

INTEGRATING TECHNOLOGY TO REDUCE FRATRICIDE

Larry Doton

The high incidence of fratricide during the Gulf War requires materiel developers to anticipate and compensate for the consequences of partially or completely non-integrated technology. Solutions include thorough risk assessments for all systems, combat identification capability equal to the range of the weapons employed, and service integration of IFF technology.

This paper will analyze the application of technology in our modern warfighting systems, evaluating the potential adverse impacts of applying mismatched, non-integrated, or incomplete technology to a requirement. It will substantiate the criticality of thorough requirements analysis prior to implementation of technology in major weapons systems. The paper will show that the high fratricide rates in the Gulf War were due to incomplete and non-integrated applications of technology, resulting in a 'blind' spot for the lethal warfighting systems. The paper will discuss fixes made during the Gulf War and current initiatives to solve the problem. Finally, it will offer recommendations to minimize the incidence of fratricide in future conflicts.

Given the lethality of our warfighting systems, it is imperative that the application of technology be carefully ana-

lyzed and that the consequences of inappropriate or incomplete application be averted. Columnist and retired Army colonel Harry Summers recently addressed an argument made by Walter Lippmann, writing in December, 1941, that air and sea power would prevail in World War II with ground forces playing only a minor role. Wrote Summers:

Lippman [did] not understand the dynamics of the Army where man is still dominant and the machine merely a tool. Technology must serve the soldier, not vice versa (Summers, 1995).

Summers is right. Requirements should drive the technology, not vice versa. We must critically evaluate the importance of the man-machine interface to minimize the possibility of fratricide.

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 1996		2. REPORT TYPE		3. DATES COVERED 00-00-1996 to 00-00-1996	
4. TITLE AND SUBTITLE Integrating Technology to Reduce Fratricide				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Defense Systems Management College ,9820 Belvoir Road,Fort Belvoir,VA,22060-5565				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES Acquisition Review Quarterly, Winter 1996					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 18	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

The Gulf War verified the importance of superior knowledge on the battlefield. This control of knowledge, and its denial to the enemy, proved to be an indispensable factor. As Alan Campen noted in the Introduction to The First Information War, allied forces could see, hear, and talk all through the war. After a few hours, the enemy could not. Campen also discusses the ability of information warfare technology to support a leaner and cheaper force while continuing to effectively support the nation's goals and objectives. Victory in any future conflict will hinge on our ability to win the information war. A vital part of winning the information war is the prevention and minimization of fratricide.

WHAT IS FRATRICIDE?

To understand the lack of serious attention given this problem prior to the Gulf War, it is important to grasp how restrictive the official definition of fratricide is. The Center for Army Lessons Learned, quoting from the U.S. Army Training and Doctrine Command's Fratricide Action Plan, defines fratricide as:

The employment of friendly weapons and munitions with the intent to kill the enemy or destroy his

equipment or facilities, which results in unforeseen and unintentional death or injury to friendly personnel (Department of the Army, 1992).

In a recently published study on fratricide, Army Col. Kenneth Steinweg, a physician, argues that, "This restrictive definition precludes accidental weapon explosions and misfires, training accidents, casualties from unexploded ordnance, or self wounding of any kind. This artificially reduces the true fratricide percentage rate" (Steinweg, 1994).

In his 1982 paper on the same subject, Army Lt.Col. Charles Shrader coined the term amicide. He derived this from the legitimate combination of the Latin noun *amicus* (friend) with the common latin suffix for killing (-cide) (Shrader, 1982). The term *fratricide* was at that time applied most often to casualties inflicted by artillery projectiles. This limited definition artificially lowered true fratricide rates.

HISTORY OF FRATRICIDE IN WAR

A brief history of fratricide since the 18th century illustrates the evolution of problems in positive combat identification. This history documents that combat identification remains a critical problem, particularly with our techno-

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logical capability to engage targets at previously unfathomable ranges. These ranges go beyond the capability to visually distinguish friend from foe.

