Architecture of the Counter Insurgency Experiment

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ABSTRACT

The Counter Insurgency (COIN) Experiment was performed in March 2007 using a distributed network. It was focused on simulating urban operations in Central Asia in 2015. A major goal of the experiment was to demonstrate the use of a complex Models and Simulation federation to train and evaluate doctrine for a Counter Insurgency Environment. Participating federates included OFOTB, FireSim, JSAF, CultureSim, EADSim, CMS2, Universal Controller, ACRT, ACRT-DR, JNEM, ISM, SAServer, MC2, CERDEC CES, AOIServer, EffectsServer, Reporter, DataLogger, SEAMS. This was an entity-level distributed simulation event that included sites at Ft Knox, Ft Sill, Ft Bliss, and Huntsville, using the DIS and HLA protocols. Approximate entity counts included 1000 US vehicles and soldiers, 1000 Local Police and Army, 1200 insurgents, and 20,000 civilians from various population groups.

Several new and enhanced models contributed to the richness of the COIN environment. A Force model was developed that allowed each station to control its rules of engagement, crucial for a situation where the enemy depended on who and where you were. A model of uniformed entities versus plain clothes was added since insurgents don't generally show themselves as such. JNEM/ISM provided real-time feedback on the mood of the various civilian population groups. A new model of IEDs was developed that simulated several trigger types, decoys and countermeasures. Suppressive effects were added including non-lethal rounds. The area-of-interest model was improved to allow good simulation performance in a dense urban environment. The terrain database had 10000 fully modeled multi-elevation buildings along with 650,000 volume buildings.

ABOUT THE AUTHOR

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INTRODUCTION

Omni Fusion 07 (OF7) Counter Insurgency (COIN) was a real-time man-in-the-loop Unit of Action Maneuver Battle Lab (UAMBL) experiment consisting of four phases (BCTP Instruction, Seminar, CAMEX, and SIMEX). Using the scenario from a previous urban experiment, the free play SIMEX portion of OF07 had three primary objectives: Assess the FBCT's capability to operate in a COIN environment, Update and refine the FBCT's TACSOP, organization and doctrinal manuals, and facilitate future Training and Doctrine Command (TRADOC) COIN-specific live, virtual and constructive (LVC) experimentation by providing lessons learned.

The following battle labs and organizations were major contributors to the achievement of those objectives by providing simulations or battle command systems and technical support: Fires Battle Lab (FBL), Space and Missile Defense Battle Lab (SMDBL), Air & Missile Defense Battle Lab (AMDBL), Battle Command Battle Lab-Gordon (BCBL-G), National Simulations Center (NSC), Communications & Electronics Research Development & Engineering Center (CERDEC), and Night Vision (NVESD).

This paper will briefly describe the principal components of the experiment, will describe some of the new and enhanced models that contributed to the richness and realism of the modeled environment, and will discuss successes, challenges, and areas that need future development to model the complex urban battlefield with the highest possible fidelity.

