Training Strategies for a Deployed, Distributed Virtual Environment

Peter Crane
Air Force Research Laboratory
Mesa, Arizona
peter.crane@mesa.afmc.af.mil

Capt Erik Jilson
USMC Training & Education Command
Quantico, Virginia
erik.jilson@usmc.mil

Eileen Entin, Rebecca Morley
Aptima, Inc.
Woburn, Massachusetts
ebe@aptima.com, rmorley@aptima.com

Matthew Archer
SDS International, Inc.
Orlando, Florida
marcher@sdslink.com

ABSTRACT

Distributed Mission Operations (DMO) is a U. S. Air Force program to augment aircraft training with multi-participant, simulator training. DMO Mission Training Centers have been established for F-15 and F-16 fighters and for AWACS mission crews. In addition, a DMO research testbed has been developed at the Air Force Research Laboratory in Mesa, Arizona centered around four, high-fidelity F-16 simulators with full field-of-view visual display systems. DMO training centers typically focus on a single platform using large-footprint systems at a fixed location. In contrast, the U. S. Marine Corps' Deployable Virtual Training Environment (DVTE) consists of networked laptop computers that support simulation for the many weapons types and Military Occupational Specialties that comprise a Marine Air Ground Task Force. DVTE systems are low-cost and lightweight so that they can be used on shipboard or in a deployed environment. Although physically very different systems, DMO and DVTE are both designed to provide mission-oriented, scenario-based team training that will enhance warfighter skills in teamwork, communication, situation awareness, and tactical execution. The Air Force Research Laboratory's Warfighter Readiness Research Division and the Marine Corps Training and Education Command, Training and Education Technology Division, supported by SDS International's Advanced Technologies Division and Aptima, Inc., are working together to develop a training strategy for DVTE based on lessons learned from DMO effectiveness research. Training strategies derived from Air Force experience using DMO are being applied to Marine Fire Support Team (FiST) training using DVTE.

ABOUT THE AUTHORS

Peter Crane is a Research Psychologist at the Air Force Research Laboratory, Warfighter Training Readiness Division in Mesa, AZ. His major research interest is enhancing effectiveness in distributed simulation systems. Dr. Crane earned a PhD in Experimental Psychology from Miami University in Ohio.

Eileen Entin is a Senior Research Psychologist at Aptima, Inc. in Woburn, MA. Her major research interests include simulation-based training and performance assessment. Dr. Entin earned a PhD in Experimental Psychology from Ohio University in Athens, Ohio

Rebecca Morley is a Human Factors Analyst at Aptima, Inc. in Woburn, MA. Her major research interests include various knowledge elicitation techniques (MECs, CTA, CWA), team training systems, and immersive technologies (spatial audio displays, HMDs).

Capt Erik Jilson graduated from the United States Naval Academy with a BS in Mathematics in 1995 and was commissioned as a Second Lieutenant in the United States Marine Corps. He graduated from the Naval Postgraduate School with a Masters in Modeling Simulation and Virtual Environments (MOVES). He is presently a Modeling and Simulation Analyst with Technology Division, Training and Education Command in Quantico, VA.

Matthew Archer is a Senior Software Engineer at SDS International in Orlando, FL. He has been involved in the development of simulation training systems for over 12 years, and his major research interests are computer graphics and real-time modeling and simulation.

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The US Air Force Distributed Mission Operations (DMO) and US Marine Corps Deployed Virtual Training Environment (DVTE) programs are team training systems using very different technologies and different training applications. Unlike individual, procedural skills trainers, both DMO and DVTE systems are designed to enhance warfighter team skills and to complement range training exercises for experienced practitioners. The similarity between these programs is that both systems employ a mission-oriented, scenario-based training strategy designed to enhance warfighter skills in teamwork, communication, situation awareness, and tactical execution. The Air Force Research Laboratory's Warfighter Readiness Research Division and the Marine Corps Training and Education Command, Training and Education Technology Division, supported by SDS International's Advanced Technologies Division and Aptima, Inc., are working together to develop a common training strategy for using DVTE for many combat teams and tasks based on lessons learned from DMO.

