ADVANCED WEAPONS TEAM TRAINING TECHNOLOGY

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ABSTRACT

Many simulator-based weapon team trainers currently use technology which restricts both realism and the ability for thorough team performance measurements in tactical training situations. This paper describes a training system prototype which uses new technology to improve simulation training for weapon fire teams. These new developments include intelligent video branching, *location detection of trainees, interaction between trainees and their on-screen aggressors,* computer networking of multiple video projection screens within multiple rooms, a wireless data communication system allowing full unrestricted mobility, a high speed weapon tracking system, and a digital MIDI controlled sound system.

The simulator developed at the Naval Training System Center will allow up to nine trainees to practice and rehearse close combat training exercises such as low intensity conflict, light infantry, SWAT, and security operations with a high level of realism and feedback. Typical events *might include security operations, hostage rescue, shoot-no-shoot, outdoor squad engagements,* and routine law enforcement operations in a common threat team training environment.

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INTRODUCTION

The need for training military and law enforcement teams in close combat tactics has been demonstrated dramatically in recent months in foreign and domestic operations. Situations requiring the extraction of personnel, expulsion of terrorists, or recovery of property challenge individual and team skills in decision-making, marksmanship, and engagement tactics. While several marksmanship training systems currently exist for training close combat skills, there are serious deficiencies in these systems which detract from their effectiveness. This paper describes an advanced training system prototype, the Weapons Team Engagement Trainer (WTET). The WTET was developed specifically to address the need for improved fidelity in weapon team trainers.

Typical small arms training systems use technology which restricts both the *fidelity of the tactical training situations* and the ability to thoroughly measure both individual and team performance. Current training systems suffer reduced fidelity in the following ways:

- Trainees are tethered to the training apparatus, often by bulky cables, reducing the amount of available tactical movement within the training environment.
- Trainees are not engaged or "shot at" by the on-screen aggressors in a manner which instills a sense of urgency or realism.
- Aggressor targets do not realistically react to the actions of the training team.
- Trainees do not receive complete feedback on their behavior in terms of tactical movement, weapon handling, and overall mission success.

The WTET provides a multiple room training environment in which a team of up to nine trainees engage aggressor targets displayed on video projection screens. A training team can freely move within the training environment while participating in room clearing, hostage rescue, or outdoor squad engagement scenarios. The WTET allows real-time interaction between the aggressor targets and training team. During each scenario the training team must use proper tactics and take appropriate cover to successfully complete the mission. Also, an extensive after action review of individual and team performance measures allows the instructor to identify remedial training needs.

SYSTEM DESCRIPTION

The WTET accommodates training for nine military or law enforcement trainees in a *common threat scenario.* The trainees interact with multiple video projection screens setup in different training rooms. Video disc players display scenario scenes and target images for training team interaction. A network of multiple computer systems control the scenario's progression based upon the tactical doctrine of the aggressor force and the real-time behavior of the training team. An extensive after action review incorporates a variable speed replay using graphical icons and messages. A separate icon is displayed for each trainee providing information on shots fired, weapon status and shot location. In addition, a video recording of the training team's movements is displayed in synchronization with the after action review.

A modular system design was used to allow system flexibility. Each video screen's target presentation is controlled by a subsystem (Video Station). An Instructor Operator Station performs real-time data collection, network control and monitoring of each Video Station. This approach allows the training environment to be reconfigurable by varying the number of training rooms and video stations within those rooms. The current prototype of the WTET uses a configuration of three video stations within two rooms. Figure 1 shows an example configuration of the training environment. An additional adjacent wall video station was added to illustrate expandability of the training environment.

