AIRCREW TRAINING SYSTEM: TEST AND EVALUATION

J. J. Shaw
SIMTEC, Inc.
Manassas, Virginia

ABSTRACT

The recent initiatives by the U.S. Air Force to implement total contractor Aircrew Training Systems, (ATS) have invoked various levels of accountability with respect to development and performance. The ATS contractor(s) are faced with new, completely interrelated design verification procedures, quality assurance requirements, and implementation/interface controls. Test and Evaluation concepts established by DOD policy are directly applicable to this new environment. However, the processes are complex, requiring rigorous basic disciplines from development through the full life cycle of the system. Recognition of the T&E requirements as design objectives will significantly reduce the risks and improve utility, supportability, and the contractors profitability. This paper provides an approach to the philosophical and functional management issues associated with the measurement, evaluation and qualification of the various elements of an Aircrew Training System during both the development and the operational program phases. Included are considerations for system testability to certify the ISD, Media, Curriculum, and the trainee. The paper also addresses the Test and Evaluation contributions to performance management, product improvements, and cost benefits throughout the life of the contract.

INTRODUCTION

Current projections by the U.S. Air Force to selectively replace traditional organic Aircrew Training Systems with total contractor Aircrew Training System (ATS) has triggered some formidable challenges for industry, the acquisition community and, most importantly, the using agency.

One of the more significant challenges, ***Test and Evaluation Throughout the Life Cycle of total contractor Aircrew Training System*** is the subject of this paper. The principal issues addressed are the requirements for, and mechanization, of Test and Evaluation in these areas:

- o Development/Operational Test and Evaluation (DT&E, OT&E)
- o Performance Management
- o Aircrew Proficiency

For the purposes of this paper the terminology "Test and Evaluation" means the measurement, recording, assessment, and reporting of the characteristics to be evaluated.

DEVELOPMENT/OPERATIONAL TEST & EVALUATION

The factors influencing the Test and Evaluation decisions in the ATS acquisition management processes are compounded by development issues, type of weapon system, maturity of the weapon system, mission requirements, and the associated technologies. The current candidates for contractor training systems include emerging weapon systems (C-17, ATF, etc.) as well as existing weapon systems (C-141, C-130, F-16, F-111, etc.). Each has unique advantages, and development risks, that dictate tailored approaches to performance verification requirements. This paper discusses generic issues associated with Test & Evaluation objectives rather than specific T&E requirements.

In the recent revision of the DoD Directive 5000.3, March 12, 1986, "Test and Evaluation," the Government has re-directed emphasis toward the objectives of ensuring operational effectiveness throughout the life cycle of major programs. Applying the intent of these policies to training system acquisitions, in conjunction with other applicable directives, standards and specifications, it is apparent that an integrated Test and Evaluation process is essential throughout all phases of the program. This imperative includes a capability to certify continuing system performance in the out years.

The relationship of program phases and T&E phases is illustrated in Figure 1. Program Development includes all aspects from requirements analysis through total system implementation. The operational phase extends from completion of implementation through the life of the training system. T&E supports the program through each phase, wherein the formative evaluations are integral processes to progressively verify the analysis, design, production, integration, and deployment. The summative evaluations consist of concurrent Development and Initial Operational testing (DT&E/IOT&E), which accomplishes the performance verification and operational suitability evaluations of the total system, operating at full capacity in the operational environment. Completion of summative evalution establishes the baseline of system capability for continuous operation in the out years. The program Operational Phase is supported by the Follow-on Operational Test & Evaluation (FOT&E) processes. The continuous application of FOT&E validates performance, and provides appropriate visibility and control for system management objectives.

The Development Test & Evaluation (DT&E) requirements are listed in Table 1 which delineates the principal areas and suggested components to be evaluated. Generally, for each component or subcomponent it is necessary to

