

Authoring Effective Demonstrations

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Abstract

The changing tactics of asymmetric threats present an ongoing need to disseminate lessons learned from the battlefield to a wide audience of personnel. Interactive virtual environments have been shown to be effective for team training, and distributed game-based architectures contribute an added benefit of wide accessibility. Reusable and distributable virtual training demonstrations can help minimize the cost of utilizing virtual environments to convey new knowledge, by limiting the need for new simulation behaviors or human role-players for each training event. We report our ongoing efforts to (1) research the nature and purpose of demonstration, articulating guidelines for effective demonstration within a training context, and (2) develop real world use cases where gaming technologies can produce effective training demonstrations.

Keywords

Demonstration, Training demonstration, Serious games, Massively multiplayer online games, MMOG

1 INTRODUCTION

In modern warfare the changing tactics of asymmetric threats present an ongoing need to disseminate lessons learned straight from the battlefield to a wide audience of personnel. The ways in which battles are waged have changed significantly at the company level and below. It has been well established that asymmetric adversaries evolve: they probe, experiment, learn, and refine their behavior at a pace that drives an ongoing need for the Army to rapidly disseminate new operational and tactical concepts just as quickly if not instantly.

One commonly held Army tenet is that live demonstrations are the most effective way to disseminate information to warfighters (FM 7-1). Complex and dense concepts can be conveyed quickly with face-to-face live demonstration, leaving little to the imagination. Unfortunately, live demonstrations require moving all demonstrators, observers, and materiel to the same place at the same time, lengthening the lag between the times warfighters refine a new technique, to eventual pedagogical delivery. As a result of these logistical costs, the dissemination of concepts just learned from the field has been largely through written explanations—through AKO (Army Knowledge Online) for example.

These methods of transmission are inferior to demonstrations whether live, simulated, or recorded. Demonstrations have been favored by the Army as a complement to more traditional written training materials because they accelerate learning, stimulate interest, and communicate better than text. They also can be delivered on a wide variety of hardware platforms and accomplish almost instantaneous shared knowledge.

Research in the field of organizational psychology has confirmed that visual demonstrations prepared in virtual or constructive environments can accelerate the learning process by illustrating correct behaviors, establishing a shared mental model of team behavior (Salas & Cannon-Bowers 2000), and supporting such advanced techniques as cross training (Salas & Cannon-Bowers, 2000.). However, demonstrations require an adequate instructional framework to ensure their effectiveness in improving trainee performance. Unfortunately, demonstrations have received little attention in the research literature and there is little consensus on what constitutes a good demonstration.

From a technology perspective, there are many approaches and platforms that can potentially be employed for demonstrations, each with their own strengths and weaknesses, such as film, video, and computer-based instructional aids. The aerospace industry has been a leader in both team training and in virtual training environments, but these techniques are becoming more broadly available and accepted. Modern simulation technology affords a variety of capabilities such as 3-D visualization, transparency, and multiple synthetic agents who can function as instructors, teammates, or adversaries. The virtual environments supported by COTS (commercial off-the-shelf) game engines are increasingly being used for training, and likewise embody great potential as demonstration platforms, although demonstration is a relatively new application for “serious games”.

Below we describe our research into the nature and purpose of demonstration, articulating guidelines for effective demonstration within a training context. We develop real world use cases where gaming technologies can produce effective training demonstrations.

2 THE NATURE OF DEMONSTRATION

Organizations like the military, the aviation industry, and the medical communities face an array of rapidly changing problems, to be solved with a rapidly developing range of technologies. These organizations will thrive by fostering learners that are fast, efficient and self-correcting. So learning has become a mantra in many industries and agencies. Organizations have put in place formal and informal mechanisms for individuals and teams to learn, at a huge investment—\$250 billion per year (ASTD, 2005). Such an investment deserves tangible outcomes in personnel skill acquisition, increased productivity, lower rates of error, better decisions, and, of course, competitive edge. But the instructional

outcomes are not there. Recent research indicates that only 10% of what is learned is applied to the job (Tannenbaum, 2001).

