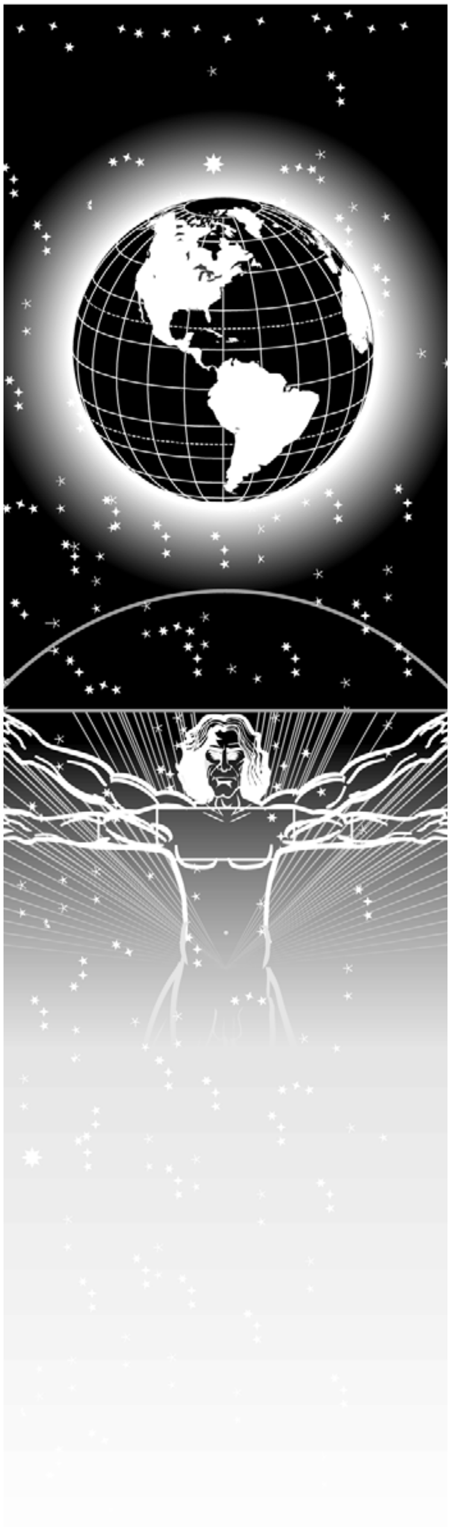
AFRL-HE-AZ-TP-2002-0003



UNITED STATES AIR FORCE RESEARCH LABORATORY

USAF SECURITY FORCES DISTRIBUTED MISSION TRAINING: EVOLUTION OF THE DESIGN CONCEPT

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October 2002

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REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (FROM - TO)
01-10-2002	Interim	xx-01-2001 to xx-12-2001

4. TITLE AND SUBTITLE
USAF Security Forces Distributed Mission Training: Evolution of the Design Concept
Unclassified

5a. CONTRACT NUMBER
F41624-97-D-5000

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
63231F

6. AUTHOR(S)
Weeks, Joseph L. ; Author
McDonald, L. Bruce ; Author
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5d. PROJECT NUMBER
4924

5e. TASK NUMBER
B2

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME AND ADDRESS
Air Force Research Laboratory
Warfighter Training Research Division
6030 South Kent Street
Mesa, AZ85212-6061

8. PERFORMING ORGANIZATION REPORT NUMBER
AFRL-HE-AZ-TP-2002-0003

9. SPONSORING/MONITORING AGENCY NAME AND ADDRESS
Air Force Research Laboratory
Warfighter Training Research Division
6030 South Kent Street
Mesa, AZ85212-6061

10. SPONSOR/MONITOR'S ACRONYM(S)
AFRL; AFRL/HEA

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
APUBLIC RELEASE
,

13. SUPPLEMENTARY NOTES
Air Force Research Laboratory Technical Monitor: Dr Joseph L. Weeks, 480.988.6561 x-249, DSN 474-6249. This documents a presentation at the 2001 Interservice/Industry Training, Simulation, and Education Conference, held 26-29 Nov 01, held in Orlando FL.

