 TFE-19 ARMAMENT	75	11	34	0	120	465 TOTAL								[illegible]
12	MT F-15 MSIP TFE-15	116	26	85	NONE	227	434 TOTAL								1[illegible]
13	MT F-15 MSIP TFE-16	115	26	82	NONE	223	188 TOTAL								5[illegible]
14	MT CH-47 EL SYS	20	N/A	40	?	60									
15	MT AH-1S EL SYS	14	4	46	?	64									
16	MT UH-1N BASIC	13	2	15	?	30									
17	WST B-1B SIMULATOR SYSTEM	37	233	260	336	[illegible]66	?	?	?	?	?	?	?	?	1860K

	PROGRAM	INSPECT	ANALY	DEMO	TEST		CDR TO HSI HW	CDR TO HSI SW	HSI TO TRR HW	HSI TO TRR SW	TRR TO SELL	INTERNAL	CLOSE DR	LATE DATA	LCC [illegible]
1	737-300 STD #1	?	?	?	?	0	?	?	?	?	?	?	?	?	
2	737-300 #4 Phase II	?	?	?	?	0	?	?	?	?	?	?	?	?	
3	MD88 #1 PHASE II SIMUL'R	?	?	?	?	0	?	?	?	?	?	?	?	?	
4	AIRBUS A320 SIMULATOR #3	?	?	?	?	0	?	?	?	?	?	?	?	?	
5	757 #2 AST PHASE II SIM	?	?	?	?	0	?	?	?	?	?	?	?	?	
6	UAL 747-400	?	?	?	?	0	?	?	?	?	?	?	?	?	
7	AST C-5B WST-1					0									
8	NUCLEAR POWER PLANT SIM	?	?	?	?	0	?	?	?	?	?	?	?	?	
9	HS601 TEST EQUIPMENT	2	6	15	27	50	?	50		100	15	?	?		130K

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MILESTONES MET/DELAYED (DAYS)	GBU-15	F-15E LANTURN	F-16 ADF	AV-8B	EF-111 OFT	F-15E WST	
1 START TRR	-182	-31	-245	-4	0	-199	
2 DEVEL/ENGR TEST COMPLETE	-198	-31	-240	0	-300	-257	
3 SHIP	-201	0	-240	0	UNK	-318	
4 START ON-SITE ACCEPT	-201	0	-219	0	-300	-329	
5 FINISH ON-SITE ACCEPT	-211	0	-217	0	-332	-330	
6 OPS EVAL/FAA EVAL ON-SITE	-213	0	N.A.	0	-345	-318	
7 DD-250/SELL-OFF	-213	0	-217	-30	-385	330	
TEST DESCREPENCIES							
8 TOTAL NUMBER OF TD's	94	638	83	557	1209	1100	
9 NUMBER OF RESUBMITS	5	20	UNK	28	UNK	48	
10 POST SELL-OFF DD 250	0	92	4	81	102	0	
11 OUT OF SCOPE	0	13	0	20	UNK	1	
TEST PHASE DURATION (PLAN DAYS/ACTUAL DAYS)							
12 INPLANT DEVEL TEST	18/29	18/18	10/5	38/54	70/300	156/149	
13 ON-SITE ACCEPT	14/11	5/6	5/3	42/42	30/32	21/A	SEE NOTE A
14 ON-SITE OPS/FAA EVAL	30/30	10/10	N.A.	9/9	10/10	14/A	SEE NOTE A
15 TOTAL PLAN/TOTAL ACTUAL	62/70	33/34	15/8	80/96	110/342	191/A	SEE NOTE A
							SEE NOTE B
TEST PROCEDURE							
16 NUMBER OF PAGES ATP	400	862	461	4950	2400	6500	
17 STEPS PER PAGE	2.5	9	7	5	7	7	
18 PERCENT INSPECTION	48%	5%	46%	14%	20%	29%	
19 PERCENT ANALYIS	11%	5%	4%	9%	27%	16%	
20 PERCENT DEMOSTRATION	41%	70%	32%	47%	17%	37%	
21 PERCENT TEST	0%	20%	18%	30%	35%	18%	

NOTES: A = TEST PHASE NOT COMPLETE
B = EXCLUDES TEARDOWN, PACK, SHIP, ON-SITE INSTALL AND CHECKOUT ACTIVITIES.