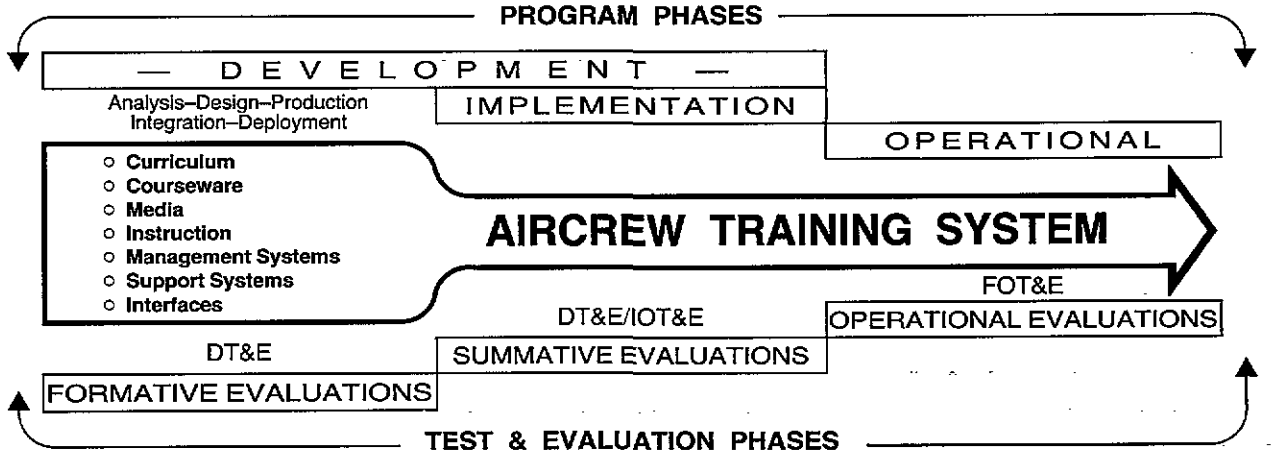

FIGURE 1

establish the appropriate functional characteristics to be measured, analyzed, or otherwise assessed. Accordingly, for each characteristic, it is necessary to develop the appropriate performance criterion. Typical characteristics include capabilities, (capacity, responses, flow, demand, etc.) and qualities (reliability, maintainability, supportability, etc.). The final phase of DT&E includes the summative evaluation which is a fully integrated and deployed performance verification of the total system. It should be noted that the summative evaluation is identified as a concurrent Development Test & Evaluation/Initial Operational Test & Evaluation (DT&E/IOT&E).

The Operation Test & Evaluation (OT&E) requirements are listed in Table 2, which delineates the major operational requirements and the suggested components to be evaluated for operational suitability of the developed system. Generally, these components must be quantified using established standards and criterion to develop an objective measurement of performance.

A primary consideration is that the ATS and it's sub-systems are composed of many inter-related resources (including people) that collectively provide the system capabilities to accomplish the required training. Therefore, evaluation must not only qualify the equipment, it must certify the policies, procedures, standards, the organization, personnel, and all interfaces (both internal and external).

A secondary issue for consideration is the requirement for the contractor to ensure the capability of recompetition of the ATS. This requirement invokes a variety of obligations for accountability, audit trails, verification and validation of all assets, developments and other contractually defined system elements. Accordingly, the contractor is responsible for rigorous baseline management that must be provisioned within the development process and supported throughout the life cycle. Related to this aspect is the potential requirement for the system to revert back to the organic training concept.

CONTRACTOR'S T&E REQUIREMENTS - DT&E

The training system contractor will be involved in a variety of development testing activities, principally to support his program requirements, design objectives, quality assurance, and proof of design. In addition, the contractual obligations to conduct those tests, inspections, and analyses required to identify and assess risks, ensure acquisition compliance and fielding of an effective and supportable system. Accordingly, the DT&E requirements, as indicated in Table 1, apply to all aspects of development including delivered equipment (hardware and software), curriculum, training system management, instructional delivery systems, and associated support functions such as administration, scheduling, logistics, maintenance, engineering, courseware authoring, etc. As each of the system elements are developed, designed, and integrated, it is necessary to qualify it's capability and functional characteristics with respect to the design objectives. The DT&E processes must provide the appropriate evaluations, data, and reports that assess the compliance, quality, and risks associated with each of the system elements and it's integration.

One area that illustrates the integral T&E requirements is the ISD, Courseware Development/Production, and Summative Evaluation processes. To qualify the development of the final products (training materials), it is necessary to evaluate the initial development, mission analysis, and other baseline data. In addition, within the typical policies[1] and specifications[2] are requirements for embedded Quality Control (QC) functions. Accordingly, the DT&E objectives must address both the integrity of the baseline source data and the in-process QC associated with development. This example also illustrates the requirements for testability provisions applicable to QC and DT&E, wherein certain measurements and data are used for both objectives. The design of these provisions should address not only DT&E, and OT&E but the long term operational needs for ongoing curriculum development associated with new mission objectives, aircraft changes, and most importantly, proficiency advancement.

