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A-TES STO Phase 1: Final Report

University of Central Florida Institute for Simulation and Training

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US Army Contract BAA 97-02
CDRL A002

Institute for Simulation and Training
University of Central Florida

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A-TES STO Phase 1
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1. Introduction

1.1. Background

The Advanced Tactical Engagement Simulation (A-TES) Science and Technology Objective (STO) is a research and development project designed to solve problems associated with live force-on-force training of soldiers in the use of advanced weapon systems. This U.S. Army STRICOM funded project has four phases, each associated with a fiscal year from 1999 through 2002. This document is the Final Report from IST for Phase 1, the first year of the project.

Existing tactical engagement simulation systems will not adequately address training problems posed by advanced weapon systems currently under development. For example, laser-based shooter-target pairing systems will not support training with the high explosive area effect munitions of the Objective Individual Combat Weapon (OICW) and the Objective Crew Served Weapon (OCSW).

This "training gap" will be exacerbated as more advanced technologies derived from the U.S. Army's Force XXI and Army After Next initiatives are developed. The introduction of smart weapons, non-lethal weapons, combatant identification technology, advanced communications, and widely distributed processing will significantly contribute to the obsolescence of existing tactical engagement training systems.

The purpose of the A-TES STO is to identify and develop tactical engagement simulation technologies that will address the potential training gap, allowing training systems to keep pace with future weapon system deployments while meeting the system-level challenges of low cost, portability, and C4I interoperability.

The initial focus of the A-TES STO has been on training with dismounted infantry weapons such as the OICW in urban environments. This scenario was emphasized because it presents several of the most general problems in their most difficult forms. Specifically, the non-direct fire capability of weapons like the OICW introduces a requirement to perform weapon orientation determination with extreme accuracy while urban environments present significant challenges for the technologies that are required to perform simulated munition flyouts and real time casualty assessment and communication. These critical technologies include the complex three-dimensional terrain databases that are required to represent urban environments and accurate player geopositioning systems that can function in an environment where GPS systems are particularly ineffective (e.g., inside buildings). Finally, the wireless communication problems posed by urban environments, particularly by multipath interference, represent challenging communications issues.

1.2. General Approach

As illustrated in Figure 1, there are many aspects to the work performed in support of the A-TES STO.

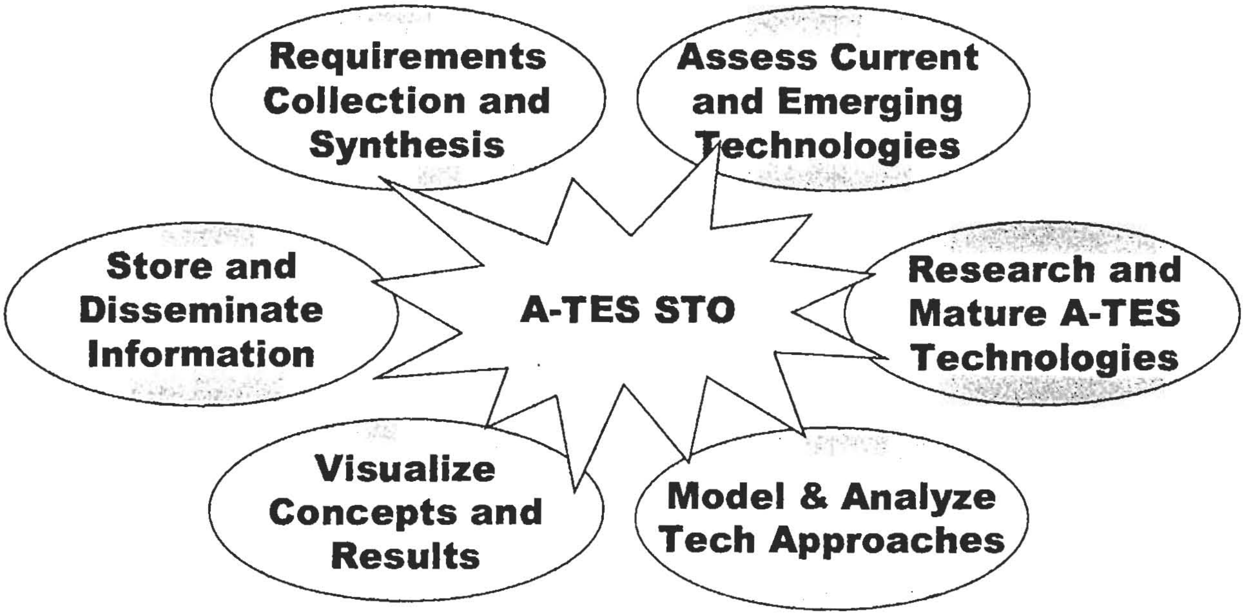

Figure 1. Aspects of the A-TES STO

The general approach taken by the A-TES STO may be summarized as follows:

- Organize workforce into functionally specific working groups.
- Deploy a simulation testbed with advanced modeling, analysis, and visualization capabilities.
- Evaluate advanced tactical engagement system requirements.
- Evaluate candidate technologies relative to system requirements.

Simulate promising technologies.

- Visualize and analyze results.
- Evolve promising simulations into system prototypes.
- Help transition successful prototype technologies into developmental systems under the leadership of the appropriate PMs.
- Disseminate relevant information.

Seven working groups were identified within the A-TES STO workforce. Most individuals were members of multiple groups. The names of the seven working groups, along with brief descriptions of their primary areas of responsibility, are:

- Strategic Development Group – Responsible for project direction.
- Testbed Architecture Group – Responsible for designing the simulation testbed.
- Modeling Group – Responsible for designing and implementing simulation models and scenarios.

- Analysis Group - Responsible for performing simulation data reduction, analysis, and interpretation.
- Visualization Group - Responsible for visualizing concepts, processes, and simulation data.
- Intelligence Group – Responsible for gathering required information.
- Testbed Support Group - Responsible for installing and maintaining testbed hardware and software.