CONVERGENT EVOLUTION OF A TRAINING STRATEGY

By itself, practicing a known task does not provide effective training for experienced performers. Free play in a combat environment can be effective (Alluisi, 1991) but is unfocused and inefficient. Ericsson, Krampe, & Tesch-Römer (1993) describe a training regimen they called deliberate practice, which is "a highly structured activity, the explicit goal of which is to improve performance," (p. 368). Compared to simple repetition of a task or to free-play, deliberate practice:

- includes activities that have been specifically designed to improve the current level of performance;
- provides instruction in use of effective strategies to allow diagnosis of errors; and,
- allows for repeated experiences in which the individual or team can attend to the critical aspects of the situation.

Many training communities that use real-time synthetic environments incorporating virtual and constructive simulations have converged on training strategies incorporating the principles of deliberate practice. Several examples of training strategies reflecting the concept of deliberate practice were described at the 2003 I/ITSEC. Walwanis-Nelson, Smith, Owens, & Bergondy-Wilhelm (2003) describe development of technologies in support of the US Navy's implementation of Distributed Mission Training for Naval aviation. These technologies are designed for Scenario Based Training (Oser, Cannon-Bowers, Salas, & Dwyer, 1999). Walwanis-Nelson et al. describe Scenario Based Training as a strategy in which, "scenarios are designed to provide the participant with the opportunity to practice / exercise critical competencies. Learning objectives are transformed into scenario events and conditions to stimulate performance," (p. 380). Giebenrath at al. (2003) describe a Naval coalition training exercise for surface fleets using an objective-based training approach called the Team Learning Methodology. Using this method, domain-specific tasks are selected for incorporation into scenarios based on specified learning objectives. These events, in turn, form the basis for organizing after-action reviews and measures of performance. A similar strategy, Problem Based Embedded Training (Kirkley, Kirkley, Myers, Lindsay, & Singer, 2003), provides the structure for US Army embedded training programs. This strategy, which is used with both live and virtual simulations, is founded on Problem Based Learning (Savery & Duffy, 1996), "a systematic process for designing instruction that focuses on complex and authentic real-world problems and situations," (Kirkley et al., 2003, p. 1032). In Problem Based Learning, the instructional designer selects an authentic task and creates a learning environment incorporating the complexities of the task. Scenarios include problems that the learner must solve followed by after-action review which provides opportunities for reflection. In research supporting the US Air Force DMO program, Alliger et al. (2003) and, Colegrove & Alliger (2002) outline a formal program for defining the Mission Essential Competencies required to perform specific combat missions. These top-level Mission Essential Competencies together with specifications of required knowledge, skills, and experiences serve to define the domain-specific and authentic tasks to be incorporated into a training scenario. Carolan et al. (2003) show how the specified competencies can be used to define measures of training effectiveness in training scenarios.

Development of multi-participant, real-time simulation systems has fostered convergent evolution of similar training strategies across a variety of communities. This mission-oriented, scenario-based strategy provides focus and structure to team training activities by linking specific competencies and objectives to events in training scenarios. Formal specification of Mission Essential Competencies further provides detailed training objectives and the basis for developing measures of training effectiveness.

USAF DISTRIBUTED MISSION OPERATIONS

The concept of DMO was described by then Commander of Air Combat Command, Gen Richard Hawley during his keynote addresses at I/ITSEC 1997 and 1998. Networked, Mission Training Centers incorporating four or more high-fidelity simulators plus player-stations and constructive forces are being installed at bases around the world. Bills & Devol (2003) describe the capabilities of an F-16 Mission Training Center at Shaw AFB. Such training centers are supporting individual, team, and inter-team training for a broad spectrum of warfighters. Air Force Research Laboratory's Warfighter Readiness Research Division in Mesa, AZ developed an F-16 DMO testbed for use in training effectiveness research. AFRL's testbed system incorporates:

- Large-footprint, high-fidelity cockpits with full field-of-view visual displays, Figure 1
- Observer and control station, Figure 2
- Replay and debrief systems, Figure 3
- Programmable, constructive forces
- Secure, wide area networking capabilities.

Research using this system has demonstrated training benefits for both USAF pilots (Crane, Robbins, & Bennett, 2001) and coalition forces (McIntyre, Smith, & Bennett, 2002). Research has also identified the best practices and most effective strategies for implementing training to m3et defined objectives (Bennett & Crane, 2002; Bennett, Schreiber, & Andrews, 2002).