COMPONENTS

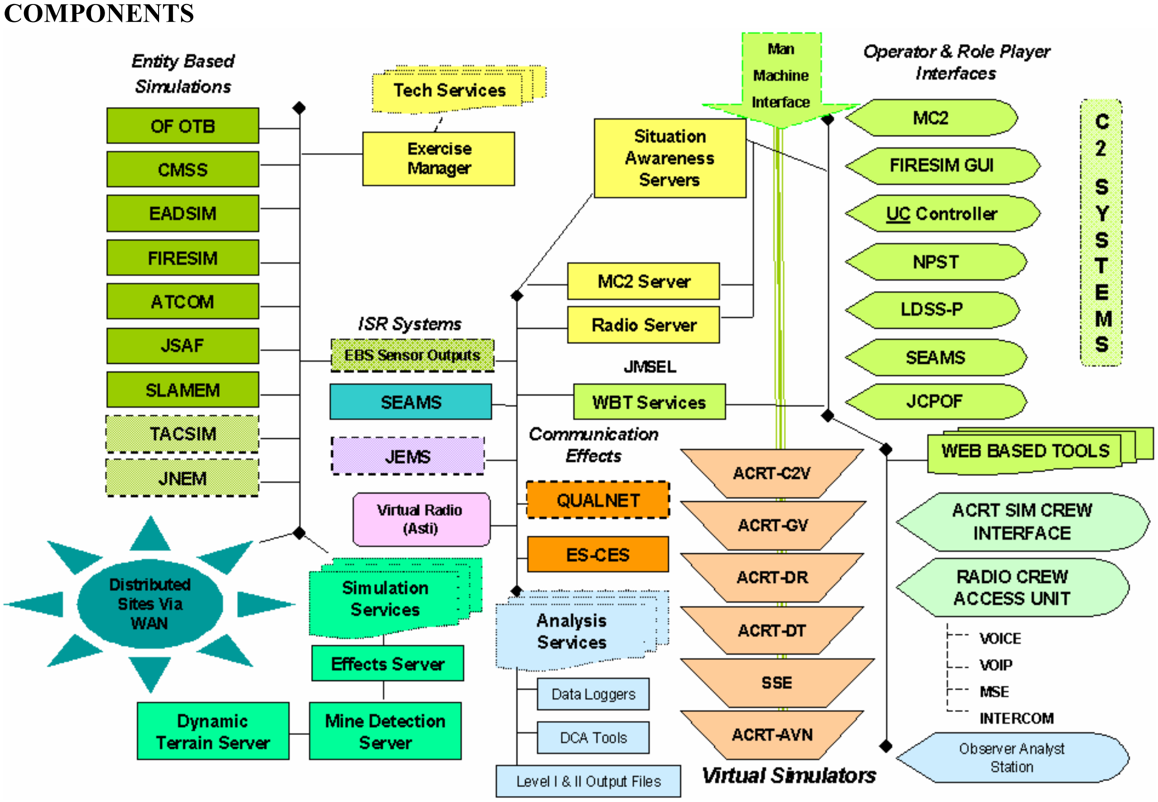

Figure 1. Modeling and Simulation Federation

Table 1. Simulation Federates

Objective Force OneSAF Test Bed	OFOTB	Simulated most ground vehicles and individual combatants
Fire Simulation XXI	FireSim	Simulated artillery
Extended Air Defense Simulation	EADSim	Simulated air defense, mortars, artillery
Simulation of the Location and Attack of Mobile Enemy Missiles	SLAMEM	Simulated UAVs, AWACS
Comprehensive Mine Sensor Server	CMS2	Simulated mines, IMS, UGS, IEDs
Counter Mine Server	CMS	Simulated mine detection sensors, ASTAMIDS, GSTAMIDS
Universal Controller	UC	Provided manned control of robots and UAVs
Joint Semi-Autonomous Forces (JSAF) Culture Simulation	CultureSim	Simulated large number of unarmed civilians
Advanced Concepts Research Tool	ACRT	Man-in-loop simulator of ground vehicles and of individual combatants
Effects Server	EFS	Assessed damage from shot events for all other federates

Table 2. Battle Command Federates

Mobile Command and Control	MC2	Command and Control system that showed friendly and enemy COPs, interacted with NetFires
Network Planning and Simulation Tool	NPST	Used by Signal Planner to evaluate communications status of BLUFOR.
Situational Awareness Server	SA Server	Constructed friendly and enemy COPs from simulation network traffic, while considering comm. effects. Supported C2 functions like NetFires.
Sensor Exploitation and Management System	SEAMS	Fused multiple sensors into single COP
LSI QUALNET Communications Effects Server	CES	Calculated point-to-point communications status, taking routing and bandwidth into account
Digital Audio Communications Systems	DACS	Simulated digital radio with comm. effects
Joint Non-Kinetic Effects Module	JNEM	Monitored simulation network traffic to model effects as changes in civilian satisfaction levels
Independent Stimulation Module	ISM	Used JNEM civilian activity reports to create realistic intelligence sources.

