Computer Generated Forces for Joint Close Air Support and Live Virtual Constructive Training

Mr. Craig Eidman
Air Force Research Laboratory, Warfighter Readiness Research Division, Mesa, AZ
craig.eidman@mesa.afmc.af.mil

1Lt Clinton Kam
Air Force Research Laboratory, Warfighter Readiness Research Division, Mesa, AZ
clinton.kam@mesa.afmc.af.mil

ABSTRACT

Conducting robust, reoccurring Joint CAS training for Terminal Attack Controllers (JTACs) on live ranges is problematic. While stationary observation points and targets are useful for initial and basic call for fire training, live bombing ranges do not provide mobile, realistic targets for training in troops in contact, joint/coalition training, and operations in urban terrain. Distributed simulation and Live-Virtual-Constructive networks can provide JTACS with training to enhance their team, inter-team, and joint skills with greater frequency, at lower cost, and potentially more combat realism than live-range training exercises. One of the key advantages of distributed simulation training for JTACs working with attack aircraft, is that the activities can be focused on specific skills such preparing and communicating 9-line coordination briefings, procedurally “talking aircraft on to” targets, and coordinating for directives, priorities and deconfliction of fires. Fidelity requirements for computer generated forces (CGFs) have typically revolved around air-to-air fighter training or large scale wargaming. In 2004, the Air Force Research Laboratory initiated a Joint Terminal Attack Control Training and Rehearsal System research and development project. The goal of this effort was enhancing JTAC readiness by designing, developing and evaluating an immersive, DMO compatible training system using fully integrated JTAC equipment. After initial system evaluations by JTAC subject matter experts, it was apparent that the CGF scripting, intelligent behavior, systems models, and weapons would need major modifications to support effective JCAS training. To overcome these difficulties researchers developed a rapidly customizable CGF environment and instructor operator station. This paper discusses some of the unique modifications made to CGFs to support JTAC training and overall lessons learned from modeling and simulation of the JTAC environment to include behavior scripting, artillery models, realistic air-to-ground weapons delivery simulation, modeling the air-to-ground C2 environment, instructor tools, and scenario management.

ABOUT THE AUTHORS

Mr. Craig Eidman is an Electrical Engineer with the Air Force Research Laboratory, Warfighter Readiness Research Division, Mesa Research Site. He is the Lead Engineer for all laboratory synthetic environments, Electronic Warfare Training, and advanced targeting pod S&T efforts. Mr. Eidman attended the United States Air Force Academy where he earned a Bachelor of Science in Electrical Engineering in 1983. He served in the Air Force as a Command Pilot flying F-16, A-10, and OA-37 aircraft in multiple theaters and as an Evaluator Forward Air Controller. Additionally, he has a Masters of Aeronautical Science, Embry-Riddle Aeronautical University, With Distinction and is an Outstanding Graduate of the Air War College.

1Lt Clinton Kam is currently assigned to the Warfighter Readiness Research Division in Mesa, Arizona working as the Threat Systems Engineer for the Immersive Environments Branch. Lt Kam holds a B.S. in Aerospace Engineering from the University of Texas. He has worked on several projects spanning the modeling and simulation and training spectrum including simulation performance testing and optimization, HLA networking, and high fidelity piloted and unpiloted threat models.

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1Lt Clinton Kam
Air Force Research Laboratory, Warfighter Readiness Research Division, Mesa, AZ
clinton.kam@meas.afmc.af.mil

JCAS TRAINING REQUIREMENTS

Conducting robust, reoccurring Joint Close Air Support (JCAS) training for Joint Terminal Attack Controllers (JTACs) on live ranges is challenging. While fixed observation points and stationary targets are useful for initial and basic call for fire training, live bombing ranges do not provide mobile, realistic targets for training in troops in contact, joint/coalition integration, airspace deconfliction, operations in urban terrain and advanced tactics development.

JTAC Live Range Training Shortfalls

For a JTAC, the live fire training range environment is often a limited representation of actual combat operations. A typical airstrike control training event on a live range may have a small JTAC team operating independently at a pre-surveyed observation position, coordinating with a single 2-ship of attack aircraft engaging various mock-up targets with either training munitions (if allowed) or more likely "dry passes" where weapons deliveries are notional. Range target arrays are typically maximized for aircrew training and not JCAS training (often airfield complexes). If live ordnance is used, it is only on specific targets, often miles away from the JTAC location. Any realistic coordination with ground forces, artillery fires, and moving targets does not occur. Troops in contact can only be done in a "notional" sense – real ordnance or even training ordnance cannot be expended in the vicinity of the ground parties for safety reasons.

Compare this with a JTAC in a fully joint exercise or actual combat. Enemy targets are mobile, hidden, and exposed for only a limited amount of time. The JTAC is coordinating through three to four different radio networks simultaneously to control fighters, manage airspace, coordinate with ground units and deconflict fires. The observation point for an airstrike may not be optimal, in fact the JTAC may not even have "eyes on target". Intentional and unintentional obscurants or weather may hamper vision. In a worst case scenario, troops will be engaged in actual fire fights at close distances.

