HIERARCHICAL TRAINING FOR ARMY AVIATION

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ABSTRACT

In 1993, the Army Aviation community conducted a review of simulation and training requirements for deployable simulators and devices that support individual/crew sustainment training, collective training, and combined arms training. Following the review, the Army's Mobile Aircrew Sustainment Trainer (MAST), Future Aircrew Sustainment Trainer (FAST), and Aviation Combined Arms Tactical Trainer (AVCATT) programs all underwent scrutiny to determine if they could meet the training requirements within the constraints of today's austere budgets. This paper presents a training concept that consolidates Army Aviation simulation and training requirements under one program offering a single hierarchy of individual/crew and collective training devices. A basic tenet of the paper is that a single program could provide better training at a lower cost than several independent programs. The key to affordability resides in:

- Using state-of-the-art technology to reduce the recurring cost associated with training device hardware development.
- Tailoring training device fidelity to meet the "margin" of acceptable training for each level of training.
- Reducing non-recurring software costs by flowing software from full-fidelity training devices down to lower-fidelity devices.

ABOUT THE AUTHORS

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Dr. Sandra Szabo is an experimental psychologist with more than ten years of experience in human factors engineering and training system development for Army aviation systems. Her primary areas of expertise include mission/task analysis, operator workload prediction, and training and weapons system design. As a collocated contractor representative, she has provided technical advisory support to system program managers and developmental engineers at the U.S. Army Aviation and Troop Command in St. Louis, Missouri, and to training and combat developers at the U.S. Army Aviation Center at Fort Rucker, Alabama. Her last assignment was Manager of Training Operations for Army programs at CAE-Link Corporation in Binghamton, New York. Today, she is Technical Lead, Human Factors Engineering, for Comanche Crew Systems Design at Sikorsky Aircraft in Stratford Connecticut.

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INTRODUCTION

Since the 1970's, individual/crew training devices have provided a means for Army aviators to acquire and sustain skills in aircraft and systems operations. During the past two decades, simulation popularity among aviators has grown substantially, due in large part to advances in technology that offer more powerful visual systems, faster computers, realistic aural cues, and improved visual displays.

During the 1970's, state-of-the-art technology provided just enough device performance to meet the margin for satisfactory training. In contrast, today's medium fidelity technology provides more training performance at a lower cost than yesterday's high-fidelity technology. Army planners and industry training developers can take advantage of this technology to meet aviation training and simulation requirements within present-day budget constraints.

Currently, several independent Army programs are attempting to fulfill the requirements for affordable and deployable devices to support individual/crew sustainment, collective, and combined arms training. In today's funding environment, a strong possibility exists that one or more of these programs may be postponed or cancelled. A solution is needed to avoid the potential degradation to training that budget cuts might cause. This paper proposes a potential solution that consolidates all Army aviation training requirements under a single program that would cost less than multiple independent programs. Specifically, the paper proposes a hierarchy of training devices that meets both individual/crew and collective training requirements for Army aviators. While training programs for new systems such as the OH-58D, Longbow, and RAH-66 would benefit most from this strategy, training devices for fielded systems could also benefit from the proposed training concept. In both cases, the potential exists to fulfill all training needs at a more affordable cost.

The training hierarchy proposed herein is based upon the authors' experience in training, training systems analysis, and training device development and has not undergone a Systems Approach to Training (SAT) process. Consequently, we propose that, prior to the implementation of any ideas contained in the paper, a full SAT analysis be conducted to confirm the value of our proposed training solution.

BACKGROUND

The Training Hierarchy

Current Army aviation training uses a building block approach in which individual/crew skill training at the school house precedes sustainment and collective task training in the aviation unit. Individual/crew training focuses on the acquisition and sustainment of skills required to fly the aircraft and operate its systems. The suite of devices used to conduct this training provides a hierarchy of device fidelity that parallels the complexity of the individual/crew training requirements. These devices typically range along a continuum from cockpit procedures and part-task trainers to high-fidelity simulators. Once in the field, aviators use the aircraft and any available training devices to sustain their individual/crew skills.

Traditionally, collective training has been taught in the aircraft after the aviator arrives at the unit. During collective training, the aviator learns to operate the aircraft, first as a member of a team (2 to 3 aircraft), then as a member of a platoon or troop, and finally as part of a battalion or squadron.