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Advanced Distributed Learning; Communication Functionality; Distributed Interactive Simulations; Distributed Mission Training; Security forces; Simulation Control; Training needs; Virtual Entities/Models;

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19. NAME OF RESPONSIBLE PERSON
			Public Release	14	Casey, Liz liz.casey@williams.af.mil
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified			19b. TELEPHONE NUMBER International Area Code Area Code Telephone Number 480988-6561 DSN 474-6188

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39.18

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This paper has been reviewed and is approved for publication.

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Copies of this report may be requested from:

Defense Technical Information Center
8725 John J. Kingman Road, Suite 0944
Ft. Belvoir, VA 22060-6218
http://stinet.dtic.mil

REPORT DOCUMENTATION PAGE						Form Approved OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
October 2002

2. REPORT TYPE
Interim

3. DATES COVERED *(From - To)*
Jan 01 to Dec 01

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AFRL; AFRL/HEA

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
AFRL-HE-AZ-TP-2002-0003

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

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					Liz Casey
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** *(include area code)*
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNLIMITED	14	480.988.6561 x-188 DSN 474-6188

PREFACE

This research was conducted for the Air Force Research Laboratory, Human Effectiveness Directorate, Warfighter Training Research Division (AFRL/HEA) under USAF Contract No. F41624-97-D-5000, and Work Unit 4924B206, Force Protection: Distributed Mission Training. The Laboratory Technical Monitor was Dr Joseph L. Weeks, AFRL/HEA.

This technical paper documents a presentation at the 2001 Interservice/Industry Training, Simulation, and Education Conference, held 26-29 Nov 01, in Orlando FL.

USAF Security Forces
Distributed Mission Training:
Evolution of the design concept

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Distributed Interactive Simulations, Distributed Mission Training, Advanced Distributed Learning, Virtual Entities/Models, Communication Functionality, Simulation Control

ABSTRACT: The Air Force Research Laboratory and McDonald Research Associates have initiated research into distributed interactive simulation technology for USAF security forces. Security forces have a pivotal role in force protection. Their responsibilities include installation security and air base defense. Within these duty areas, training needs surveys have indicated that tactical decisionmaking and team coordination are high emphasis skills for training. Although field training exercises are the best way to acquire these skills, distributed interactive simulations could offer affordable supplements to field training. The goals of the R&D project are to develop and demonstrate a capability for distributed training and to use this capability for investigating issues related to computer simulation, communications, and instruction. Since the introduction of this project during the Fall 2000 SIW (Paper number OOF-SIW-117), the system design plan has evolved. The preliminary design plan included a link between constructive simulations and combat arms simulators. The plan has changed to a singular concentration on constructive simulations due to probability of use considerations. The preliminary design plan also called for hosting the training capability on the Internet. The plan has changed to hosting the capability on a local area network due to expectations relating to training effectiveness, technology obstacles, and schedule/cost considerations. The purpose of this paper is to describe the current design plan for security forces distributed mission training by illustrating virtual entities/models, communications, and simulation control. Project challenges and technology obstacles are also discussed.

1.0 Introduction

Security forces (SF) represent one of the largest active duty, career fields in the United States Air Force (USAF). SF ensure USAF combat capability through providing the functions of security for resources, installations, weapons systems; force protection; air base defense; military police services; information, personnel, and industrial security; military working dog activities; and combat arms ("Security Forces Officer Specialty, Career Field Education and Training Plan", 2001). Training needs surveys have been conducted for both enlisted and officer career fields. Surveys indicated that skills involving tactical decisionmaking and team coordination are among the highest in training emphasis (Weeks, Garza, Archuleta, and McDonald, 2001).

