



Manpack terminal,
Enduring Freedom.

55th Signal Company (Jeremy Colvin)

Ground Radar Surveillance and Targeting

By PRICE T. BINGHAM

Developing the capability to quickly defeat an enemy on land, with fewer and more agile forces, is a significant challenge for the military. Desert Storm, Allied Force, Enduring Freedom, and Iraqi Freedom involved severely punishing or defeating enemy

ground forces. Although many thought those operations would require a large number of heavily armed troops in close combat, logistic difficulties and the concern over casualties made such operations unsuitable in three of the four conflicts. Those realities will likely have an even greater impact in the future because of the threat of anti-access capabilities and weapons of mass destruction.

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Scud missile bunkers,
Desert Storm.

U.S. Navy

Military transformation is feasible in part because of wide-area, high-performance ground moving target indicator (GMTI) radar capabilities. Today the E-8 joint surveillance target attack radar system (JSTARS) of 116th Air Control Wing is their principal source. Various systems will offer such capabilities in the future including Global Hawk unmanned aerial vehicles, B-2 bombers, F-35 joint strike fighters, F/A-18E/F and F/A-22 aircraft, aerial common sensors, multi-sensor command and control aircraft, and space based radars.

Ground radar disrupts and dislocates enemy forces through the integration of maneuver and standoff attacks. Using these means rather than mass and attrition can transform war by making it possible to defeat land forces quickly and decisively with fewer and lighter forces while reducing risks to military and civilian personnel. Despite this potential, use of E-8 ground radar systems in recent conflicts reveals obstacles that will require a transformation in training.

Enabling Transformation

Ground radar can enable military transformation because almost every army, even primitive forces such as the Taliban, relies on vehicular movement for offensive and defensive operations. Before the massive and heavily mechanized Easter offensive by the North Vietnamese in 1972, their operational

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effectiveness depended largely on logistic support along the Ho Chi Minh trail. Commanders have used movement to gain advantages in force ratios, position, and surprise, but during the 20th century most armies came to rely on motorized vehicles. Today that dependence is greater than ever. Vehicles furnish not only mobility but heavy firepower, armored protection, and logistic and engineering support. And with the capability of the Armed Forces to precisely attack fixed targets, vehicles such as missile transporter

erector launchers are being used increasingly to improve survivability.

JSTARS is unique in its ability to turn reliance on vehicular movement into an information advantage in both peace and war. With ground radar, the system can reliably detect, accurately locate, and precisely track vehicles from a significant standoff distance within a large coverage area even in darkness and bad weather. It can identify vehicles being tracked. Data on movement can be used to cue unmanned aerial vehicles with high-resolution but limited fields-of-view electro-optical/infrared sensors. This information, especially when collected over days or weeks and used as the context for integrating other forms of data, can provide unprecedented situational awareness of threats and opportunities.

If a vehicle being tracked by ground radar is identified as hostile, the E-8 crew and capable communications make it possible to exploit this real-time information by supporting air and missile attacks before the vehicle can threaten friendly forces. In a development with major implications for such targeting, tests in the affordable moving surface target engagement program have shown that ground radar information can be used in guiding seekerless weapons in standoff, all-weather attacks against moving vehicles. This capability, applicable to the

joint direct attack munition and missile systems, could reduce civilian casualties, collateral damage, and aircraft losses. Moreover, precise strikes on vehicles in all weather from standoff ranges might inhibit an enemy from risking militarily significant movements.

Perhaps the transformational importance of radar ground surveillance and targeting such as the affordable moving surface target engagement program can be appreciated by recognizing the limitations that faced the Armed Forces before those capabilities existed. Available sensors in the form of human sight and cameras could locate moving vehicles but only at short ranges and in daylight and fair weather. Commanders were thus denied situational awareness on the location, movement, and strength of

enemy forces. Fighter bombers on armed reconnaissance sorties provided the only means for detecting and targeting individual vehicles before they could engage in close combat.