The A-TES STO's strategic approach is to use a series of focused activities called Testbed Implementation Exercises (TIEs) to bring together all aspects of the program. This concept is illustrated in Figure 2

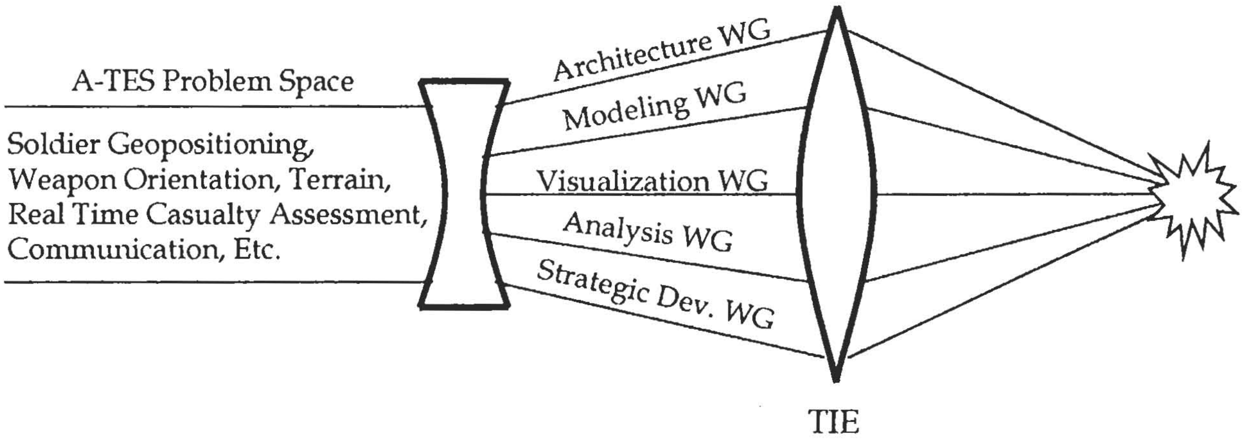

Figure 2. Testbed Implementation Exercises Focus Working Group Activities

2. Technology Assessment

2.1. Problem Decomposition

The initial focus of the A-TES STO has been on training with dismounted infantry weapons such as the OICW in urban environments. As explained in section 1.1, this scenario was emphasized because it presents several of the most general problems in their most difficult forms.

In order to identify the most critical capabilities of a successful advanced tactical engagement system, the problem of simulating a non-direct fire engagement involving an OICW in a MOUT facility was considered. All concrete system concepts envisioned by A-TES program personnel involved simulations derived from detailed knowledge of three things:

- Weapon location and orientation at time of firing
- Location and orientation of all potential targets
- Environment, particularly terrain

It was taken as a given that any successful system implementation would necessarily require an advanced communication infrastructure.

The purely simulated aspects of the various system concepts were common to all proposed systems. These common aspects included:

- Simulated environment (including stationary targets)
- Simulated munition flyout (with or without environment interaction)
- Simulated munition detonation and fragmentation
- Simulated casualty assessment

The immediate goal of identifying the most promising system concept or concepts involved a focus on the remaining system differences. Therefore, assuming the availability of adequate computational power, system concepts could be distinguished primarily on the basis of:

- Knowledge of weapon location and orientation at time of firing
- Knowledge of location and orientation of all mobile targets
- Capabilities of communication infrastructure

Of these items, weapon orientation errors are likely to be the primary discriminating factor for evaluating relative system performance because weapon orientation errors are amplified by munition flyout while other factors influencing overall system performance are not magnified in this way.

In the following section, the three areas listed above are used as the basis of technology assessment for the purpose of selecting candidate technologies for further research.

2.2. Technology Assessment and Selection

The following categories of candidate technologies were evaluated with respect to their abilities to determine weapon and player locations and orientations:

- Range-measuring geopositioning systems (e.g., GPS-like ranging beacons).
- Direction-measuring geopositioning systems (e.g., optical systems detecting infrared beacons).
- Geopositioning systems based on comparing weapon-mounted video to detailed terrain maps.
- Environmental orientation sensors (e.g., compasses, inclinometers, and accelerometers).
- Inertial sensors (e.g., gyroscopes and accelerometers).
- Hybrid systems combining two or more of the above system types.

Range-measuring geopositioning systems compute the location of an object from the distances between the object and multiple references with known locations. By locating more than one point on an object, object orientations may also be determined. The technique of determining an object's location from multiple ranges is called multilateration.

Existing range-measuring geopositioning systems like GPS and Differential GPS have two major shortcomings. First, their measurement errors are at least an order of magnitude greater than what is required to implement a successful A-TES system. Second, they are particularly ineffective in many battlefield situations (e.g., in dense foliage and inside buildings).

Direction-measuring geopositioning systems have two major shortcomings. First, due to their reliance on angular measurements, their ability to resolve the location of an object decreases significantly as the range between the object and the references increases. Second, because they are implemented as optical systems, they require direct lines of sight, implying that they would require a very large number of references and that they would not operate in the presence of battlefield obscurants or poor weather.

The idea of implementing a geopositioning system based upon comparing weapon-mounted video to detailed terrain maps was determined to be impractical for several reasons. First, it would require extremely precise terrain maps that would be costly and time consuming to generate. Second, it would be likely to fail as vehicles and other objects moved within the field of play. Third, it would require either distributed terrain maps or the transfer of large amounts of video data. Fourth, it would require extremely complex image processing algorithms. Finally, being optically based, this system would not operate in many typical battlefield conditions.

Compasses and inclinometers are relatively mature environmental sensor technologies that display inconsistent performance due to environmental anomalies and are unreliable when they are accelerated. Under the best of conditions, they have orientation errors that are roughly a factor of 2 beyond what is considered desirable for an A-TES system.

Gyroscopes and accelerometers are relatively mature inertial sensing technologies that experience problems of excessive drift when used to measure locations and orientations.

The A-TES project concluded that an adequate A-TES system could not be built relying primarily upon existing mature technologies. However, an emerging communications technology that holds great promise for addressing A-TES concerns was identified. This emerging technology is referred to as Time Modulated Ultrawideband (TM-UWB).

TM-UWB appears to represent a major breakthrough with respect to each of the critical capabilities identified in the previous section as being vital to A-TES success. Existing prototypes have demonstrated sub-inch point-to-point ranging accuracy, which should allow the development of geopositioning systems with similar accuracy. This level of accuracy exceeds the A-TES requirements for weapon and player location accuracy. Technology capability projections strongly suggest that the TM-UWB ranging accuracy will quickly drop below 1 mm as the technology matures, enabling weapon orientation accuracy to also exceed A-TES requirements. Since TM-UWB is fundamentally a communication technology, it also directly addresses the third major basis of system comparison. As documented in the references, TM-UWB communications are inherently secure and reliable in environments where traditional frequency modulated communication technologies are not.

In addition to directly addressing the three primary areas of A-TES concern, TM-UWB appears to offer many other advantages. Specifically, due to successful miniaturization efforts and communications market forces, in the relatively near future, TM-UWB devices are expected to be relatively inexpensive, small, lightweight, and have very low power consumption.

Not surprisingly, the A-TES project decided to focus its efforts on system designs based upon TM-UWB technology. Recognizing that hybrid designs involving TM-UWB and environmental and/or inertial sensors may hold significant promise, the A-TES project explicitly chose to pursue a pure TM-UWB approach first, assuming that integration of mature technologies would be a relatively minor change at a later time.