In 1758, during the French and Indian War, the commander of a British detachment and Col. George Washington, then a colonial officer of the British Army, mistakenly identified each others' forces as French. In his papers, Washington reported that between 13 and 40 British soldiers died at the hands of their own forces during the ensuing engagement (Abbot, 1988). Uniforms at that time identified alliance. Due to the 'fog of war,' that means of identification proved to be ineffective.

Of the five million French casualties in World War I, artillery caused two-thirds, regardless of friend or foe. French General Alexandre Percin believed that French artillery fire caused one million, or 20 percent of French casualties (Hawkins, 1994). During the breakout from Normandy in the Second World War, British aircraft inadvertently bombed the 30th Division for over two days, killing, among others, American Lt.Gen. Leslie J. McNair. At the Battle of the Bulge, the First Infantry Division became the target of heavy 'friendly' bombing. In St. Lo, over 750 casualties occurred as a result of U.S. bombers attacking American ground forces.

Meanwhile, in the Pacific theater, an allied destroyer depth-charged and sank an allied submarine; likewise, in the Caribbean, friendly fire sank the American submarine USS Dorado.

The Korean War saw similar occurrences: A napalm bomb dropped by an

American plane incinerated nearly an entire U.S. Marine platoon. And combat identification problems continued in Vietnam. In his study of fratricide, Shrader referenced many Vietnam friendly fire occurrences. Among them was a terrible artillery incident. It happened in 1967 when a gun crew cut an incorrect powder charge. The 'long' round killed one and wounded 37 U.S. soldiers. Compounding the tragedy, the victim's unit initiated extremely accurate counterbattery fire, resulting in an additional 53 casualties. The entire incident occurred in the short span of 23 minutes (Shrader, 1982, p. 21).

In a recent keynote address on fratricide, the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence reported that fratricide caused over 30 percent of all aircraft losses during the 1973 Israeli-Egyptian War (Paige, 1994). Incidents of fratricide also occurred in Grenada and Panama. In Grenada, four Navy A-7 aircraft strafed a U.S. Army command post, inflicting 17 American casualties. Similarly, in Panama, friendly fire incidents accounted for three of 23 killed and between 16 and 37 of 310 wounded, as reported by Defense Department spokesman Pete Williams during the June 19, 1990 daily DoD press briefing (Department of Defense, 1990).

As this brief history documents, fratricide is not a new phenomenon, but a recurring and deadly problem in combat identification. Despite the evolution of high technology systems for warfighting, 'blind' spots exist and fratricide continues to occur.

OPERATION DESERT STORM: THE FIRST HIGH TECHNOLOGY WAR

Ground combat identification again emerged as the core issue related to fratricide during the Gulf War. In an article published in the *Journal of Electronic Defense*, Vito DeMonte succinctly described the friendly fire statistics of Operation Desert Storm.

Never before have we fought such a short war, in such a confusing environment, with such a great percentage of deaths due to friendly fire (Demonte, 1992).

Friendly fire killed 35 Americans and wounded 72 during the Gulf War. In a special column in *The Washington Post*, Robert MacKay reported that of the 35 Americans who died, 24 died as a result of ground-to-ground fire, and 11 succumbed to fire from U.S. aircraft

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(MacKay, 1993). The Office of Technology Assessment (OTA) determined that the official friendly fire casualty

rate for Desert Storm was 24 percent (Office of Technology Assessment, 1993). This figure did not include the British soldiers killed by aircraft bombing, nor did it include engineer and medical personnel, who were casualties of unexploded ordnance. As documented in his paper on unexploded ordnance, Lt.Col. Gary Wright stated that 94 separate incidents involving unexploded ordnance occurred during

Operation Desert Storm. These incidents equated to 104 woundings and 30 deaths, 10 percent of total casualties in the operation (Wright, 1993). Rick Atkinson of *The Washington Post* reported that despite the hundreds of fixed and rotary-winged aircraft from more than a dozen allied nations, none of the Gulf War fratricide cases involved air-to-air fratricide (Atkinson, 1994).

