3

Munitions

Modern munitions include a wide variety of bombs and missiles that are used for air-to-surface, air-to-air, surface-to-air, and plain on-the-ground warfare. In recent years, beginning with the Gulf War, technology has enabled these munitions to increase their range and accuracy while making them easier for coalition forces to "fire and forget." This fire-and-forget capability enables them to launch their weapons and continue their other tasks as the weapon is guided toward its intended target. The current trend is for smarter, more accurate weapons that can be launched from increased standoff distances from an increasing range of aircraft platforms to protect our troops by keeping them out of range of enemy defenses.

In the Gulf War, one of the weapons of choice was the Tomahawk cruise missile and various forms of laser-guided bombs (LGBs). The LGBs were an improvement over conventional, or "dumb" bombs that fall with gravity, because they could be guided to their targets using laser designation. Despite the precision of LGBs, the problem with this form of targeting was that aircraft pilots needed to remain in the vicinity of the target to designate the target with the laser until the actual bomb impact. This increased the danger to the air crew, and the laser designation meant that these bombs could be used effectively only in good weather conditions that permitted clear visibility of the target.

Subsequent to the Gulf War, there has been considerable progress in weapons technology that has exhibited increased standoff distances, improved all-weather capabilities, and autonomous guidance without the need for air crew or on-the-ground laser designation. The percentage of precision-guided munitions delivered has risen from about 8 percent during the first war in the Persian Gulf region to 80 percent during the second. There has also been an increase in the number of precision-guided munitions (PGMs) that have been capable of delivery during adverse weather. This number rose from 13 percent in the first Gulf War to 90 percent in Afghanistan.

One of the more recent technologies to enable these precision, adverse-weather capabilities has been the use of the Global Positioning System (GPS), coupled with inertially guided navigation. The best known weapons employing these techniques have been the Joint Direct Attack Munition (JDAM) and the Joint Standoff Weapon (JSOW). The JDAM is essentially a $21,000 strap-on kit that converts a dumb bomb into a GPS-guided smart bomb. The JSOW is a standoff glide weapon that can carry a variety of modular payloads. Both weapons saw action during Operation Iraqi Freedom and were responsible for hitting targets such as the Baathist Party Headquarters and the Iraqi Information Ministry.

In recent years, weapons have also been specially created, adapted, and hurried into service to meet specific mission requirements. The bunker buster was not even in the planning stages when Kuwait was invaded in 1990. This bomb, designed to penetrate hardened command centers deep underground, was rapidly developed and within months was in service during the Gulf War. Another weapon, the Massive Ordnance Air Blast (MOAB), was first seen by the public during tests at Eglin Air Force Base (AFB) in Florida. This weapon is currently the largest non-nuclear weapon in the U.S. military arsenal, and during tests its devastating effects were seen and heard up to 19 miles from the target site.

The Hellfire missile has also seen some innovative uses outside of its typical role on board Navy, Army, and Marine Corps helicopters. It gained prominence when it was used in November 2002 against six suspected al Qaeda terrorists in a vehicle in Yemen. It is also being adapted to carry a thermobaric warhead to enable its use against caves and bunkers.

There are also new weapons designed for non-lethal but equally decisive effects. The secretive "Blackout Bomb" is capable of shutting down the electrical power grid of an entire city. It releases hundreds of submunitions that fall to ground via parachute. These submunitions then release carbon fiber filaments that short-circuit power distribution equipment. The blackout bomb was used in Operation Allied Force against Serbia and possibly during Operation Iraqi Freedom.

Turning to missile defense, the Patriot Advanced Capability-3 (PAC-3) uses a new approach for destroying enemy ballistic missiles. Instead of exploding near its target with a fragmentation warhead, hoping to destroy or at least knock the target missile off course, it uses kinetic (or motion) energy to completely destroy its target with a head-on collision equivalent to a bullet hitting another bullet.

The Tomahawk cruise missile is gaining new capabilities, as well. The next generation, the Tactical Tomahawk, can be reprogrammed in flight to strike either any of 15 preprogrammed alternate targets or a new target designated via GPS coordinates. It can also loiter over a designated area and provide target information or battle damage assessment information back to its commanders using an onboard camera before being committed to use.

This chapter completes its coverage of present-day munitions with a look at some of the intercontinental ballistic missile (ICBM) and submarine-launched ballistic missile (SLBM) warheads that are a legacy of the Cold War and part of America's strategic nuclear deterrent—the Minuteman, Peacekeeper, and Trident Fleet Ballistic Missile.

GBU-28/GBU-37 "Bunker Buster"

The GBU-28 and GBU-37 are "bunker-buster" bombs that are used to penetrate hardened command centers deep underground and to destroy enemy weapons of mass destruction. The weapon was first introduced during the Gulf War and can penetrate over 20 feet of concrete or more than 100 feet of solid earth. It is typically launched from U.S. Air Force aircraft, including the F-15E Strike Eagle and the B-2 Spirit. The original weapon used during the Gulf War was designed and placed into combat operation in less than one month in February 1991 in order to attack Iraqi underground command centers.

Features

The GBU-28 is an LGB that carries a 4,400-pound penetrating warhead. It can be dropped by either the F-15E Strike Eagle or the B-2 Spirit. The GBU-37 is satellite-guided and is dropped from the B-2 Spirit at heights of 40,000 feet. The bomb measures approximately 19 feet in length and is 14.5 inches in diameter. The warhead, located inside a surplus 8-inch artillery gun tube, includes over 600 pounds of high explosives plus what is believed to be depleted uranium. Because this material is radioactive, it can be harmful if ingested. However, its alpha rays cannot pass though skin or clothing, so it is relatively safe in its solid form. Advanced fuzes inside the weapon mean that it can count the rooms it is passing through and can be set to detonate when it reaches a specific floor level. These fuzes can also be set to detonate when they encounter a designated air space or a specific altitude.

In addition to being used to penetrate hardened bunkers, the weapon can also be used to destroy weapons of mass destruction. It achieves this by carrying "agent defeat material" that can incinerate chemical and biological weapons with intense flash fires. This technique can help to prevent the spread of these agents into the air and into surrounding areas with flash fires that can burn at thousands of degrees Fahrenheit.