Today's Hierarchy of Training Devices

Figure 1 illustrates the current hierarchy of devices that support Army aviator training. At the lowest level of the hierarchy Cockpit Procedures Trainers (CPTs) support training in cockpit switchology, engine start, and subsystems operations. At the second level, Part Task Trainers (PTTs) provide the means to train complex, time-consuming tasks. An example of a PTT is the Army's Target Acquisition and Designation System (TADS) System Task Trainer (TSTT) used by Apache pilots to learn sensor and weapons skills. At the third level in the hierarchy, is the Operational Flight Trainer (OFT) or Flight Simulator (FS), which supports flight training and total system operation. These devices typically have sophisticated flight models, high-fidelity visual systems,

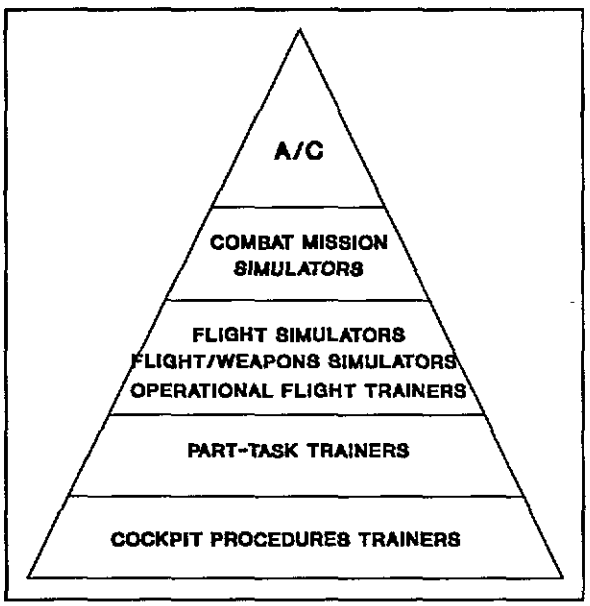

Figure 1 – Today's Individual/Crew Training Device Hierarchy

and six degree-of-freedom (6-DOF) motion systems. An OFT or FS may also support weapons training, in which case it is called a Flight and Weapons Simulator (FWS). Combat Mission Simulators (CMSs) comprise the fourth level in the training hierarchy. A CMS is an OFT, FS, or FWS that includes simulation of interactive threats to enable the crew to operate their simulated aircraft in athreat environment.

The operational aircraft used to be considered the ultimate training device in the training device hierarchy and the only means to train collectively. However, due to the lack of range space, lack of an interactive threat force, safety considerations, budget reductions and cutbacks, aircraft are no longer used to sustain aviator combat proficiency on a regular basis. Until the AVCATT system is fielded, the Army does not have an aviation collective training device.

TOMORROW'S HIERARCHY OF TRAINING DEVICES

This paper proposes an alternative suite of training devices that supports the training of both individual/crew and collective skills. The devices use state-of-the-art technology to provide a level of training fidelity specifically tailored to the margin of training appropriate to each level of individual/crew and collective training. A basic premise of the paper is that a single hierarchy of devices could significantly reduce training system cost. The primary cost savings accrue from flowing software down from the highest fidelity device to lower fidelity devices and by substituting or eliminating high-fidelity hardware in the lower fidelity devices.

Figure 2 illustrates the proposed training device hierarchy. The Simulator (Enhanced) trainer, called the SIM (E) is the highest fidelity device in the hierarchy. Individual/crew training devices representing decreasing levels of fidelity extend to the left of the SIM (E) device, while collective training devices representing decreasing levels of fidelity extend to the right of the SIM (E) device.

Individual/Crew Training Devices

The proposed individual/crew training device hierarchy includes four training devices:

- Cockpit Procedures Trainer (CPT)
- Part-Task Trainer (PTT)
- *Simulator Enhanced*, SIM (E)
- Simulator Plus, SIM (+)

The CPT and PTT devices possess the same general level of fidelity and support the same training functions as the CPTs and PTTs included in today's hierarchy. The SIM (E) device is comparable to traditional full-fidelity simulators and is characterized by high-fidelity flight models, high-resolution visual systems, and 6-DOF motion systems. However, in the proposed hierarchy, the SIM (E) trainers are used only to conduct initial acquisition of individual/crew skills at the school house. That is, unlike the simulators in today's hierarchy, the SIM (E) devices are not used to support individual/crew sustainment training in the units. Instead, the proposed hierarchy includes a

