The Bradley Fighting Vehicle

The **Bradley Fighting Vehicle (BFV)**, commonly known as the "Bradley," is a tracked armored vehicle for transporting troops to critical battlefield points, providing fire coverage for dismounting troops, and delivering offensive attack capability at enemy armored vehicles and troops. There are two models of the Bradley used for army ground operations: the M2 Infantry Fighting Vehicle (IFV), designed for troop transport, and the M3 Cavalry Fighting Vehicle (CFV), deployed for reconnaissance missions and tank combat. Of the Bradleys that have been built through the mid-1990s, 4,671 are IFVs and 2,083 are CFVs.

Both models of the **Bradley (M2/M3)** carry an identical three-man crew, comprised of a gunner and commander in the turret, and a driver seated under a hatch, in the front hull. The M2 Infantry Fighting Vehicle carries six infantry dismounts, and possesses firing portholes on either side of the vehicle. The M3 Cavalry Fighting Vehicle has sealed portholes and carries two observers and four infantry troops.

Bradley M2/M3s are housed in aluminum armor protection on all sides and spaced laminate armor on the rear and back. The Bradley's mounted armament includes a Bushmaster chain gun; a coaxial mounted machine gun for armored vehicle encounters; smoke grenade launchers; and a TOW (tube-launched, optically-tracked, wire-data-link-guided) missile launcher. It transports up to twelve TOW anti-tank missiles for great distance and firing accuracy (up to 4km), in addition to ammunition for each piece of artillery. Bradleys can travel up to 40mph on ground, and 2.5mph in water via attached inflatable barrier. It takes up to thirty minutes to be deployed as an amphibious vehicle.

A Success in Today's Battlefield/ A Failure in Efficient Research and Development

Although the Bradley destroyed many enemy tanks and experienced fairly low rates of casualty in the First Gulf War and the Iraq War, the vehicle's recent battlefield performance was not acquired through efficient planning and project management. The origins of the modern Bradley span decades of troubled development; the involvement of many stakeholders; inflexible and questionable requirements; a failure of contractors to make design tradeoffs for fear of losing capability; billions of dollars in R&D costs; and numerous Congressional interventions, including House Armed Service Committee hearings investigating Bradley testing protocol.[1] The Bradley has been described at different times, by military officers and historians, as a weapon that means "all things to all people," a "quintessential hybrid," and "a proverbial camel…that does nothing well".[2]

Accounts of the Bradley even inspired a 1998 satirical film called *The Pentagon Wars* that starred Cary Elwes as Colonel Burton, an Air Force Officer who sought to enforce better testing of the Bradley's vulnerabilities in the 1980s, and Kelsey Grammar as General Partridge, an Army officer who disagreed with Burton's methods. Clips from the film

Bradley M3A3
Cavalry Fighting Vehicle
(image courtesy of http://kr.blog.yahoo.com/shinecommerce/22042.html)

will be used periodically in this background brief to illustrate some of the issues encountered by the Bradley, from the 1960s to the present. Given its problems, the Bradley Fighting Vehicle is a classic case study for engineers, contractors, policymakers, and military officials who are designing any complex system.

Original need and the M113 armored personnel carrier (1960-1966)

In the 1950s and 1960s, the Army began to incorporate the idea of an infantry force equipped with specialized armored transport–a "mechanized infantry"–into its doctrine and corresponding technology.[3] Whereas "motorization" of the infantry referred to the use of motor vehicles with infantry units, "mechanization" was a more ambiguous concept referring to ground combat using tanks and other vehicles with increasing specialization and capabilities.[4] Designed by military contractor FMC in 1960, the M113 typified the new military requirements, including secure troop transport under possible threat of nuclear, biological, and chemical warfare. The M113 was an armored personnel carrier with aluminum on all sides, machine gun armament, and an eleven-troop capacity. It possessed the important capability of keeping pace with the M60 tank.

In 1964, the Office of the Chief of Research and Development at the Department of Defense issued a directive ordering the development of a mechanized infantry combat vehicle (MICV) with the following requirements: armored troop transport of eleven soldiers; enough speed to accompany the new M1 Abrams tanks; protection of infantry from nuclear, biological, and chemical agents; amphibious capability; and the ability to fire at small artillery and tanks. The existing M113 appeared to fit most of these requirements, except that seated troops could not fire from inside the vehicle.

