Experimenting for the Future

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by Robert Clover

Experimenting for the Future

Simulation of an Advanced Fire Support System

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For some soldiers the word "simulation" connotes "sham," but among engineers the word is understood to mean "examination of a problem not subject to direct experimentation."[1] Last spring a panel of the Army Science Board (ASS) exploring technologies for the Army after 2010 sought a quick, inexpensive way to gain insights into the military worth of a novel concept for direct support fires: containerized, loitering missiles coupled with sensors, both under the direct control of the maneuver battalion. Caretakers of constructive simulations of war shook their heads: they could model such a system, but it would take time and money that the ASS could not afford. Object-oriented virtual simulations seemed less onerous, but still beyond the ASB's time-frame and means. The Simulation Center of the Institute for Defense Analyses (IDA) then proposed using two existing simulations to analyze the characteristics of modem small unit operations, especially target arrays that develop therein, to deduce whether decentralized fire control and loitering missiles seemed to make sense. IDA offered to use a virtual simulation to bound the pace and reach of modem armored combat, and to employ records of a live simulation, the Task Force XXI Advanced Warfighting Experiment (AWE), to determine the frequency and persistence of prospective targets.

These ideas struck a responsive chord with the ASB panel, because they had been told that howitzers and mortars firing ballistic projectiles, being vulnerable to radar tracking and to counter-fire, were usually held separate from, and to the rear of, maneuver units.

Requests for fire therefore necessitated time-consuming inter-unit communications -- usually some eight minutes for each echelon transited. Moreover, high-priority deep targets often preempted close fires.[2] Hence, ballistic projectiles, whether shells or missiles, had difficulty in arriving in time to hit moving targets, and in being synchronized with swiftly maneuvering friendly forces. The answer seemed to lie in means organic to the maneuver battalion for detecting and prosecuting targets that obviated calls for fire.

The ASB hypothesized that forward-controlled packets of small fly-out missiles able to dwell for a period over a potential target area could provide front line units with enhanced synchronization and increased lethality. Several technologies being explored by the Defense Advanced Research Projects Agency (DARPA) seemed highly relevant sensors and sensor-control means for small units referred to situation awareness systems (SAS), and the Advanced Fire Support System (AFSS). DARPA's SAS includes (I) Discoverer II, spaced-based radar tasked by and displayed to battalion commanders; (2) strewn, linked unattended ground sensors (SLUGS); (3) robotic observation posts (ROP) capable of ATR and target designation; and (4) porteed micro aerial vehicles (P~MAV) , missile-delivered to potential target areas.

DARPA's AFSS deploys containers of small, cheap cruise missiles that launch on radio command. An AFSS fire-unit could be positioned by parachute, by helicopter, or by ground vehicle, and its control could be assigned to a specific commander. Moreover, each missile once aloft would fly to a target area, orbit while seeking targets, and then dive to deliver accurately lethal munitions.

The missiles were assumed to have these characteristics:

- Range > 20 km
- Lethality > current 155mrn cargo round
- Flight profile:
  - Climb to ~ 3 km --Can be sent to a specific geographic coordinate
  - Glide/fly to target vicinity --Can cooperate with sensors to pinpoint target
  - Loiter for 5 to 15 minutes --Can attack upon "lock-on" or upon command

IDA devised two experiments to test the ASB hypothesis. In both, a form of tactical engagement simulation (TES) would furnish an analytical framework for evaluating sensors and weapons that will not be available for another decade.)

The first employed The Battle of 73 Easting, an advanced form of virtual TES from the Defense Advanced Research Projects Agency, produced five years ago at the request of General Gordon Sullivan, then VCSA. General Sullivan was aware, from the book America's First Battles,[3] that among "first battles" of all previous wars the only decisive victory had been won by the 2d Cavalry Regiment in 1846. Intrigued by reports that the 2d Cavalry had fought and won the "first battle" of Desert Storm in 1991, he ordered teams to begin within hours of the engagement to collect data on the battlefield and from all available sources, establishing minute-by- minute the positions and sequential actions of the U.S. and Iraqi antagonists. DARPA, employing semi-automated forces, then used these data to actuate icons within a synthetic battle environment. The result is a vivid, four-dimension representation of every combatant on both sides - accurately portrayed, and positioned precisely by latitude, longitude, altitude, and time. IDA analysts could

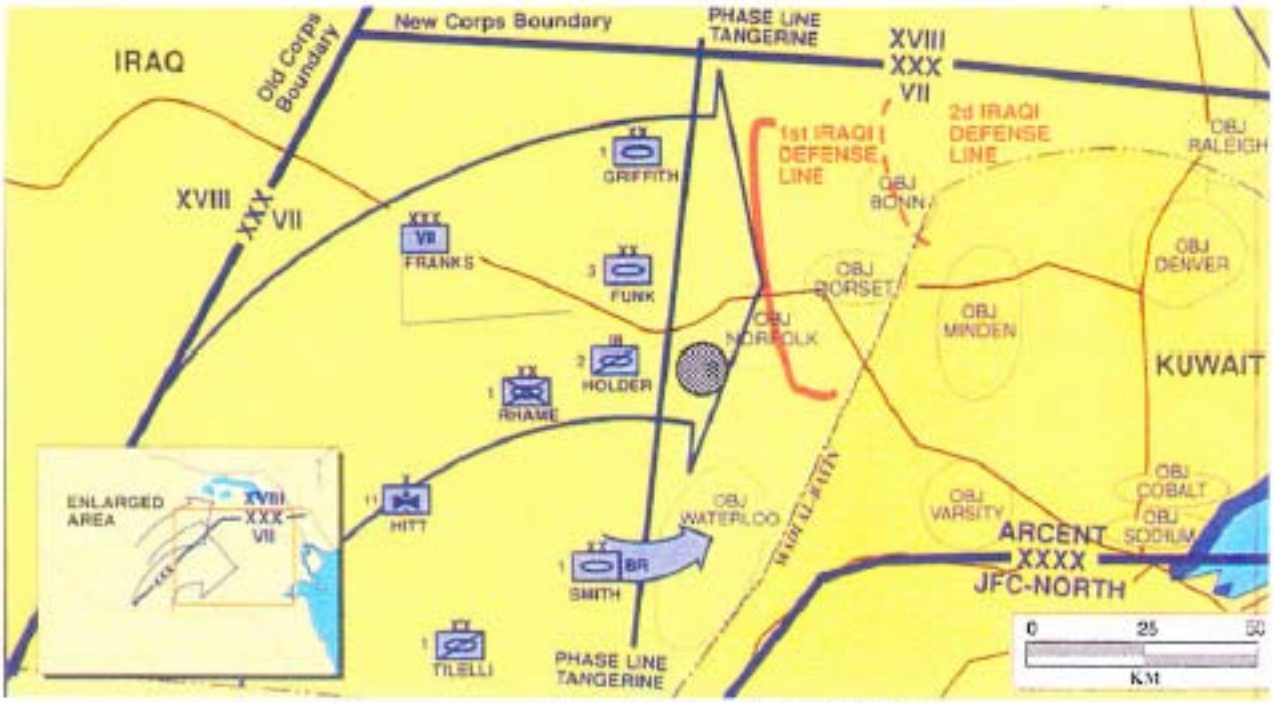
examine the battle by roaming within that virtual simulation at will, adopting any point of view they wished, with the opponents static or dynamic, shown in real time, fast-forward, or fast-rearward. In particular, they could get a sense of the timelines of engagements among armored fighting vehicles (AFV), and flag instances where loitering missiles could have been useful.

The TF XXI AWE was two-sided live TES at the National Training Center, a vast instrumented range were records are kept of each AFV, red or blue. The TRADOC Analysis Center has published a CD-ROM entitled **Operational Test VISualization (OTVIS) Playback of Selected Task Force XXI Missions - March 1997.** OTVIS presents a series of "movies" showing, by successive frames derived from NTC instrumentation, key engagements during the A WE between the canny NTC OPFOR and the newly "digitized" Task Force XXI, a brigade of the 4th Infantry Division (Mechanized). IDA analysts could use OTVIS to ascertain the positions of armored fighting vehicles (AFV) and helicopters of both protagonists at specified times. Of particular interest were the behaviors of OPFOR, widely regarded as the best trained military force in the world, especially the occasions when OPFOR would have been vulnerable to SAS and AFSS.