Scheduling and range availability are also limiting factors. In the majority of cases, JTACS are assigned with US Army units and may not be close to impact areas or ranges used by live aircraft. On many of these Army ranges the target arrays are designed for ground operations and not air operations. JTACS must travel to Air Force ranges requiring coordinated scheduling and the transport of tactical equipment to practice live call for fire training. Operational pace for both the JTAC units and the supporting attack aircraft units make this coordination challenging.

The costs in fuel, travel and equipment wear and tear are a burden to many operational units. Quite often live fire range training entails only the use of portable battery powered radios due to the limited availability and cost of vehicle mounted radio pallets. Other critical systems necessary in combat may also be unavailable. For example, JTACS in Opertion Iraqi Freedom and Operation Enduring Freedom regularly employ systems like the Remote-Operations Video-Enhanced Receiver (ROVER) to conduct airstrikes. This system receives streaming data from airborne sensor platforms like Unmanned Aerial vehicles (UAVs) or fighter and bomber aircraft targeting pods. (Erwin, 2008) The supporting sensor platforms are often unavailable for training activities. (USAF, 2007)

Finally, the Air Force centric range is often a poor representation of the joint or coalition combat environment. In a true joint environment a JTAC is managing airspace, deconflicting indirect fires, managing joint suppression of enemy air defenses, coordinating with the ground forces chain of command and fire centers and coordinating with the air support operations center (ASOC), all while controlling the actual airstrike. None of these complex tasks are available on most Air Force bombing ranges unless other Tactical Air Control Party (TACP) members role play these agencies.

These training shortfalls are well understood by senior policy officials. According to a 2002 United States General Accounting Office report on issues relating to training and equipment issues hampering air support to ground units:

"We found that adequate realistic training is often not available because of (1) Ground and air forces have limited opportunities to train together in a joint environment. When such joint training does occur, according to DOD reports and unit officials, it is often ineffective. (2) Similarly, the training that troops receive at their home stations is usually unrealistic because of range restrictions; moreover, it lacks variety—for example, pilots often receive rote, repetitive training because of limited air space and other restrictions." (United States Government Accounting Office, 2003)

Simulation for JTAC Training

Distributed simulation and Live-Virtual-Constructive networks can provide JTACS with training to enhance their team, inter-team and joint skills with greater frequency, at lower cost and potentially more combat realism than live-range training exercises. One of the key advantages of distributed simulation training for JTACs working with attack aircraft is that the activities can be focused on specific skills such as preparing and communicating 9-line coordination briefings, procedurally "talking aircraft on to" targets, coordinating for directives, priorities and deconfliction of fires. The 2007 Joint Close Air Support Action Plan recognizes that simulation now offers realistic and affordable training options to compensate for these gaps:

"Although simulation will never replace all live JCAS training, current technology allows credible substitution for specific events in initial, continuation and collective training for air and ground personnel and units. Stand-alone virtual simulators may enhance training opportunities and potentially mitigate the shortfall in selected JTAC training events for initial qualification and continuation training. Current Service, USJFCOM and USSOCOM efforts already contain many foundation elements for virtual collective training. Constructive simulations that network staff and liaison elements to practice battle management and fire support integration are also feasible." (JCAS Action Plan, 2007)

Simulation also enables advanced training and tactics development and validation. The success of Distributed Mission Operations for air-to-air training is an example of this success. During current ground conflicts, new systems, missions and weapons platforms have been integrated into the JCAS environment utilizing un-practiced employment tactics. For example, in the past JCAS was limited to a subset of fighter and special operations aircraft. Today, bomber aircrews and UAVs regularly conduct precision airstrikes against targets in support of ground forces. Often the JTAC is coordinating these airstrikes from locations where he cannot observe the actual targets, yet the targets are close to friendly ground troops. Simulation allows a safe, effective methodology to develop procedures for complex tactics and troops in contact scenarios.

JCAS TRAINING RESEARCH PROGRAM

In 2004, the Air Force Research Laboratory initiated a Joint Terminal Attack Control Training and Rehearsal System (JTAC TRS) research and development project. The goal of this effort was enhancing JTAC readiness by designing, developing and evaluating an immersive, DMO compatible training system using fully integrated JTAC sensor, target designation and communications equipment operating in real time.

Part-Task JCAS Training Solutions

Acting upon an initial request from JTAC training units, AFRL worked with industry to develop a demonstration JCAS training system using a generic pilot station integrated with a single screen visualization capability for target viewing. The resulting system, the Indirect Fire-Forward-Air Control Trainer (I-FACT) was deployed at the Air Ground Operation School (AGOS) at Nellis AFB for evaluation. This successful training system has since been deployed at a variety of JTAC and Special Operations units. (Kauchak, 2008) It has proven extremely useful in basic training of JTACS to prepare and present 9-line briefings for pilots and conduct basic airstrike control interactions.