Different contractors produced several variations of the M113 with gunports for infantry firing. One prototype, designed by Pacific Car & Foundry company, was an armored personnel carrier with a two-man turret, mounted machine gun, and a nine-person troop carrying capacity. All of the prototypes were rejected by the military because of inadequate off-road mobility and oversized hull width, which meant that they could not fit into transport aircraft.

More Requirements for the Mechanized Infantry Combat Vehicle (1967-1972)

In 1967, the Soviet Union introduced the BMP, an amphibious, tracked vehicle with tank and armored personnel carrier capabilities. Despite the BMP's serious design flaws -its small hull size, for example, meant that it could only carry Soviet soldiers of short stature- the United States rushed to develop a comparable American military vehicle that was part tank, part armored troop carrier. The "Casey Board," a committee created by the Army Vice Chief of Staff to refine requirements for the MICV program, recommended the development of a vehicle with a two-man turret, cannon, coaxial machine gun, and nine-person troop carrying capacity. FMC then presented the army with another variation of the M113. It weighed in at 15 tons, but had an improved engine, armor, turret-mounted cannon, gunports, and a nine-person troop carrying capacity. Although the M113 variant performed well during testing, the Army rejected it based on a computerized cost-effectiveness model that showed that the was slow and that designs for an entirely new MICV would perform better.[5]

M113 Armored Personnel Carrier
(image courtesy of Wikimedia Commons)

The list of MICV requirements grew as more agencies and individuals made recommendations and further additions to the design. The Office of the Secretary of Defense continued to support the inclusion of firing ports, a cannon, and antitank-guided munitions, while armor officers advocated the addition of long-range TOW missiles used during the Arab-Israeli War.[6] Although concerns about the vehicle's increasing weight, cost, and ability to ford streams were discussed, FMC continued development per the military's requests without making design or cost tradeoffs. The XM723, another variant of the M113, was designed in 1972 as an infantry fighting vehicle with a nine-person troop carrying capacity, a one-person turret, and 20mm automatic cannon.

From Mechanized Infantry Combat Vehicle to Bradley Fighting Vehicle (1970s-1981)

Meanwhile, the Army was also developing an armored reconnaissance scout vehicle for the cavalry. However, two prototype armored scout vehicles were deemed slower than the M113 and the program was halted. In 1976, the XM723 prototype was merged with the scout vehicle program, on the basis of their having similar requirements.[7] At this point, the Army's desire to create a completely new vehicle that could meet both infantry and cavalry vehicle requirements overrode any plans to improve the existing M113 platform, which had proven to be a reliable army transport vehicle with limited tank firing capabilities. A task force headed by Brigadier General Richard Larkin then determined that the cavalry version of the "infantry fighting" vehicle would carry a smaller crew and more ammunition, but would omit firing portholes. The inclusion of a two-person turret to fit the needs of the cavalry led to the IFV's decreased troop carrying capacity from nine to seven troops, thus decreasing the vehicle's troop carrying capacity and departing from its original design requirements to securely transport up to eleven military personnel. The Army named the MICV program "Fighting Vehicle Systems," and contracts were awarded in 1977- again to FMC- to create a XM2 Infantry Fighting Vehicle (IFV) and a XM3 Cavalry Fighting Vehicle (CFV).

The following montage from The Pentagon Wars illustrates the Bradley's changes from Armored Personnel Carrier to hybrid infantry-cavalry vehicle.

YouTube Clips from The Pentagon Wars: Early development of the Infantry Fighting Vehicle and Changing Requirements

Part 3, 3:41-10:25
http://www.youtube.com/watch?v=YYbjk298hNk&feature=related

Part 4, 00:00-4:11
http://www.youtube.com/watch?v=Z-1yOB4JHLU&NR=1

Montage of evolution of Bradley from 1968-1971 as armored personnel carrier into "infantry fighting vehicle." Various generals continue to add requirements to the original armored personnel carrier design. The designer adds a turret, cannon, armor, and anti-tank missiles as the vehicle takes on characteristics of a scout and tank-killing machine. The colonel in charge of the project complies with the generals' demands.