Although field-training exercises are the best way to acquire these skills, distributed interactive simulations could offer affordable supplements to field training. The Air Force Research Laboratory and McDonald Research Associates are conducting research into distributed interactive simulations for USAF security forces (McDonald, Weeks, & Harris, 2000; McDonald, Weeks, & Hughs, 2001). The goals of the project are to develop and demonstrate a capability for distributed training and to use this capability to investigate issues related to computer simulations, communication networks, and instructional subsystems.

2.0 Objective

The objective of this paper is to describe the current design concept for the distributed training capability. Such a capability could be developed for any of several functions including law enforcement, installation security, nuclear weapons security, or air base defense. The described capability focuses on air base defense. The virtual environment, communications, and simulation control are illustrated and challenges are discussed.

3.0 The virtual environment

The distributed training capability is based on the simulation toolkit, VR-Forces™, by MÄK Technologies. McDonald Research Associates under contract with AFRL are adapting VR-Forces™ to provide support for training tactical decisionmaking and team coordination. To provide the training platform, simulations will be distributed over a local area network (LAN) in accordance with standards for distributed interactive simulations and the high level architecture (DIS/HLA). The entities and models that will populate the virtual environment are presented in Figure 1.

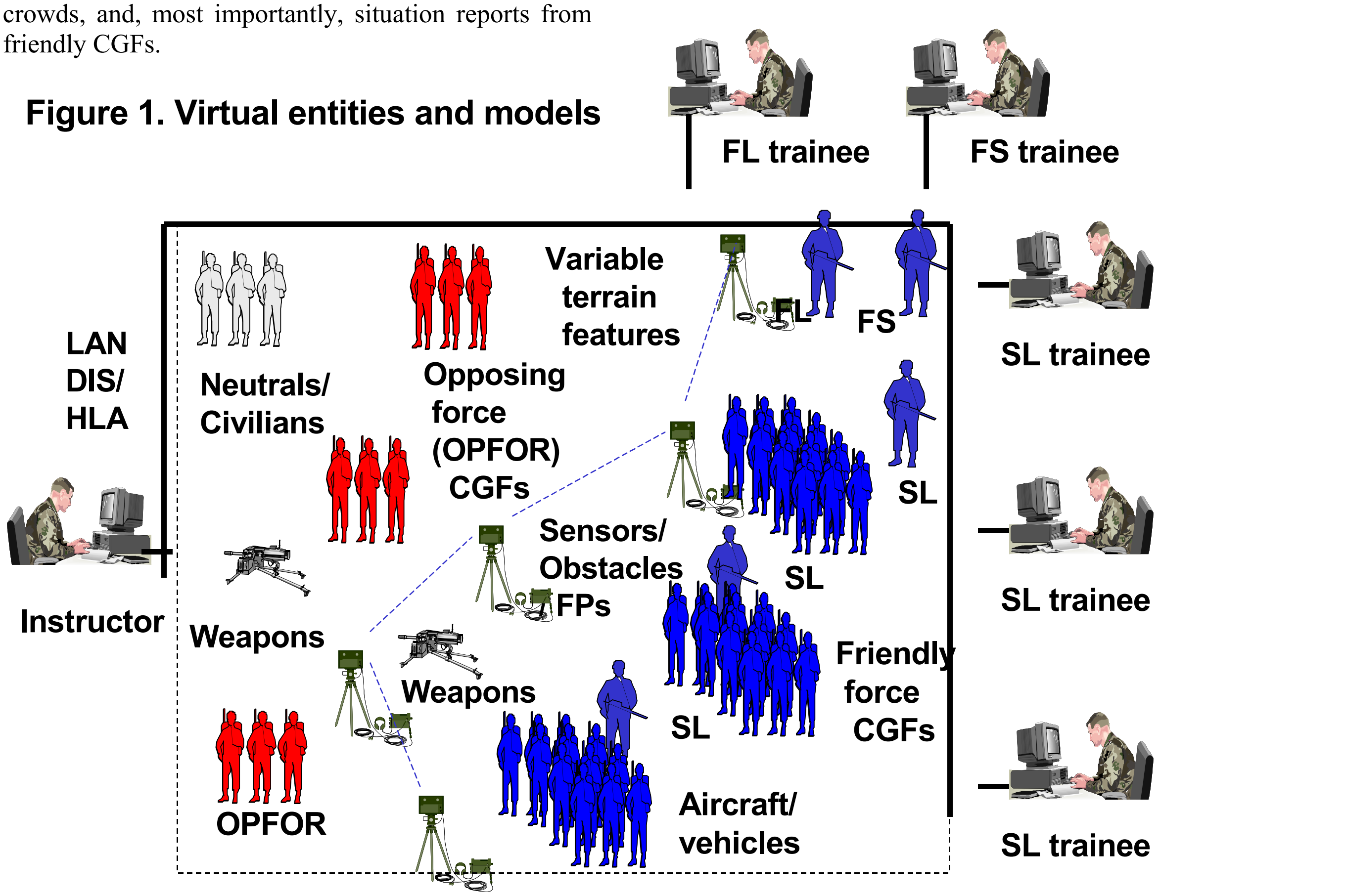
An instructor will give trainees access to a two dimensional terrain map. The terrain map and communications linking the instructor to trainees will provide the stage for training. The minimum trainee group will consist of security forces flight leader (FL), flight sergeant (FS), and 3 squad leaders (SLs). The virtual environment will consist of a 3-dimensional battlespace for the interaction of enemy (OPFOR) and friendly computer generated forces (CGFs). The virtual landscape will include variable terrain features. It will be based on terrain samples represented by 10-meter elevation postings and polygons that could, for the purpose of line of sight calculations, occlude OPFOR CGFs hiding in gullies or behind high points. Variable terrain features will provide the cues for defensive planning.