Background

When Kuwait was invaded in 1990, the GBU-28 (Figure 3–1) was not even in the planning stages. The U.S. Air Force rapidly put the bomb

Figure 3–1 The GBU-28/GBU-37 "Bunker Buster."(*Source:* U.S. Air Force)

together using a surplus 8-inch artillery gun tube for increased strength and weight. The first bomb was made on February 1, 1990. Flight and sled tests proved the bomb's ability to penetrate hardened targets and by February 27, the first two bombs had been delivered to the Gulf region. Both weapons were dropped from F-111s.

Two bunker-buster bombs were also used to destroy a national communications center that operated the Iraqi telephone system in Baghdad on March 27, 2003 during Operation Iraqi Freedom. They were dropped from a B-2 Spirit stealth bomber.

Facts

Targets: Fixed, hard targets, such as underground command centers and bunkers
Guidance: Laser-guided (GBU-28) and satellite-guided (GBU-37)
Length: 19 feet, 2 inches
Diameter: 14.5 inches
Penetration: Over 20 feet (concrete), over 100 feet (earth)
Warhead: 4,400 pounds with 630 pounds of high explosives and rest depleted uranium
Platform: F-15E Strike Eagle and B-2 Spirit
Service: U.S. Air Force
Date Deployed: 1991

BLU-114/B "Blackout Bomb"

The BLU-114/B "Blackout Bomb" is used to knock out the electrical power grid of an enemy by releasing hundreds of submunitions that fall to ground via a small parachute. These submunitions then release carbon fiber filaments that short-circuit electrical power distribution equipment and shut down the supply. The weapon is highly secretive, and very little is known or released about this high-tech yet simple device. What is known is that it was used in Operation Allied Force against Serbia and possibly again during Operation Iraqi Freedom.

Features

The BLU-114/B is dropped from a U.S. Air Force stealth fighter, such as the F-117A Nighthawk. It is believed that LGBs are used to deliver these submunitions accurately to their target area. Additionally, it is possible that a variant of the JSOW could be used to deliver the submunitions because it is designed to carry a variety of payloads within its modular design. The advantage of the JSOW would be that it is a "fire-and-forget" weapon that can be released from a long-standoff distance of up to 40 nautical miles and uses GPS for guidance. This would make the JSOW ideal for such a dangerous stealth mission to shut down an enemy electrical system.

Once released, the drink-can-sized submunitions, of which there could be several hundred within a single weapon, fall toward their target and are slowed by a small parachute. They then disperse a cloud of carbon fiber filaments just a few hundredths of an inch in thickness. These filaments float down until they strike their intended target, which is electrical power distribution equipment, such as transformers and switching stations. The filaments conduct electricity and cause an immediate short-circuit in the equipment, thus shutting down the power supply.

Background

During the Gulf War, the U.S. Navy used what was called a "Kit-2" dispenser inside a Tomahawk cruise missile in order to cause a blackout in parts of Iraq. This Kit-2 dispenser carried carbon fiber filaments for creating short-circuits on electrical equipment. The BLU-

Figure 3–2 BLU-114/B. (*Source:* FAS)

114/B (Figure 3–2) is believed to be descended from this initial use of the technology. It was first used as part of Operation Allied Force against Serbia on May 2 and May 9, 1999. The strike was successful in knocking out the power supply over 70 percent of the country, and canisters were later discovered with the BLU-114/B marking.

During Operation Iraqi Freedom, the blackout in Baghdad that occurred in early April 2003 as the allied forces captured the international airport was suspected to be due to the use of the BLU-114/B but was never confirmed by the military. In fact, this was denied by the military with statements that it did not want to target civilian infrastructure. The intent, if this was indeed the case, would have been to allow special operations forces to enter the city with greater cover of darkness and to provide allied troops with a greater advantage from night vision goggles.

Facts

Targets: Electrical power distribution equipment
Guidance: Laser-guided munitions or INS/GPS navigation based on carrier weapon system for the submunitions
Warhead: Carbon fiber filaments (submunitions)
Platform: F-117A Nighthawk
Service: U.S. Air Force
Date Deployed: 1999

Source: FAS and others

BLU-82/B "Daisy Cutter"

The BLU-82/B is a conventional 15,000-pound bomb that is one of the largest in the U.S. military inventory other than the more recent Massive Ordnance Air Blast (MOAB). The BLU-82/B, or "Daisy Cutter," has been used in Vietnam, in Iraq during the Gulf War, and in Afghanistan during Operation Enduring Freedom. Its primary purpose is for clearing minefields, clearing helicopter landing zones, and for psychological purposes against enemy troops.

Features

The BLU-82/B is known as a "Daisy Cutter" due to its massive blast just above ground level. The explosion is triggered by a 38-inch fuze, which sticks out from the nose of the bomb. This blast generates an air pressure of 1,000 pounds per square inch, which can clear and totally level an area of dense vegetation, including trees, approximately 260 feet in diameter. The weapons mine-clearing effects are reportedly up to 3 miles in diameter.

The bomb itself is a thin-walled, cylindrical metal tank filled with 12,600 pounds of an explosive slurry mixture called GSX. Due to the weight of the bomb, it can be dropped only from cargo planes such as the C-130 Hercules and variants such as the MC-130 Combat Talon. The bomb uses a cargo extraction parachute to pull it clear of the plane, then falls with a stabilization parachute following a ballistic (free-trajectory) path. Because the bomb is unguided, it needs to be released from the aircraft at a precise location in order to hit its intended target. The target has historically been mine clearance or clearance of dense jungle foliage to create helicopter landing zones.

Background

The BLU-82/B (Figure 3–3) was first used in Vietnam in March 1970 as a replacement for the 10,000-pound M121 bombs for blasting helicopter-landing zones in dense jungle areas. During Vietnam, the bomb was also used by the U.S. Air Force for tactical airlift operations called "Commando Vault," which is another name for this weapon. During the Gulf War, 11 BLU-82/Bs were used for mine clearing and for psychological effects. As part of the psychological

Figure 3–3 BLU-82/B. (*Source*: USAF Museum)

warfare, leaflets were also dropped that showed an image of the bomb together with the slogan "Flee and Live, or Stay and Die!" In Afghanistan during Operation Enduring Freedom, the weapons were used to target al Qaeda tunnels and caves.

