APPLYING THE INSTRUCTIONAL SYSTEM DEVELOPMENT (ISD) PROCESS IN U.S. AIR FORCE DEFENSE SYSTEM ACQUISITION

Ben H. Catalina
Southwest Research Institute
San Antonio, Texas

Conrad G. Bills
Loral Defense Systems
Akron, Ohio

ABSTRACT

The United States Air Force (USAF) has completed a new series of guides for designers of instructional systems—Air Force Handbook 36-2235, Information for Designers of Instructional Systems. Volume 3, Application to Acquisition, covers the major phases of the instructional system development (ISD) process and addresses them to the various phases of defense system acquisition. The ISD process has application in all acquisition phases, but the major effort occurs between the demonstration and validation phase and the production and deployment phase. The new Air Force ISD model incorporates the necessary functions for fielding successful total training systems. Fielding a new defense system with a total training system is a project that requires considerable management, coordination, and integration. Interface of the ISD process with the system engineering process ensures that critical functions are not overlooked early in the overall design and that these requirements are tracked throughout the acquisition for full implementation and life cycle support. This guide incorporates lessons learned from the past, applying a systematic, orderly process of integrated product development and treating ISD and system acquisition as a total system.

This paper discusses this new application of the ISD process in acquisition, the redefinition of activities leading to a common terminology for instructional designers and system engineers, and the orientation to quality improvement of the total training system throughout the life cycle of the defense system.

ABOUT THE AUTHORS

Ben H. Catalina is a senior project manager and instructional developer in the Instructional Systems Section. He has over 24 years of experience in training development, training management, and defense systems acquisition for the U.S. Air Force and industry. He has worked extensively with the USAF on the ISD project and is now serving as project manager for the field evaluation, revisions and new pamphlets development contract. He has a B.S. in Business Education from Mississippi State University and an M.Ed in School Administration/Supervision of Instruction from the University of Southern Mississippi.

Conrad G. Bills is senior training systems analyst for Simulation and Training Engineering, Loral Defense Systems. He has 20 years of experience with the U.S. Air Force operations and support programs in training and education, instructional system development (ISD), evaluation and administration, scientific management, and applied psychology. During the past seven years with the Air Force, he was senior training systems analyst for the Training Systems Product Group and Support Systems Engineering at the Aeronautical Systems Center, Wright-Patterson AFB, Ohio. He directed the contract for updating the Air Force ISD process, including the first volume for application of ISD in training system acquisition. He has an M.S. and B.S. in counseling and psychology/mathematics education from Brigham Young University.

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INTRODUCTION

Background

The application of the Instructional System Development (ISD) process in Aircrew Training System (ATS) acquisition for the U.S. Air Force brought to attention the need to update the Air Force ISD process. A baseline analysis was accomplished across the operational and support communities which apply the ISD process. A recommendation to the Air Force based on the results of the baseline analysis was that separate guidelines be developed for major instructional applications to address the unique requirements of each, written in a style suitable to the users' needs. The unique performance requirement defined for acquisition was the interrelation of engineering and training information. As the result of this recommendation, the Field Test AFP 50-68, Volume 3, Information for Designers of Instructional Systems—Application to Acquisition, was developed. This volume summarized the charted results of the Aeronautical Systems Center (ASC) Courseware Process Action Team (PAT). The Courseware PAT charted the courseware development process occurring within the system engineering process for total training system acquisition. This process was compiled and then coordinated with the government/industry steering group for training system acquisition. (During the field test of AFP 50-68, the Air Force publications office changed the nomenclature to AFH 36-2235.)

Volume 3 is the user's guide designed for personnel to use while applying the ISD process in defense system acquisition. It is intended to be an easy-reading document designed for the ISD novice as well as the veteran. Its purpose is to incorporate many applicable regulations and manuals into a single document that covers the phases of the ISD process and addresses them to the various phases of defense system acquisition. Volume 3 treats ISD with acquisition as a **total system**, incorporating the principles of integrated product development (IPD). There is considerable emphasis on system integration tasks and tasks not typical of ISD. The key to all of these tasks and ISD is integration to the **total system**. This paper provides an overview of Volume 3, focusing on some of the atypical aspects of ISD and defense system acquisition.