UNDERSTATEMENT OF FRATRICIDE RATES

The high incidence of fratricide in the Gulf War brought new and heightened attention to this historically troubling problem. The Office of Technology Assessment agreed (with Steinweg) that past rates of fratricide were systematically and substantially underestimated (Office of Technology Assessment, 1995, p. 1). Shrader's 1992 study, though "primarily historical, narrative, and highly selective," concluded that "casualties attributable to friendly fire in modern war constitute a statistically insignificant portion of total casualties (perhaps less than two percent)" (Shrader, 1982, p. vii). Because of the dearth of published documents on this subject, Shrader's assessment had become the de facto standard. In subsequent published articles, Shrader acknowledged that actual fratricide rates are considerably higher than two percent (Shrader, 1992). In a 1993 interview, Shrader further acknowledged that higher rates are prevalent. He stated that "It just seemed to be the number that I kept coming up with, based on the materials that I had to

work with, which were pretty limited” (MacKay, 1993, p. A-4).

In a 1994 paper on the subject, Steinweg substantiated his thesis that fratricide rates during conflicts of the 20th century equaled at least five to eight times the generally accepted two percent figure (Steinweg, 1994, p. 1). Steinweg’s study examined historical evidence of the 20th century, experiences at the National Training Centers, and the application of technology. Because the casualty reporting system failed (and continues to fail) to accurately document fratricide, Steinweg also used medical documents in substantiating his thesis. Steinweg concluded that “Fratricide rates have been and are conservatively 10-15 percent of our casualties, not two percent” (Steinweg, 1994, p. 29).

In 1992 another Army physician, Col. David M. Sa’adah, presented a paper to the 31st U.S. Army Operations Research Symposium at Fort Lee, Virginia. Sa’adah compared data from five casualty surveys (three in the Pacific during World War II and two from the Vietnam War) with Desert Storm data. He concluded that all weapons available on the battlefield are potential contributors to friendly fire incidents. Further, he asserted that movement from defensive to offensive operations resulted in increased fratricide rates, sometimes by a factor of two (Sa’adah, 1992).

Operation Desert Storm was the first major conflict in which America’s fighting forces used the high technology weapons systems designed and built during the Reagan Administration. It proved to be a major test of the billions of dollars invested. The One Hundred

Hour War did liberate Kuwait and severely defeated Saddam Hussein’s forces.

In an article published shortly after the Gulf War, John D. Morrocco, a writer for *Aviation Week & Space Technology*, lauded the performance of the high technology systems used during the conflict. He also postulated that the Department of Defense would continue to press for high-leverage advanced technology systems.

Operation Desert Storm [has] validated the U.S. military’s emphasis on quality versus quantity in weapon systems and provided a tremendous boost to the credibility of high-technology programs now in development (Morrocco, 1991).

Yet, the fratricide rate for the Gulf War rivaled that of all conflicts in this century.

In previous conflicts, artillery inflicted the highest percentage of fratricide deaths. The Office of Technology Assessment reported that the sole artillery fratricide incident in Desert Storm occurred on February 26, 1991, when one

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soldier died from injuries inflicted by the premature burst of an artillery round (Office of Technology Assessment, 1993, p. 27). That single incident accounted for less than two percent of the fratricide casualties in the conflict. Steinweg and Sa’adah’s research sub-

stantiates previous fratricide figures as routinely in the 15-20 percent range, vice the previously quoted Shrader rate of two percent.

Desert Storm data revealed a new paradigm. At the 1994 Combat Identification System Conference, Col. Sa'adah reported that the M1A1 Abrams tank inflicted 71 percent of fratricide casualties during the war (Sa'adah, 1994). Journal of Electronic Defense writer Zachary Lum further substantiated Sa'adah's findings.

The Abrams M1A1 was the worst offender in the Gulf, responsible for 85 percent of the fratricide casualties. (The U.S. lost 10 tanks in the war, seven to fratricide; of 28 Bradley Fighting Vehicles destroyed, 22-23 were victims of fratricide.) (Lum, 1993).