Unfortunately, armed reconnaissance has proven inefficient and often ineffective in finding and attacking mobile forces. The limited fields of view of a fighter-bomber pilot was one reason armed reconnaissance fell short. Limited vision made it necessary to fly many sorties to search a large area for vehicles. It also made it necessary to search at low altitudes where an aircraft was exposed to short-range air defenses. Even when many sorties could be flown and the losses from air defenses were acceptable, operations in World War II, Korea, and Vietnam demonstrated that armed reconnaissance failed to locate and attack suitable targets. Camouflage, concealment, and deception often caused fighter-bombers to miss suitable targets or attack invalid ones like decoys or previously destroyed vehicles. More importantly, enemy land forces were able to reduce the risk of detection and attack by moving during darkness or bad weather.

The inability of the Air Force to find and target vehicles before they approached friendly land forces helps explain why it was necessary until recently to find opposing land forces through contact with friendly land forces, why until then victory depended on close combat, and how that created its own problems. Prevailing in close combat usually called for heavy land forces, which led to concerns over casualties. Deploying those forces also required significant time and resources. However, radar ground capabilities provide effective and efficient alternatives to relying on both close combat and visual armed reconnaissance.

With the development of the affordable moving surface target engagement program, high-performance ground radar surveillance and targeting systems are transforming operations against armies much as radar did

against air forces. Radar made it possible to detect, locate, and track aircraft flying in a large airspace even when light and weather were poor. As early as the Battle of Britain, where radar provided unprecedented wide-area situational awareness, the use of maneuver by the Royal Air Force to engage or avoid enemy aircraft was enhanced and the danger of surprise was reduced. When radar was applied to weapons, it became possible to precisely target aircraft from a significant standoff distance in both darkness and bad weather.

Today ground moving target indicator radar offers similar capabilities against vehicles that move over a large area. In contrast to air warfare, however, only U.S. and allied forces (several European nations and NATO members) have these high-performance systems. Moreover, even if an enemy obtained such technology, it would not gain an advantage because the effective operation of the systems, unlike radar against air forces, requires an air- or space-borne platform, and the Pentagon can deny the ability to operate such a platform. Yet despite the immense potential of ground radar for transforming operations, a review of recent conflicts reveals that realizing it has been slow. Iraqi Freedom is not addressed here, but early reports indicated that fully utilizing radar surveillance and targeting capabilities remains a problem. Some personnel

manning the Combined Air Operations Center were reportedly unfamiliar with the system.

The Gulf War

Because JSTARS was intended to counter the Warsaw Pact, many believed that it was no longer needed with the end of the Cold War. However, the employment of two prototype E-8A aircraft during the Gulf War quickly proved otherwise. During their attack on Al-Khafji only two weeks after the system reached the theater, the Iraqis learned that they could no longer assume that moving at night protected them from detection and attack. E-8A ground radar made it possible to locate enemy units and target them with devastating air strikes before they could close with Coalition forces. In addition to enhancing the efficiency and effectiveness of air attacks, many deep within Kuwait, the system helped Coalition leaders understand that the Al-Khafji attack was not a feint designed to mask a larger offensive.

During an offensive in some of the worst weather of the war, E-8A ground radar quickly revealed enemy efforts to reposition their forces, providing advancing Coalition land forces with information to defeat the Iraqi maneuver before it became a serious threat. When the Iraqis began pulling out of Kuwait, GMTI radar surveillance indicated that a large-scale withdrawal

Desert Storm

The United Nations called on Iraq to withdraw its invasion forces from Kuwait in August 1990. Then, in response to requests by Saudi Arabia, the United States formed a coalition and sent troops to the region. The United Nations authorized the use of force if Iraq did not withdraw by mid-January 1991. Coalition forces of some 700,000 were fielded by January 1991, including 540,000 Americans. Desert Storm commenced on January 17 with airpower focused on enemy air defenses before turning to infrastructure, oil refineries, and military targets. The ground offensive began on February 24. Kuwait City was liberated in three days and the operation ended after only 100 hours. Although no official statistics exist, the estimated level of Iraqi forces in theater ranged from 180,000 to 630,000 with 8,000 to 100,000 casualties. In contrast, the Coalition lost only about 300 troops. A Security Council resolution in April required Iraq to destroy or render harmless its chemical and biological weapons, halt its nuclear weapons development, and eliminate its ballistic missiles with a range greater than 150 kilometers.