Although the ISD process has application in all acquisition phases, the focus of Volume 3 is where the major effort occurs between the demonstration and validation phase (I) and the production and deployment phase (III). Since the acquisition of major defense systems can routinely take ten years or more, it is imperative that one learns how to apply the phases of ISD with the phases of acquisition. This is equally important for modifications to current systems. Frequent coordination and evaluation are a requirement of success, as is revisiting of prior efforts and modifications where required. Figure 1 depicts the acquisition life cycle milestones and phases.

Lessons Learned

There is a definite contrast between the early application of ISD in defense system acquisition and the process applied in Volume 3. In the early application of ISD, the consideration for training was often an afterthought and was treated as part of the logistics elements important after the system was fielded. The burden of integrating a training system was on the operational command. ISD organizations were set up to begin preparation of the training curriculum in a time frame that closely

corresponded to the fielding of the defense system. These organizations quickly recognized the importance of obtaining long-lead items such as training simulators well in advance of the first defense system delivery. For example, the F100 jet engine (used in the F-15 and F-16 fighter aircraft) was not available for training purposes until eight years after deployment. As a result, efficient and effective maintenance was not available. In another example, operational E-3A AWACS (Airborne Warning and Control System) aircraft had to be used as trainers because trainers were not purchased with the defense system. In contrast, the application of the process in Volume 3 in a total quality environment resulted in the reduction of courseware development time by 40 percent for the C-17 ATS. The first crews trained in the C-17 training system were received by the test force at Edwards AFB, California, and were complimented by the test force as being the best-prepared crews ever. Delivery of the integrated training system, including full-mission simulation, was at the home base when required. The application does what the process was designed to do in the first place—improve training effectiveness and efficiency.

TOTAL TRAINING SYSTEM

A total training system is all-inclusive for meeting the training requirements. The training system is systematically developed to include the entire life cycle curriculum as well as the courseware, classroom aids, training simulators and devices, and operational equipment to present the curriculum. The training system also includes the personnel and logistic support to operate, maintain, or employ a defense system.

Fielding a new defense system with a total instructional system is a project that requires considerable management, coordination, and

