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Report to the Chairman, Subcommittee on Regulation, Business Opportunities, and Energy, Committee on Small Business, House of Representatives

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OPERATION DESERT STORM

Early Performance Assessment of Bradley and Abrams

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National Security and
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The Honorable Ron Wyden
Chairman, Subcommittee on Regulation,
Business Opportunities, and Energy
Committee on Small Business
House of Representatives

Dear Mr. Chairman:

In response to your request, we have developed information on the performance of the Bradley Fighting Vehicle and the Abrams tank during the Persian Gulf war. Specifically, you asked that we obtain information from Bradley and Abrams crews on (1) how well their systems performed during the war and whether improvements were needed, (2) what types of problems the two systems experienced, and (3) how well combat support vehicles were able to recover or keep pace with the Bradley and the Abrams. On October 23, 1991, we briefed your staff on the results of our work. This letter summarizes the information discussed at that meeting, and appendixes I through IV present more detailed information.

Our report is based on information we obtained from Army troops and Army reports on the war. Army agencies are currently analyzing war data regarding weapons lethality, systems survivability, and destroyed vehicles but are not to report until a later date. When these reports are completed, additional information on the performance of these vehicles may come forth.

During our review we sought information on Bradley and Abrams system performance using five parameters:

- Reliability: The degree to which a vehicle is operable (that is, able to move, shoot, and communicate) for combat and the ease with which it can be maintained.
- Survivability: The ability of the crew and the vehicle to withstand or avoid hostile fire; includes the vehicle's armor protection, speed, and agility.
- Lethality: The ability of the vehicle's weapon systems to destroy intended targets.
- Mobility: The vehicle's ability to traverse varying terrains; based on speed and agility.
- Range: The maximum distance a vehicle can travel without refueling.

Results in Brief

Crews from both the Bradley Fighting Vehicle and the Abrams tank, as well as other Army personnel, praised the overall performance of the vehicles in the Persian Gulf war. Crews said that the vehicles demonstrated good lethality and mobility. Survivability of the Abrams was perceived as good by the crews, and they felt safer in the Bradley A2 models compared to the older models. Mission capability rates were reported high. Bradley crews identified some problems and desired system improvements, such as a higher reverse speed and a laser range finder. Abrams crews indicated that its range was limited because it frequently had to stop to (1) refuel to compensate for high fuel consumption and faulty fuel pumps and (2) clean air filters due to extremely sandy conditions.

Bradley and Abrams crews reported problems obtaining repair parts, and many had exhausted their limited supply of some parts by the end of the 100-hour ground war. Because of these problems, according to some Army logistics personnel, sustainability could have become a major problem had the war lasted longer. Crews also experienced problems in positively identifying enemy targets and in having to use outdated and unreliable radios.

Many of the older generation Army vehicles used to support the Bradley and the Abrams were unreliable and had difficulties keeping up with the rapid pace of the offensive assault. For example, Bradley and Abrams crews reported that the M109 self-propelled howitzer and various M113 series combat support vehicles had slowed their movement. The Army has acquisition programs designed to overcome some of these problems.

Background

The Bradley Fighting Vehicle and the Abrams Main Battle Tank are the Army's premier ground combat vehicles. Both were fielded in the early 1980s. They were designed by the Army to accompany each other into battle as part of a combined arms team.

As of February 26, 1991, a total of 2,200 Bradley Fighting Vehicles were in the Persian Gulf area. Of these, a total of 1,730 were assigned to the deployed units, and the remaining 470 Bradleys were held in reserve. Of the 1,730 Bradleys assigned to the deployed units, 834 were the newest model Bradley—the A2 high survivability model. Some Army units that did not have the A2 model Bradley vehicle prior to deploying deployed with older models but were provided the A2 models as they became available.

At the same time, a total of 3,113 Abrams tanks were in the Persian Gulf area. Of these, 2,024 tanks were assigned to deployed units, and the remaining 1,089 tanks were held in reserve. Of the 2,024 tanks that were assigned to troops, 1,904 were M1A1s, and 120 were M1s. Some Army units deployed with the older model Abrams, but most exchanged their older model Abrams for M1A1s once they were in the Persian Gulf.

Bradley Performed Well, but Some Problems Were Identified

The Bradley Fighting Vehicle performed well during the war, according to the observations of commanders, crews, maintenance personnel, and Army after action reports. It exhibited good reliability, lethality, mobility, and range, and crews perceived the A2 model to have good survivability. The Army reported readiness rates for the Bradley that were generally 90 percent or higher during the ground war—indicating its high availability to move, shoot, and communicate during combat. The Bradley proved to be lethal, as crews reported that its 25-mm automatic gun was effective against a variety of targets and that its Tube-Launched, Optically-Tracked, Wire-Guided (TOW) missile system was able to destroy tanks. Crews also said the Bradley was fast, maneuvered well in the desert terrain, and exhibited good range. The A2 high survivability model Bradley was praised for its added engine power and maneuverability, and crews felt safer with its increased armor protection.

Although crews were very satisfied with the Bradley's performance, they identified various hardware deficiencies that they believe should be fixed, though these problems usually did not stop the system in combat. Army officials were aware of most of them—leaking radiators, unreliable heaters, and misdirected exhaust—and are planning or are implementing corrective actions. Army crews also identified other needed vehicle improvements, such as the addition of a laser range finder and an identification of friend or foe system, better sight magnification and resolution, and a faster reverse speed. Army officials said these and other enhancements were being considered for future vehicle improvements (see app. I).

Abrams Was Effective, but Its Range Was Limited

During the war, the Abrams tank exhibited good reliability, lethality, survivability, and mobility, but limited range, according to the observations of commanders, crews, maintenance personnel, and Army after action reports. Reported Army readiness rates for the Abrams were 90 percent or higher during the ground war—indicating a high availability to move, shoot, and communicate during combat. The Abrams was lethal, as crews said its 120-mm gun was accurate and its ammunition deadly against all forms of Iraqi armor. Army observers attribute the gun's high degree of accuracy to superior sights, high levels of tank readiness, and soldier training. The

Abrams also survived well on the battlefield. For example, according to officials from the Center for Army Lessons Learned, several M1A1 crews reported receiving direct frontal hits from Iraqi T-72s with minimal damage. In fact, the enemy destroyed no Abrams tanks during the Persian Gulf war, according to the Army. Crews said Abrams tanks were fast and maneuvered well in the sand.

Abrams crews were impressed with the power and performance of the Abrams' turbine engine, but they were concerned about its high fuel consumption and the need to frequently clean air filters in the sandy desert environment. Refueling was a constant concern, and faulty fuel pumps further compounded the problem. The harsh desert environment demanded frequent air filter cleaning because sand-clogged filters reduced engine power and speed. In extreme cases, sand damaged engines. Army officials are aware of the problems with high fuel consumption, unreliable fuel pumps, and sand ingestion. They are working on solutions to improve fuel economy, fuel pump design, and the air filtration system. Abrams crews also identified other desired tank improvements, including better sight magnification and resolution and the addition of an identification of friend or foe system, a turret/hull reference indicator, and driver's and commander's thermal viewers. Army officials said these and other enhancements were being considered for future Abrams improvements (see app. II).

Problems Common to Bradley and Abrams

Fighting a war in the desert highlighted a number of concerns common to both the Abrams and Bradley systems. The Army had difficulty establishing an effective parts supply distribution network in the Persian Gulf. Although the Army shipped large quantities of parts to the Persian Gulf area, combat units experienced problems obtaining repair parts through the established Army logistics system. For example, logistics personnel from the 1st Cavalry Division told us that about 60 percent of the parts they were authorized had zero balances by the end of the war. To compensate for the inability of the established system to provide needed parts, combat units had to search logistics bases for needed parts, to trade with other combat units, or to take parts from other vehicles. According to some Army personnel, the inability to replenish parts reserves could have impeded sustained combat operations in a longer war.

Friendly fire emerged as a major concern in the desert, in part because Army gunners were able to acquire targets at longer ranges than they were able to positively identify targets as friend or enemy. According to the

Army, 23 Abrams were destroyed or damaged in the Persian Gulf area. Of the nine Abrams destroyed, seven were due to friendly fire, and two were intentionally destroyed to prevent capture after they became disabled. Similarly, of the 28 Bradleys destroyed or damaged, 20 were due to friendly fire. Moreover, weapon system capabilities were not optimized because the weapons' ranges were greater than the sights' ranges. Crews also noted problems with ineffective radios and suggested that a navigation system be installed in every Bradley and Abrams. Army officials recognized the need for improvements in these areas (see app. III).

Some Combat and Support Vehicles Inadequate

The war experience highlighted significant shortcomings with combat support vehicles and other equipment that supported the Bradley and Abrams systems. The M88A1 recovery vehicle proved to be unreliable and was often unable to recover the M1A1 Abrams tank. The Army did not have enough Heavy Equipment Transporters, and many experienced performance problems. According to division officers, crews, and maintenance personnel, the Bradley and Abrams had to slow down to allow the M109 self-propelled artillery vehicles and older M113 series combat vehicles, with the exception of the M113A3 model, to catch up. Older cargo trucks were also criticized by division personnel for poor mobility and reliability (see app. IV).