2.3. Development of the A-TES TM-UWB Concept System

The baseline A-TES system would use emerging TM-UWB technology to support direct-fire and indirect-fire force-on-force training for soldiers, ground vehicles, aircraft, and assorted weapon systems.

In this concept, very low power TM-UWB devices would be used to implement a geopositioning system and a high-bandwidth secure wireless network. The geopositioning system would precisely determine the locations and orientations of

3. Geopositioning Algorithm Development

3.1. Introduction

This section of the report describes the geopositioning concepts that are fundamental to successfully implementing an A-TES system based upon the selected TM-UWB technology. It begins with a brief summary of point geopositioning, expands this concept to include rigid body geopositioning and human body geopositioning, then it presents geopositioning-related lessons that were learned during the first two TIEs. Finally, it addresses geopositioning concerns and concepts that are unique to A-TES scenarios.

3.2. Point Geopositioning

Range-measuring geopositioning systems compute the location of an object from the distances between the object and multiple references with known locations. This technique, called multilateration, is used by GPS systems to determine the location of a GPS receiver from ranges to multiple satellite references. In the A-TES TM-UWB system concept, the reference locations are fixed, as illustrated in Figure 4.

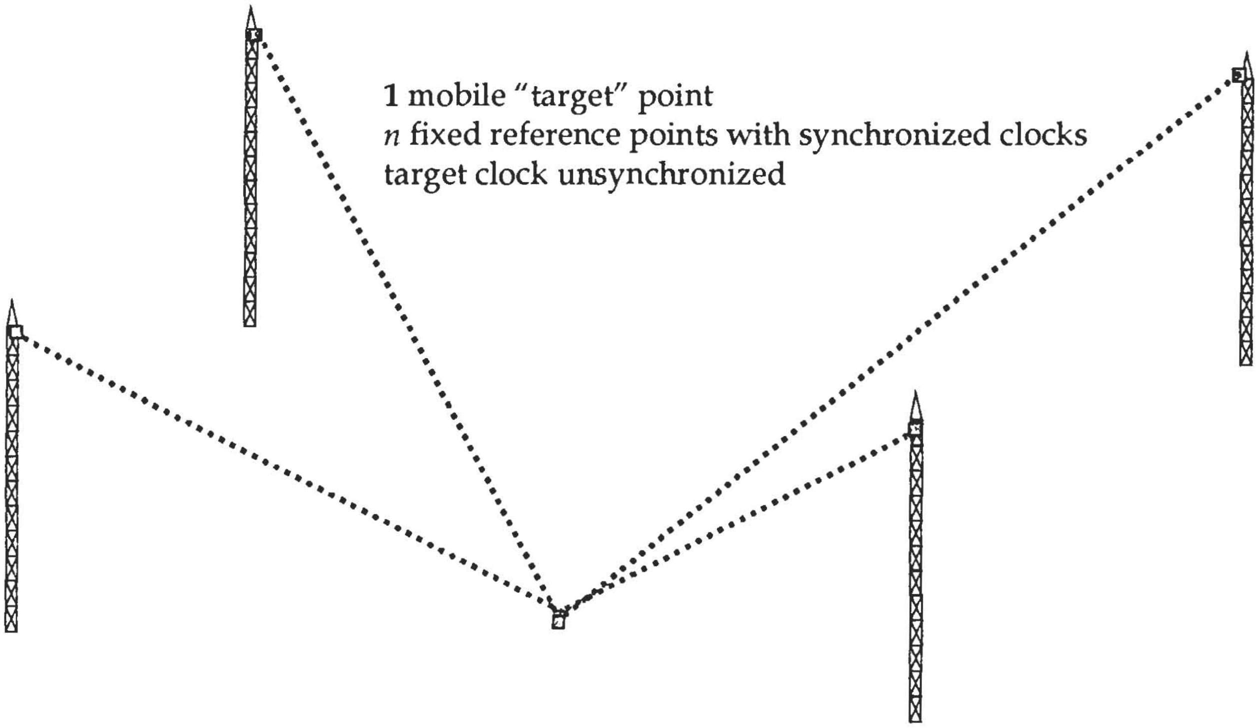

Figure 4. Point Geopositioning

Figure 4 represents the general point geopositioning problem in an A-TES context. In this problem, there is one mobile "target" point and *n* fixed references. Clocks associated with the references are synchronized. In general, the target clock is not synchronized with the reference clocks.

Either a ping signal from the target to the references, or a synchronized ping from the references to the target, is transmitted. The direction of transmission does not affect the mathematics but does influence system architecture. In either case, there are *n* transmissions and the system knows the delta times of arrival associated with these transmissions.

Typically, ranges are computed from ping signal transmission times and transmission rates, so the synchronization of the references is particularly important.

The solution to this problem, the *A-TES STO Triangulation Study*, may be summarized as follows: From what is known, the problem may be represented by a set of *n* equations in 4 unknowns. The 4 unknowns represent the three-dimensional location of the target plus one target-reference synchronization degree of freedom. The approximate numerical solution of the equations is straightforward given good initial estimates for the 4 unknowns. A method for making a good initial guess is developed.

Once a solution is obtained for the first ping, solutions for subsequent pings are significantly easier to obtain for two reasons. First, the initial solution for the target-reference synchronization degree of freedom effectively synchronizes the target clock with the reference clocks, reducing the number of unknowns by one. Second, the target location associated with any particular ping may be used as an initial estimate for the subsequent ping.

3.3. Rigid Body Geopositioning

By locating more than one target point on an object, object orientations may also be determined. By placing at least 3 target points on a rigid body (e.g., a weapon), we may solve for the rigid body's full set of 6 degrees of freedom (i.e., its three dimensional location and three dimensional orientation). This concept is illustrated in Figure 5.

In rigid body geopositioning, there are *m* fixed target points on a mobile rigid body and there are *n* fixed reference points. Clocks associated with the references are synchronized. In general, clocks associated with the target points are synchronized with each other but not with the reference clocks.

Either a synchronized ping signal from the target points to the references, or a synchronized ping from the references to the target points, is transmitted. Again, the direction of transmission does not affect the mathematics but does influence system architecture. In either case, there are *m*x*n* transmissions and the system knows the delta times of arrival associated with these transmissions.

One approach to this problem is to individually locate the three target points using point multilateration, then determine the rigid body's location and orientation from the target point locations. A mathematically superior approach is to take advantage of the constraints implied by the fixed locations of the target points with respect to the rigid body.