Friendly CGFs will be equipped with standard security forces weapons including pistol, rifle, grenade-firing rifle, light machine guns, and heavy weapons including 50-caliber machine gun and small mortar. OPFOR weapons will include rifles, rocket-propelled grenades, and conventional satchel charges. Obstacles in the form of wire and barricades are being modeled as well as seismic and infrared sensors. Re-locatable friendly fighting positions (FPs) are being modeled to accommodate different weapons and provide adjustable fields of fire. VR-Forces™ provides virtual trucks for crashing through entry control points and rotary-wing aircraft to support decisions related to casualty evacuation.

In addition to terrain and equipment models, CGFs are being developed. CGFs will include friendly, OPFOR, neutral combatants, and civilians. CGFs are virtual entities having pre-programmed behaviors that allow them to move, sense, and shoot. They are capable of executing high-level commands such as "Move to waypoint X" without running into obstacles or "Make contact with OPFOR and fire" without violating rules of engagement". A unique feature of SecForDMT is that CGFs are being developed to support training in decisionmaking and team coordination for small scale contingency operations. Civilian and neutral CGFs are being developed to display actions varying from compliant to assaultive behaviors including a capability for lethal force. CGF rules of engagement include the standard options (i.e., "Hold" - Do not fire under any conditions, "Tight" - Fire if fired upon, and "Free" - Fire at will) plus an additional option, "Fire if hostile intent". This last option would occur if a neutral or civilian CGF were to aim a rifle in the direction of a friendly CGF without firing. Such an option offers greater realism for support of decisionmaking and team coordination training for small scale contingency operations. In addition, friendly combatant CGF behaviors will include “Challenge”, “Surrender”, and “Escort detainees to the rear”.

Each trainee will be represented by a CGF to provide the means of determining what battlefield sounds to deliver to the trainee’s computer work station. Audio data files will be developed for providing battlefield sounds representing weapons discharge, detonation of explosives, vehicles, aircraft, taunts from hostile crowds, and, most importantly, situation reports from friendly CGFs.