Facts

Type: Air-to-surface conventional bomb
Contractor: Classified
Targets: Used for area clearance, including minefield and helicopter landing zones, as well as for psychological effects
Guidance: Ballistic
Length: 141.6 inches
Diameter: 54 inches
Weight: 15,000 pounds
Warhead: 12,600 pounds of GSX
Platform: MC-130 Combat Talon
Total Produced: 225
Service: U.S. Air Force
Date Deployed: 23 March 23, 1970

Source: FAS and others

Massive Ordnance Air Blast Bomb

The MOAB is currently the largest non-nuclear weapon in the U.S. military, giving it the nickname of the "Mother Of All Bombs." It first gained visibility when it was tested by the U.S. Air Force in Florida prior to the start of Operation Iraqi Freedom. Although it was shipped over to the Iraq region, it was not used during the conflict. It is thought to be used for psychological effect, due to its extensive mushroom cloud, in addition to use against above-ground, hardened targets and large troop formations. By detonating before impact, the bomb can maximize the horizontal target area affected.

Features

The MOAB is a 21,500-pound bomb that is dropped from the rear of a C-130 Hercules cargo plane. It is a successor to the 15,000 pound "Daisy Cutter" used in Vietnam and Afghanistan. A parachute is used to deploy the bomb, sitting on a sled, from the rear of the C-130. Once ejected from the aircraft, the bomb then glides toward its target, and when it nears the ground, it disperses a flammable mist and ignites it to create a large blast over a wide horizontal area.

MOAB uses satellite (GPS) and inertial guidance and has an aerodynamic body to help it find its target. The denotation typically occurs six feet above the ground. The MOAB is not the largest bomb ever to be created but is currently the largest within the U.S. military arsenal. Larger bombs have included the 22,000-pound Grand Slam dropped from Lancaster bombers during World War II and the 44,000-pound T-12 Cloudmaker carried by U.S. B-36 bombers in the 1950s.

Background

The MOAB (Figure 3–4) is an Air Force Research Laboratory technology project that began in fiscal year 2002 and is scheduled to be completed in late 2003. The first public images of the bomb were made available during the U.S. Air Force tests at Eglin AFB in Florida. During this test, on March 11, 2003, the explosion could be seen up to 19 miles away from the target site. Residents also heard the blast up to a similar distance. It is suspected that the bomb development and related tests were timed to coincide with the building political

Figure 3–4 Massive Ordnance Air Blast weapon is prepared for testing at the Eglin Air Force Armament Center. (*Source*: DefenseLink)

pressure mounting on Saddam Hussein prior to Operation Iraqi Freedom. The U.S. Air Force is believed to have another similar weapon in the works that is code-named "Big Blue" and is 30,000 pounds in size—50 percent larger than the current MOAB.

Facts

Type: Air-to-surface conventional bomb
Contractor: Dynetics
Targets: Used for area clearance, including large structures and troop formations, as well as for psychological effects
Guidance: Satellite and Inertial Navigation System (INS)
Length: 30 feet
Diameter: 40.5 inches
Weight: 21,500 pounds
Warhead: 18,000 pounds of explosives
Platform: C-130 Hercules cargo plane
Service: U.S. Air Force
Date Deployed: 2003 (Testing)

Source: DefenseLink

AGM-114B/K/M/N Hellfire

The Hellfire missile is a laser-guided, air-to-ground missile that is primarily fired from Navy, Army, and Marine Corps helicopters such as the Seahawk, Apache, and Super Cobra. It is used as an anti-tank weapon or for other point targets, such as ground vehicles, structures, and bunkers. It can also be used in air-to-air scenarios against other helicopters or slow-moving fixed-wing aircraft. The weapon gained prominence with the public when it was used in November 2002 against suspected al Qaeda terrorists in a vehicle in Yemen.

Features

The Hellfire is manufactured by Boeing and Lockheed Martin and features a solid-propellant rocket for power. The missile travels at subsonic speeds and features a laser seeker for guidance. Laser designation of the target can be made either within the aircraft or from a ground-based position.

The Hellfire warhead varies, according to the missile designation. The warhead is typically a shaped charge or blast fragmentation warhead but more recently, the AGM-114N has been used as a thermobaric Hellfire. The thermobaric warhead produces increased heat and pressure when it explodes and can be used against caves and bunkers more effectively than the conventional warheads.

Background

The name *Hellfire* (Figure 3–5) is short for Helicopter-launched fire-and-forget missile. It was first funded in 1972; later in the same year, the Hellfire Project Office was established. The program was a result of the Army's requirement to "develop a helicopter-launched, direct/indirect fire-and-forget, laser semi-active guided, terminal homing, anti-tank, hard-point weapon system." After a series of tests, it was approved for full-scale production in March 1982. In March 1988, the 1st Attack Helicopter Battalion, 6th CAV, III Corps was the first operational unit to fire Hellfire missiles.

Figure 3–5 AGM-114 Hellfire. (*Source*: Boeing)

The first combat use of the Hellfire missile was on December 20, 1989, when AH-64 Apache helicopters fired seven Hellfire missiles during Operation Just Cause in Panama.

In August 1990, Hellfire equipment was deployed to support Operation Desert Shield and later Operation Desert Storm. The first shots of Operation Desert Storm occurred when eight Apache helicopters used Hellfire missiles and Hydra-70 rockets to target and destroy two Iraqi early warning radar sites in January 1991.

On March 22, 2003, the first kill by an armed unmanned aerial vehicle occurred in Iraq when a Predator UAV destroyed a radar-guided anti-aircraft artillery piece using a Hellfire II missile outside the Iraqi town of Al Amarah. During Operation Iraqi Freedom, the U.S. fired over 500 Hellfire missiles from a total of approximately 20,000 guided munitions, according to the April 30, 2003, "By the Numbers" report from the U.S. Air Force Assessment and Analysis Division.

Facts

Type: Point target/anti-armor weapon, semi-active laser seeker
Four Variants: AGM-114B/K/M/N
Contractor: Boeing, Lockheed Martin
Powerplant: Solid-propellant rocket
Length: 5.33 feet (1.6246 meters)
Launch Weight: 98–107 pounds (44.45–48.54 kilograms)
Diameter: 7 inches (17.78 centimeters)
Wingspan: 28 inches (0.71 meter)
Speed: Subsonic
Warhead: Shaped charge, blast fragmentation, thermobaric
Aircraft Platforms:
>> *Navy:* SH-60B/HH-60H Seahawk
>> *Army:* AH-64 Apache
>> *Marine:* AH-1W Super Cobra

Source: U.S. Navy

AIM-9 Sidewinder

The AIM-9 Sidewinder is a supersonic, heat-seeking, air-to-air missile used by the U.S. Air Force and U.S. Navy on fighter aircraft such as the F-15 and Sea Harrier. The Sidewinder has been produced for 27 other nations and is one of the most successful weapons in the U.S. inventory, due to its longevity, low cost, and the high number of missiles produced.