Figure 1. F-16 DMO simulator at AFRL.

Figure 2. Observation and control console.

Figure 3. Replay and debrief system.

USMC DEPLOYED VIRTUAL TRAINING ENVIRONMENT

DVTE has been described in detail by Bailey & Armstrong (2002) and, Bailey & Guckenberger (2002). The concept for DVTE is to provide a deployable, robust, Marine-friendly, multi-participant simulator system that can support training for the warfighters in a Marine Air Ground Task Force. DVTE uses commercial off-the-shelf, laptop computers that can be reconfigured to support a variety of training tasks [see Figure 4].

Figure 4. Marines training with DVTE

To provide training for various military specialties, DVTE incorporates different modules that use common instructor tools such as after-action review capabilities. One tool, the Fire Team Cognitive Skills Trainer (FTCST) which is part of the Infantry Tool Kit, is described by Armstrong & Bailey (2002) as:

> … a fully interactive, three-dimensional training tool that allows small units (groups of five to 15 Marines) to solve specific missions. The emphasis is on teamwork and the execution of tactical decision making skills. FTCST is built using the Virtual Battlefield Simulation (VBS), which is based upon the commercial gaming engine Oxygen II. Individual entities in the training environment are maneuvered and fought by individual Marines sitting in front of networked laptop computers. The physical ground truth is represented in the FTCST; the verbal interaction of the team members and the leadership of the team happen just as in a field environment. As such, a team can think through different problems while in a deployed status. (p. 846) [see Figure 5].

DVTE after-action review tools include three-dimensional visualization of the battlespace plus graphical representations of positions of forces, control-measures, and weapons trajectories / effects. After-action review can be controlled by the instructor as playback, individual time-slices based on events, or jumps to tactical bookmarks inserted by the instructor during the mission [see Figure 6]. (Bailey & Guckenberger, 2002).

Figure 5. Screen shot from DVTE real-time engagement

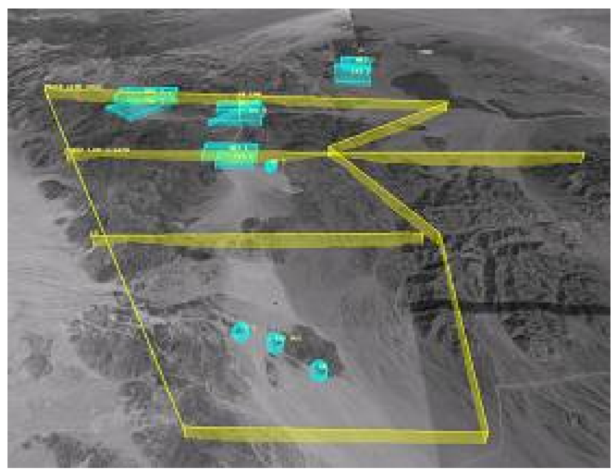

Figure 6. After-Action Review screen from DVTE

APPLYING LESSONS LEARNED FROM DMO TO DVTE

By themselves, DVTE and DMO are simulation systems. Applying the principles of deliberate practice based on analyses of required competencies is required to create focused training. Experiences gained in developing systems and procedures for implementing DMO training are being applied to DVTE. These systems include procedures for knowledge extraction from experienced practioners to identify required skills, development of training scenarios incorporating specific trigger events that exercise required skills, tools and procedures to support teams preparing for simulated missions, real-time simulation systems, and tools for conducting after-action reviews.

Analyses of Required Skills

DMO. Bennett et al. (2002) describe how the specification of Mission Essential Competencies serves as the foundation for developing DMO training syllabi, scenarios, and performance measurement systems. Mission Essential Competencies are defined as, "the higher-order team and inter-team competencies that a fully prepared pilot, crew, or flight requires for successful mission completion," (p. 775). Mission Essential Competencies for a given weapons system or specialty are generated from an extensive set of workshops, questionnaires, and interviews with subject matter experts (Alliger et al., 2003). Objectives for a given training event are selected by instructors from the set of Mission Essential Competencies.