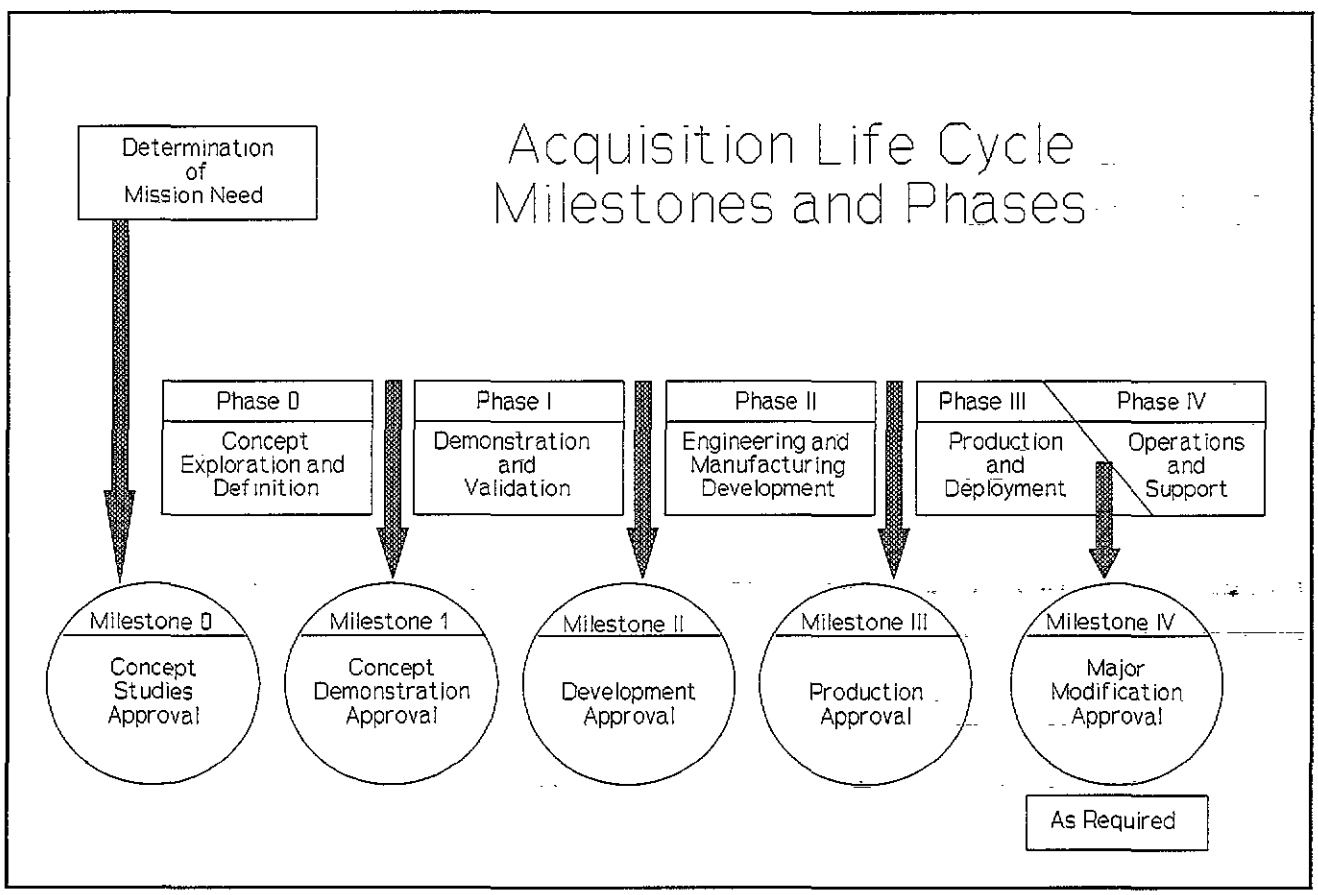

Figure 1. System Acquisition Life Cycle

integration. Lessons learned in fielding total instructional systems have shown that organizations responsible for integration of the system have often been left scrambling. Why? Because important and sometimes even critical functions were overlooked early in the overall design. The shortfalls range from "common sense" such as failing to analyze student production requirements, to "technical" such as improper integration of out-the-cockpit visual system design with the design of the simulator. Analysis of successful programs concluded that there are basic top-level functions required for operation of a total instructional system.

System Functions

The basic top-level functions must be in place before a training system can operate. These system functions, shown in Figure 2, include **management, support, administration, and delivery, and evaluation** which occurs throughout the process.

Management is the function of directing or controlling all aspects of the instructional system. These activities are an integral part of conducting instruction. **Support** includes those activities that provide for and maintain the system on a day-to-day and long-term basis. This includes long-range planning as well as day-to-day activities. **Administration** is the part of management that performs the day-to-day tasks of operating an instructional system. This includes functions such as documentation, student assignments, and student records.

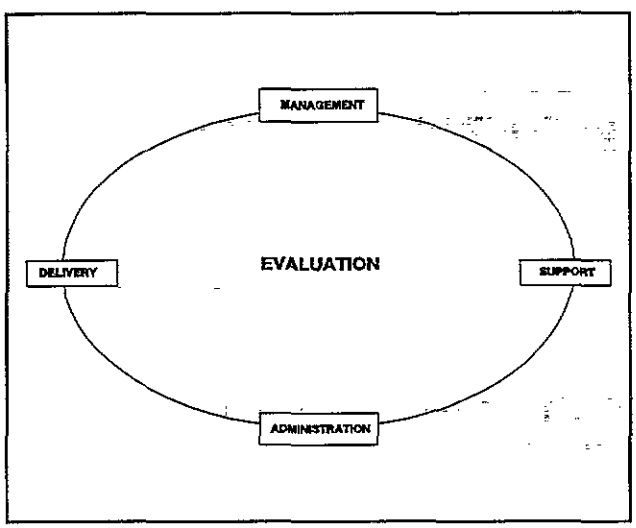

Figure 2. System Functions

Delivery is the means of giving students the instruction. Instructors, computers, and textbooks are examples of ways to deliver instruction. **Evaluation** is the continuous process of gathering feedback data through formative, summative, and operational evaluation to assess the system and, most importantly, assess student performance.

Using these essential functions to design the overall training system architecture and then allocating them to the respective system components, or people responsible, ensures that these functions are operational when the total instructional system is fielded. ISD products are integrated into the total system, and aspects of the system functions are active throughout all phases of the ISD process.

ISD Phases

The ISD phases used in the systems approach are **analysis, design, development, and implementation.** Evaluation activities are integrated into each phase of this process. To summarize these phases:

- **Analyze** and determine what instruction is needed.
- **Design** instruction to meet the need.
- **Develop** instructional materials to support system requirements.
- **Implement** the instructional system.