Experiment 1: 73 Easting

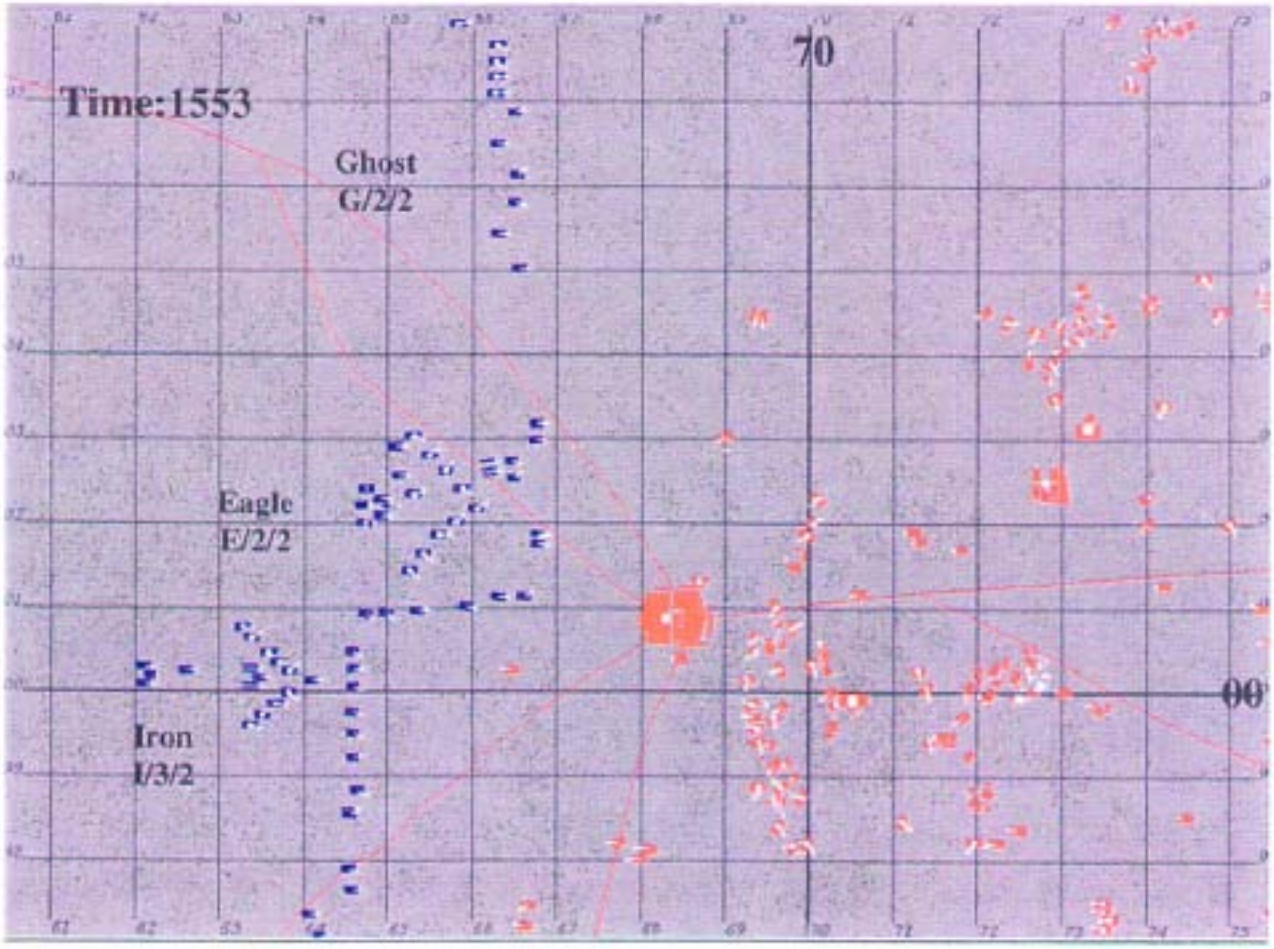
On the third day of DESERT STORM, VII Corps (LTG. Franks) had penetrated deep into Iraq, and had turned eastward thrust to engage divisions of Iraq's elite Republican Guards. The latter, equipped with late-model Soviet armored fighting vehicles

(AFV), were in the positions shown as Objectives Norfolk, Dorset and Bonn, screening Iraq's withdrawal from Kuwait.[4]



The 2d Armored Cavalry (Col. Holder) was on the Corp's right (south) flank. Behind the 2d ACR was the 1st Infantry Division (Mechanized) (MG Rahme), racing to pass through the 2d ACR to form on line with the 3d Armored Division (MG Funk) and the 1st Armored Division (MG Griffith). At 1525, passing 65 Easting[5] (Phase Line Tangerine), the 2d ACR had its 2d Squadron on the north, its 3d in the center, and its 1st in the south. Most of the cavalrymen sensed that the enemy was near. A sandstorm was blowing under a low overcast, often reducing visibility to less than 1000 meters. There was neither air support nor aerial scouts. An order was passed to the lead elements to advance to 70 Easting, and to wait there for further instructions.

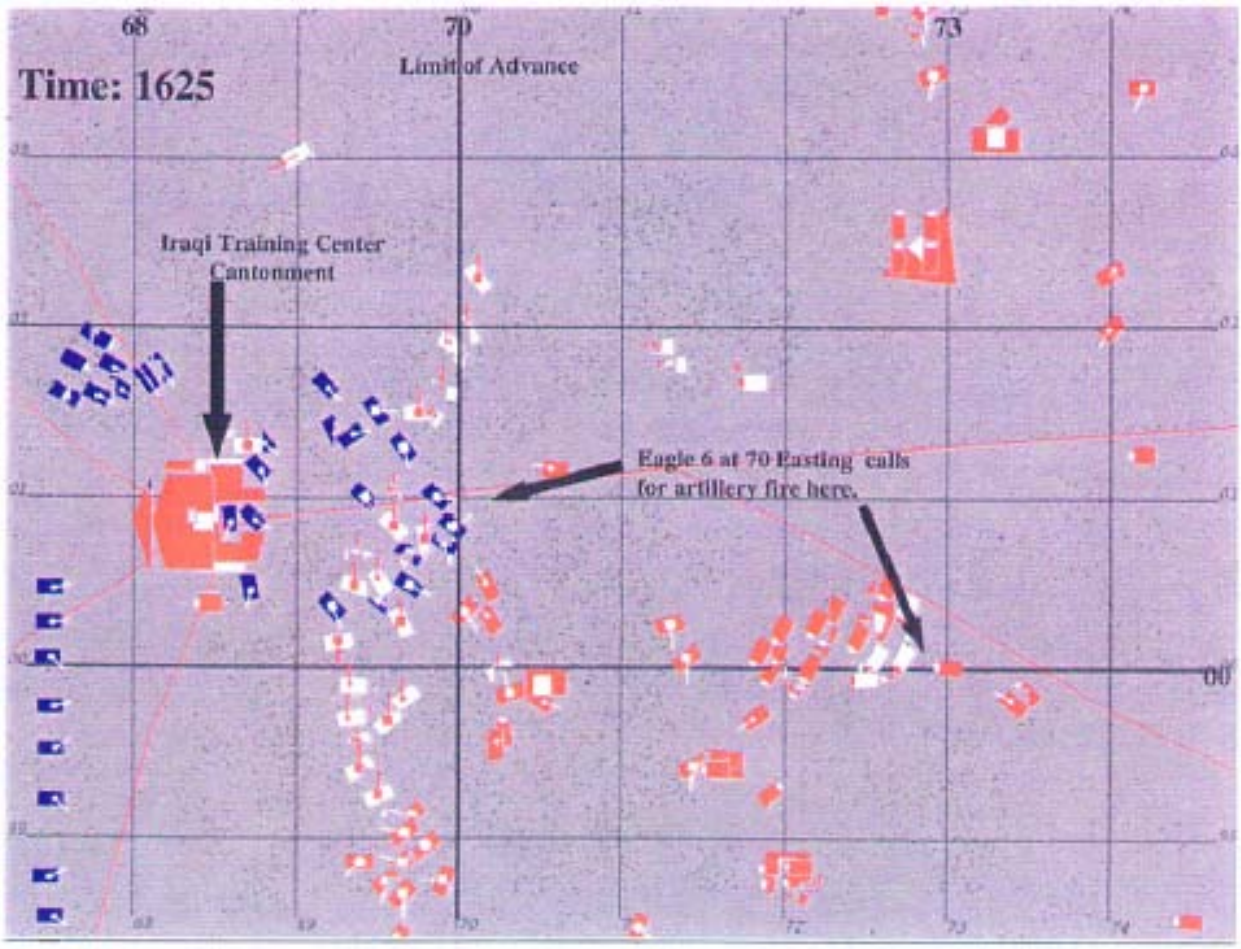
At 1553, among the most advanced elements of VII Corps were Ghost and Eagle Troops[6] of the 2d Squadron, 2d Cavalry, moving abreast at 25-30 miles per hour, approaching 67 Easting. Iron Troop of the Third Squadron was to their southwest, nearing 65 Easting. Eagle's scouts (in Bradley AFV) on the troop's southern flank were echeloned back to keep Iron in sight.



