

# TRAINING SYSTEM DESIGN FOR THE CRUSADER

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Training system design for major weapons historically began with a mature weapons system design, having been overlooked during the critical design and development phases. The Crusader program will reshape the Army's training system design paradigm through concurrent development of training. The Crusader program will field the cornerstone 21st century cannon artillery and artillery resupply systems, the Crusader Self Propelled Howitzer (SPH) and the Crusader Resupply Vehicle (RSV). In order to meet the requirements of the United States Field Artillery School, the Crusader prime contractor must consider technologies such as Embedded Training, Distributed Interactive Simulation, and Tactical Engagement Simulation during the early phases of weapons system development. The Crusader materiel developer must make decisions regarding training and the allocation of training tasks to various training media early in the acquisition process, prior to Crusader design freeze. The Crusader training program will examine training needs with early soldier-in-the-loop simulators and will leverage concepts from these simulators into the emerging training system design. This paper examines the goals, philosophies, and challenges faced by the Army as it develops a total training system for Crusader.

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Mr. Copeland and Mrs. Jones are STRICOM's recognized experts in Embedded Training and Embedded Training technology.

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## I. BACKGROUND

### System Description.

The Crusader is an Army Acquisition Category I program and is considered a system of systems. The current Crusader concept consists of the two complementary vehicles shown below; the Crusader Self-Propelled Howitzer (SPH), and the Crusader ReSupply Vehicle (RSV).

**Crusader Self-Propelled Howitzer (SPH).** The SPH will be the indirect fire support system providing direct support, reinforcing, general support-reinforcing and general support fires to the maneuver forces on the future battlefield. As part of a "system of systems" consisting of the SPH and the RSV, the SPH will provide close, tactical, and operational fires during both offensive and defensive operations. The SPH will be a 155mm self-propelled howitzer with significantly increased capabilities over the M109A6 Paladin. It will provide increased lethality, allowing for more flexibility for employment in pairs, platoons, batteries and battalions, as well as the added capability for independent mission execution.<sup>1</sup>

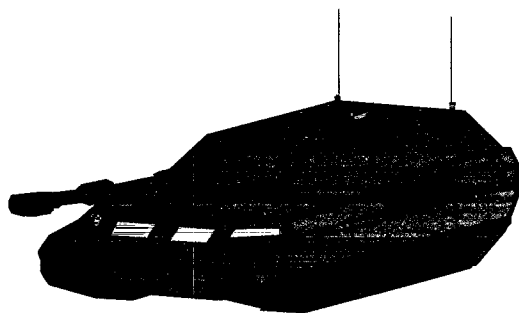


Figure 1 - Crusader SPH

**Crusader ReSupply Vehicle (RSV).** The RSV, the companion resupply vehicle to the SPH, will sustain SPH with ammunition,

propellant, and fuel. It will be a self-propelled armored vehicle with significantly increased capabilities over the current system - the M992 Forward Artillery Ammunition Supply Vehicle (FAASV). The RSV will automate ammunition and fuel resupply functions, provide an increase in payload carrying capability, and increased survivability.<sup>2</sup>

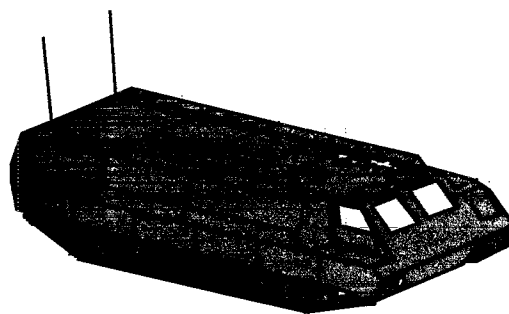


Figure 2 - Crusader RSV

Both vehicle systems will be deployable worldwide. Both systems will facilitate forward maintenance support and employ future maintenance concepts to increase sustainability and help enable Crusader achieve increased responsiveness and independent mission execution.