Table 3. Supporting Federates

Data Collection and Analysis	DCA	Collected simulation and support data. Produced Level 1 and Level 2 reports.
Reporter	Reporter	Provided real-time analysis for experiment monitoring and configuration management
Force Structure Database	FSD	Used to design complete force structure. Supported game-time cross attachments.
Area of Interest Server	AOI Server	Improved performance of simulation systems by reducing the number of entities a particular system saw.

Network Design

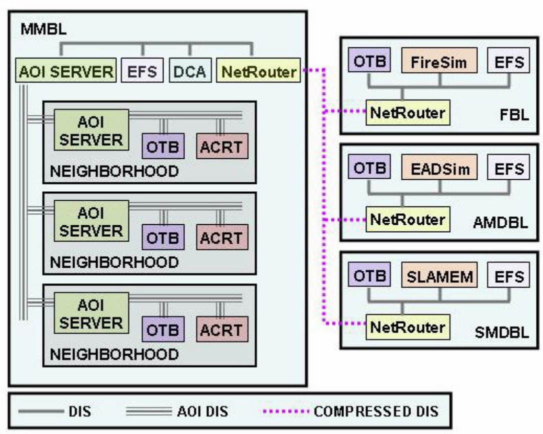

Figure 2. Notional Network Layout

The network design had several objectives:

- Connect the remote sites, including Ft Knox, Ft Sill, Ft Bliss, and Huntsville
- Improve the performance of the simulations while supporting up to 50,000 entities
- Limit the scope of any failure
- Minimize changes to existing federates while preserving their current reliability

The performance problems experienced by OTB during previous urban simulations were primarily addressed by the AOI Server. The entities were grouped into relatively small neighborhoods that were geographically separated from each other. Each neighborhood was supported by an AOI Server that periodically determined the total extent of its entities, and recalculated the AOI regions for the neighborhood accordingly. This allowed the AOI regions to be as small as possible without requiring any manual configuration.

All long-haul traffic was handled by the NetRouter. It maximized the use of that network by compressing and bundling the DIS PDUs. The complete experiment involved about 2000 computers, 1500 multicast groups, and 75 domains.

Terrain Database

The terrain database for COIN covered a 90x110km area centered on a large metropolitan area in Central Asia. It was created by MWTB personnel using the TerraVista application. Input data from NGA included DTED Level 2, Vector Interim Terrain Data (VITD), Urban Vector Map (UVMAP), and Enhanced UVMAP. The input data was selected so that the highest resolution data was present in the central gaming area (Figure 3).

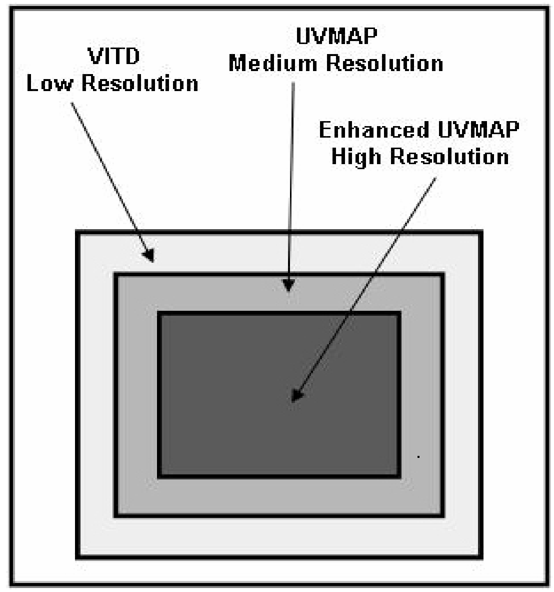

Figure 3. Variable resolution across terrain

The terrain included approximately 650,000 volume buildings that were generated by an automatic extrusion of their footprint. While each was unique, none was designed to accurately represent an actual geospecific building in Central Asia. The terrain also included about 10,000 multi-elevation (MES) buildings from a pool of twenty unique geotypical variants, with interiors that included walls, windows, doors, and stairways. These buildings were concentrated in three areas of operations, and along the connecting corridors. As with the volume buildings, the MES buildings did not represent actual geospecific structures.