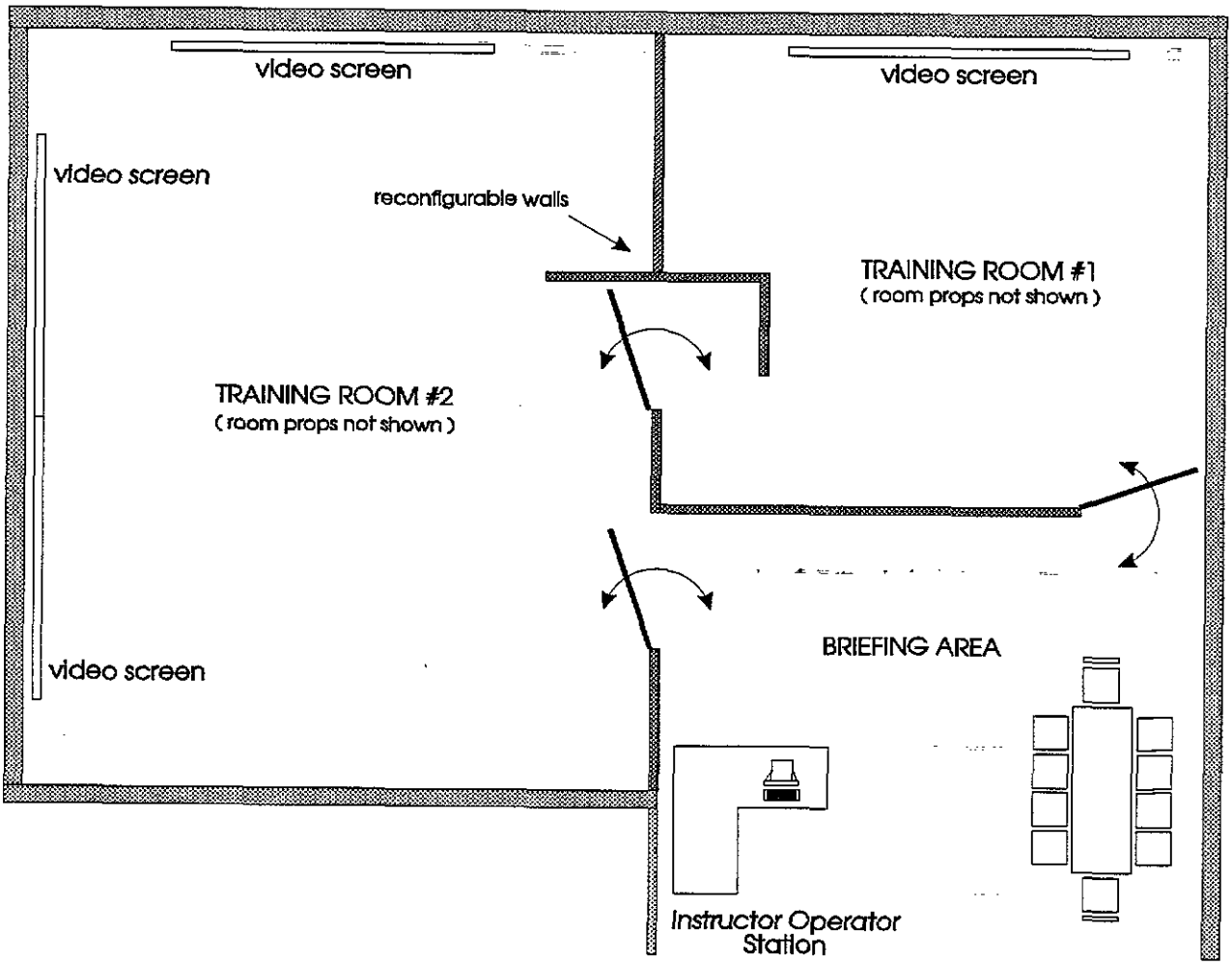

Figure 1. Layout of WTET Training Environment.

The WTET training environment is designed to allow training teams to prepare for missions, execute missions, and receive feedback on critical dimensions of performance. A briefing area allows teams to coordinate mission prebrief information. Scenario diversity is increased by incorporating reconfigurable walls and movable props in training rooms.

Each trainee is equipped with a miniature wireless communication system using RF spread spectrum technology. This RF communication system is located on a MILES type detector harness. The MILES type harness is used to determine each trainee's location and visibility. Each trainee's weapon has a barrel-mounted collimated infrared (IR) source, aligned to the weapon's sight line. The IR source places an eye-safe IR spot on the projection screen's surface. A high speed IR spot tracking system continuously determines each trainee's on-screen weapon aim point. Figure 2 shows a trainee equipped for the WTET. Trainees are able to freely move throughout the training environment while their weapon position, weapon status, and physical location are continuously monitored by the training system.

Figure 2. Trainee Wearing WTET Equipment.

SYSTEM DESIGN

The WTET system development addressed the shortcomings inherent in the technology currently used in weapon team training systems. For this reason, the WTET system design incorporates both off the shelf components and custom designed electronic subsystems. An RF communication system allows free trainee mobility. A high speed tracking system produces accurate and continuously measured weapon aim point position for multiple trainees. A trainee location system determines each trainee's location and visibility. Processing is distributed between the Instructor Operator Station (IOS) and the Video Stations. The components of the Instructor Operator Station and Video Station are shown in Figures 3 and 4.

