ANTIAIR

AMRAAM (AIM- 120)

The AMRAAM (Advanced Medium-Range Air-to-Air Missile) was developed jointly by the US Air Force and Navy as a follow-on to the AIM-7 Sparrow III AAM. The core of AMRAAM's performance specification is a high kill probability at short and long range under all weather conditions while subjected to heavy Electronic Countermeasures (ECM) and clutter. It is a "look-down, shoot-down" missile and can be launched at any aircraft speed or target angle. Although AMRAAM is to be more capable than the AIM-7, it is lighter and thinner and has a smaller warhead.

Unlike the AIM-7, whose target must be illuminated by the launch aircraft's radar, the AMRAAM is fitted with an active radar seeker whose 5-in (127-mm) antenna is energized by a small Traveling-Wave Tube (TWT) transmitter. To operate the missile most effectively, the launch aircraft needs a track-while-scan radar and the ability to assign targets simultaneously to more than one missile. The active monopulse seeker uses a pulse-Doppler programmable waveform to' penetrate clutter and precipitation. Rapid automatic gain control and digital signal processing contribute to the seeker's Electronic Counter-Countermeasures (ECCM) capabilities.

After launch, the missile can operate autonomously, turning on its active seeker at a preset time or distance. Alternatively, AMRAAM can receive midcourse guidance updates to refine its terminal homing track. When presentedwith more than one target, AMRAAM will choose a particular target and ignore the others. The continuous-rod warhead of the AIM-7 has been replaced by a blast-fragmentation warhead with a "smart" fuze.

DEVELOPMENT • Full-scale development of the AMRAAM began in 1981, and its initial operational capability was in 1991. Flight tests began in 1985. The initial series production of 105 missiles began in October 1987. The Air Force received the first production AMRAAMs from Hughes and Raytheon in January 1989. The AMRAAM was originally intended for US and NATO service. AMRAAM is one of the US/European family of weapons first proposed in 1978. A 1980 Memorandum of Understanding (MoU) among the United States, Great Britain, and West Germany agreed that the medium-range missile would also be produced in Europe. Norway signed the MoU in 1989, and France has observer status within the European group. The US AMRAAM requirement had been 24,320 missiles, but later reviews reduced the total to 15,500 missiles.

The EURAAM joint venture was established in Britain in July 1987 to oversee European production of the AMRAAM. EURAAM consisted of AEG, British Aerospace, Marconi Defence Systems, and MBB. Responsibility for European production was reallocated to Germany in August 1988. In exchange, British Aerospace was named prime contractor on the ASRAAM-Advanced Short-Range Air-to-Air Missile.

In 1989, the AMRAAM's reliability was

rated 'clearly unacceptable,' and the production schedule was jeopardized. In February 1990, the US Air Force refused deliveries of the AMRAAM because of structural defects caused by vibrations and g-forces when carried on F-15s. In May 1990, the four-on-four test was conducted again and the missile performed successfully. The Air Force again accepted AMRAAM deliveries in mid-August 1990.

Germany ordered 200 ASRAAM missiles from Hughes. In May 1990, the US announced AMRAAM sales to Denmark (150 missiles and 70 launchers) and Norway (100 missiles and 132 launchers). In July 1990, a sale of 200 AMRAAMs and 55 launchers to Spain was announced. Norway ordered AMRAAMs in 1994 to outfit its ground-based Adapted HAWK missile batteries; the system, which entered service in early 1995, is called the Norwegian Advanced Surface-to-Air Missile System (NSAMS). Sweden bought 100 AMRAAMs in 1994 to equip its new JAS 39 Gripens and Turkey purchased 80 AMRAAMs.

VARIANTS • APREP (AMRAAM Producibility Enhancement Program), Preplanned Product Improvement (P31) program, Advanced Tactical Fighter AMRAAM, Sea AMRAAM (proposed), Ground-Based AMRAAM (Norwegian).

COMBAT EXPERIENCE • During Operation Desert Storm, the Air Force deployed AMRAAMs as antiair and anti-Scud tactical ballistic missile weapons on F-15 aircraft, but none was fired.

SPECIFICATIONS •

MANUFACTURER
Hughes Aircraft
Raytheon (secondary)

MISSILE **WEIGHT** 345 lb (156.8 kg)
warhead 30-50 lb (13.6-22.7 kg)

DIMENSIONS
configuration resembles Sparrow III but smaller diameter; long pointed nose, cruciform delta mainplanes indexed in line with steerable "cropped delta" tailplanes
length 12 ft (3.66 m)
diameter 7 in (178 mm)
wingspan 1 ft 9 in (0.53 m)
tail span 2 ft 1 in (0.63 m)

PROPULSION Hercules high-thrust, reduced-smoke, solid-fuel boost-sustain rocket motor

PERFORMANCE
speed approx Mach 4
max range approx 40 nm (46.1 mi; 74.1 km)

WARHEAD conventional high-explosive

SENSORS/FIRE CONTROL
Track-While-Scan (TWS) multiple-target tracking radar
inertial reference for each AMRAAM before launch
Nortronics midcourse updates to AMRAAM during flight terminal phase
Hughes I/J-band pulse-Doppler active radar with pulse compression and programmable waveforms, glint reduction

Phoenix (AIM-54)

The AIM-54 Phoenix was the US Navy's long-range fleet air defense missile against aircraft of the former Soviet Union. The Phoenix remains the most sophisticated and longest-range air-to-air missile in service with any nation. It is part of the Grumman F-14 Tomcat weapons system, which also includes the Hughes AWG-9 or AWG-17 radar/fire control system.

DEVELOPMENT • The initial operational capability for the AIM-54A was in 1974 and for the AIM-54C in December 1986. First flight tests were 1965 (AIM-54A), 1980 (AIM-54C), and August

1990 (AIM-54C+). The first flight test of a Raytheon-built AIM-54C was on June 6, 1989.

AIM-54A production was over 2,500, ending in 1980. AIM-54C in production beginning in FY1983, AIM-54C+ in production beginning in March 1986. The Phoenix is employed by the US Navy and on Iranian F-14A Tomcats.

The Phoenix has had a history of problems, including overpayments, schedule slippages, and unreliable fuzes.

Production funding was deleted from the FY1991 budget request.

VARIANTS • AAM-N-1 1, AIM-54A, AIM-54B (not produced), AIM-54C+, Phoenix Point Defense Missile System (PDMS) (not produced).

COMBAT EXPERIENCE • The AIM-54A was provided to the Imperial Iranian Air Force prior to the fall of the shah in 1979. However, the Iranian Air Force probably did not use Phoenix missiles in combat.

The Phoenix was deployed on US Navy F-14s during Operation Desert Storm, but none was fired.

SPECIFICATIONS •
MANUFACTURER
Hughes Aircraft
Raytheon (AIM-54C) (secondary)
MISSILE WEIGHT
AIM-54A: 985 lb (447 kg)
AIM-54C: 1,008 lb (457 kg)
warhead 135 lb (61 kg)
DIMENSIONS
configuration resembles earlier Hughes Falcon (AIM-4) ; cylindrical body, pointed nose; extreme delta cruciform wings near tail with rectangular cruciform control surfaces just behind them
length 13 ft (3.96 m)
diameter 15 in (380 mm)
wingspan 3 ft (0.91 m)
PROPULSION Aerojet Mk 60 or Rocketdyne Flexadyne Mk 47 long-burn-time solid-fuel rocket
PERFORMANCE
speed Mach 5
max range 110 nm (127 mi; 204 km)
WARHEAD expanding continuous-rod (AIM-54A), controlled fragmentation (AIM-54C)
SENSORS/FIRE CONTROL
digital electronics unit with software reprogrammability
Northrop strap-down inertial reference system
solid-state transmitter/receiver
Motorola DSU-28 Target Detecting Device (TDD)
semiactive radar homing (midcourse)
pulse-Doppler radar terminal homing
AWG-9 pulse-Doppler radar in F-14 can track 24 targets, select 6 targets, and guide 6 AIM-54s to interceptions

Sparrow III (AIM-7)

The Sparrow III is a radar-guided, medium-range air-to-air missile that has been in service for more than 30 years. The Sparrow III uses semiactive radar-homing guidance and either continuous-wave or pulse-Doppler radars for target illumination. Its guidance, warhead, and range have been improved to such an extent that later variants represent a new missile in the original airframe.

DEVELOPMENT • The AIM-7C's initial operational capability was in 1958, the AIM-7E in 1963, AIM-7F in 1976, and AIM-7M in 1983. The missile's first airborne test firing was in 1952. Over 40,000 have been manufactured. Three different Sparrow missiles were developed in the early 1950s, with Sparrow III by far the most massively produced.

AIM-7M production ended in 1990 while the AIM-7P was in development. In March 1990, Japanese license production of the AIM-7M was approved; Mitsubishi Electric Corp. (MELCO) is prime contractor. A Kuwaiti order for 200 AIM-7Fs was approved in August 1988.

In addition to the US Air Force, Navy and Marines, Sparrow missiles are operated by about 15 other nations in Europe, Asia, and the Middle East, along with Canada and Australia.

Although the US Navy requested no AIM-7 missiles in the Amended FYl988-89 Biennial Budget, delays in the Advanced Medium-Range Air-to-Air Missile (AMRAAM) program, which is planned to replace the Sparrow, resulted in the appropriation of $52.3 million in FYI989 to purchase 450 missiles.

VARIANTS • (Designation note: The first designation predated the 1962 tri-service redesignation scheme represented by the second.) AAM-N-2/AIM-7A Sparrow I, AAM-N-6/AIM-7B Sparrow II, AAM-N-6/AIM-7C Sparrow III, AAM-N-6B/AIM-7E, AIM-7F, AIM-7H, AIM-7M, AIM-'/N, AIM-7P, (Missile Homing Improvement Program/MHIP), AIM-7R (proposed).

COMBAT EXPERIENCE • While the Sparrow saw combat experience in Vietnam, its experiences demonstrated the limitation of the AIM-7E and prompted the development of the -7E2 and -7F versions. The Sparrow has not been a good dogfighting missile, being much more effective in nonmaneuvering interceptions. In engagements against Libyan aircraft in 1981 and 1989 and an August 1987 interception of an Iranian F-4 well within the missile's stated range, five out of six Sparrows missed their targets for a variety of reasons. In the 1987 F-4 engagement, the first missile's motor failed to fire and the other was launched at nearly its minimum range and missed the evading target. In January 1989, two F-14s from the aircraft carrier John F. *Kennedy* (CV 67) engaged two Libyan MiG-23 Floggers off the coast of Libya. The lead F-14 fired two Sparrows that failed to hold lock-on and missed the MiGs. The second F-14 downed one of the MiGs with a Sparrow. The other MiG was downed by a Sidewinder AIM-9.

In Operation Desert Storm, unlike its previous lack of success in combat, the Sparrow performed well. 23 Iraqi combat aircraft were shot down by AIM-7s during the seven-week war, 69% of the total Iraqi aircraft losses. Reports suggested that the missile operated reliably, due in part to better pilot training and solid-state electronics.