Sa'adah's research documented the redundant lethality of what he termed weapons 'platforms.'

The fratricide agent is not the specific weapon, but the platform where the firing decision resides... The main gun is accurate and lethal to the target vehicle, but it was the follow-on with the lesser armament that created the majority of casualties (Sa'adah, 1994, p. 8).

The variation in calculated fratricide rates highlights the difficulty in definition (Shrader and Steinweg), as well as the non-standard application of calculation methodologies. Nevertheless, figures clearly substantiate the significance of the problem and fall in line with

Steinweg and Sa'adah's finding.

As a result of the Desert Storm figures, fratricide became a topic of increased attention. The Department of Defense and the services formed Fratricide Task Forces. In an August, 1993 article in the Journal of Electronic Defense, Col. David O. Bird, Team Chief of the Army Materiel Command's Fratricide Task Force, spoke of the high priority in coming to the quickest possible total solution for fratricide reduction. "Reducing fratricide is 'right near the top, if not right at the top' of the list of critical areas that the Army is currently exploring" (Lum, 1993, p.48). Retired Navy Commander George Cornelius reported in a Signal magazine article that the Gulf War experience, because of air supremacy, rendered air-to-air and ground-to-air identification problems nearly irrelevant. However, the problem of air-to-ground and ground-to-ground encounters revealed serious shortcomings in combat identification capabilities (Cornelius, 1994).

The Department of Defense and the Clinton Administration have indicated that they recognize that the probability of fratricide cannot be eliminated. Their reasonable goal is the reduction of fratricide. Secretary of Defense William Perry charged the services to rapidly develop and field, as a high priority, an integrated, enhanced identification capability to reduce the risk of fratricide to armor, aircraft, and ships. He further declared that the Army should reduce the possibility of fratricide through enhancement of situational awareness technology (Paige, 1994, p.2). Situational awareness is officially defined by the U.S. Army Combined Arms

Command as:

The real-time accurate knowledge of one's own location (and orientation), as well as the locations of friendly, enemy, neutrals, and non-combatants. This includes awareness of the METT-T conditions that impact the operation (Department of the Army, 1992).

Similarly, Maj.Gen. Wesley K. Clark, then a deputy chief of staff at the U.S. Army Training and Doctrine Command, was quoted as saying "So we've got to focus on the minimization... recognize that we will never be able to prevent all instances of fratricide" (Gellman and Lancaster, 1991).

The Office of Technology Assessment also recognized that reduction of fratricide is a correct and reasonable approach.

Reducing fratricide is desirable and feasible, but eliminating it is not. Although programs to reduce fratricide are certainly needed, setting a goal of eliminating it is unrealistic and probably counterproductive (Office of Technology Assessment, 1993, p. 2).

Believing that the application of technology alone will solve the problem is fallacious and foolhardy. As Cornelius stated in an article published by the U.S. Naval Institute Proceedings, "Electrons, however marvelous, can never relieve humans of the awful responsibility of the final, lethal decision to fire" (Cornelius, 1993).

Advances in technology, ironically enough, can exacerbate, rather than improve some situations. They are but one piece of the pie. Emmett Paige, Jr., Assistant Secretary of Defense for Command, Control, Communications, and Intelligence, recently substantiated this point in a keynote address to the 1994 DoD Joint Service Combat Identification Systems Conference.

Unless we have reliable means of positively identifying foes at long range, the technological advantage we have achieved in our weapon systems, at great expense, will be partly negated (Paige, 1994, p. 3).

Beyond Visual Range (BVR) technology permits detection of potential targets at previously unattainable ranges. As the term implies, the eye cannot detect, let alone identify a target as either friend or foe. BVR technology can detect targets significantly smaller than a pixel on our sensors, thereby precluding positive identification. Unfortunately, the Desert Storm record of fratricide proved a downside to these technological advancements. DeMonte highlights the major reason. "Engagement ranges became so extended that differentiation between friend or enemy leapt beyond the capability of the 'sensor-aided eyeball'" (DeMonte, 1992, p. 35).