The function of the IOS is to perform real-time data acquisition and intelligent scenario control. The IOS provides a user friendly menu system which allows the instructor to control scenario parameters. A digital parallel I/O adapter controls the RF communication system and the trainee location system. An analog input adapter interfaces the high speed tracking system. A MIDI adapter sends sound effect messages to the digital sampler module within the sound system. An Ethernet adapter transfers data packets to the Video Stations and monitors the status of each station in real-time.

Each Video Station responds to network data and command packets. A video disc player generates scenario scene and target images. Transitions between video segments (branching) is smoothed by using the frame grabbing capability of the video graphics adapter. Instantaneous branching has been demonstrated using the combination of two video disc players and a video switcher. Also, recent developments in video disc technology allow rapid branching capability without loss of video sync signal (built in frame grab capability). A computer controlled S-VHS deck allows synchronized video recording of the trainee movements within the training environment.

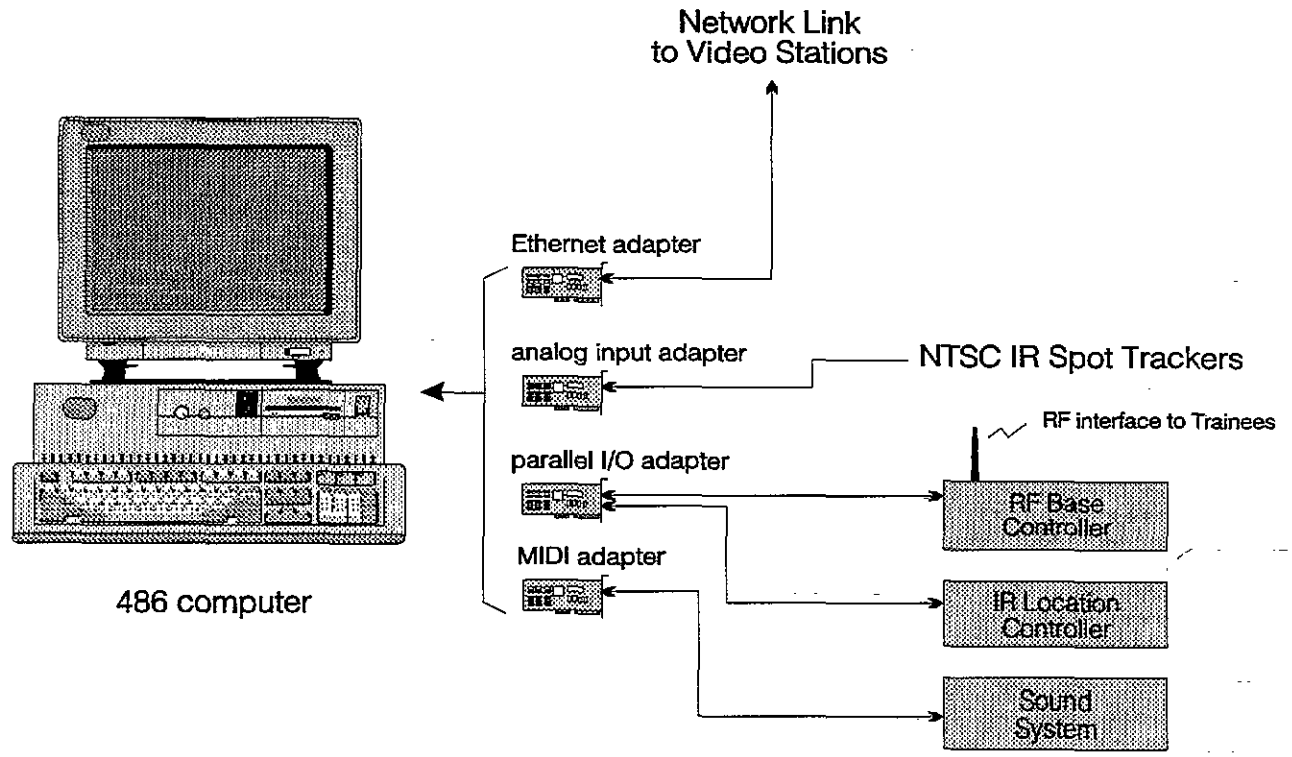

Figure 3. Components of Instructor Operator Station.