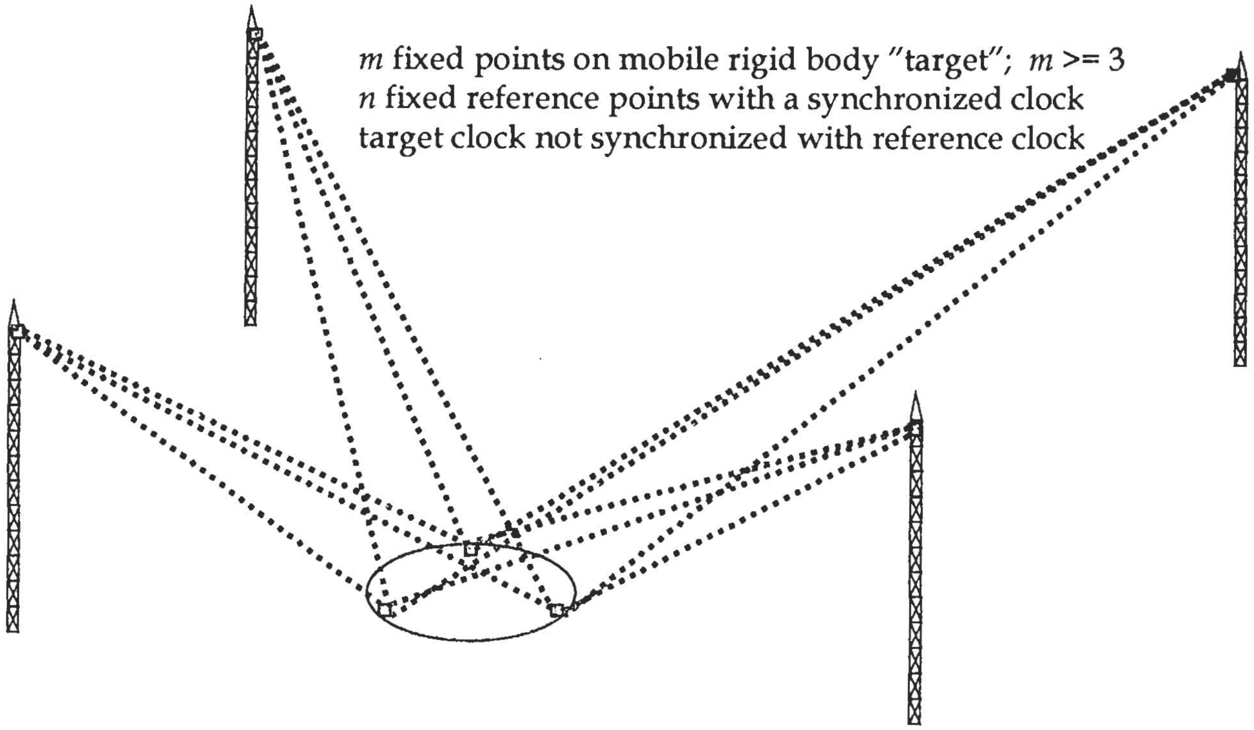

Figure 5. Rigid Body Geopositioning

Directly extending the point geopositioning problem formulation yields mxn equations in $3m+1$ unknowns. The unknowns represent the three dimensional locations of the m target points plus one target-reference synchronization degree of freedom. Introducing the rigid body constraints mentioned above allows the $3m$ location degrees of freedom to be transformed into 6 rigid body degrees of freedom, resulting in mxn equations in only 7 unknowns. The approximate numerical solution of these equations is straightforward as before.

3.4. Human Body Geopositioning

The human body may be modeled as an articulated structure composed of rigid bodies. Therefore, it is conceptually straightforward to extend the rigid body geopositioning concept introduced in the previous section to measure a substantial portion of the range of human motion.

For example, torso motion could be well characterized using one target point at each shoulder and one at the waist; this concept is employed in TIE #3. Eight more targets would be required to capture the gross motor activity of the limbs and three additional targets would be required to completely capture head motion.

Tracking player motions in this level of detail would allow casualty assessment simulations to be extremely accurate, fully accounting for player shielding and orientation relative to detonations.

3.5. Importance of Reference Locations

In the course of implementing TIE #1, it became obvious that tiny range errors could result in significant location errors unless reference point geometry was carefully chosen. The reason for this is illustrated in Figure 6.

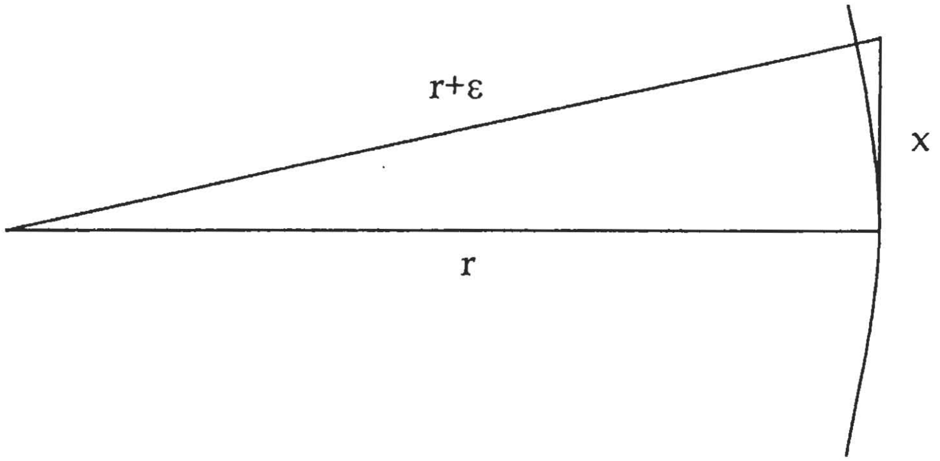

Figure 6. Small Range Errors Can Cause Large Lateral Location Errors

In Figure 6, we consider a ping transmission between a single reference and a single target point. In this figure, *r* represents the actual range between the reference and target, ε represents the range error, and *x* represents a corresponding location error in a direction normal to the transmission path. It may be easily shown that

$$\frac{x}{\varepsilon} = \sqrt{\frac{2r}{\varepsilon} + 1}$$

In other words, even for small range errors, the implied lateral location error may be quite large. This potential problem is easy to address. The lesson learned is that reference locations are very important; they must be located so that they have relatively orthogonal directions with respect to all potential target locations. Given this knowledge, there are a variety of simple schemes for ensuring adequate reference geometries.

3.6. Importance of Reference Count

Relatively few references are required to obtain mathematical solutions to the geopositioning problems posed above. However, it is important to recognize that there are many significant advantages to using additional references. For example, additional references:

- Help assure good reference point geometry
- Overspecify the problem which tends to result in a more accurate solution
- Allow solutions when some signals aren't received
- Desensitize the solution to slight reference motions

Changing the number of references has broad implications for the system architecture, so estimating the optimal number of references for any given scenario is a task that would lend itself well to simulation-based approaches.