AFRL found that while these part task training solutions provide valuable training, this training was limited in scope due the fidelity of supporting models and interfaces. I-FACT was a training solution focused solely on the JTAC and his control of CAS and artillery assets and gave operators the capability of being on a simulated battlefield with appropriate ground threats and air assets. AFRL's initial system had no scripting capability for robust Computer Generated Forces (CGFs). Aircraft on CAS attacks could be created and fly only after a mission was executed. They had no orbit or ingress points, only a final attack heading for the target. The student would call in an attack heading and look for the aircraft to "Clear Hot" but at the end of the mission the aircraft would fly out to the horizon then disappear from the simulation. Similarly, artillery models did not use physics based calculations to determine max altitudes and time of flights of their rounds. The instructor selected the location of the detonation and immediately upon execution the rounds impacted. The man in the loop flight simulation station, which played a single aircraft, did not represent the complexities of controlling multiple fighters in a single flight and multiple flights of aircraft simultaneously. The navigation and target acquisition problems faced by a real pilot in the JCAS environment were not replicated and consequently the methods and "target talk on" a JTAC would use with real aircraft were not realistic. The system operated only at an unclassified level making integration with high fidelity classified flight simulators difficult.

Fully Immersive JTAC Training Systems

To study the benefits of a more immersive training environment for JTACS, Air Force Research Laboratory (AFRL) developed a science and technology proof-of-concept Training and Rehearsal System (TRS) to provide high-fidelity, fully immersive, realistic training with real-time sensor, simulator and database correlation along with a robust instructor operator station (IOS) and scenario generation capability. This system was designed to support performance assessment of JTAC personnel as well as study technology requirements for future immersive JCAS training systems. The design would allow stand alone training driven by the IOS aided by constructive simulations as well as distributed training with other high fidelity simulators using established Distributed Interactive Simulation (DIS) protocols.

Figure 1. Fixed 360x180 FOV Dome

A visualization of an immersive ground combat environment has significantly different requirements than that of a typical flight simulator. AFRL constructed a fixed 360x180 field of view visual dome at its facility in Mesa, Arizona to initiate research studies into immersive JTAC training. The system was developed using state-of-the-art image generators (IGs), high resolution color photo-specific databases (some sampled at as low as 40 cm) and proven system hardware. The IGs and network interfaces were identical to fielded A-10 simulators allowing shared correlated databases, 3-dimensional models, special effects and Instructor Operator control. This allowed near perfect interaction and correlation with operational A-10 units, a natural networked training audience for training research activities.

The dome's visual system was accompanied by a set of sensor devices and emulators to further immerse the student into the scenario. These devices include a simulated M-22 Binoculars, GLID II Laser Target Designator and Mk VII Laser Range Finder. In addition to the simulated devices, software was developed to give students the ability to use their actual AN/PSN -11 or 13 GPS receivers and AN/PRC-117 or PRC-148 radios.

Figure 2. Sensor Devices

The first unit deployed JTAC TRS dome was installed at the Air to Ground Operations School (AGOS) at Nellis AFB in January, 2008. Substantial feedback has been received from the schoolhouse since that time and AFRL continues its work on the JTAC program to improve the training capabilities for the students.

Computer Generated Forces

To manage the training scenarios and provide constructive models and computer generated forces, AFRL turned to their in-house CGF development platform, XCITE, to fill the role. XCITE is AFRL's prototype CGF software based on the Next Generation

Threat System (NGTS). XCITE's government owned source code can be rapidly modified to meet the requirements of various research projects. After initial system evaluations by JTAC subject matter experts, it was apparent that the CGF scripting, intelligent behavior, systems models and weapons would need major modifications to support effective JCAS training. To overcome these difficulties researchers developed a rapidly customizable CGF environment and instructor operator station.

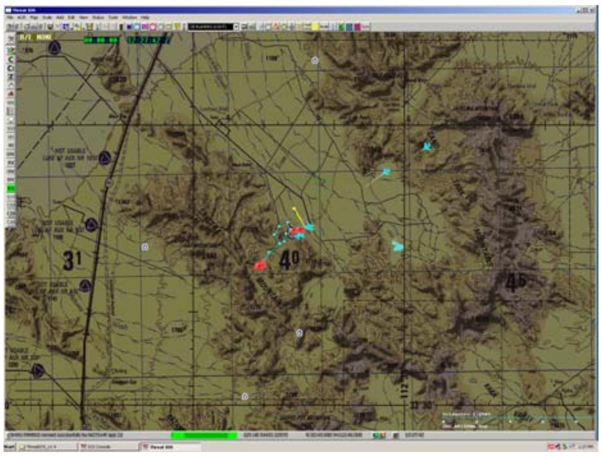

Figure 3. XCITE Instructor Operator Station

CGF SHORTFALLS AND IMPROVEMENTS

Fidelity requirements for CGFs have typically revolved around air-to-air fighter training or large scale wargaming. Initial NGTS research and design revolved around methods to conduct high fidelity, physics-based electronic warfare and air-to-air training in fighter simulators. To support this research, NGTS was designed to utilize physics-based maneuvering and aero models and high fidelity threat avionics models running at real time. Although an excellent air-to-air trainer for pilots, it did not have the capabilities for a "ground perspective" for scenario management and control. Few ground entities were modeled – mostly Surface-to-Air (SAM) sites and their associated radars. Also, the autonomous air assets had no close air support relevant tactics. New JCAS specific aircraft maneuvers, ground entities and artillery control would need to be added.