Features

The AIM-9 is included here not because it is particularly new but because of its successful track record and the continual evolution of the missile over time since its inception in the 1950s. Over time, this missile has increased its speed, range, maneuverability, and warhead capabilities, in addition to its reliability, maintainability, and shelf-life.

The AIM-9 features a high-explosive blast fragmentation warhead, an infrared guidance system, and a rocket motor for propulsion. The infrared guidance system allows it to home in on the exhaust heat signature of target aircraft. This enables both day and night operation and avoids problems with electronic countermeasures. Over time, with subsequent upgrades, the missile has increased its ability to engage with targets from increased launch angles and distances such that the pilot does not have to be positioned directly behind and close to the target aircraft. In fact, the control surfaces behind the nose of the missile enable it to pull many tens of Gs when pursuing its target so that it can take sharp turns and accelerate during engagement.

Background

The AIM-9 (Figure 3–6) is a weapon for symmetric warfare, when one fighter takes on another fighter in aerial combat. Given the currently asymmetrical nature of today's battlefield, the weapon has not seen much combat action in recent years because many enemy aircraft fail to get off the runway to engage.

The AIM-9A was first fired in September 1953. The AIM-9B entered operational use in 1956 with the U.S. Air Force. Successive generations included the E, J, L, M, and P variants, the 9X being a future variant that is currently under development. Improvements in the early models included the greater maneuverability, speed, and range of the J model in 1977; the ability to attack from all angles with the L model in 1976; and the improved defense against infrared countermeasures, enhanced background discrimination capability, and reduced-smoke rocket motor of the M model in 1983. The AIM-9M is the current operational model.

Facts

Type: Air-to-air missile
Contractor: Raytheon and Loral Martin
Powerplant: Hercules and Bermite Mk-36 Mod 11 single-stage, solid-propellant rocket motor
Length: 9 feet 5 inches (2.87 meters)
Diameter: 5 inches (0.13 meters)
Finspan: 2 feet 3/4 inches (0.63 meters)
Speed: Supersonic (Mach 2.5+)

Figure 3–6 AIM-9X Sidewinder. (*Source*: Raytheon)

Warhead: Blast fragmentation (conventional) weighing 20.8 pounds
Launch Weight: 190 pounds (85.5 kilograms)
Range: 10+ miles (8.7 nautical miles, 16 kilometers)
Guidance System: Solid-state infrared homing system
Introduction Date: 1956
Unit Cost: $41,300 (U.S. Navy), $84,000 (U.S. Air Force)

Source: U.S. Air Force and U.S. Navy

Joint Direct Attack Munition

The JDAM is a low-cost guidance tail kit manufactured by Boeing Corporation and used by the U.S. Navy and Air Force, with the Air Force as the lead service. The JDAM kit converts existing free-fall bombs into guided "smart" bombs by using INS and GPS as part of the tail kit. The JDAM greatly improves the accuracy of general-purpose bombs, works in any weather conditions, including clouds, rain, and snow, and can be launched from up to 15 miles from the target. JDAM accuracy is within 13 meters or less of "circular error probable" (CEP). CEP is an indicator of the accuracy of a missile or projectile and is used as a factor in determining probable damage to a target. It is the radius of a circle within which half of the missiles or projectiles are expected to fall.

Features

The JDAM kits attach to a variety of general-purpose warheads, including the 2,000-pound BLU-109/MK 84 and the 1,000-pound BLU-110/MK 83. One of the technical features of the JDAM is that it can operate with or without GPS guidance. As mentioned, with GPS guidance, it can achieve an accuracy of within 13 meters or less. Without GPS guidance, it can rely on the INS on board the tail kit to obtain an accuracy of 30 meter CEP for flight times of less than 100 seconds. This means that the weapon can be effective even in conditions where GPS data is unavailable, such as due to GPS jamming technologies in effect from the enemy.

The JDAM kit is comprised of the tail kit itself plus strakes, or fins, which are attached to the main body of the bomb to facilitate guided flight. The target coordinates are transferred from the carrying aircraft to the weapon either before takeoff or during flight prior to deployment. The weapon can be carried by a number of Air Force and Navy fighters and bombers, including the B-1, B-2, B-52, F-15E, F-16, F-22, F-117, and F/A-18. More than one JDAM can be launched on a single pass and can be directed at single or multiple targets on the ground.

Background

Operation Desert Storm highlighted the need for adverse weather precision-guided munitions. At the time, most bombs used were unguided weapons with limited accuracy, due to mid- to high-attitude deployments. Additionally, poor weather limited the ability to use precision-guided munitions, such as LGBs. Research and development began in 1992 to look into "adverse weather precision-guided munitions" to solve these problems, and the first JDAMs (Figure 3–7) were certified as operational-capable on the B-2 in July 1997. JDAMs were used in combat for the first time during Operation Allied Force in Kosovo in 1999 and later during Operation Iraqi Freedom by both British and American aircraft in April 2003. During Iraqi Freedom, successful targets for the JDAMs included the Baathist Party headquarters and the Iraqi Information Ministry. JDAMs have also been

Figure 3–7 Joint Direct Attack Munition. (*Source*: U.S. Air Force)

involved in friendly fire accidents, such as an incident that killed three U.S. soldiers in Kandahar, Afghanistan in December 2001.