3.7. Direction of Transmission

In sections 3.2 and 3.3, it was mentioned that having targets ping references was mathematically equivalent to having references ping targets. While this is true, the direction of ping transmission significantly impacts the system architecture by affecting where critical data is available.

If mobile targets ping fixed references, it is relatively easy to guarantee that pings occur at times of interest (e.g., at the time of weapon fire) and, for this reason, fewer pings may be required. However, in this case, a potential bottleneck associated with reference communications significantly limits system scalability. The references must be capable of listening for signals from all of the targets and, as ping signals arrive at references, the signal times of arrival must be transmitted to some central location for geopositioning processing. At some point, the number of targets will not be able to be increased because it will overwhelm the reference communication system.

If fixed references ping mobile targets, this potential bottleneck is eliminated. Without additional communication, the delta times of signal arrival are available to the mobile targets allowing them to compute their own locations. By distributing geopositioning processing in this way, a virtually unlimited number of targets may be accommodated. In addition, this architecture allows more advanced target instrumentation to be deployed as it is developed (e.g., human body geopositioning systems) without altering the fixed references that constitute the range instrumentation.

3.8. A-TES -Specific Accuracy Issues

Rigid body geopositioning accuracy may be decomposed into location accuracy and orientation accuracy. Because, as illustrated in Figure 7, weapon orientation errors are amplified by munition flyout while location errors are not, weapon orientation accuracy is likely to be the primary factor influencing A-TES system performance.

Figure 3. Weapon Orientation Error is Amplified by Munition Flyout

An alternative to the rigid body geopositioning technique presented in section 3.3 exists which could be employed to minimize weapon orientation errors. Consider how the target points on a rigid body process a ping from one reference. If the time of arrival errors associated with each of the target points are identical, then there is no corresponding rigid body orientation error. This desirable situation is illustrated in Figure 8.

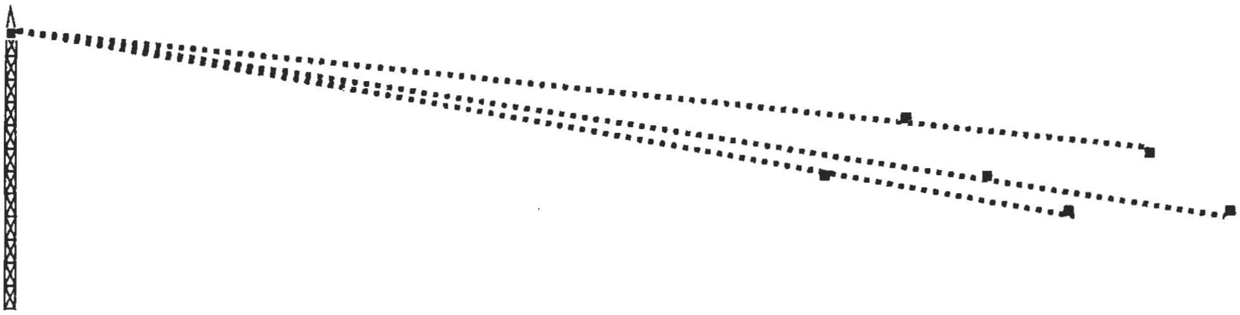

Figure 8. Identical Time of Arrival Errors Produce No Orientation Error

An A-TES rigid body geopositioning system could be designed to produce time of arrival errors that were highly correlated in this way by connecting multiple TM-UWB antennas to a single processor. Such a device could use interferometric techniques to more accurately determine the delta times of arrivals that determine rigid body orientation.

A geopositioning system customized for rigid bodies would have several other significant benefits. Specifically, it would:

- reduce communication requirements by localizing all of the data required for rigid body geopositioning
- provide an appropriate place to deploy more sophisticated rigid body geopositioning algorithms
- lower power consumption due to the reduction in the number of processors

The concept of deploying specialized geopositioning target equipment for hardware with special requirements generalizes well. For example, a similar but more complex design could be deployed to address human body geopositioning.

4. Significant Accomplishments

4.1. Testbed Deployment

4.1.1. Testbed Overview

The A-TES Testbed supports a simulation and visualization environment with an online interactive database repository. It is designed to accommodate substantial growth as A-TES STO requirements change. The figure below illustrates the key components of the Testbed and presents a high level view of its LAN architecture. The primary components of the Testbed are three PC Nodes which are connected via a 100 Base-T LAN to a Linux-based firewall that serves as a gateway to the IST/STRICOM WAN. Refer to Figure 9.

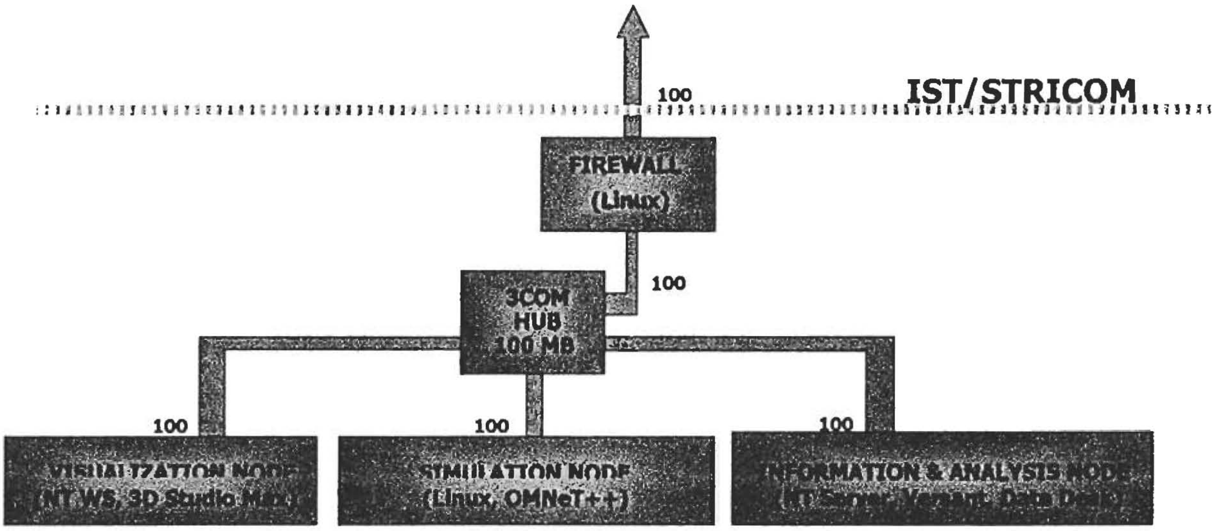

Figure 4. A-TES Testbed and LAN Overview

4.1.2. Visualization Node

The Visualization Node supports the development and implementation of graphical approaches to communicating A-TES related information. This information includes simulation data and results, research findings, and conceptual overviews.

