The Joint Training Experimentation Program: Hotwash from the Second Demonstration

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ABSTRACT: *The Joint Training Experimentation Program (JTEP) is a multiphase, multiyear effort to develop a distributed training capability for the California National Guard that includes live, virtual, and constructive training simulations. JTEP uses existing and readily available systems to address the unique training needs of the Guard, i.e., limited training time and units distributed around the state. The initial phase of JTEP is to develop a battalion-level training capability for ground forces training. Subsequent phases will expand on this capability to provide training for brigade-level exercises, joint and interstate exercises, and training for the Guard's Military Support for Civilian Authority (MSCA) mission.*

On 11 December 2003 JTEP conducted its second demonstration, a live-virtual-constructive system linkage. This demo linked the Deployable Force-on-Force Instrumented Range System (DFIRST^{TM}) and the Integrated GPS Radio System (IGRS), both live instrumented training systems, at Camp Roberts, California, with the Close Combat Tactical Trainer (CCTT), a virtual training system, and the Joint Combat and Tactical Simulation (JCATS), a constructive simulation. Both CCTT and JCATS were located at Camp San Luis Obispo, California, about 50 miles away. In addition, the demonstration included the use of a mixed virtual/constructive Hunter unmanned aerial vehicle (UAV) to provide real-time intelligence of the battlefield. The integration included direct and indirect fire engagements between constructive and live entities and constructive and virtual entities. Furthermore the CCTT-JCATS integration enabled correct task organization so that one of the three companies included a blend of CCTT and JCATS entities. The linkage of the three systems was enabled by the creation of a common correlated terrain database on which all federates could operate. This area, the result of stitching pieces of Camp Roberts terrain and CCTT Grafenfels terrain, was called Grafenbob and became the location for the battlefield playbox.

This paper provides an overview of the demonstration and lessons learned. Subsequent papers will discuss selected topics of simulation interoperability in more detail.

1. Introduction

1.1 JTEP overview

The Joint Training Experimentation Program (JTEP) is a National Guard Bureau program managed by the California National Guard (CNG). The Guard currently uses advanced live, virtual, and constructive (LVC) systems[1] to support training, but each system is stand-alone. JTEP was conceived to bring to the Guard the benefits of integrating existing or readily available training environments, and to enable LVC interaction over non-dedicated wide-area networks (WANs).

JTEP is an experimentation program that will leverage the integration successes of other programs whenever possible, but will also advance the state of the art in system and simulation interoperability as needed to meet Guard training needs. JTEP started with an initial study to determine which candidate systems and integration mechanisms will achieve the greatest training impact. After the initial study, the first demonstration, linking live and constructive training systems, was conducted in May 2003 [Ref. 1]. The second demonstration, conducted in December 2003, built on the successes of the first and the results of the initial systems analysis study.

This second demonstration provided a battalion-level training capability for the California National Guard by linking existing live, virtual, and constructive training systems. In particular, JTEP linked two live training systems, the Deployable Force-on-Force Instrumented Range System (DFIRST), which provides instrumentation and engagement simulation for ground vehicles, and the Integrated Global Positioning System (GPS) Radio System (IGRS), which provides tracking for dismounts and interface to the Multiple Integrated Laser Engagement System (MILES) 2000 for engagement simulation. Live entities were able to engage other live entities and constructive Joint Combat and Tactical Simulation (JCATS) entities. Additionally, the demonstration included the Close Combat Tactical Trainer (CCTT) virtual simulation, which was capable of engaging JCATS entities, and the virtual-constructive Unmanned Aerial Vehicle (UAV), which had a common view of the battlespace and all LVC entities. The systems were integrated according to DIS protocols, and the participants at each simulation type (L, V, and C) communicated via DIS radios.

[1] A live simulation comprises real people, real vehicles, a real environment, and simulated weapons. A virtual simulation comprises real people, simulated vehicles, a simulated environment, and simulated weapons. A constructive simulation comprises some real people, some simulated people, simulated vehicles, a simulated environment, and simulated weapons.

In accordance with JTEP program goals, each demonstration is designed not only to determine the LVC systems that provide useful training but also to establish an integrated LVC training capability that can serve as the basis of a leave-behind capability suitable for routine usage in training. This configuration, therefore, provided the basis for a battalion-level LVC training capability.

1.2 JTEP schedule

JTEP is currently in the second year of a multiyear program. The first year covered the initial system analysis, the first demonstration, and the development of technology to support battalion-level training. This second year addresses Military Support for Civilian Authority (MSCA), the completion of the battalion-level LVC demonstration, and the development of technical capabilities for additional sites and brigade-level training. The third and subsequent years will expand on both the MSCA and combat training functions, adding Air Guard units for true joint training and additional states to expand the geographic scope of the program. In these phases, the program also will leverage the technology developed for both Combat JTEP and MSCA JTEP to develop a training capability called Urban JTEP, i.e., training for the Guard's expanding operations in urban areas supporting both domestic missions and overseas deployments in both combat and peacekeeping missions.