TABLE 1

DEVELOPMENT TEST & EVALUATION REQUIREMENTS

Training Media - Development
(DT&E)

- o Hands-on Media
  - Training Devices (WST, OFT, CPT, PTT, etc.)
  - Aircraft (Embedded Training etc.)
  - Ranges (Threats, Targets, etc.)
  - Loadmaster Training Devices, Etc.
  - Others
- o Academic Media
  - Computer Based Training (CBT/CAI/CMI)
  - Audio-Visual (Videos, Slides, etc.)
  - Printed Matter (Guides, Study Material etc.)
  - Lectures, Presentations and Interactions

Training Curriculum - Developments
(DT&E)

- o Instruction System Development (ISD)
  - Mission Analysis
  - Task Listings/Analysis/Cueing Requirements
  - Performance Objectives & Criterion Tests
  - Media Selection Model(s)
  - Syllabus Development
  - Lesson Specifications
- o Courseware Development & Production
  - Formative Evaluations
    - ~ Initial Authoring/Review Process
    - ~ Individual Tryout Process
    - ~ Small Group Tryout Process
    - ~ Media Compatibility Eval. Process
    - ~ Trainee Tests (Effectiveness/Utility)
    - ~ Course Effectiveness & Diagnostics
    - ~ QC Processes-Audits
  - Training Materials Production-Standards
  - Specification Compliance/Revision
- o Courseware Supportability

Training Management System - Development
(DT&E)

- o Training Management System (Equip/Software)
- o Performance Measurement/Reporting System

Training System Logistics Support Development
(DT&E)

- o Training System Support Center TSSC (Equipment)
- o Media Maintenance and Engineering Capability
- o Support Packages (Spares, Tools, Services, etc.)

Training System - Summative Evaluation
(DT&E/IOT&E)

- o Implementation of Training Courses
  - Courseware Effectiveness (Strengths/Weaknesses)
    - ~ Individual Courses
    - ~ Integration of Courses
  - Courseware Delivery
    - ~ Academics (CBT/Others)
    - ~ Hands-on (ATD/Aircraft)
  - Media Compatibility
  - Aircrew Member Qualifications
    - ~ Exit Level Performance
    - ~ In-unit Proficiency (Initial & Aged)
  - Quality Controls & Feedback
    - ~ Internal
    - ~ External
  - Supportability
    - ~ Ease of Change (Time/Effort)
    - ~ Traceability & Configuration Control
- o Implementation of Training Media
  - Media Integration/Correlations
  - Media Utilization
  - Media Qualification
  - Media Maintenance
- o Implementation of Instructional System
  - Instructional Standards/Procedures
  - Instructional Methods/Qualifications
  - Instructional Quality
  - Instructional Reporting
  - Instructional "Stan-Eval"
- o Implementation of Management Systems
  - Trainee Scheduling
  - Trainee Records
  - Instructor/Instruction Scheduling
  - Instructor Qualifications & Records
  - Resource Scheduling (Including Media)
  - Training Management System
  - Configuration Management
  - System Interface and Accounting
- o Implementation of Support Systems
  - Media, Engineering, Maintenance
  - Courseware, Authoring, Maintenance
  - Logistics Support Packages

TABLE 2

OPERATIONAL TEST & EVALUATION REQUIREMENTS
- IOT&E/FOT&E -

Training Effectiveness

- o Entry Level Skill Ranking (Trainee/Class)
- o Progress Rates in Each Course Element
- o Skill Acquisition in Each Course Element
- o Trainee Weaknesses and Strengths
- o Remedial Requirements (Trainee/Courses)
- o Exit Level Qualifications (Trainee/Course)
- o Throughput (Trainee/Course/Crew Position)
- o Proficiency In-unit (Trainee/Courses)
- o Recurrent Training: Entry Level Ranking

Training Efficiency

- o Throughput (Trainee/Courses/Crew Position)
- o Time to Completion (Trainee/Class/Courses)
- o Time in Each Media (Trainee/Course)
- o Time in Remedial Processes (Trainee/Course)
- o Media Utilization vs Media Availability (Class)
- o Alternate Media: Utilization/Availability
- o Media Reliability: Delays/Interruptions
- o Instructional Delivery:Utilization/Availability

System Palatability

- o Users Perceived Value of Training Received
- o System Conformity to Acceptable Practices
- o System is Perceived as Flexible and Consistent

System Capacity/Growth

- o Surge Capacity/Responsiveness
- o Curriculum Expansion for Mission Needs

System Reliability

- o Level of Trainee Qualification Rejects
- o Level of Remedial Training
- o Level of System Grievances
- o Level of Availability

System Maintainability

- o System Diagnostics
- o Trainee Diagnostics
- o System Configuration Management
- o System Adaptability