Weapons, Aircraft, and Ground Forces Models

While many aircraft air-to-ground weapons models were available in XCITE, JCAS specific air-to-ground weapons were needed including friendly and threat indirect fire artillery, white phosphorus and colored smoke marking rounds, air-to-ground rockets, mortars, "Katyusha" type rockets and newly deployed air-to-ground weapons like the AGM-65E Maverick laser guided air-to-ground missile. Additionally, special effects for colored non-explosive smoke markers required development. AFRL worked with the standards development communities and established protocols for smoke marking rockets and warheads to support JCAS modeling and simulation.

Most available ground target types were Soviet Era centric. More Global War on Terror (GWOT) centric targets were required. Models and scripting were developed for pickup truck mounted machine guns, civilian vehicles, single-use rocket launchers, small mortars and enemy observers.

XCITE's aircraft database was modified to allow a greater number of air-to-ground weapons loadouts. For more realistic maneuvering, an energy based aero model was added. Low altitude flight profiles and logic were added for ridge crossings. Some friendly aircraft models still require further development like AC-130 gunships, attack/observation helicopters and UAVs.

Tactical Maneuvering and Scripting

An important aspect of a CGF is its ability to accurately portray how air and ground forces move and interact with each other. Although the existing XCITE software gave instructors the ability to vector aircraft and attack ground targets, some missions required additional scripting. Aircraft on CAS missions must be able to fly to ingress and egress points, pop-up and attack ground targets and maintain restricted final attack headings. It is unreasonable to expect an instructor to control all of these behaviors, so the XCITE software was modified to autonomously fly the aircraft given mission parameters. These 3-dimensional flight profiles were significantly more difficult to script than air-to-air profiles due to the complexities of terrain interactions and dynamic maneuvering in reference to target locations. Additionally, release altitudes and dive angles for specific attacks vary greatly depending upon aircraft, weapons, terrain and tactics. As a starting point, AFRL concentrated on perfecting three generic ground attack profiles. These included a low altitude 20 degree pop-up attack, a medium attitude 30 degree dive bomb attack and a high altitude level attack replicating a precision guided bomb. AFRL engineers spent significant efforts improving scripting for these activities. Wingman flight profiles for each attack profile were also developed, but still require improvements to appear tactically realistic.

Holding and Ingress

Management of forces and airspace control are critical JTAC training tasks. Holding and attack ingress tactics were also modified to allow CGF fighters to hold at specific Contact Points (CP) points, attack from specific Initial Points (IP), attack from a right or left roll-in and return to a CP or hold at a target area. These scripts are exceptionally complex and CGF airspace management is typically still done as an IOS control input for more advanced attacks.

Coalition Scripting and Unusual Fighter Tactics

After demonstrating this attack scripting to JTAC subject matter experts, it became apparent that coalition allies employed different tactics in close air support missions than those of US pilots. For example, in actual combat British Tornado aircraft occasionally employed extremely low-altitude level attacks due to weapons and avionics requirements. Fighter and bomber aircraft are occasionally flown over target areas at low altitude and high airspeeds as a psychological show of force.

Weather Effects

A key area not fulfilled in today's DMO training environment is inclement weather effects on weapons targeting. Hot vehicle surfaces, sun angle, terrain heating and cooling, clouds and background all effect target acquisition sensors and weapon engagement zones (WEZ) of sensor targeted air-to-ground munitions. AFRL used Target Acquisition Weapon Software (TAWS), a government owned mission planning software package, to build a database of engagement zone distances for an AGM-65D Maverick missile attacking a tank from an A-10. The database was tabulated for multiple headings, altitudes, times of day, humidity, background terrain and cloud state to create a weather "Hypercube". XCITE was modified to read and check against the newly created Hypercube to obtain a validated weapons lock-on and engagement range. Although a simple demonstration on its own, it was a powerful proof of concept of how to create real-time weather affects for JCAS munitions. Before a scenario is executed, a Hypercube database of all ground targets and missile seekers could be generated under the appropriate weather conditions to support high fidelity weather based weapon engagement zones. Alternatively, the TAWS program could be stripped to a modular weather service and act as a "TAWS on demand." CGF software would request an engagement zone for any seeker against any target at any time to allow dynamic scenario changes. Work continues at AFRL to more fully develop this concept.