The TerraVista application was used to produce the terrain in formats for OTB, JSAF, OOS, and MetaVR. It also output the terrain in Flight format that was converted for the NVL Image Generator (NVL-IG).

The initial development of this terrain included Light Detection and Ranging (LIDAR) elevation data with a very small spacing. A collision between technical problems and the schedule meant that the LIDAR data was not used.

ENHANCED MODELS

Lessons learned from previous urban experiments pointed to several areas that needed improvement, especially concerning dismounted operations in a dense urban environment where the enemy is hard to identify.

Sides

The traditional Blue/Red/Neutral force model doesn't really work in a COIN situation, where there are many groups with dynamic adversarial relationships. While the current DIS standard allows for multiple forces, this newer approach is not supported by all of the federates that participated in the COIN Experiment. Instead, we used the country code in the Entity Type field to denote side. To separate one secular group from another, we defined separate countries for each, as SecularGroup1, SecularGroup1, etc. These sides influenced perception and rules of engagement.

Uniformed / Armed / Unarmed

In a conventional battle, the fighters wear uniforms and non-combatants don't. A casual observer can easily distinguish the two, and can also determine whether a dismount is carrying a rifle or an ATGM. In the COIN environment, some combatants like Army and Police are uniformed and carry their weapons openly. Others try to hide their weapons and dress in a way that is identical with the civilian populace. We used two approaches for this critical issue.

First, each entity was defined as being uniformed or plainclothed. Any entity that was part of a recognized organization and would be assumed to be always armed was considered to be uniformed. These included Coalition forces, Host Nation National Police, Host Nation Special Police, Host Nation traffic police, and UN Officials. All other entities were plainclothed.

As shown in Table 4, we used the DIS EntityType fields in the EntityState PDU to convey whether an entity was uniformed or not. If it was uniformed, the actual entity type was used for both primary and alternate EntityType values. If an entity was plainclothed, the actual entity type was used for the primary EntityType value, but a generic entity type was used for the alternate value.

Table 4. Entity Types for Uniformed and Plainclothed

Actual Entity Type	Uniformed	Primary Entity Type	Alternate Entity Type
US_IC_M4	X	US_IC_M4	US_IC_M4
HostNationPolice_IC_AK47	X	HostNation_IC_AK47	HostNation_IC_AK47
UN_Election_Official	X	UN_Election_Official	UN_Election_Official
SecularGp1_IC		SecularGp1_IC	IC
SecularGp1_IC_AK47		SecularGp1_IC_AK47	IC_Rifle
SecularGp2_IC_AK47		SecularGp2_IC_AK47	IC_Rifle
SecularGp2_IC_Mortar		SecularGp2_IC_Mortar	IC_Mortar
ForeignFighter_IC_Mortar		ForeignFighter _IC_Mortar	IC_Mortar

Which entity type was used to depict an entity depended on the sides of the observer and of the observed. The primary entity was used if the sides matched, and the alternate was used if they didn't. A SecularGp1 observer would then see Coalition entities as they really were, and would also see other SecularGp1s as they really were, but the SecularGp3 entities would appear as generic entities. Everyone could tell that a US Army entity was Coalition, but only a SecularGp3 observer could pick out another SecularGp3 from a crowd of SecularGp1s.

While this approach obscured the identity of entities in a realistic way, it didn't address our requirement that entities needed to be able to become armed at any time by retrieving weapons from a cache. Changing the entity type of a particular entity during an experiment is a bad idea, since it greatly confuses experiment monitoring and analysis tools. We chose to use the ammo status as a surrogate for armed. If an entity was carrying a weapon but had no ammo for the weapon, we defined that entity as being unarmed. If the entity retrieved ammo from a cache, it became armed, and it could become unarmed again by placing its ammo back in the cache. Since a weapon without ammo is useless, this approach was functionally equivalent to picking up and dropping the weapon itself. The entity conveyed that it was unarmed by zeroing the weapon deployment bits in the Appearance field in the Entity State PDU. An observer would depict the unarmed entity as an IC. If an entity retrieved ammo, it became armed, it set the weapon deployment bits, and it appeared armed with the weapon specified by its entity type.