Figure 1. Virtual entities and models



4.0 Communications

Figure 2 illustrates the communication links that will support the command and control training capability. Radio communications through earphones and microphone will be the primary means by which the instructor will interact with trainees, trainees will interact with each other, and friendly CGFs will report to trainees (i.e., “report above”). The instructor will role-play the commander, monitor trainee communications, and provide feedback. For example, in a typical exercise the instructor will communicate operation orders to the FL who will communicate with the FS to formulate plans in response to orders. Templates for development and transmission of written operations orders are also provided as an option. Friendly CGFs will communicate with the SL to report situation status, observations of other CGFs, and logistic needs. Based on friendly CGF observation reports, SLs will use simple functions to annotate their “on screen” terrain maps to indicate last known positions of enemy CGFs. The SL will relay reports to the FL or FS who will be responsible for reporting to the commander, role-played by the instructor. Communications will support both deliberative and reactive decisionmaking.

Reactive decisionmaking occurs when there is high time pressure. For reactive decisionmaking, a FL trainee would receive immediate-reaction orders from the base defense operations center (i.e., the instructor) and communicate with the FS to conduct mission analyses, formulate alternative courses of action (COAs), evaluate and select a COA, inform SLs on the selected COA, start execution, and monitor/control execution. Selected SLs would execute the plan by using a simplified graphical user interface to direct friendly CGFs. During the process, they would communicate the commander's intent, rules of engagement, and reporting requirements.

Deliberative decisionmaking occurs when there is relatively less time pressure. For deliberative decisionmaking, trainees will formulate sector defense plans. The FL, FS, and SLs will communicate and collaborate to develop the plan. During this process, they will evaluate sector terrain features, identify avenues of approach, and dead spaces and decide how to use defensive resources like sensors, obstacles, and defense forces to address defensive vulnerabilities and protect high value assets.

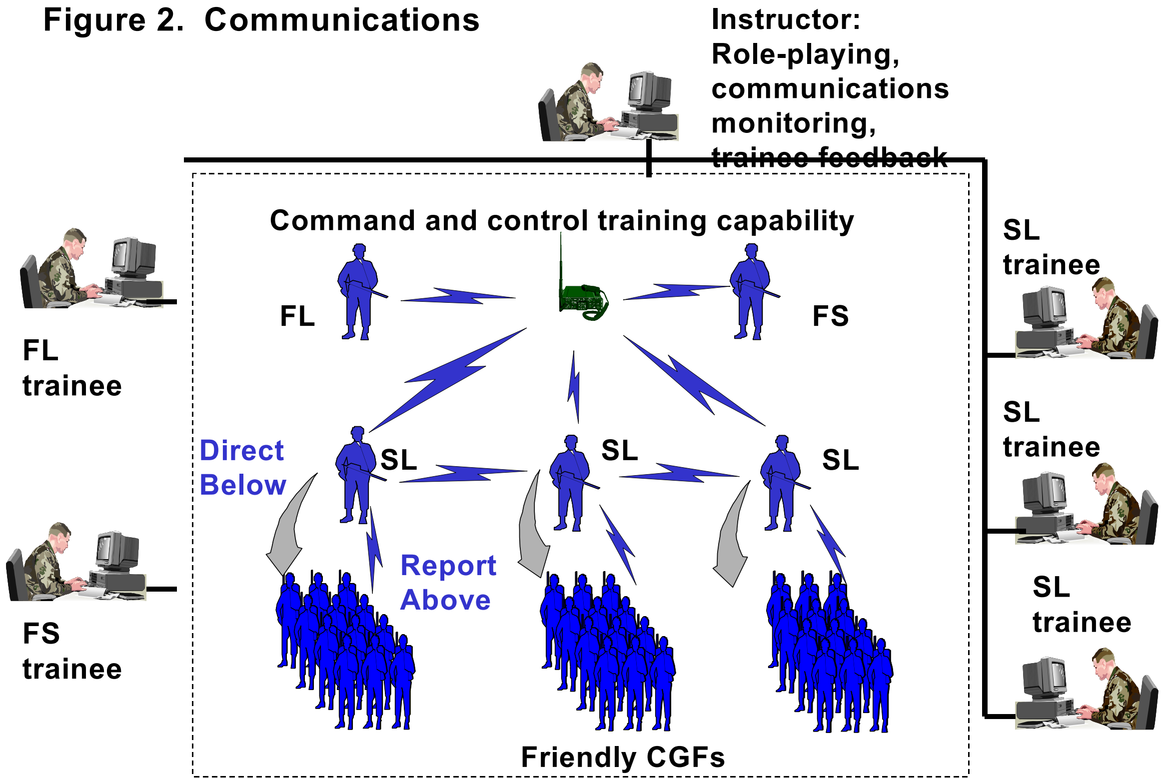
During defense planning, communications will be facilitated by graphic functions. These functions will allow trainees to develop and share transportable maps illustrating sector defense plans. Maps will show terrain features using topographic symbols, positions of FPs, weapons, fields of fire, obstacles, and sensors. After completion, the FL will electronically transmit plans to the commander, role-played by the instructor.