Database Correlation of Weapons

Although image generators have the ability to ground clamp models, munitions and detonations did not correlate perfectly. Though the IGs and XCITE constructive forces were using the exact same terrain data, how data was processed resulted in significant elevation deviations. The IG ground clamping rendered targets properly, but an air to ground missile powered by the CGF tracked to the target below the ground. On the visual system the missile fell short of the tank and detonated dozens of feet below the target. The missile properly hit the target but visually appeared as a miss. The XCITE database was switched to natively utilize the MetaVR IG's Metadesic tile data for elevations. This technique resulted in perfect correlation between the IG and the CGF models.

IOS AND SCENARIO CONTROL

To be embraced by the operational community, the instructor software had to be designed so a minimally trained JTAC could control all air and ground assets. AFRL's goal was to provide an easy to operate Instructor Operator Station (IOS) that did not require technical support for day-to-day training activities.

AFRL took the approach of implementing the JTAC's actual radio templates and call-for-fire formats into the IOS. The instructor would only have to transcribe the student's verbal control commands into the template window, select "Execute" and the mission would commence as requested. Similarly, to clear an aircraft hot or abort a mission consisted of a single click on a "Cleared Hot" or "Abort" button. Without switching between windows or navigating through menus, an instructor could model the aircraft's mission.

This first attempt at a "9-Line" JCAS briefing template worked well in demonstration, but proved insufficient for operational training. Instructors requested the ability to see more status information of the aircraft and its mission on a single screen. They specifically wanted exact time to target calculations for the scripted fighters to prevent the need to estimate the pilot's time-to-target or use manual clocks. Additional hooks were added between the IOS and XCITE to handle these on demand time-to-target calculations. By selecting the "Apply" button, the mission time would display for the instructor without commanding the aircraft. Instructors would then be able to relay to their students the first available

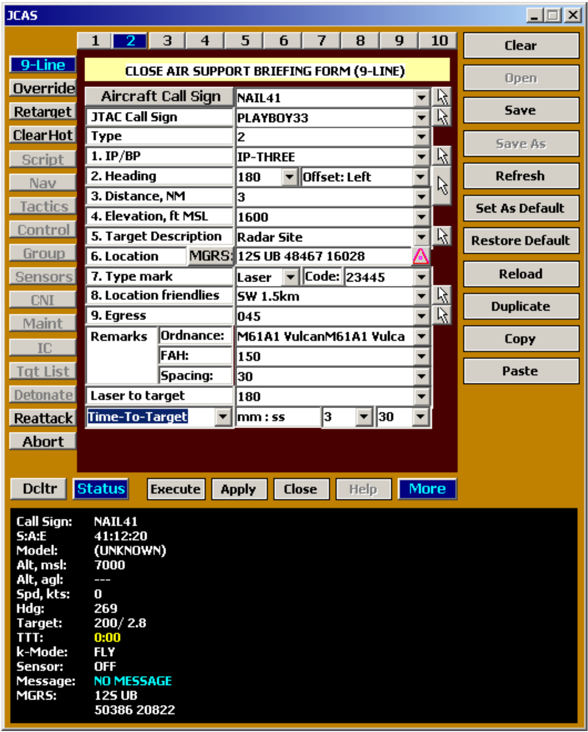

Figure 4. Revised JCAS 9-Line on IOS

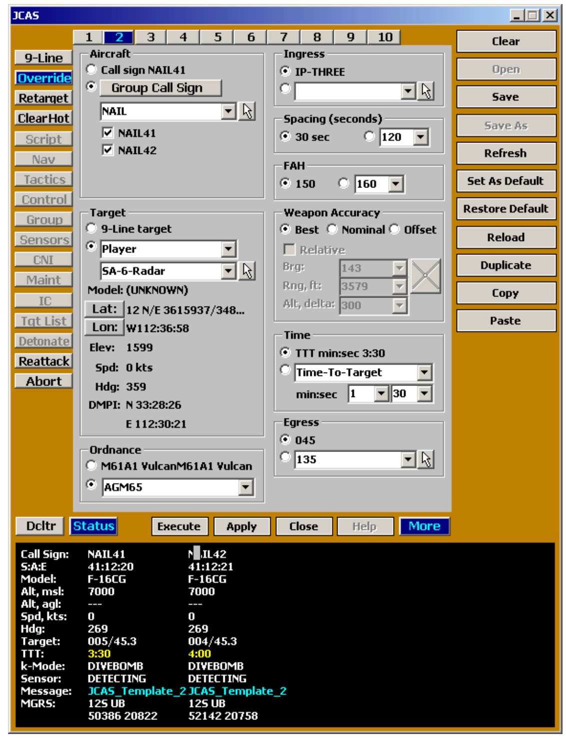

Figure 5. CAS Override on IOS

time of attack for an aircraft. Selecting "Execute" would execute the mission and display a countdown timer as the aircraft vectored towards the target. The instructor at any time could then relay to the student over the radio the pilot's time-to-target.