### Operational Requirements.

The Operational Requirements pertaining to Crusader training are stated in the Training Support Requirements (TSR) annex to the Operational Requirements Document (ORD). The training requirements include required embedded training capabilities for individual training (Category A), crew training (Category B), and crews in collective combined arms training (Category D) environments. It is important that the Crusader materiel developer consider ET requirements at the earliest stages of system design.

**Training Support Requirements.** The TSR also identifies an initial suite of stand-alone operator and maintenance training systems envisioned for the Crusader system. These systems will evolve as the government/contractor team iterates the system design, allocates training tasks to ET, and conducts formal training system concept formulation. The ORD and TSR were used to generate performance specifications for the SPH and RSV.

**Performance Specifications.**

Through application of the Department of Defense and Army Systems Engineering process, PM Crusader developed functional performance specifications for the SPH and the RSV. Training was identified as one of the eight SPH subsystems, and as one of the seven RSV subsystems during the functional allocation of requirements.

**General Performance Specifications.** Based on acquisition reform the Crusader performance specifications are intended to convey what is required without attempting to tell the contractor how to design the system. The Crusader system will use an integrated training approach, including the appropriate mix of stand-alone training devices, fully embedded training, appended embedded training, umbilical embedded training, actual equipment training, classroom training and other training methodologies to meet all individual, crew and force level training needs. The integrated training approach will meet the operator and maintainer training needs of the units and institutions. The capability will include networked simulation functionality and interfaces. Capabilities providing for force-on-force training at the combat training centers and home stations will be included in the system design. The training system will include a network interface which uses Distributed Interactive Simulation (DIS) protocols and standards.

**Detailed Performance Specifications.** In addition to the general requirements stated above detailed Crusader specification requirements are listed below:

- Training Interface: General DIS specification requirements.
- Training Safety: Operational state lockout to prevent inadvertent live firings.

- Unit Training: Operator and Maintenance training at the unit.

- Institutional Training: Operator and Maintenance training at the institution.

- Embedded Training: Details on ET specification requirements.

- Training Content: Instructional features including feedback and After Action Review (AAR) capabilities.

- Training Location: Where training is to take place.

- Tactical Engagement Simulation: TES interface specification requirements.

- Distributed Interactive Simulation: Detailed DIS specification requirements.

**Acquisition Strategy.**

The Army has determined that the most effective means to ensure success in meeting the Crusader weapons system acquisition objectives is to use a non-competitive approach and designate the prime contractor for Demonstration/Validation (Dem/Val) through Engineering and Manufacturing Development (EMD). The prime contractor has formed a highly leveraged team of subcontractors to accomplish Crusader program objectives. The partnerships formed by the prime allows the Army to capitalize on the investments made during the Crusader Concept Exploration phase and continue current technology efforts. As part of the overall strategy the prime contractor is responsible for the concurrent development of the total training system. The government and prime contractor have formed a Training Product Development Team (PDT) chartered and empowered to develop all Crusader training products. First and foremost the total training system must meet the requirements of the ORD and the performance specifications.

**Simulation Support Plan.**

The Crusader Simulation Support Plan (SSP) was developed by STRICOM to support the Crusader Program Decision Milestone (PDM) I. The SSP includes strategies for using DIS and synthetic environments to refine and develop the Crusader training system. The Crusader prime contractor, building on the Army developed SSP, plans on using an in-house Synthetic Battlefield (SB) testbed for training, testing, and system development.

## II. CRUSADER TRAINING

### Crusader Training Concept.

The user wants training to be conducted at the unit whenever possible, especially individual and crew-level sustainment training. In addition, the user would like to conduct force-on-force collective training in the garrison environment. Crusader training will be integrated into the curriculum at the U. S. Army Field Artillery School, U. S. Army Ordnance Center & School, and the U. S. Army Ordnance, Missile and Munitions Center & School. Field sustainment training will be supported primarily through ET. The training capability will include networked simulation functionality and interfaces. Capabilities providing force-on-force training at the combat training centers and home stations will be included in the Crusader system design.