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		BCAC	US AIR	DELTA	NWA	DELTA	UAL	[illegible]
	MILESTONES MET/DELAYED (DAYS)	737-300 STD #1	737-300 #4 PHASE II	MD88 #1 PHASE II	A-320	757 #2 AST	UAL 747	[illegible]
1	START TEST	5	-65	-110	NOTE "C"	NOTE "C"	0	[illegible]
2	DEVEL/ENGR TEST COMPLETE	21	-75	-160	NOTE "C"	NOTE "C"	0	[illegible]
3	SHIP	25	-47	-183	-24	UNK	0	
4	START ON-SITE ACCEPT	14	-53	-149	14	27	0	
5	FINISH ON-SITE ACCEPT	-5	-53	-164	-3	-4	0	[illegible]
6	OPS EVAL/FAA EVAL ON-SITE	-4	-53	-164	-7	-9	0	[illegible]
7	SELL-OFF	-2	-54	-157	-4	-10	0	

	TEST DESCREPENCIES							
8	TOTAL NUMBER OF TD's	607	451	544	374	275	810	1040
9	NUMBER OF RESUBMITS	75	62	162	40	30	30	236
10	POST SELL-OFF DD 250	42	21	27	237	25	150	224
11	OUT OF SCOPE	24	UNK	27	0	7	10	[illegible]

	TEST PHASE DURATION (PLAN DAYS/ACTUAL DAYS)							
12	INPLANT DEVEL TEST	51/35	20/30	30/80	NOTE "C"	NOTE "C"	35/35	60/60
13	ON-SITE ACCEPT	15/34	20/20	30/45	40/44	48/79	15/15	30/30
14	ON-SITE OPS/FAA EVAL	5/2	3/3	3/2.5	3/3	3/3.5	3/3	3/3
15	TOTAL TEST/TOTAL PROGRAM	71/71	43/53	63/127.5	43/47	51/81.5	53/53	93/93

	TEST PROCEDURE							
16	NUMBER OF PAGES ATP	1000	2000	2000	2453	2400	UNK	[illegible]
17	STEPS PER PAGE	10	4	2	6	6	UNK	[illegible]
18	PERCENT INSPECT	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
19	PERCENT ANAL	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
20	PERCENT DEMO	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
21	PERCENT TEST	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

NOTES: C = IN-PLANT TEST NOT PLANNED, THESE ARE PRODUCTION UNITS

APPENDIX G

INITIAL DATA OBSERVATIONS:

Notes recorded during analysis
of the data charts

A. Milestones - Met or delayed:

1. Military systems are always late getting to test. Commercial systems are usually on time getting to test. Why?

   1a. Nothing can be determined from available data - the following is supposition.

   - Bad Data
   - Military is 1st article
   - Lack of systems engineering
   - ECP activity (?)
   - Lack of/Poor Management control.

2. Once test starts, it usually runs on time or the magnitude of delay is held constant. In some cases, system delays are reduced in test, in no case does test time increase more than ten (10) percent beyond the time programmed. Why is this true?

   2a. Statement in general is validated by data! Caused by work around or padded TPS schedules.

3. Is test time planned too long? Is test planning pessimistic?

   3a. The ratio of military to commercial correlates to and supports the fact that military schedules are realistic. The fact that the military schedule is 80 days average versus 60 days for commercial is answered because of the complexity of device.

   - Military has tactics.

   Waste: Multiple TRRs, cold starts, TD clearance.

4. Is the start of test planned too early?

   4a. Indicators are that the planned start of test is O.K. and is realistic in terms of RFT. The problem is that the test starts before "we're ready to test."

   Waste: Excessive resources applied to meet schedule.

5. Ops/FAA eval appears to run on time. Why are these scheduled goals met?

   5a. FAA & Crew availability: Crews are available for finite time and PS Eval/FAA Eval are a fixed scheduled event: a well defined task/time span based on historical data and device maturity.

6. Why do some programs recover schedule during testing?

   6a. The schedule recover is due to sloppy (excessive) Teardown/Pack/Ship duration. Data also indicates that on site there is extended work week/hours per day, added resources, and added management attention.

7. Why is the maximum slip in testing only five to ten percent?

   7a. The slip of only 5 - 10% (additional) is indicative of

      -- Workaround Plans

      -- Well defined Scope of Activity

      -- Pressure.

8. Appears to finish on schedule because -

   -- Maturity of Device

   -- Fewer Problems to Identify

   -- Reduced Scope of Test - ATP, not DTP.

9. How did AIRBUS and USAir 737 gain schedule time?

   9a. Data provides some indicators. AIRBUS drop shipped 24 days early. Made up time in T/P/S. USAir had 30 days for T/P/S and used 3. The schedule gain is not a function of Test.

10. The amount of Air Force Test Team preparation and experience seems to be adequate since the test schedule does not seem to be impacted. Does preparation and experience impact on the duration of daily test time and the number of days per week require for test?

   10a. No evidence to indicate that the qualification of AF Acceptance team impact test schedule. The quality of test personnel remain an important factor to hold schedule.

   An observation was made during discussions on Question 10 - There is correlation between Military and Commercial Daily test time 10 to 12 hours/day, 5 days/ week.

B. <u>Test Discrepancies</u>:

1. Why did GBU-15 have so few TDs?

   1a. GBU-15 had 3 dry runs of ATP (including 3rd time with QA). GBU was small device - only 400 pages in ATP. It must be noted that this did not result in schedule reduction - Plan = 60 days/Actuals = 70 days.

2. Why do the quantity of TDs appear to correlate with the complexity of the training device -- but not always?

   2a. F15 LANTIRN and EF III indicators do not conform to TD/complexity curve. However, it must be noted that both devices are prototype devices (20 TDs per day is average in both Military and Commercial).