During training exercises, instructors required the ability to easily change information a student had radioed without losing the student's original 9-line briefing data. A new "Override" tab was created that repeated data from the student's 9-line briefing and allowed the instructor to modify the data on the fly or to emphasize a desired learning outcome. A student could give a coordinate location of a moving target and the instructor could enter that information onto the 9-line screen. Then, as the student "talks on" the pilot, the instructor can override the called in location and select a specific entity target. The original coordinates stay recorded so during debrief the instructor can review the talk on procedure.

The override tab brings about an additional level of training for more experienced JTACs. Instructors can command the aircraft to make mistakes or react. The instructor can send the aircraft to an incorrect target, a wrong final attack heading or a different time-to-target and still save the student's original instructions. It is then up to the student to recognize the errors, compensate and abort the mission, if needed.

Laser Designation

Operationally, pilots and JTACS share laser designation information to identify targets or common reference points. In actual practice, it is difficult to hold a laser spot on a specific target due to line-of-site and pointing inaccuracies. JTACS may also designate locations near a target instead of the target itself. Simply having the entity being lased broadcast to all players that it is being designated would not fulfill all training requirements. To support these designation tactics a "laser spot" menu was devised which allows the IOS operator to lase a specific entity, a location on a database, or a small area around a point to simulate a shaking designator. The resulting DIS PDU contained information which supports the emulated GLID-II laser designator as well as simulations of other laser spot tracking systems. The laser code of the designator is also encoded in the PDU.

Artillery and Call for Fire Control

Without physics-based fly outs of artillery rounds, instructors could not properly train students to de-conflict air assets and artillery fire. Instructors needed the ability to report the time of flight of rounds and the maximum altitude the ordinance would achieve to allow the JTAC to manage artillery control airspace. AFRL continued its approach of using actual JTAC templates for the artillery call for fire missions. "Call For Fire" and "Fire Direction Control" templates were implemented into the IOS to give instructors control of artillery assets. Similar to the 9-line, items on the list could either be typed in or selected from a drop down list. Like the initial 9-line format, this worked in a demonstration but not at an operational level.

To give instructors full control over the artillery assets, the templates were further expanded. The Fire Direction Control template was completely overhauled to allow every input given by a student on the Call For Fire tab to be modified. Figure 7 shows the target being manually edited by the instructor. Like the 9-line, the instructor can select the target the student called in on the CFF template or override with a new target location.

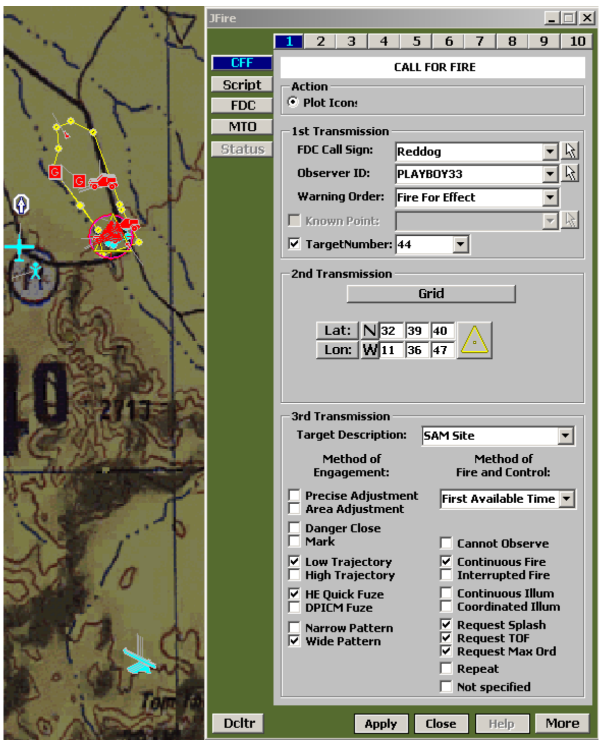

Figure 6. Revised CFF on IOS

Scenario Management

The existing scenario development tools in XCITE successfully supported experienced JTACs building custom scenarios for continuation training. Scenario management for upgrading JTACs required more stringent scenario controls. The Air Ground Operations School has developed a well-defined syllabus supporting simulation training missions.

Typically, students would sit in a mass briefing where all received the same pre-briefing on that day's scenario. Using I-FACTs, six students then trained on a scenario together. One disadvantage of the more immersive dome training system is that it permitted training only a small 2-3 JTAC team at a time. Scenario development is underway to match the existing I-FACT scenarios to the dome IOS to evaluate the training effectiveness of this system in upgrade training.

Among their criteria for scenarios, AGOS did not want the battlefield populated with static targets. Experienced JTACs quickly realized that moving targets are far more difficult for a student and the simulator could compensate for the lack of moving targets on the live range. Students would calculate a target's position but due to distractions or taskings would lose track of the enemy vehicle's location. The AGOS instructors also

Figure 7. New FDC on IOS

developed scenarios that mixed high threat surface-to-air missile amongst enemy target arrays to force students to actually employ suppression of enemy air defenses fires prior to effectively conducting an airstrike.