DVTE. DVTE supports ongoing and iterative analysis of required skills, concepts, and associated processes for the operational life-cycle of DVTE systems. During the initial development of DVTE, existing USMC training standards were utilized to provide the baseline specification of required skills. Further, Marines utilized prototype DVTE systems during multiple User Scrutiny Events which included virtual simulations of USMC live-fire training exercises. Both structured questionnaires and free form feedback were employed during these events to iteratively improve each spiral of the DVTE developmental processes. Following the DMO example of direct and continuing interactions between warfighters and system developers, those areas that were better trained in DVTE and those that were better trained in live exercises were identified. Specifically, DVTE reinforced successful training and rehearsal features as derived from the User Scrutiny Events and at the same time defined areas better left in live training domains. Such insights enable intelligent and efficient allocation of training to the DVTE and live in a synergistic fashion, just as DMO has been synergistically allocated to enhance USAF range training.

The DVTE simulation system is initially being used as a platform for training members of the Marine Fire Support Team (FiST). Our initial focus has been on training for the Forward Observer (FO). To determine the training needs of the FO that can be supported in the DVTE environment, our first step was to conduct an analysis to determine the skills required for expert performance in this position. A less extensive knowledge extraction process than that used for generating Mission Essential Competencies was employed for identifying skills, and developing a prototype syllabus and scenarios for the FO position.

The duties of the FO are described in FM-30 (Headquarters Department of the Army, 1991). Using the duties described there and working with subject matter experts (SMEs), we identified that the FO's mission is comprised of six sequential phases:

1. Selection of Observer Position (OP)
2. OP Occupation
3. Target Location
4. Call for Fires
5. Adjust Fires
6. Battle Damage Assessment

For each phase, we then developed a flow diagram to illustrate the sequence of actions required for successful performance during that phase. An example for Phase 2 (OP Occupation) is shown in Figure 7. Using the actions required, we worked with a SME to determine the underlying skills needed to perform those actions. As the next step, we identified potential measures of effectiveness that the instructor can use to evaluate the trainee's performance [see Figure 7]. These are data points that the instructor can ascertain at his workstation and can use to evaluate the trainee's level of competence during specific phases of the mission.

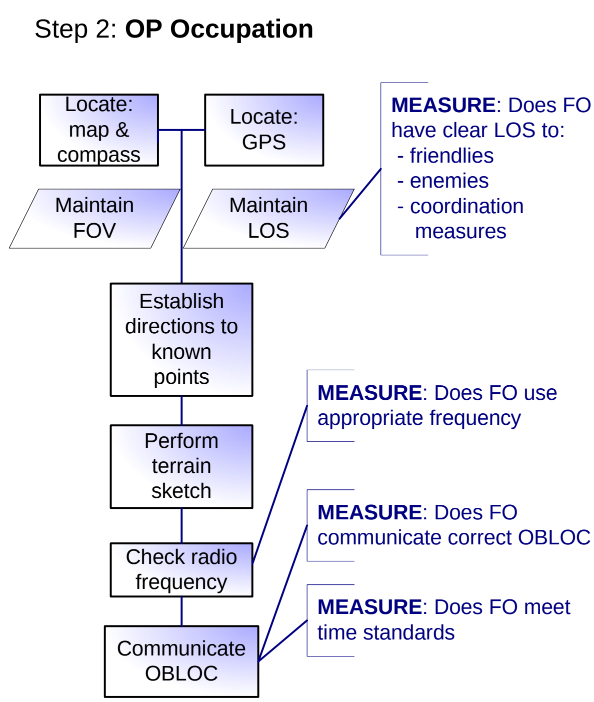

Figure 7. Sequence of Actions taken by FO in OP Occupation.

Once we had identified the actions required for each phase, in order to develop scenarios that provide an effective problem-based learning environment (Kirkley et al., 2003; Savery and Duffy 1996), we needed to determine which of these actions can be exercised by the DVTE. Tasks such as friendly and enemy position location can be realistically performed in the DVTE. However, some tasks such as actual coordinated use of operational equipment (e.g. Laser Designator or Radios) cannot be practiced in this environment and must be trained in other ways. Identifying the limits of the training environment is a necessary step in developing scenario-based training.