3. Does the quantity of TDs correlate with test duration?

   3a. Plots of days in Test versus TD Count indicates that the number of TDs reasonably correlates to days in Test -- 20 TD per day average.

4. Why are the number of C-5B re-submits and post sell-off TDs higher than the other systems?

   4a. Analysis of re-submits indicates that bulk of re-submits were in 2 major subsystems. Inexperienced engineers assign to both systems.

   The higher number of post sell-off TDs for C5 was the result of the sell-off plan. The base-line unit was unit #6, and design changes accumulated through all six devices.

5. Do re-submits become an issue during the test phase? Why do re-submits appear not to affect the test schedule?

   5a. Re-submits do not become an issue. Re-submits do not affect schedule because there is parallel effort in TD correction plus small number of re-submits.

   Waste: Lack of complete or incomplete engineering corrective action.

6. How/Why do 90% of the TDs get resolved during the testing period? Most TDs do not appear to require major redesigns, so why were these relatively minor TDs not caught and corrected by the contractor prior to test?

   6a. Large parallel effort (off shift), 2nd unit available (more asset). (Opinion) Design blindness; Interpretation of data or wrong data.

7. The customer seems willing to accept the trainer with greater than 10% TDs remaining at sell-off. How does this correlate with the test schedule and why will the customer do this? How long do these post sell-off TDs remain?

   7a. Customers desire/need for device forces customer to start using device with large number of open TDs at sell-off -- TDs are minor in nature: TDs do not cause negative training: usually agreement with contractor as to correcting discrepancies.

Part 2. Test schedule does not allow time to clean up TDs and still meet RFT date. The customer needs training device.

Part 3. No data available.

8. Why do out-of-scope TDs not affect the test schedule?

   8a. Out-of-Scope TDs do not affect test schedule because the TDs are Out-of-Scope. There are methods to contest Out-of-Scope TDs without hampering program. On the other hand, "Got to Have" will affect program.

9. Is there a correlation between the number of TDs and the start of the test schedule?

   9a. No correlation exists between Test Schedule and TD count.

10. How many TDs were open at TRR? What is the level of quality internal to the contractor prior to TRR? How many total TDs are the result of the contractor validation? Are there undocumented TDs discovered/known by the contractor which are unresolved prior to beginning test?

   10a. No definitized answers from respondents.

C. <u>Days in Test</u>:

1. Why do the number of planned test days correlate well with the actual test days?

   1a. See answer A-2 and A-7.

2. What is the percent of acceptance test time to total program schedule? (Total ratio of test days to total program.)

   2a. This data will be provided to Bill.

3. Why do breaks in the test schedule for redesign activity not seem to significantly affect days in test?

   3a. Minimal impact is felt because of extended work week, parallel effort on 2nd device, desire to continue test, addition resources.

4. What kind of workarounds are used to maintain test schedules? Do these include Software Support Centers, 2nd Article tests, daily work time/days/weekends, etc.? How are overall scheduled maintained without an order of magnitude increase in test days? Observations are that planned and actual days in

test correlate well. Complexity does not seem to affect the planned/actual test schedule ratio -- Why?

4a. Part 1 -- Workarounds used include those cited in C3 and defer test to site.

Part 2 -- No data required.

Part 3 -- Complexity does not affect planned/actual est schedule; up-front planning takes into account complexity.

D. Test Documents:

1. Why is the B-1B ATP so large? Does this indicate complexity or is it an error? Why are there 18 test steps per page? This data is suspect.

1a. Chip reports that data as provided on B-1B is correct.

Waste: Excessive Documentation (Comment).

2. What makes the BGU-15 only 1.3 steps per page?

2a. GBU-15 has 2.5 steps/page. This document contains numerous illustrations/graphs.

3. What is the correlation between the number of ATP pages, TDs, and the length of the test schedule?

3a. No correlation exists between ATP and Test Schedule.

4. Why does the Test Matrix categories not correlate between the various programs?

4a. Analysis is generally a small number Test and Demo is a matter of interpretation.

Inspection - 30 to 40%.

There is a correlation, though basically an opinion not totally supported by data.

5. To what level were the ATPs written (i.e., qualified operator, inexperienced person, etc.)?

5a. There is no indication from available data concerning ATP Level. CPT opinion is that the documents were written for semi-qualified personnel.

Waste: Opinion is that document is written at too low a level.

6. How much FAM training does the customer require to accomplish the ATPs?

   6a. Customer training is insignificant (approx. 1 week).

7. Why is the Demo category of the Test Matrix percentage larger than expected?

   7a. See D4.

8. Why can't we increase the percentage of the Inspection and the Analysis categories of the Specification Verification Matrix? What is wrong with the Test category being reduced to zero percentage? What minimum level of the Test category is acceptable?

   8a. In opinion of CPT members - WE CAN!!

   Opinions -

   Test Category - Zero (0)

   Mission Test Plan (MTP) at Functional Level

   Waste: Duplication of contractors test.