In the meantime, the Government Accounting Office (GAO) of Congress investigated the infantry/cavalry fighting vehicle's swimming capability, reporting in 1977 that the vehicle was too heavy, and that it took too long to inflate the barrier in preparation for water travel. Additionally, the GAO argued that swimming was a completely unnecessary capability, since the proposed vehicles would travel with non-amphibious tanks. The XM3 was also cited in the report as inferior to the M1 Abrams tank in terms of speed and armor protection. The recommendations of GAO were significant enough to take the Fighting Vehicle Systems program out of the 1979 Army budget.

The Army was nevertheless determined to push the XM2 and XM3 into production, retaining the amphibious requirement and including TOW missiles to the design in order to convince Congress of the vehicle's combat firepower capabilities (without TOWs, the XM2 and 3 were only slightly different, but more costly, than the M113s).[8] Two independent Army task forces and heavy lobbying by FMC convinced Congress to reinstate funds for production in 1978. FMC then created yet another prototype after Congressional approval, this time with increased armor protection. When production began in 1981, the M2 (the X was dropped, as it referred in military terms to "experimental") and M3 weighed over twenty-five tons. The final vehicle system was hybrid in more ways than one: it was hybrid in its combination of hardware, and in the fact that it served dual roles in the infantry and cavalry.

Live Fire Testing – A crucial turning point in the Bradley's survivability (1981-1987)

Expenditures on the development of the vehicle now called the Bradley M2 and M3 caught the attention of the press and public in the 1980s. Military reformer, theorist, and retired Air Force Colonel John Boyd and his follower Air Force Colonel John G. Burton seized the opportunity to examine the Bradley within the broader context of problems in Pentagon and DoD weapons acquisitions, development, and testing procedures. When the Army and Air Force agreed to participate in a Joint Live Fire Testing (LFT) Program of the Bradley in 1984, Colonel Burton was assigned to oversee testing of the Bradley's combat survivability. Over several years and two phases of testing, Aberdeen Proving Ground's Ballistics Research Laboratory (BRL)- the Army agency in charge of conducting the Bradley tests- ran into frequent conflicts with Burton's testing philosophy and protocol.

Burton strove for combat "realism" in tests and was focused on casualty prevention, urging BRL to conduct tests where the Bradley would stand, fully loaded and engine running, against overmatches- attacks with U.S. and Rus-

sian munitions that would clearly destroy the vehicle.[9] BRL, on the other hand, wanted to test individual Bradley components in measured, incremental units using computerized vulnerability models. Burton also favored random angle ballistics testing, disagreeing with BRL's method of testing against a computerized system and also with their rationale of conserving ammunition and "preventing extensive duplication" by using "preplanned shots to gather maximum information about selected vulnerabilities."[10]

Although no soldiers were placed inside the vehicles in testing scenarios, numerous issues concerning troop safety and the Bradley emerged as a result of Burton's insistence on testing the Bradley with maximum firepower. Secondary fires from damaged ammunition supplies, interior shock and pressure from explosive impacts, and potentially lethal chemical interactions with heat and the vehicle's exterior armor were some of the possible situations that could negatively affect the Bradley's crew and troops.

Below are two clips where Burton is skeptical of a test of the Bradley's armor. (The film is based on true events, but is exaggerated for effect.)

YouTube clips from The Pentagon Wars: Bradley Live Fire Testing I

Pt 2, 2:46-4:32:
http://www.youtube.com/watch?v=rEwKOFHNhjo&feature=related

First "successful" test on Bradley with a rocket propeller grenade launcher; Lt. Colonel Burton is not allowed a closer post-test inspection of vehicle.

Pt 2, 8:58-10:00
http://www.youtube.com/watch?v=rEwKOFHNhjo&feature=related

Pt 3, 00:08-00:49 (continued)
http://www.youtube.com/watch?v=YYbjk298hNk&feature=related

Burton is suspicious of the ammunition. He finds out that it is from Romania. After ordering a test of the ammunition fired on a metal door, he learns that the Army used a dud.