1.3 Scope and organization of this paper

This paper provides a top-level overview of the second JTEP demonstration conducted on 11 December 2003. It summarizes what was accomplished and provides some key technical findings. Four additional abstracts have been accepted for the next Simulation Interoperability Workshop (SIW) for papers that will provide additional technical detail on specific areas that are beyond the scope of this paper and warrant more analysis than can reasonably be addressed at this early date. These abstracts address the following four topics: (1) the training value provided from this demonstration ("A Funny Thing Happened on the Way to LVC Integration: Great Training," submitted as 04E-SIW-065 [Ref. 2]), (2) the creation of stitched terrain combining portions of Camp Roberts and Grafenfels ("The Creation of Grafenbob for the JTEP LVC Demo," submitted as 04E-SIW-069 [Ref. 3]), (3) the integration of the Close Combat Tactical Trainer (CCTT) and the Joint Conflict and Tactical Simulation (JCATS) ("Integration of CCTT and JCATS in an LVC Exercise," submitted as 04E-SIW-066 [Ref. 4]), and (4) the development of a distributed After-Action Review (DAAR) capability for distributed training exercises ("The Development of a Distributed After-Action Review (DAAR) for the JTEP LVC Demonstration," submitted as 04E-SIW-063 [Ref. 5]). This paper, then, serves as a common introduction to these four proposed papers as well as an overview of the entire exercise.

The paper is divided into the following major sections. Section 2 describes the demonstration, including the scenario, the federates involved, and the system architecture. Section 3 addresses the top-level lessons learned from the demo in the following areas: (1) hybrid and correlated terrain, (2) CCTT/JCATS integration, (3) JCATS/DFIRST/IGRS integration, (4) the Virtual-Constructive UAV, (5) Distributed Interactive Simulation (DIS) radios, (6) the use of the California Army National Guard (CA-ARNG) Network, (7) the DAAR, and (8) the training value provided. Section 4 provides an overview of next steps for the JTEP program, and Section 5 provides a summary and conclusions.

2. The JTEP LVC Demonstration

2.1 System analysis

As reported in Ref. [1], JTEP commenced in September 2002 with a trade-off study of candidate systems and LVC integration mechanisms. Because of the Guard's training and acquisition requirements, preference was given to systems currently used or readily available for use by the CNG to train armored forces, but other systems were examined for suitability and affordability. The study was completed in January 2003. The selected systems are as follows:

- Constructive: Joint Conflict and Tactical Simulation (JCATS). The CNG used Janus-T, but the lack of an interoperability interface mandated the selection of an alternative.
- Virtual: Close Combat Tactical Trainer (CCTT). The CNG has a platoon-size mobile suite.
- Live: Deployable Force-on-Force Instrumented Training System (DFIRST). The CNG has a company-size system. For this demonstration the Integrated GPS Radio System and MILES 2000 were added for dismounts. Both of these systems are currently owned by the CNG.
- Interoperability: Distributed Interactive Simulation (DIS). Although the High-Level Architecture (HLA) was preferred for technical, performance, and future growth reasons, DIS was selected because it is already fully supported by all of the selected LVC systems, and is being used by the Digital Battlestaff Sustainment Trainer (DBST) for a related JCATS-CCTT integration task.
- Network: GuardNet/CA-ARNG[2] network. Initial studies suggested that sufficient bandwidth was available to support the first two JTEP demonstrations; however, the results of this demonstration suggested that the network as configured for this exercise may not support the planned expansion of JTEP to brigade-level exercises without some effort in data compression and/or filtering or the development of a dedicated link.

2.2 Scenario

The scenario used for the JTEP LVC demonstration is a movement-to-contact mission for a mechanized infantry task force against a counter-reconnaissance element. The primary participating unit was the 3rd Battalion, 160th Infantry (Mech). The original scenario called for two infantry company teams and one armor company team advancing along two axes to OBJ WASHINGTON. One infantry company team instrumented by DFIRST and IGRS advanced along AXIS BLAZERS in Camp Roberts, California toward OBJ STUART to support by fire (SBF) the main effort; the second infantry company team and the armor company team, advanced along AXIS NETS in Grafenfels on OBJ WASHINGTON.

As addressed in more detail below in Section 3.8, after the first day of demo rehearsals the training audience quickly realized the ability of the LVC integration to enhance the overall training value of the exercise and asked to revise the scenario to take advantage of the integration. Figure 1 is a notional depiction of the eventual scenario developed. In this scenario, the movement-to-contact mission remained intact, but the virtual and constructive forces were mixed, or task organized, in order to match tactical doctrine more closely. The mission of the live forces remained as originally planned, i.e., advance along AXIS BLAZERS to OBJ STUART then SBF the advance on OBJ WASHINGTON. An armor-heavy team (three CCTT-modeled M1s [Co. CDR plus two platoon leaders] with CCTT SAF tethered M1s as the platoon elements and one platoon of JCATS-modeled M2s) advances along the principal AXIS NETS toward OBJ WASHINGTON. Along AXIS KINGS, an infantry company team (one CCTT-modeled M1 [platoon leader] with CCTT SAF tethered M1s as the platoon elements and two platoons of JCATS-modeled M2s) advances on OBJ LEE to SBF the main advance on OBJ WASHINGTON.

[2] The CA-ARNG Network is the augmented California node of the National Guard's GuardNet. The original JTEP charter, to use GuardNet, is fulfilled for California applications by the use of CA-ARNG. As JTEP expands to other states, we will use GuardNet specifically, along with CA-ARNG for sites within California.