Training is the systematic acquisition of the knowledge, skill, and attitude (KSA) competencies targeted for acquisition (Goldstein & Ford, 2001). In general, training consists of five core elements: the provision of information (e.g., classroom lectures), demonstration (e.g., live demonstrations, video recorded examples of task performance), practice-based methods (e.g., simulation, guided on-the-job performance), feedback (e.g., knowledge of results), and remediation (i.e., the selection of future training; Salas, Priest, Wilson, & Burke, 2006). Of these components, the scientific and practice-based literature surrounding demonstration is likely the least organized. Therefore, this section forwards a conceptual definition of a demonstration as well as a review of the theoretical basis underlying the use of demonstrations for training. Subsequently, guidelines for the development of effective demonstrations synthesized from the empirical and theoretical literature are summarized.

Although an exact and widely accepted definition of a demonstration is currently lacking (Williams, Davids, & Williams, 1999), demonstration-based training can be understood in general terms as a learner's observation of task performance, components of task performance (i.e., part-task performance) either in real time or through some form of recorded or computer generated medium, or characteristics of the task environment that have been targeted for acquisition. Demonstrations are often conceived of simply as an example of task performance; however, demonstrations are rightfully thought of as carefully engineered experiences where learners are prompted to actively process the informational content of the example, and to systematically and reliably acquire targeted KSA's and transfer them to the work environment. In this vein, Rosen, Salas, and Upshaw (2007, p. 6) provide a working definition of demonstration:

“A demonstration is a strategically crafted, dynamic example of partial or whole task performance or of characteristics of the task environment intended to increase the learner's performance by illustrating (with modeling, simulation, or any visualization approach) the enactment of knowledge, skills, and attitudes (KSA's) targeted for skill acquisition.”

Demonstrations vary in terms of informational and physical characteristics (e.g., content, form of presentation). Demonstrations also vary in terms of the activities that the learner engages in prior to, during and after observing the example of task performance (these activities will be discussed in the typology of demonstrations presented below). Therefore, we distinguish between an example, which is the observational component of the demonstration, and the demonstration, which is the entirety of the example and the additional activities and information provided that are intended to maximize the acquisition and transfer of targeted KSA's by viewing the example. In the following section we review the theoretical literature pertinent to designing effective demonstrations.

2.1 The Theoretical Basis for Demonstration-based Training

The power of learning through observation has been one of the fundamental means of acquiring knowledge and skills in both systematic and informal training. This section briefly reviews two of the research traditions in basic and applied behavioral science that form the cornerstones of our understanding of demonstration-based training: observational learning and behavior modeling training.

2.1.1 Observational Learning

Bandura (1986) describes four observational learning processes:

1. attention (whereby people must actively process what they are observing in order to learn),
2. retention (wherein what is observed must be stored symbolically in order to affect future behavior),

3. production (whereby the stored symbolic knowledge must be reconverted into overt actions), and
4. motivation (whereby the perceived consequences of performing the observed behavior must be favorable enough to strengthen the likelihood of future performance).

This theory has received much empirical attention with the majority of research conducted under the general observational learning heading tending to involve lower level motor tasks. Hence, the generalizability of the empirical findings from these studies to types of complex tasks trained by organizations is suspect. Still, Bandura's observational learning theory remains the most widely researched and applied.

2.1.2 Behavioral Modeling Training

Behavioral modeling training (BMT) is one of the most extensively used training methods available to modern organizations (Taylor, Russ-Eft, & Chan, 2005). BMT is based on Bandura's social learning theory (Hogan, Hakel, & Decker, 1986). Utilizing the model provided by social learning theory, BMT includes processes such as modeling, a retention process, behavioral rehearsal, feedback, and methods of training transfer to encourage the greatest transfer of training possible (Kraut, 1976; Doo, 2005). Specifically, during BMT

1. trainees are given a list of well-defined skills and facts to be learned during training,
2. during training models and visual aids are used to illustrate effective behaviors and skills,
3. trainees are provided ample opportunities to practice newly learned skills,
4. trainees are provided feedback and social reinforcement by trainers and other trainees, and
5. trainers and the organization utilize many methods to promote transfer of training (Decker & Nathan, 1985).

Using all these methods, behavioral modeling training has proven to be an effective training tool in developing skills, resulting in high transfer of training. Additionally, BMT has been tested and found effective in a number of scenarios including training technical and interpersonal skills.