SPECIFICATIONS •

MANUFACTURER
Raytheon
General Dynamics (since 1977)

MISSILE WEIGHT 510 lb (231 kg)
warhead 86 lb (39 kg)

DIMENSIONS
configuration long cylinder with pointed nose, 2 sets of cruciform delta wings indexed in line, the steerable foreplanes at midbody, another fixed set at the tail
length 11 ft 10 in (3.6 m)
diameter 8 in (203 mm)
wingspan 3 ft 4 in (1.02 m)
tail span 2 ft 8 in (0.81.m)

PROPULSION Hercules Mk 58 or Aerojet General Mk 65 boost-sustained solid-fuel rocket

PERFORMANCE
speed Mach 4+
max range approx 30 nm (34.5 mi; 56 km)

WARHEAD Mk 71 controlled fragmentation high-explosive

SENSORS/FIRE CONTROL
inverse monopulse semiactive radar-

homing seeker with digital signal processor, improved autopilot and fuze (which can work as contact or proximity type)

upgrades provide better electronic countermeasures resistance, improved look-down, shoot-down performance

Sidewinder (AIM-9)

The Sidewinder is a simple, effective infrared-homing, widely used Air-to-Air Missile (AAM), with over 110,000 produced. Its unique "rolleron" stabilization system consists of air-driven wheels fitted in the rear outside corner of the rear fins. The spinning wheels gyroscopically stabilize the missile effectively with few moving parts and at low cost.

The Sidewinder is used by a variety of Western fixed-wing combat aircraft and helicopters. As the Chaparral missile, it has been adopted for a surface-to-air mission.

DEVELOPMENT • The Sidewinder's initial operational capability as the AIM-9B was in 1956, the AIM-SE in 1967, the AIM-9H in 1973, the AIM-9J in 1977, the AIM-9L/P in 1978, and the AIM-9M in 1983. Development of the missile began in 1949 at the Naval Weapons Center in China Lake, California. Its first flight was on September 11, 1953.

The Sidewinder is operated throughout the world by 36 countries in South America, Europe, Asia, the Middle East, and Africa.

VARIANTS • XAAM-N-7 (prototype), SW-l (production), AAM-N-7 (USN), GAR-8 (USAF), AIM-9 (assigned to all Sidewinders, 1962), AIM-S/A/B, AIM-SF, AIM-SC/D, AIM-SE, AIM-9G/H, AIM-9H (USN/USAF), AIM-9J/N, AIM-9L/M (third generation), AIM-9P, AIM-9Q AIM-9R, AIM-9S, AIM-9X (USN/USAF Sidewinder successor), Box Office/ Improved Sidewinder, Boa, Helicopter-Launched Sidewinder, MIM72 (Chaparral) .

COMBAT EXPERIENCE • The Sidewinder's first combat was in October 1958, when Taiwanese in F-86s launched them against Chinese MiG-17s, claiming as many as 14 shot down in one day. AIM-9s scored most of the air-to-air kills made by US Navy and Air Force aircraft in the Vietnam War, and by the Israeli Air Force in the 1967 and 1973 wars in the Middle East.

During the 1982 air engagements over Lebanon's Bekaa Valley, 51 out of the 55 Syrian-flown MiGs shot down were hit by Sidewinders.

In the 1982 conflict in the Falkland Islands, between Great Britain and Argentina, British Sea Harriers used AIM-9L Sidewinders for 16 confirmed kills and one probable against Argentine aircraft (of a total 20 air-to-air kills).

Ironically, the Sidewinder was used relatively little during Operation Desert Storm's air assault against Iraqi targets. However, Sidewinders fired by USAF F-15C Eagle jets downed six Iraqi combat aircraft. Two more Su-22 Fitters were shot down by AIM-9s three weeks after the cease-fire. A Saudi F-15 pilot downed two French-built Iraqi Mirage Fls with Sidewinders in a single attack. Two F/A-18 Hornets and an F-14 Tomcat scored with AIM-9s, the Hornets shooting down MiG-21 Fishbeds and the Tomcat downing a helicopter.

SPECIFICATIONS •

MANUFACTURER

Loral Aeronutronics

Raytheon

Bodenseewerk Geratetechnik consor-, tium (Germany-Britain-Italy-Norway)

Mitsubishi Industries (Japan)

MISSILE **WEIGHT**

AIM-9H: 186 lb (84.4 kg)

AIM-9L/M: 191 lb (86.5 kg)

warhead AIM-9B/E/J/N/P: 10 lb (4.5 kg)
AIM-SD/G/H: 22.4 lb (10.2 kg)
AIM-9L/M: 20.8 lb (9.4 kg)

DIMENSIONS
configuration simple thin cylinder, 4 cruciform "cropped delta" wings with stabilizing "rollerons" on the trailing edges, steerable cruciform foreplanes
length *(AIM-9L/M)* 9 ft 6 in (2.85 m)
diameter 5 in (127 mm)
wingspan 2 ft 1 in (635 mm)

PROPULSION
solid-fuel rocket by Aerojet, Hercules, Rockwell, or Thiokol
Mk 17 on B/E/J/N/P
Mk 36 with flexadyne propellant on H/L/M

PERFORMANCE
speed Mach 2+
max range 10 nm (11.5 mi; 18.5 km)

WARHEAD (AIM-9L/M) annular blast fragmentation wrapped in a sheath of preformed rods

SENSORS/FIRE CONTROL
except for AIM-SC, all versions have used infrared homing
AIM-9L/M is the first with all-aspect seeker analog roll-control autopilot

Stinger (FIM-92A)

The FIM-92 Stinger is a lightweight, short-range surface-to-air missile that was initially deployed as a portable weapon by the US Army as the successor to the FIM-43 Redeye missile. It has also been deployed on several aircraft, including the AH-64 Apache and the OH-58D Kiowa Warrior.

The Stinger system consists of a reusable battery pack and gripstock with sight. The launch tube is a "wooden round" requiring no field maintenance. The missile is a "fire and forget" weapon with a relatively simple firing sequence. After an Identification Friend or Foe (IFF) query confirms the target is hostile, the gunner cools the passive, all-aspect Infrared (IR) seeker and fires the missile when the seeker's "growl" tells him it has locked onto the target.

Most Stinger launchers have a simple plastic sight akin to the fixed "ring and bead" of older antiaircraft guns.

A gas generator pops the missile out of the tube; when it is a few yards away from the launcher, the dual-thrust main motor ignites and accelerates the missile to supersonic speed. Tail fins roll-stabilize the Stinger and an on-board processor uses twist-and-steer commands on two of the four canard surfaces. Proportional navigation with lead bias predicts an intercept point and guides the missile over the shortest path to that point. The missile has impact fuzing only.

DEVELOPMENT • The Stinger's initial ‘operational capability was in 1981. It began advanced development in 1967, and engineering development began in 1972. Over 16,000 Stinger missiles have been produced.

In October 1988, the United States awarded a license to the Stinger Project Group (SPG) to produce missiles in Europe. SPG was formed following a 1983 Memorandum of Understanding (MoU) concluded among West Germany, Greece, the Netherlands, and Turkey. SPG's lead company is Dornier GmbH of Germany; subcontractors from the other MoU countries will also be involved. Manufacture of approximately 12,500 missiles was planned for the SPG countries, with low-rate production beginning in 1992; the license does not permit SPG to sell to non-SPG countries.

The Stinger is in service with the US Army, Navy, and Marine Corps and over 20 other countries and groups. When needed, Stingers are deployed on board US Navy ships, as in the August 1990 deployments for Operation Desert Storm.

In September 1988, Switzerland selected the Stinger over the French Mistral after a two-year evaluation, for approximately 2,500 to 3,000 missiles.

Iran and Qatar are known to have Stingers that they obtained through diversions from other users. The Stinger has also been used by Afghan Mujahideen rebels, UNITA antigovernment forces in Angola, and various factions in Lebanon. In the early to middle 1990s, the US attempted to recover the remaining Stingers held by the Afghan rebels.

In May 1990, two alleged Colombian drug dealers were charged with attempting to purchase Stingers for use against Colombian government aircraft.

VARIANTS • FIM-92C Stinger-POST (Passive Optical Seeker Technique), FIM-92C Stinger-POST RMP (Reprogrammable Microprocessor), FIM-92 Stinger Plus, Stinger Night Sight, Avenger Pedestal-Mounted (PMS) , Setter, Air-to-Air Stinger (ATAS).

COMBAT EXPERIENCE • Afghan rebels received approximately 900 Stingers and used them effectively against Soviet helicopters, transports, and attack aircraft. The introduction of the Stinger in October 1986 had a significant effect on Soviet air tactics.

During the 1982 Falkland Islands conflict, the British Royal Marines' Special Boat Squadron employed Stinger missiles that were credited with destroying an Argentine aircraft.

Stingers were deployed on board US warships in the Persian Gulf in 1987-88 as a last-resort missile defense. However, the missile's lack of design for shipboard stowage or handling influenced the Navy to curtail its procurement in April 1988.

In April 1988, Israel reported that some Palestinian militia groups in Lebanon had obtained Stingers from Afghanistan or Iran and may have fired them at Israeli aircraft.

Although Stingers were deployed with both the ground and naval forces during Desert Storm, none was fired in combat, since no enemy aircraft came within range. Some Special Operations forces in Desert Storm were fitted with WASP-equipped Stingers.

SPECIFICATIONS •

MANUFACTURER
Hughes
Raytheon (second source, 1987)

WEIGHTS
system 34.5 lb (15.2 kg)
missile 22.0 lb (10.0 kg)

DIMENSIONS
configuration
long cylinder with blunt nose, pop-out cruciform rectangular foreplanes, tapered exhaust with full-diameter nozzle, cruciform tailfins
length 5 ft (1.52 m)
diameter 2¾ in (70 mm)

PROPULSION Atlantic Research Mk 27 dual-thrust solid-fuel rocket

PERFORMANCE
speed 2,297 ft/sec (700 m/sec) or Mach 1+
max *range* 3 mi (4.8 km)
max *altitude* 9,840 ft (3,000 m)

WARHEAD 2.2 lb (1.0 kg) penetrating high-explosive

SENSORS/FIRE CONTROL
proportional navigation with lead bias
all-aspect automatic passive infrared homing
Identification Friend or Foe (IFF) interrogator
Magnavox M934 impact fuze

Patriot (MIM-104)

The Patriot is a US medium-to-high-altitude surface-to-air missile system developed as an area defense weapon to replace Nike-Hercules missile batteries in Europe. The Patriot gained widespread notoriety for its reported successes after being deployed in the early 1990s to Saudi Arabia, Israel, and Turkey as a defense against Iraqi-launched tactical ballistic missiles. A Patriot battery or fire unit consists of a phased-array radar, an Engagement Control Station (ECS), and electric generators (two 150-kW generators). Up to eight M901 trailer-mounted, four-tube launchers will be deployed; each tube is sealed at the factory and the missile requires no field maintenance.