The Visualization Node is a 450 MHz P-III Intergraph TDZ 2000GL2 with an Intergraph Wildcat 3D graphics card, 512 MB of memory, and 36 GB of hard drive storage. Its current operating system is Microsoft Windows NT 4.0 Workstation. Installed software packages include 3D Studio Max.

4.1.3. Simulation Node

The Simulation Node supports the design, implementation, documentation, and maintenance of A-TES simulation models and scenarios. In addition to serving as the controller of running simulations, the Simulation Node produces data to support visualization and analysis of A-TES scenarios.

The Simulation Node is a 450 MHz P-III Intergraph TDZ 2000 GL2 Workstation with 256 MB of memory and 36 GB of hard drive storage. Its current operating system is RedHat Linux 6.0.

The primary simulation software is a package named OMNeT++, an open source, C++-based simulation environment available at http://www.hit.bme.hu/phd/vargaa/omnetpp.htm. OMNeT++ is supported by András Varga, a professor at Technical University of Budapest. It was selected after an evaluation of potential simulation environments. The criteria used during the evaluation are documented in Reference 16, entitled *A-TES Simulation Environment Requirements.* OMNeT++ has performed extremely well in support of the A-TES simulations.

4.1.4. Information and Analysis Node

The purposes of the Information and Analysis Node are to provide an Information Repository for storage and retrieval of data produced by or relevant to the A-TES STO efforts and to provide statistical analysis of simulation output data.

The Information and Analysis Node is a 450 MHz P-II Dell Precision 610 workstation with 256 MB of memory and 36 GB of hard drive storage. Its current operating system is Microsoft Windows NT Server 4.0. Installed software packages include Versant's ODBMS with JVI, Apache webserver with JServ module, Sun JDK 1.1.8, Sun JSDK 2.0, and Desk's Statistical Package.

4.2. Information Repository Development

4.2.1. Purpose and Content

To support the Testbed research activity, maintain awareness of emerging technology, and fully leverage the results of the A-TES STO initiative, a web-based object repository was implemented. The role of the Information Repository is to provide long-term storage and retrieval of data and documentation relating to the A-TES STO. It supports Testbed activities by allowing rapid storage and retrieval of simulation and visualization data and software, it facilitates document and information sharing among A-TES working groups, and it serves as a central repository for global access to A-TES related documents.

The repository content includes A-TES technology source documents, concept and visualization demonstration materials, simulation data, analytical data, and information from related weapons systems development programs.

4.2.2. Architecture

Figure 10 illustrates the Information Repository architecture as well as the available data access paths.

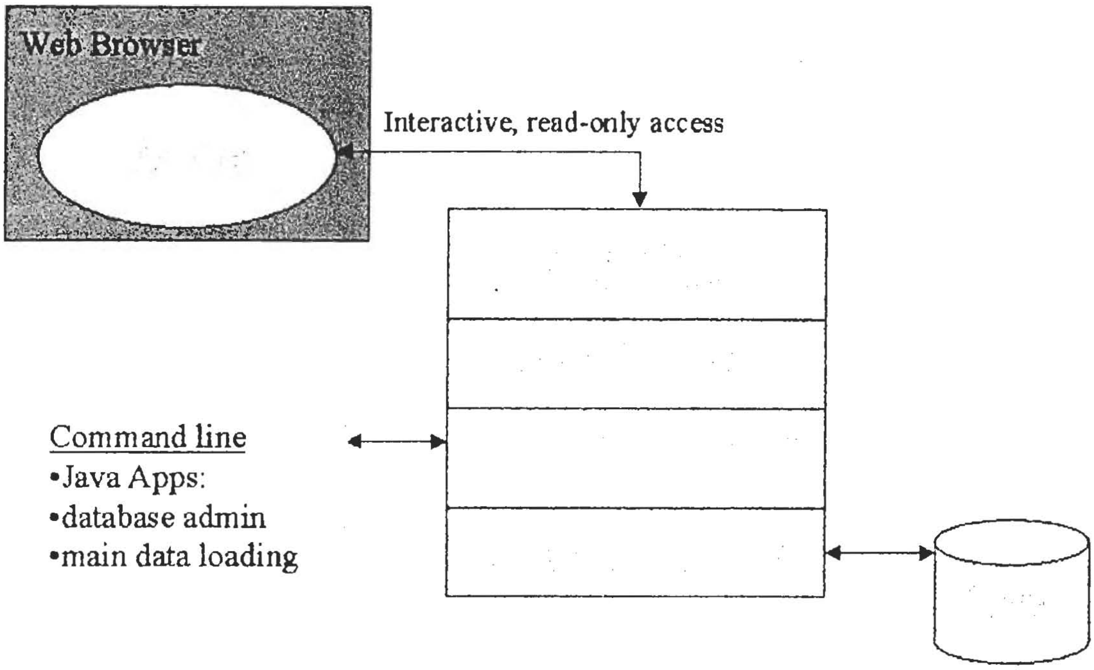

Figure 10. Information Repository Architecture

Versant's Object-Oriented Database was chosen as the primary software package for implementing the A-TES Information Repository. The Versant database supports multiple user access via the web using the Java interface and allows for user defined security. Versant provides a Java-Versant API with which to develop and use the Versant database. The interface allows programmatic control of the database schema and its contents using the Java programming language. JVI-enhanced Java programs create, store, modify, and retrieve database information through extended Java base classes. Java objects are stored in the database as serialized data through the Versant Object-Oriented Database Management System.

The Information Repository architecture allows two methods of access. The first method is local access through Java applications. Both command line and GUI driven Java applications were implemented to use this access method to perform administrative tasks such as defining the initial schema and loading the initial data.

The second access method is remote, web-based access to the Information Repository. Upon access to the database web site, a Java enabled browser downloads an applet through which the user will view information in the database. The applet sends HTTP requests to the web server that has an extended module that allows for overloaded HTTP calls to be handled by Java servlets. Java servlets are server side Java applications that can extend functionality to normal server applications such as web servers and e-mail servers. The servlets then access the database through the JVI and pass data objects back to the applet for display.

4.2.3. Access

The Information Repository website, which resides on a Dell Precision machine in the Testbed, can be accessed at http://neutron.ist.ucf.edu. Accessing this site will download a Java applet that will communicate with the Information Repository. It requires Netscape, preferably 4.61 or above, and the Java 1.1.2 or Java 1.2 plug-in from Sun; there are links on the Repository web page to download the plug-in. The user accesses the Repository contents using a window that behaves similarly to the "My Computer" window found in Microsoft Windows98. Clicking on a folder button goes into those folders and clicking on the ".." folder button navigates up on directory level. Clicking on a file brings up the familiar "Download or Open File" dialog box. Figure 11 illustrates the view that the applet provides to users.