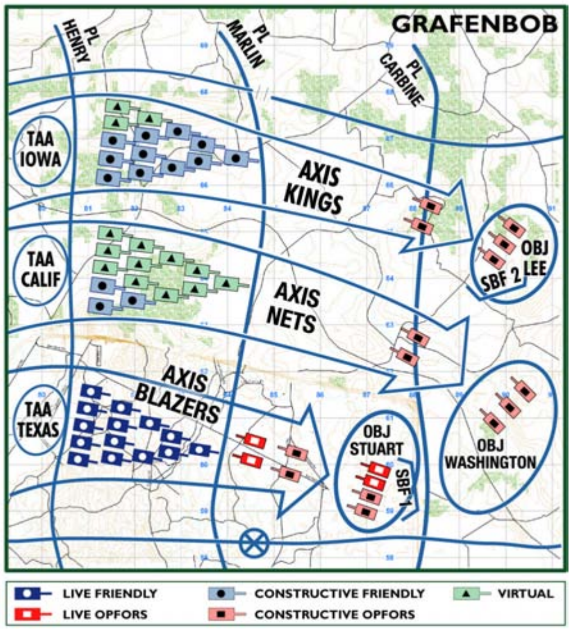

Figure 1. JTEP LVC Demonstration Scenario

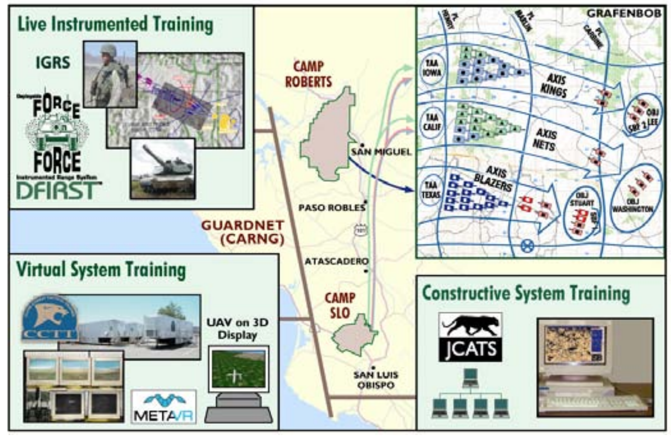

Figure 2. JTEP LVC Demonstration Components Mapped to Scenario Entities

As shown in Figure 1, the opposing force (OPFOR) for the live company was a mix of live instrumented entities and constructive JCATS entities. As was done in the previous JTEP LC demo [Ref. 1], JCATS entities were mimicked by pop-up tank gunnery targets to provide a visual stimulation to the live crews. The OPFOR for the virtual and constructive forces advancing along AXES NETS and KINGS were all constructive JCATS entities.
The resulting scenario provided a more realistic force structure to enhance the level of training provided by the LVC integration. Additionally, as a result of the successful tight integration of CCTT and JCATS entities, including cross-attached units and direct-fire engagements, the modified scenario provided a greater technical demonstration of the capabilities and value of LVC integration.

2.3 Demonstration architecture

The distribution of components between the Camp San Luis Obispo and Camp Roberts sites is shown in Figure 2. The Tactical Operations Center (TOC), constructive JCATS elements, virtual CCTT elements, and virtual UAV were at Camp San Luis Obispo. Live instrumented DFIRST and IGRS elements and pop-up targets (mimicking JCATS constructive entities) were at Camp Roberts.

The Camp San Luis Obispo components and network are shown in Figure 3. The Camp Roberts components and network are shown in Figure 4. The DAAR architecture is shown in Figure 5. The major components are:

- JCATS, CCTT, DFIRST, and IGRS broadcast and received DIS entity state, weapons fire, and detonation PDUs.

- Voice communications were broadcast between systems as DIS signal PDUs. In the TOC and at the JCATS stations, standard tactical handsets were connected to DIS radio interface boxes. CCTT had organic DIS radio equipment. In DFIRST, tactical Single-Channel Ground and Airborne Radio System (SINCGARS) radios were connected to the DIS radio interface boxes.

- The DFIRST and IGRS player instrumentation tracked participants in their true Camp Roberts coordinates. Player positions were translated to Grafenbob coordinates in the DFIRST Base Station.

- The 2-D SRI Display and 3-D MetaVR Virtual Reality Scene Generator (VRSG) received DIS entity state, weapons fire, and detonation PDUs, and displayed entities and engagement effects on 2-D and 3-D representations of the Grafenbob terrain.

- One MetaVR VRSG display was adapted for use as a virtual UAV. JCATS simulated the UAV flight path and the VRSG operator controlled the UAV's camera viewpoint.

- DFIRST software mediated indirect and direct fire engagements between DFIRST and JCATS. Since pop-up targets were modeled as JCATS entities, target up and down commands were associated with data sent from JCATS to DFIRST, i.e., a target