5.0 Simulation Control

Figure 3 illustrates the simulation control concept. Affordability has driven the requirement for a low-immersion virtual environment. Trainees will not have a 3-dimensinonal view of the virtual environment. Their perception of the tactical operations will be based on a 2-dimensional terrain map, predetermined defensive plans, and radio communications from friendly CGFs. This design concept is a realistic representation for night operations, operations in thick vegetation, or urban environments where visibility is limited. For the trainee, the computer monitor will provide visual feedback in the form of the 2-dimensional terrain map with icons representing the location of obstacles, sensors, FPs, and friendly CGFs. For the instructor, the computer monitor will provide the same visual feedback plus locations for enemy, neutral, and civilian CGFs. The simulation control interface will consist of a computer keyboard, mouse, and computer video monitor.

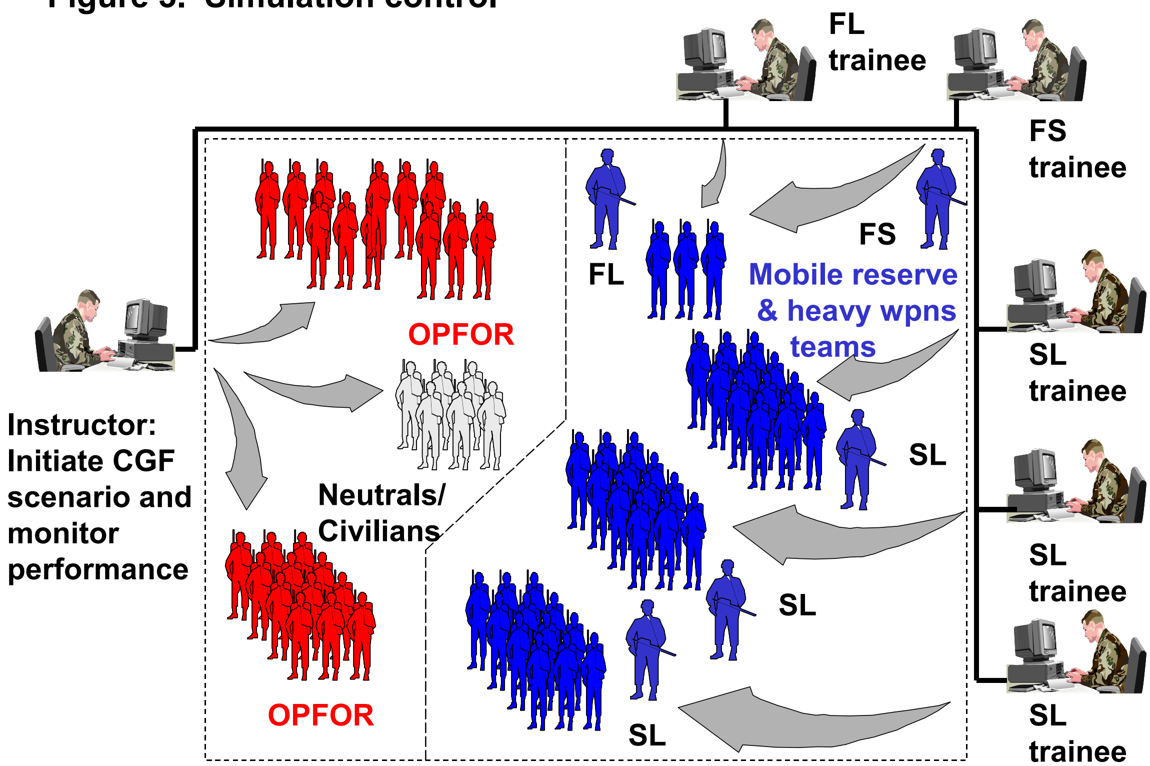
For defensive planning, trainees will use the mouse to position icons for sensors, obstacles, FPs, weapons, and adjust weapon field of fire by selecting and dragging firing boundaries to the desired position. The FL and