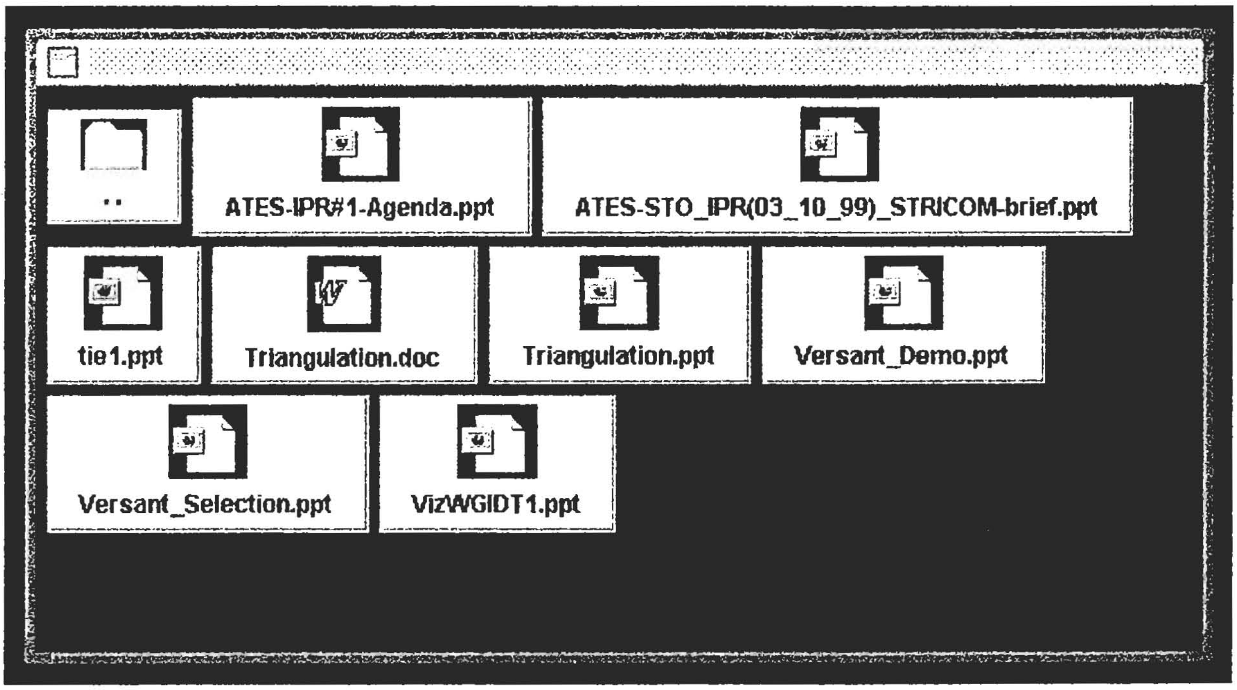

Figure 5. Remote Information Repository View

4.3. Concept Visualization

4.3.1. Objective

The objective of the A-TES Concept Visualization effort was to produce a multimedia presentation to clearly communicate the overall A-TES STO concept and "reason for being" to a non-technical audience. The resulting presentation illustrates the limitations of extending existing tactical engagement systems to include infantry-level area effects weapons such as the OICW and the inability to perform real-time casualty assessment using such systems. The presentation also introduces the emerging TM-UWB technology and explains its role in addressing these limitations.

4.3.2. Concept Presentation

The presentation is in the form of text, video clips, and 2D and 3D graphics supported by an explanatory narration. The running time of the A-TES Concept Visualization is approximately 8 minutes and 20 seconds. Topics covered in the A-TES Concept Visualization include:

- Focus on the OICW
- Training problems presented by non-LOS weaponry
- Overview of TM-UWB technology for communications and geopositioning
- The role of the Combat Server
- High-level A-TES system architecture
- Advantages of the A-TES approach
- Additional weapons systems supportable by A-TES approach

4.4. VRML Visualization

4.4.1. Purpose and Approach

The Virtual Reality Modeling Language (VRML) is an open-standard graphical modeling language that is designed to depict three-dimensional environments across the World Wide Web. Much like a Hypertext Markup Language (HTML) file, a VRML file is human-readable, interpreted source code that may be viewed using a VRML browser. VRML browsers are typically implemented as plug-ins to Internet web browsers such as Netscape Navigator or Microsoft Internet Explorer.

VRML was used to showcase three concept demonstrations for the A-TES STO program. The three demonstrations are:

- A-TES STO Concepts
- OICW Munition Variance
- OICW Concepts of Operation

All of these concept demonstrations employ a VRML model of a soldier which is illustrated in Figure 12. For each concept demonstration, a storyboard was laid out and a script was written. A text-to-speech converter was used to create digital audio files containing the narration for each of the demonstrations.

Figure 12. VRML Soldier Holding OICW

4.4.2. A-TES STO Concepts

The A-TES STO Concepts VRML demonstration (See Figure 13 below) showcases the basic concepts of the A-TES STO program. The demonstration shows historical tactical engagement simulation using MILES gear and illustrates current limitations. The concepts of multilateration and time-based modulation are then presented.

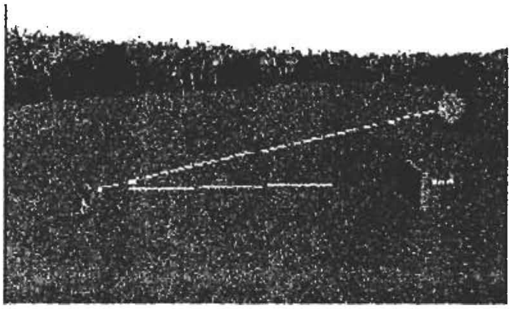

Figure 13. A-TES STO Concepts

4.4.3. OICW Munition Variance

The OICW Munition Variance concept demonstration (See Figure 14 below) illustrates the concept of munition variance in weapon firing. The idea is to show that range, azimuth, and elevation dispersion creates variances in munition burst points, even without the influence of human error. Such variances are caused by slight imperfections in the weapon and round.

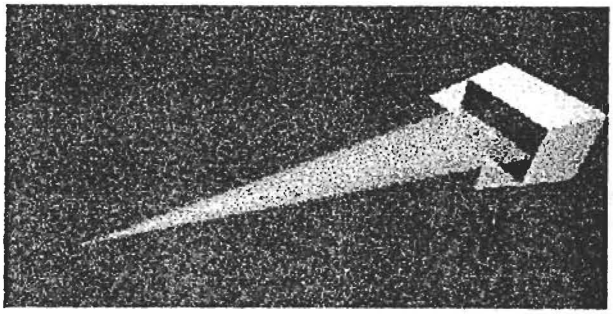

Figure 14. OICW Munitions Variance

4.4.4. OICW Concepts of Operation

The OICW Concepts of Operation demonstration (See Figure 15) addresses the features and use of the OICW. This demonstration shows the OICW's kinetic energy and high explosive modes of operation and illustrates how the aiming and laser range finding works.