Some weapons are small enough that they can be easily hidden beneath clothing. This means that an armed person might appear to be unarmed. We modeled this by causing some of the entities that were armed (had a weapon and ammo) to display themselves as unarmed. Similarly, a real person could brandish a weapon but not have ammo for it. This person would be perceived as armed, even though he wasn't by our definition. Our model falsely showed about half of the armed entities as being unarmed, and showed a small fraction of the unarmed entities as being armed. Since an ATGM is not really concealable like an AK47, this model of falsely changing the armed state was only applied to small caliber weapons.

The result of the uniformed/plainclothed and armed/unarmed models was that operators of Coalition forces had a lot of trouble determining who was a threat and who should be engaged. Foreign fighters would hide in a crowd of SecularGp2 civilians. Unarmed civilians would walk into a building and come out armed and dangerous.

Rules of Engagement

As with sides, the traditional approach to rules of engagement (ROE) is based on BLUFOR versus OPFOR. Since there is no OPFOR in the COIN environment, this approach doesn't work. Instead, we designed a model where each OFOTB operator could design his own ROE based on his commander's guidance. The tool grouped the battlefield into Blue, Red, Armed Green, and Unarmed Green. The operator could select which of the groups were threatening, which should be engaged to kill, and which should be engaged to suppress.

For example, an operator that controlled Coalition forces would normally select Armed Green as threatening, and nothing for engagement or suppression. The operator would manually fire at specific entities only when he verified that those entities had engaged Coalition forces. While under attack, the operator would select all Green for automatic Suppression.

When the operator's entities entered a building, he would select Armed Green for engagement and select Free Fire. If his troops saw armed Green entities in the building, they automatically engaged to kill.

The model prevented a particular side from engaging that same side. So if SecularGp1s selected Armed Green for engagement, those SecularGp1s would engage SecularGp2s and SecularGp3s, but not other SecularGp1s. Similarly, the Host Nation Police could be configured to engage Coalition forces by selecting Blue for engagement.

The approach allowed complete flexibility in the ROE. Each operator could alter his own ROE at any time, and his alterations only affected his own entities. So while one small group of SecularGp2s engaged Coalition forces, SecularGp2s in another part of the city could engage SecularGp3s.

Even with the new ROE model, most engagements were performed manually, where the OFOTB operator selects the target, the ammo, and whether to kill or suppress. Current OFOTB behaviors are completely inadequate for accurately assessing the exact threat while avoiding collateral damage. Even real soldiers have a lot of trouble with this.

IEDs

CMS2 and CMS modeled the IEDs and IED countermeasures. IED types included Roadside Artillery, Buried Artillery, Roadside Explosive, Buried Explosive, OnRoad Explosive, Explosively Formed Projectile (EFP), and Decoys. Fifteen different visual models for IEDs included various animals, construction debris, etc. These images could be used with or without the actual IED so that the crews couldn't assume that every dead dog was an IED. Detonation methods included Command Wire, Remote Control using cell phone, Victim Activated, and Timer. Visual acquisition by the crew of a manned simulator was the primary method of detection.

Vehicle Borne Improvised Devices (VBID) modeled by OFOTB included Chest Pack, Car Bomb, Truck Bomb, and Bus Bomb. This model could be applied to any entity, including manned simulators.

Barriers, Craters and Rubble

Jersey, Texas, and HESCO barriers were essential elements for controlling traffic and force protection. We used 1600 barriers to support the Coalition and Host Nation forces. Each barrier was a separate entity that could be loaded on a truck and placed in position.

The Dynamic Terrain Server generated craters and rubble according to munition detonations. The effects were conveyed with an Experimental PDU, and were implemented by defining the cratered or rubbled area as having a special soil type. The Standard Mobility model, which uses soil types to regulate mobility performance, caused entities to have reduced mobility in the affected area, depending on the vehicle's characteristics.