It must be emphasized that evaluation is a central function that takes place at every phase. ISD is a continuous, systematic process with continuous evaluation. ISD in the Air Force is used as a tool to ensure that quality systems are built to the customer's satisfaction. It helps managers and instructional developers build programs that teach what Air Force people need to know, when they need to know it, in the most effective and most efficient manner possible.

Quality Improvement Process

The ISD process implements all of the principles of the Quality Air Force (QAF) program. Quality is the vehicle to ensure that instructional systems are built and delivered customer-centered. Quality improvement (QI) is the continuous, organized creation of beneficial change. It occurs throughout the ISD process. The updated ISD model, shown in Figure 3, depicts the interaction

of the ISD phases with the system functions and quality improvement.

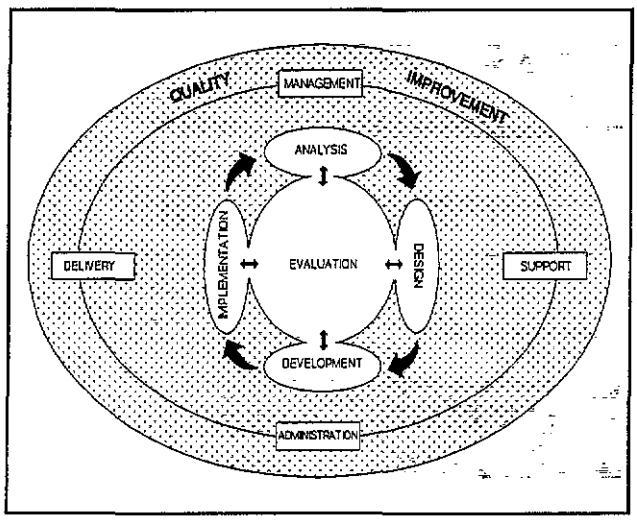

Figure 3. Updated ISD Model

APPLICATION TO DEFENSE SYSTEMS ACQUISITION

Manpower, personnel, and training (MPT) issues cycle throughout the entire weapon system acquisition process. The result of effectively handling these MPT issues can be concurrent delivery of these support elements with the delivery of the defense system. Once delivered, these MPT elements are sustained with the defense system throughout its life cycle.

ISD is the process for managing the acquisition of the training system for the defense system. This training system must be developed in the context of manpower and personnel estimates as well as defense system hardware and software design. Since the training system must be current with the weapon system design, development and production, and then systems engineering must also address the interface of ISD.

System engineering is a process which has been used for systematic development of the defense system as well as the training device hardware and software. The recent expansion of the training system concept to encompass the full life cycle of training for aircrew and maintenance personnel within a defense system acquisition has brought about an integration of the traditional ISD process within the system engineering process. This makes training system development a part of the integrated product development (IPD) team. Preliminary to the formation of the IPD team, the operational command forms a training planning team (TPT).

Training Planning Team

The Air Force recognizes the need for coordination and integration and requires that a Training Planning Team (TPT) be formed early in the acquisition cycle. A TPT is defined as an action group composed of representatives from all pertinent functional areas, disciplines, and interests involved in the life cycle of a specific defense training system. For a new acquisition, the TPT is formed at pre-concept and continues throughout the acquisition and day-to-day operation of the training system. The personnel on the TPT represent the using command, the system program office, and other concerned agencies. The TPT develops and uses the System Training Plan (STP) to ensure that training considerations, constraints and opportunities are adequately addressed in the defense system acquisition modification process.

The primary objective of the training planning team is to get the right agencies communicating and coordinating from the very beginning as a team. Once a System Program Office (SPO) is formed, the TPT bridges between the SPO and the operating command. The goal is to develop the STP and keep it current throughout the life cycle of the defense system.

Likewise, the primary operating command will establish and chair TPTs throughout the life cycle of the defense system. While the TPT may not meet every day, every week, or even every quarter, they will meet frequently enough to evaluate changes in the defense system for their effect on the training system. The TPT will update the STP annually or when changes occur that affect training in:

- Tactics
- Personnel
  - Structure
  - Demographics
  - Manning levels
- Defense system
  - Hardware
  - Software
  - Subsystem

- Training assets availability
- Funding priorities/levels
- Basing
- Operating commands

The TPT develops and implements alternate training strategies until the training system becomes current again with the defense system.