2.2 A Typology of Demonstrations

Drawing from the theoretical and empirical literatures from the two research traditions described above, Rosen, Salas, and Upshaw (2007) have created a typology of demonstrations shown in Figure 1. It represents classes of features that can be included within a demonstration. Any one demonstration may (and likely will) have features from more than one category. This framework organizes the space of possibilities and provides a common language for discussing demonstrations.

We distinguish between two types of knowledge: procedural and strategic. **Procedural knowledge** is "how-to" knowledge; it involves knowledge about the sequences of actions involved in task performance (Willingham, Nissen, & Bullemer, 1989). It is a rehearsed and static sequence of behaviors performed to reach a task goal, such as performing a "stack" as part of a forced entry sequence. **Strategic knowledge** is "how-to-know-when-to-do-what" knowledge (Konto-giannis & Shepherd, 1999) and is generally associated with problem solving. Strategic knowledge involves learning aspects of the task that are not specific to one context, such as deciding when to initiate communication during an operation. .

There are two high level categories concerning the types of activities and information provided in the demonstration. First, **passive** demonstrations do not require any activity on the part of the learner outside of the act of observing. These are by far the most frequently encountered demonstrations in day to day life and training programs. Passive demonstrations rely entirely on the content of the example and sometimes guiding information to focus the attention of the learner, but do not incorporate any directions that require action (behavioral or cognitive) on the part of the learner. **Active** demonstrations impose demands on the learners outside of passively observing an example of task performance. They require the

learner to engage in activities designed to increase the retention of knowledge and transfer of skill. The six categories of passive and active demonstrations are summarized in Table 1.

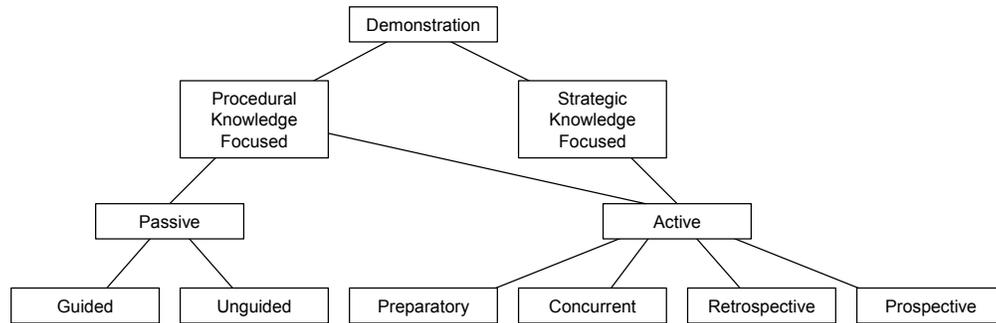


Figure 1. Typology of Demonstrations for Simulation-based Training (from Rosen, Salas, & Upshaw, 2007)

Table 1. Description of demonstration types (adapted from Rosen, Salas, & Upshaw, 2007)

Demonstration Type	Description	Example Features	Citations
Passive-unguided	Learners given no requirements or information outside of that present in the example of task performance or task environment characteristics	N/A	(Austin & Laurence, 1992; Berry, 1991; Blandin & Proteau, 2000; Palmiter & Elkerton, 1993)
Passive-guided	Learners are given pre-demonstration information intended to increase learning	Attentional advice, provision of learning points	(Decker & Nathan, 1985; Jentsch et al., 2001)
Active-preparatory	Learners engage in activities (designed to orient and focus the learner) before viewing the example for the observation experience to come before viewing the example	instruction on self-regulatory skills for observation, goal setting, and perceived self-efficacy	(Cumming, Clark, Ste-Marie, McCullagh, & Hall, 2005; Hard, Lozano, & Tversky, 2006)
Active-concurrent	Learners engage in activities during observation of example	note taking, perspective taking	(Lozano, Hard, & Tversky, 2006)
Active-retrospective	Learners engage in activities after viewing the demonstration designed to focus attention on salient aspects of performance	symbolic mental rehearsal, learner-generated learning points	(Davis & Yi, 2004; Hogan, Hakel, & Decker, 1986)
Active-prospective	Learners engage in activities after observing the example that focus the learner on how it can be applied to other contexts	goal setting exercises, the generation of practice scenarios by the learners	(Latham & Saari, 1979; Taylor et al., 2005)