The diagram is a plan-view screen-capture. The plan-view was chosen for the experiment because it provides a birds-eye view of friendly and enemy positions, records time, and facilitates changing the scale and speed of the action. The solid blue and red icons - scaled up x50 an actual vehicle - mark the positions of AFV; a tank bears a white dot and line to indicate the azimuth of its gun, while an infantry fighting vehicle bears a

lesser white line. (In subsequent frames, whitened icons identify vehicles that have been hit and destroyed). The larger, red polygons show Iraqi buildings or other structures.

Minutes later, lead 8radJeys of Eagle Troop came under fire from automatic weapons positioned in the building complex shown in the center of the screen (between 68 and 69 Easting). Eagle had driven into the Republican Guard's armor training center. Captain McMaster, commanding Eagle Troop, decided to hit the enemy buildings hard and to bypass the complex to the north. He brought all 9 of his Abrams tanks on line to fire a volley of 120mm HEAT rounds into the complex, suppressing the enemy fire. As Eagle swung past the buildings the troop saw to its front approximately 30 T-72 tanks and a dozen BMP in revetted positions, interconnected by infantry-manned trenches. Without hesitation, McMaster attacked southeasterly, knifing through the enemy defenses.



The commander of the enemy brigade, expecting the Americans to advance up the roads to the Training Center, had oriented his force to the southwest. His tankers had set their sights at 1800 meters, the standard Soviet battle range, and presumed that Americans were firing from the halt, as they were trained. Many Iraqis shot back, but their fire was wildly inaccurate. The Americans, of course, were shooting on the move aided by gun stabilization. Eagle's AFV commanders opened at ranges as great as 2400 meters, consistently fired first, and used their thermal sights and laser range finders for precision gunnery. By 1625, as the diagram shows, all enemy AFV in range were flaming, and Iraqis were surrendering. The Iraqi commander later reported that over the

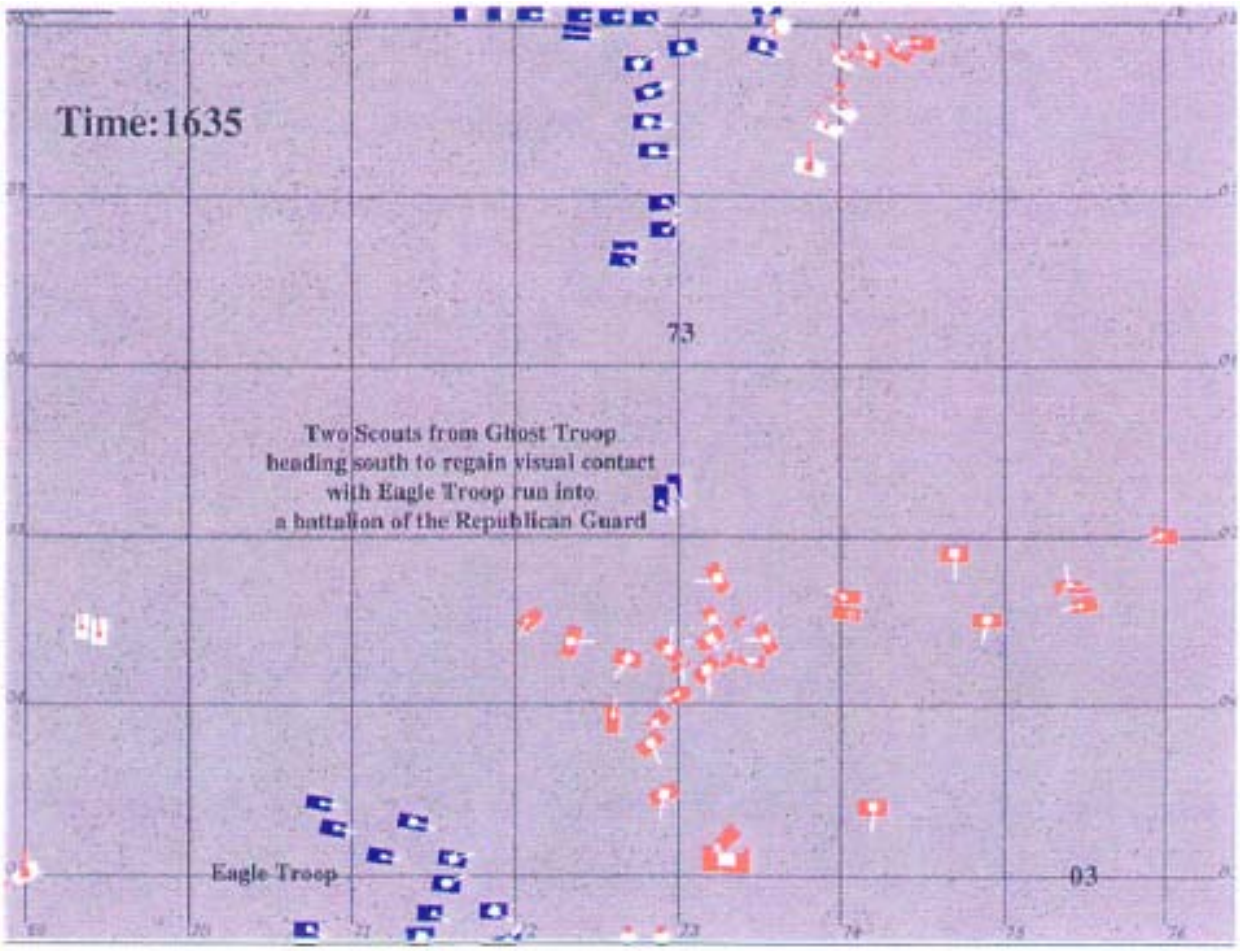
preceding five weeks he had lost only 2 of 39 tanks to air attacks, but that in less than 6 minutes, Eagle troop had annihilated his entire command.

However, McMaster's aggressive attack had crossed into the path of the Iron Troop. Moreover, Eagle could see a much larger enemy force just out of range to the east. The Squadron Commander directed that Eagle turn northeast. McMaster complied, but at 1625, to cover his right flank, he requested artillery fires at "grid 730005." There ensued a classic example of the fog of war (tape-recorded as it happened): the Fire Support Officer, apparently believing that Eagle troop was still short of 70 Easting, the Limit of Advance, responded "Roger, grid **7005**." This exchange was repeated twice more. McMaster, fearing that the artillery would shoot into Eagle at "grid 7005," called "Cease Fire!" and moved without supporting fires, traveling for 10-15 minutes vulnerable from the flank.

Loitering, AFV-killing missiles organic to the troop -e.g. AFSS in lieu of 4.2 inch mortars - could have served to secure the exposed flank of the troop on the move, and to confuse and to inflict losses on enemy forces that had been located, but were beyond range of direct fire. There is, of course, the possibility that the low ceiling and the blowing sand would have interfered with the missiles, but McMaster's judgement is that they would have worked, especially if they had thermal seekers.

In the meantime, another threat developed to the northeast. Ghost troop had detailed two of its scout vehicles to keep Eagle in sight, but these had been delayed by an enemy minefield, and had dropped behind, When firing flared between Ghost and the Iraqis, the scouts moved rapidly to join the fray, but were ordered to find Eagle. As the two scouts

moved south, they ran into a large armored force. Cautiously, they inched forward. As they closed to within 400-500 meters, they could see that they had stumbled upon an enemy battalion.