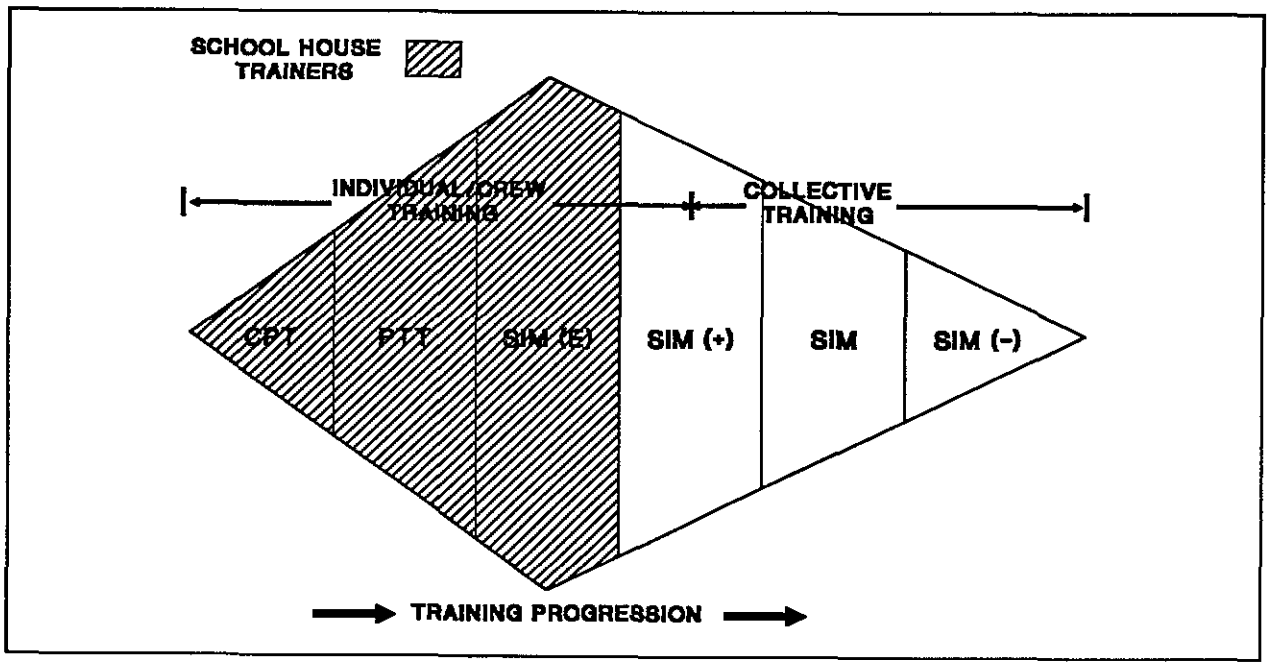

Figure 2 – Proposed Future Army Aviation Device Hierarchy

variant of the SIM (E), called the SIM (+) trainer, to conduct sustainment training.

The SIM (+) is best characterized as a medium fidelity training device whose principal differences from the SIM (E) include a lower fidelity visual system and seat-shaker motion cuing. Because of the reduced hardware associated with the lower fidelity visual and motion systems, the SIM (+) is a self-contained training device that can be housed in a government building or a mobile facility. This feature contrasts dramatically with the "brick and mortar" facility requirements associated with traditional simulators. Furthermore, it allows the SIM (+) to be deployed with the troops or to move from installation to installation, supporting training in units with low aviator populations and providing training to aviators worldwide.

Collective Training Devices

The proposed suite of collective training devices includes three variants of the SIM (E) trainer. The three variants, each representing decreasing fidelity, are designated SIM (+), SIM, and SIM (-). The SIM (+) is a "double-duty" training device and supports both individual/crew sustainment training and collective training. In the collective training hierarchy, the SIM (+) is used to support training at the lowest echelon level -- the team/platoon level. Thus, the SIM (+) provides the transition from high-fidelity individual/crew training to low echelon collective training.

The core simulator in the proposed collective training device hierarchy is the SIM. The SIM is a variant of the SIM (+) trainer with non-essential, non-mission equipment simulated as facsimile panels in the cockpit. After mastering collective team operations in the SIM (+) device, the aviator transitions to the SIM trainer. The primary objective of the SIM trainer is to support company/battalion level collective training.

The SIM training device is supported by a set of four auxiliary work stations, called the SIM (-) team set. The networked SIM (-) work stations enable additional pilots to enter the collective training environment, thereby increasing the number of players in the loop for any training scenario. The SIM (-) is designed to provide year-round unit collective training at the aviation battalion/squadron level.

Figure 3 presents a comparison of the hierarchy of training devices currently used to conduct Army aviation training and the hierarchy of devices proposed herein.