For tutoring and evaluation conducted in a *distributed* environment, it is also necessary to ascertain which actions that are performed are captured in the simulation, and which ones are performed by individual participants “offline”. Because DVTE is a distributed simulation, those actions performed offline are not visible to other participants in the simulation or to the instructor. Thus, while most or all the underlying actions for a phase might be exercised, only those that result in actions in the DVTE simulation can be directly evaluated. For example, in the OP Occupation phase, the FO makes a terrain sketch on paper. Since it is not visible to the instructor or other participants, they cannot evaluate the accuracy of the sketch. Likewise, although the FO will transmit his position as part of the DVTE simulation, thereby allowing the instructor to ascertain whether the trainee has determined the correct position, the calculations the trainee makes to ascertain his position are done offline, and therefore any mistakes made in the calculation process are not visible to the instructor. In a training program, where the focus is on helping the trainees gain competence rather than on performance evaluation, the invisibility of some of the lower-level actions performed by the trainee presents a challenge.

According to the principles of deliberate practice (Ericcson et al., 1993), if the trainee is having difficulty, the instructor needs to be able to identify the source of the problem and guide the trainee through the exercise by asking pointed questions and making recommendations for alternative approaches. In order to use the DVTE effectively for “guided training”, when the trainee makes errors, the instructor must be able figure out where the trainee has gone wrong. For example, if the FO trainee does not correctly locate his/her position, the instructor can ask the trainee what method of self-location he/she used, and then ask for some interim calculations or data points to narrow in on where the FO erred. Thus, part of the development task requires providing instructors with a template of probing questions they can use to help them understand what the trainee is doing “offline” in order to identify the source(s) of an error In general, these questions will be based on typical mistakes that inexperienced FOs make. For example, novice FOs will occasionally send inaccurate information when using polar coordinates, because they can easily transpose direction and distance, sending the information in the wrong order. In this case, the instructor might specifically ask the trainee about direction and distance.

In order to support instructors in using the DTVE for training, we are working with experienced SMEs to develop a set of typical errors that novice FOs make that result in inappropriate actions or decisions, and questions instructors can ask the trainee about calculations or actions that are not visible in the distributed environment. As the system is used for training, we can gather more information about typical errors that can be incorporated as additional guidance for instructors.

Scenario Development

DMO. Once the training objectives have been identified, scenarios are generated incorporating different trigger events. A trigger event is the action of a controlled entity which is designed to elicit responses from trainees that reflect the desired skill (Bennett et al., 2002). For example, the Mission Essential Competencies for beyond visual range, air-to-air combat state that pilots must locate targets using their radar, evaluate enemy tactics, and select their own tactics appropriately. Trigger events in different scenarios, therefore, would include, “enemy forces entering the engagement as a single group, as two groups separated in horizontal distribution, as two groups separated in altitude, or as a group of three at medium altitude followed by a single, high, fast flying enemy aircraft,” (Bennett et al., 2002, p.778).

DVTE. DVTE scientists and developers directly leveraged many of the DMO lessons learned in the arena of scenario based training. The essential Marine philosophy of training to standards was preserved by utilizing validated live fire exercises as the baseline to provide a known context in which to judge DVTE effectiveness. Interestingly, just as DMO instructors developed scenario variations that discourage overly aggressive or poorly planned attacks, DVTE instructors similarly developed multiple scenario variations. The DMO "playbook" philosophy of multiple scenarios at each level of difficulty was designed into the DVTE simulation control capacities.

For an effective problem-based training program, it is necessary to structure the exercises from less to more difficult, and to provide sufficient practice at each level of difficulty. Thus, in developing the training program for each task, multiple practice opportunities are provided at a given level of difficulty. We provide multiple variations on the same scenario by, for example, positioning the FO or enemy units in different locations. Once a trainee achieves an acceptable level of mastery at a given level of difficulty, he or she must practice at a more difficult level. To vary the difficulty level, we can change the environmental or situational conditions in which the scenario occurs, for example by going from a daylight to a nighttime mission, by simulating a clear versus an overcast weather situation, or by adding in obscurants in the terrain. We can also increase the level of difficulty by varying the assets the FO has, for example providing or taking away a GPS unit, or by modifying the level of accuracy those assets are providing.