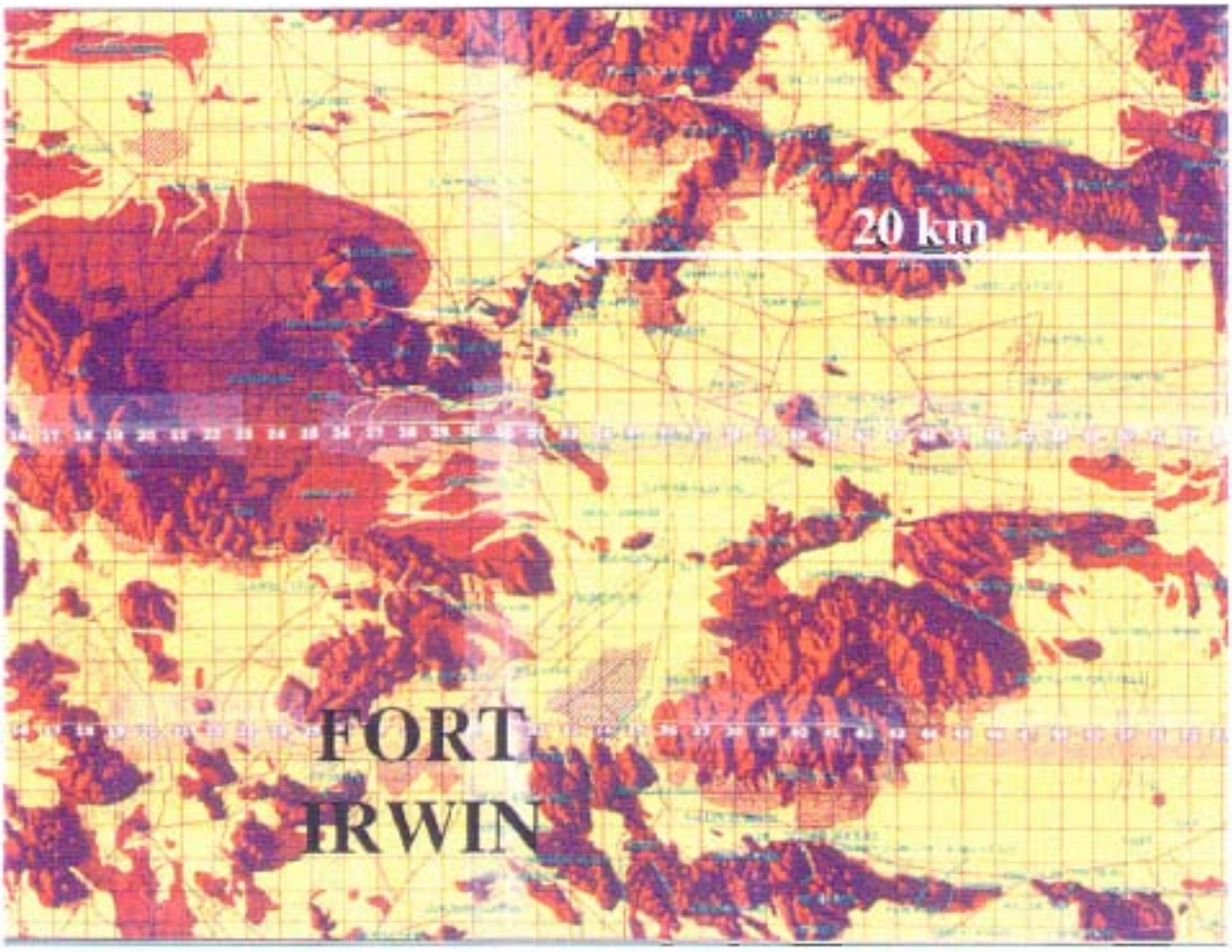
The two scout vehicles prudently hunkered down, but succeeded in raising Eagle on the radio to inform them that there was a large enemy force to their north. For the next 15 minutes, they coordinated with Eagle Troop as it turned to face the new foe. When Eagle opened fire, the Ghost scouts fired TOW missiles into the enemy, and withdrew northward. Within 30 minutes, the entire Iraqi force between Eagle and Ghost was in flames.

Loitering missiles could have been a genuine force multiplier, enabling the two Ghost scouts to engage the enemy battalion without revealing position. With reliable "blue" situation awareness, they could have collaborated with Eagle, designating precise targets for missile strikes synchronized with Eagle's attack.

The fighting continued until after 1800. Neither Eagle nor Ghost sustained casualties. While direct fire engagements accounted for most of their kills, the cavalry's mortars and howitzers were not idle. The 2d Squadron fired 2000 howitzer rounds at targets beyond the range of its Abrams and Bradleys. Regimental artillerymen fired 128 tank-killer howitzer rounds and 12 MLRS rockets (130,000 bomblets) on a distant target located from a recent aerial photograph, a strike that subsequent inspection showed destroyed a company of tanks and 40 trucks. Almost all the enemy targets were static, and the revetments thrown up around their AFV were inconsequential: the American l20mm tank round could easily penetrate through the dirt wall and the tank as well. Nonetheless, the enemy AFV would have been more easily found by, and would have been more vulnerable to, top-attack missiles.

Loitering missiles could have been used by Eagle and Ghost to extend their control eastward, and by Iron to attack the enemy force out of range to its front. Collaborative engagement by Iron and Eagle would have been possible, with Eagle pinpointing enemy vehicles to be attacked by Iron's missiles.

Experiment 2: Task Force XXI AWE



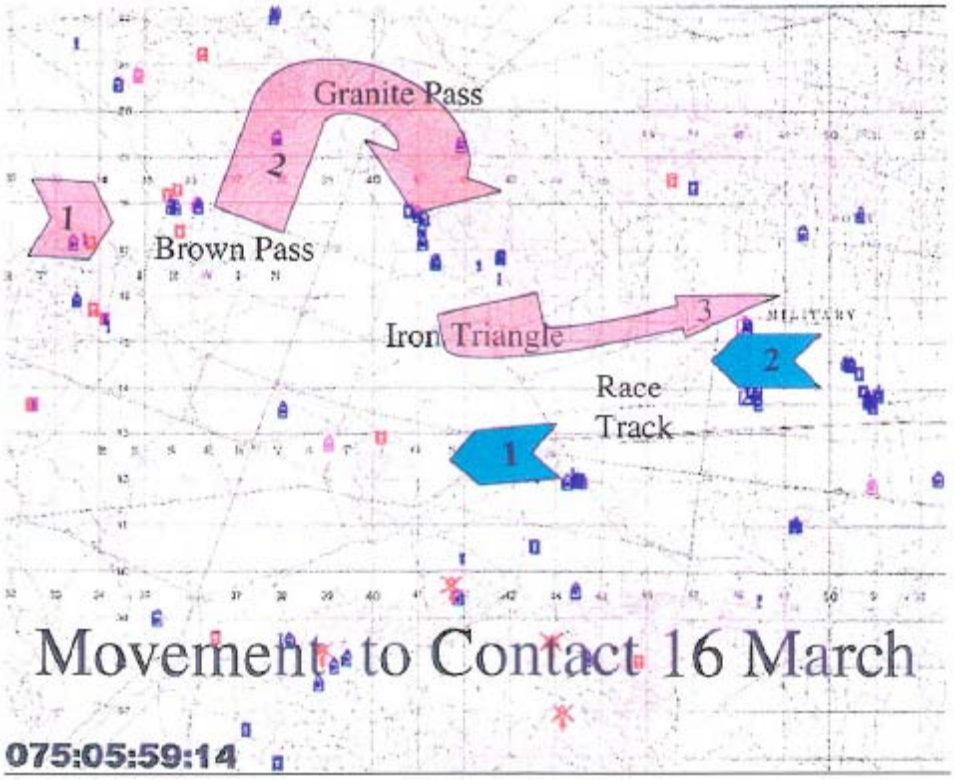
The terrain at the NTC is well illustrated on this picto-map: rugged mountains jutting out of the high Mojave Desert dominating deeply eroded valleys; countless de files that constrain the movement of mounted forces; observation, fields of fire, cover and concealment that vary from one to another of the 1 kilometer grid squares shown. The arrow on the map is 20 kilometers in length, the assumed range of the AFSS missiles.