Figure 2. Communications



FS will be responsible for controlling mobile reserve forces
and heavy weapons teams (e.g., 50 caliber machine gun and small mortar) if given authority to do so by the base defense operations center. In the field, each SL has responsibility for three, 4-man fire teams. SL trainees will have responsibility for three, 4-man fire teams represented by CGFs. In most cases, SLs will control fire teams as a unit rather than controlling each member of the fire team individually. During the exercise, trainees will direct friendly CGFs to engage OPFOR CGFs in accordance with the selected COA. This will be accomplished by clicking on a fire team and entering a menu selection indicating movement along a route to make contact with OPFOR. CGFs will automatically engage given line of sight and fire in accordance with applicable rules of engagement. SLs will not be required to control their own personal CGF.

Figure 3. Simulation control



In a video game, an avatar is the virtual representation of the player. Avatars are generally dumb representations of human players. The player must control the avatar's movement, speed, avoid obstacles, and fire weapons. This detailed level of control often requires a joystick/controller or multiple keyboard commands. Avatars typically impose a heavy control burden but this is not the case for the intended training capability. CGFs representing trainees will not be like computer-game avatars. Generally, trainee CGFs will be included in the formation of the friendly CGF fire team and be pre-programmed to move as part of the formation. If a trainee chooses to move his personal CGF independent of the formation, the trainee would click on the CGF and enter a menu selection indicating movement to waypoint X or along route Y. However, the personal CGF would automatically avoid obstacles and fire weapons in accordance with rules of engagement.

Instructors will be responsible for using the keyboard and mouse for starting / pausing / stopping the simulation. They will be responsible for role-playing to facilitate the flow of the exercise and bound decision alternatives. During a simulation exercise, the instructor will not be responsible for controlling CGFs. Instead, the instructor will select a previously created simulation exercise from a scenario folder and simply start the simulation. A scenario consists of a map with embedded CGFs having pre-programmed behaviors intended to provide cues for decision making and team coordination in support of specific learning objectives. Although instructors may enter menu selections to modify a scenario during a simulation exercise, there is no requirement for detailed control of CGFs. Minimum CGF control requirements for instructors was an important design objective because their primary role consists of monitoring and evaluating trainee performance, providing feedback, and leading team self-assessments during after action reviews. To assist in after action reviews, a data logger will provide for replay of simulation segments with associated trainee and CGF voice communications.

6.0 Challenges

The anticipated challenges related to development of distributed interactive simulation capability included affordability, usability, and functional validity.