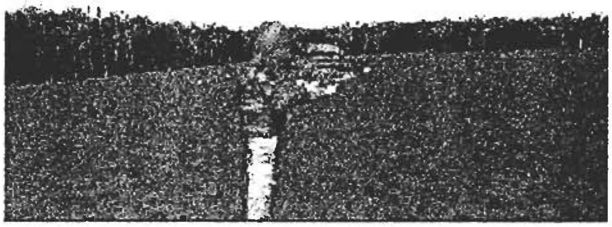

Figure 5. OICW Concepts of Operation

4.5. Marketing Efforts

4.5.1. Purpose and Approach

A major focus of a Science and Technology Objective (STO) is to disseminate the data, results, and conclusions from the STO to members of the user community. To allow for the ultimate success of the STO by transitioning prototype technologies to developmental systems, effective and efficient marketing methods must be used to disseminate the information.

Several methods were identified to market information on the work being performed in the A-TES STO including approach, findings, results, progress, planning, and goals. These methods include:

- Comprehensive Briefing
- Email Reflectors
- Website
- Online Encyclopedia

4.5.2. Comprehensive Briefing

A comprehensive A-TES STO briefing was developed to describe the purpose, scope, and benefits of the STO. This briefing was presented to a variety of organizations including PM ITTS, JSSAP at Picatinny Arsenal, PM CATT, PM Small Arms, and PM TRADE.

4.5.3. Email Reflectors

An email reflector allows users to subscribe to receive all email messages sent to a special reflector address. This mechanism efficiently supports shared conversations among the subscribing members. Members may subscribe and unsubscribe without requiring other members to update their personal address books. In addition, all previous electronic conference traffic is archived and made available for retrieval by any subscriber. This allows new subscribers to review old traffic to catch up on the discussions.

Currently, A-TES employs three email reflectors: ATES-STO-PUBLIC, ATES-PRIV-TECH, and ATES-PRIV-PROG. The PRIV (private) reflectors are used internally by the A-TES team to distribute information and guidance on programmatic and technical issues concerning the A-TES STO. Membership in each reflector is administered by IST. IST provides a web-based interface to all messages sent via the reflectors. This versatile interface permits A-TES users to sort and query messages on the From, Subject, Body, and Date fields.

To subscribe to a conference, send an email message to listproc@sc.ist.ucf.edu. The subject may be anything you wish, but the body must have exactly one line of the form:

subscribe reflectorName yourFirstName yourLastName

4.5.4. Web Site

An A-TES web (www.a-tes.org) site was developed, which contains the following features:

- *About* - A description of the A-TES STO.
- *FAQ* - A comprehensive list of frequently asked questions about the A-TES STO.
- *Documents* - This application provides the ability to post pertinent documents and information which may be accessed by those interested in the A-TES STO or other related topics such as multilateration or live, force-on-force training and testing for emerging U.S. Army Force XXI weapons.
- *Contacts* - This application identifies key individuals who may be contacted for additional information.
- *Forums* - A list of forums, symposiums, and conferences pertinent to the STO.
- *Links* - Links URLs of interest to the STO.

4.5.5. Encyclopedia

An online encyclopedia has been developed to familiarize the interested reader with TES-related subjects as well as the A-TES program. The encyclopedia's URL is http://www.vsl.ist.ucf.edu/people/jmontill/ates/html/, there is also a link to the encyclopedia from the main A-TES web site. It consists of two parts. The first part provides information related to the evolution of the A-TES program and includes these topics:

- Historical, Existing, and Future Tactical Engagement Simulation (TES) Capabilities
- Small Arms Weapons
- Instrumentation Technologies
- Instrumentation Communication Technologies
- Pairing Technologies
- Player Feedback Technologies

The second part of the encyclopedia presents information and results generated by the A-TES program. This information includes simulation descriptions, results, visualizations, and analyses for the various Testbed Implementation Exercises.

A. A-TES STO Acronyms

AAN	Army After Next
AAR	After Action Review
ACTD	Advanced Concept Technology Demonstrator
API	Application Programming Interface
ASIC	Application Specific Integrated Circuit
ATD	Advanced Technology Demonstration
A-TES	Advanced Tactical Engagement Simulation
C3	Command, Control, and Communications
C4I	Command, Control, Communications, Computers, and Intelligence
CDRL	Contract Data Requirements List
CECOM	Communications Electronics Command
CID/IFF	Combat Identification/Identification Friend or Foe
CTC	Combat Training Center
DGPS	Differential GPS
DoD	Department of Defense
FCS	Fire Control System
GPS	Global Positioning System
GUI	Graphical User Interface
HE	High Explosive
HTTP	HyperText Transfer Protocol
HWIL	Hardware in the Loop
INVEST	Intervehicular Embedded Simulation and Training
IPR	Interim Program Review
IST	Institute for Simulation and Training
JDK	Java Development Kit
JRTC	Joint Readiness Training Center
JSDK	Java Servlet Development Kit
JVI	Java Versant Interface
LAN	Local Area Network

LETS	Logistics Engineering Technical Support
LOS	Line of Sight
LW-PDD	Lightweight Personal Detection Device
MAIS	Mobile Automated Instrumentation Suite
MILES	Multiple Integrated Laser Engagement System
MOUT	Military Operations Urban Terrain
NAWC-TSD	Naval Air Warfare Center - Training Systems Division
OCSW	Objective Crew Served Weapon
ODBMS	Object Database Management System
OICW	Objective Individual Combat Weapon
OIS	Objective Instrumentation System
PCM	Pulse Code Modulated
PM	Project Manager
PM CATT	Project Manager Combined Arms Tactical Trainer
PM ITTS	Project Manager Instrumentation Targets and Threat Simulators
PM TRADE	Project Manager Training Devices
PSD	Power Spectral Density
R&D	Research and Development
RTCA	Real Time Casualty Assessment
SAT	Small Arms Transmitter
SAWE	Simulated Area Weapons Effects
STO	Science and Technology Objective
STRICOM	Simulation Training and Instrumentation Command
TDMA	Time Division Multiple Access
TES	Tactical Engagement Simulation
TIE	Testbed Implementation Exercise
TM-UWB	Time Modulated Ultrawideband
UHF	Ultra High Frequency
URL	Universal Resource Locator
VRML	Virtual Reality Modeling Language
WAN	Wide Area Network