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NON-INTEGRATED APPLICATION OF TECHNOLOGY

To a large degree, the fratricide experienced during the Gulf War was a legacy of previous weapons acquisition policies. Planners and designers of high technology warfighting systems, such as the Bradley Fighting Vehicle, the Abram's tank, the Multiple Launched Rocket System (MLRS), improved conventional munitions, and scatterable mines failed to account for collateral or unforeseen impacts. Employment of BVR technology without evaluating all consequences, resulted in a 'blind' spot in the positive identification of ground combat vehicles.

A review of official documents reveals recognition of the need to improve combat identification. However, prior to the Desert Storm experience with fratricide, little substantive progress occurred in reducing its incidence. The commander of the Combat Develop-

...“failure to consider effects of unexploded submunitions increased the potential for friendly deaths.”

ments Command, in a November, 1967 letter to the Army Chief of Staff (Department of the

Army, 1967), observed that soldiers must be conditioned to distinguish between friend and foe. He recommended a study to analyze modification of training firing ranges to condition trainees to make distinctions among targets prior to firing.

The November, 1967 letter also reported that improvements in techniques for visual recognition of friendly personnel and procedures for battlefield

identification appeared necessary.

Review of applicable Cost and Operational Effectiveness Analyses (COEA) for combat vehicles in the late 1970's (i.e., for the systems later used in Desert Storm) revealed that combat identification was not a system requirement. In the area of survivability, COEA data consistently concentrated on the areas of large and small caliber direct fire weapons; indirect fire; mines; nuclear, biological, and chemical weapons; and air attack (Department of the Army, 1978). In no single COEA was there a reference to combat identification or identification friend-or-foe (IFF) technology (Department of the Army, 1963). Built-in features such as fire suppression, blow-out panels, hardened armor, and protective linings served to increase survivability. These measures proved effective in minimizing the impacts of friendly fire during the Gulf War. As it turned out, the incorporation of IFF would have been a more effective survivability factor.

In a February, 1974 letter following the 1973 Arab-Israeli conflict and the Israeli's difficulty in identifying friendly from enemy tanks, the Assistant Secretary of the Army for Research and Development acknowledged that there was not a battlefield IFF system for use with tanks (Department of the Army, 1974). He directed the Army staff and the U.S. Army Training and Doctrine Command to determine the Army's need for a battlefield IFF system for tanks.

In June, 1982, J.R. Sculley, the Assistant Secretary of the Army for Research, Development, and Acquisition, in a memorandum for the Under Secretary of Defense (Research and En-

gineering), concluded that there was no requirement for an electronic question and answer system for ground combat vehicles (Department of the Army, 1982). The Assistant Secretary based his recommendation on the results of a Battlefield Identification Friend-or-Foe (BIFF) study (Science Applications, 1979).

The Rand Corporation conducted a study on ground-to-ground fratricide at the National Training Center in 1986. In the study entitled *Applying the National Training Center Experience - Incidence of Ground-to-Ground Fratricide*, Martin Goldsmith provided several conclusions. His data revealed that half of the recorded fratricides were preventable if the shooter had proper knowledge of the location of friendly units. Further, he found that one third of the fratricides were preventable if tank gunners had knowledge of the location of individual friendly vehicles. Finally, Goldsmith found that 17 percent of fratricides were also preventable with the implementation of IFF devices on combat vehicles.

In the case of the MLRS, a 'blind' spot in doctrine emerged during the Gulf War. In his paper on the problem of unexploded ordnance on the battlefield, Lt.Col. Gary Wright calculated that more than 1.5 million unexploded munitions (UXO) remain on the Gulf War battlefield. Wright further documented that vast amounts of submunitions targeted beyond the Forward Support Coordination Line caused maneuver problems as ground forces thundered into Iraq. Wright documented that "Many units found themselves in areas that were saturated

with submunitions" (Wright, 1993, p. 17). Further, Wright stated that "The transfer or sharing of UXO information is not currently in our Joint or Service doctrine" (Wright, 1993).