The AN/MSQ-104 ECS includes the weapons control computer, and Identification Friend or Foe (IFF) is performed by the colocated AN/TPX-46(V)7. The electronically steered phased-array radar is the trailer-mounted, G-band (4-6 GHz) AN/MPQ-53, which performs target acquisition, tracking, and missile guidance. The system can track more than 100 targets, interrogate, and assign priorities to those identified as hostile.

Patriots based in Saudi Arabia and Israel were linked to Defense Support Program (DSP) missile-warning satellites for launch warnings, increasing warning times to as much as five minutes.

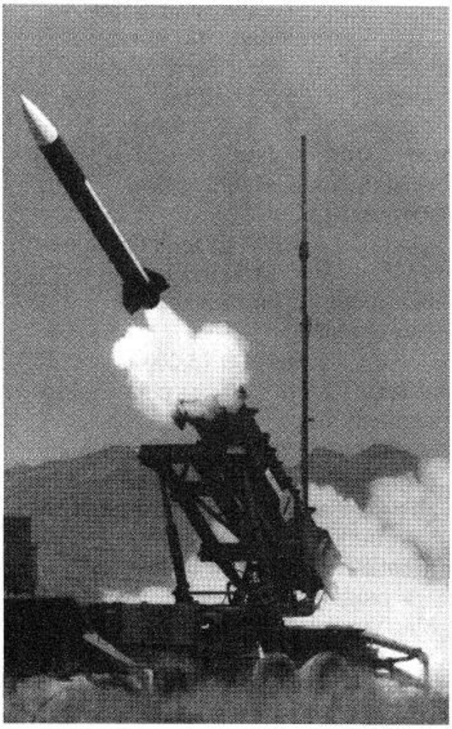
Raytheon's upgrade to the ECS includes developing Very-High-Speed Integrated Circuit (VHSIC) technology to replace 200 modules in the ECS computer with 13 modules in a much smaller volume.

The Patriot system has the ability to guide several missiles simultaneously while tracking other targets, and also has a limited Anti-Tactical Ballistic Missile (ATBM) defense capability. In a 1986 test of its potential, a Patriot missile intercepted and destroyed a Lance tactical ballistic missile.

The Patriot's accuracy is due to its Track via Missile (TVM) terminal guidance method. Targets are selected by the system and illuminated by the GCS phased-array radars. Tracking "gates" in the software permit the radar to concentrate on a relatively small sector in which the missile is likely to appear next, which improves the precision of the tracking.

When the missile is launched, it maneuvers using tail control, with independently activated fins that move the after end of the body. Body lift generated by the missile's shape and speed steers the missile in the desired direction.

Typically, two missiles are automatically fired against a target missile in a "shoot-shoot" sequence to ensure interception. Later development could result in an earlier "shoot-look-shoot" sequence that allows counteraction at a greater distance from the target.



Patriot Missile
U.S. GOVERNMENT DEPARTMENT OF DEFENSE

The missile's on-board semiactive homing monopulse seeker senses the reflected energy from the target, establishes its position relative to the target, and relays that information to the ground-based AN/MSQ-104 ECS through a radio data link. At the same time, smaller ground-based radars are tracking the target. High-speed computers in the ECS compare the positions reported by the missile and the ground radars and calculate course corrections that direct the missile to fly the most efficient intercept course. If the ground-based system is jammed by Electronic Countermeasures (ECM), the TVM channel gives the system an alternate tracking mode.

The missile's warhead is designed to spray an aircraft with high-velocity fragments that are likely to hit vital systems. When used against a missile, the blast at least diverts the incoming missile and prevents the warhead from exploding; it is not usually massive enough to obliterate a missile.

DEVELOPMENT • The Patriot's initial operational capability was in 1985. Patriot development began as the Field Army Ballistic Missile Defense System (FABMDS) and Army Air Defense System of the 1970s (AADS-70) programs, which were combined into the SAM-D program in August 1965.

First flight tests began in 1970. Full-scale development began in 1972 but was delayed by a 1974 decision to incorporate a TVM ability into the system. In 1976 (the US bicentennial year), the name Patriot was selected and said to be an acronym for Phased-Array Tracking to Intercept of Target.

Limited production was authorized in August 1980, with first deliveries in 1982. The original plan was to procure 104 fire units but was later revised by budgetary constraints to 60 fire units planned.

In March 1988, Italy signed an air defense agreement that includes the purchase and coproduction of 20 Patriot missile batteries with 160 launchers and 1,000 missiles. A new consortium-Italmissile-composed of Selenia, BPD, and OTO Melara would coordinate Italian industrial participation and manufacture the missiles and launchers.

Japan signed a license-production agreement for 26 batteries (130 launchers and 1,300 missiles) in 1985; prime contractor is Mitsubishi Heavy Industries. Japan's first three fire units were declared operational in April 1990 with the 3rd Air Defense Missile Group (ADMG) .

Siemens is prime contractor for German production. 36 fire units in six wings. 12 squadrons are owned and operated by the German Air Force. 12 will be owned by the US Army for 10 years and then turned over to the GAF, which has operated the batteries from the start. The last 12 are owned by the US Army but will be operated by the GAF until the year 2000. Four other squadrons (two "floating" and two training) are being fielded.

The Patriot is operational with the US Army and six other nations.

VARIANTS • PAC-1, PAC-2, quick-reaction upgrade, PAC-3/Advanced Tactical (AT) Patriot/Patriot Growth Missile (US/German), Launcher Improvement Program.

COMBAT EXPERIENCE • In August 1990, Patriot missile batteries were deployed to Saudi Arabia as part of Operation Desert Storm. Israeli Patriot batteries were delivered in early January 1991 and launched their first missiles on January 22.

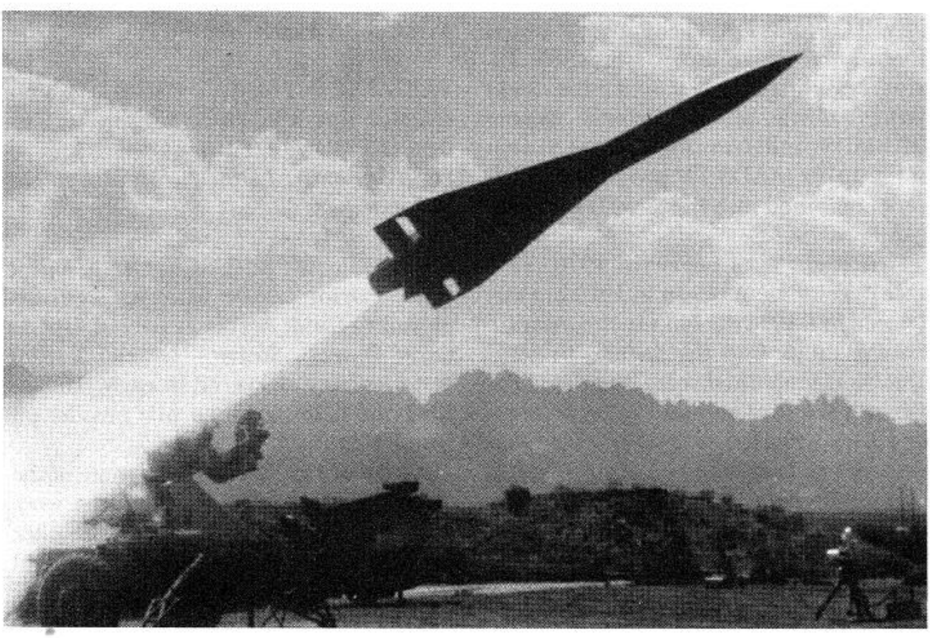
A total of 158 Patriots from some of the more than 90 launchers deployed were fired at 47 TBM in both theaters; another 39 TBM were aimed at targets outside of the Patriot batteries' envelope.

In Saudi Arabia, the US Army claimed that more than 80% of the missiles that entered the Patriot's "coverage zone" were successfully engaged. This claim was hotly challenged by critics.

SPECIFICATIONS •
MANUFACTURFX
Raytheon (prime)
Siemens (prime German contractor)
Japan (license producer)
WEIGHTS
missile 1,534 lb (700 kg)
zuarhead 198 lb (90 kg)
DIMENSIONS
configuration long cylinder with cruciform "cropped delta" tailfins and ogival nose
length 17 ft 5 in (5.31 m)
diameter 16 in (406 mm)
fin span 3 ft (914 mm)
PROPULSION Thiokol TX-486 single-stage solid-fuel rocket burns for 11 seconds
PERFORMANCE
speed more than 1,722 kts (1,983 mph; 3,191 km/h) or Mach 3 (sources report Mach 4 or 5)
range max more than 43 nm (50 mi; 80 km)
min approx 1.6 nm (1.9 mi; 3 km)
WARHEAD conventional blast fragmentation
SENSORS/FIRE CONTROL
AN/MPQ-53 phased-array radar
AN/TPX-46(V) 7 IFF
AN/MSQ-104 ECS
Track via Missile (TVM) terminal guidance
M818E2 dual-beam fuze in PAC-2 variant

HAWK (MIM-23)

The HAWK and Improved HAWK (I-HAWK) are the primary US low-to-medium-altitude ground-based surface-to-air missile systems. It is carried on a



Launch of HAWK Air Defense Missile
U S GOVERNMENT DEPARTMENT OF DEFENSE

three-missile towed launcher. In the US Army, HAWK batteries consist of two platoons, each containing three three-missile launchers. The Triad battery, used to augment normal antiair capability, has three platoons. The US Army plans to retain HAWK missile batteries in active service indefinitely.

The MIM-23's name, HAWK, is said to be an acronym for Homing All the Way Killer.

DEVELOPMENT • The HAWK's initial operational capability was in August 1960. HAWKs for European countries were built by NATO HAWK Management Office established in the 1960s. Charter members, beginning in 1958, were Belgium, France, West Germany, and the Netherlands. Greece joined in 1972 and Denmark in 1974. In production and in service with several countries. Procurement by the United States was terminated in the FYl991 budget request. License-built in Japan by Mitsubishi and Toshiba.

In addition to the US Army and Marine Corps, over 20 other nations worldwide except for Latin America use the HAWK.

18 HAWK missiles were supplied to Iran from Israeli stocks in November 1985.

VARIANTS' • I-HAWK (Improved), HAWK Mobility Enhancement (HME/ Dutch and Raytheon), NOAH (Norwegian Adapted HAWK/Kongsberg Vapenfabrikk SA, Norway, and Hughes Aircraft), Israeli upgrades.

COMBAT EXPERIENCE • Israeli basic HAWKs succeeded in shooting down more than 20 MiG aircraft during the 1973 Yom Kippur War. In 1982, a HAWK missile guided by an Israeli-modified radar intercepted a MiG-25 Foxbat reconnaissance aircraft flying at 75,000 ft (22,860 m) .