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had begun and provided targeting data to support air attacks along the so-called Highway of Death. Despite the description of attacks on that escape route, relatively few Iraqis were killed there; throughout the war they rarely stayed in place once their vehicles were targeted. Moreover, had the ground offensive not been suspended after only 100 hours, surveillance and targeting support might have played a major role in preventing Republican Guard divisions from escaping intact.

Ground radar surveillance and targeting contributed to Desert Storm by defeating enemy land forces despite major handicaps. One was that only two prototype systems were available, and they did not reach the theater until just before the air offensive. However, thanks to heroic efforts by the

JSTARS was not used to its full potential to help target mobile Serbian land forces

JSTARS team, composed of military and contractor personnel, one of the two systems flew every night of the war. But with only one system airborne and only at night, it was impossible to provide continuous ground radar coverage. Consistency was further reduced because commanders had urgent requirements across the theater for its unprecedented system capabilities. E-8As were often tasked during a single mission to conduct surveillance from the far west of Iraq (to look for Scuds) to the border between Kuwait and Saudi Arabia (where the Al-Khafji attack took place).

Since the system was still in development during the invasion of Kuwait, another handicap was widespread unfamiliarity with JSTARS. As the joint force air component commander noted, "We who were responsible for planning and orchestrating air operations had little appreciation of the system's capabilities and limitations."¹ Lack of familiarity extended to crews, which had to be trained while the systems were en route to the theater.

Even the concept of operation had not been fully developed. But thanks to the ability of the JSTARS team to refine

the system during combat and explain its capabilities, the Coalition quickly exploited advantages in ground surveillance and targeting.

Kosovo

In the case of radar ground surveillance and targeting, Allied Force did not begin where Desert Storm left off; JSTARS was not used to its full potential to help target mobile Serbian land forces. To some extent the failure to exploit the system from the outset of hostilities can be explained by major differences between the conflicts.

Unlike the terrain in Kuwait and southwestern Iraq, which is relatively flat desert, Kosovo is mountainous with heavy foliage that increased screening and made it more difficult for E-8A ground surveillance to detect,

locate, and track mobile forces, especially from the orbit assigned to the system. Another difference was that Ser-

bian forces faced little immediate danger from a land force. Thus they had scant need to move to develop advantages in mass, position, and surprise. By remaining dispersed they could avoid providing the large number of lucrative moving targets JSTARS detected in the Gulf War.

The lack of enemy land forces contributed to the failure of NATO to perform intelligence preparation of the battlespace until it was too late. Currently, only land components make such preparations. Task Force Hawk, the deployment of two battalions of Apache and other helicopters together with infantry, tanks, artillery, engineer, and headquarters assets, provided NATO airmen with expertise in

developing the ground order of battle, which significantly aided the employment of airpower.

Civilians the Serbs used for protection were another factor. Their presence led NATO to require positive visual identification before attacking targets to reduce harm to noncombatants. Operations revealed that ground radar surveillance could play a valuable role in target identification by providing cues to airborne forward air controllers and operators of unmanned aerial vehicles on locations where movement was occurring. JSTARS, Rivet Joint, forward air controllers, C-130 command and control aircraft, U-2s, and Predator unmanned vehicles were all linked. These cues made forward air control and unmanned aerial vehicles more efficient since targeteers did not have to conduct the initial search for movers using limited fields-of-view sensors.

Another difference was the impact of basing on JSTARS employment. Swiss and Austrian refusal to allow overflights required E-8s to fly a long distance to reach an orbit from their base in Germany, which reduced on-station time and increased air refueling.