System Supportability

- o Logistics Capabilities
- o Maintenance Capabilities
- o Engineering Capabilities
- o Courseware Authoring Capability
- o Instructional Delivery

System Manageability

- o Trainee Administration Capability
- o Resource Administration Capability
- o Trainee Performance Measurement
- o System Performance Measurement
- o System Accountability
- o System Interfaces

The most intense aspect of the training system performance verification process occurs during the summative evaluation (See Table 1) wherein all previously qualified system elements have been integrated, fully deployed, and implemented. This phase of Test and Evaluation is designated as concurrent DT&E/ OT&E. The total system including its support services, interfaces, management organizations, communications, networks and procedures are formally evaluated in the operational environment.

CONTRACTORS T&E REQUIREMENTS - OT&E

The Operational Test and Evaluation (OT&E) objectives are directed at the assessment of the operational effectiveness and suitability of the developed system. Table 2 delineates the suggested characteristics necessary to satisfy the OT&E objectives of a typical ATS.

Aircrew Training System *effectiveness* is derived from two principal components.

a) Achieved competency levels of graduate aircrew members versus the targeted proficiency requirements for mission readiness.

b) System Level Attributes: Throughput, skill acquisition, retention, course-to-course training integration, remedial training, and entry level control.

Measurement, assessment, and control of these components is an essential requirement. Ratification of success is not the primary objective of the effectiveness evaluations. Determination of strengths, weaknesses, and trends will improve the system effectiveness which will yield a higher competency level which is the success objective.

System training *efficiency* is derived from "time-in-learning" and the resources expended for each unit of training. Accordingly, the factoring of various learning time measurements, including remedial training time, student throughput, media use, and other relevant factors will yield an objective projection for system training efficiency, including potentials for improvement.

System *palatability* is a highly subjective but meaningful attribute that should be continuously monitored and statistically evaluated to establish a quantifiable ranking. Generally, the level of relevance is an appropriate term for palatability.

The system provisions for ***reliability, maintainability, and supportability*** require initial evaluations to determine suitability for the design life cycle of the total system.

The ***manageability*** of the system is determined by assessing capability to administer the trainee, the resources (including all Government assets), and system personnel. Included in this requirement is the capability and utility of the various automated tools developed with the system, and management control of interfaces (both internal and external), accountability, responsiveness, reporting, concurrency, and record keeping.

System ***capacity/growth*** is the capability to accommodate short term variations in throughput and the provisions for expansion in curriculum and/or changes in course elements without adverse effects on the basic system. The overall system design flexibility and resource management shall determine the efficiencies associated with growth requirements.

The measurement, recording, and assessment of these characteristics requires that the system design incorporate the testability provisions, the data base provisions, and appropriate analytical tools to meet the evaluation requirements.

During the summative evaluation, these characteristics will be validated to ensure the accuracy of the measurements, analysis, and reporting.

CONTRACTORS FOLLOW-ON T&E REQUIREMENTS - FOT&E

The fully developed and approved ATS enters the Follow-on Test and Evaluation (FOT&E) phase at the satisfactory completion of the summative evaluation and extends through the life cycle of the ATS. The objective of FOT&E is to continuously assess the system performance and provide visibility and control for improvements of performance and capability. During this phase new development activity may require some aspects of DT&E. Certain changes to curriculum, media, management systems, and support packages that alter the original development baseline will require a formative evaluation to ensure system design is not adversely affected.

The primary consideration during this phase is the continued optimum levels of satisfactory system performance wherein all elements are operating effectively, efficiently, and that quality controls for each system element are fully operative. The potential for achieving acceptable performance is dependent on multi-variant factors such as system size, complexity, distribution, dynamics, criticality, and overall risks. Accordingly, the contractor should consider the up-front acknowledgment that the ATS is a "less than perfect system" and that errors, problems, and perturbations will occur. The potential costs associated with these incidents is unpredictable, however, the cost control will be a function of early detection and responsiveness. Therefore, it is essential that the system include an independent product assurance scheme that monitors the products (aircrew members) the performance of the system and provides appropriate management visibility. To accommodate this capability, the necessary provisions must be integrated into the initial design and supported through the life cycle of the system. As the system improves, matures, and conditions warrant, the product assurance support levels should be revised as appropriate. However, the T&E facilities must be maintained as required to support the system needs for future expansion, recompetition, and/or major changes.

The principal characteristics to be evaluated in FOT&E are essentially the same as those in the OT&E requirements identified in Table 2. Routine, periodic checks of appropriate characteristics are mandatory, whereas others would be measured and assessed based upon need.