Although BRL's vulnerability models were designed to accompany and predict the results of live fire testing, discrepancies arose when comparing the results of the model to the actual tests, leading Burton to question the fidelity of the ballistics vulnerability models.[11] Prolonged disagreement with BRL about testing conditions led to Burton's reassignment to another Army post and his subsequent resignation.

Below are clips of some of Burton's demands, including testing the Bradley's armor for possible gaseous interactions due to combat fire:

YouTube clips from The Pentagon Wars: Bradley Live Fire Testing II

Pt 6, 00:54-1:47
http://www.youtube.com/watch?v=uLWldlWeyEk&feature=related

Lt. Colonel Burton approaches another general about aluminum armor on Bradley. According to a British report, aluminum is not resistant to firing and in fact releases a toxic gas that affects all personnel inside the vehicle. "Bradley is a death trap"- General tells Burton that the Bradley hasn't been tested with humans so they don't know anything about the effects of toxic gas.

Part 6, 8:28-9:17
http://www.youtube.com/watch?v=uLWldlWeyEk&feature=related

Burton is upset that none of his tests have been conducted according to plan. He again asks for a live fire test under combat conditions, stating that the safety of soldiers is his first priority and the survival of the vehicle is second.

Eventually, Congress was notified of the controversy surrounding the tests, and Burton was ordered to testify before the House Armed Services Committee, where he defended the need for proper live fire testing conditions.

After the Congressional investigation, the Army resumed live fire testing in simulated combat conditions, taking into account recommendations made by Burton. The results of this second phase of testing led to the Bradley's redesign, as significant improvements in vehicle suspension, armor, and munitions storage were made in order to enhance survivability and performance in the battlefield.

Summary of a troubled history

In summary, the final version of the vehicle was quite different from its original specifications as an armored personnel carrier that permitted troops to fire from inside. After multiple requests for proposals, each with additional requirements, and after numerous prototypes failed to meet the needs of one or more branches of the armed forces because they were too heavy, too slow, or unworkable in the planned environment, the version that went into combat was 13 tons heavier than originally specified, carried less people, and retained features that called for

variable missions and new forms of training. Furthermore, it took 16 years from the time of the first requirements document in 1964 to the time the vehicle was finally approved for production in the early 1980s. Changes did not end with the first round of production - more had to be made after a highly charged debate between Army officers led to a series of tests that showed the vehicle was vulnerable to live fire. After the vehicle went into the field during the First Gulf War, even more changes had to be made when vehicle proved to be vulnerable to friendly fire.

Below is a clip from The Pentagon Wars summarizing the monetary cost, lack of teamwork, and extensive development time needed to create the Bradley:

YouTube clips from The Pentagon Wars: The Bradley's Problems with Cost, Time & Teamwork

Pt 9, 00:06-5:02

http://www.youtube.com/watch?v=QFLQ3nioYmk&feature=related

Colonel Burton testifies before the House Armed Services Committee about the failure of the military to conduct realistic tests of the Bradley Fighting Vehicle and its survivability in combat conditions. General Partridge offers an opposing view, arguing that the threat of the Soviet Army is evidence of "realism."

Partridge tells the Committee that the Bradley took 17 years and $14 billion to produce, as of the time of 1986 hearing. The head of HASC orders a live-fire test under combat conditions.

The Bradley Fighting Vehicle System- upgrades to an extensible platform (1990s-present)

In the First Gulf War, twenty Bradleys were lost, mostly to friendly fire. To prevent vehicles from mistakenly targeting each other, the Army installed combat identification panels that give off reverse polarity heat when viewed with a thermal imaging weapon sight.[12] Since the beginning of the Iraq War, at least 50 Bradleys have been destroyed by improvised explosive devices and RPG fire.[13]

Current versions of the Bradley– M2A2 and M2A3 IFVs, and the M3A2 and M3A3 CFVs (A3s being the most upgraded versions)– belong to the Bradley Fighting Vehicle System. From 2000 to 2003, the Army awarded numerous contracts to United Defense to upgrade various components of the Bradley M2A3 with improvised explosive device mine armor; improved situational awareness technologies; and an eye-safe laser rangefinder capable of calculating the exact distance of a target, among other additions. Recent Bradley models are also equipped with GPS; flat display panels for the commander, driver, and troops; improved ammunition storage; an automatic fire detection and suppression system; and a central biological weapons protective suite. A3 Bradleys have a thermal imaging system for precise, heat-based targeting, as well as a sophisticated digital command and control (C3) system for integrating vehicle communications, fire control, and combat identification systems. The Bradley's C3 system is also linked to the Army's tactical internet for frequent updates of ground, air and enemy positions.