Brief / Debrief in IOS

Debrief for air-to-air training typically involves a detailed review of the entire mission. AFRL uses DIS recorders installed on the simulation network to allow full recording of all entity actions and radio calls. After the mission the instructor can playback the entire mission or jump to a specific event. For the JCAS

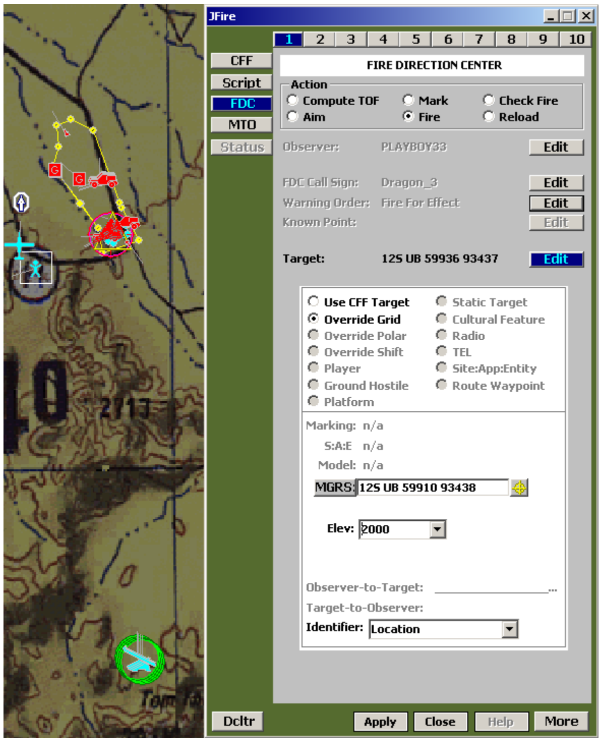

Figure 8. Example Override Menu on IOS

Figure 9. JCAS Brief / Debrief System

debriefing system, AFRL utilized the same visual database and IOS as the dome to maintain familiarity. The recorder and playback utilities were built similarly to those used for typical air-to-air engagements where pilots fly for approximately one hour then debrief for one to three hours.

Observation of JTACs using the training systems found that students typically conducted a one hour mission followed by a short debrief. Additionally, instructors regularly froze the scenarios to discuss training issues as they arose, a technique not typically used by instructors conducting air-to-air training. Since audio recordings were not made while the scenario was frozen, the debrief inevitably involved disagreements between the student and instructor as to what was said and when. The instructors were heavily tasked: controlling the scenario, acting as voice for the pilots and grading the student simultaneously. Hand written notes of student performance were written down hastily as the scenario progressed. Automated performance measurement tools and immediate feedback may be more useful in future systems than full-scenario playback capabilities, though full-scenario playback should still be available for more complex DMO events.

Figure 10. JTACS Training in Immersive Dome

AFRL is working to introduce automated real-time DIS speech to text transcription of the scenarios. The instructors could then refer to the transcript for a no-argument "you said this" during debrief with the students. Students would be able take their transcripts with them when they leave so they can further review what they did right and wrong in the mission. Additionally, a secondary radio frequency could be setup for the instructor to allow him to make comments as the mission progressed that the student would be unable to hear. After the mission those comments could be played back or read from the transcript.

Scenario Generation for ROVER Training

The requirement for training indirect control of JCAS assets was highlighted in previous sections. The United States Air Forces in Europe Warrior Preparation Center developed a method that allows unique training with the ROVER system. A predator UAV was flown using the Air Force Synthetic Environment for Reconnaissance and Surveillance / Multiple Unified Simulation Environment (AFSERS/MUSE) which supported a sensor representation through a network connection to a ROVER laptop computer. XCITE was used to generate targets, strike aircraft and munitions. Correlation between the ROVER sensor visualization and the XCITE CGF was excellent. This system has provided superb training to develop advanced tactics and prepare for combat deployments and demonstrates the potential for interfacing multiple CGFs to provide targeted training activities for advanced systems.

LIVE-VIRTUAL-CONTRUCTIVE JCAS

In 2007, AFRL showcased a Live Virtual Constructive (LVC) demonstration at the Air Force Association and Interservice/Industry Training, Simulation, & Education conferences. In these demonstrations, a transportable 5 meter JTAC dome along with two deployable F-16 cockpits were setup on the exhibit floor. Utilizing ACMI pods and Link-16 connections, the JTACs within the dome were able to see and control the live aircraft flying throughout the DMO environment. The JTACs real radio was linked with emulation software to transmit the data over the DIS network and the live F-16 pilots used their UHF radios to transmit to a similar conversion device at Luke AFB.