In September 1987, a French Army HAWK battery shot down a Libyan Air Force Tu-22 Blinder over Chad.

Although no HAWK missiles were fired by coalition forces during Operation Desert Storm, Kuwaiti missile batteries downed almost two dozen aircraft during the Iraqi invasion of August 1990.

Iraqi forces subsequently captured HAWK missile batteries, but how many of Kuwait's five batteries and 150 missiles was never determined. In January 1991, the Iraqis claimed to have restored two batteries to service.

SPECIFICATIONS •

MANUFACTURER Raytheon

MISSILE WEIGHT 1,383 lb (627.3 kg)
warhead 120 lb (54.4 kg)

DIMENSIONS
configuration cylindrical body, cruciform long-chord, "cropped delta" wings with control surfaces separated from trailing edges by narrow slot, ogival nose, narrowed nozzle at tail
length 16 ft 6 in (5.03 m) diameter 14 in (360 mm)
wingspan 3 ft 11% in (1.21 m)

PROPULSION Aerojet dual-thrust solid-fuel rocket

PERFORMANCE
speed Mach 2.5
max range 21.6 nm (25 mi; 40 km)
altitude minimum: less than 98 ft (30 m)
max: approx 60,000 ft (18,290 m)

WARHEAD conventional high-explosive blast fragmentation with proximity and contact fuzes

SENSORS/FIRE CONTROL
Hawk battery of 6 launchers is colocated with several radars and sensors
2 acquisition radars, synchronized in azimuth: Lband Pulse Acquisition Radar (PAR) for high-to-medium targets and Continuous-Wave Ac-

quisition Radar (CWAR) for low-altitude detection through heavy clutter
- 2 High-Power Illuminators (HPI) operating in X band illuminate target for missile
- K-band Range-Only Radar (ROR) used when other radars are jammed
- Tracking Adjunct System (TAS) passive electro-optical tracker
- missile has proportional navigation guidance coupled with CW and semiactive terminal homing

Sea Sparrow (RIM-7)

The Sea Sparrow naval Surface-to-Air Missile (SAM) system was originally developed in the late 1960s as an interim Basic Point Defense Missile System (BPDMS) against Soviet antiship missiles. Later versions\ include the Improved BPDMS and the NATO Sea Sparrow Surface Missile System (NSSMS). All use modified Sparrow III Air-to-Air Missiles (AAM) in an eight-cell launcher that can be fitted in a variety of ships.

The Mk 48 Sea Sparrow Vertical Launch System (VLS) was first tested on the Canadian destroyer Huron in April 1981. The system is designed to be assembled in groups of two vertical canisters and can be set either in the deck, exhausting vertically (Mod 0), on a bulkhead with overboard exhausting (Mod 1), or in a superstructure mount with vertical exhaust (Mod 2). The missile is fitted with Jet Vane Control (JVC) to quickly pitch the missile into cruise attitude from its vertical takeoff. Maximum missile turning rate during boost is 283deg/sec.

The Mk 41 VLS, in US service on some *Ticonderoga* (CG 47)-class cruisers and Spruance-class destroyers, can also launch VL Sea Sparrows. Four Evolved Sea Sparrows (ESS) could fit in each Mk 41 VLS cell.

DEVELOPMENT • The BPDMS with RIM-7E initial operational capability was in 1969, NSSMS with RIM-7H around 1977, RIM-7M in 1983. International program was established by July 1968 Memorandum of Understanding (MoU) between Denmark, Italy, Norway, and the United States. Later, Belgium and the Netherlands in 1970, West Germany in 1977, Canada and Greece in 1982, and Turkey in 1986 signed.

The Sea Sparrow is mounted in several types of US Navy surface combatants, amphibious ships, and underway replenishment ships, fired from either the NATO Sea Sparrow Mk 29 launcher or the BPDMS Mk 25 launcher. Both launchers have eight cells, although some Mk 29 launchers will be refitted to fire RAM (RIM-l 16) missiles from two of the eight cells.

In production and in service with US Navy and other navies. In non-US navies the Sea Sparrow is mounted in Mk 29 launchers in destroyer and frigate classes except for Mk 48 VLS in new-construction ships. A launch system and 21 RIM-7M Sea Sparrow missiles will be fitted to the lead ship of the South Korean Destroyer Experimental (KDX) class, scheduled for service entry in 1995. Over a dozen other nations in Europe, Asia, and Canada have the Sea Sparrow system deployed on their destroyers and frigates.

VARIANTS • Basic Point Defense Missile System (BPDMS), NATO Sea Sparrow Surface Missile System (NSSMS), Guided Missile Vertical Launch System (GMVLS) , RIM-7P, RIM-7R / Missile Homing Improvement Program (MHIP), Evolved Sea Sparrow (ESS) .

COMBAT EXPERIENCE • Although Sea Sparrow launchers were the most widely deployed naval weapons system in Desert Storm, no missiles were fired against Iraqi aircraft or missiles.

SPECIFICATIONS •

MANUFACTURER

Raytheon (primary)
Hughes (secondary)

SUBCONTRACTORS

Belgium Manufacture Belge de Lampes et de Materiel (MBLE)
Canada EBCO
Raytheon Canada
Denmark DISA
NEA-Lindberg
Germany Motorenwerk Bremerhaven GmBH
Italy Selenia
Netherlands Bronswerk Fokker-VFW
Norway Norsk Forsvarsteknologi (NFT)
Turkey Aselsan Military Electronics
US Ball Aerospace

WEIGHTS

system BPDMS 39,000 lb (17,690 kg)
NSSMS 28,479 lb (12,918 kg)
Mk 48 VLS (16 missiles)
Mod 0
above decks: 32,480 lb (14,896 kg)
below decks: 1,793 lb (814 kg)
Mod 1
above decks: 29,960 lb (12,256 kg)
below decks: 1,793 lb (814 kg)

missile RIM-7H: 450 lb (205 kg)
RIM-7M: 510 lb (231 kg)
warhead: 88 lb (40 kg)

DIMENSIONS

configuration long cylinder with ogival nose, cruciform, folding "cropped delta" mainplanes, clipped tail fins, JVC pack on tail of VLS variant
length 12 ft (3.66 m)
diameter 8 in (203 mm)
wingspan 3 ft 4 in (1.02 m)
tail span 2 ft (0.61 m)

PROPULSION Hercules Mk 58 single-stage solid-fuel rocket (Mk 58 Mod 4 in RIM-7M)

PERFORMANCE

speed Mach 2.5
max range 8 nm (9.2 mi; 14.8 km)

WARHEAD

RIM-7H: high-explosive continuous rod
RIM-7M: WAU-17/B high-explosive blast fragmentation

SENSORS/FIRE CONTROL

BPDMS Continuous Wave (CW) illumination from Mk 51 radar
Mk 115 manually operated fire control system
Semiactive Radar (SAR) homing in RIM-7E

NSSMS Mk 91 fire control system; Mod 0 has single director, Mod 1 has dual directors
Ball Mk 6 Mod 0 LLLTV system
Hughes Mk 23 Target Acquisition System (TAS) update

RIM-7M introduced inverse monopulse seeker, reprogrammable digital Missile-Borne Computer (MBC)

Rolling Airframe Missile-RAM (RIM-116)

The RAM (Rolling Airframe Missile) is being developed to provide a rapid-reaction, short-range Surface-to-Air Missile (SAM) for shipboard defense using "off-the-shelf" components. RAM has the Infrared (IR) seeker from the Stinger SAM and the rocket motor, fuze, and warhead from the Sidewinder Air-to-Air Missile (AAM).

The RAM is the first US Navy shipboard "fire and forget" missile and the only Navy missile that rolls during flight (i.e., is not aerodynamically stabilized).

In the initial flight phase, the missile uses passive Radio Frequency (RF) to home on target emissions to point its IR seeker at the target. RAM switches to IR homing during the terminal phase of flight. The guidance system measures the IR signal-to-noise ratio and determines when it is appropriate to switch to terminal IR homing. If the IR seeker cannot acquire the target, the missile continues on to target using the RF guidance.

There are three types of launchers. The production RAM Mk 31 launcher has 21 cells. Some NATO Sea Sparrow Mk 29 launchers will be modified so two of the eight cells would each launch five missiles. The RAM Alternative Launching System (RALS), a lighter, eight-round launcher for small combatants, is under development by TransLant Inc., a joint venture of General Dynamics and German RAM System.

DEVELOPMENT • The RAM's initial operating capability was originally planned for 1992-93. Funding for development was initially shared by the US, West Germany, and Denmark on a 49% 49% 2% basis. Denmark withdrew financial support from the project but participates on an ad hoc basis.

Although the RAM did not have immediate test success, with seven of 15 launched in an early 1985 series failing, later trials aboard the US destroyer *David R.* Ray (DD 971) from December 1986 to February 1987 resulted in 11 successes out of 13 attempts.

The US Navy established a requirement for 30 launchers and 4,900 missiles; the first allotment of 240 missiles is scheduled for the mid-1990s. Germany's requirement is for 55 launchers and 2,000 missiles.

The RAM will be deployed on US amphibious, command, and landing ships and frigates, German destroyers, frigates, and small combatants, and Danish frigates and small combatants.

Hughes and RAM System are working separately to develop an improved seeker for the RAM. The new seeker would retain the dual RF/IR capability, but the IR seeker would use an image scanning concept to improve its field of view. The improvement will augment RAM's capability against antiship missiles using inertial guidance and IR homing.

SPECIFICATIONS •

MANUFACTURER
Hughes (primary)
RAM System (German consortium)

MISSILE WEIGHT 162 lb (73.5 kg)
warhead 25 lb (11.3 kg)

DIMENSIONS
configuration long, thin cylinder with blunt nose, 2 folding steerable foreplanes, small cruciform folding tailfins; EX-8 sealed canister round imparts a spin to the RAM as the missile is launched
length 9 ft 3 in (2.82 m)
diameter 5 in (127 mm)

PROPULSION Mk 36 Mod 8 solid-propellant rocket

SPEED supersonic

WARHEAD conventional high-explosive

SENSORS/FIRE CONTROL passive dual-mode RF/IR acquisition

MODIFTED MK 29 SEA SPARROW LAUNCHER
capacity 10 RAM, 6 Sea Sparrow

MK 31 **RAM STANDARD LAUNCHER**
weight above decks: 11,424 lb (5,182 kg) with missiles
below decks: 2,105 lb (955 kg)
elevation -25deg/+80deg
traverse 360deg
capacity 21 rounds

RALS
weight above decks: less than 6,500 lb (2,950 kg) with missiles
below decks: 1,600 lb (726 kg)

elevation -25deg/+80deg
traverse 175” to either side of centerline
capacity 8 rounds

Standard SM-1 MR (RIM-66B)

The Standard Surface-to-Air Missile (SAM) series was, developed as a replacement for the three “T” missiles, the trouble-plagued Talos, Terrier, and Tartar. The Standard missile family was the result of an improvement program that began in the late 1950s. The SM-1 MR (Medium Range) is the oldest Standard type remaining in service, being a relatively short-range weapon with single-stage rocket propulsion.