Scope and Methodology

To obtain information on vehicle performance, we interviewed division, brigade, battalion, platoon, and vehicle commanders, as well as gunners, drivers, mechanics, and logistics personnel who participated in the war. Detailed maintenance records were not consistently available or uniformly maintained by Army units. Therefore, our primary source of maintenance information was discussions with the Army personnel we identify above. In addition, we obtained operational readiness data reported to the U.S. Army Tank-Automotive Command on the Army Materiel Command's situation reports. In order to ascertain vehicle performance, we focused on the ground war—the period of most intensive use for the majority of the units we visited. We visited the following Army units that fought in the war:

- 1st Armored Division, Ansbach, Germany;
- 1st Cavalry Division, Fort Hood, Texas;
- 1st Infantry Division (Mechanized), Fort Riley, Kansas;
- 2nd Armored Cavalry Regiment, Nuremberg, Germany; and
- 24th Infantry Division (Mechanized), Fort Stewart, Georgia.

To follow up on crew comments regarding various vehicles' performance and problems, we met with Army and Department of Defense officials responsible for managing and reporting on the performance of systems used in the war. Army agencies are now analyzing actual battle damage to determine more precisely how combat systems performed. We discussed systems' performance and deficiencies and the status of corrective actions with officials at the following organizations:

- the Abrams Tank System Program Office, Warren, Michigan;
- the Army Armor Center, Fort Knox, Kentucky;
- the Army Ballistics Research Laboratory, Aberdeen, Maryland;
- the Army Center for Lessons Learned, Fort Leavenworth, Kansas;
- the Office of the Program Manager, Global Positioning System, Ft. Monmouth, New Jersey, and Los Angeles Air Force Base, Los Angeles, California;
- the Office of the Program Manager, Single Channel Ground and Airborne Radio System, Ft. Monmouth, New Jersey;
- the Army Foreign Science Technology Center, Charlottesville, Virginia;
- the Army Infantry Center, Fort Benning, Georgia;
- the Army Materiel Systems Analysis Activity, Aberdeen, Maryland;
- the Army Missile Command, Huntsville, Alabama;
- the Army Tank-Automotive Command, Warren, Michigan;
- the Bradley Fighting Vehicle Systems Program Office, Warren, Michigan;
- the Defense Intelligence Agency, Washington, D.C.; and
- the Department of Defense and Army Headquarters, Washington, D.C.

We conducted our review between April and November 1991 in accordance with generally accepted government auditing standards. As requested, we did not obtain agency comments on this report. However, we discussed the information we gathered with Army and Department of Defense program officials and have incorporated their views when appropriate.

We are sending copies of this report to the Chairmen of the House and Senate Committees on Armed Services and on Appropriations, the House Committee on Government Operations, the Senate Committee on Governmental Affairs, the Secretary of Defense, and other interested parties. We will also make copies available to others upon request.

Please contact Richard Davis, Director, Army Issues, at (202) 275-4141 if you or your staff have any questions concerning this report. Major contributors to this report are listed in appendix V.

Sincerely yours,

Frank C. Conahan

Frank C. Conahan
Assistant Comptroller General

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Abbreviations

AMSAA	Army Materiel Systems Analysis Activity
BRL	Ballistics Research Laboratory
CALL	Center for Army Lessons Learned
CFV	Cavalry Fighting Vehicle
GPS	Global Positioning System
HET	Heavy Equipment Transporter
IFF	identification of friend or foe
IFV	Infantry Fighting Vehicle
PLGR	Precision Lightweight GPS Receiver
SINCGARS	Single Channel Ground and Airborne Radio System
SLGR	Small Lightweight GPS Receiver
TACOM	Tank-Automotive Command
TOW	Tube-Launched, Optically-Tracked, Wire-Guided

Bradley Performed Well, but Some Problems Were Identified

Overall, according to the observations of commanders, crews, maintenance personnel, operational readiness data, and Army after action reports, the Bradley Fighting Vehicle proved to be reliable; was perceived to have good survivability; and exhibited good lethality, mobility, and range during the Persian Gulf war. In particular, in those units that had the A2 model Bradley, commanders, crews, and maintenance personnel were impressed with the added reliability, mobility, and perceived survivability that the A2 Bradley offered. While personnel judged the overall performance of the Bradley to be favorable, they noted some automotive and weapon system problems and desirable system improvements.

Background

The Bradley Fighting Vehicle, initially deployed in 1983, comes in two versions: the M2 Infantry Fighting Vehicle (IFV) and the M3 Cavalry Fighting Vehicle (CFV). The IFV's mission is to transport the infantry squad into battle and, once there, to support the squad and the accompanying tanks by suppressing enemy infantry and lightly armored vehicles. The CFV's mission is to perform reconnaissance and scouting roles in armored units. Both vehicles have a 25-mm automatic gun; a Tube-Launched, Optically-Tracked, Wire-Guided (TOW) antitank missile launcher; and a coaxial machine gun.

Survivability Enhancements

Because of concerns about the Bradley's vulnerability, the Army conducted a series of live-fire vulnerability tests from March 1985 through May 1987. The tests showed that the Bradley, as then configured, was highly vulnerable to anti-armor weapons. As a result, in the late 1980s, the Army began to incorporate a number of survivability enhancements into a Bradley high-survivability configuration referred to as the "A2 model" (see fig. I.1). The high-survivability modifications for the A2 model include the following:

- Addition of steel applique armor. This armor, consisting of steel plates added to existing armor on parts of the turret and hull, increased protection from 14.5-mm to 30-mm ammunition.
- Addition of spall liners. Spall liners were added to the interior of the crew compartment to protect the crew from high-velocity debris (spall) caused by rounds' penetrating the vehicle.
- Relocation of ammunition. Twenty-five millimeter ammunition and TOW missiles stowed internally were moved to less vulnerable areas located in the rear, lower part of the crew compartment. In addition, to the extent

possible, mines and pyrotechnics (signals and flares) were stowed in external rear storage compartments.

- Addition of attachment points. Attachment points were added to the exterior of the vehicle (the front, sides, and turret) for the purpose of attaching reactive or passive armor tiles. The Army has not yet fielded these tiles. The decision to add passive or reactive armor tiles to the Bradley is under review.
- Modification of automatic fire extinguishing system. Current system was to be modified to incorporate a dual-shot system, which automatically activates after a 1/2-second delay to protect against a second hit. To further protect the system, cables were rerouted, and spall protection was added. A dual-shot system has not been added due to affordability constraints.
- Increase of engine power. The engine's power was increased from 500- to 600-horsepower to accommodate the heavier vehicle weight resulting from survivability modifications.
- Modification of transmission. The transmission was modified to improve reliability and to match the horsepower increase of the engine.
- Modification of internal fuel supply system. This system was modified to empty fuel from vulnerable upper fuel cells before fuel from the more protected lower fuel cells is used (upper fuel cells will be emptied after the first 40 gallons of fuel are burned).

Figure I.1: The A2 Bradley Fighting Vehicle

Source: U.S. Army.

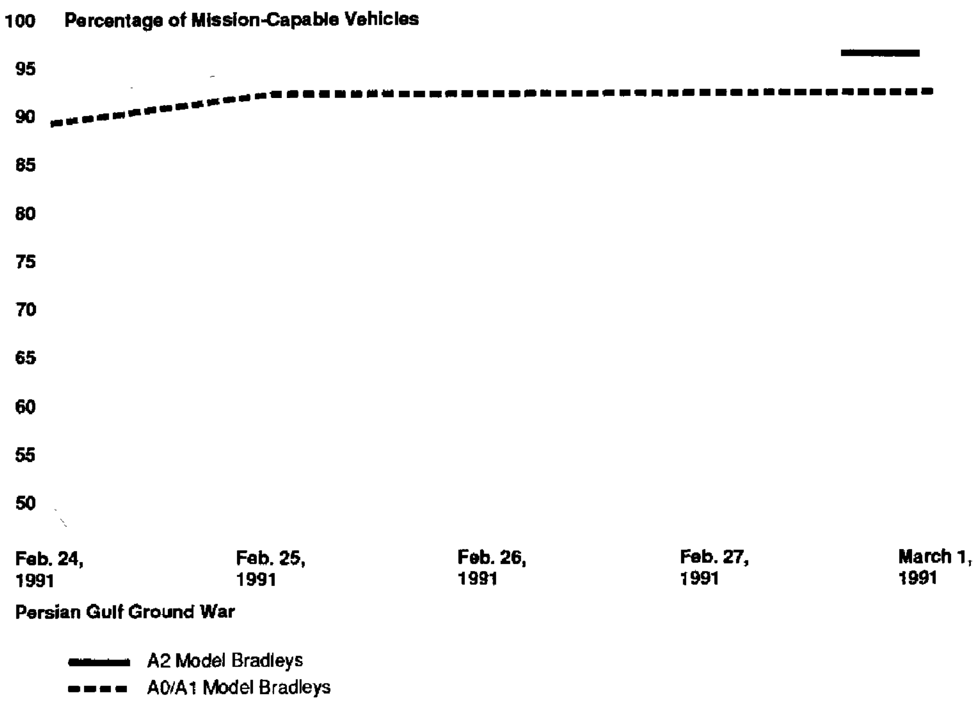
Good Reliability, but Some Hardware Deficiencies Identified

The Bradley Fighting Vehicle exhibited good reliability during the Persian Gulf war. We measured reliability using operational readiness rates—the percentage of mission-capable vehicles on a given day. Operational readiness rates reported during the Persian Gulf war at units we visited were generally based on whether the vehicle could move, shoot, and communicate. This differed from peacetime reporting standards, which are based on mission-capable criteria specified in the vehicle operator's and maintenance manuals. For example, if an A2 model's engine access door cannot be raised, the operator's manual states that the vehicle is to be reported as not mission-capable. However, a vehicle with the same problem during the war would typically have been reported as mission-capable because the problem did not affect the vehicle's capability to move, shoot, and communicate.