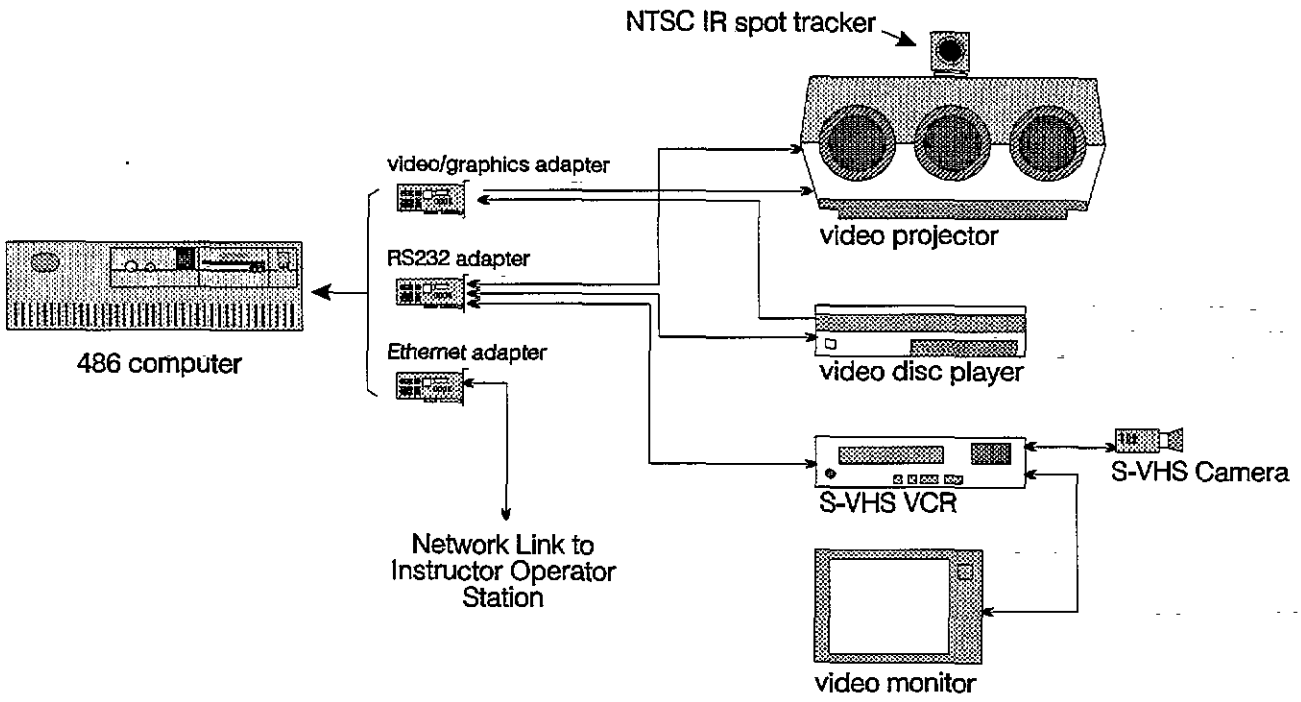

Figure 4. Components of Video Station.

Hardware Developments

The hardware developments consisted primarily of the following systems:

- High-Speed Infrared Spot Tracking System
- Trainee Location and Aggressor Shoot back System
- Wireless Data Communication System
- Digital Sound System

High-Speed Infrared Spot Tracker - To overcome the disadvantages of typical CCD-based tracking systems, NTSC has developed a low-cost, high-speed, Infrared Spot Tracker (IST) utilizing a two dimensional lateral-effect photo diode, the Position Sensing Detector (PSD) [1, 2]. The PSD is not a discrete charge transfer device, but rather a continuous analog output device. In contrast to other types of position sensing devices such as CCD detectors, the PSD offers higher resolution, faster speed, larger dynamic range, and simpler signal processing.

When a light spot falls on a PSD, an electric charge proportional to the light energy is generated at the incident position. The electric charge travels through the resistive material of the PSD and is collected by four outer electrodes. Because the detector resistivity is uniform, the photo current is inversely proportional to the distance between the incident light position and the electrodes. An A/D board in the computer is used to read the four analog tracker output voltages V_{x1}, V_{x2}, V_{y1}, and V_{y2} and calculate the position coordinates based on two simple equations.

$$X_{loc} = (V_{x2} - V_{x1}) / (V_{x2} + V_{x1})$$

$$Y_{loc} = (V_{y2} - V_{y1}) / (V_{y2} + V_{y1})$$

In operation, the IST views the entire active video projection screen area with a custom designed low F/number wide angle lens. The collimated infrared light spot from the weapon is imaged onto the screen and then re-imaged onto the PSD by the wide angle lens. The PSD and associated electronics converts the normalized incident light into weapon position data.