Similarities to the Gulf War also limited the initial contribution of the system. Even though JSTARS was no longer a prototype, the fleet consisted of only four operational systems; thus for most of Allied Force only two systems were deployed in theater. But, as in Desert Storm, the team excelled in generating sorties between February 22 and June 28, 1999, flying 83 sorties for a total of 730.7 on-station hours. Yet even with this level of effort, the

Allied Force

After the failure of negotiations at Rambouillet in March 1999, NATO launched an air campaign designed to compel President Slobodan Milosevic of Yugoslavia to end abuses against ethnic Albanians by Serbian forces in Kosovo. Air strikes continued for 78 days and were halted in early June when Milosevic acceded to NATO demands to withdraw from the province. The Alliance generated over 38,000 combat sorties without any combat losses in the largest operation in its history. Allied Force was the third largest strategic application of U.S. airpower since World War II at the time, exceeded only by the Vietnam War and Desert Storm.

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JSTARS landing,
Iraqi Freedom.



116th Air Control Wing (Tom McKenzie)

limited number of aircraft and the distances involved prevented JSTARS from providing 24-hour coverage, which allowed Serbian forces to move without the risk of being detected, located, or tracked by radar.

A further similarity to the Gulf War was the lack of familiarity with system capabilities and limitations on the part of those responsible for air operations. That may explain why JSTARS was not deployed early in the crisis when vehicular information could have revealed the magnitude of the Serbian deployment. Once deployed, unfamiliarity also contributed to delays in including the system in the air tasking order and to placing the system in a less than ideal orbit. Choosing orbits for surveillance of rough terrain requires special software to ensure that the screening of key areas such as road segments will be minimized. Lack of familiarity caused the system to be used initially for only surveillance and not targeting. Because the small number of operational aircraft constrained training, some crewmembers were unfamiliar with targeting capabilities used in

Desert Storm. Nor were crews initially prepared to help forward air controllers with information on movement.

Like Desert Storm, operational experience gave NATO commanders, staffs, and aircrews the opportunity to learn more about system capabilities and an appreciation of its contribution to air operations. Fighter pilots recognized that the capability of JSTARS to detect, locate, and track vehicular movement eliminated the need for inefficient visual search and reduced deception by decoys and camouflage. During the conflict, the system began to cue both forward air controllers and unmanned aerial vehicles on the locations of vehicular traffic, allowing for more effective and efficient targeting of Serbian forces.

Another similarity was weather in the initial phases, which resembled what the ground offensive experienced in the Gulf War. When conditions improved, the so-called Kosovo Liberation Army began an offensive that forced the Serbs to move and mass. Even though the offensive was not powerful, it enabled E-8 surveillance and targeting capabilities to present Serb forces with an operational

dilemma. If they maneuvered in response to the offensive, they were visible to ground radar; but if they did not move for fear of being detected, they handicapped their ability to achieve the force ratios and position needed to defeat the light Kosovar forces with minimum casualties. As the JSTARS squadron commander put it, "The Serbs got smart—they realized that when they moved, they died; they attempted to move in smaller numbers—that didn't work either. JSTARS was able to see what was going on, share the information, bring iron on target, and help bring an end to the conflict."² According to the NATO air component commander, Lieutenant General Mike Short, Serb forces "got spanked from JSTARS and [unmanned aerial vehicle] cross cues."³

The dilemma that faced the Serbians may have been key to their decision to withdraw from Kosovo. After the conflict, the Supreme Allied Commander Europe reaffirmed the value of the system, testifying that "JSTARS was a big winner for us here. It is also all-weather; it really helped us understand what was going on both in the early stages and in the late stages."⁴

Afghanistan

One difference in Afghanistan was the delay in deploying JSTARS, which did not arrive in theater until after several weeks of combat. Although the Commander, U.S. Central Command, reported to President George Bush that he needed the system operating in the environment, much of the Taliban and al Qaeda vehicle movement had ceased by the time it was available.