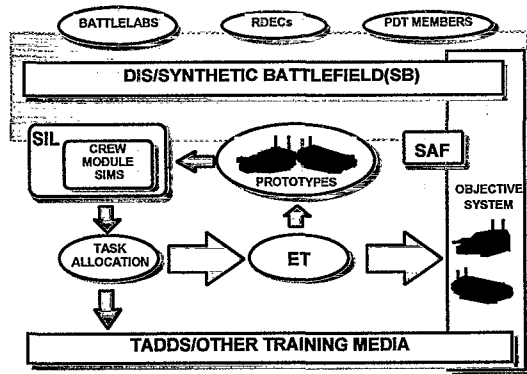


Figure 3 - Crusader Training Concept

### Training System Design Process.

The integrated training approach will be developed using a modified Instructional Systems Design (ISD) approach. The training PDT has based their ISD and training system design approach on a tailored version of MIL-STD-1379D. Adjustments to the ISD process will be made for ET and the PDT process.

### User Expectations.

Embedded training is one element of a total training solution, but not the only solution. The Crusader program will accomplish a total training system by filling all the users training needs with minimal overlap. The program will apply a variety of training methods, and will use simulation for training, as well as operational considerations. The Crusader program is based on simulation and training development concurrent with the weapons system design.

User requirements state that training is required in garrison, unprotected environments of actual combat assembly areas, and in harsh environments associated with CTC force-on-force (FOF) training. In addition the user expects the training system to simulate realistic combat scenarios by providing accurate visual/aural stimulus, and responses, of crew actions in a manner duplicating the performance expected during actual combat. The ET portion of the total training system should be designed as part of the system with interfaces to the crew member controls and displays. All training systems should provide an assortment of readily available combat training scenarios that directly simulate system functions or provide stimulation of actual on-board systems. The ET operation must be transparent to the SPH or RSV crew and cannot interfere with the normal operation of the system. Any training function embedded in a Crusader system must be designed to prevent inadvertent access to the combat or operational mode while engaged in the training mode. The actual design of the ET system and other training functions is being left to the system prime contractor and the training PDT.<sup>3</sup>

### Early Decisions regarding ET.

The goal of Crusader is to field a supportable weapon system, including training. During the Dem/Val phase of the program ET will be the focus of the training PDT. The goal of early decisions regarding ET is to design flexibility into the system which accommodates embedded training. It may be determined that through analysis some tasks are better trained using stand alone devices, classroom instruction, or other means. For the Crusader program, ET will be evaluated in the laboratory environment and a select number of ET tasks will be demonstrated in the Crusader prototypes. ET is considered feasible for the Crusader system for several reasons including: minimal or no 3-D computer image generation required, decision aids and performance support system are operational software requirements, and the Graphic User Interface (GUI) will be designed for both training and operations. One of the complications encountered during the Armored Systems Modernization (ASM) program was the perceived requirement for all image generation capabilities to be fully embedded. This is not a Crusader requirement.

### Categories of ET and Roles.

According to TRADOC's ET Action Plan the following are the definitions and categories of ET.<sup>4</sup>

**Definition.** Embedded Training is training provided by capabilities designed to be built into or added onto operational systems to enhance and maintain the skill proficiency necessary to operate and maintain that equipment end item. ET will not adversely impact the operational requirements or capabilities of the system, and should be identified early enough to be incorporated into initial prototype designs. ET may also train any tasks, from individual through force-level, as required. ET is subdivided into four categories (user needs):

- Category A (Individual/ Operator).
- Category B (Crew).
- Category C (Functional).
- Category D (Force-level Combined Arms Command and Battle Staff).

ET is built into or added onto systems using one or a combination of the following technical methods:

**Fully Embedded.** All features, with the exception of easily installed components such as software or courseware, are contained in the prime system. ET is distributed with the prime system, usually on a one-for-one basis.

**Appended Embedded.** ET features are installed or attached to the prime system when needed, and removed when not needed. It is likely to require permanent, designed-in components, such as sensors, mounting brackets, connectors, etc.

**Umbilical Embedded.** This method is like appended, but involves additional physical connection(s) to external components, such as computers, telephone systems, Local Area Network (LAN), etc. Umbilical ET may interconnect many systems, as in networked simulations for force-on-force training.