Human Interaction

A major obstacle in previous urban experiments was the inability for Coalition Forces to interact with civilians and Host Nation forces. We developed the Human Interaction Tool to provide a simple chat-like capability for communication and interrogation. It was widely used with constructive and virtual entities, and all of the messages were logged along with other simulation traffic. Some of the interrogations of Green by Blue became quite heated, as Green intentionally tried to antagonize the Blue players.

Variety of Civilians

The COIN environment has a lot more variety than the typical heavy tank battle. We used two approaches for creating a richer and more complex battlefield. We used a variety of civilian entities for each population group, including adults, children, and protestors, both friendly and hostile. The NVL-IG also had over one hundred different visual models for a civilian person. It randomized the choice of a specific model for each specific entity, and then communicated the choice to the other IGs so that they could make the same choice. These resulted in a battlefield that looked about as varied as an actual city.

Suppression and Non-Lethal Rounds

Suppression is an integral part of any battlefield, and is especially important in urban operations. Civilian entities became suppressed when rounds were fired or landed near them. While suppressed, civilians lied down and could not fire their own weapons, if any. Civilian vehicles executed suppression by stopping their movement. Suppressive fire, where the rounds don't actually hit the target, could be performed automatically according to the ROE, or manually by the operator.

The Active Denial System (ADS) was mounted on some OFOTB entities and on the manned simulators. The actual ADS sends microwaves which heat the skin of the targets. Our version sent an Experimental PDU that triggered temporary suppression in nearby entities.

Coalition troops carried rubber bullets. These caused suppression and were fired manually by the OFOTB operator.

Spot Reports

Spot Reports are the principal driver of the Command and Control system, since they form the basis of the Common Operating Picture (COP). We used the "threatening" level of the ROE model to regulate when Spot Reports were created. Each operator was able to control the reporting behavior of their own forces. This produced a more realistic set of Reports than in previous experiments

Surrender

A Surrender Tool was developed that caused the designated entities to raise their hands, kneel down, and become firepower killed. Captured personnel were loaded onto trucks and taken to a detainment area.

Crowd Noise

We developed a tool in OFOTB that played background environmental sounds. These included periodic sounds, like Call to Prayer, and geographically-located, like Market Place.

Identifiers and Black Targets

Actual civilians do not have the bumper number-like markings that appear on a tank, but individual people are still recognizable. For example, an observer standing outside a Walmart can tell when a particular person enters and leaves the store, even if the observer doesn't know the person and has never seen him before. Of course, the observer still would not know anything else about the person, except that he shopped at Walmart.

To simulate this process, we used a hashing method to generate a mostly-unique "marking" for each entity from another side. The marking itself was meaningless, but it allowed an observer to track a particular entity, and multiple observers could talk about that particular entity. Of course, same side entities were displayed with their actual markings.

We also had a small set of Gray and Black targets. These are targets that are known on sight, like Osama bin Laden. Their marking was preserved, both in the simulation and also through the Command and Control system.

Population Mood

JNEM and ISM partnered to infer the mood of the various civilian population groups as affected by battlefield actions. These mood measures were used to evaluate the success of the Coalition operations, and also influenced how the civilian simulation systems were employed.

Command and Control Aids

CERDEC developed several pattern analysis tools for the MC2 to help the commander make sense of the battlefield. These included a Time/Event Chart, an Association Matrix, and Link Analysis capabilities.

Active Protection System (APS)

The APS model that was already present in the EFS was improved for more complete and accurate behavior in an urban environment.

SUCCESSES AND FAILURES

COIN was a very successful event, especially from a technical standpoint. The simulation environment exceeded expectations at creating confusion and vulnerability in the minds of the Coalition players. Using coordinated attacks, the Green insurgents were frequently able to penetrate Forward Operating Bases (FOB) with VBIDs. The Insurgents were also able to stress the Coalition sufficiently so that the Coalition would sometimes respond to snipers with overwhelming force. The mood of the civilian population obviously suffered accordingly.