As shown in figure I.2, the percentage of Bradleys reported as being combat ready—based on whether the vehicle could move, shoot, and communicate—was near or above 90 percent during the ground war. The Bradley A2s had very high readiness rates—ranging from 92 to 96 percent of the vehicles combat ready throughout the ground war. The older A0 and A1 models exhibited readiness rates ranging from 89 to 92 percent of the vehicles combat ready throughout the ground war.

The Bradley's high system reliability, indicated by the availability rates shown in figure I.2, was supported by crew and maintenance personnel's observations at each unit we visited. Bradley crews and mechanics consistently praised the reliability of the A2 model, citing its improved reliability and maintainability over the older models'.

Figure I.2: Percentage of Bradley Fighting Vehicles That Were Combat Ready From February 24 Through March 1, 1991



Note. Data for February 28, 1991, was not available.

Source: Army Materiel Command Southwest Asia Situation Reports.

While the Bradley exhibited good reliability, crews and mechanics at units we visited identified a number of recurring hardware deficiencies, as shown in table I.1. These deficiencies were relatively minor in that they generally did not affect the vehicle's ability to move, shoot, and communicate. Officials from the Army Infantry Center and the Bradley Fighting Vehicle Systems Program Office, as well as Army after action reports, confirmed these deficiencies. The Army has recognized these problems and has begun to implement corrective actions.

Officials from the Bradley Fighting Vehicle Systems Program Office stated that they were previously aware of most of the hardware deficiencies listed in table I.1. and in some cases had already begun to implement corrective actions.

Table I.1: Bradley Hardware Deficiencies

Component	Deficiency	Corrective actions planned/taken
Engine access door pump	Hydraulic pump on A2 Bradley, used to raise armored engine access door, frequently failed.	Army has implemented interim fixes to resolve pump failures. Long-term fix involves redesign of pump unit.
Heaters	Personnel heaters were not reliable and did not provide uniform heat distribution.	Heaters are an across-the-board problem with Army vehicles. The Army Tank-Automotive Command (TACOM) has created a task force to identify potential solutions and has obtained funds for a new heater program.
Integrated sight unit ballistic door cables	Cables used to close the armored doors protecting the sight on A2 Bradley broke. Problem attributed to cables not being strong enough and crews improperly closing doors.	Improved cables and proper closing procedures for doors distributed to units in the Persian Gulf. Engineering change implemented to make stronger cables.
Lower side armor skirts	Buildup of mud and rock caused lower rear, side armor skirt bolts to shear and skirts to pop off on A2s.	A strengthened side skirt design has been approved. The new design was scheduled to be put on new production vehicles beginning in November 1991. A decision to install the new design on existing vehicles is on hold pending availability of funding.
Machine gun	Machine gun subject to sand ingestion.	Redesign in process to modify feed chute to eliminate sand accumulation, and covers are being developed to reduce the amount of dirt, sand, and dust entering the turret and machine gun.
Radiator	Radiators on A2s developed leaks due to corrosive residue left on the solder joints during manufacture.	Army has determined current design is acceptable. Corrective action included additional rinsing, addition of preservative to final rinse, and emphasis on quality control.
Radiator grille intake bolts	Heads of bolts that attach radiator screen to hull sheared off.	As an interim fix, units are to use higher grade bolts. Long-term fix will increase the size of the bolts in the grille and the number of bolts from four to eight.
Radiator water coolant drain pipe	Radiator pipes on A2s leaked due to improperly prepared weld sites and inadequate pipe strength.	Some units received replacement pipes in the Persian Gulf area. Other units rewelded pipes. Modification kit developed to correct problem will be put on existing vehicles as necessary, and improved materials have been put into production.

(continued)

Component	Deficiency	Corrective actions planned/taken
TOW missile system	The TOW launcher, on the A1s and A2s, experienced failures from crews' (1) failing to properly prepare TOW rounds prior to loading and (2) loading damaged rounds. Additional launcher failures were brought about by sand and dust ingestion.	Care of TOW rounds has been emphasized. Design changes have been made to modify launcher to reduce the frequency of launcher failures as a result of crew errors and to correct sand- and dust-related problems.
Vehicle exhaust outlet	A2's exhaust outlet directs exhaust in commander's face and into crew compartment.	Redesign in process to direct exhaust away from vehicle. Prototypes are being tested.
Vehicle hatches	Hatches leaked and hatch seals subject to sand damage. Seals built up with sand, making it difficult to close hatches.	Hatch seals are being redesigned for improved sealing from water, and solutions to reduce sand buildup are being investigated.

Survivability Data Limited, but A2 Modifications Increased Crew Confidence

The U.S. Army Ballistics Research Laboratory (BRL), in its ongoing study of battle damage, has not drawn any firm conclusions on survivability. As a result, information on the effectiveness of the steel applique armor and spall liners on the A2 model in withstanding enemy fire is limited. BRL has determined that most of the destroyed Bradley Fighting Vehicles it examined were destroyed in "overmatch" situations. That is, these Bradleys were destroyed by weapons systems, such as tanks, that far exceeded their designed survivability capabilities. However, BRL indicated that the Bradley's fire suppression system worked well.

According to information provided by the Army's Office of the Deputy Chief of Staff for Operations and Plans, 20 Bradleys were destroyed during the Persian Gulf war. Another 12 Bradleys were damaged, but 4 of these were quickly repaired. Friendly fire accounted for 17 of the destroyed Bradleys and 3 of the damaged ones.

The Army has not yet fielded a Bradley with reactive or passive armor tiles. However, commanders and crews who had A2s were glad to have the added steel applique armor protection, spall liners, and increased speed and acceleration that the larger 600-horsepower engine offered over the older models. They stated that the added armor, spall liners, and engine power made them feel safer.

Although the ammunition storage space was changed on the A2 model to improve survivability, crews said they had carried extra ammunition and stored it wherever it would fit. They were far more concerned about running out of ammunition than they were about the potential impact of carrying extra ammunition. Although BRL did not measure the impact of carrying extra ammunition on the survivability of the Bradley, BRL officials were concerned that carrying extra ammunition could lead to an increased loss of life.

Bradley Is Lethal, but Some System Enhancements Are Desired

The Bradley's weapon systems proved to be lethal and effective against a variety of enemy targets. Commanders, crews, and officials from the Center for Army Lessons Learned (CALL) and the Army Infantry Center reported that the 25-mm automatic gun was a very versatile weapon. Crews we spoke with used the 25-mm automatic gun primarily for clearing bunkers and firing on lightly armored vehicles. While the 25-mm automatic gun is not the weapon of choice for engaging tanks, vehicle commanders, crews, and CALL and Army Infantry Center personnel reported isolated instances in which the 25-mm automatic gun had killed tanks. Officials from the Army Materiel Systems Analysis Activity (AMSAA) also stated that, according to crews, the 25-mm automatic gun had killed tanks. However, AMSAA officials stated that, on the basis of their ongoing assessment of combat vehicles in the Persian Gulf war, for the 25-mm automatic gun to kill a tank, the tank would have to be hit at close range in its more vulnerable areas.

The Bradley's TOW missile system was lethal at long ranges against all forms of enemy armor, such as tanks, with few missile failures reported. For example, crews from the 1st Armored Division and 2nd Armored Cavalry Regiment stated they had used the TOW to destroy Iraqi tanks. Crews reported destroying tanks at ranges from 800 to 3,700 meters. Some Bradley commanders, crews, gunners, and Army Infantry Center officials expressed concerns about being exposed to enemy fire until the missile hit its target. At its maximum range of 3,750 meters, the TOW takes about 20 seconds to hit its target. From the time the TOW is fired until it hits its target, the Bradley must remain in a stationary position. During the time the Bradley is stationary, it is more vulnerable to enemy fire. As a result, some Bradley commanders, gunners, and crews, as well as the Army Infantry Center, want a "fire-and-forget" weapon to replace the TOW.

Crews, as well as CALL and Army Infantry Center officials, stated that they want a built-in laser range finder to accurately determine the distance to the target before firing the TOW or the 25-mm automatic gun. The featureless desert terrain made targets easier to see but more difficult for gunners to determine whether targets were within range. According to CALL officials, there were many instances in which gunners fired at targets well beyond the TOW missile's range, resulting in missiles falling short of the target. While some Bradley crews used hand-held laser range finders, crews complained that these subjected the operators to enemy fire, that it was difficult to obtain accurate readings under combat conditions, and that they were cumbersome to operate. The Army is investigating the option of adding a built-in laser range finder to the Bradley.