Mission Preparation

DMO. In DMO training research exercises at AFRL, teams of pilots and an air weapons director plan and brief the simulator mission as they would before a range training mission. One major difference between DMO and range briefings is that in DMO, flying specific events such as take-off and landing are not briefed. However, since DMO missions are flown with real-time kill removal for the virtual F-16s, teams must plan and brief events that rarely occur during range flying such as three-ship game plans if one of their aircraft is killed by enemy actions. Other contingencies that must be briefed include low-fuel plans and low-missile plans. The mission briefing is conducted by the flight lead with input from an instructor pilot, if one is present, only after completion of the formal briefing.

DVTE. For initial training applications, DVTE mission preparations have mimicked field briefings except for the initial instructor scenario briefing to the collective Marines providing background for the simulation exercise. In a conventional manner, Marines Officers and NCOs utilize standard map planning techniques and Marine quick-brief formats to construct and brief their plan(s). It is important to note that DVTE is not a copy of DMO. It is a distributed simulation developed for specific Marine deployed training and rehearsal enhancements. Wholly unique DVTE features include direct production of quick-time movies for briefing and debriefing. Another key technical advance has been the integration of the DVTE 3D Stealth with the Operational Comand & Control Personal Computer planning and monitoring software. The use of the actual operational software as the front end to the DVTE process aids in the realism of the training and rehearsal processes. To insure the establishment of a realistic training environment, trainees need to receive a mission briefing that includes the background to the situation, the objectives of the mission, and the rules of engagement. As part of the training package, we plan to include a standard pre-mission briefing for each scenario. The same briefing can be used when the trainee practices on multiple variations of the same scenario, or modified appropriately to accommodate variations attributable to the difficulty level of the scenario.

DVTE creates a virtual play box for a training audience. This virtual play box allows the creation of an exercise with unlimited possibilities. Preparation for participating in a virtual exercise is most effective when it is conducted in the same manner as it would be conducted in a field exercise or in real world operations. Instructors or unit leaders can run an exercise based on their training objectives. There are additional advantages to having the DVTE capability. In preparation for a live training or operational event, a virtual walk through of the training area can be conducted, a movie can be played showing the terrain, or past exercises can be reviewed all adding to the orientation and situation awareness of the trainees.

Mission Execution

DMO. In DMO training research exercises at AFRL, simulator sessions are designed to increase time on task for the most complex portions of the mission. For offensive air-to-air missions, friendly and enemy forces are initiated in the air, just beyond radar range of the fighters. The AWACS air weapons controller will first detect the enemy forces and communicate the air picture to the fighters over the radio. The engagement is terminated when the friendly or enemy forces have been killed or all training objectives have been met. Reset requires no more than a minute or two allowing six to eight engagements in an hour. For defensive air-to-air missions in which friendly forces are protecting a target such as an airfield, missions run continuously for up to thirty minutes with fuel running and real-time removal of all aircraft that are killed. Two to three missions are conducted in a one-hour simulator session

DVTE. Using the DTVE, an instructor can allow a trainee (or trainees) to execute an entire training scenario without intervening, regardless of how successful the trainee is in performing the mission. Alternatively, the instructor can choose to temporarily halt the scenario at any time, to ask the trainee a question or make a suggestion. Or, especially in a case where the trainee has made errors that have compounded one another, the instructor can choose to give the trainee some guidance and restart the scenario. Unless trainee errors compromise the value of the training, emphasis is on conducting training that is as close to live training as possible. Simulator operators communicate with their higher headquarters and each other over tactical networks. Location of red forces is concealed from blue forces, unless normal detection has occurred. A facilitator is on hand to ensure that technique, tactics, and procedures are followed correctly.

Replay and After-Action Review

DMO. Missions are digitally recorded for replay and debrief including a map-like plan-view display, information from each F-16 cockpit including radar and head-up display, and audio communications. Replay and debrief are conducted by the flight lead who relates mission execution to the briefed plan. Focus is on what went well, what went badly, and lessons learned.