Facts

Type: Guided air-to-surface weapon
Contractor: Boeing
Length (JDAM and warhead):
>> GBU-31 (v) 1/B: 152.7 inches (387.9 centimeters)
>> GBU-31 (v) 3/B: 148.6 inches (377.4 centimeters)
>> GBU-32 (v) 1/B: 119.5 inches (303.5 centimeters)
Weight (JDAM and warhead):
>> GBU-31 (v) 1/B: 2,036 pounds (925.4 kilograms)
>> GBU-31 (v) 3/B: 2,115 pounds (961.4 kilograms)
>> GBU-32 (v) 1/B: 1,013 pounds (460.5 kilograms)
Wingspan:
>> GBU-31: 25 inches (63.5 centimeters)
>> GBU-32: 19.6 inches (49.8 centimeters)
Range: Up to 15 miles (24 kilometers)
Ceiling: 45,000+ feet (13,677 meters)

Guidance System: GPS-aided INS
Unit Cost: Approximately $21,000

Source: U.S. Navy

AGM-154 Joint Standoff Weapon

The JSOW is a low-cost, precision-guided, air-to-ground weapon system used by U.S. Navy and Air Force strike aircraft. It can be deployed at increased standoff distances from enemy targets out of range of most enemy fire, such as medium-range surface-to-air missiles (SAMs). This standoff distance, which ranges from 12 to 40 nautical miles, based on whether the weapon is launched at low or high altitude, enables greater aircraft survivability. The JSOW uses INS and GPS information for midcourse guidance as in the JDAM. One of its three variants also incorporates infrared imaging terminal guidance for increased accuracy.

Features

Because the JSOW is designed specifically as a standoff glide weapon with an aerodynamically efficient airframe, it has further standoff distance than the JDAM. The unpowered JSOW can be launched at standoff distances of 12–40 nautical miles. A powered version of the JSOW is even more effective and can reach standoff distances of up to 120 nautical miles. The JDAM, in contrast, has less efficient aerodynamic capabilities because it is essentially an add-on tail kit to general-purpose, free-fall bombs.

The JSOW is especially useful for initial attacks on land and sea targets, such as air defense sites, parked aircraft, and other facilities where enemy defenses have not been softened and where there is an increased threat of attack from the ground. Like the JDAM, the JSOW can be launched from a variety of altitudes and in a variety of weather conditions, such as clouds, rain, and snow during day or night. Its GPS and INS help it to stay on course toward predetermined targets without any pilot intervention.

The JSOW measures about 13 feet in length and weighs between 1,000 and 1,500 pounds, based on its payload. It has a modular design that allows for various payloads to be carried, including lethal and non-lethal items. In fact, the modular design can allow anything from warheads to pamphlets to be carried as a payload. The three current variants of the JSOW include the AGM-154A, which carries 145 BLU-97/B submunitions; the AGM-154B, which carries 6 BLU-108/B submunitions; and the AGM-154C, which carries the BLU-111/B variant of the Mk-82, 500-pound general-purpose bomb.

The JSOW is carried by a number of U.S. Navy and Air Force aircraft, including the F/A-18, F-16, B-52, and B-2 aircraft, and will soon be flying on the B-1 and F-15E.

Background

Engineering and manufacturing development of the JSOW (Figure 3–8) was begun by Texas Instruments in 1992. In 1997, the Texas Instruments division working on the JSOW, the Defense Systems & Electronics division, was acquired by Raytheon Corporation.

The JSOW AGM-154A variant was first used in combat during air strikes against anti-aircraft defense sites in Iraq. Three JSOWs were launched by Navy F/A-18C Hornet strike fighters against the Iraqi targets on January 25, 1999. In 2003, during Operation Iraqi Freedom, F/A-18 Hornets launched from the USS *Kitty Hawk* used JSOW weapons to target various sites in Baghdad during severe sandstorms. The GPS guidance of the weapons allowed them to perform accurately even when visibility was greatly reduced.

In terms of procurement, the Navy awarded an $80 million contract to Raytheon on March 19, 2003 for the production of 337 JSOW-As, allocating 313 for the Navy and 24 for the Air Force. This contract is expected to be completed by February 2005. In total, the Pentagon plans to spend over $4 billion to purchase 14,000 JSOWs through the year 2007. The JSOW will be employed on the following aircraft: F/A-18A/B, C/D, and E/F; AV-8B; F-14A/B and /D; F-16C/D; F-15E; F-117; B-1B; and B-52.

Facts

Type: Air-to-surface standoff weapon for use against a variety of targets, depending on payload
Contractor: Raytheon

Guidance: GPS/INS
Length: 160 inches (4.1 meters)
Diameter: Box-shaped 13 inches on a side
Weight: From 1,065 pounds (483 kilograms) to 1,500 pounds (681 kilograms), depending on payload, sensor, and propulsion combination
Wingspan: 106 inches
Aircraft Compatibility: F/A-18, F-16, AV-8B, P-3
Range:
>> Low-altitude launch 12 nautical miles
>> High-altitude launch 40 nautical miles
Warhead:
>> BLU-97 Combined-effects bomblets
>> BLU-108 Sensor-fuzed weapon
>> BLU-111 500-pound general-purpose warhead
Date Deployed: January 1999
Unit Cost: $150,000

Source: U.S. Navy

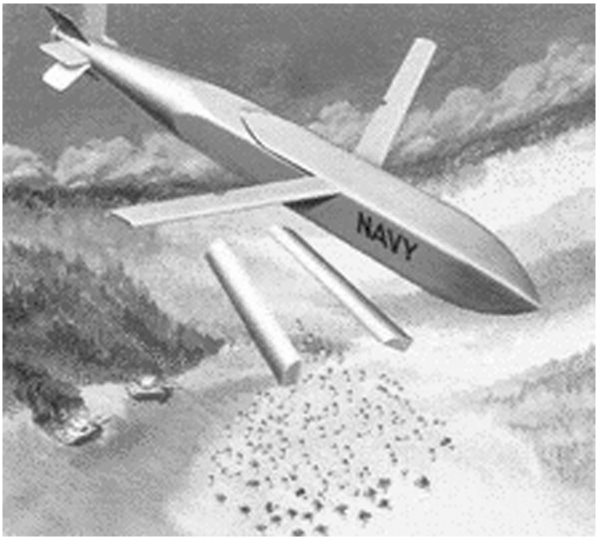

Figure 3–8 Joint Standoff Weapon. (*Source:* U.S. Navy)

Patriot Advanced Capability-3

The PAC-3 is a land-based, guided SAM defense system that can protect against tactical ballistic missiles, cruise missiles, and hostile fixed-wing aircraft and helicopters using a "hit-to-kill" approach. Instead of using fragmentation warheads that explode near the target, as in the prior Patriot missiles, the PAC-3 system uses the kinetic (motion) energy of the missile to completely destroy its targets in a head-on collision. In terms of the accuracy required to achieve this capability, this is like a bullet hitting another bullet. With the proliferation of ballistic missiles and even the increased terrorist threats against commercial airliners, such as the recent failed attempts in Kenya, the PAC-3 forms an essential part of the U.S. Army's defense and will be in service at least until 2008.