Affordability imposed a major constraint on system design from the start. An important early design decision was to limit the system to a low-immersion visual system. Limiting the trainee's view to a 2-dimensional terrain box displayed on a computer monitor avoids the costs of an immersive, 3-dimensional visual system, associated software, and support equipment. In addition, the decision was made to de-emphasize development of a Stealth display. A Stealth display offers a view into the 3-dimensional battlespace from a computer monitor but imposes additional software and equipment costs. Immersive visual systems, even the Stealth display, are being avoided to minimize system acquisition and sustainment costs.

The challenge of usability relates to the design for the simulation control interface. The interface for VR-Forces™ is designed for an engineer or battle master rather than security forces instructors or trainees. The challenge is to design a simple interface that instructors and trainees can learn quickly. The current approach is to avoid arcane menu option labels like "life forms and objects" and replace them with labels representing personnel and equipment familiar to security forces. The performance goal is to develop a simulation control interface that students can learn to use in one-half hour and instructors can learn to use in two hours.

The challenge of functional validity relates to developing computer models of weapons and sensors that present realistic simulations. Efforts are being made to accurately model weapons based on probabilities of hit and kill depending on variable firing positions, target distance, and different percentages of target occlusion. Sensors are being modeled based on sensitivity and sensor volume.

In addition to the anticipated challenges, other challenges emerged through interaction with customers and consideration of training effectiveness.

Since the introduction of this project during the Fall 2000 SIW (Paper number OOF-SIW-117), the preliminary system design concept has changed. The preliminary design concept included a link between constructive simulations and combat arms simulators. Although such a link remains a technology goal worthy of pursuit, the decision was made to concentrate on development of constructive simulations alone. An important argument for this design change involved expectations concerning the use of combat arms simulators. Dedicating combat arms simulators to support training for decisionmaking and team coordination could result in an unacceptable opportunity cost at the unit level. If time is available on combat arms simulators, it would most likely be dedicated to marksmanship training rather than decisionmaking and team coordination training. A corollary is that a stand-alone, constructive simulation capability would have a greater probability of use because such support does not currently exist in the inventory of training devices for USAF security forces.

In addition to changes related to combat arms simulators, the preliminary design plan has changed from hosting simulations on the Internet to hosting simulations on a local area network (LAN). An important argument for this change involves expected training effectiveness. Recent research has revealed important differences between centralized simulation training and long-haul simulation training. When trainees learn and rehearse the same mission in the same simulation at a central location and at geographically-separated locations, training is less effective for geographically-separated trainees (Singer, Grant, Commarford, Kring, & Zavod, 2001). Singer, et al. (2001) hypothesize that subtle intervening variables involving team cohesion and communication lead to less effective training when instructor and trainees are geographically-separated.

One way to provide for greater team cohesion and communications would be to provide technology for robust after action reviews. Currently, HLA-compliant simulations do not have capabilities for a distributed data logger, distributed simulation replay, and distributed replay control[1]. These capabilities are important for contributing to the equivalency of centralized and long-haul distributed simulation training. In addition to the after action review, it would be necessary to have robust communications among trainees for building team cohesion and between trainees and instructor for performance feedback. Because of the risk to training effectiveness associated with long-haul simulation training and associated technology obstacles, the decision was made to develop the simulation capability for hosting on a LAN in a centralized location. This design modification is considered a critical step in contributing to training effectiveness in view of existing cost and schedule constraints.

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JOSEPH WEEKS is program manager for the force protection distributed mission training program at the Air Force Research Laboratory, Warfighter Training Research Division. He is responsible for the administrative, financial, and technical management of advanced technology development projects for warfighter training. His research interests include decisionmaking, team performance, and simulation training effectiveness. He holds a master of science from Trinity University and a doctor of philosophy from the University of Texas at Austin.

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[1] We are indebted to Len Granowetter from MÄK Technologies for pointing out technology development opportunities.

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