The Blue Forces (BFOR) were contending with a new command and control system. Moreover, they were conducting operations against the best-trained unit of the U.S.

Army, the NTC OPFOR, who knew well how to exploit the terrain at Fort Irwin, and to pose a formidable and continuous challenge.

Before we move into the analyses of some of these battles, it may be appropriate to explain how the OPFOR "wins" consistently at the NTC. Knowing the "going" thoroughly, they employ a powerful combination of deception, swiftness, and mass. They usually present to BFOR a medley of feints and false indicators to flood BFOR intelligence with a bewildering set of enemy capabilities, and to draw BFOR fires upon diversionary targets. In the midst of confusion they then move at top speed to concentrate an overwhelming mass of armor against some pivotal BFOR unit. Analysis of NTC engagements shows that BFOR units pick their way through the boulders and washes at about four hundred meters per minute (15 miles per hour). OPFOR can maintain speeds twice as fast, and presses its attacks as rapidly as the terrain and their vehicles will allow, thereby literally moving inside the BFOR artillery decision loops, taking full advantage of the queue of fire missions waiting to be serviced at the artillery fire direction computer. A BFOR observer detecting the OPFOR concentration may call for priority of fires, but by the time his request has worked its way through the Direct Support and General Support Battalions - and perhaps the Division Artillery - the OFOR is upon the defenders, and often the observer himself has been overrun.

In the close fight BFOR units bring as many direct-fire weapons as can be brought to bear upon the selected BFOR unit, and simply overwhelms the defender at whatever the cost. These tactics figure in the following examples.



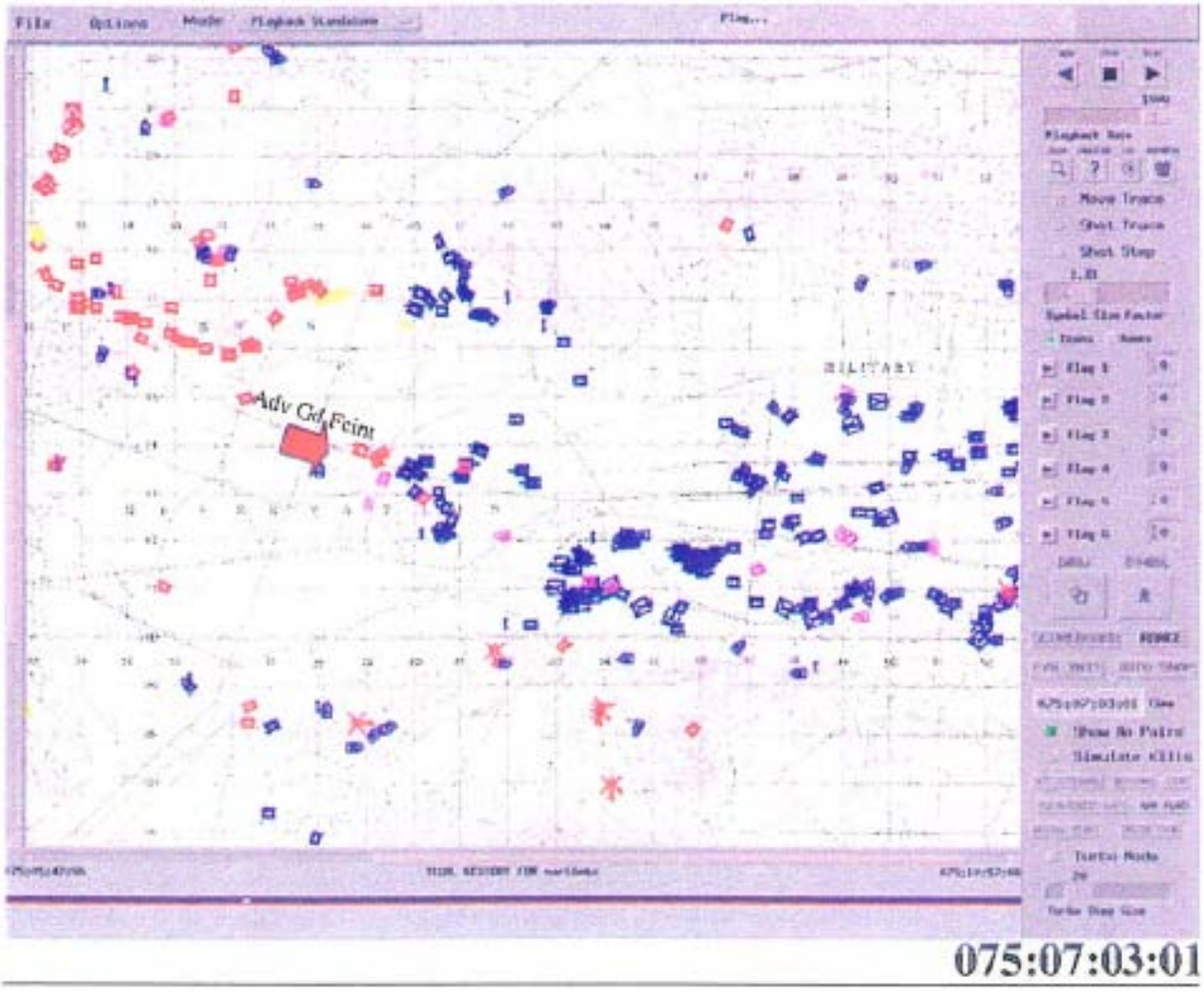
The date is March 16, 1997 (Day 075), and the time is 05:59 in the morning. Reconnaissance elements from both sides have been active throughout the night. The bulk of Blue Force (BFOR) is off the map on the right (east); the main body of Opposing Force (OPFOR) is off the map to the left (west). Both have received orders to attack at 0600, and a meeting engagement on the ground displayed is imminent. The situation depicted shows the disposition of reconnaissance elements. Scouts from both sides have been positioned to overlook BROWN PASS on the western entrance to the valley. Note that OPFOR has inserted observers onto the high ground overlooking IRON TRIANGLE from the south. BFOR has posted a security element northwest of IRON TRIANGLE, designed to preclude OPFOR reconnaissance elements from occupying critical terrain. At

0545 OPFOR fired a persistent nerve agent south and east of RACE TRACK; BFOR has not yet reacted.[7]

The BFOR commander's plan is to advance westward up the valley over RACE TRACK with two battalion Task Forces echeloned to the right [blue arrows I and 2]. The lead Task Force is to seize high ground north and south of IRON TRIANGLE, and the following TF will then attack to destroy remaining OPFOR.

OPFOR has prepared four options, the choice among them to be determined when the BFOR plan becomes clear. One of these, Plan FORK is shown: if BFOR attacks up the valley over RACE TRACK, OPFOR Advance Guard is to exit Brown Pass [red arrow 1], hook northeast [red arrow 2] to control IRON TRIANGLE and to facilitate the passage of the massed regiment in an attack along the north edge of the valley [red arrow 3].

Below is the display used for analyses. On the right are various controls and a timer. In the meeting engagement sequence, the data are presented in frames about 30 seconds apart, and these can be displayed frame by frame, or as a "movie," forward or reverse.