Features

With its "hit-to-kill" approach, the PAC-3 system represents a far more effective method for countering enemy missile threats. The fragmentation warhead exploded in close proximity to the target typically only damages or redirects the threat because there is no direct impact. Conversely, the "hit-to-kill" approach can totally destroy the threat and its contents, which may include biological or chemical agents. When compared with the earlier versions of Patriot, the PAC-3 is also smaller and more accurate. Accuracy is improved by way of the Ka-band millimeter Wave (mmW) seeker, which is an onboard active radar seeker that provides terminal guidance to the target.

The entire Patriot system (or "fire unit," as it is called) is comprised of a radar, launcher, and engagement control station (ECS). The radar is a 5,000-element phased-array radar with no moving parts that can perform target search, detection, and tracking plus target identification, target illumination, missile guidance, and countermeasures protection. The launcher is trailer-mounted and can hold 16 PAC-3 missiles per launcher. This is another improvement over the PAC-2 configuration, which supported only four missiles per launcher. The launcher can be operated up to 1 kilometer away via a remote VHF or fiberoptic data link. The launcher is not required to be aimed prior to launch of the missiles. The engagement control station is used for battle management, command, control, and communications. A human operator can view a display screen showing sector coverage and any incoming targets. Operation can either be "man-in-the-loop" or completely automated.

When the PAC-3 missile is launched, it is initially guided by the ground radar portion of the fire unit until the onboard active seeker acquires and engages the target. In-flight corrective maneuvers can then be applied in order to hit the target.

Background

The original Patriot was proven in combat during Operation Desert Storm, when it was used to intercept Iraqi SCUD missiles. Production for the Patriot began in 1980, and it is currently deployed by the United States, Germany, Saudi Arabia, Kuwait, The Netherlands, Japan, Israel, Taiwan, and Greece. The PAC-2 (Figure 3–9) version of the system was fielded in January 1991.

Research Development Test and Evaluation (RDT&E) and procurement responsibility for the PAC-3 are due to transfer to the U.S. Army in 2003. The Missile Defense Agency (MDA) is also integrating the PAC-3 system in its layered Ballistic Missile Defense System (BMDS) that combines several programs into a complete system that can engage enemy targets in all phases of flight path, from the boost phase through the midcourse phase and into the terminal phase.

Facts

Type: Air defense system against tactical ballistic missiles, cruise missiles, and aircraft
Contractor: Lockheed Martin
Guidance: Inertial plus active onboard radar seeker (Ka-band mmW seeker)
Length: 17 feet 1 inch
Diameter: 10 inches
Weight: 312 kilogram
Number per launcher: 16
Maximum Speed: Mach 5
Maximum Range: 15 kilometers
Maximum Altitude: 15 kilometers

Figure 3–9 Patriot launch. (*Source*: Raytheon)

Warhead: "Hit-to-kill" using simple kinetic energy (motion) plus 73-kilogram HE blast/fragmentation with proximity fuze
Date Deployed: 1980
Cost: Over $3 billion in past 10 years (over 9,000 missiles and 170 fire units)

Source: FAS, Raytheon, and others

Tomahawk Cruise Missile

The Tomahawk Cruise Missile is the U.S. Navy's surface- and submarine-launched, precision-strike standoff weapon. It is used as a weapon of choice for critical, long-range, precision-strike missions against high-value, heavily defended enemy targets. Over 1,000 missiles have been used in military operations, including Operation Desert Storm, Iraq, Bosnia, Operation Desert Fox, and Operation Allied Force. The latest generation Tomahawk, the Tactical Tomahawk, had its first test with a live warhead in May 2003 and flew over 700 nautical miles on a sea test range.

Features

The Tomahawk missile is approximately 18 feet in length and 20 inches in diameter. It is powered by a solid propellant after launch until it reaches its cruising speed of approximately 550 mph, at which time a turbofan engine takes over for the cruise portion of its flight. The missile flies at subsonic speeds and low altitudes, and is able to navigate to its target by using a combination of guidance systems. In the Block II configuration, these guidance systems include INS, Terrain Contour Marching (TERCOM), and Digital Scene Matching Area Correlation (DSMAC). In Block III, introduced in 1994, the navigation capabilities are enhanced with the addition of GPS navigation, which can be used instead of or in addition to the Block II navigation capabilities. The benefit of GPS, of course, is that it frees the missile from having to rely on terrain matching to find its target. Time of Arrival (TOA) control means that these missiles can be timed to hit their targets in conjunction with anticipated events or with the arrival of other missiles.

The missile is difficult to detect on radar, due to its small cross-section and low-altitude flight. In addition, it has a low thermal profile because the turbofan engine makes it difficult to locate via infrared detection. In terms of the warhead configurations, the Tomahawk can carry either a 1,000-pound blast/fragmentary unitary warhead or a general-purpose submunition dispenser with combined-effects bomblets.

Tomahawk missiles are deployed worldwide on numerous U.S. Navy surface ships and submarines, including Aegis-class cruisers, guided-missile destroyers, and Seawolf- and Los Angeles-class submarines.

The Tactical Tomahawk represents the next-generation Tomahawk and has many advanced capabilities. First, the missile can be reprogrammed in flight to strike either any of 15 preprogrammed alternate targets or a new target designated via GPS coordinates. The missile has the capability to loiter over a designated area and can provide target information or battle damage assessment information back to its commanders, using an onboard camera. This gives them the ability to verify the target area and assess potential existing damages prior to committing this expensive weapon to its target destination.

Background

First introduced in 1986, the Tomahawk (Figure 3–10) has been fielded successfully in many campaigns, including Operation Desert Storm in 1991, Iraq in 1993, Bosnia in 1995, Iraq in 1996, Operation Desert Fox in 1998, and Operation Allied Force in 1999. It has been highly praised for its long range, lethality, and accuracy.

During Operation Iraqi Freedom, the Los Angeles-class attack submarine USS *Cheyenne* (SSN 773) was one of the U.S. Navy's first ships to launch a Tomahawk cruise missile on March 18, 2003. This number grew to four ships and two submarines launching Tomahawks on March 19, and by March 21, a total of 30 U.S. Navy and coalition warships had launched Tomahawk missiles.