	Information	Demonstration				Practice	Feedback	Remediation
		Pre-Demonstration Information	Pre-Demonstration Practice	During Demonstration	Post-Demonstration Information			
Passive-unguided	X					X	X	X
Passive-guided	X	X				X	X	X
Active-preparatory	X		X			X	X	X
Active-concurrent	X			X		X	X	X
Active-retrospective	X				X	X	X	X
Active-prospective	X				X	X	X	X

Figure 2. Typology of Demonstrations within the Elements of Training

Figure 2 shows our demonstration typology mapped to the training process. The cells with an “X” indicate where the type of demonstration will take place within the broader training context. Other than guided vs. unguided, the types are not mutually exclusive, and so a demonstration can be both active-preparatory and active-retrospective for example.

3 PLATFORMS AND TECHNOLOGIES

A major thread of inquiry was a review of platforms and technologies. For the purposes of leveraging technologies for demonstration, there are numerous choices available today. This portion of the investigation sought to characterize the space of choices, but our intention was not to perform a comprehensive survey as we sought to identify a subset of technologies for commercial purposes. This section outlines the broad types of gaming technologies and links them to demonstration guidelines that seek to maximize demonstration effectiveness.

Fu, Jensen, & Hinkelman (2007) characterize platforms according to two dimensions: *depiction* and *plurality*. The most popular type of game depiction is 3-D, which makes the visualization as realistic as possible. The other type is 2-D which is not as realistic. The second dimension is the number of participants: single player, multiplayer, or massively multiplayer online (MMO). Using these two dimensions, we now outline the most popular combinations.

3.1.1 2-D, Single Player Games

Two dimensional displays depict a point of view either from overhead or from the side. 2-D depictions could be most useful for “big picture” understanding, such as training coordination among teammates. 2-D game engines, compared to others, offer the lowest amount of fidelity. Their use for demonstration-based training is limited.

3.1.2 3-D Single Player Games

A 3-D single player game displays the virtual environment by rendering it from parameters and descriptions of 3-D objects. It assumes the player is the only person operating in the environment, and that anything else independently moving is controlled by artificial means. The engine may support many “cameras” or viewpoints within the environment, such as first person, tethered, overhead, or a user-controllable point of view. It may support display of several cameras simultaneously on one screen. There are three major genres: first-person shooter (FPS), real-time strategy (RTS), and role-playing game (RPG). Briefly, FPS depicts a first-person point of view. Emphasis is on real-time shooting ability. RTS depicts scenes from an overhead, angled perspective. The player will control several units from above. RPG is similar to RTS, but there is no real-time component.

3.1.3 3-D Multiplayer Games

A multiplayer game engine increases the number of human players involved. One might think of multiplayer as the same as single player except that the control for avatars is supplanted by real human control.

3.1.4 3-D Massively Multiplayer

Massively multiplayer online games (MMO’s or MMOG’s) are similar to 3-D multiplayer except on a bigger scale. They feature a huge virtual world, potentially as big as the earth, where one may explore and

meet other avatars and objects. Unlike the multiplayer games whose participants assemble temporarily and then disperse when the game round concludes, MMOG's retain history in the virtual world: the world changes and so do the avatars in it.

3.2 Guidelines for Developing Effective Demonstrations

There is no consensus of what makes a good demonstration or how to best incorporate demonstrations into the broader training system. Although demonstration has been relatively neglected by researchers within training, learning through observation has received large amounts of attention in other research communities. However, much of the existing related research concerns tasks that are more abstract and simple (e.g., generic laboratory tasks) rather than the types of tasks organizations like the Army generally choose to train. Given these limitations, a set of seven preliminary and empirically based guidelines are summarized in Table 2 which are a subset of guidelines listed in (Rosen, Salas, & Upshaw, 2007).