The update program’s emphasis was on the achievement of greater range and reliability than Tartar and Terrier. A more powerful dual-thrust rocket motor boosted intercept altitude by 25% and range by 45%. Reliability was enhanced by replacing vacuum-tube electronics and hydraulic controls with solid-state circuitry and electronically powered controls. Warm-up time was reduced from 26 seconds for the Improved Tartar to one second for the SM-1.

DEVELOPMENT • The SM-l’s initial operational capability was in 1970. It is no longer in production but in service on destroyers and frigates in the US Navy and the navies of Australia, France, Germany, Italy, Japan, Netherlands, and Spain.

VARIANTS • RIM-66B, RIM-66E, RGM-66D Standard ARM, RGM-66E, RGM-66F, AGM-78 (air-launched ARM, see separate listing), RIM-67A, RIM-67B, RIM-67C, RIM-67D (rail-launched).

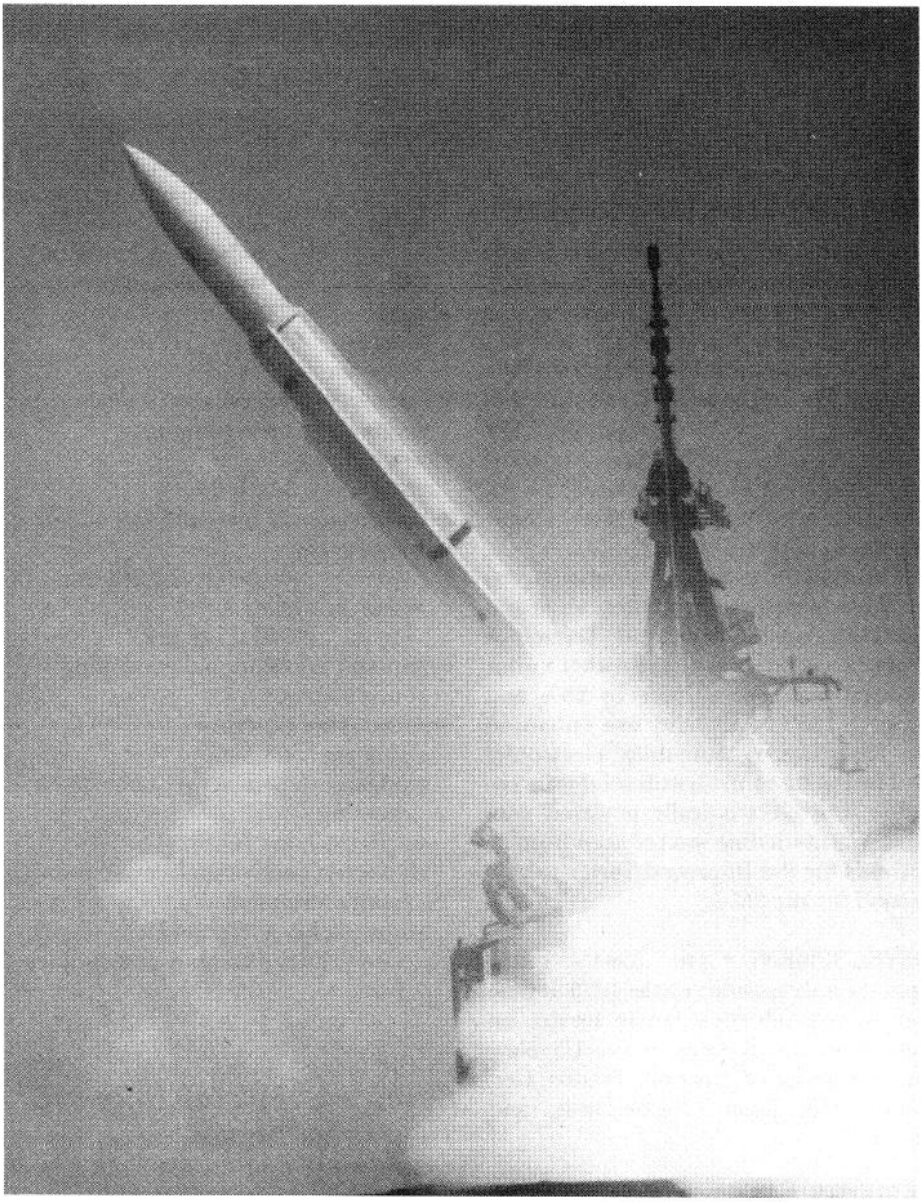
COMBAT EXPERIENCE • Although 13 Perry-class frigates participated in Operation Desert Storm, none fired its Standard missiles.

SPECIFICATIONS •
MANUFACTURER Hughes
MISSILE WEIGHT 1,100 lb (499 kg)
DIMENSIONS
configuration slim cylinder with pointed nose, cruciform narrow long-chord mainplanes indexed in line with steerable tailplanes
length 14 ft 8 in (4.47 m)
diameter 13% in (342 mm)
wingspan 3 ft 6 in (1.07 m)
PROPULSION Mk 56 Mod 0 dual-thrust single-stage rocket motor
PERFORMANCE
speed Mach 2+
max range 25 nm (28.8 mi; 46.3 km)
max altitude 60,000 ft (18,288 m)
minimum altitude 150 ft (46 m)
WARHEAD conventional expanding, continuous rod
SENSORS/FIRE CONTROL
missile guidance
conical scan Semiactive Radar (SAR) homing
single sideband receiver
all-electric control surface actuation
adaptive autopilot
Motorola Mk 45 Target Detecting Device (TDD) proximity and contact fuze

Standard SM-2 MR (RIM-66C)

The SM-2 MR (Medium Range) has increased range over the SM-1 MR (about equal to the range of the SM-2 ER) as well as the addition of midcourse guidance and enhanced resistance to Electronic Countermeasures (ECM).

The SM-2 MR is being procured in several versions and Blocks, which has resulted in a proliferation of type designations. Block II and Block III variants are separated into three subtypes, each with a different letter suffix depending on



SM-2 MR
U.S. GOVERNMENT DEPARTMENT OF DEFENSE

whether the missile is intended for the Aegis missile system, a Vertical Launch System (VLS), or a Tartar guided-missile ship.

DEVELOPMENT • Initial operational capability was in 1981. Production by Hughes.

In service with US Navy *Ticonderoga-, California-,* and Virginia-class cruisers and *Kidd-* and Burke-class destroyers, Canadian *Iroquois-class* destroyers, and Japanese Kongo-class destroyers.

COMBAT EXPERIENCE • The first operational use of SM-2 missiles occurred on July 3, 1988, when two missiles were fired from the USS *Vicennes (CG 49)* at a target believed to be an Iranian F-14 Tomcat fighter. One or both missiles struck the aircraft, which was a civilian Iran Air Airbus 300 airliner carrying 290 passengers. All aboard were killed.

A total of 43 US, four Australian, two Netherlands, and two Spanish ships fitted with Standard SAM launchers deployed to the Persian Gulf during Operation Desert Storm. Because of the rapid destruction of Iraq's antiship weapons (principally the Mirage Fl-EQ attack aircraft carrying Exocet missiles and the ground-launched Silkworm antiship missile), no Standards were launched during the deployments.

SPECIFICATIONS •

MANUFACTURER Hughes
Raytheon (secondary, Block II and III)

MISSILE WEIGHT
Block I: 1,350 lb (613 kg)
Block II/III: 1,556 lb (706 kg)

DIMENSIONS
configuration cylinder with cruciform long-chord mainplanes, cruciform steerable tail fins, ogival nose
length Block I: 14 ft 7 in (4.44 m)
Block II/III: 15 ft 6 in (4.72 m)
diameter 13% in (342 mm)
wingspan 3 ft 6 in (1.07 m)

PROPULSION single-stage dual-thrust Aerojet Mk 56 Mod 2 (Block I) or Morton Thiokol Mk 104 (Block II/III) solid-fuel rocket

PERFORMANCE
speed Mach 2+
max range Block I: approx 40 nm (46 mi; 74 km)
Block II: approx 90 nm (104 mi; 167 km)

WARHEAD high-velocity controlled fragmentation conventional high explosive

SENSORS/FIRE CONTROL
inertial navigation with P-way communication link for midcourse guidance from warship
digital guidance computer
monopulse Semiactive Radar (SAR) homing
Motorola Mk 45 Target Detecting Device (TDD) proximity and contact fuzes

Standard SM-2 ER (RIM-67A/B and 67C/D)

The SM-2 ER (Extended Range) version has extended range, midcourse guidance, an inertial reference system, and improved resistance to Electronic Countermeasures (ECM) compared to earlier missiles. The SM-2 ER is a two-stage missile that can reach an altitude of about 80,000 feet.

DEVELOPMENT • Initial operational capability was in 1981. The RIM-67A/B was deployed on the US Navy's *Bainbridge, Truxtun,* and *Long* Beach-class cruisers, and Coon&class destroyers, and the RIM-67C/D was deployed on *Leahy* and *Belknap-class* cruisers.

COMBAT EXPERIENCE - Three *Leahy* class and four *Belknap-class* cruisers fitted with RIM-67C/D and three Farragut-class destroyers armed with RIM-67B missiles deployed during Operation Desert Storm, but no Standards were launched,

SPECIFICATIONS •
MANUFACTURER General Dynamics
MISSILE WEIGHT 2,920 lb (1,324 kg)
DIMENSIONS
configuration
cylindrical booster with cruciform steerable "cropped delta" tailplanes, necked top for mating to missile; cylindrical missile with cruciform long-chord mainplanes, cruciform steerable tailplanes, ogival nose
length 27 ft (8.23 m)
diameter booster: 18 in (460 mm)
missile: 13% in (342 mm)
wingspan booster: 5 ft 3 in (1.6 m)
missile: 3 ft 6 in (1.06 m)
PROPULSION
two-stage solid fuel rocket
Mk 70 booster in SM-2 ER
Mk 56 or IO4 sustainer
PERFORMANCE
speed Mach 2+
max range 75-90 nm (86-104 mi; 139-167 km)
max altitude
approx 80,000 ft (24,384 m)
WARHEAD conventional high-explosive controlled fragmentation
SENSORS/FIRE CONTROL
inertial navigation with two-way communication link for midcourse guidance from warship
digital guidance computer
monopulse Semiactive Radar (SAR) homing
Motorola Mk 45 Target Detecting Device (TDD) proximity and contact fuze

Standard SM-2 AER (RIM-67B)

The latest Standard variant is the Aegis Extended Range, which is considerably changed from earlier Standard missiles. Aegis ER launches from the Mk 41 Vertical Launching System on *Ticonderoga* and *Arleigh* Burke classes. The basic airframe resembles earlier Standards, although the dorsal fins have been enlarged.