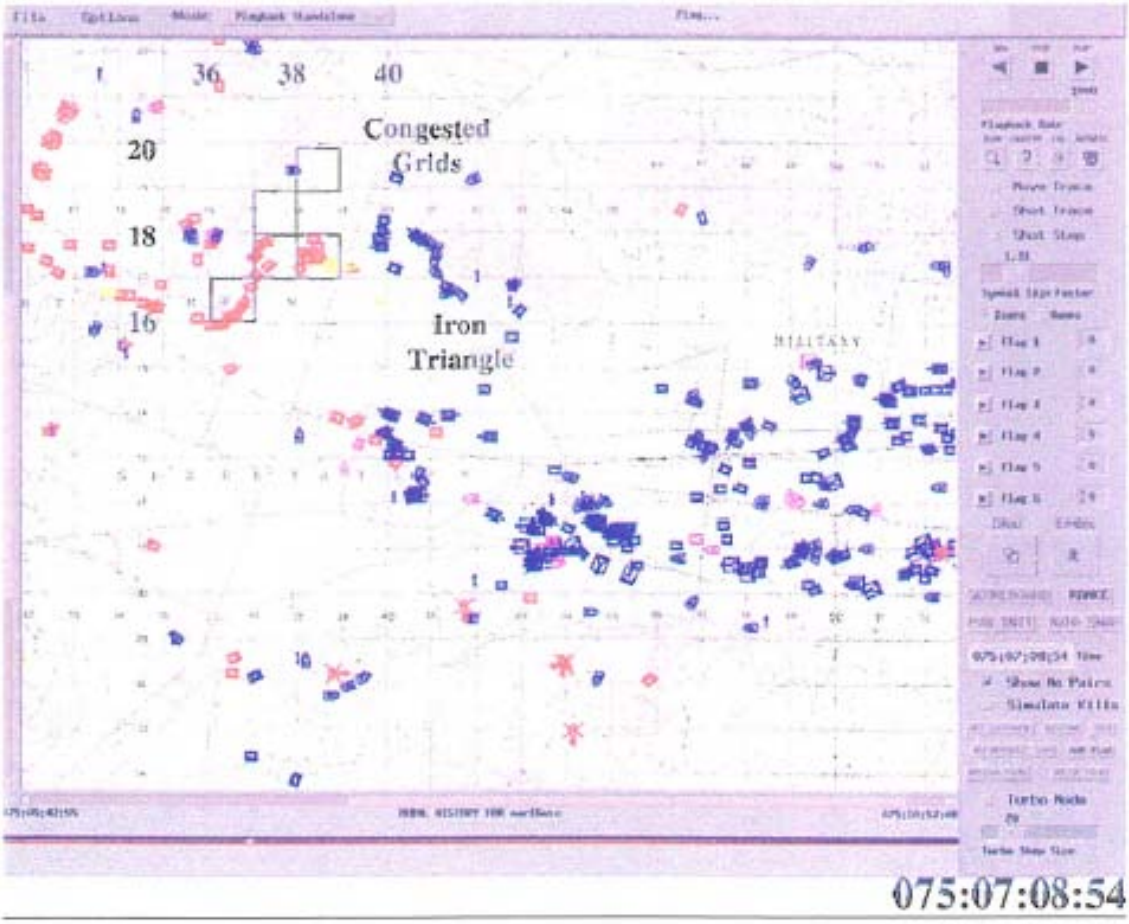


One hour later BFOR had advanced with two task forces in echelon right. The lead TF had occupied IRON TRIANGLE and the high ground to its north and south. The lead task force sent a team north of IRON TRIANGLE and the TF (-) occupied high ground to the south. However, the following BFOR TF had difficulty in locating the persistent nerve agent vicinity RACE TRACK, and was both delayed and disorganized. OPFOR exacerbated the resultant confusion by firing two volleys of F AS CAM to extend the obstacle northward, and three lines of non-persistent chemical agents to the southeast of the obstacle so that the northeasterly breeze would drift the gas over forces struggling with the obstacle.

OPFOR elected to execute Plan FORK. The screen portrays the Advance Guard on the west entering the valley from vicinity BROWN PASS. The foremost team of the Advance Guard is making a diversionary attack on the BFOR elements south of IRON TRANGLE, while the remainder turns northeast per plan.

BFOR sought to deny BROWN PASS with a FASCAM volley, but OPFOR quickly moved south of the obstacle via an alternate route (BROWN CUT).

Positioning sensors in the defiles, and using returns from these to cue FASCAM and AFSS might have better defended BROWN PASS and its environs.

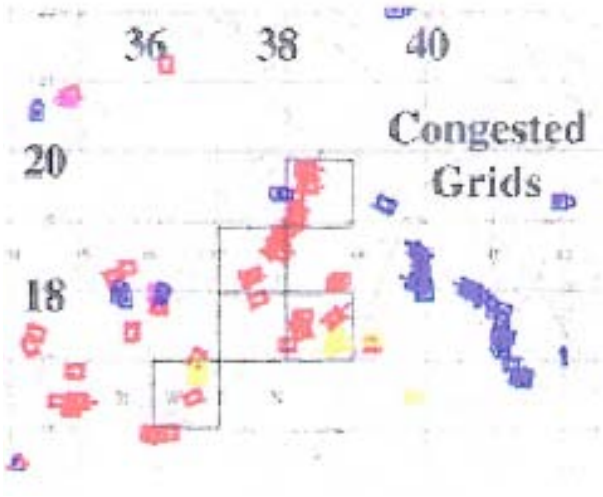


The OPFOR Advance Guard moved briskly, at about 30-35 mph (nearly I grid square per minute). At grid 3817, OPFOR's lead team encountered a stout BFOR defense,

causing the OPFOR column to jam up. The Advance Guard commander ordered his unengaged elements to move northeasterly toward the mouth of GRANITE PASS to envelop the BFOR defenders. The screen highlights several grid squares useful for assessing the locus and persistence of the target sets engendered by the OPFOR congestion. [IDA defined lucrative target as ten or more AFV per 1 square km. E.g., grid squares 3616 and 3817 at the time shown.]

The BFOR defense could have been more effective had loitering missiles been used to extend the range of the Abrams and Bradleys. For targets within sight, but out of range, the defenders might have used their laser range finders to pin-point targets for the missiles.

At 07:18 the OPFOR flanking maneuver was well underway. The snapshot below shows the same five grids highlighted on the previous screen. Just ten minutes later the lucrative target sets have moved over two kilometers to the northeast, to grids 3718 and 3819.



OPFOR feinted at several places to the south and center of the BFOR positions, but the OPFOR main body was pressing at top speed toward BROWN CUT to reinforce its Advance Guard. By 7:28 the OPFOR Advance Guard had fixed the north flank of BFOR, and lead elements of the OPFOR main body have begun to move through. By 7:38 OPFOR was rolling up the BFOR flank. Dense target arrays had been presented, but these were usually of short duration:

Grid Square	Start	End	Persistence
3616	7:09	7:14	5 minutes
3616	7:24	7:38	14 minutes
3717	7:13	7:19	4 minutes
3817	7:09	7: 19	10 minutes
3718	7:12	7:19	7 minutes
38 19	7: 14	7:35	21 minutes

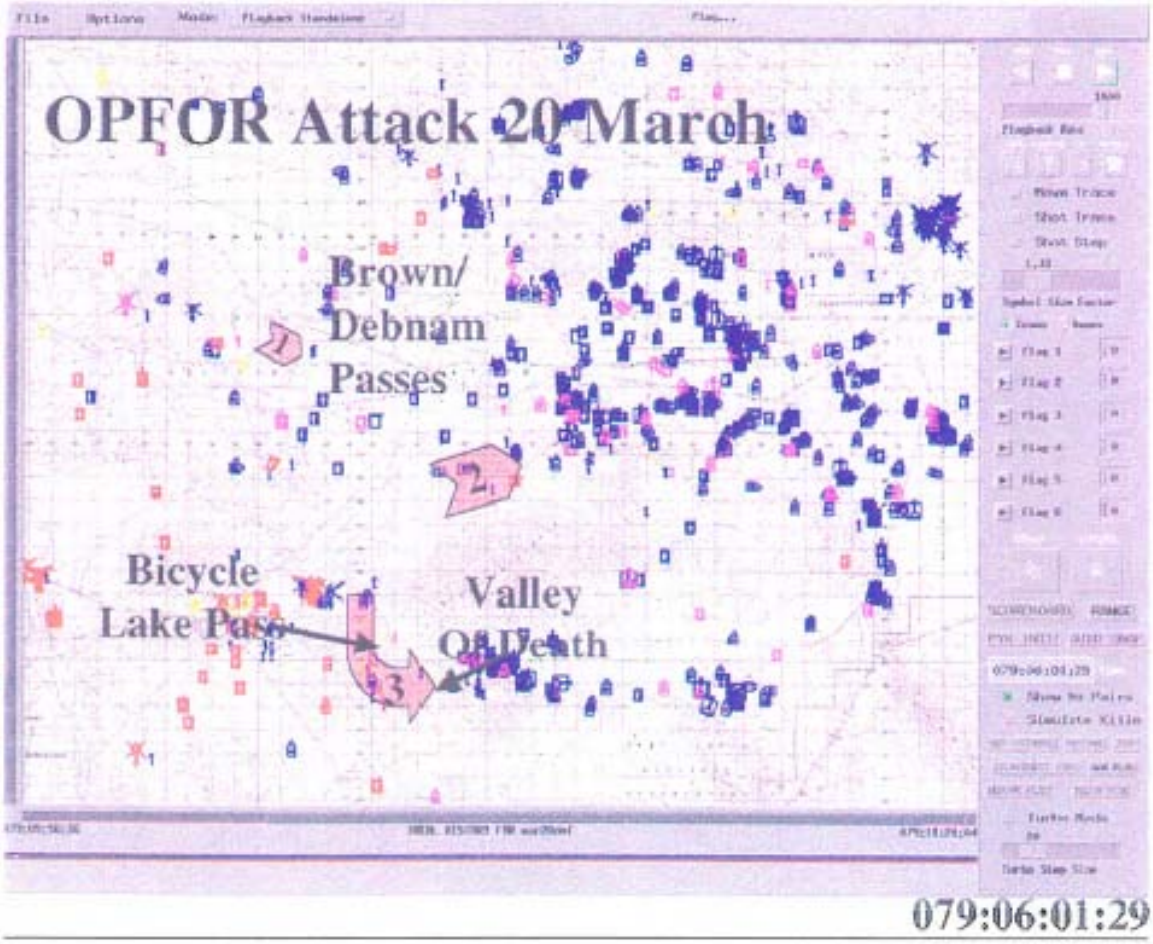
Of the grid squares examined during this half-hour, 3616 and 3819 offered the greatest potential for BFOR targeting. Over the entire engagement, ten or more OPFOR AFV were passing through 3616 from 7:49 through 8:29, nearly an hour in all.