Although ET can be categorized into the above four general categories, these can overlap and be implemented in any order. The three technologies used to implement ET can also overlap the categories, making clear distinctions difficult.

#### **Iterative Concept Formulation Process.**

The Training PDT, consisting of members from the PM, STRICOM, and the prime contractor will investigate all feasible training alternatives for the Crusader system. The training PDT will first focus on the user requirements for ET, since these may impose design constraints on the Crusader system. The Training Concept Formulation Process (CFP) will determine and analyze the various alternatives which are deemed feasible for training and will recommend an approach to be taken with regard to the Crusader total training system. The resultant analysis will yield answers to the following questions:

- Which critical operator and maintainer tasks/standards are allocated to ET and which are allocated to other training methods? Decisions regarding stand alone devices can be deferred. However, ET may impose additional burdens on the Crusader vehicles.
- How will training impact design with regard to Reliability, Availability and Maintainability if crew station controls/displays usage rates increase as anticipated? This applies to both embedded and stand alone training systems.
- What training functions can be reasonably stored/processed by on-board Crusader resources?
- Should the training scenarios/databases/software be stored in "soft" (ie; CD-ROM) format and loaded into the vehicle computer only when training is conducted? If so, can the same soft media be used in stand alone devices as well?
- How will electronic, microcomputer, and network communication technology mature during the next five years? This question must consider the increased data rates and capacities required for training and interfaces to collective training environments.
- Should Crusader integrated sensors be jointly used for operational and Tactical Engagement Simulation training modes?
- Is ET cost effective when compared to other training alternatives? What is the most cost effective method for training each task?

**Functional/Fidelity/Task Analysis.** One of the early efforts to be accomplished by the training PDT will be a Functional/Fidelity/Task Analysis. This analysis will be performed to determine the design drivers for the total training system architecture. Unlike traditional task

analyses, which are dependent on existing systems, this effort will be an iterative process done concurrently with Crusader system design.

**Allocation of Tasks.** As a result of the task analysis, training tasks will be identified. Allocation of tasks to various training methods will be made based on cost-effectiveness, suitability of the method to the task, and training effectiveness. It is envisioned that the initial allocation will place many tasks within the vehicle. As concept formulation proceeds, and the Crusader design matures, a certain number of these tasks will be reallocated to other training methods, such as stand alone devices.

### III. LESSONS LEARNED APPLIED AND LEVERAGING OPPORTUNITIES

#### **Training for Operational Test.**

Training for and proving a weapon system's capability during Operational Test (OT) has generally been accomplished by using an instrumented surrogate for the weapon system. The Javelin program was the first to use a training device for Initial Operational Test and Evaluation (IOTE). Several lessons were learned resulting from the use of the Field Tactical Trainer (FTT) for Javelin force on force (FOF) events.<sup>5</sup>

The Javelin is a man-portable fire-and-forget anti-tank weapon system consisting of a round and a command launch unit (CLU).

Lessons learned when using an embedded training device for Operational Test include:

- Adequate time must be spent using the device "in the field" prior to the OT,
- The ET RAM requirements must be consistent with the prime system RAM for operation in a field environment.

As the Army's approach for more embedded training systems become a reality, it will be necessary to ensure that when training devices are used for Operational Test that they closely replicate the functionality and reliability of the weapon systems.

For the Crusader system, OT will be accomplished with a variety of embedded training, stand alone simulators, and distributed simulations. Building upon the lessons learned from Javelin, the user plans to train with the

systems prior to actual operational testing. In addition, live operational tests may be rehearsed in a distributed synthetic battlefield prior to actual tests.

#### **Armored Systems Modernization (ASM).**

The goal of the ASM program was to field six new vehicles, based on a common heavy chassis to replace aging armored systems. The Crusader program leverages off of early ASM ET efforts. The ASM Program intended to take advantage of emerging technologies and to emphasize commonality among the vehicles to reduce life cycle costs. Included in the program was the requirement for an Integrated Training System, consisting of Institutional training and Unit training. The concept of using common hardware and software across the ASM fleet remains a goal for the two Crusader vehicles. It was also a design goal to concurrently develop a fully embedded capability and an interface for Tactical Engagement Simulation (TES).