Table 2. Platform Evaluation with Guidelines

Guideline	2-D	3-D		
		Single player	Multiplayer	MMO
1. The KSA's targeted for demonstration-based training must be perceivable by the learner.	Operational	Tactical, Operational	Tactical, Operational	Tactical, Operational
2. Direct the learner's attention to the cues relevant to learning.	Operational	Tactical, Operational	Tactical, Operational	Tactical, Operational
3. Use instructional narratives to make covert aspects of performance accessible to learners.	Operational	Tactical, Operational	Tactical, Operational	Tactical, Operational
4. Utilize mixed models, as opposed to positive-only models, to display both positive and negative behaviors and outcomes.	No	Tactical, Operational	Tactical, Operational	Tactical, Operational
5. Show the consequences of behaviors.	No	Tactical	Tactical	Tactical
6. Instruct learners to create their own scenarios in which to rehearse behaviors.	No	No	No	Tactical
7. Instruct learners to symbolically or mentally rehearse behaviors and skills before rehearsing them.	No	Tactical	Tactical	Tactical

As remarked earlier, 2-D views are most likely to be used in team training situations to improve situation awareness. Oftentimes it is helpful for teammates to understand the “why” and “where” of coordination. These were labeled as “operational” in the Table. 3-D views, especially FPS, are naturally suited for tactical understanding. These were labeled “tactical” in the Table. For the most part, all 3-D platform types offer identical functionality. What separates them from 2-D is the necessary presence of a physics engine that provides for realistic movement. What separates an MMO from a multiplayer are persistence and scalability:

- **Persistence:** MMO avatars can modify the world permanently whereas with multiplayer the level restarts every so often. MMO's might also restart scenarios as well, but one key distinguishing factor is that avatars driven by students can participate in the construction of their scenario. Indeed, in an MMO such as Second Life one may create artifacts from scratch to be sold, all within the confines of the game. This is an enabling factor for Guideline #6.
- **Scalability:** MMO's can host thousands of participants whereas multiplayer games usually involve thirty-two or fewer players. For training purposes, the ability to host larger-scale

exercises such as combined arms or crowd control may be desirable. Based on our platform investigation, we used the MMOG OLIVE as a basis for in-depth investigation. Although it addresses most demonstration needs, its MMOG architecture was not deemed critical because constructing a demonstration or exercising practice-based training methods demands repeatable experiences. Still, MMOG architectures afford advantages and efficiencies for potential distributed use cases and also scalability to scenarios populated by the avatars for large numbers of role-players or spectators.

4 EXAMPLE USE CASES

Our goal in constructing a set of example use cases was to establish training needs in terms of existing curricula, and highlight a cross-section of knowledge types and training contexts for which virtual demonstration using a MMOG can be purposed. Our use cases consist of the following:

- **Augment existing training materials.** Supplement the Interactive Electronic Technical Manuals (IETMs) provided with basic courses.
- **Widely disseminate demonstrations of new enemy tactics.** This explores the rapid tempo of modern asymmetric warfare, where new countermeasures must be continually adopted to face a dynamic enemy.
- **Augment interactive training.** Broadening the range of demonstration construction approaches, there is a synergy resulting from using a common virtual environment both for immersive scenario based training and also for demonstration authoring and presentation.

The following examples do not address the development of other materials in a training package or instructional strategy in which the demonstrations are used. Although the consideration of the instructional context in this sense is an important driver for the design of demonstration authoring capabilities, the creation of other materials is treated as an implicit authoring step for which other tools and practices are used.

4.1 Augment Existing Training Materials

Example domain:	Stryker vehicle safety
Instructional context:	Accompanying IETMs provided with the basic Stryker driver training course
Demonstration type:	Standalone video, fully annotated and developed in detail by Army SMEs
Delivery mechanism:	Any media player, with content provided in compressed video file format or on digital media (eg, DVD)

Basic Stryker driver training is a two-week course, conducted as much as possible hands on with actual vehicles (Army TC 7-21, 2006). It presently introduces an Interactive Electronic Technical Manual (IETM) for vehicle maintenance checks. While materials such as IETMs are useful references, they often do not make for compelling learning experiences. It is well-documented in training literature that the most effective methods are those that engage the training audience and provide them opportunities to practice skills. Scenario-based training (Salas, Priest, Wilson & Burke, 2006) embeds opportunities for practice and evaluation of desired performance within a rich context that mimics a realistic task setting. This allows trainees to develop the skills necessary for making complex decisions. However, given the vast space of military training domains, there simply are not the resources to provide scenario-based training for many subject areas and task areas. Within this space, virtual demonstrations can be a low-cost means to augment the most basic training materials such as manuals, and provide a more compelling learning experience.