Loitering missiles on call of the BLUFOR armor team commander in the north could have extended the reach of his defense, enabled engagement without position-disclosing muzzle flash and blast, and exacted a heavy toll for the enemy's massing his armor on the flank.

Planning for and synchronization of SAS with AFSS will have to be artful. BFOR should have positioned ground sensors at key defiles such as 3616 and 3819, and as these sensors became active, supplemented them with aerial overwatch. Such arrays could have reported the particularly lucrative target sets in locus and time, and could have cued AFSS.

The BFOR commander at the scene - the battle captain - ought to have had an opportunity to prepare the battlefield by setting up sensor arrays, and have been furnished sufficient AFSS fire units to destroy the lead OPFOR attackers. With access to additional AFSS assets he could have inflicted a decisive defeat. The timelines here seem to make it imperative that the forward commander has direct control of both the sensors and his supporting fires.

By 1056 on 16 March the exercise terminated. OPFOR had broken through the BFOR defenses, and was in a position to deliver fires or to maneuver throughout the BFOR rear.

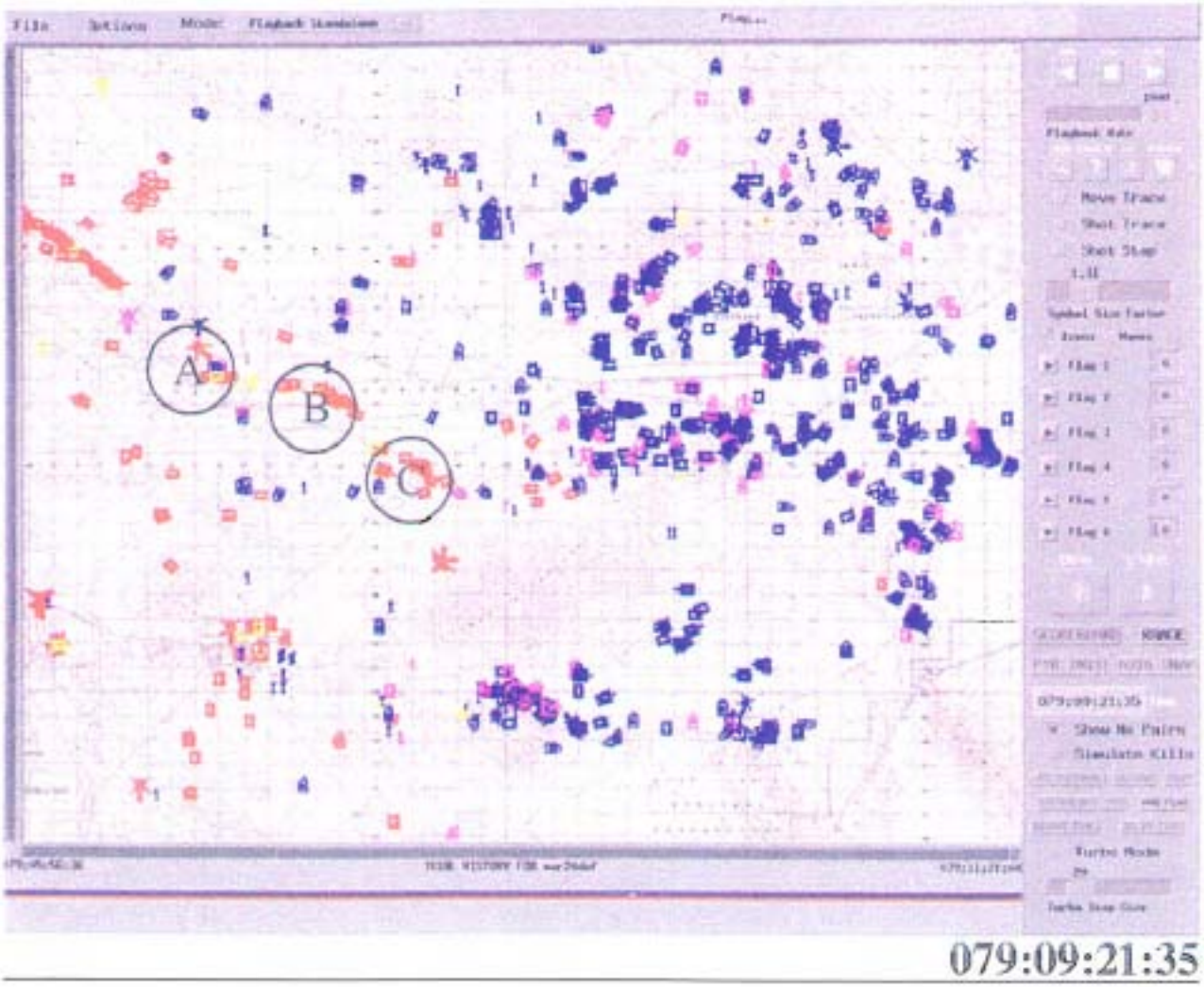


It is 20 March, 1997. In the narrative that follows, the reader is asked to imagine that the action takes place on March 20, 2012, and that DARPA's SAS and AFSS figure directly in the battle.

BFOR had been provided with 48 tanks, 46 Bradleys, and a contingent of light infantry, and assigned the mission of defending the sector shown - largely the ground over which it had attacked on 16 March. The BFOR commander had organized the terrain under three task forces, one in the south assigned to emplace and to defend

obstacles in the Valley of Death, and two task forces in the north tasked to defend vicinity IRON TRIANGLE and RACE TRACK.

OPFOR, as the numerous purple icons marking destroyed BFOR vehicles indicate, had been probing the BFOR position from the air and on the ground. The OPFOR commander, with twice the number of AFV available to BFOR, had prepared several attack options. In the light of what his reconnaissance had shown him, he decided to launch the attack diagrammed. His plan called for his Advance Guard to pass through the Brown/ Debnam Passes into the valley [red arrow I] for a diversionary attack into the BFOR center [red arrow 2J. The OPFOR main attack, however, was to strike southeast through Bicycle Lake Pass and the Valley of Death [red arrow three}, and thence into the BFOR left rear.



Throughout the early morning of20 March, OPFOR conducted a series of demonstrations and hit and run attacks across the BFOR front. In front of the center Task Force, these activities were particularly intense, causing that Task Force commander to request Discoverer II coverage of the Brown/Debnam Passes.

Around 0845, the OPFOR Advance Guard began its passage of defiles leading into center sector, and the Discoverer II reported the movement. At 0900 the center Task Force commander laid down three sensor fields, shown above as A, B, and C, each with a coverage about four kilometers in diameter, to supplement the Discoverer II coverage.