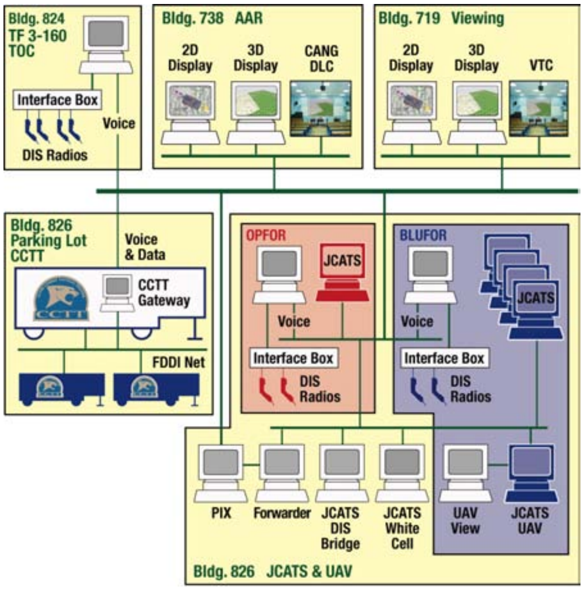

Figure 3. Camp San Luis Obispo Architecture

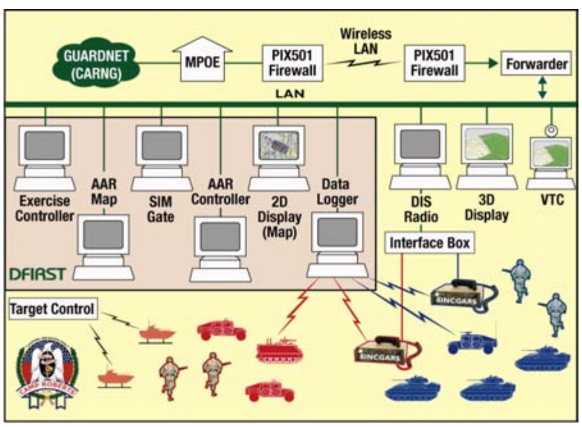

Figure 4. Camp Roberts Architecture

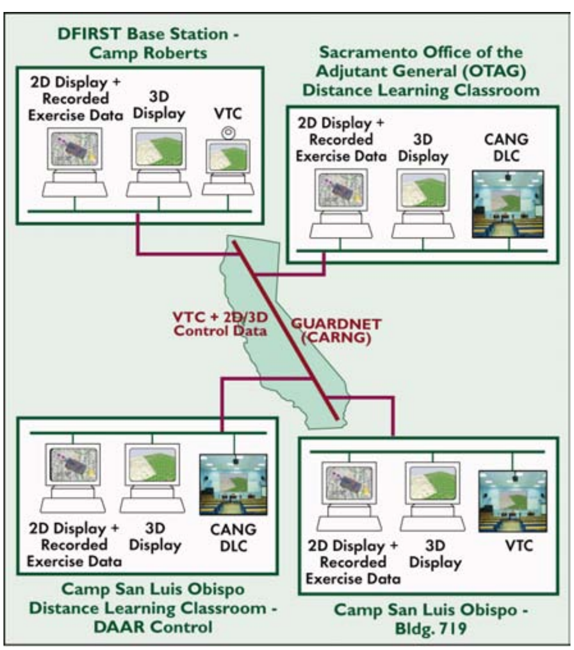

Figure 5. Distributed AAR Architecture

emerging from defilade was raised, and a killed target was dropped. Commands were issued to personnel controlling the target via voice radio.

- In the CCTT mobile stations, JCATS computer generated forces were used along with native CCTT semiautomated forces (SAF)
- The computers at Camp San Luis Obispo, Camp Roberts, and OTAG were connected by a virtual local-area network (LAN) over the CA-ARNG WAN. DataRouter software managed communications between sites.
- Because an Ethernet connection to the CA-ARNG network was not available at the DFIRST Base Station, a wireless LAN was used to send and receive JTEP network traffic. A PIX501 Firewall was used to secure the CA-ARNG network against possible access intrusion from a wireless LAN eavesdropper.
- The master DAAR site in Camp San Luis Obispo and the remote site at OTAG were both nodes on the dedicated CNG DLC network. The networking center in Sacramento temporarily bridged the JTEP DLC nodes to the JTEP nodes on the CA-ARNG WAN to allow the non-DLC nodes to participate in the DAAR.

3. Key Accomplishments and Lessons Learned

3.1 Correlated terrain

For the JTEP federates to fully interoperate, it is not sufficient that they fight in the same world location. They must fight on the same terrain. If federates do not have strong agreement on the shape and features of the earth, direct fire interaction is not possible. The degree of terrain correlation is how closely the versions of the common playbox's synthetic natural environment match. JTEP's experience with correlation will be examined in detail in a future paper [Ref. 3].

To get the degree of correlation required, one federate's terrain must be treated as the canonical version and the terrains used by the other federates must be created directly from that [Ref. 7]. It is not sufficient to simply use the same source data or model the same physical place on earth. For the December exercise, CCTT's P6 (Grafenfels) database was chosen as the baseline terrain, due to the difficulty of creating new CCTT terrain. The live federates, however, also use a terrain that is difficult to create: the physical world sampled by GPS in real time. Thus, we had to use two terrains that could not be easily changed. The GPS tracks could, however, be translated.

This idea gave us our solution: a hybrid terrain of P6 with a bit of California stitched onto a corner.

This solution allowed CCTT to be immutable, and the GPS tracks to be moved but not deformed. Translating California was computationally easy to do in real time, but deforming it would have been difficult to do in real time and injurious to the quality of simulation for the live federate users. The final canonical terrain was an area 13 km x 13 km with California in the SW corner and P6 in the remaining space. The area was located in Germany, as it was easier to not shift P6.

The terrain products that were created from the hybrid terrain were a JCATS terrain, a set of paper maps, a 2-D terrain for use with DFIRST and IGRS, an Openflight version of the terrain for export and distribution, a terrain in mdx format for the UAV, and an mdx terrain with unit graphics overlaid for the stealth viewer.

The process of creating these products was complex. Ref. [3] will discuss the terrain lab toolkit and testbed, the challenges of the development, and the lessons learned.

The successful CCTT-JCATS and DFIRST-JCATS direct fire engagements that occurred in the December exercise were made possible by the strong terrain correlation. The different terrains were transparent to the end users. From their point of view, there was one battlefield.

A principal accomplishment of the terrain creation process was keeping the heavily technical exercise centered on the warfighter's needs. The transparency of the terrain was the first step. The Camp Roberts terrain was lifted and the stitching redone in order to enable a commander to maneuver JCATS forces between Camp Roberts and P6.

Another accomplishment was the ability of the terrain creation process to accommodate dynamic battle plans. As part of this process, unit graphics were overlaid on the 3-D view, i.e., the mdx version of the terrain contained unit graphics. As the scenario was modified to accommodate user requirements, these graphics needed to be revised, effectively requiring a modification to one of the terrain products. Specifically, the unit graphics used in the exercise were changed twice in the two days leading up to the main event. For each scenario and graphics revision, the terrain process was sufficiently robust to permit battalion commanders to make revisions as they normally would have done by using paper maps with acetate overlays. Each revision to the acetate was able to be reflected within hours as revised unit graphics in the 3-D view.