For this example use case, the objective is to construct a training demonstration (or set of demonstrations) for Stryker safety procedures, focusing on the coordination of the vehicle with multiple team members and other aspects of the environment. The training objectives are primarily oriented toward procedural knowledge (as defined earlier). The demonstration could be made available in conjunction with other training materials such as IETMs, to specifically illustrate correct procedures and potentially negative examples as well, that is, to show what can go wrong if procedures are not followed. Training domains involving safety are likely to be compelling applications for negative demonstration examples, as they show the consequences of behaviors, which has been identified as helping retention (Jentsch et al., 2001).



Figure 3: Example OLIVE view from inside a vehicle, demonstrating driver visibility to dismount

4.2 Widely Disseminate Knowledge about New Enemy Tactics

Example domain:	Combating IEDs in convoy operations
Instructional context:	Army directive learning channels, such as the Center for Army Lessons Learned
Demonstration type:	Standalone video, developed by Army SMEs based on reports direct from the theater
Delivery mechanism:	Any media player, with content provided in compressed video file format or on digital media (eg, DVD)

Modern asymmetric warfare conditions are increasingly characterized by an action and reaction cycle where the enemy is continually adapting tactics in response to measures employed by US forces. As new enemy tactics are encountered in theater, and as new countermeasures are developed in response, this cycle often functions at a far faster speed than the traditional process of updating doctrinal TTPs and distributing them accordingly. Although an individual demonstration in isolation may not achieve a comprehensive goal with respect to strategic knowledge, demonstrations in this example collectively contribute to strategic knowledge in dealing with asymmetric threats. For this example, we examine the domain of combating IEDs. Consider an insurgent convoy ambush tactic involving a sequence as shown in Figure 4.

The function of the demonstration in this case would be not only to show a top-down 2-D view that affords full situational awareness of the tactics carried out against the convoy, but also to show perspectives from individual vehicles where their knowledge of battlefield conditions is limited to first-hand observation and communication with other vehicles.

The authoring process could involve two scenario executions – the first to demonstrate the enemy tactic carried out successfully, and the second to demonstrate a response that is effective against this tactic. For example, in the positive variant, a combination of advance assignments and communication can create 360 degree awareness, rendering the RPG attack unsuccessful.

The scenario is designed on geo-typical terrain based on descriptions from deployed Soldiers in theater. With a distributed server-based architecture for the virtual environment in which the scenario is executed, it is possible to involve deployed Soldiers in the execution of the scenario, either with active role-playing participation, or in an oversight role to verify that the tactics and events unfold as intended. The human role-players make a valuable contribution to the effectiveness of the demonstration by not only controlling actions and movements, but also for the communications during the scenario, which play a key role in the situational awareness element of the IED scenario. After conducting the two executions with human role-players, the post-production stage can be carried out by a single author, who directs all switching between different viewpoints during playback and adds any markup or annotation. While the rapid creation and distribution of demonstrations may tend to reduce the amount of instructional framework included in the videos, the authors' choice of camera angles, zooms etc may serve to fulfill the requirement of making sure viewers' attention is directed in a manner that serves the author's instructional goals. Figure 5 shows example angles. The resulting content is then exported to portable digital video formats and distributed.