The guidance, ECM equipment, and airframe improvements derived from several other Raytheon missile programs. Aegis ER's digital autopilot is based on Raytheon's AIM-120 AMRAAM Air-to-Air Missile (AAM) update design. The digital signal processor techniques are taken from AMRAAM and AIM-7 Sparrow AAMs and the ground-based MIM-104 Patriot SAM. Sparrow Electronic Counter-Countermeasures (ECCM) from Sparrow AAM. To cope with the heating imposed by a longer period of high-speed flight, the fused-silica radome developed for the Patriot has been adopted.

DEVELOPMENT • The SM-2 AER's initial operational capability was in 1992. This is the first Standard missile design for which Raytheon is prime contractor; all previous variants were led by General Dynamics. The missile is deployed on the US Navy *Ticonderoga-class* cruisers and *Arleigh* Burke-class destroyers.

SPECIFICATIONS •
MANUFACTURER Raytheon
MISSILE WEIGHT 3,200 lb (1,451 kg)
DIMENSIONS
configuration
cylindrical booster with necked top for mating to missile; cylindrical missile with cruciform long-chord mainplanes, cruciform steerable tailplanes, ogival nose
length missile only: 16 ft (4.88 m)

with booster: 21 ft 6 in (6.55 m)
diameter booster: 21 in (533 mm)
missile: 13.7 in (348 mm)
missile wingspan: 3 ft 6 in (1.06 m)

PROPULSION
two-stage solid-fuel rocket
EX-72 booster
Mk 104 dual-thrust rocket motor sustainer

PERFORMANCE larger envelope than Block II/Block III

WARHEAD conventional high-explosive controlled fragmentation

SENSORS/FIRE CONTROL
inertial navigation with two-way communication link for midcourse guidance from warship
digital guidance computer
monopulse Semiactive Radar (SAR) homing

Nike Hercules (MIM-14)

The Nike Hercules Surface-to-Air Missile (SAM) system is one of the oldest US-designed SAMs still in active service. It is capable of interceptions at relatively high altitudes and long ranges but is not suitable for low-altitude defense. It can also perform in a Surface-to-Surface Missile (SSM) role. The fixed batteries that formed part of the North American air defense system have been dismantled; mobile Nike batteries are still in service in several other countries.

When targets are detected by the system's tracking radar, the Nike launcher is elevated to 85" and the missile is fired. After the boosters are spent and jettisoned, the missile-tracking radar guides the missile to the target. Detonation of the high-explosive or nuclear warhead is by radio command.

DEVELOPMENT • The Nike's initial operational capability was in 1958. Although no longer in production or US service, the Nike is in service in several European and Asian countries.

VARIANTS • MIM-14C (1981 modification).

SPECIFICATIONS •

MANUFACTURER
Western Electric (prime)
Douglas Aircraft (missile)
Mitsubishi (Japanese license)
AT&T (upgrade prime)

MISSILE WEIGHT 10,710 lb (4,858 kg)

DIMENSIONS
configuration 2-stage missile, 4 booster cluster, each booster with croppeddelta stabilizer, tapered cylinder, small cruciform delta noseplanes indexed in line with extremely swept delta mainplanes, control surfacesjoined to mainplanes by actuators
length 39 ft 8 in (12.1 m)
diameter 2 ft 7% in (.8 m)
wingspan 6 ft 2 in (1.88 m)

PROPULSION
Hercules 4motor solid-propellant booster cluster
Thiokol solid-propellant sustainer

PERFORMANCE
speed Mach 3.65
max range more than 75 nm (87 mi; 140 km)
max altitude more than 24.3 nm (28 mi; 45 km)

WARHEAD conventional high-explosive or nuclear

SENSORS/FIRE CONTROL
guidance MIM-14A command and control by Western Electric
MIM-14C has Norden DCS, General Electric AN/MPQ-43 HIPAR

Super Falcon (AIM-4)

The Super Falcon is the final generation of one of the earliest Air-to-Air Missiles (AAM) in the US inventory. The AIM-4G has an all-aspect homing capability. The AIM-4D has only a tail engagement capability but has greater maneuverability and was designed as an antifighter weapon.

DEVELOPMENT • The Super Falcon's initial operational capability as the AIM-4 was in 1956, the AIM-4E in 1958, AIM-4F/G in 1960, and AIM-4D in 1963. Over 56,000 AIM-4series missiles were built, most of which were AIM-4A/B/C variants. It is no longer in production but is still in service with the US Air Force and Air National Guard.

The Falcon's success was based on a light airframe containing a generous amount of Glass-Reinforced Plastics (GRP) and the best miniaturized electronics then available.

All Falcons were originally designated GAR (Guided Air Rockets) the AIM designation and revised numbering were instituted in 1962.

Super Falcons are operated by the air forces of Finland, Japan, Sweden, Switzerland, Turkey, and Taiwan.

VARIANTS • GAR-1/1D (AIM-4/4A), GAR-2 /2A (AIM-4B/4C), GAR-3/3A (AIM-4E/4F), GAR-4A (AIM-4G), GAR-2B (AIM-4D), XAIM-4H (test), XGAR-11 /GAR-1 1 / 11A (XAIM-26/ AIM-26A/26B), GAR-9 (AIM-47A), RB-27 (AIM-26B) and RB-28 (AIM-4D) (Swedish license-built).

SPECIFICATIONS •

MANUFACTURER
Hughes Aircraft
Saab-Scania (Sweden)

MISSILE WEIGHT
AIM-4D: 135 lb (61 kg)
AIM-4F: 150 lb (68 kg)
AIM-4G: 145 lb (66 kg)
warhead 40 lb (18.14 kg)

DIMENSIONS
configuration cylindrical body with blunt nose (opaque for Semiactive Radar/SAR, clear for Infrared/IR seeker), four small aerial "ears" on forebody (AIM-4F/G only), extreme delta cruciform wings with large control services attached at trailing edge; AIM-4D has 4 fixed, semicircular canards near the nose, AIM-4F/G have long leading-edge extensions
length AIM-4D: 6 ft 8 in (2.02 m)
AIM-4F: 7 ft 2 in (2.18 m)
AIM-4G: 6 ft 9 in (2.06 m)
diameter AIM-4D: 6% in (165 mm)
AIM-4F/G: 6.6 in (168 mm)
wingspan AIM-4D: 1 ft 8 in (0.51 m)
AIM-4F/G: 2 ft (0.61 m)

PROPULSION Thiokol M46 two-stage solid-fuel motor with first-stage thrust rating of 6,000 lb (26.7 kN) static thrust; second stage has lower rating for sustaining speed

PERFORMANCE
speed Mach 3
max range 7 mi (11.3 km)

WARHEAD conventional high explosive

SENSORS/FIRE CONTROL
AIM-4D has an Infrared (IR) seeker
AIM-4F has a Hughes semiactive radar-homing seeker
AIM-4G has an all-aspect IR seeker

ANTIRADAR MISSILES

HARM(AGM-88)

The AGM-88 HARM missile was developed as a replacement for the AGM-45 Shrike and AGM-78 Standard Antiradiation Radar Missiles (ARM). It is an expensive missile, but one with a broad capability against ground- and ship-based radars.

The HARM can be fired in several modes: As a long-range standoff missile against preselected targets, HARM can delay acquisition of target until after launch. The all-aspect passive radar-homing seeker can be used to search for targets of opportunity; the missile is then fired manually. The missile can be launched in "range-known" and "range-unknown" and can home on back and sidelobe radiation. It can also be used as a self-defense missile in concert with aircraft Electronic Support Measures (ESM) equipment.

HARM has a digital autopilot and strap-down inertial navigation, a low-smoke solid-propellant rocket, and digital processing in both the missile and the launch aircraft, which allows the HARM to attack a broad frequency spectrum (four-octave bandwidth from 0.5 to 20 GHz) of hostile radars.

The high-explosive warhead is prefragmented into thousands of small steel cubes designed specifically to damage radar antenna and other fragile equipment.

DEVELOPMENT • The missile's initial operational capability was in 1984. It was developed by the Naval Weapons Center at China Lake, California; Texas Instruments began participation in 1974. A total of 14,000 were planned for the US services. West Germany ordered 1,000 HARMs in 1986 and took its first delivery in November 1987. The 10,000th HARM was delivered in 1990.

In an attempt to increase the number of firms capable of producing antiradiation seekers, the Navy began developing the Low-Cost Seeker (LCS) program in 1984. While Texas Instruments continued developing the Block IV seeker, Ford Aerospace and Raytheon Corp. offered a competing LCS, with the Navy choosing the Ford design in 1988. (Ford Aerospace was later acquired by Loral Corp.)

Texas Instruments received a $459-million contract in February 1989 for the production of 2,449 missiles. Deliveries began in late 1990, to be completed by late 1991; the contract covers 1,319 missiles for the Navy, 950 for the Air Force, and 180 for Germany. In 1990, Spain ordered 200 HARMs for carriage by EF-18 Hornet aircraft.

The HARM has frequently been criticized for high cost, and in early 1986, the Navy briefly stopped accepting the missile because of quality control problems. Its future as the principal air-launched antiradar missile was assured, however, by its competent performance during the 1986 US naval air strikes against Libya.

Platforms for the HARM include fighters, electronic aircraft and attack (US), attack and electronic aircraft (Germany), and electronic (Spain).

VARIANTS • AGM-88A, AGM-88B, AGM-88C.

COMBAT EXPERIENCE • US Navy carrier-based aircraft launched 40 HARMs against Libyan surface-to-air missile radars, primarily SA-5s, in March-April 1986 air strikes against Libya.

When Operation Desert Storm's air

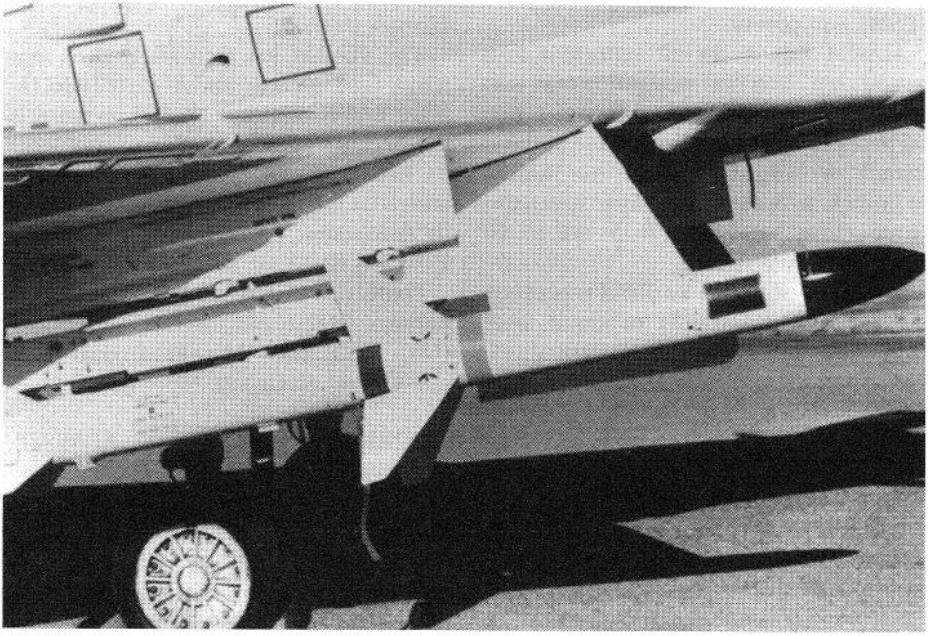
war began in January 1991, HARMS were a heavy contributor to the collapse of the Iraqi air defense radar network. Most of the more than 1,000 HARMS fired (661 by US Navy aircraft, 233 more by the US Marine Corps) were launched during the first half of the campaign.