Unfortunately, this is not a new phenomenon. It applies, as well, to minefield placement. In the November, 1967 letter previously cited, the commander of the U.S. Army Combat Developments Command noted the inadequate reporting and recording of friendly protective minefields. The commander reported that casualties in Vietnam occurred because units failed to record or retrieve minefields before moving. The report recommended renewed compliance with the published doctrine.

Project office technical management engineers and the Studies Branch Chief in the System Manager's Office for MLRS confirmed that:

The battlefield safety of operating areas where submunitions had been delivered was not considered during the design and early production of the system (MLRS). They [the System's Manager's Office, Training and Doctrine Command] said the Army believed the weapon would most likely be used against the Soviet threat in Europe, where U.S. troops would probably be in a defensive position. Therefore, U.S. soldiers were not expected to occupy submunitions-contaminated areas (General Accounting Office, 1993).

The U.S. Army Training and Doctrine Command's System Manager for

Cannon acknowledged that the “failure to consider effects of unexploded submunitions increased the potential for friendly deaths” (General Accounting Office, 1993, p. 8).

Tank developers likewise failed to recognize the consequences of a non-integrated application of technology (i.e., IFF for ground combat vehicles). A senior Army officer who served over 29 years as a tank expert reported in an interview that the issue of tanks’ vulnerability to fratricide was not a significant part of building a better tank. Further, he indicated that such technologies as transponder systems were excluded from tank designs for a number of reasons (Tyler, 1991). Cornelius’ research indicates that Army planners routinely dismissed IFF technology. Arguments for rejection included maintenance complexity, better use of room used otherwise, and perceived dangers that emissions might reveal a unit’s location (Cornelius, 1993, p. 89).

In the previously mentioned Gulf War friendly fire incident, an AH-64 Apache battalion commander, due to inadequate combat identification, mistakenly engaged a Bradley Fighting Vehicle, killing two persons and injuring four. This showed clearly that despite all of its high-tech gadgetry, the Apache and its human pilot cannot distinguish between friendly and enemy forces in adverse weather conditions obscuring visual identification and verification (Johnson and Solomon, 1991). Without some sort of transponder or IFF device, American and coalition ground combat vehicles could continue to be mistaken targets in future conflicts.

As previously documented, ground combat identification accounted for nearly all the incidents of fratricide in the Gulf War. Admittedly, however, combat identification is not a simple task. Rudolf Buser, director of the U.S. Army Communications and Electronics Command’s (CECOM) Night Vision and Electro-Optics Directorate at Fort Belvoir, Virginia, succinctly delineated the complexities of combat identification.

Combat identification is a complex problem involving tradeoffs in performance, covertness, cost, and other factors, and no single solution exists. The Army is pursuing a number of technical approaches to solve the problem (Morzenti, 1991).

The Desert Storm experience served as a wake-up call for those designing and developing future systems. In the future, combat and materiel developers must fully consider positive combat identification. The capability to positively identify ground combat vehicles must be equal to or greater than the engagement range. Technology must be integrated and matched to minimize the occurrence of fratricide.

OPERATION DESERT STORM QUICK FIXES

Following the first incidence of fratricide during the Gulf War at the battle of Kafja, a number of emergency efforts were made to prevent fratricide. These efforts recognized the combat identifi-

cation gap as it applied to ground combat vehicles. With a full-fledged ground war impending, the Department of Defense initiated a number of quick fixes. One of the devices was an infrared beacon, termed an Anti-Fratricide Identification Device (AFID). Procured in only 24 days by the Defense Advanced Research Projects Agency (DARPA), the infrared beacon used two high-powered infrared diodes to emit optical power. Because of air supremacy, there was little danger that Iraqi aircraft would use emissions from the devices to target coalition vehicles. The AFID employed a protective collar to prevent infrared energy from being seen by ground forces. Used in conjunction with Night Vision Goggles, the devices allowed coalition pilots to detect and identify the AFID emissions from as far away as 8-10 kilometers. Between inception and full-scale production, engineers made over 100 mechanical, electrical, and functional design changes in just four days. Though initially called AFID, it became known as the DARPA light, after the agency that procured it. The DARPA light had a 50-hour battery life. Each device shipped to the desert had two additional battery packs (Hughes, 1991).