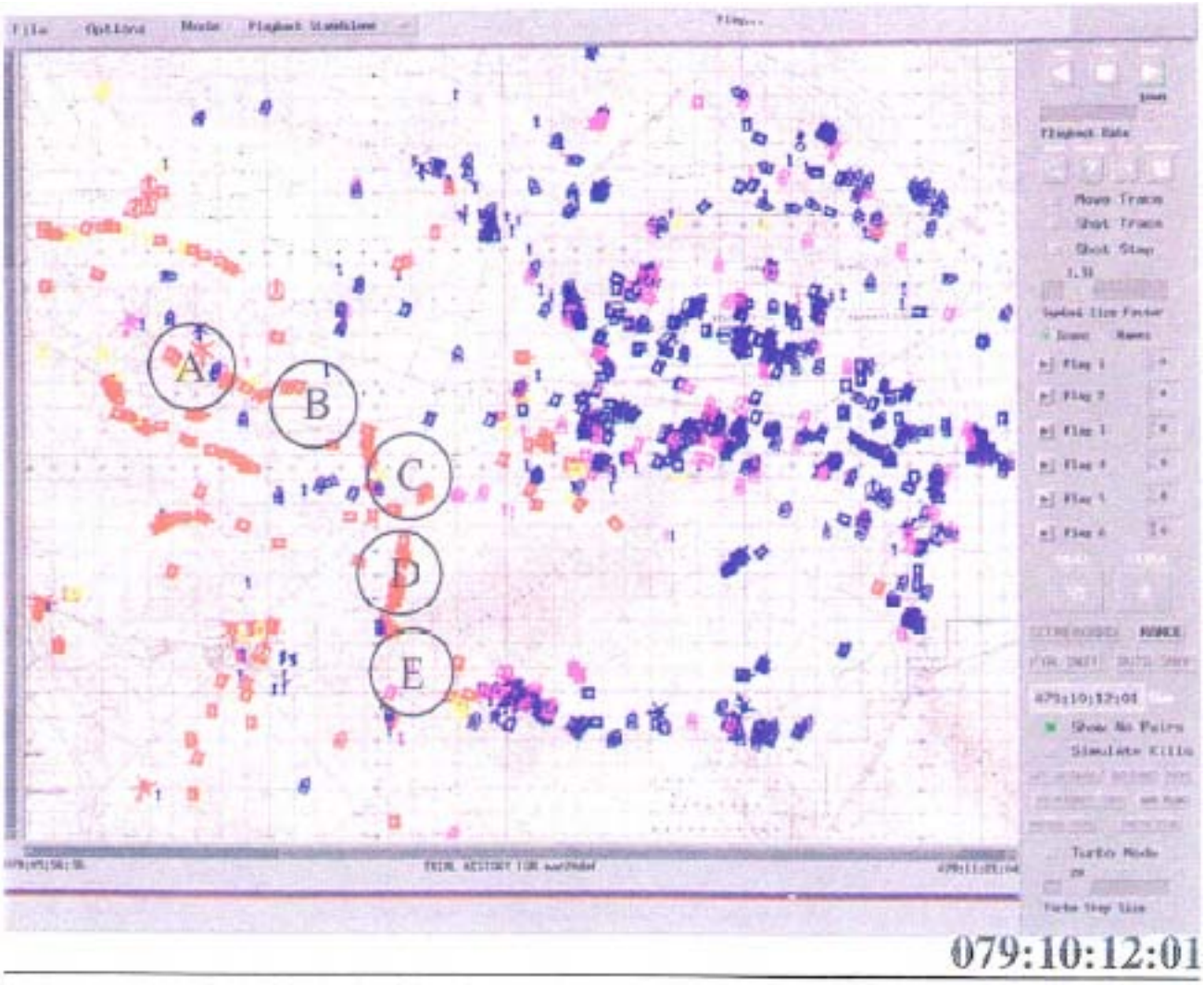
At the time shown, indications were that the OPFOR had committed at least two company-sized OPFOR units, moving at high speed, to attack BFOR's center Task Force.

Spaced-based radar coverage can focus the emplacement of more discriminate sensor fields, or deployment of micro-AV. Together these can produce precise targeting information for AFSS missiles. With the information shown, two sets of ten missiles could be launched, flown to B and C, to attack. The seekers on the missiles would confirm and extend the coverage of the sensors.

Five minutes later only a few AFV could be detected moving within A, B, or C, but there clearly was an attack underway upon the center Task Force. Ten minutes later, sensor field A reactivated, and the center Task Force reported that OPFOR was trying to envelop their south flank. The TF called for another AFSS strike for A, and summoned attack helicopters to support its south flank company team.

At 1000 all three sensor fields - A. B, and C- were detected significant activity, but C reported the enemy moving southward, not eastward. This sensing of OPFOR redirection caused the BFOR commander to direct the emplacement of additional sensor fields between his center and south task forces.

Four minutes later the additional sensor fields, D and E, were in place, and confirming that OPFOR AFV were moving rapidly down the road toward Bicycle Pass.



An AFSS strike was launched for D at 10:10, and at 10:14, ten missiles, delivered in rapid succession, struck into the OPFOR column. By 10:18 it had become clear that OPFOR elements are converging on E, (Bicycle Pass), and another AFSS strike was launched on OPFOR in that area. At 10:33 additional AFSS strikes often missiles each were fired at B, D, and E respectively.

To summarize the firings of I O-missile salvos:

Area	TOT
A	0936
B	0922, 1033
C	0922
D	1010, 1033
E	1021, 1033

A total of 80 AFV-killing missiles were delivered, flown to precisely located targets, and attacked by diving from above with terminal guidance. Assuming 90% probability of hit upon targets counted in the various sensor fields, the AFSS eliminated some 72 OPFOR AFV.

In the actual 1997 AWE, the OPFOR had a total of 224 AFV - 63 tanks and 161 BMP. Around 1100 on 20 March, 1997 the OPFOR succeeded in massing before the BFOR defenses in the Valley of Death, crashed through, and turned the BFOR southern flank. But that success proceeded from accepting 64% attrition: OPFOR emerged from the fight with only 70 AFV. Had OPFOR lost 72 AFV forward of the BFOR defensive positions to SAS and AFSS strikes, as per above, even before it could deliver its main attack on the BFOR defenses in the Valley of Death, there can be little doubt that the outcome would have been quite different.

Some will argue that OPFOR, faced with the sensors and shooters hypothesized here would change tactics to adapt to new circumstances. If so, BFOR would have exercised control of the battlefield that is not now possible, denying OPFOR two of his principal tactical advantages: speed and mass.

The conclusions of the two IDA experiments were as follows:

1) **Direct fire -fights among AFVs are usually of short duration: 15 minutes or less.**
2) **Formations of AFV on the move in NTC terrain present dense target arrays that persist for less than ten minutes.**
3) **A non-ballistic missile with loiter time of up to 15 minutes would be useful:**
4) **To extend the control of U.s. AFV (range, lethality) by exploiting their fire control and the Battlefield Combat Identification System.**
   a) **To cover the front, flank, or rear of AFV on the move.**
   b) **To synchronize maneuver with direct and indirect fires.**
   c) **To foreclose having to disclose position by muzzle flash**
   d) **To engage transient targets identified by collaborative sensors.**

The Army Science Board panel on Technology for the Army After 2010 has incorporated in its report to the Chief of Staff and the Secretary of the Army IDA's account of using past simulations to illuminate the future.

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1 Webster's New Collegiate Dictionary.
2 Major General Robert H. Scales, Commandant, U.S. Anny War College
3 This article is illustrated with frames from the imagery that supported the analyses , but the reader should understand that the analysts viewed these data in motion, and were able to control the speed of display, to change scale at will, and to record times, to measure ranges and velocity of movement, and to observe the result of firing events,
4 Scales, BGen. Robert H. Certain Victory. OCSA, Department of the Anny, 1993. Pp. 262-263.
5 In lieu of maps, the cavalrymen were navigating with GPS and a numbered grid of one-kilometer squares, the north-south lines of which were referred to as "(number) Easting."
6 The cavalrymen used a phonetic name for each troop that began with the troop's letter designator.
7 Red icons indicate OPFOR AFV; the3e rum yellow when hit. Blue icons are for BFOR IFV, which turn purple when hit.