The Bradley has also expanded its role from an infantry and cavalry fighting vehicle to include missions in fire support, battle command, and transport for army engineers. Bradleys can also be distinguished by the team and missiles they carry– the Bradley Stinger Fighting Vehicle, for instance, carries a MANPADS (man-portable air defense systems, including shoulder-launched surface to air missiles) team with Stinger missiles under armor.[14]

The contractor for Bradley Fighting Vehicle System is BAE Systems, formerly United Defense. The Federation of American Scientists estimates the yearly cost of the Bradley program to be over $5 billion and cost per vehicle to be $3 million; however, this figure does not account for the billions of dollars and several decades that were spent in the development of the vehicle. [15]

Bradley A3 Infantry Fighting Vehicle
(image courtesy of militaryimages.net)

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Notes:

[1] Many of the problems associated with the Bradley Fighting Vehicle, including requirement changes, inefficient development time, high cost, and reluctance by army personnel to changes in testing protocol were documented in *The Pentagon Wars: Reformers Challenge the Old Guard*, a brief published in 1993 by Colonel James G. Burton. *The Pentagon Wars* was later adapted into an HBO film (1998) by the same name starring Kelsey Grammer as Major General Partridge, and Cary Elwes as Lieutenant Colonel (rank changed in film) Burton. The clips in this background brief are excerpted from the film adaptation of *The Pentagon Wars* for illustrative purposes.

[2] Lauren Holland, *Weapons Under Fire* (New York: Garland Publishing, 1997), 16-17.

[3] W. Blair Haworth, *The Bradley and How It Got That Way* (Westport: Greenwood Press, 1999), 2.

[4] According to military historian W. Blair Haworth, army strategists and officials wrestled with several larger doctrinal questions about the role of the "mechanized infantry" and armored vehicles that informed the design, and many of the debates, behind the Bradley: "Is the mechanized infantry a body of infantrymen who happen to be issued armored vehicles, or…armored vehicle crewmen who happen to dismount for some combat situations? Conversely, is the main weapon of the vehicle the troops carried within, or the armament?" Ibid., 2.

[5] The Congressional Budget Office's M-113-based alternative promised 2.5 billion dollars saved over five years, but the military rejected the design in favor of continuing with the MICV program. Thomas L. McNaugher, *New Weapons Old Politics* (Washington DC: Brookings Institution, 1989), 200.

[6] Holland, *Weapons Under Fire*, 16-17.

[7] How Stuff Works, "How Bradley Fighting Vehicles Work," http://science.howstuffworks.com/bradley.htm.

[8] Michael Green and James Brown, *M2/M3 Bradley At War* (Minneapolis: Zenith, 2007), 28-30.

[9] James G. Burton, *The Pentagon Wars (*Annapolis: Naval Institute Press, 1993), 2-5.

[10] Haworth, T*he Bradley and How It Got That Way*, 131.

[11] How Stuff Works, "How Bradley Fighting Vehicles Work," http://science.howstuffworks.com/bradley.htm.

[12] Green, *M2/M3 Bradley at War*, 45.

[13] The loss of 50 Bradleys was reported in a 2006 white paper by Lawrence J. Korb, and sourced from Army Times. The figure may now be higher. Loren Thompson, Lawrence J. Korb, and Caroline P. Wadhams, Army Equipment After Iraq (Washington DC: Lexington Institute, 2006), 6.

[14] Global Security, "M2 and M3 Bradley Fighting Vehicle System (BFVS)," http://www.globalsecurity.org/military/systems/ground/m2.htm.

[15] Federation of American Scientists, "M2A2 and M3A3 Bradley Fighting Vehicle System," http://www.fas.org/man/dod-101/sys/land/m2.htm.

For more photos visit:

http://www.militaryphotos.net/forums/showthread.php?148976-Bradley-s

Rear view of Bradley
(image courtesy of militaryphotos.net)