Closely related to the development of terrain is the 3-D visualization of the terrain. In this area, we used inexpensive PC-based hardware instead of expensive "big iron" solutions. This approach leverages the rapidly advancing commercial gaming technology, e.g., video cards, to support advances in visualization.

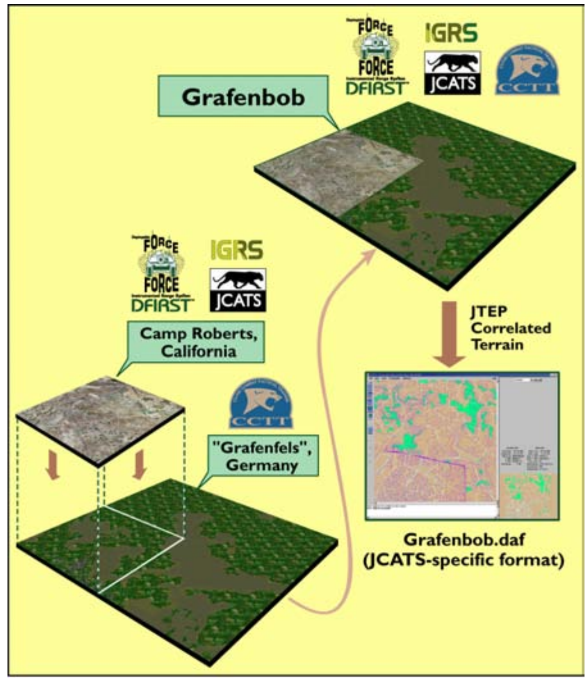

Figure 6. Creation of Grafenbob

3.2 CCTT/JCATS integration

JCATS and CCTT entities successfully exchanged direct fire, and entities from each system were able to inflict damage on entities from the other system. The CCTT entities were made up of computer-generated (CG) forces, as well as the manned virtual trainers and both types of CCTT entities exchanged direct fire with JCATS entities. The carefully correlated Grafenbob terrain made this successful interaction possible. The CCTT gateway software was utilized but the feature that enabled ground clamping of external (JCATS) entities was intentionally unused. The gateway then served primarily as the electromechanical bridge between the CCTT Fiber Distributed Data Interface (FDDI) LAN and the JCATS Ethernet LAN.

Prior to the availability of the correlated Grafenbob terrain, we conducted JCATS vs. CCTT Semiautomated Forces (SAF) testing in our laboratory (i.e., the JTEP Testbed). These tests qualitatively showed that one system typically had a distinct advantage over the other, due to terrain mismatches. Since our correlated terrain was in the works, in-depth quantitative analysis of these mismatches was not warranted. Anecdotally, it appeared that entities from one system were perceived as floating or flying in the other system and were therefore easy targets. Conversely, from the other system's point of view, entities external to that system were underground and difficult or impossible to acquire. It is important to note that neither JCATS nor CCTT had any permanent, built-in advantage over the other, since it was the nature of the terrain mismatches that dictated the characteristics of the system interactions. Again, when using our correlated terrain, we no longer observed these discrepancies.

Indirect fire was also utilized in this demonstration event. JCATS friendly forces, or BLUFOR, artillery, and mortar workstations were operated by CNG soldiers and fire missions were requested by CCTT commanders.

JCATS and CCTT entities were cross-attached for increased training realism.[3] This was actually requested by the troops being trained, and the JTEP team was able to accommodate this request in the field. Computer-generated vehicles were subordinate to platoon leaders manning CCTT virtual trainers. These CG vehicles were modeled in JCATS and controlled by the JCATS Maneuver commander. CCTT platoon leaders reported a high degree of satisfaction with this approach compared with the simple tethering of CG forces without human intervention (i.e., no "man-in-the-loop").

The version of JCATS used in this demonstration was 4.1 and the CCTT version was 10.0.

3.3 JCATS/DFIRST/IGRS integration

The live-constructive interactions between JCATS and DFIRST/IGRS were largely similar to those observed in the previous demonstration during May 2003 [Ref. 1]. The primary enhancements were the increase from platoon-sized to company-sized vehicle assets and the introduction of dismounts instrumented with IGRS units and MILES vests. Both direct and indirect fire engagements were once again demonstrated. Direct fire was achieved using pop-up targets to present JCATS OPFOR targets to the live BLUFOR crews. Indirect fire was called for by the live BLUFOR crews and detected by OPFOR crews as virtual detonations made audible in the DFIRST crew compartments.

IGRS dismounts were tracked and visible to both live JCATS entities. Because laser-based engagements require a physical target with a sensor for successful engagement, the dismount direct fire engagements were limited to MILES interactions. The integration of IGRS into the demonstration enabled indirect fire interactions and provided for dismount position and engagements to be included in the overall After-Action Review (AAR).

We were initially concerned about the JCATS/DFIRST terrain correlation since the JCATS Camp Roberts model was elevated (to better match the Grafenfels elevation) as well as translated in latitude and longitude to Germany. Even with the JCATS terrain located on a different "computational continent" from the physical Camp Roberts, this demonstration event was not qualitatively degraded in any way. Nevertheless, we do plan a quantitative evaluation of the effects that this combined translation and elevation change may have had on the live-constructive interactions.