SPECIFICATIONS •

MANUFACTURER (see Development)
MISSILE WEIGHT 796-807 lb (361-366 kg)
warhead 145 lb (66 kg)
DIMENSIONS
configuration long cylinder with ogival nose, cruciform steerable double-delta foreplanes indexed in line with stubby fins at tail
length 13 ft 8% in (4.17 m)
diameter 10 in (254 mm)
wingspan 3 ft 8% in (1.13 m)
PROPULSION Thiokol YSR-113-TC-1 dual-thrust reduced-smoke solid-fuel rocket (Hercules is second source)
PERFORMANCE
speed Mach 2+
range 10 nm (11.5 mi; 18.5 km)
WARHEAD conventional high explosive with prefragmented steel-cube warhead
SENSORS/FIRE CONTROL
all-aspect passive radar homing
Motorola DSU-19 active optical fuzing system

Shrike (AGM-45)

The AGM-45 is the first missile built specifically for the antiradar mission to enter mass production in the United States. It is based, in part, on the AIM-7 Sparrow air-to-air missile, which it resembles. It consists of four sections: a guidance system, the warhead, the control system, and the rocket motor.



Shrike
U.S. GOVERNMENT DEPARTMENT OF DEFENSE

The Shrike has had many subvariants. all of which differ principally in their seeker. It is gradually being replaced by the AGM-88 HARM missile.

DEVELOPMENT • The Shrike's initial operational capability was in 1963, and its first test flights were in 1962. Over 20,000 had been produced before production ceased.

The Shrike is deployed on US Air Force F-4Gs and F-16Cs and Ds, US Navy A-6Es, A-7Es, and F/A-18s, and Israeli F-4s and Kfirs.

The Shrike had several major limitations that reduce its effectiveness: it must be pointing at the target at the moment of launch and the target radar must be radiating throughout the missile's flight. Although upgrades have improved the Shrike's performance, the lack of a readily reprogrammable seeker remains an intrinsic limitation.

VARIANTS • AGM-45-9A Shrike G-Bias upgrade.

COMBAT EXPERIENCE • Shrikes were first used in combat in Vietnam in 1966. They were used extensively as a penetration aid by the US Air Force and Navy, but the missile's limitations-including a need for the target to continue radiating during the entire flight-led to many modifications.

The Israelis used the Shrike during the 1973 Yom Kippur War with success against SA-2 and SA-3 missiles, but ineffectively against the SA-6. It was also used by Israeli aircraft in the 1982 Lebanese conflict.

It was used ineffectively by British Vulcan bombers in the 1982 Falklands War and launched by the US Navy against Lib yan radars in the 1986 US raid.

Although the AGM-88 HARM was used much more extensively in Operation Desert Storm, the US Air Force, Navy, and Marine Corps also launched Shrikes against Iraqi radars. Fewer than 100 were fired, however, and very little was said about their success rate.

SPECIFICATIONS •

MANUFACTURER
Texas Instruments
Sperry Rand/Univac

MISSILE WEIGHT 390 lb (176.9 kg), varies with subtype
warhead 145 lb (65.8 kg)

DIMENSIONS
configuration resembles Sparrow AAM (AIM-7) long cylinder, ogival nose, cruciform delta steerable foreplanes at midbody, stubby tailfins
length 10 ft (3.05 m)
diameter 8 in (203 mm)
wingspan 3 ft (0.91 m)

PROPULSION Rocketdyne Mk 39 or Aerojet Mk 53 polybutadiene solid-fuel rocket; Aerojet Mk 78 polyurethane dual-thrust solid-fuel rocket for AGM-45B

PERFORMANCE
speed Mach 2
max range approx 10 nm (11.5 mi; 18.5 km)
up to 25 nm (28.8 mi; 40.2 km) reported for improved rocket motor

WARHEAD conventional high explosive/fragmentation

SENSORS/FIRE CONTROL
at least 18 variations, with over 13 variations on the seeker; other variations include increased range and safety features; AGM-45-9 and -10 have the widest range of coverage
fuzing is proximity and contact

Sidearm (AGM- 122)

The Sidearm is a short-range, antiradar missile developed to counter air defense weapons. It is an inexpensive selfdefense missile for Marine Corps fixed-wing and helicopter aircraft.

The missile uses components from the AIM-SC Sidewinder, which has been in storage since the 1970s. The AIM-SC was a relatively unsuccessful Semiactive Radar (SAR)-homing variant of the Sidewinder; all other Sidewinders are Infrared (IR)-homing missiles.

The Naval Weapons Center at China Lake, California, modified the AIM-SC's narrowband semiactive seeker, creating a broadband passive seeker. The seeker achieves a conical scan by mounting the antenna off center on a spinning gyroscope wheel. The DSU-15A/B Target Detection Device (TDD) flown in the AIM-9L has also been modified for air-to-ground use.

Sidearm is intended primarily for low-altitude use, and the AIM-SC control system has been modified to cause the missile to pitch up soon after launch. This change allows aircraft to launch Sidearms while flying Nap of the Earth (NOE) profiles.

Former Soviet J-band tracking radars such as the Flap Wheel and Gun Dish were the principal targets.

DEVELOPMENT • Approximately 1,000 AIM-9Cs were converted to the Sidearm configuration before funding ended in FYI988 with the purchase of 276 units. The last was delivered in late 1990. The missile is deployable by any aircraft qualified to fire the Sidewinder.

The Marines have used the missile on its Harrier and Bronco planes and the Cobra helicopter.

SPECIFICATIONS •

MANUFACTURER Motorola

MISSILE WEIGHT *200* lb (90.7 kg)

warhead *22.4* lb (10.15 kg)

DIMENSIONS

configuration thin cylinder with cruciform steerable delta foreplanes, trapezoidal mainplanes at rear, hemispherical radome on nose

length 10 ft (3.0 m)

diameter *5* in (127 mm)

PROPULSION Mk 36 Mod 9 or Mod 12 solid-fuel rocket

PERFORMANCE

speed Mach 2.5

max range *9.6* nm (11 mi; 17.7 km)

WARHEAD continuous rod, conventional high explosive

SENSORS/FIRE CONTROL passive radar homing with broadband seeker

Standard Antiradar Missile (ARM) (AGM-78)

The US Standard Antiradar Missile (ARM) is a large, air-launched weapon based on the shipboard RIM-66A Standard SM-1 surface-to-air missile. It was developed to supplement the AGM-45 Shrike, which had shown range, seeker, and warhead-size limitations during early US use in Vietnam.

The first Standard ARM (AGM-78A) variant used the Texas Instruments seeker from the Shrike, which was pretuned to a given frequency band before fitting it to the aircraft. Later variants (from AGM-78B) used a Maxson Electronics wideband, gimballed seeker. This seeker does not require pretuning, can track a radar emitter from a wider range of attack angles, and has an on-board memory that allows it to continue attacks on shut-down radars. The Target Identification and Acquisition System (TIAS) on the launch aircraft provides targeting data to the Standard ARM before launch. When the missile hits, a smoke cloud reveals the impact point.

DEVELOPMENT • The missile's initial operational capability was in 1968, and its flight tests were conducted in 1967-68. It is no longer in production. It was retired from US Air Force service in 1984 with the last F-105 Thunderchief. In service only with the Israeli Air Force.

VARIANTS • AGM-78A, AGM-78B, AGM-78C, AGM-78D, Purple Fist (Israeli development).

COMBAT EXPERIENCE • Used by US Air Force and Navy aircraft against North Vietnamese radars. Purple Fist missiles (Standard ARMs with improved warheads) were launched by Israeli pilots against Syrian air defense radars in the Bekaa Valley during the 1982 Peace in Galilee invasion of Lebanon.

SPECIFICATIONS •
MANUFACTURER General Dynamics
MISSILE WEIGHT 1,799 lb (816 kg)
warhead 215 lb (97.5 kg)

DIMENSIONS
configuration thin cylinder with pointed nose, cruciform long-chord ultra-low aspect ratio lifting strakes indexed in line with trapezoidal steerable tailplanes
length 15 ft (4.57 m)
diameter 13% in (343 mm)
tail span 3 ft 7 in (1.09 m)
PROPULSION Aerojet General Mk 27 Mod 4 dual-thrust solid-propellant rocket motor
PERFORMANCE
speed Mach 2.5
maximum range 16-30 nm (18.4-34.8 mi; 30-56 km)
WARHEAD high-explosive blast/fragmentation
SENSORS/FIRE CONTROL
guidance: passive radar homing
direct and proximity fuzes

ANTISHIP MISSILES

Harpoon (AGM-84/RGM-84/UGM-84)

The series of AGM/RGM/UGM-84 Harpoons are long-range sea-skimming, antiship missiles that are the mostwidely used antiship missiles in the West. The ship-launched version of the Harpoon was originally conceived as an air-to-surface missile to attack surfaced Soviet Echo-class cruise missile submarines. The missile is deployed in surface ships and submarines, in land-based coastal defense positions, and on aircraft for a broad antiship role. All Harpoons in US service have been upgraded to AGM/RGM/UGM-84D (Block 1C) level.

All Harpoons through Block 1C have the same missile body; different launch systems will use different body wings and fins, and restraint shoes. Harpoons launched from surface ships, submarines, or coastal defense platforms require a booster that is the same for all applications. Air-launched Harpoons do not require a booster and have pylon-attachment lugs instead of shoes. The Block 1D (AGM/RGM-84F) has a 23.2-in (592-mm) plug for more fuel capacity, relocated wings, and a Missile Guidance Unit (MGU) based on the AGM-84E SLAM.

Like the French Exocet missile, the Harpoon is a “fire and forget” weapon.

Target information is developed in different ways depending on the platform. Surface ships use the Harpoon Shipboard Command and Launch Control Set (HSCLCS, pronounced "Sickles"). Larger aircraft-P-3, F27 Maritime, B-52G, and Nimrod-are fitted with the "stand-alone" Aircraft Command and Launch Control Set (HACLCS or "Hackles"). Others-S-3 Viking and the Australian F-111C Pig-have a hybrid system that depends in part on the aircraft's weapons control system.