While the 25-mm automatic gun and the TOW proved to be lethal weapons, crews, Army after action reports, and CALL and Army Infantry Center officials reported that the weapons had exceeded the sight's capability to identify targets. They cite the need for added sight magnification and resolution to accurately identify targets and to prevent incidents of fratricide. Soldiers and Army Infantry Center officials we interviewed also want an identification of friend or foe (IFF) system to further aid in preventing fratricide. For more information on the need for added sight magnification and an IFF system, see appendix III.

Good Mobility and Range, but Some Improvements Wanted

Commanders and crews praised the Bradley's mobility and speed, stating that the Bradley had maneuvered well in the desert terrain and had had no problem keeping up with the Abrams tank. In particular, crews who had recently traded an older model for an A2 model were pleased with the added power and maneuverability that the new 600-horsepower engine provided, compared to the 500-horsepower engine on the older models.

The Bradley exhibited good range and fuel consumption. Crews we spoke with said that range and fuel consumption were not problems. For example, the 2nd Armored Cavalry Regiment traveled 120 miles in 82 hours during the ground war. Crews we spoke with from the 2nd Armored Cavalry Regiment stated that they could have gone the entire ground war without refueling. In addition, several crews noted that at stops to refuel the Abrams tank, they were never below 1/2 to 3/4 of a tank.

While the Bradley performed well in terms of overall speed and mobility, some crews indicated that a faster reverse speed for the Bradley was needed. The Bradley had no problems keeping up with the Abrams tank when traveling forward. However, the Bradley's reverse speed is no match for that of the Abrams. The A2 Bradley's reverse speed is approximately 7 miles per hour, while the Abrams' reverse speed is about 20 miles per hour. During the war, there were incidents in which the Abrams tanks moved quickly in reverse, leaving the Bradley Fighting Vehicles on the battlefield by themselves or forcing the Bradleys to turn and expose the more vulnerable rear of the vehicle to the enemy. The Army has asked General

Electric, the Bradley transmission's manufacturer, to review the options available for providing the Bradley with a faster reverse speed.

Bradley crews, CALL and Army Infantry Center officials, and Army after action reports cite the need for a driver's thermal viewer. A driver's thermal viewer would allow the driver to see better in dust and fog and at night. Currently, the Bradley is equipped with a driver's night viewer, which magnifies available light and assists in nighttime navigation. A driver's thermal viewer would use thermal sight technology similar to that used in the Bradley's thermal Integrated Sight Unit. Bradley program officials stated that a driver's thermal viewer is being developed, but a decision to incorporate it into the Bradley has not been made.

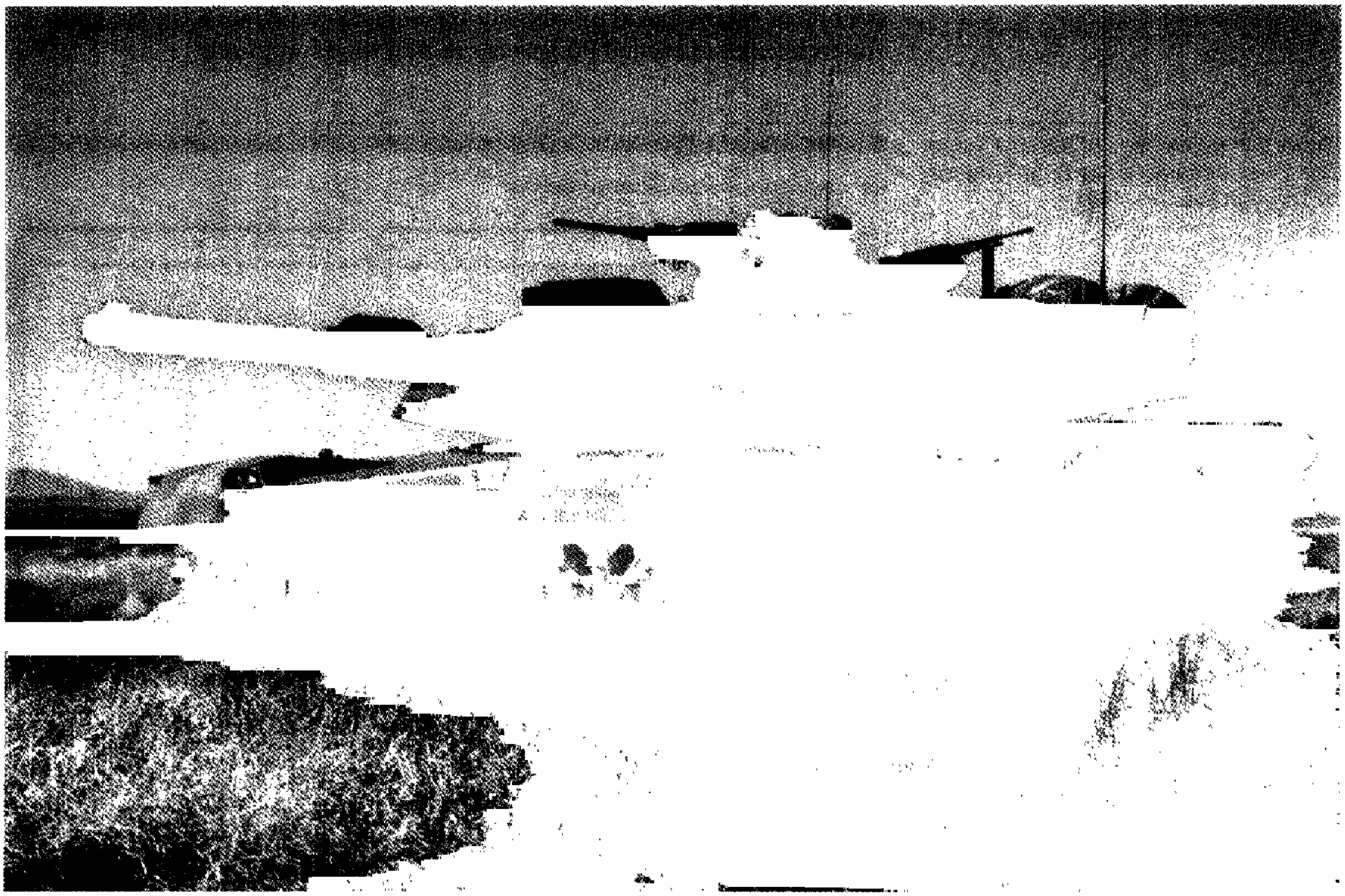
Abrams Tank Receives High Marks for Performance, but Range Was Limited

According to the observations of commanders, crews, maintenance personnel, and operational readiness data and Army after action reports, the Abrams system performed well in the Persian Gulf war, receiving high marks for reliability, mobility, lethality, and survivability. Identified system deficiencies, however, have implications on the range of the tank. These deficiencies concerned (1) high fuel consumption, (2) reliability problems with the tank's fuel system, and (3) frequent maintenance of the tank's air filtration system.

Background

The M1 series Abrams tank was fielded in 1981 and had a 105-mm main gun, a day and night fire control system, a compartmentalization of fuel and main gun ammunition, and an automatic fire detection and suppression system. The M1A1 series Abrams tank is an improved version of the M1 tank and was fielded in 1986. The M1A1 improvements include increased lethality, with a more powerful 120-mm main gun; increased survivability, with improved armor; and a nuclear, biological, and chemical overpressure protection system (see fig. II.1).

Figure II.1: The M1A1 Abrams Tank



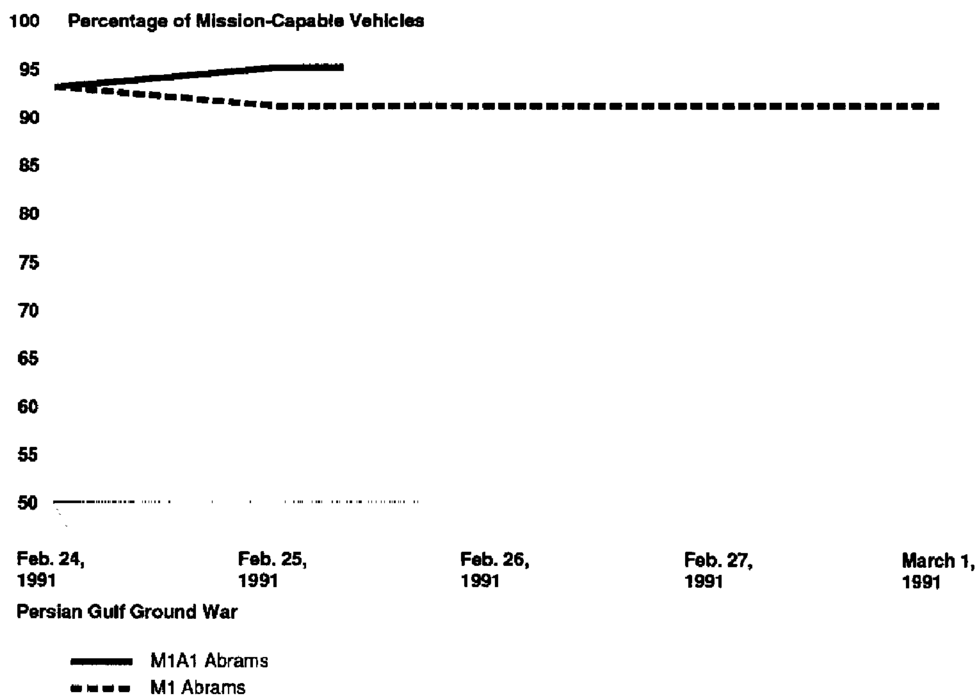
Source: U.S. Army.