3.4 Virtual-constructive UAV

The UAV's role on the battlefield is rapidly increasing. With a rapid change in tactical technology, training is essential. For the National Guard, the chances of getting a UAV to use for a weekend of maneuver training are slim. JTEP had an opportunity to provide the TOC with annotated EO and IR imagery from a simulated UAV. A live UAV would only see the California engagements, but the synthetic UAV was able to see the entire battlefield with all the participants. Additionally, the simulated UAV could be engaged by antiaircraft weapons in JCATS.

The UAV was a combination of virtual and constructive systems. The body and flight path were controlled by JCATS and the sensor was simulated by MetaVR's VRSG. Physically, two people were responsible for the UAV information. A sensor operator who had a joystick for slewing and zooming the turret-mounted camera, and an analyst who culled, annotated, and delivered the imagery to the TOC. Both people sat at their own workstations. Both of these workstations were COTS PCs with standard graphics cards. The final piece of physical equipment was a laser printer for outputting the images.

In practice, the UAV proved to be very popular with the soldiers. The scenario guided the choice of aircraft, a Hunter. Also, doctrine informed the way information flowed. It was determined that the TOC would not be able to directly task the UAV and that analysis would be performed outside of the TOC. Additionally, the time lag that would occur in the delivery of the information was enforced by the analyst.

In the future much can be done to improve the training value of the Virtual-Constructive UAV. More realistic information flow, better sensor operator training, and a more authentic method of delivering the intelligence would improve the product. Finally, working with actual analysts of UAV information would greatly help the JTEP team to create maximum fidelity for the UAV analyst's station.

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[3] For each company team, an M1 platoon consisted of one manned module and three CCTT SAF-generated M1s. A mechanized infantry platoon consisted of JCATS-generated M2s. The virtual or SAF and constructive platoons were cross-attached to work as a company team.

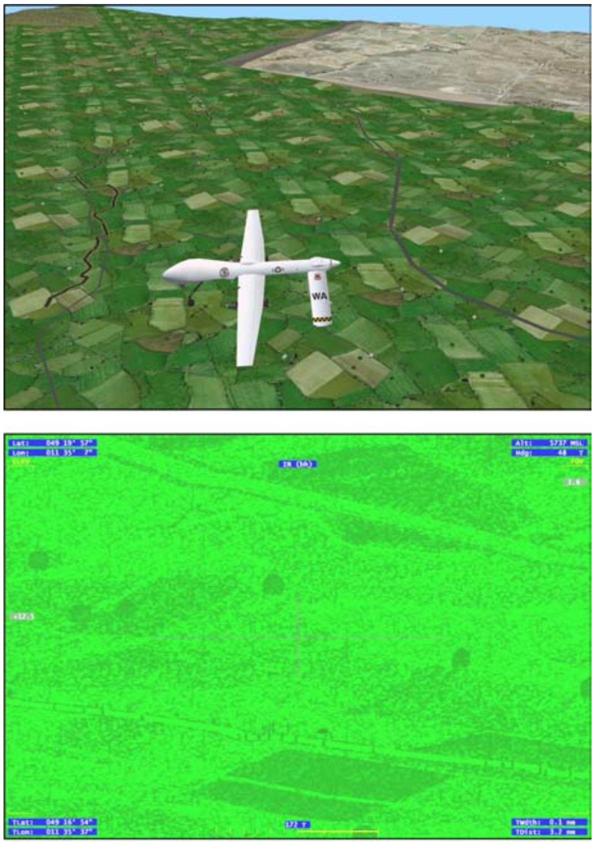

Figure 7. Virtual-Constructive UAV

3.5 DIS radios

Tactical voice from simulated radios at the headquarters element at Camp San Luis Obispo and to/from the simulated SINGCARS tactical radios in each CCTT trainer was connected to real vehicle commanders in the field using DIS radio technology. The DIS networked transmissions were decoded at the DFIRST base station at Camp Roberts, and the transmit and receive audio and radio control interfaced to four real SINGCARS radios that communicated with the vehicles maneuvering at Camp Roberts. Commercial off-the-shelf (COTS) software and government off-the-shelf (GOTS) radios were used with SRI-developed hardware and software interfaces as in the May demonstration.

For the December demonstration, seven radio nets were required (four live or simulated and three where all member radios were simulated). SRI provided 24 simulated radio sets in addition to the four real radios and the four simulated radios integral to CCTT. The simulated radios used an improved version of the hardware designed for the first demonstration, and SRI-developed DIS radio software based on a commercially available application development kit.

Simulated radio terminals provided communications for the TOC, company commanders at JCATS workstations, the CCTT trainers (using their own organic DIS radios) and units in the field (via interfaces to real SINCGARS sets provided by CNG.

The DIS standard allows several voice compression algorithm choices, including CVSD (Continuous Variable Slope Delta Modulation) at 25 kbps and muLaw at 64 kbps. This was the first time CCTT DIS radios were on the JTEP networks, and it was found that the CVSD audio encoding/compression option, apparently hard coded into the CCTT radios, was incompatible with the muLaw encoding that had been found best during the workup to the May JTEP demonstration. CCTT uses a version of CVSD that, while requiring less bandwidth (greater compression), appeared to have degraded clarity at the Camp Roberts end of the link, compared with the earlier experience. However, to enable them to interoperate, we shifted all radios to the CCTT encoding scheme.

Because of the degraded end-to-end fidelity compared with that observed in May, SRI is currently working to integrate a CCTT “bridge” into the network. This will allow the independent selection of voice encoding methods on the rest of the network when it is interconnecting with CCTT.

3.6 Use of the CA-ARNG network

We continued to use the CA-ARNG WAN for this second demonstration, this time setting up a virtual LAN over the CA-ARNG WAN, connecting Camp San Luis Obispo, Camp Roberts, and OTAG in Sacramento. While not strictly necessary for this event, this virtual LAN was extremely valuable for system testing, maintenance, and configuration, allowing key technical personnel at any site to remotely access any computer at any other site.