Among the lessons learned from the ASM program are the following: ET must be considered as early as possible, either in the Concept Exploration and Definition (CED) or Dem/Val phase; onboard computer resources must be allocated for ET; operational software should consider the total training system applications during design; and training concepts can be evaluated in a Systems Integration Laboratory (SIL) environment.

#### **Advanced Field Artillery System (AFAS) Advanced Technology Demonstrator (ATD) Crew Module.**

During the AFAS (the Crusader SPH was previously known as the AFAS) CED phase a crew module was developed for MANPRINT analysis. This crew module was used to determine allocation of tasks among the crew and to define crew manning requirements. The lessons learned from the crew module are: variances in soldier performance were due to experience and maturity rather than the soldier machine interface; automation/reallocation of tasks allowed for smaller crew size without decreasing performance; the crew station layout is ideal for training; with minimal modification the crew module can be made DIS compliant/compatible; and out the window visuals are not required for critical fire mission tasks.

#### **Early ModSAF development.**

PM Crusader, through STRICOM, has developed a Crusader Modular Semi-Automated

Forces (ModSAF) capability. The prime contractor plans to utilize ModSAF and an in-house synthetic environment to test and evaluate training on the synthetic battlefield. ModSAF will also provide a scenario generation capability for individual and crew training.

#### **Demonstration and Validation Systems Integration Laboratory.**

The prime contractor will implement a Systems Integration Laboratory (SIL) to support training system development. The training PDT plans on developing all ET capabilities in the SIL while slowly migrating these functions onto the prototype Crusader vehicles.

#### **Crew Module Simulators.**

The prime contractor plans on developing mobile crew modules to support development, training development, operational test, and training for operational test. The training PDT will leverage lessons learned from these "simulators" into the design process for the institutional and combined arms training systems.

#### **Tactical System Software Reuse.**

One of the user requirements is to maximum use of tactical system software in all training systems. Instructional and student software will be developed in parallel to the operational system software.

#### **Embedded Training in Prototypes.**

The current plans call for development of two SPH and two RSV prototypes for delivery at the end of Dem/Val (~FY99). The Crusader program will demonstrate limited ET tasks for each Crusader PDT in the four prototypes. The Government will make the determination of which tasks will be demonstrated.

### **IV. CONCLUSION**

The Crusader Training Product Development Team is empowered with developing both the training system development process and training products for the Crusader system. The key to success for the training PDT is the cooperation and teamwork between all team members. During the ongoing requirements analysis phase, the training PDT is developing an initial training system design process. Initial is the key word, since this process will iterate several times during the next four years of Demonstration/ Validation. The training design process must be flexible enough to allow for a

constantly changing Crusader system design. To achieve this flexibility and maintain a linkage to the Crusader weapons system, the training PDT will leverage off many of the same tools being used for system development. Tools such as mobile crew module simulators, the SIL, and the Synthetic Battlefield will serve to define, analyze, and further refine the training product. These tools will allow the PDT to make decisions and trade-offs regarding training and will provide the U.S. Army with a quality training system.

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<sup>1</sup> AFAS and FARV Operational Requirements Document, U.S. Army Field Artillery School, Ft. Sill OK, 14 Jun 1993.

<sup>2</sup> AFAS and FARV Operational Requirements Document, U.S. Army Field Artillery School, Ft. Sill OK, 14 Jun 1993.

<sup>3</sup> AFAS and FARV Operational Requirements Document, U.S. Army Field Artillery School, Ft. Sill OK, 14 Jun 1993.

<sup>4</sup> Assistant Deputy Chief of Staff for Training, TRADOC, Embedded Training Action Plan, dated 1 October 1994.

<sup>5</sup> U.S. Army Operational Test and Evaluation Command, Test and Evaluation Report, Initial Operational Test and Evaluation, Javelin, Report 94-OT-1217, dated April 1994.