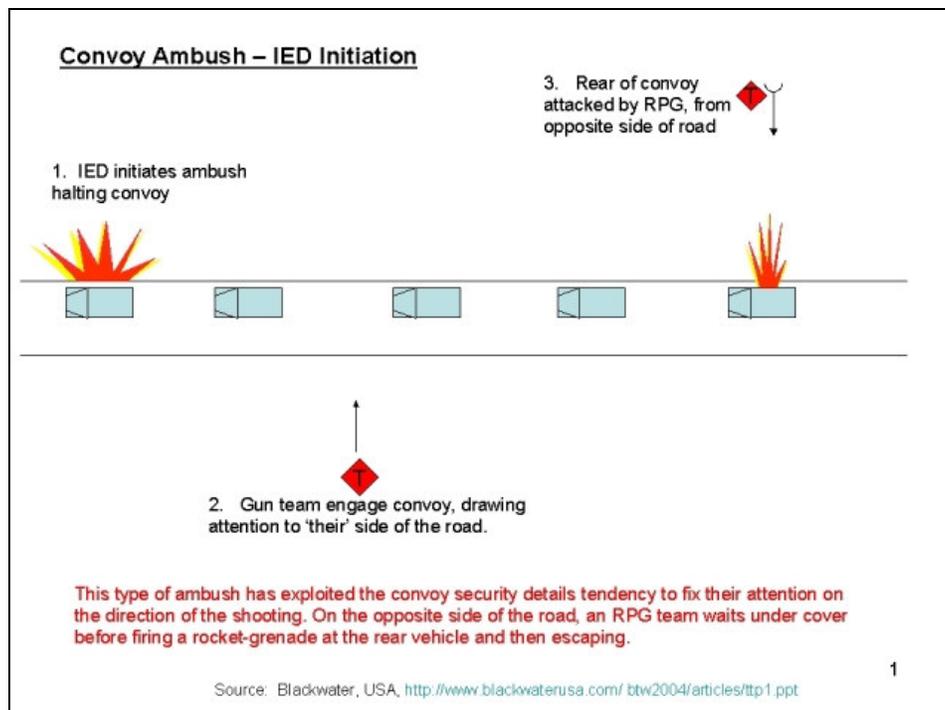


Figure 4: IED tactic against convoy



Figure 5: Alternate simultaneous 3-D views of an IED tactic against convoy

4.3 Augment Interactive Training

Example domain:	Cordon and search, in an asymmetric urban warfare setting with cultural implications
Instructional context:	CONUS home base classroom leadership training
Demonstration type:	Server driven playback with interactive POV control
Delivery mechanism:	Virtual environment client stations viewing slaved playback

The example domain in this use case is a direct extension from a technology demonstration created at Army RDECOM for an Asymmetric Warfare ATO in 2005 for a search and cordon scenario in urban terrain typical of Iraq. Several role-players assumed the virtual avatars for the local characters, with Soldiers conducting the search and cordon mission in the virtual environment. The objective was to show how the virtual environment can be used to provide units with practice as part of a training program in preparation for deployment.

The mission execution sequence in the scenario involves a sequence of scenes, starting with a civil unrest situation outside an overwatch residence in the cordon area, continuing to the entry of a residence, and a hostage situation in the interior. The sequence ends with a virtual AAR – essentially a review conducted between avatars still in the virtual environment.

The RDECOM scenario presents a compelling training use case, showing not only how the virtual environment can give effective practice, but also how the architecture easily supports participation in a virtual co-located exercise from participants in distributed locations. There are several ways that virtual demonstration authoring capabilities could be integrated into an instructional strategy following the lead of RDECOM’s use case. The line distinguishing AAR tools from demonstration authoring tools fades or disappears entirely when the target audience has synchronous access to playback clients, as in a classroom setting or even a distributed classroom. An instructor can conceivably drive a dynamic playback experience which also affords some individualized interactivity for the training audience, with little additional effort beyond “pushing the play button” on an already authored playback sequence.



Figure 6: Search and Cordon Scenario

Whether used for demonstration authoring or for interactive training, a key component of the virtual environment in this example domain is the ability to present situations requiring both team coordination and communications with local characters, which includes the portrayal of cultural gestures and clothing. For this case, there may be several simultaneous dialogs carried out between avatars during playback, for which the demonstration author may make use of tools specifically aimed at sorting out communications and playing back those that are most relevant to a given portion of the playback at any time.

5 CONCLUSION

This paper summarizes three threads of related investigation: the nature of demonstration, suitable technologies, and potential use cases. We provided a working definition of demonstration and offered a typology of demonstrations with according guidelines. These results informed our review of available technologies. Platforms were then evaluated using our typology, guidelines, and performance criteria. Finally, we summarized a few example use cases that illustrate the potential of MMOG gaming technologies in particular.

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