Weeks prior to the event we measured the available bandwidth between Camp San Luis Obispo and Camp Roberts and found it to be as high as 1000 kbps. During the demonstration event itself we measured our average bandwidth usage at about 500 kbps and a peak of 700 kbps. Bandwidth was dominated (~90%) by the traffic from the DIS radios.

Previous estimates and measurements indicated that 500–1000 kbps would be adequate to support the December demonstration; however, when we began the demonstration setup we learned that this shared network was heavily utilized by the intensive administrative processing associated with the upcoming troop mobilizations that were occurring at Camp Roberts. As a result, we noticed some degradation in performance, particularly in the voice nets. The activity associated with the upcoming mobilization had a higher priority than the

JTEP demo, so we had no way to secure additional bandwidth.

These bandwidth limitations did not adversely affect the outcome of the demonstration, but they did sensitize us to the potential limitations of using this shared network. Even without these mobilizations and increased demand, battalion-level training may be the limit for JTEP in this shared network configuration. Future JTEP efforts will examine data compression and/or filtering, especially of DIS radio traffic, since radio data accounted for 90% of our exercise bandwidth consumption.

3.7 Distributed AAR

The first JTEP demonstration in May 2003 introduced a JTEP AAR capability that included:

- Synchronized playback of recorded tracking and engagement data and tactical voice nets.
- A 2-D display that shows maneuvers and engagements against the background of a tactical map and maneuver planning graphics.
- A 3-D display showing the same data and graphics on Camp Roberts.

The second demonstration added a distributed After-Action Review (DAAR) that allowed commanders and observers at each JTEP site to view exercise playback on the JTEP high-resolution 2-D and 3-D map displays, and to view and interact with the DAAR presenters via a standard video teleconference (VTC). Each site had two screens. One screen showed the VTC, and the other switched between 2-D and 3-D displays.

The master site was located in the CNG Distance Learning Center at Camp San Luis Obispo. Three additional participating sites were located at Camp San Luis Obispo, Camp Roberts, and OTAG. Each site was a node for DLC-hosted VTC capabilities.

One option was for participants at remote sites to view 2-D and 3-D map displays via the VTC. However VTC resolution and update rate limitations would have resulted in an unacceptably degraded view. Instead, we opted to run synchronized local instances of the 2-D and 3-D displays at each site. Each of the four sites hosted a full complement of JTEP AAR software and hardware.

The primary technical challenge was to provide lossless remote viewing while staying within the limited bandwidth allocated to JTEP on the CA-ARNG network. The allocated bandwidth was adequate for distributing DIS data and voice PDUs to all sites during live operations. However, this bandwidth was not sufficient to carry this load plus a VTC and the greater number of PDUs generated by faster-than-real-time playback. The approach taken was to run local instances of the playback process at all sites, each playing local copies of the data. In order for all sites to have the same set of recorded data, the data were distributed to each site in compressed format during the 1½ hour interval between the end of the exercise and the start of the DAAR; but if the DAAR had been scheduled to follow the exercise immediately, it would have been possible to use the backup logs recorded at each site during the live exercise.

During the DAAR, only control information was sent over the network. The master playback controller sent start, stop, and time sync control PDUs to the local log playback processes. The master 2-D display controlled the slave 2-D displays by sending PDUs reporting map center, zoom factor, and other view control information. The master 3-D display controlled the slave 3-D displays by sending PDUs reporting the "camera eye" viewpoint. At each remote site, an operator switched the projected image between 2-D and 3-D displays as directed by verbal cues that were transmitted with the VTC.

Control PDUs consumed very little bandwidth, leaving most of it available for the VTC. The master-slave control approach succeeded in seamlessly synchronizing the operation of the distributed playback and display components during the DAAR.

The primary logistical challenge of the DAAR was to effectively stage a simultaneous VTC and combined 2-D and 3-D playback. However, insufficient rehearsal with the VTC appliances prevented a valid demonstration of this aspect of the technology. The next demonstration will concentrate on more effective integration of the VTC into the DAAR.

A forthcoming paper, to be delivered at the Summer 2004 SIW [Ref. 5], will discuss the DAAR technical approach in greater detail and will describe enhancements that are planned for the next JTEP demonstration.

3.8 Training value

Although JTEP is a program to develop an LVC training capability for the Guard, the JTEP LVC event was designed as a demonstration of a technological capability. Soldiers participated in the exercise as though it were a training event, but the battalion leadership was briefed that, for this iteration, the focus was on demonstrating the potential of the LVC technology for providing useful training, not specifically providing training during the exercise. The result, however, was much more positive. After the first day of demonstration rehearsals, the participants recognized the value of the architecture for providing real training. They also effectively "took over" the conduct of the exercise as though JTEP were an operational training system instead of a technology demonstration. As a result, the battalion requested a change in the original scenario to task organize, or cross-attach JCATS and CCTT entities and divide the virtual and constructive forces into two separate axes of advance. This change was requested because the configuration is more realistic tactically and, would, therefore, provide better training for the soldiers. The scenario was modified as requested (as indicated in Figure 1), and the next two scheduled rehearsal days were spent in training.

This revised configuration and focus enabled JTEP to examine aspects of the exercise that were not previously envisioned. First, cross-attaching CCTT and JCATS entities provided a much more robust test of the integration of the two systems (as addressed above in Section 3.2). Second, the focus on training enabled an examination of the actual value that LVC provides to the training audience.