The IST allows the WTET to sequentially track the X and Y weapon aiming position coordinates for up to nine trainees at roughly 30 Hz, the same rate a typical CCD based tracker would require to track one weapon. Due to the high speed of the IST, continuous data is available in real time for all active weapons. This data is subsequently used to determine real time weapon tracking, hit and miss data, and during replay, tracing with color coded icons, how each trainee moved his weapon during the scenario. This data is also used to determine when and if he pulled the trigger, and if he hit, wounded, or missed the intended target.

Trainee Location and Aggressor Shoot Back System - The WTET training environment allows for an enormous amount of data collection and flexibility. Three important aspects of the data collection during a scenario involve the following: 1) the location of each trainee, 2) the identification of each trainee, and 3) whether or not the trainee has taken proper cover from his on-screen adversaries and from possible friendly fire from other team members.

The method used by the WTET for trainee location, detection, and identification consists of multiple eye-safe Infrared Emitting Diode (IRED) arrays strategically located throughout the training environment. Furthermore, each trainee wears a MILES type torso harness with photo detectors and an audible Sonalert alarm. As the scenario progresses each IRED array is turned on in sequence, during the active time slot allocated for each trainee, such that the entire WTET training environment is mapped out in a grid like fashion. In this manner the location, detection, and identification of each trainee within any predefined zone is collected in real time and transmitted via an RF data link to the system computer during the allocated active weapon time slot for each trainee. A statistical prediction algorithm, based on the past movements of the trainee, is used to predict the current location of the trainee during the brief periods he is not detected by the torso harness photo diodes. The trainee avoids hostile fire (detection) as he would in the real world; he must take appropriate cover

as he engages the on-screen adversaries or risk being wounded or killed and thereby eliminated from the scenario.

The real time location and detection data of each trainee is used by the system computer to intelligently control the video branching (selection of sequential scenes to be displayed) as well as determine if and when the trainee is exposed to hostile fire from the on-screen adversaries. The location data in conjunction with the identification data is also used by the system computer to control the rifle sound effects. Statistical methods based on detection data are used by the system computer to determine the probability of a hit, miss, or wound. The location, detection, and identification data can ultimately be utilized during the replay for instructor analysis and debriefing.

Wireless RF Communications System - The wireless RF Data Communications System (WDCS) allows up to nine trainees to freely maneuver inside the training environment without being physically tethered or restricted to the system computer. This allows the trainees to evade hostile fire from on-screen adversaries as they would in the real world while moving to and from multiple rooms in a tactical manner. The WDCS further allows for the essential and rapid exchange of data between the system computer and the trainees for effective training.

The transceivers used in the Base Controller (BC) and the Weapon Controller (WC) are modular Spread Spectrum (SS) radio transceivers with no on board intelligence. These radios are controlled via a custom microcontroller interface for each particular application. By externally controlling the timing and the data protocol through embedded software the SS radio operation can easily be optimized for any one particular application. Utilizing spread spectrum technology also takes advantages of the high noise immunity, high data rates, and fast switching times associated with this license free technology.

The complete Spread Spectrum RF transceiver system consists of a central base station (Base Controller or BC) with 9 individual trainee located transceiver boards (Weapon Controller) for communication to and from the central base station. The trainee located transceiver boards are mounted on the torso harness and the batteries are located in the ammunition pouch on the trainee's side.

In operation, the BC receives an interrupt from the system computer and transmits a 10 bit data packet encoded with a unique start code, weapon ID, and sonalert status to all receiving weapons. Only one WC will recognize this data packet as being valid. All other weapons will continue to listen for a valid data packet while ignoring the current data packet. After the BC completes its transmission the BC is placed in the receive mode and waits for weapon status data from the active weapon.