The President recognized the relevance of movement, according to a reporter: "Our strategy is to . . . get the bad guys moving. We get 'em moving, we can see them, we can hit them."⁵ The Chairman also perceived the need to attack mobile rather than fixed targets but realized, "We've got a military that does great against fixed targets. We don't do so well against mobile targets. You're not going to topple a regime with this [fixed] target list."

Despite the delay, JSTARS operations were similar to previous conflicts. For example, the system was not deployed in numbers sufficient for persistent coverage. And like the final days of Allied Force, ground radar data cued the employment of other sensors, such as high-resolution but soda-straw fields-of-view sensors. Another encouraging similarity was system reliability. From November 7, 2001, to April 27, 2002, E-8s flew 249 missions (100 percent of those scheduled) and 245 (98.4 percent) were effective. Of the final 189 missions, 188 (99.5 percent) were effective. Yet like Kosovo, the distance the aircraft had to fly to reach an orbit reduced on-station time and increased air refueling requirements.

Like the Gulf War and the final days of Allied Force when the Kosovar offensive occurred, the presence of friendly land forces greatly enhanced the air operations JSTARS supported.

The threat the Northern Alliance presented was sufficient to cause Taliban and al Qaeda forces to move and concentrate and to rely on vehicles for firepower and armor, making it easier to detect, locate, track, and target them. Enhancing the contribution of ground radar information to targeting was the fact that almost no one except the Taliban or al Qaeda had vehicles.⁶

Nevertheless, fear of hitting civilians influenced the rules of engagement and exploitation of ground radar targeting. Reportedly, positive

GMTI radar is essential to an integrated network that provides situational awareness

identification was required to select civilian vehicles for air attack, often by land forces that actually saw the targets. Such rules not only handicapped an asymmetrical advantage, but also put military and civilian personnel at greater risk. Deploying eyes on the ground in proximity to an enemy is dangerous. Moreover, when vehicles are allowed to escape, their potential remains intact. And when the enemy in question is al Qaeda, Americans around the world are further endangered.

The terrain in Afghanistan also made screening a challenge, as it did in Kosovo. But it was not a major problem initially, given the relatively flat areas where Northern Alliance forces fought Taliban and al Qaeda forces. Moreover, even the ability to screen radar surveillance and targeting could be offset because it also constrained vehicle movement. Thus terrain can actually enhance radar surveillance and targeting when orbits

are well planned and capabilities such as unmanned aerial vehicles, U-2s, and Special Operations Forces complement radar surveillance.

The Way Ahead

GMTI radar is essential to an integrated network that provides situational awareness and the ability to attack across a large area before enemy units can close with friendly land forces. At the same time, experience shows that the learning curve for exploitation of such capabilities has not been steep, with many of the same problems arising in each conflict. To some extent the learning problems can be traced to the unprecedented nature of ground radar and the limited numbers of systems available for training. But a greater reason is the profound difference between peacetime training and combat.

The value of wide-area ground radar is more apparent on the operational than tactical level of war. The preponderance of training involving such surveillance and targeting capabilities is neither joint nor focused on the operational level; service training centers are geared toward combat by a single service, though forces from other services occasionally participate. And with a focus on combat, the importance of pre-hostility ground radar surveillance is neglected. Moreover, much combat training is devoted to the tactical level, ignoring the role of the operational level in determining when, where, or whether engagements must be fought. For example, the National Training Center is focused on the training brigade or lower echelons to fight regimental-size opposing forces in close combat.