Whenever possible, advance notice of changes should be provided to the TPT to allow training of personnel prior to implementation of defense system changes.

System Engineering Interaction

With a properly operating Training Planning Team and a System Training Plan that is kept current, proper interfaces should be occurring with other defense system acquisition and life cycle support functions continuously. One important way that the ISD process meshes with the defense system is through interaction with system engineering. An "interaction" is a two-way street: ISD and system engineering communicate and support each other. But why is it important and how does it happen? First of all, a system is a composite of skilled people and equipment (hardware and software) that provide an operational capability to perform a stated mission. As mentioned earlier, ISD is the systematic process employed to design and develop training for a defense system.

The system engineering process is a logical sequence of activities and decisions transforming an operational need into a description of system performance parameters and a preferred system configuration. System engineering must consider personnel, the skills they require, and the training program to teach these skills as integral parts of the defense system. Failure to integrate ISD into system engineering can result in an inadequately supported system.

System engineering addresses those training system design issues having to do with translation of training system functional requirements (stated by ISD) into hardware and software. It considers the defense system hardware, software, support equipment, operations, and maintenance concept. System engineering examines new technology, similar systems, and existing systems to arrive at a functional description of the system in terms of hardware and software requirements. The system engineering process is used to produce the management and design decisions and data upon which the training system is based. ISD alone cannot fulfill all the needs of a total training system.

ISD and system engineering are two complementary processes that are used to design and develop training systems for defense systems. The processes have many similarities and each process accomplishes functions not accomplished by the other. All individuals involved with acquisition must ensure that ISD is considered in system engineering and vice versa. Many avenues exist for this interaction. Among them are:

- Acquisition strategy
- Training planning teams
- System training plans
- Integrated Manpower, Personnel and Comprehensive Training & Safety (IMPACTS)
- Requests for Proposal (RFP)
- Logistic support plans
- Logistic support analysis
- Technical interchange meetings
- Quality control
- Test plans
- Design reviews
- Program development plans

System engineering reviews of system requirements (SRR), system design reviews (SDR), preliminary design reviews (PDR), critical design reviews (CDR), and others should include instructional system reviews. Functional configuration audits (FCA) and physical configuration audits have a corresponding courseware readiness review (CRR). Tradeoffs are necessities in system engineering. This includes instructional system options considered at each phase of the process. Design decisions are reflected not only in hardware and software but also in courseware.

Acquisition Strategy

At a point when the TPT is formed and the STP is being written, a preliminary decision will be made on whether or not to contract for all or parts of the training. Assuming the decision is to have contractors develop at least a part of the training, the command with program management responsibility will develop an acquisition strategy. The acquisition strategy is finalized before each contracted activity.

In developing an acquisition strategy, the following should be considered by the SPO in coordination with the user.

- Current federal acquisition regulations
- Funding availability and constraints
- Defense system schedules
- Complexity of training system
- Types of training being acquired (operator/maintenance/other)
- Sole vs. multiple sourcing
- Lease vs. purchase
- Trained personnel requirements
  - How many?
  - When needed?
- One-time course vs. life cycle use
- Total contractor training vs. turnkey (using command operation)
- Other considerations

Getting the "big picture" is important in developing the acquisition strategy. The total instructional system perspective is needed to understand its full scope and how the integration will take place in order to have a fully operational system. Though a contracted activity may be treated as independent, the tie into the "big picture" ensures a good fit. Always consider how the instructional system fits into the overall defense system acquisition. Choosing the wrong acquisition strategy not only affects the instructional system, but can also cause delays in the defense system testing, support, and initial operational capability.

Evaluation

Evaluation occurs throughout the ISD process. Once instruction has been conducted, the Air Force will be specifically concerned with determining how well the training is achieving its objectives. Evaluation is the feedback that helps ensure that training objectives are achieved and the quality of graduates' performance is acceptable. The process continuously evaluates the course to determine if it is operating as designed. For example, six months after students graduate, are they still able to meet job performance requirements? If not, why not? Is it because of shortfalls in the course? Have mission requirements changed? Should changes in the course be undertaken? These are the kinds of questions you must ask and reviews you must make to ensure that the training that was developed is effective and efficient.

While evaluation occurs throughout the ISD process, **formative evaluation** should start early and continue through development, production, and test activities. It is the period from the beginning of planning to course readiness review or validation of materials.