Reliability High

The Abrams exhibited good reliability during the Persian Gulf war. We measured reliability in terms of operational readiness rates—the percentage of mission-capable vehicles on a given day. Operational readiness rates reported during the Persian Gulf war at the units we visited were generally based on whether the vehicle could move, shoot, and communicate. This differed from peacetime reporting standards, which are based on mission-capable criteria specified in the vehicle operator's and maintenance manuals.

As shown in figure II.2, the percentage of Abrams tanks that were reported as combat ready, based on whether the vehicle could move, shoot, and communicate, exceeded 90 percent during the ground war.

Figure II.2: Percentage of Abrams Tanks That Were Combat Ready From February 24 Through March 1, 1991



Note: Data for February 28, 1991, was not available.

Source: Army Materiel Command Southwest Asia Situation Reports.

The high reliability indicated by the readiness rates shown in figure II.2 was supported by the observations of tank commanders, crews, and maintenance personnel at each unit we visited. According to those we interviewed, the Abrams' reliability throughout the ground campaign was very good, provided the necessary spare and repair parts were available. Some crews reported that the Abrams tanks were the "best combat vehicles on the battlefield." Others stated that they traveled unprecedented distances with few reliability problems.

Speed, Mobility, and Maneuverability Demonstrated in Desert

Overall, tank commanders and crews at units we visited reported that the Abrams was quick, agile, and able to effectively maneuver over varying types of terrain. Commanders and crews were able to conduct missions rapidly over wide and varied expanses of desert terrain, including soft sand and rocky areas. Although the Abrams' speed varied, depending on mission and terrain, according to commanders and crews, the tank "set the pace." At times, the tanks were forced to slow down to allow supporting vehicles, with the exception of the Bradley Fighting Vehicle, to catch up.

Weapon System Accurate and Lethal, but Some Improvements Wanted

According to tank commanders and gunners, it was uncommon to hear of anything except first-round catastrophic kills of Iraqi tanks from users of the 120-mm main gun. Further, they said that the capability of the tank's thermal sight to acquire targets through darkness, smoke, and haze, coupled with new armor-piercing ammunition, proved devastating against Iraqi armor and often resulted in one-shot kills. However, added sight magnification and resolution, along with an IFF system, are wanted to match the 120-mm weapon's range (see app. III for more discussion of this issue). Further, some tank commanders and crew members reported the need for a turret/hull reference indicator, which would help in determining the turret's orientation to the vehicle.

The M1A1 Abrams' performance in the area of hit probability is being assessed by AMSAA. AMSAA's preliminary findings indicate that the Abrams 120-mm gun's accuracy in the Persian Gulf war exceeded AMSAA's expectations based on pre-war hit probability projections. It attributed the higher hit probability in the Persian Gulf war to

- superior sighting capabilities that allowed U.S. tanks to engage Iraqi tanks at long distances under conditions of poor visibility, such as sandstorms, smoke, or fog;
- a short war, which caused less wear and tear on troops and equipment; and
- high levels of tank readiness and soldier training.

Emerging observations from CALL, Army Armor Center officials, and Army unit after action reports also noted the need for greater sight magnification/resolution and an IFF system to improve weapon effectiveness and prevent incidents of fratricide. CALL and Army Armor Center officials also cited a need for a driver's and commander's independent thermal viewer, which would allow the commander to view the entire battlefield and permit the commander to search for targets while the gunners engaged others. CALL also confirmed the need for a turret/hull reference indicator.

The Army is incorporating a commander's independent thermal viewer into the new M1A2 model tanks. The Army is also looking into the need for the turret/hull reference indicator.

Survivability High

According to BRL, preliminary data from CALL, and Abrams crews, the Abrams' survivability was high during the ground war. The Army's Office of Deputy Chief of Staff for Operations and Plans reported that the enemy destroyed no Abrams tanks during the Persian Gulf war.

BRL sent a team to the Persian Gulf area to examine combat vehicles destroyed or damaged during the hostilities. The destroyed tanks, according to BRL officials, were hit in vulnerable locations in the rear or above the turret ring. BRL officials also told us that their analysis had indicated that the Abrams' survivability was good and that the blow-out panels and fire suppression system had contributed to crew survivability.

According to the Army's Office of Deputy Chief of Staff for Operations and Plans, 23 Abrams tanks were destroyed or damaged in the Persian Gulf area. Of the nine Abrams destroyed, seven were due to friendly fire, and two were intentionally destroyed to prevent capture after they became disabled. Other Abrams tanks were damaged by enemy fire, land mines, on-board fires, or to prevent capture after they became disabled.

Preliminary data from CALL also credits the Abrams with having high survivability. CALL data showed that several M1A1 crews reported receiving direct frontal hits from Iraqi T-72s with minimal damage. CALL cites one incident in which an Abrams was reportedly struck twice by a T-72 tank firing from 2,000 meters. CALL reported that the crew involved in the incident stated that one projectile had bounced off the tank and the other had embedded itself in the armor. CALL also reported that two tanks had hit enemy antitank mines; the incidents caused minor damage, and the crews survived.

Crews credited several features of the system with increasing their confidence in survivability. These features included (1) nuclear, biological, and chemical protection; (2) the vehicle fire suppression system; (3) added armor; and (4) the tank's speed, agility, and lethality.

Range Limited by System Deficiencies

Although the Abrams tank received high marks from crews and maintenance personnel for reliability, mobility, lethality, and survivability, some system deficiencies were identified that limited the range of the tank. As a result of high fuel consumption and reliability problems with the fuel system, the tanks required frequent refueling. Moreover, the tank engine's air filters required frequent cleaning due to the harsh desert environment.

High Fuel Consumption a Constant Operational Concern

High fuel consumption limited the tank's range, and refueling the tank was a constant consideration in operational planning throughout the ground war. Tanks were refilled with fuel at every opportunity in order to keep the fuel tanks as full as possible. Prior to the start of the ground war, units practiced refueling procedures—such as refueling on the move and in organized columns. Once in the Persian Gulf area, Army operational plans generally called for refueling every 3 to 5 hours. Although these efforts provided optimum fuel availability, almost everyone we interviewed agreed that the tank's high fuel consumption was a concern. Typically, those we interviewed said that high fuel consumption was a trade-off for increased power and speed but that fuel economy could be improved by the addition of an auxiliary power unit.

The Abrams' M1A1 fuel capacity is about 500 gallons compartmentalized in four fuel cells—two forward cells and two rear cells. Fuel in the forward cells supplies the rear cells as they become depleted. Fuel use, according to Army estimates, is about 7 gallons of fuel per mile, with the tank consuming about the same amount of fuel idling as cruising. The Abrams tank is idling about 70 percent of the time in order to run the tank's electrical subsystems.

During the war, the Army's overall refueling strategy was to operate the tanks primarily off the rear fuel cells. This strategy was due, in part, to the time-consuming and more difficult task of refilling the forward fuel cells. The turret extends out over the forward fuel port, making the forward fuel port harder to reach. The turret must be traversed away from the fuel port to refill the forward fuel cells. As a result, the fuel in the front cells was designated as a backup source of fuel, and every effort was made to make sure the rear fuel cells were always full.

High fuel consumption placed a strain on the logistics system in that refueling the tanks was a constant operational concern in the Persian Gulf area. According to officials from the Abrams Tank Program Office, the Army has been aware of high Abrams fuel consumption and is focusing corrective actions on

- reducing idling time by incorporating an auxiliary power unit that will power the tank's electrical systems without running the engines and
- procuring a digital electronic control unit, which will improve fuel economy by 18 to 20 percent through automatic adjustment of fuel usage during times when the tank's engine must idle.

Fuel Pumps Were Unreliable

Another factor driving the Army's overall strategy of refueling every 3 to 5 hours was frequent reliability problems with the tank's fuel pumps. Fuel is pumped from the rear fuel cells to the engine by two in-cell fuel pumps. The two rear fuel cells are connected, so that if one in-cell fuel pump fails, the other pump serves as a backup to ensure the engine gets fuel. When the fuel level in the rear cells drops below one-eighth full, fuel is transferred from the forward to the rear cells by a transfer pump. If the transfer pump fails, the tank's fuel supply is virtually cut in half, since the fuel in the forward cells is no longer accessible. All units we visited reported reliability problems with both the in-cell and transfer pumps. Some units reported difficulties in obtaining replacement pumps.