Why a Training Hierarchy

During training, an aviator progresses sequentially through two hierarchies of training. The first hierarchy is individual/crew training where the aviator learns to fly the aircraft and operate the systems. As the aviator progresses through the levels of individual/crew training, the complexity and cost of the individual/crew training devices increase in direct proportion to the level of training performed.

Having acquired the necessary individual/ crew skills, the aviator then progresses to the collective hierarchy of training. Collective training provides a means for the aviators to learn to operate their aircraft on the battlefield as a member of the combined arms team. Collective training should occur in stages of progressively higher echelons beginning at the team level and progressing to the company, battalion, squadron, brigade, and higher levels. The required level of fidelity for collective training devices is inversely proportional to the echelon level of collective training.

Using the Hierarchy to Train

Having completed initial acquisition training in individual/crew skills at the school house, an aviator arriving in the unit is already qualified to fly the aircraft and operate its systems. The SIM (+) version of the high-fidelity SIM (E) device provides sufficient fidelity to sustain the individual/crew skills of the unit aviators. As a derivative of the SIM (E) trainer, the SIM (+) includes most of the software and training potential of the SIM (E), but at a significantly lower cost.

Upon entry into the collective training hierarchy, the aviator begins training at the lowest echelon, the team level, and progress to higher echelons. In the proposed training device hierarchy, team training is conducted in the highest fidelity collective training device, the SIM (+). The SIM (+) device imposes total aircraft and subsystem operation responsibility on the aviator while simultaneously introducing the skills required to coordinate the mission as a member of an aviation team. An advantage of the SIM (+) device is that it minimizes the negative transfer of training in basic flight skills the aviator might experience during the transition from individual/crew operations to collective team operations. That is, the SIM (+) bridges the gap between the high fidelity flight and systems models in the individual/crew training devices and the reduced fidelity models that characterize the higher echelon collective training devices. Gradual transition into the lower fidelity devices enables the aviators to learn to cope with the additional demands of collective mission operations without degrading their individual/crew skills. Although the SIM (+) objective is to support team level collective training, it can be networked to other compatible trainers to support company/ battalion level training. Higher echelon training with the SIM (+) is conducted on a limited basis and only to reinforce the complexity of collective training in a full fidelity aircraft.

		SCHOOL HOUSE				UNIT
INDIVIDUAL/ CREW TRAINING	TODAY	CPT	PTT	OFT/FS FWS	CMS	OFT/FS/ FWS/CMS
	TOMORROW	CPT	PTT	SIM (E)		SIM (+)

		TEAM TRAINING	COMPANY/ BATTALION TRAINING	SUPPLEMENTAL TRAINERS/UNIT TRAINERS
COLLECTIVE TRAINING	TOMORROW	SIM (+)	SIM	SIM (-)

Figure 3 – A Comparison of Hierarchies, Today and Tomorrow

As the level of collective training increases to the company and battalion echelons, the training emphasis changes from aircraft and system operation task loading to higher echelon decision making and improving the aviator's ability to impart cause and effect on the battle. Having gained an appreciation for the complexity of both aircraft operation and mission responsibilities during team collective training in the SIM (+) device, the aviator can now progress to training at the next level of collective operations. The SIM trainer is the core training device for company/troop level operations. Like the SIM (+), the SIM may be networked with other training devices to provide collective training at higher echelon levels.

In the company/battalion level collective training scenarios, the number of players is limited by the number of networked SIM (+) and SIM devices. The number of networked devices, in turn, is constrained by budgets and training throughput. The SIM (–) is proposed as a low-cost device that increases the number of players who experience year-round collective training. The Sim (–) provides a set of four networked work stations supporting four pilots operating as a team. SIM (–) operators may also include staff officers observing the mission from stealth vehicles (vehicles not seen in the visual scene).

The SIM (–) work stations provide an enroute flight mode to teach maneuver skills and a battle position engagement/observation mode to teach weapons and sensor operations. With SIM (–), teams can train independent of SIM training or supplement to SIM training. The independent mode enables every aviation unit to have year-round collective training, sustaining a higher level of mission proficiency and providing greater benefits from annual collective training exercises. The SIM (–) team set would become part of the aviation battalion/squadron Table of Organization and Equipment (TOE).