The activated WC, having acknowledged the valid data packet, will proceed to control the weapon in question. The WC electronics "enables" the weapon mounted high-power eye safe IRED for the IST for approximately 3 msec. The WC is then placed in the transmit mode in preparation for transmitting the most recently acquired weapon status data. Once this data has been collected and stored in memory the WC transmits a 10 bit data packet encoded with a unique start code, detection data, low battery data, trigger data, selector data, and magazine data. The WC is then placed back into the receive mode waiting for the next valid data packet.

The BC decodes and acknowledges the data reception from the valid weapon and places the BC back into the transmit mode in preparation for the next system computer interrupt and subsequent weapon selection. The current data is then made available to the system computer. An error detection scheme, using the unique start codes and a watchdog timer, virtually eliminates the possibility of an erroneous response to an invalid data packet due to an RF data error.

Digital Sound System - The digital sound system provides a multitude of sound effects from various sources including commercially

available sound effects, actual live recordings from the field and a variety of synthesized sound effects. The sound effects, in conjunction with the video display, help to create a realistic atmosphere in which the trainee feels he is actually immersed within the training environment.

The digital sound system, in its current configuration, consists of a MIDI controller board, a sequencer, a digital sampler, a mixer, four processors, six audio amplifiers, eight speakers, and two sub woofers [2].

During an actual scenario the computer sends the appropriate commands to the sampler via the MIDI merge unit and the sequencer. The sampler recreates the appropriate sound effects from digitized samples stored in memory and sends the analog signals to the appropriate amplifiers through a mixer and four signal processors which drive foreground and background sounds.

SCENARIO INTERACTION

An expert system capability is built into the WTET to control scenario progression based on the overall training objectives and the behavior of the training team. A WTET scenario is composed of multiple video segments stored on video disc. Video branching allows aggressor targets to interact with the training team. Branching is accomplished by rapidly selecting and displaying video segments as the scenario progresses. Among the trainee behaviors which may affect branching are:

- Trainee / Team position
- Trainee/Team wound/kill status
- Weapon status (aim point, ammunition, shot fired, target coverage)

SCENARIO REPLAY / FEEDBACK

After a WTET mission is complete, detailed feedback of trainee performance is available through instructor station control. A variable speed mission replay using graphical icons and messages indicates trainees performance for the duration of the mission.

A hand held pointer (collimated IR source) connected to a trainee MILES type harness allows the instructor to control the replay. The pointer is controlled and monitored in the same manner as each trainee's weapon. A graphical cursor is displayed during replay to indicate the on screen position of the pointer. A graphical replay control menu is displayed during the mission replay. This allows the instructor to move through the training environment and stop, start, reverse and vary the speed of the synchronized mission replay.

During replay, the IOS synchronizes each Video Station's mission replay. Time into the mission is displayed as an event timer. Each trainee's continuous weapon aim point is indicated using graphical icons overlaid on a video replay. The icons are numbered to show trainee identification. Color coding provides weapon and trainee status. The color of the icon changes to indicate the following:

- Shot fired (miss)
- Shot fired (hit)
- Shot fired (wound)
- Shot fired (target kill)
- Trainee Hit
- Trainee Disabled

These graphical icons, along with event messages and a team performance summary, provide a detailed feedback of individual and team performance. In addition, a video recording of the training team's movements is displayed in synchronization with the after action review.

TRAINING EFFECTIVENESS

A training effectiveness test plan has been developed to test the WTET's individual device features and overall system effectiveness. This plan includes collecting subject matter expert ratings of device features as well as an attempt to establish student performance improvement as a result of using the system. Several local and

national law enforcement, as well as Department of Defense, agencies have expressed interest in evaluating this system. Data are currently being collect to determine what impact the major device features will have on improving trainee and team skills. These data will be presented at the *Conference.*

SUMMARY

The technological developments employed in the WTET improve training system fidelity for a variety of weapon team tactical training situations. The modular aspects of this system allow a great deal of flexibility in designing training environments and developing unique engagement scenarios. By accurately and continuously measuring *trainee movements, weapon conditions and* other interactive behaviors, instructors can provide detailed feedback on individual and team performance. The WTET prototype is ideally structured for agencies requiring close combat tactical training for individuals and small squads. The capability of the WTET to deliver a variety of threat scenarios is essentially limited only by what has been scripted and recorded.

REFERENCES

1. Marshall,. Wolff, McCormack, and Purvis. "Weapons Team Engagement Simulator", Proc.of the 12th Annual I/ITSC, Nov. 1990.

2. NTSC, "Weapons Team Engagement Trainer", Government Furnished Information, Dec. 1992.