DVTE. DVTE provides the capability to record and play back a scenario run. Unique features of the DVTE replay and after-action-review module are instructor / facilitator support tools and automated insertion of tactical bookmarks into the recorded exercises. This enables feedback and debriefing immediately following the conclusion of the distributed exercises. Specifically, the tactical bookmarks can be inserted for any training / rehearsal event of interest at the instructor station and by the monitoring and recording sub-module that automatically tags fratricides and other identified events of interest. Collectively these capabilities are utilized in after action reviews to review the team's performance and to discuss actions they have taken as well as alternative actions that might have been equally or more appropriate. For example, in review the instructor might point out that the trainee did not send the required information in a timely manner. Guidelines for diagnosis and feedback should be an integral part of the training program. When the trainee performs the scenario without any feedback, the questions developed to guide the trainee during execution of the scenario will be useful for discussion during the debriefing.

BEST USES OF TRAINING TECHNOLOGIES

All training technologies including large force exercises and live-fire ranges have limitations that restrict the scope of training. Matching training objectives to training system capabilities takes best advantage of both aircraft and simulator training. Restrictions on live training include resource constraints such as lack of airspace and cost of opposing forces, environmental considerations, safety, and security.

DMO high-fidelity simulators

Compared to range training, simulator training has different strengths and limitations. The lack of force cuing and insufficient visual acuity provided by most out-the-window visual display systems limit the effectiveness of simulator training for within-visual range, air combat maneuvering. This task, however, is well supported by range training. In contrast, DMO training can provide air weapons controllers, computer generated enemy aircraft, and unlimited airspace that supports multi-aircraft, multi-bandit, beyond-visual-range air combat training. Further, DMO can increase time-on-task for critical mission phases by providing multiple engagements within one simulator session. Building block scenarios based on programmable computer-generated threats provide more complex problems based on required competencies than most range training exercises.

DVTE laptop simulators

Unlike large-footprint systems, DVTE simulators are inexpensive and portable for use in garrison, on deployments, or shipboard. Limitations in physical fidelity restrict some uses such as equipment operating procedures. High functional fidelity provides opportunities for training where access to ranges is unavailable and for specific operating areas.

In this paper we have focused on the use of the DVTE as a training platform for the FO. The FO, however, operates as a member of the FiST, and thus for most of the skills that need to be trained the training situation must include or simulate the other members of the team. This can be accomplished by having the instructor or some other individual(s) who are not the focus of training play the other roles. It can also be accomplished by having other members of the team participate in the training. One point of caution, however, is that it is often difficult to develop a training scenario that is equally effective for training multiple positions. In our initial work, we are designing a set of scenarios that are optimized for training the skill set required by the FO. In future work we will identify the skills required by other team members such as the Forward Air Controller, and modify the basic scenarios we have developed to optimize the exercise of those skills. Similarly we will specify how the difficulty level should be varied in a way that is appropriate for these other team members.

CONCLUSION

Training communities employing multi-participant, real-time simulators across a range of applications are converging on a common training strategy reflecting Ericsson et al.'s (1993) concept of Deliberate Practice. This strategy incorporates a systematic, end-to-end approach which ensures that training is focused and efficient, from specification of required competencies, design and conduct of training, and assessment of trainee performance. Careful matching of training objectives with the capabilities and limitations of training technologies increases the value of training resources including trainee and instructor time. Systematic application of this common strategy ensures best use of simulator systems across a wide range of capabilities including both large, high-fidelity fighter aircraft simulators and a network of laptop-computers. A key conclusion is that the convergence of strategies used in DMO, DVTE, and other scenario-based training processes using distributed simulation technologies continues to evolve training and rehearsal applications for effective, efficient warfighter support.

REFERENCES

Alliger, G., Garrity, M. J., Morley, R. M., McCall, J. M., Beer, L., & Rodriguez, D. (2003). Mission Essential Competencies for the AOC: A Basis for Training Needs Analysis and Performance Improvement. *Proceedings of 2003 Industry / Interservice Training Systems Conference*, Orlando, FL: National Security Industrial Association.

Alluisi, E. (1991). The development of technology for collective training: SIMNET, A case history. *Human Factors, 33*, 343-362.

Bailey, M. P., & Armstrong, R. (2002). The Deployable Virtual Training Environment. *Proceedings of 2002 Industry / Interservice Training Systems Conference*, Orlando, FL: National Security Industrial Association.

Bailey, M. P., & Guckenberger, D. (2002). Advanced Distributed Simulations Efficiencies & Tradeoffs DVTE, DMT & BFTT Experiences. *Proceedings of 2002 Industry / Interservice Training Systems Conference*, Orlando, FL: National Security Industrial Association.