The Cost Savings

The high costs of operating aircraft makes simulation a cost-effective component of Army aviation training systems. Although all levels of training can be conducted in a single high fidelity device (CMS, FS, or OFT), a hierarchy of devices enables many training requirements to be fulfilled in lower cost devices (CPTs and PTTs). Off loading training requirements to lower fidelity devices means fewer CMS or FS device hours are needed, reducing both the acquisition and life-cycle costs of the total training system.

The potential savings realized by building a hierarchy of devices are enormous. Most of the software originating in the SIM (E) device is common across the device hierarchy. From the SIM (E) starting point, hardware is deleted or alternative lower cost hardware is substituted ineach lower fidelity device in accordance with the training requirements. This approach to training system development results in a total cost for all trainers that is less than the cost of building a single, high-fidelity sustainment training device and a different collective training device under separate programs.

Device Cost and Fidelity Differences

In the proposed training device hierarchy, CPT and PTT devices will support individual/crew training requirements as in the past. The fidelity and cost of CPT and PTT devices in the future hierarchy are comparable to similar devices included in the present training hierarchy. The SIM (E) device will replace the FS, OFT, FWS, and CMS in the future school house. New technology for high-fidelity visual and motion systems should accommodate a recurring cost for SIM (E) at half the cost of past CMSs.

In the future hierarchy, the SIM (+), will pull double duty as an individual/crew sustainment trainer and an introductory team collective trainer. The SIM (+) software loads will be identical to the SIM (E) software; however, SIM (+) will have less motion fidelity than the SIM (E) device and a lower cost visual system. The recurring cost of the SIM (+) device will be 40 percent of the cost of the CMS device it will replace.

The SIM device is the core collective trainer in the future training hierarchy. The SIM is characterized by minimum motion cuing, a reduced cost visual system, and facsimile panels for non-essential cockpit controls and displays. Consequently, the recurring cost of the SIM device will beone-third the cost of a SIM (+) device.

A SIM (–) device consists of a set of four work stations that provide an enroute flight mode and a battle position engagement or observation mode with auto-pilot. The SIM (–) is fully reconfigurable to support the simulation of flight, weapons and sensor systems for all aircraft types. The weapons and sensor system software for SIM (–) is flowed down from the SIM (E). The affordability of SIM (–) will enable 24 additional aviators to participate in a collective training scenario in six SIM (–) team sets for the same recurring cost as a single SIM device.

Design to Cost Goals

To achieve the cost reductions for the proposed training devices, design to cost (DTC) goals must be established for major simulator subsystems. Examples of two major subsystem cost drivers, visual image generators and motion systems, are presented below. The DTCs established for each subsystem include the cost of state-of-the-art technology available today. These cost goals describe system performance at the training margin for each level of training. Higher cost systems may exceed the margin for individual/ crew training and collective training needs.

- Visual Image Generator (IG): 6 channels, 2,000 polygons per channel; 1M pixel resolution with special effects, weapons effects and 60 Hz iteration rate. Recurring DTC: $2M, SIM (E) and SIM (+) devices.

- Visual Image Generator (IG): 4 channels, 2,000 polygons per channel; 750K pixel resolution with special effects, weapons effects and 60 Hz iteration rate. Recurring DTC: $1.2M, SIM device.

- Visual Image Generator (IG): 4 channels, 1,000 polygons per channel; 750K pixel resolution with special effects, weapons effects and 30 Hz iteration rate. Recurring DTC: $200K, SIM (-) device.

- Motion Cuing: Recurring DTC: $1.2M, SIM (E) device.

- Motion Cuing: Recurring DTC: $300K, SIM (+) device.

SUMMARY

With state-of-the-art technology, the costs of simulation and training devices are slowly coming down. To control costs, it is important to define the margin for training performance and to select the appropriate technical solution. An alternative approach is to establish both a training margin and a DTC for each required trainer. This approach would allow (1) industry to bid the bestperformance possible within the DTC budget and (2) the Army to select vendors who offer the "best value training solution. Otherwise, the Army must select the vendor who meets the margin of training performance at the lowest cost.

A hierarchy of trainers can significantly reduce the overall non-recurring costs, especially the costs of software development. Design work is also reduced if all devices are a variant of a higher order device. The cost benefits attributable to design commonality, hardware modularity, and life-cycle support savings afford an opportunity to meet current training requirements within the constraints of today's austere budgets.

Additionally, the hierarchy proposed herein ensures that all levels of training can be provided to all aviators. Collective trainers designed to be mobile can be deployed with the troops or relocated from one installation to another. Mobile training devices provide a particular advantage for National Guard and Reserve aviator training. Containerized training devices also appreciably reduce building construction costs.