Although this center provides one of the few opportunities for the Air Force to train against a realistic opposing land force, it is usually confined to close air support. Moreover, according to the Chief of Staff of the Air Force, "The results [of close air support in exercises] are never fully appreciated. If we attrited the red force with air, then they'd never get engaged on the ground. When you think about what's the lesson taught to generations of

Enduring Freedom

When the Taliban in Afghanistan failed to deliver terrorist leaders and close their training camps in the wake of 9/11, the United States initiated air strikes in early October 2001 to support resistance by the Northern Alliance. The Taliban regime fell from power by December and the operation was subsequently focused on stabilization and reconstruction. Periodic efforts to kill or capture al Qaeda and Taliban members continued, however, such as Operation Anaconda in March 2002. **JFQ**

Global Hawk,
Enduring Freedom.



1st Combat Camera Squadron (Feynaldob Pennon)

young soldiers, [it's] 'Y'all got these airplanes but they're no help to me.'"⁷ Such training clearly does not support the operational level, in which targeting combat units and, often more importantly, logistic support can eliminate the need for close combat. Given the single service, tactical, and close combat orientation for most peacetime training, it is not surprising that learning to fully exploit radar ground surveillance and targeting capabilities has been largely confined to on-the-job training during conflicts.

The Pentagon is reportedly considering a project known as T2. The Secretary of Defense noted that "we

need to train like we fight and fight like we train, and too often we don't."⁸ The strategic plan for transforming training makes establishing a joint national training capability a top priority. This would provide tools to train regularly with forces from multiple services using live-fire and training simulators. It also includes augmentation by computer-generated synthetic forces, which would provide the realistic operational-level environment needed to put the tactical level into perspective. Clearly, a joint national training capability would provide commanders an

opportunity to learn in peacetime how to fully exploit ground radar surveillance and targeting.

Training is an essential prerequisite for the military transformation in meeting the strategic implications of enemy land forces. Commanders must use joint training to integrate land and air forces by using maneuver and standoff air attack to create an intractable operational dilemma for an enemy while maneuvering to avoid close combat, except when overwhelming advantages and close combat make contributing to campaign objectives worth the risks.

A commander attempting to create such a dilemma will soon find that enemy vehicular movement provides a more reliable means for assessment than attrition. For example, when the objective is stopping movement, ground moving target indicator radar will quickly reveal whether the attack was successful. And thanks to this surveillance, it is possible to make this assessment in real time, even in darkness and bad weather. With the realistic joint training the transformation in training is designed to achieve, commanders should become confident that it is feasible to quickly defeat opposing land forces using fewer and lighter land forces. **JFQ**

NOTES

¹ Charles A. Horner, "An Information Superiority Lesson," *ISR Journal*, vol. 1, no. 1 (January/February 2002), p. 17.

² Tony Capaccio, "Northrop Grumman Joint Stars Led Most Lethal Attacks on Serbs," *Bloomberg News* (June 29, 1999).

³ Briefing, 93^d Air Control Wing, Robins Air Force Base, May 31, 1999.

⁴ Wesley K. Clark, testimony before the Senate Armed Services Committee, July 1, 1999.

⁵ Bob Woodward, *Bush at War* (New York: Simon and Schuster, 2002), pp. 153, 174.

⁶ "Targeting Improving; No Problems with Coordination, Rumsfeld Says," *Aerospace Daily* (November 20, 2001), p. 4.

⁷ "CAS Role Damaged by Staffing, Training Structure, Jumper Says," *Aerospace Daily* (February 27, 2003), p. 4.

⁸ "Joint National Training Capability: The Next Wave in Transformation," *Inside the Pentagon* (February 20, 2003), p. 1.

Iraqi Freedom

The U.N. Security Council found in November 2002 that Iraq remained in material breach of resolutions banning weapons of mass destruction. Later in the month inspectors returned to verify the disarmament efforts. But members of the Security Council were divided over whether Baghdad was cooperating with the inspections. In March 2003 the United States, which had begun to deploy forces to the region, suspended negotiations and demanded that Saddam Hussein leave Iraq within 48 hours or face war. When he refused to comply, U.S. and allied forces launched combat operations. Organized enemy resistance ended by mid-April. Approximately 467,000 Americans and 43,000 coalition troops were deployed during the combat phase of the operation. **JFQ**