The support battalion was divided between soldiers in the field at Camp Roberts, those operating JCATS at Camp San Luis Obispo, and those staffing the Battalion TOC, also at Camp San Luis Obispo. Additional participants were operating the CCTT manned virtual M1 trainers. The participants were linked with communications provided by the DIS radio network discussed above.

Initial observations were strongly positive. The participants completely embraced the realism provided by the exercise environment. The promise of LVC integration appeared to be realized.

- An LVC architecture was able to conduct a realistic battalion-level training exercise with fewer than 100 soldiers.

- LVC enabled true multiechelon training.

- The JTEP architecture provided the ability to conduct this type of training over geographically separated locations.

Specific observations received by the participants reflected the training accomplishments of the demonstration.

- Armor soldiers in the CCTT were delighted to be able to operate as part of a task force rather than only as a tank platoon, as is usually the case with the CCTT suite used by the California National Guard. (Part of the benefit came from having real human controllers on JCATS operating the computer-generated forces.)

- The battalion commander, though skeptical at first, found that the LVC architecture was able to offer a range of realistic training experiences that had not been expected. He also saw the potential for the use of this training architecture while units are deployed, as his was soon to be.

- Many participants reported the best training they had ever received in the Guard.

In short, the JTEP LVC demonstration was a confirmation of the value of LVC integration for training. LVC integration works, and it provides a training capability that participants felt was second to none.

4. Next Steps for JTEP

JTEP has two major areas of focus in the next year: (1) Combat JTEP, supports combined arms training exercises and (2) MSCA JTEP supports training for the Guard's mission supporting civilian authority in natural disasters and homeland defense. The next Combat JTEP demonstration, currently planned for fall 2004, will expand the training focus to encompass a brigade-level exercise. The principal expansion will be the addition of LVC component federates and expansion of the communications networks. New participants may include Air Guard and Marine Reserve units to make the exercise truly joint. The next demonstration is likely to include participants in other states, which will require at least one long-haul link to connect them. If live instrumented participants are distributed across two locations, additional terrain will need to be stitched into Grafenbob. MSCA JTEP conducted its first demonstration of the Simulation-based Multi-agency Response Training (SMART) concept in January 2004. This exercise was designed to introduce simulation-based training (via JCATS) to the civil response community. As a result of this exercise, JTEP is planning to conduct a demonstration of some of the program technologies developed to date, including the capability to integrate disparate systems, the integration of live and constructive entities into agencies' geographic information systems (GIS), and the use of micro-geo-specific synthetic terrain (i.e., photo-realistic 3-D buildings) with 3-D displays. This demonstration is planned for summer 2004.

The eventual goal of the program is to combine Combat JTEP and MSCA JTEP technologies in "Urban JTEP." Urban JTEP will support Guard LVC training for a variety of urban missions.

5. Summary and Conclusions

The second JTEP demonstration, an integrated LVC exercise, was conducted on 11 December 2003 at Camp Roberts, Camp San Luis Obispo, and OTAG in

Sacramento, California. This demonstration successfully integrated DFIRST/IGRS live instrumented systems with CCTT virtual trainers, the JCATS constructive system, and a Virtual-Constructive UAV that provided a comprehensive view of the seamless LVC battlespace. As a result of this demonstration, the JTEP program has documented a number of accomplishments and lessons learned in the following areas: (1) stitched and correlated terrain, (2) CCTT/JCATS integration, (3) JCATS/ DFIRST/IGRS integration, (4) virtual-constructive UAV, (5) DIS radios, (6) use of the CA-ARNG network, (7) the DAAR, and (8) the training value provided. For some of these, we have proposed detailed discussions of individual topics in four future papers [Ref. 2–5]. This paper, then, serves as a common introduction to those four proposed papers as well as an overview of the exercise.

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Author Biographies

JOHN SHOCKLEY, Senior Research Engineer at SRI International, has 20 years of experience in test and training range instrumentation systems for the Army, Navy, and Air Force. He began working on modeling and simulation aspects of these systems and has since participated in DIS/HLA standards development activities for over 11 years, concentrating on integrating live and virtual systems. He is the JTEP project leader.

REGINALD FORD, Software Development Manager at SRI International, has 24 years of experience in test and training range instrumentation systems for the Army, Navy, Air Force, and Marine Corps. He helped establish SRI's Software Engineering and Development Program. He manages DFIRST software development and the integration of JTEP software systems and components.

MICHAEL BEEBE, Research Engineer at SRI International, has experience in systems engineering, remote sensing, GIS, and terrain database creation. In addition to being active in the development of DFIRST for the National Guard, he has worked with the Special Operations community. His primary JTEP responsibility is synthetic natural environments.

COL (Ret.) JOHN BERNATZ, JTEP Program Manager for the California National Guard, is a retired armor officer who has commanded armor and cavalry units through brigade level. He has over 33 years of experience as an Army trainer and training manager and was the Operations Officer for the 40th Infantry Division, Mechanized, during the Los Angeles riots of 1992 and the Northridge earthquake of 1994.

MARK JOHNSON, Senior Software Engineer at SRI International, has over 20 years of experience in engineering and simulation and is a member of SRI's Software Engineering and Development Program. On the JTEP project he concentrates on JCATS, CCTT and the interoperation of these systems.

GERALD V. LUCHA, Principal Engineer at SRI International, has worked for 29 years on a wide variety of SRI projects related to instrumented test and training ranges of the Army, Navy, and Air Force. His experience includes not only studies and analysis of range requirements, instrumentation concepts, and performance, but also on-site assessments of numerous land, air, and sea combat training ranges in the United States and abroad. He currently serves as the DFIRST Chief Engineer and was responsible for assuring network connectivity in the field for JTEP as well as the Camp Roberts end of the demonstration.