In-Cell Fuel Pumps

The in-cell fuel pumps experienced high failure rates in the Persian Gulf area. Tank crews and mechanics at units we visited indicated that tanks frequently operated with only one functioning in-cell fuel pump. There are two in-cell fuel pumps, so if one fails, there is a backup pump to ensure the engine receives fuel. Thus, a tank can perform its mission with only one in-cell fuel pump working. Moreover, if both in-cell fuel pumps fail, the engine can still receive fuel through gravity feed, but power and speed are reduced. The maintenance required to replace in-cell fuel pumps is extensive (about 4 to 5 hours for the right pump, due to its location, and about 2 to 3 hours for the left pump, which is more accessible). Further, problems obtaining replacement pumps were also encountered, forcing some units to rebuild the in-cell pumps.

Transfer Pumps

The fuel transfer pumps also experienced high failure rates in the Persian Gulf area. Overall, replacement data was not maintained, but tank crews and mechanics at most units we visited reported that transfer pumps failed frequently. Some crews attributed this problem to the accumulation of sediments on the bottom of the forward cells because the fuel sat for long periods of time prior to deployment. Many crews said that, prior to deployment, the tanks were not driven long distances and fuel sat in the forward cells for long periods of time. According to crew members, the fuel sediment accumulated on the bottom of the fuel cell and when the transfer pump transferred fuel on long road marches, the sediments clogged and broke the pump.

Although a malfunctioning fuel transfer pump will not cause the vehicle to cease operating, the fuel in the forward cells is not accessible. Therefore, when the transfer pump fails, the driving range of the tank is virtually cut in half. According to some crews we spoke with at the 1st Infantry Division, 3 of 14 tanks in one company did not see battle due to transfer pump failures. Crews also noted problems in obtaining replacement transfer pumps, so they had to rebuild them whenever possible.

In one Army report, every brigade commander interviewed had reported problems with both the in-cell and transfer pumps. Further, emerging Army observations on lessons learned from the war show that the necessity of frequently refueling to avoid problems with transfer pumps disrupted the high tempo of operations during the war.

Officials from the Abrams Tank Program Office said that the Army was aware of the low reliability of the in-cell fuel pumps prior to the war and had a testing program in process when the war began. These officials also said that the Army had conducted studies prior to the war to determine the impact of in-cell pump reliability problems on war operations. Refueling objectives were adjusted; however, the Army was aware that if both in-cell pumps malfunctioned, gravity feed of fuel to the engine would occur, although some performance qualities such as speed and power would be lost. The Army is procuring new in-cell fuel pumps, which are said to have a longer operational life. The new in-cell pumps are expected to last about 3,000 hours, whereas the old ones were estimated to last about 1,000 hours.

According to officials from the Abrams Tank Program Office, unlike the in-cell fuel pumps, the transfer pump had not been a big problem in the past. The Army believes that the problems experienced with the transfer pump may be due more to operational factors than to mechanical factors. Although early indications seem to point to the lack of use as the cause of pump failure, the Army is studying the entire fuel system and exploring three corrective actions. The simplest fix is a fuel additive that would prevent the accumulation of sediments. The Army is also looking into changing the transfer pump design in one of two ways. One possible design change is to make the fuel transfer pump transfer fuel at three-quarters full as opposed to one-eighth. This change would ensure more frequent fuel transfer and decrease the possibility of sediment accumulation. Another possible change would make the fuel transfer pump larger and more capable of handling some fuel sediments without clogging.

Sand Ingestion a Constant Problem and Operational Concern

In the Persian Gulf area, the Abrams tank engine faced an extreme desert environment, which affected operational planning and caused concerns over sand ingestion. The Abrams tank's 1,500-horsepower gas turbine engine requires extensive air intake to perform optimally. The tank's air filtration system is adequate for conditions normally found in Europe and the United States, including the Army's National Training Center located in the California desert. In the Persian Gulf area, however, the tank's air filtration system required frequent cleaning because of the fine talc-like desert sand.

According to crews we interviewed, fine sand was thrown up into the air by the tank's tracks and accumulated on top of the tank's air intake vent, which is located on the rear deck of the tank. The sand clogged the system's air filters, thus reducing the flow of air to the engine and causing a loss of engine power and speed. In extreme cases, sand passed through the filtering system and damaged the engine.

The Army had taken the extreme desert environment into consideration in deploying armored units to the Persian Gulf area, and it stressed the need for frequent and intensive maintenance of the air filtration system. Despite these early warnings, problems with sand ingestion began to appear soon after deployment, and engine losses due to sand ingestion were encountered by all units we visited. The 24th Infantry Division (Mechanized), which was one of the first to deploy, experienced a disproportionate number of engine failures due to sand ingestion early in its deployment. The 24th Infantry Division's experience was exacerbated by an Army-wide shortage of filters during the period leading up to its deployment, resulting in its having to deploy without changing filters. Deploying units were alerted to the potential for sand ingestion problems and the need for intensive air-filtration system maintenance.

Despite emphasis on intensified maintenance prior to deployment, units arriving after the 24th Infantry Division also experienced engine damage due to sand ingestion. Maintenance personnel from the 1st Cavalry Division said that since they had deployed after the 24th Infantry Division, they were aware of the dangers of sand ingestion. However, they incurred about

16 engine losses in one of their initial training maneuvers after deploying—indicating that "you had to see the fine talc-like sand to believe it." Since maintenance records were not always kept, the exact number of engines lost due to sand ingestion is not known. However, other combat units we visited provided similar reports of engine losses to sand ingestion. As a result, tank commanders and crews told us they quickly learned the importance of maintaining the turbine engine's air filtration system in the harsh desert environment. Filter cleaning actions included

- the use of a high-pressured air wand usually connected to an accompanying tank to blow sand out of the filters;
- the use of a portable trailer-mounted vacuum, which involved pulling the dirty air filters off, replacing them with clean ones, and sending the dirty ones to a maintenance site for vacuum cleaning; and
- "shaking out" the filters or rapping them against the side of the tank or on the ground to remove the sand.

Most tank crews indicated that during the war "shaking out" the filters was the most frequently used method, since it was the quickest and simplest. Crews indicated that frequent air filter cleaning was a constant concern. Tank crews said they had been instructed to check and clean their filters at each refueling stop—generally planned for every 3 to 5 hours. Several tank crews told us that, depending on weather conditions, they had to stop even more frequently to clean their air filters. Even with intensive maintenance efforts, some tanks lost power during battle due to clogged air filters.

Some soldiers told us that if the weather going into Iraq had been more like the weather they encountered on the way out, the air filtration problems would have been even more severe. Crews from the 1st Armored Division said the weather became very dry and dusty as troops were leaving Iraq, and they experienced increased difficulties with clogged filters, engine power loss, and reduced speed. Soldiers from the 2nd Armored Cavalry Regiment observed that on their way out of Iraq they had seen tanks stopped in their tracks due to severe sand ingestion encountered during a sandstorm. One crew said it had encountered a sandstorm and five tanks in its company had shut down due to clogged filters. All five tank crews stopped to clean their air filters, but within 15 minutes, two of the same five tanks shut down again due to sand ingestion.

Officials from the Abrams Tank Program Office told us that the Army is looking at two potential fixes for the air filtration problems experienced in the Persian Gulf area. One possible solution is a self-cleaning air filter, which would reduce the air filter maintenance requirement. Another possible solution is an air induction tower added to the top of the tank's air vent, which would rise above the sand being thrown up by the tank's tracks.

Issues Common to the Bradley and Abrams Systems

Bradley and Abrams systems shared a number of common problems which impacted their performance in the Persian Gulf war. For example, Army units experienced difficulties obtaining spare and repair parts. Bradley and Abrams crews also reported that their weapons outshot their ability to positively identify targets. These sight limitations meant that weapon system capabilities were not optimized and led to difficulty distinguishing between friend or foe at long ranges. Bradley and Abrams crews also noted problems with the reliability of outdated radios. Finally, because the Global Positioning System (GPS) received high marks as a key navigation aid, crews and commanders believed it should have been more widely available.

Combat Units Had Difficulty Obtaining Parts

Parts supply was a general problem throughout the Persian Gulf theater. Parts were generally available in Saudi Arabia at the theater level, but their distribution to combat units was inadequate. Consequently, mechanics and logistics personnel in combat units had to work around the formal parts distribution system and "scrounge" for needed parts. Because of the difficulties experienced by combat units in obtaining parts for the Bradley and Abrams systems, sustainability could have become a major problem had the war lasted any longer, according to some logistics personnel and commanders.

According to commanders, Army combat units deployed to the Persian Gulf area with as many spare parts as possible because the theater-level logistics system hastily established in Saudi Arabia was still immature. In some cases, units deployed with fewer parts than authorized. For example, as reported in our earlier report, some units experienced significant parts shortages because large numbers of their spare and repair parts had been sent to other units that had deployed to the Persian Gulf area earlier.[1] Also, a portion of the parts did not reach the units after they arrived in the Persian Gulf area. For example, the Commander of the 1st Armored Division told us that as much as one-half of the division's spare and repair parts were not received by his unit in the Persian Gulf area.