The first flight of the Tactical Tomahawk occurred in August 2002 at the Naval Air Systems Command's Western Test Range, Pt. Mugu, California. Johns Hopkins University Applied Physics Laboratory (APL) served as the strike controller during the test and exchanged messages with the missile via satellite during its 550-mile flight.

The first launch of the Tactical Tomahawk from an operational surface ship occurred in April 2003 from USS *Stethem* (DDG 63) off southern California. In May 2003, Raytheon and the U.S. Navy fired the first test of Tactical Tomahawk, again from USS *Stethem*, with a live warhead as part of their technical evaluation flights. The Tactical Tomahawk is scheduled for introduction into the fleet in 2004 and will cost less than half the cost of a newly built Block III missile.

Facts

Type: Long-range subsonic cruise missile for striking high-value or heavily defended land targets

Contractor: Raytheon

Powerplant: Williams International F107-WR-402 cruise turbofan engine; CSD/ARC solid-fuel booster

Length: 18 feet 3 inches (5.56 meters); with booster: 20 feet 6 inches (6.25 meters)

Weight: 2,900 pounds (1,315.44 kilograms); 3,500 pounds (1,587.6 kilograms) with booster

Figure 3–10 Tactical Tomahawk. (*Source*: Raytheon)

Diameter: 20.4 inches (51.81 centimeters)
Wingspan: 8 feet 9 inches (2.67 meters)
Range: 870 nautical miles (1,000 statute miles; 1,609 kilometers)
Speed: Subsonic about 550 mph (880 kph)
Guidance System: TERCOM, DSMAC, and GPS (Block III only)
Warheads: 1,000 pounds or conventional submunitions dispenser with combined-effect bomblets
Date Deployed: 1986—IOC; 1994—Block III; 2004—Tactical Tomahawk
Unit Cost: approximately $600,000 (from last production contract)

Source: U.S. Navy

LGM-30 Minuteman III

The LGM-30 Minuteman III is a solid-fuel ICBM that is a key part of the U.S. strategic nuclear deterrent. It represents the major land portion of the strategic nuclear "triad," which is comprised of the ability to launch nuclear weapons from land, sea, and air. Ballistic missiles are defined as those that assume a free-falling ballistic trajectory after an initial self-powered ascent. The ballistic trajectory is acted upon only by gravity and the aerodynamic drag of the missile.

There are currently 500 Minuteman IIIs located at three U.S. air force bases in the U.S. Midwest. The Boeing-manufactured missiles are capable of traveling at approximately 15,000 mph with a range of over 6,000 miles and a maximum altitude of over 700 miles. The Minuteman weapon system has been in operation since the early 1960s and has gradually been scaled back in terms of the number of missiles and the number of nuclear warheads after the START I and START II arms control treaties between the United States and the Soviet Union.

Features

Minuteman III missiles can be launched within minutes from underground silos in the Midwest. The hardened launch silos protect them from attack and are connected to a Launch Control Center (LCC) approximately 50 feet under the ground. Two officers man these launch control centers in round-the-clock alert status. The President and Secretary of Defense are able to have reliable, direct communications with each launch crew by way of a variety of secure communications systems. If this connectivity is lost for any reason between the land-based launch control center and the missile launch facilities, the Air Force has specially configured E-6B aircraft that can assume command and control of the missiles from the skies.

The Minuteman III missiles are nearly 60 feet in length and have a diameter of 5.5 feet. Their payload consists of one or more nuclear warheads per missile. Initially, the Minuteman III carried three warheads in what is known as a multiple independently targeted reentry vehicle (MIRV). This enables warheads to target different areas within the overall target area of the missile and reduces the enemy's chances of destroying the missiles before impact.

Background

Minuteman I came into existence due to the need for the United States to keep up with the Soviet Union in terms of ICBM development in the 1950s. The first generation of ICBMs within the United

States, the Atlas and Titan I, were propelled by liquid fuel. This meant that they required several hours on the launch pad in preparation for firing. Instead of liquid fuel, the Minuteman I was a solid-fuel ICBM that could be launched within minutes from underground silos, thus minimizing the chances of a preemptive strike prior to launch. This capability greatly improved the U.S. nuclear deterrent, and the first Minuteman I was deployed in 1962 after planning began in 1957. By 1965, there were 800 Minuteman Is deployed at five bases across the United States.

Minuteman II was produced in 1964 and provided greater range and accuracy than its predecessor. Strategic Air Command started deploying Minuteman IIs in 1966, and by 1969 there were a total of 500 Is and 500 IIs in service.

Minuteman III (Figure 3–11), the latest version of the Minuteman, was first deployed by the U.S. Air Force's Strategic Air Command in June 1970. In 1975, there were 550 Minuteman IIIs deployed with a total of 1,650 nuclear warheads, plus 450 Minuteman IIs. The START I and START II arms control treaties negotiated by the United States and Russia have reduced the current inventory to 500 missiles with one warhead per missile.

The current Minuteman missiles reside at three locations within the U.S. Midwest: F.E. Warren AFB, Wyoming; Malmstrom AFB, Montana; and Minot AFB, North Dakota. Current plans call for the Minuteman IIIs to remain in active service until 2020.

Facts

Type: Intercontinental ballistic missile

Contractor: Boeing

Powerplant: 3 solid-propellant rocket motors

>> First stage—Thiokol

>> Second stage—Aerojet-General

>> Third stage—United Technologies Chemical Systems Division

Length: 59.9 feet (18 meters)

Weight: 79,432 pounds (32,158 kilograms)

Diameter: 5.5 feet (1.67 meters)

Range: 6,000+ miles (5,218 nautical miles)

Figure 3–11 Minuteman III ICBM. (*Source*: Boeing)

Speed: Approximately 15,000 mph (Mach 23 or 24,000 kph) at burnout
Ceiling: 700 miles (1,120 kilometers)
Thrust: First stage 202,600 pounds
Load: Reentry vehicle: Lockheed Martin Missiles and Space Mk-12 or Mk-12A
Guidance systems:
>> *Inertial system:* Boeing North American
>> *Ground electronic/security system:* Sylvania Electronics and Boeing
Date Deployed: June 1970; production cessation, December 1978
Inventory: Active force, 500; Reserve, 0; ANG, 0
Unit cost: $7 million

Source: U.S. Air Force

LG-118A Peacekeeper

The LG-118A Peacekeeper is the newest ICBM in the U.S. inventory and the most accurate. Manufactured by Boeing, it was placed into service in December 1986. The four-stage rocket ICBM is capable of delivering 10 independently targeted warheads that are housed in the reentry system at the top section of the missile. The current active force of Peacekeeper missiles is 50, located at F.E. Warren AFB in Wyoming. The United States is revising its policies toward nuclear weapons, and the Peacekeepers are scheduled to be deactivated in the near future, leaving just the 500 Minuteman IIIs for the land-based nuclear deterrent.