Another infrared emitting device, designed by Army night vision engineer Henry 'Bud' Croley, did not have a shroud to preclude ground detection. This allowed Bradley and Abrams crews to see them, as opposed to limiting detection to fixed or rotary wing aircraft. The device was dubbed the 'Budd Light,' partially in deference to Croley and also as a reminder of the customs of the host nation.

The Army rushed over 120,000 square feet of thermal tape to the theater. This tape was used to 'mark' vehicles as friendly when acquired by heat seeking target acquisition sights. Because the coalition forces had no monopoly on infrared and night-vision sensors, there was concern that the thermal panels might serve as bull's eyes for Iraqi forces. In Desert Storm this did not happen.

The device was dubbed the 'Budd Light'...

The Army also ordered over 10,000 Small Lightweight Global Positioning Receivers to assist vehicles in determining their locations. Although only effective in daylight and with good visibility, the coalition forces also used a field expedient side marking technique. VS-17 panels marked ground vehicles on the top and inverted 'V's marked side panels on coalition vehicles, identifying them as friendly forces. Inverted 'V' symbols consisted of a variety of materials, including fluorescent placards, white luminous paint, black paint, and thermal tape. Overall, these measures proved to be marginally effective.

INITIATIVES AIMED AT RESOLUTION

The immediate and overwhelmingly positive efforts in fielding expedient remedies during the Gulf War were admirable. However, these efforts did not work well and failed to negate the impacts of bad weather, poor visibility, and night combat conditions. Cornelius summarized the impact in a U.S. Naval Institute Proceedings article.

Cheap, simple measures to identify friendly armor have not worked well. Colored panels are invisible at night and at best seen only at close range; colored lights were better, but easily duplicated by the enemy (Cornelius, 1993, p. 90).

Because of the minimal positive impacts of quick fixes, efforts to return to the pursuit of IFF technology redoubled. Following the war, DoD established a Joint Combat Identification Management Office. The office coordinates the activities of the services. The U.S. Navy is the lead service in the area of cooperative airborne identification. The Navy's focus is on upgrading existing IFF systems for air-to-air and surface-to-air contacts. Under the auspices of the Program Executive Officer for Intelligence and Electronic Warfare, the U.S. Army Battlefield Combat Identification Systems Program Manager leads the largest effort. The U.S. Army Materiel Command and the Deputy Chief of Staff for Research, Development, and Acquisition provide materiel and hardware solutions. The U.S. Army Training and Doctrine Command is responsible for testing and evaluation (Starr, 1993).

The Army began installation of immediately available off-the-shelf navigational applications on the M1A1 tank, the M2/M3 Bradley Fighting Vehicles, and the 'Hummer' utility vehicle. These applications are an interim solution, pending investigation of alternative technologies. The devices add additional position/navigation (POS/NAV) and situational awareness capa-

bilities. The receivers to be installed are the Small Lightweight Global Receiver (SLGR) and the Precision Lightweight Global Receiver (PLGR) (Starr, 1993).

The Combat Identification Project Management Office currently focuses on a near-term solution to the problem. Following tests at a fly-off competition at Fort Bliss, Texas in 1992, the Army selected millimeter wave (MMW) technology for further development. Competing against infrared laser beacons, retro-reflector lasers, and radio frequency (RF) based solutions, MMW technology was selected for further development because it is least affected by smoke or bad weather (Starr, 1993).

The Project Office faces many challenges, not the least of which is cost. The estimated cost for equipping a single division's worth of vehicles is currently estimated to be \$250 million (Starr, 1993). The Assistant Secretary of Defense for Command, Control, Communications, and Intelligence, based on an assessment by the Joint Requirements Oversight Council (JROC), recommends near-term armor identification techniques on the order of \$1,000 per application (Paige, 1994, p. 3). Additionally, the Project Office must ensure that MMW technology is compatible with U.S. Navy and U.S. Air Force combat identification plans (Starr, 1993, p. 961).