PERFORMANCE MANAGEMENT OF ATS

The cost effective performance of an ATS will depend on the contractors strategies and management visibility. The day to day operations will be subjected to unpredictable factors, e.g., weather, no-shows, down-time, instructor problems, etc. The management system requires adequate information to make appropriate decisions to accommodate those problems, and take advantage of opportunities. This process is by definition reactive in nature and the level of risk is inversely proportionate to the information available to make timely decisions.

The long term management functions also require optimum visibility to ensure effective planning at minimum risks. This process includes projections based upon estimated requirements that are subject to changes. The system is critically dependent on the measurement and analysis of system performance, allocated resources, and operational need.

The products of the system (aircrew members) are the dominant dynamic factor in the system. In some cases, outstanding trainees will require minimal resources, including time (which is the principal measurement in determining both efficiency and effectiveness of the system). Conversely, less talented or experienced students will require more resources to achieve and maintain proficiency. The accurate and timely information necessary for management visibility into these situations must be developed using predictive analysis and data that is continuously revised based upon current measurements.

ATS system performance management requirements described above invoke data collection, measurements, and assessments of system characteristics, aircrew member demographics, the requirements of the flying program, and technological developments. The specific measurements, standards and evaluation processes must be defined and integrated into the system design during the development phase. In most cases the data required for FOT&E will also provide the necessary source data for performance management.

AIRCREW PROFICIENCY EVALUATION

The ultimate objective of the ATS is to develop and maintain the mission ready proficiency of the aircrew. Proficiency, as a functional characteristic, can be objectively evaluated and enhanced through the use of various techniques. The standards of evaluation are established during the ISD process based upon mission task analysis. The difference between mission ready proficiency and the students acquired proficiency in the training program, must be measured to guarantee aircrew qualification.

In the *training environment*, performance measurement of the student is achieved by various means through each element of training, be it academics, or hands-on training. The facilities to measure student skill levels are included as design features, providing the training management system with the necessary information to evaluate student performance. As such, the relative level of aircrew proficiency upon completion of each phase of training can be objectively evaluated.

The measurement and objective assessment of the proficiency of the aircrew in the *operational environment* is more difficult than in the training environment. The emerging weapon system aircraft designs incorporating embedded training features and other on-board performance measurement capabilities will permit contractors to correlate objective performance data to evaluate functional proficiency as a result of training and experience. In the existing weapon system aircraft, these sophisticated capabilities are not currently available, and the contractor must rely on less effective evaluation methods. These methods include subjective evaluations, surveys questionnaires, check flights, and other traditional processes.

Recognizing that the traditional methods have certain shortcomings, it is necessary for the contractor to compensate by developing empirical criteria to tailor the aircrew member performance for qualification in a subjective evaluation. *The process of evaluating operational performance against objective criterion using subjective methods is inconsistent and requires careful consideration and ideally the development of more effective alternatives*

CONCLUSION

The test and evaluation capabilities required to support the acquisition, development, operation, management, and product assurance of the generic ATS are used throughout the life cycle of the system. The testability provisions have multipurpose objectives serving a variety of needs. In general, the system requirements dictate an integrated performance measurement data base, appropriate automated tools, processes, and facilities to develop the information required by various users.

The more complex ATS systems using multi-site training facilities and a centralized training agency, will impose even greater demands on the system. Obviously, the integrated requirements for management visibility and product assurance will be proportionate to the magnitude of operational system elements and aircrew population.

The use of these capabilities does not of itself, guarantee success. It requires judgment, learning, and experience. Like other methodologies, the application of these processes may or may not be done well, but it should never be done in the blind.

REFERENCES

1. Air Force Regulation 50-8, "Training Instructional System Development."

2. MIL-STD-29053 (B), "Military Specification - Requirements for Training System Development."

ABOUT THE AUTHOR

Mr. J.J. Shaw is the Director of Test and Evaluation at SIMTEC, Inc. and is responsible for the development and operations of Test and Evaluation programs.

Mr. Shaw has been involved with training simulation equipment and aircrew training system operations for over thirty years. The majority of that time he was associated with commercial airlines and simulation manufacturers. Principle activities included the test, evaluation, acceptance, and FAA certification of 14 simulators. With Braniff Airways, Mr. Shaw was instrumental in achieving the industry's first Phase I and Phase II approvals under the FAA Advanced Simulation Program. He has participated in various working groups in the International Airline Transport Association (IATA), Airline Transport Association (ATA), and the American Institute of Aeronautics and Astronautics (AIAA).