Units generally had difficulty replenishing their parts reserves as they used their parts and were unable to obtain replacements. For example, a brigade of the 3rd Armored Division reported that, because its parts requisitions had not been filled, 40 percent of the parts it was authorized had zero balances after the war. Logistics personnel from the 1st Cavalry Division told us that about 60 percent of the parts they were authorized had zero

[1] Operation Desert Storm: The Services' Efforts to Provide Logistics Support for Selected Weapon Systems (GAO/NSIAD-91-321, Sept. 26, 1991).

balances by the end of the war. The 2nd Armored Cavalry Regiment also reported experiencing parts shortages as less than a quarter of its requests for additional parts had been filled.

Because combat units were often unable to obtain parts through the formal supply system, forward logistics personnel had to go outside the system to obtain the parts they needed. According to an Army Armor Center report, most divisions had supply officers posted at Dhahran—a port in Saudi Arabia—sorting through "mountains of cargo containers," searching for needed parts. Units also traded with other units, obtained parts through local purchase, and took parts from already disabled vehicles. "Scrounging" for parts in this manner proved to be a valuable method of obtaining necessary repair parts.

Although the Army shipped large quantities of parts to the Persian Gulf area, combat units had difficulty obtaining these parts due to distribution problems in the parts supply system. Once the deployment started, the Army expedited parts orders under existing contracts, made emergency parts procurements, and transferred parts from other theaters. Divisional maintenance and logistics personnel told us that parts had arrived from the United States and Germany so quickly and in such large quantities that theater logistics units did not know what parts they had or where they were stored. This lack of knowledge hindered efforts by theater logistics personnel to get needed parts to combat units. In addition, according to a CALL official, the physical process of submitting a parts requisition often took several days, in part because of incompatible computer systems and formats. When parts requisitions were filled, transportation problems often slowed efforts to get parts to combat units. Logistics personnel told us that theater-level support often did not have enough trucks or other transportation assets to move parts to forward combat units and that many of the available trucks were inadequate and unreliable. Combat units also frequently moved, sometimes making it difficult for supply trucks to find them.

Although parts were often hard to obtain, mechanics were able to maintain high Bradley and Abrams readiness rates in part because of extraordinary measures to obtain needed parts. However, some commanders and mechanics told us that the short war did not fully test the limits of this ad hoc "scrounge" parts supply system. In their opinion, the inability to replenish parts reserves could have impeded sustained combat operations in a longer war.

Weapons Outshoot Ability to Distinguish Targets

Crews, commanders, and CALL reported that greater magnification and clarity are needed for the Bradley's and Abrams' sights. The Bradley's optical system is the Integrated Sight Unit with 4-power and 12-power capability. The Abrams tank Gunners Primary Sight has 3-power and 10-power magnification. Both systems have a thermal capability that allowed crews to see in dark, smoky, and hazy conditions. Crews and commanders stated that improved vehicle optics are necessary since experience in the Persian Gulf war showed that both the Bradley and the Abrams were able to see and hit targets at greater ranges than they were able to positively identify targets. Although Bradley and Abrams gunners were able to see potential targets out to 4,000 meters or more, the images were no more than thermal "hotspots." Crews were generally unable to distinguish between friendly and enemy vehicles beyond 1,500 to 2,000 meters under clear conditions and as close as 500 to 600 meters or less during rainy conditions. However, the vehicles' main weapons could hit enemy targets well beyond this range: the Bradley's TOW missile at 3,750 meters, the Abrams' 120-mm gun at 3,000 meters or more, and the 25-mm gun on the Bradley at 2,500 meters.

The Bradley's and Abrams' inability to identify targets as far out as they could hit targets limited Bradley and Abrams combat effectiveness. Crews we spoke with reported having to hold fire while waiting for target confirmation from others. An Armor Center report noted that the Abrams' ability to engage the enemy was not optimized because the system's main gun range was greater than the vehicle's ability to identify targets.

While recognizing these limitations, Army sources also told us that Bradley and Abrams optics were superior to those in Iraqi vehicles. They said the Abrams' and Bradley's sight capability was a significant tactical advantage when engaging enemy forces. Iraqis were frequently unable to see U.S. forces when fired upon.

The inability to effectively distinguish friend from foe at long ranges contributed to incidents of U.S. forces' mistakenly firing on friendly units. In an August 13, 1991, press release, the Department of Defense reported 28 friendly fire incidents. Ten of these incidents involved U.S. tanks hitting other friendly targets. Some Bradley crews we spoke with said they feared friendly fire from Abrams tanks more than they feared the enemy. They also noted that Bradley Fighting Vehicles could easily be mistaken for enemy armored personnel carriers at long ranges. While better sights would help identify targets, Bradley and Abrams commanders and crews also cited the need for an effective, night-capable device for the identification of friend or foe.

The Army implemented several methods to help improve IFF capability in the Persian Gulf war, including painting an upside-down "V" on vehicles, attaching orange marker panels to the vehicles, and putting colored lenses in rear taillights. Bradley and Abrams crews also attached jerry-rigged IFF devices such as headlights in coffee cans, flags, and flashlights to their vehicle systems to make them more visible to other friendly vehicles. However, according to crews and commanders, these devices had limited effectiveness due to the weather, the long ranges at which most battles were fought, and the thermal sight's inability to distinguish fine points of the target.

Fratricide in the Persian Gulf war has heightened the Army's efforts to address IFF concerns. Shortly after the war, the Army Chief of Staff established the Combat Identification Task Force. The Task Force was charged with examining near-term and long-term changes to the Army's doctrine, training, organizations, leader development, and material to improve IFF capabilities. Under the aegis of this task force, the Army has a number of projects underway to study the IFF issue and develop ways to improve IFF capability.

Armor Center officials we spoke with stressed that even a perfect IFF device would not completely eliminate fratricide because confusion and the "fog of war" are endemic to combat. In their view, communication and training also play an important role in improving IFF and avoiding friendly-fire incidents. Commanders relied on communication, training, and coordination of movement to avoid friendly fire incidents in the Persian Gulf area. The Army also views the more widespread use of navigation equipment as likely to improve the identification of friend and foe. If commanders know where they are and where other friendly units are with greater accuracy, it will be easier to determine whether potential targets are friendly or not.

Vehicle Radios Ineffective and Unreliable

Bradley and Abrams commanders and crews reported that their vehicle radios were generally unreliable. Most Bradley Fighting Vehicles and Abrams tanks in the Persian Gulf war were equipped with 1960s-vintage VRC-12 series radios. A scout troop from the 1st Cavalry Division reported its radios were "almost always" broken, hindering communication with the rest of the unit. Many crews put wet paper towels on radios to keep them from overheating. Some crews also resorted to carrying several backup radios to replace failed units. In some instances, armored units had to communicate with flags and hand signals. The Army Armor Center, Infantry Center, and CALL also noted problems with the radio communication capability of the Bradley and Abrams systems.

For several years the Army has recognized the need for a new generation of radios. In 1974, the Army approved the requirement for upgraded radio capability. Production contracts for the improved Single Channel Ground and Airborne Radio System (SINCGARS) were first signed in 1983. However, a battalion from the 1st Cavalry Division was the only Army armored combat unit in the Persian Gulf area equipped with SINCGARS during the war.

Although SINCGARS' use in the Persian Gulf war was limited, reaction was positive. The Commander of the brigade in the 1st Cavalry Division, which was partially equipped with SINCGARS, said the new radios worked "great," with ranges up to 50 kilometers. The Army also reported that SINCGARS in the Persian Gulf war had 7,000 hours mean time between failure, compared with 250 hours for the older VRC-12 series.

As we reported in June 1991, the Army planned to field 150,000 additional SINCGARS radios to first-to-fight units by 1998.[2] The Army is also considering how to upgrade radio communication beyond the current SINCGARS system. Current plans are to field the follow-on radio after 1998. Whether the follow-on radio will be a new system or an upgrade of the current SINCGARS has not been determined.

Crews Would Like a Navigation System in Every Vehicle

Navigation systems enabled the Bradley and Abrams crews to determine their vehicles' location in the vast desert, but crews believed there were not enough systems available. Combat units generally had one or two navigation systems per company, or roughly one for every 6 to 12 vehicles. Two types of navigation systems were used in the Persian Gulf war: the Loran-C and GPS.

The Loran-C determines position based on radio transmissions from ground-based radio transmitters. When U.S. forces deployed to Saudi Arabia, they found a series of Loran radio transmitters already in place. To take advantage of the existing navigation infrastructure, the Army

[2] Communication Acquisition: Army Needs to Ensure Economy in SINCGARS Radio Procurement (GAO/NSIAD-91-119, June 21, 1991).

purchased 6,000 Loran-C receivers. During use in the Persian Gulf war, Loran-C enabled vehicle commanders to determine their location within 300 meters.

GPS is a space-based navigation system utilizing signals from satellites. The device used by Bradley and Abrams crews in the Persian Gulf war to receive the satellite signals was the Small Lightweight GPS Receiver (SLGR). The SLGRs used in the Persian Gulf war were hand-held units purchased from commercial vendors and slightly modified for military use. SLGRs enabled vehicle commanders to determine their location within 16 to 30 meters. The Army purchased about 8,000 SLGRs, of which roughly 3,500 were shipped to Army forces in time to be used during the ground war. Crews experienced in the use of both systems generally preferred the SLGR because it was more accurate.