A less expensive alternative to spending \$250 million per division is to equip approximately 1,500 vehicles. This would be sufficient to support a substantial contingency force. The Office of Technology Assessment estimates an outlay of about \$100 million to outfit such a force with MMW technology

(Roos, 1993).

Many positive initiatives grew from the Desert Storm experience with fratricide. In April, 1993, the Army Deputy Chief of Staff for Operations and Plans published the Operational Requirements Document (ORD) for the Battlefield Combat Identification System (BCIS) (Department of the Army, 1993). The document mandated the need for a target identification system with ground-to-ground and air-to-ground capability. This ORD supported the April, 1992 U.S. Army Training and Doctrine Command Operational and Organizational (O&O) Plan for Army Combat Identification Systems, which itself required an effective and survivable combat identification system to preclude engagement of friendly forces and noncombatants. The O&O plan mandated the capability to positively engage targets out to the maximum effective range of the designated weapons system, with or without line of sight (LOS) technologies (Department of the Army, 1992).

The U.S. Army Training and Doctrine Command published TRADDOC Pamphlet 525-58, *U.S. Army Operations Concept for Combat Identification*, in August, 1993. The pamphlet provides the Army with a concept for combat identification which will increase combat effectiveness, prevent fratricide, and protect neutrals and noncombatants.

In December, 1993, the Vice Chairman of the Joint Chiefs of Staff directed that the Joint Requirements Oversight Council (JROC) screen all future Operational Requirements Documents (ORD) to ensure that no new combat systems proceed to a Milestone I deci-

sion unless combat identification is specifically addressed (Joint Chiefs of Staff, 1993). Additionally, Department of Defense Directive 5000.2 will be modified to require evaluation of weapon systems combat identification capabilities at all milestone reviews.

CONCLUSIONS AND RECOMMENDATIONS

Operation Desert Storm confirmed a gap in the application of technology to positively identify ground combat vehicles. The incidence of fratricide, unprecedented in 20th century warfare, confirmed the need for combat and materiel developers to carefully analyze the application of technology into our major weapons systems. Although we can acquire targets at previously unfathomable ranges, we can not always confirm positive combat identification. The identification of 'blind' spots highlighted our inability to positively identify ground combat vehicles.

Implementation of quick fixes during the Gulf War was a start in resolving the combat identification problem. Current initiatives in millimeter wave technology are similarly positive. In conjunction with these initiatives, the Department of Defense and the Department of the Army should pursue the following actions to further reduce the incidence of fratricide in future conflicts.

- **Continue to emphasize the importance of combat training and rehearsals** with particular attention placed on fratricide prevention.

- **Continue the development and distribution of training materials** such as the U.S. Army Armor School's Fratricide video cassette.
- **Continue to develop joint doctrine and train to it** with more Joint Training Exercises.
- **Include fratricide prevention in all Mission Needs Statements** and associated operational requirements documents for our combat systems.
- **Continue emphasis on fratricide at all Training Centers** (e.g., the National Training Center and the Joint Readiness Training Center).
- **Require combat and materiel developers to conduct a thorough risk assessment** for all systems, including fratricide prevention capabilities.
- **Enforce the requirement that combat identification capability be equal to engagement ranges** of particular weapons systems.
- **Continue to pursue all-service integration of IFF technology**, with specific emphasis on combat ground vehicles.
- **Closely monitor and enforce consideration of combat identification capabilities** at all Milestone reviews.

While the success of the Gulf War cannot be negated, the lessons learned from the high incidence of fratricide must serve as a reminder that requirements must drive technology, not vice versa. In the future, combat and materiel developers must anticipate and compensate for the consequences of partial or non-integrated application of technology. The ultimate solution must address multiple areas to include doctrine and procedures, organization, training, the application of advanced technologies, and hardware. Fratricide prevention must be a standing requirement for all combat and materiel developments. We owe our nation's Armed Forces nothing less.

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