Bennett Jr., W., & Crane, P. (2002). The deliberate application of principles of learning and training strategies within DMT. Presented at: NATO Research & Technology Organization, Studies, Analysis, and Simulation Panel, Conference on Mission Training via Distributed Simulation (SAS-38), Brussels, Belgium.

Bennett Jr., W., Schreiber, B. T., & Andrews, D. H. (2002). Developing competency-based methods for near-real-time air combat problem solving assessment. *Computers in Human Behavior, 18*, 773 –782.

Bills, C. G. & Devol, D. (2003). How F-16 MTC Team Achieved Operational Training Capability. *Proceedings of 2003 Industry / Interservice Training Systems Conference*, Orlando, FL: National Security Industrial Association.

Colegrove, C. M., & Alliger, G. M. (2002). Mission essential competencis: Defiing combat readiness in a novel way. Paper presented at: NATO Research & Technology Organization, Studies, Analysis, and Simulation Panel, Conference on Mission Training via Distributed Simulation (SAS-38), Brussels, Belgium.

Crane, P., Robbins, R., and Bennett, Jr., W. (2001). *Using Distributed Mission Training To Augment Flight Lead Upgrade Training*. (AFRL-HE-AZ-TR-2000-0111) Mesa, AZ: Air Force Research Laboratory.

Carolan, T., Schreiber, B. T., Portray, A., MacMillan, J., Entin, E. B., Morley, R. M., Denning, T., & Bennett Jr., W. (2003). Integrated Performance Measurement and Assessment in Distributed Missions Operations Environments: Relating Measures to Competencies. *Proceedings of 2003 Industry / Interservice Training Systems Conference*, Orlando, FL: National Security Industrial Association.

Ericsson, K. A., Krampe, R. Th., and Tesch-Römer C., (1993). The role of deliberate practice in acquisition of expert performance. *Psychological Review, 100*, 363-406.

Giebenrath, J. L., Burns, J. J., Hockensmith, T. A., Hession, P. J., & Brewer, J. (2003). Extending the Team Learning Methodology to Coalition Training. *Proceedings of 2003 Industry / Interservice Training Systems Conference*, Orlando, FL: National Security Industrial Association.

Hawley, R. (1997). Plenery Address for 19th Interservice/Industry Training Simulation and Education Conference, 2 Dec 97, Orlando, Florida.

Hawley, R. (1998). Plenery Address for 20th Interservice/Industry Training Simulation and Education Conference, 1 Dec 98, Orlando, Florida.

Headquarters Department of the Army, (1991). *Field Manual 6-30. Techniques and Procedures for Observed Fires.* Washington, D.C.: U.S. Army Doctrinal Publication. http://155.217.58.58/cgi-bin/atdl.dll/fm/6-30/f630.htm.

Kirkley, J. R., Kirkley, S. E. & Singer, M. J. (2003). Problem-Based Embedded Training: An Instructional Methodology for Embedded Training Using Mixed and Virtual Reality Technologies *Proceedings of 2003 Industry / Interservice Training Systems Conference*, Orlando, FL: National Security Industrial Association.

Oser, R. L., Cannon-Bowers, J. A., Salas, E., & Dwyer, D. J. (1999). Enhancing Human Performance in Technology-Rich Environments. In, E. Salas (Ed.), *Human / Technology Interactions in Complex Systems*, *9*, 175-202.

McIntyre, H. M., Smith, E. & Bennett, Jr., W. (2002). Exploiting high fidelity simulation for aircrew training. In, *Proceedings of 2002 Industry / Interservice Training Systems Conference*, Orlando, FL: National Security Industrial Association.

Savery, J., & Duffy, T. M. (1996). Problem-based learning: An instructional model in its constructionist framework. In B. Wilson (Ed.) *Constructivist Learning Environments: Case Studies in Instructional Design.* Englewood Cliffs NJ: Educational Technology Publications.

Walwanis-Nelson, M. M., Owens, J. M., Smith, D. S., and Bergondy-Wilhelm, M. L. (2003). A Common Instructor-Operator Station Framework: Enhanced Usability and Instructional Capability. *Proceedings of 2003 Industry / Interservice Training Systems Conference*, Orlando, FL: National Security Industrial Association.