According to crews, commanders, and other Army officials, U.S. forces would not have been able to navigate the nearly featureless desert without navigation systems. Navigation systems helped U.S. armored forces quickly traverse the lightly defended desert in eastern Iraq and cut off the bulk of the Iraqi force in Kuwait. A captured Iraqi general cited the SLGR as an example of being "beaten by American technology again." Support units also used navigation systems. For example, maintenance and logistics personnel used SLGRs to locate combat units. Engineers with the 24th Infantry Division used SLGRs to mark newly created combat trails inside Iraq.

Because SLGR relied on satellite information, the system was inoperative during certain times of the day when satellites were out of range. Despite this, soldiers we interviewed believed that navigation systems should be installed in as many vehicles as possible. A TACOM report on armored systems' performance in the Persian Gulf war noted, "Without exception every person...wanted a GPS in both the Abrams and Bradley." Armor and Infantry Center reports on the Bradley's and Abrams' performance in the Persian Gulf war also recommended installing GPS receivers in both systems.

The Army, in conjunction with the other services, is developing military specifications and requirements for the next generation of GPS receivers—the Precision Lightweight GPS Receiver (PLGR). Although the commercial SLGRs used during the Persian Gulf war performed well, they did not meet military specifications. According to the Army's GPS Associate Project Manager, the Army plans to procure commercially available navigation systems modified to meet PLGR requirements. Current Army plans call for initial PLGR procurement beginning in fiscal year 1993, with a total procurement of about 42,000 units in later years.

Some Combat and Support Vehicles Inadequate

The performance of vehicles that supported the Bradley and Abrams systems in the Persian Gulf war was inadequate. Crews and commanders reported significant problems with the M88A1 Medium Recovery Vehicle and the Heavy Equipment Transporter (HET). Performance problems stemmed from the fact that neither system was designed to support the Abrams tank. There were also numerous complaints about the inability of other combat systems, such as the M113 family of vehicles and the M109 self-propelled howitzer, to keep up with the faster and more mobile Bradley and Abrams systems. Also, the Army's older cargo truck fleet suffered from a general lack of mobility and reliability during the war.

M88A1 Tank Recovery Vehicle Deemed Inadequate

The M88A1—the Army's recovery vehicle—did not perform well in the Persian Gulf war. The M88 series recovery vehicle is designed to lift, winch, and tow tanks and other Army fighting vehicles. The initial M88 was first fielded in 1961 and later upgraded to the current M88A1 configuration to be able to tow vehicles weighing less than 60 tons. Because the Abrams weighs more than 60 tons, the Army determined it needed an improved recovery vehicle as early as 1981. A 1988 analysis noted that the M88A1 lacked sufficient weight, power, mobility, and hoist-and-winch capability to recover Abrams tanks. The M88A1's performance in the Persian Gulf war confirmed these previously identified shortcomings.

During the war, single M88A1s were often unable to recover disabled Abrams tanks. Two closely coordinated M88A1s were usually required to recover and tow a single Abrams. After recovering the tank, the M88A1's top towing speed was about 5 miles per hour. Even at this speed, M88A1s often suffered from engine or transmission problems, according to maintenance crews. All the units we visited reported significant problems with M88A1 performance. Maintenance crews told us that the M88A1 needs more horsepower and improved brakes and transmission before it will be able to effectively recover Abrams tanks. Crews and commanders also reported the M88A1 had difficulty keeping up with armored columns during road marches.

Because M88A1s lacked sufficient power, speed, and reliability, tanks were often used to recover other tanks. In one brigade of the 24th Infantry Division (Mechanized), M88A1 performance was so poor that more Abrams tanks were towing M88A1s than the other way around. Conducting recovery operations with an Abrams meant that a vehicle designed for combat was being used in a support role. Moreover, tanks can be damaged when recovered by other tanks. For example, at the 1st Armored Division, an Abrams tank being towed by another tank was damaged when heat from the towing Abrams' exhaust caused a fire, igniting the towed vehicle's ammunitioon. Heat shields were developed to protect towed vehicles from towing Abrams' exhaust. However, according to some crews we spoke with, these shields were not always available.

On the basis of M88A1 performance in the Persian Gulf war, the Army has accelerated efforts to obtain an improved recovery vehicle. The Army began initial development efforts in 1985 but eliminated the program in 1989 for budgetary reasons. In 1989 Congress revived the program by directing the Army to complete full-scale development testing of five improved, prototype recovery vehicles called M88A1E1s. The Army plans to conduct tests of the M88A1E1 during fiscal years 1992 and 1993. The Army is also studying other options for improving tank recovery capability. However, as of October 1991, the Army had made no decision on the kind of recovery vehicle it planned to procure.

Heavy Equipment Transporters Suffered From Inadequate Numbers and Poor Performance

The Army did not have enough HETs and the ones it did have were not reliable. The HET is a large, semitrailer truck designed to transport armored vehicles and equipment weighing up to 60 tons over long distances. U.S. HETs proved to be unreliable when carrying Abrams tanks. Unit mechanics reported that U.S. HETs frequently blew tires, suffered bent axles, and were generally unreliable. According to a representative from the Army Transportation School, the HET's marginal performance in hauling nearly 70-ton M1A1 tanks was not a surprise, since the HET was only designed to carry 60 tons.

The Army has known for several years that the Abrams tank outweighs the HET's carrying capacity. The Army began testing prototype HETs with improved capacity as early as 1981. Improved HETs designed to haul a 70-ton load are currently in technical testing. A full- scale production decision is planned for mid-1992.

In addition to the HET's poor reliability, Army commanders found that they did not have sufficient numbers of HETs to move Abrams and Bradleys between Saudi Arabian ports and tactical assembly areas. Among all U.S. forces, there were only 456 U.S. HETs to move roughly 5,000 Abrams tanks and Bradley vehicles. The Army determined that about 1,200 HETs would be needed to move the large U.S. armored force in Saudi Arabia and authorized a worldwide procurement to fill the gap. The Program Office for Combat Support, in conjunction with TACOM, procured, leased, or obtained donations of 474 additional HETs and heavy trucks from Czechoslovakia, Italy, Germany, and U.S. companies. U.S. forces were also able to use an additional 365 HETs from Saudi Arabia and Egypt.

The Army is procuring a new HET system capable of handling the heavier Abrams tank. Current production plans call for procuring about 900 improved HET tractors and about 900 improved HET trailers for the U.S. Army by the end of fiscal year 1993. The Army Training and Doctrine Command has also recently approved an operational concept that would increase the number of HETs in heavy truck companies. The primary mission of these HETs would become maneuver unit relocation, rather than recovery. Concept implementation may require significantly more new HETs than are currently under contract.

M113 Family of Vehicles Deemed Inadequate

During the Persian Gulf war, the M113 family of vehicles was generally unable to keep up with the faster Bradley and Abrams systems. M113 vehicles were first produced in the early 1960s, with upgrades in later years. Although M113s used to transport infantry have been largely replaced by Bradley Fighting Vehicles in Army units, several combat systems used in conjunction with the Bradley and the Abrams have M113 chassis. For example, the M548 hauls cargo; M577 command vehicles are primarily used for command and control; and M981 Fire Support Team Vehicles spot for artillery units. Soldiers we interviewed believed that, with the exception of the M113A3, the M113 variants were inadequate. Crews and commanders told us they had to slow down during road marches to allow M113s to keep up. The 1st Infantry Division's after action report from Desert Storm said the M113 series "must be upgraded or eliminated," noting in particular that the M548 "is a piece of junk." An Army Armor Center report also found that M113s, except M113A3s, were unable to keep pace with the Bradley and the Abrams. The report also cited the need for a new command and control vehicle to replace the "inadequate" M577.

M109 Howitzer Lacked Speed

The M109 self-propelled 155-mm howitzer—one of the Army's primary artillery weapons—was often unable to keep up with fast-moving Bradley and Abrams formations during operations in the Persian Gulf war. In a post-operation report, the Commander of the Army's VII Corps observed that the M109, along with the older M113s, proved to be a liability because it was slower than Bradley or Abrams systems. The Army is currently modifying its M109 howitzer.

Older Cargo Trucks Had Inadequate Mobility and Lacked Reliability

Commanders and maintenance personnel at the units we visited generally believed that the Army's 2.5-ton and 800 series 5-ton trucks were unreliable and lacked adequate speed and mobility. Much of the Army's medium truck fleet in the Persian Gulf area consisted of older 2.5-ton and 800 series 5-ton trucks manufactured in the late 1960s and early 1970s. Maintenance personnel preferred the newer, 900 series 5-ton truck. The 10-ton Heavy Expanded Mobility Tactical Truck and 1.25-ton High Mobility Multipurpose Wheeled Vehicle also received high marks for their performance in the Persian Gulf war. The Army recognizes the need for improving its medium truck fleet and currently plans to purchase new 2.5- and 5-ton trucks as part of its Family of Medium Tactical Vehicles program. The Army is also looking at the feasibility of refurbishing older 2.5-ton trucks.

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