For the Coalition, the experiment was effective in demonstrating the utility of FCS technologies. The combination of advanced technologies and 21st century networked communications enabled commanders to react rapidly with a high degree of precision.

Just as in sports, practice makes perfect. In this case, most of the federates had already participated in numerous large-scale distributed experiments, and there was enough time to thoroughly test the new features before the experiment started. Most technical aspects of the simulation performed as expected.

But simulating the COIN environment still relies heavily on the operators playing the game fairly and well. A lot of technical proficiency was required to quickly identify and respond to a single sniper in a crowd, and there was probably too much cooperation between the civilian populace and the insurgents. On the other hand, the attention demanded of the operators might have helped them feel more involved. In the end, they definitely did not treat the exercise as a glorified video game, but felt that they were really immersed in the situation.

PLAYER ANECDOTES

Interviews with the players demonstrated the level of immersion achieved during COIN better than any technical analysis.

"My Host Nation Army unit was investigating an arms cache. The Coalition called over and said their UAV saw some insurgents attempting to set up an ambush. We agreed to be the bait while the Coalition took out the insurgents."

"I was controlling some of the Host Nation Police and we were guarding a polling site. We sent out a few plainclothed spies to case a safe house. The Coalition didn't get the word, and they killed some of the spies for violating the curfew."

"At my checkpoint. I used the HumInt Tool to ask each person why he was there. If he didn't respond the right way, he was turned away."

"A UAV accidentally crashed into a mosque. I moved a big crowd of civilians into the area, and we were rioting. It took a couple of hours for the Coalition forces to figure out what was happening, and they kept saying it was our UAV that had crashed. It was total chaos."

"At first, I thought the truck was one of ours. When I realized it wasn't, I started shooting. Then the mortars started coming in, and it was clear that this was an attack. We stopped the truck in the motor pool."

"I was driving the VBID into the FOB, and as I got inside the perimeter, I thought I could get near the building we had identified as their headquarters. Our mortars started to drop right on time, and that gave me a bit of extra cover. I swerved back and forth to evade their firing, and finally ended up by some trucks. I think I took out their CBR."

"My police station was attacked by machine guns and RPGs. It happened so fast I was overwhelmed, and all of my police were killed."

"It was just a couple of women and some children, but it just didn't look right. I questioned them, and it turned out that they were scouting out our FOB."

"There was supposed to be a complete curfew, but the insurgents got the civilians to keep driving anyway. My ministry tried to use the media to get the civilians to obey the orders, but the insurgents seemed to have more influence than the government."

FUTURE DEVELOPMENTS

Technical areas that could use attention include:

- Improve simulation performance. OFOTB should be modified so that it can use two CPUs by separating its Sensor Client/Server model. Other systems like US and CMS need to use AOI more effectively.
- Some barriers should be built into the terrain database. This assumes that the location of these barriers is defined sufficiently in advance of the experiment, as required by the terrain developers.
- Interiors of MES buildings are unrealistically sparse. They should contain enough furniture and other furnishings to reasonably convey the locale.
- The Dynamic Terrain Server should provide burning buildings. It should also allow removal of rubble and craters.
- The Human Interaction capability should be a lot more user-friendly, while still supporting analysis requirements. Voice recognition would be a powerful addition to the manned ACRT-DR simulator, and automatic generation of responses would greatly expand the pool of interrogation subjects.
- The civilian population needs more realistic depiction of the actual street culture, so that manners and responses can be different when interrogating the old man on the corner versus a group of teenagers in the street.
- Signal transmission and sensing needs to be modeled, so that SIGINT can augment HUMINT properly.
- Dismounts should have more interaction tools, like personnel and vehicle search, detainment, warning shots, etc.
- CultureSim should use the Effects Server for vulnerability assessment like the other simulation federates, to ensure uniform and predictable results that are based on classified AMSAA data.
- OFOTB needs a realistic model for sensing IEDs. The model should sometimes report false positives.

ACKNOWLDGEMENTS

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