Figure 11. Live Aircraft at Luke AFB

Although the interactions between the pilot and JTACs were real, the interactions with the range targets were not. Ground targets in the DMO environment could easily be engaged any time using the XCITE software, but those entities would not appear on the live range or on the instrumentation inside the F-16. A Link16 connection did permit XCITE air assets to appear on the datalink displays in the live aircraft.

Even though the F-16s were dropping real munitions at the range, weapons release data could not be passed to the JTAC Dome over unclassified lines. To allow the JTAC to observe weapons effects, a "magic bomb" was added to the IOS which allowed the instructor to drop a bomb at any location at any time within the simulation. A classified LVC connection would have permitted information such as weapon release to be relayed over the simulation network. In this case, the CGF could be switched to a weapons server to display a simulated weapons flyout over the network. It should be noted that any small errors due to latency, data dropouts or maneuvering would cause huge differences between

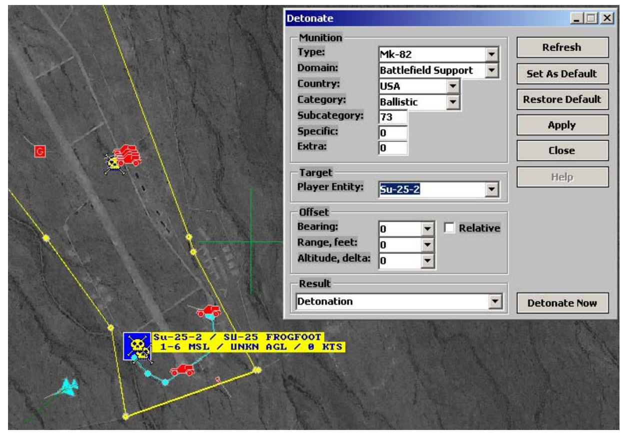

Figure 12. Magic Bomb on IOS

where the bomb actually dropped and where the simulation calculated its drop. One potential solution under consideration is to have scoring plots of actual bomb impacts mapped into the LVC network to display a correlated bomb impact. Further work is required in this area.

FUTURE REQUIREMENTS

AFRL has identified current technical shortfalls relating to JCAS training systems. The existing training system can provide only limited interactions with actual ground command and control agencies. Most interactions, like artillery fire support, are controlled by a role playing JTAC. In the future, improved command and control modeling, night and adverse weather representations, models for advanced weapons and weapons effects and seamless integration with existing CGFs in high entity count scenarios are required.

Integration to Joint Fire DMO Environments

AFRL's CGF development centered on providing models and simulations specific to Air Force JCAS Training Research. Integration with actual US Army constructive simulations and training systems is desired to fully represent the entire Theater Air Ground System. Interfaces to validated Army and Special Operations models and simulations should be developed to employ a "best of breed" approach for constructive forces support. An optimal mix of constructive forces would use air centric CGFs for aircraft, air delivered munitions and enemy surface-to-air threats while using ground centric CGFs for vehicles, convoy routing, artillery weapons and ground command and control like Blue Force Tracking, Fire Support Cells and tactical ground force command and control. Rapid integration and correlation between systems is desired.

Automated Command and Control for Rapid Scenario Generation

In high entity count scenarios, technologies that automate scenario generation, manage ground force-on-force activities and provide synthetic C2 are desirable. The Theater Air Ground System Synthetic Battlespace is an example of efforts to automate scenario generation and provide theater level of war command and control support to live virtual constructive training systems (Ales, 2006).

Improved Nighttime Simulation

The JTAC TRS system developed by AFRL did not display high fidelity, validated night vision scenes. Future JTAC training systems will require night vision representations. In this case, CGFs must be modified for both ground and air models to provide night tactics and target representations. This would include lights-on and lights-off convoy movements, modeling of target acquisition ranges for night vision and additional infrared sensors, night formation tactics for aircraft and support for night visual special effects like tracer fire. Models to support artillery and air delivered parachute flares and markers are also required.

Damage States for Models and Munitions Effects

In current operations, urban CAS and operations in cluttered terrain are the norm. A training requirement exists to mange firepower and prevent collateral damage and fratricide in urban JCAS. Due to the destructive force of air delivered munitions, precise modeling of damage effects to buildings and other representations of collateral damage could provide useful training feedback. Warhead effects need to be modeled extremely accurately and validated for precision engagement in urban terrain.

CONCLUSION

AFRL successfully demonstrated modification of an air centric constructive training environment to support a high fidelity joint close air support training system. Future acquisitions for JCAS training systems should study AFRL's lessons learned and ensure realistic models, scripting, air-to-ground tactics and realistic artillery control are available. Capabilities to support growth in advanced and coalition tactics must also be considered. Instructor operating requirements for JCAS vary greatly from those of aircraft simulators and combining scenario control features for both air and ground models in a single system is desirable. Involving constant feedback from JCAS subject matter experts while developing computer generated forces and instruction operating systems is possibly the most critical step to ensuring usability and requirements goals.

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