One purpose of the formative evaluation period is to evaluate lesson/course development during the "formative" stages. It allows for corrections (remedies) to be made before training is fully implemented. It also includes acceptance testing of equipment and software, performance verification of system components, and assessment of the overall training system integration.

Summative evaluation begins at the Courseware Readiness Review, overlaps the formative evaluation period, and terminates at the Training System Readiness Review.

During summative evaluation, the training system is tested in the operational environment to validate the requirement baseline and assess the "summed" effect of the total training process.

During summative evaluation, questions are answered, such as:

- How well has the training been accomplished as reflected by operational requirements?
- Do graduates of a course meet established training system and operational performance standards?
- Are the training system performance standards correct?
- How can the training be better accomplished?

The primary purpose of summative evaluation is to determine whether the training developed for the students is effective and efficient. It is the process of collecting data from students, instructors, and other key evaluation interfaces as they use instructional media in the actual training environment. Its purpose is also to identify instructional materials, training media or instructional management system components that result in poor learning, inefficiency, or poor student acceptance. This data will then drive improvements.

Internal and external evaluation are categories of evaluation. Internal is within the training system and external is outside the training system. Inter-

nal and external evaluation activities occur within summative and operational evaluation.

The key difference between summative and operational evaluation is a matter of degree. The evaluation activities in summative evaluation are very intense and look at every possible data input. A review is conducted daily (if not more frequently) to assess the "bugs" still in the system and get them worked out as quickly as possible. Once the training system begins to stabilize, then the more routine period of operational evaluation begins. Data is collected selectively in order to keep a pulse on the entire system and its individual components. When areas of attention are raised in importance, then more intense data collection is accomplished only on that area and then phased back as the need is met. Day-to-day evaluation is a reflection of the evaluation activities during summative evaluation but is less intense. Evaluation continues both internally and externally using some of the same methods developed for summative evaluation.

Internal evaluations can be conducted by reviewing:

- Course documents
- Resources
- Instructional facilities
- Instructor performance
- Measurement programs
- Other sources as necessary

External evaluations can be conducted by:

- Questionnaires
  - For graduates
  - For supervisors
- Field notes
- Job performance evaluations

Operational evaluation begins at the conclusion of summative evaluation and continues throughout the life of the fully operational training system. Evaluation occurs on a system regardless of whether it is contractor- or USAF-operated. Evaluation in this period is similar to summative evaluation except it is less intense and reflects long-term operational data.

The purpose of operational evaluation is to provide real-time data for use in reviews, updates and quality improvement of training systems. It is continuous improvement.

The training source and the contract determine who conducts the operational evaluation.

Operational evaluation is a general reflection of the detailed procedures and data collection begun in summative evaluation but is more selective in data which continues to be collected. It usually starts at the Training System Readiness Review and lasts throughout the life cycle of the program. The emphasis shifts from establishing the instructional value of the courses to detecting flaws or deterioration. The primary goal is to maintain and improve course quality throughout the program life cycle. The following issues should be addressed in operational evaluation:

- Measurement and assessment of student learning in comparison to established training requirements and objectives
- Measurement of terminal objectives (qualification/certification)
- Identification and resolution of discrepancies and deficiencies in courseware and the training system
- Assessment of training in light of modification/upgrades in the defense system

Operational evaluation continues by both internal and external means, using to some degree the same methods developed in summative evaluation.

SUMMARY

The ISD process is really a derivative of the system engineering process and can be integrated in the acquisition of training systems for new defense systems. The once-perceived disconnect between the ISD community and the system engineering community is more semantic than real, and AFH 36-2235, Volume 3 provides the common understanding for both communities. This application should be a part of the integrated product development process and should be managed within the training system product group for the life cycle of the defense system.

The process of total training system design begins with the basic training system functions. The training system functions are key to building the overall training system architecture, assuring that all these functions necessary for successful

operation are in fact fielded for implementation. The tracking of the training system design through the system engineering reviews ensures that the system and component level specifications map the functions into requirements. The test and evaluation of the training system and its components assures that integration of the training system functions occurs, requirements are met, and the total training system becomes operational as designed.

The quality mindset throughout the acquisition and on throughout the life cycle of the defense system keeps the dynamic processes of ISD and system engineering active. Appropriate phases of these processes are entered as the feedback from the internal and external evaluation activities gives indications for a need to improve. Continuous improvement results in a training system which meets the needs of the user and continues to be effective as well as efficient.

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