Features

The Peacekeeper has a length of 71 feet and a diameter of 7 feet 8 inches. Like the Minuteman III, it has a range of over 6,000 miles (a range of over 5,500 kilometers classifies a missile as an ICBM) and travels at up to 15,000 mph during its trajectory toward its target.

The three major sections of the missile include the boost system, the post-boost vehicle system, and the reentry system. Like other ICBMs, the Peacekeeper is launched under power during the boost phase of its flight, glides in a ballistic trajectory during the midcourse phase of flight, then reenters the Earth's atmosphere during the terminal phase. During the boost phase, three stages of the rocket use a solid propellant to accelerate the rocket into space. Once these three stages have burned out and have been separated, the fourth stage, which uses a storable liquid propellant, maneuvers the rocket in space so it is ready to deploy the reentry vehicles. The reentry vehicles consist of 10 cone-shaped Avco Mk-21 payloads, each carrying a nuclear warhead. These are separated from the remaining reentry system by a small explosive cartridge, then follow a ballistic trajectory to the ground.

Background

The Peacekeeper's (Figure 3–12) first test flight was on June 17, 1983 from Vandenburg AFB in California. During this test, the missile trav-

Figure 3–12 LG-118A Peacekeeper. (*Source:* U.S. Air Force)

eled 4,190 miles and dropped six unarmed test reentry vehicles onto a missile test range in the Pacific Ocean.

The initial operating capability was achieved with 10 Peacekeepers deployed at F.E. Warren AFB in December 1986. Full operational capability was achieved two years later in December 1988 with a squadron of 50 missiles.

Facts

Type: Strategic deterrence
Contractor: Boeing
Powerplant:
>> *First Three Stages:* Solid propellant
>> *Fourth Stage:* Storable liquid (by Thiokol, Aerojet, Hercules, and Rocketdyne)
Warheads: 10
Load: Avco Mk-21 reentry vehicles
Guidance System:
>> Inertial: integration by Boeing North American
>> IMU: Northrop and Boeing North American

Thrust: First stage, 500,000 pounds
Length: 71 feet (21.8 meters)
Weight: 195,000 pounds (87,750 kilograms), including reentry vehicles
Diameter: 7 feet, 8 inches (2.3 meters)
Range: Greater than 6,000 miles (5,217 nautical miles)
Speed: Approximately 15,000 mph at burnout (Mach 20 at sea level)
Date Deployed: December 1986
Inventory: Active force, 50; ANG, 0; Reserve, 0
Unit Cost: $70 million

Source: U.S. Air Force

Trident Fleet Ballistic Missile

Trident is an SLBM that has been in service with the U.S. Navy since 1979 when Trident I (C4) was first deployed. The primary function of the Trident missiles is strategic nuclear deterrence. The missiles can travel over 4,000 nautical miles and are deployed in Ohio-class (Trident) submarines.

Features

Trident missiles represent 50 percent of the total number of U.S. strategic warheads that are part of the triad of the strategic deterrent—on land, sea, and air. Each Ohio-class ballistic missile submarine, of which there are 18, carries 24 Trident missiles. The three-stage, solid-propellant missiles are launched by pressurized gas from their launch tubes. Then, once the missile is clear of the submarine, the first motor of the three stages kicks in to propel the missile toward its target. By the time the third stage motor kicks in after about two minutes of flight, the missile is traveling at greater than 20,000 feet per second.

The missiles are 44 feet in length and 83 inches in diameter, weigh 130,000 pounds, and have an inertial guidance system for navigation. While on deterrent missions aboard Ohio-class submarines, the missiles have no preprogrammed target coordinates, but these coordinates can be rapidly loaded into the system using sea-based communications links.

Background

The Trident missile (Figure 3–13) is the U.S. Navy's latest fleet ballistic missile and supercedes the earlier Polaris (A1), Polaris (A2), Polaris (A3), and Poseidon (C3) SLBMs, which date back to 1956 with the Polaris (A1) program. As mentioned, Trident I (C4) was first deployed in 1979 and Trident II (D5) in 1990.

The Trident II (D5) is also carried aboard four Vanguard Class nuclear-powered submarines belonging to the British Royal Navy. These have replaced Polaris as the United Kingdom's nuclear strategic deterrent. The Vanguard Class submarine has 16 missile tubes and carries a total of 48 warheads, 3 per missile. Tridents entered service in the United Kingdom in December 1994 and were purchased under the terms of the 1963 Polaris Sales Agreement.

With over 10 years since initial deployment, the Trident II has set a record of over 87 consecutive and successful test launches. Also during this time, the U.S. Navy conducted over 200 deterrent patrols, with the first patrol being the USS *Tennessee* in March 1990, sailing from Submarine Base, Kings Bay, Georgia.

Facts

Trident I (C4)

Type: Strategic nuclear deterrence
Contractor: Lockheed Martin Missiles & Space
Propulsion: 3-stage solid-propellant rocket
Length: 34 feet (10.2 meters)
Weight: 73,000 pounds (33,142 kilograms)
Diameter: 74 inches (1.8 meters)
Range: 4,000 nautical miles (4,600 statute miles or 7,360 kilometers)
Guidance System: Inertial
Warhead: Nuclear MIRV
Date Deployed: 1979

Trident II (D5)

Type: Strategic nuclear deterrence
Contractor: Lockheed Martin Missiles & Space

Figure 3–13 Trident fleet ballistic missile. (*Source:* Lockheed Martin Missiles & Space)

Powerplant: 3-stage solid-propellant rocket
Length: 44 feet (13.41 meters)
Weight: 130,000 pounds (58,500 kilograms)
Diameter: 83 inches (2.11 meters)
Range: Greater than 4,000 nautical miles (4,600 statute miles, or 7,360 kilometers)
Guidance System: Inertial
Warheads: Nuclear MIRV
Date Deployed: 1990
Unit Cost: $30.9 million

Source: U.S. Navy