The F-16's Harpoon Interface Adapter Kit (HIAK) is a hybrid variant having software changes and a control box fitted in the underwing stores pylon. Full integration is also found on US, British Royal Navy, Australian, and Netherlands Navy submarines. Other non-US submarines are fitted with the Encapsulated Harpoon Command and Launch Control Set (EHCLS or "Eckles").

The MGU uses a Northrop or Smiths Industries (formerly Lear-Siegler) strapdown, three-axis Attitude Reference Assembly (ARA) to monitor the missile's relation to its launch platform (rather than in relation to the earth, as in inertial guidance). If terrain or nonhostile targets need to be avoided, a high-altitude flyout is preferred. A stealthier approach is to drop down to a presearch sea-skimming altitude.

The starting point for a circular search is offset from the target in the direction that offers the best chance of acquiring the intended target. The Bearing Only Launch (BOL) is used when the range to the target is not known or when target bearing or range is imprecisely known.

In the Block 1C, the missile has improved Electronic Counter- Countermeasures (ECCM) as part of the missile upgrade.

Surface-ship-launched Harpoons are loaded into one of three types of reusable launch canisters at the factory or at a weapons station. The Harpoon can be fired from Mk 11 twin-rail and Mk 13 single-rail Surface-to-Air Missile (SAM) launchers, or from four cells (two outer on each end) of the eight-cell Mk 16 Antisubmarine Rocket (ASROC) launcher.

Submarine-launched Harpoons are carried in a buoyant capsule that is launched from a standard 21-in (533-mm) torpedo tube.

DEVELOPMENT • The missile's initial operational capability was in 1977 for surface ships and submarines, in 1979 in P-3C antisubmarine patrol aircraft, and 1981 in A-6E attack aircraft. Initial operational capability for AGM/RGM-84D was in 1984.

First air-launched tests were in 1972. Over 6,400 Harpoons and SLAMs had been ordered by the end of 1991. The missile is intended to continue in US service well into the 21st century.

The Harpoon has been deployed on US Air Force B-52G bombers and several US Navy aircraft. The missile is also deployed in the aircraft of eight European and Asian nations, as well as on board several classes of US Navy cruisers, destroyers, frigates, and small combatants, and the surface warships of 19 other nations. The UGM-84 is deployed in submarines of the US Navy and nine other navies.

The land-launched coastal defense missile variant of the Harpoon was ordered by South Korea (three batteries), Denmark, and Norway. This missile was identical to the production version, with quad canister and launched from a buyer-supplied vehicle.

VARIANTS • AGM/RGM-84A, UGM-84B (S&Harpoon, UK), RGM-84C, AGM/RGM-/UGM-84D, AGM/RGM-84F.

COMBAT EXPERIENCE • The first combat use of the Harpoon was by US naval forces against Libyan missile corvettes in the Gulf of Sidra in March 1986. During three separate incidents, at least two, and possibly an unconfirmed third, missile craft were destroyed by US Navy A-6E Intruders.

On April 18, 1988, US Navy frigate *Bagley* (FF 1069) launched a single RGM-84D Harpoon missile at the Iranian missile craft *Joshan* as she fired an RGM-84A Harpoon at US ships. Harpoons were fired on several occasions during the expanded US ship operations against Iraq that year.

During Operation Desert Storm, US Navy ships had very few chances for using Harpoons, as most Iraqi naval ships and craft were sunk by air-launched bombs and rockets. In late January 1991, the Saudis reported that one of their missile craft sank an Iraqi ship with a Harpoon.

SPECIFICATIONS •

MANUFACTURER McDonnell Douglas

MISSILE WEIGHT

AGM-84D: 1,172 lb (531.6 kg)
RGM-84D
Mk 11/13: 1,527 lb (692.6 kg)
Mk 16: 1,466 lb (665.0 kg)
canister/capsule: 1,530 lb (694.0 kg)
AGM-84F: 1,390 lb (630.5 kg)
RGM-84F: 1,757 lb (797.0 kg)

DIMENSIONS

configuration thick cylinder with pointed nose, cruciform trapezoidal wings at midbody, cruciform in-line swept "cropped delta" control fins at tail; wings and control surfaces fold for storage, pop out after launch; engine has nearly flush ventral air intake; surface-launch version has short booster section with cruciform fins

length AGM-84D: 12 ft 7% in (3.898 m)
RGM/UGM-84D/coastal: 15 ft 2% in (4.635 m)
AGM-84F: 14 ft 7 in (4.445 m)
RGM-84F: 17 ft 2 in (5.232 m)

diameter 13% in (340 mm)

wingspan 3 ft (0.914 m)

PROPULSION

booster (surface-/coastal-/submarine-launch) : Aerojet or Thiokol solid-fuel rocket (avg 12,000 lb/5,444 kg static thrust)

Teledyne Continental CAE-J402-CA-400 turbojet sustainer developing 600 lb (273 kg) static thrust; 100 lb (45.4 kg) fuel (JP-10 in Block 1C/1D missiles)

PERFORMANCE

speed Mach 0.85

max range AGM-84D: 75-80 nm (86.3-92.1 mi; 139-148 km)
AGM-84F: approx 150 nm (173 mi; 278 km)

WARHEAD 500 lb (227 kg) conventional high explosive with some penetration capability

SENSORS/FIRE CONTROL

HCLS provides targeting data; no updates once missile is launched

on-board Midcourse Guidance Unit (MGU): IBM digital computer, Smiths Industries 3-axis ARA, and Honeywell AN/APN-194 short-pulse radar or Kollsman Frequency-Modulated Continuous Wave (FMCW) altimeter

Texas Instruments PR-53/DSQ-28 monopulse frequency-agile, jittered Pulse Repetition Frequency (PRF) active radar-homing seeker switched on at preplanned point

Skipper II (AGM-123)

The Skipper is a laser-guided standoff antiship missile originally based on existing missile and bomb components. The "body" is a standard Mk 83 1,000-lb (454 kg) bomb. The rocket motor is derived from the Shrike antiradar missile (AGM-45). The seeker, based on the Paveway II laser-guided bomb series, homes on a remotely designated laser reflected from the target.

DEVELOPMENT • The missile's initial operational capability was in 1985. In service with the US Navy on A-6E Intruder aircraft. The Skipper II was developed by the Naval Weapons Center at China Lake, California. Although the missile is comparatively low in cost and composed of already tested components, its deployment was delayed through a lack of strong support by the Navy.

The FOGS (Fiber-Optic Guided Skipper) is a variation of the Skipper using US Army-developed fiber-optic data link for Non Line of Sight (NLOS) launch. After discouraging testing and other technical problems, the Navy abandoned the program in March 1991, and reprogrammed funding to support development of the Advanced Interdiction Weapons System (AIWS), which itself was later cancelled.

COMBAT EXPERIENCE • On April 18, 1988, a US Navy A-6 Intruder struck the Iranian frigate *Sahand* with an AGM-123 after the ship engaged US Navy warships in the Strait of Hormuz. The *Sahand* also sustained hits from an air-launched AGM-84 Harpoon and an RGM-84 launched by the USS *Joseph Strauss* (DDG 16) and sank later that night.

Three Skippers were launched by US Marine Corps aircraft in January-February 1991 during Operation Desert Storm.

SPECIFICATIONS •

MANUFACTURFX
Aerojet General (rocket motor)
Emerson Electric (guidance)

MISSILE WEIGHT 1,283 lb (582 kg)
warhead 1,000 lb (454 kg)

DIMENSIONS
configuration Mk 83 bomb has tapered body; guidance section pivots on nose, has cruciform fixed "cropped delta" fins, ringed tip; booster section at tail has cruciform, pop-out swept wings
length 14 ft (4.27 m)
wingspan' 5 ft 3 in (1.6 m)

PROPULSION Aerojet General solid-fuel booster

PERFORMANCE
speed 500 kts (575 mph; 926 km/h)
range approx 5.2 nm (6 mi; 9.7 km) at 500 kts and 300 ft (91.4 m) launch altitude

WARHEAD conventional high explosive with FMU-376 fuze

SENSORS/FIRE CONTROL guidance: laser homing from remote designator

ANTITANK MISSILES

Copperhead (M712)

The M712 Copperhead Cannon-Launched Guided Projectile (CLGP) is a highly accurate, laser-guided projectile fired from standard 155-mm howitzers.

The projectile's semiactive laser seeker searches for a target illuminated by a forward ground- or aircraft-based observer using a coded laser. Copperhead aerodynamically adjusts its flight path to hit the target. The impact "footprint" is approximately 1,100 yd (1,000 m) from the nominal aim point. The Copperhead is biased to hit slightly above the aim point, the turret ring in the case of a tank, to ensure a hit. In one test at maximum range, the round dropped down the open hatch of a moving tank.

The warhead can penetrate every tank now in service. The standard CLGP has been modified with a time-delay fuze, which permits the warhead to penetrate reactive armor without detonating it.

The Copperhead can be fired using shallow flight path angles when cloud cover is below 3,000 ft (914 m). This increases guidance time below clouds, and consequently acquisition range is increased. The Copperhead can be fired from most US 155-mm towed and self-propelled howitzers, French GCT self-propelled gun, International FH-70, and Japanese Type 75 self-propelled howitzer.

DEVELOPMENT • The missile's initial operational capability was in 1982 following over 12 years in development. Its first tests were in 1974 between Martin Marietta and Texas Instruments prototypes, which ended with the selection of Martin Marietta. Full production began with FYl984 funding.

The Copperhead is operated by the US Army and Marine Corps and by Egypt.

VARIANTS • None operational.

COMBAT EXPERIENCE • During Operation Desert Storm, the VII Corps and XVIII Airborne Corps fired approximately 90 Copperheads against a variety of targets with "a high success rate." The principal constraint on Copperhead use came from the limited speed and mobility of the M981 FSV tracked vehicles used to designate targets; these vehicles often could not range far enough ahead of the artillery during the rapid maneuvers that characterized the ground war.

The commander of the 24th Mechanized Infantry Division's artillery claimed that every Copperhead fired during Desert Shield training had scored a hit.

SPECIFICATIONS •

MANUFACTURER Martin Marietta
COMBAT WEIGHT 137.0 lb (63.0 kg)
warhead 49.5 lb (22.5 kg)
filler 14.0 lb (6.4 kg) Composition B
DIMENSIONS
configuration kept in storage container until use; cylindrical body with rounded-cone nose; pop-out cruciform midwings; tail-mounted cruciform guidance fins
length 4 ft 6 in (1.37 m)
width 6 in (152 mm)
PROPULSION launched by 155-mm howitzer
PERFORMANCE
max range 17,498 yd (16,000 m)
minimum *range* 3,281 yd (3,000 m)
WARHEAD 49.6 lb (22.5 kg) High-

Explosive Antitank (HEAT), 14.1 lb (6.4 kg) explosive weight

SENSORS/FIRE CONTROL semiactive homing on laser designator

Dragon (M47)

The US M47 Dragon is a shoulder-fired, lightweight, antitank guided missile originally known as the Medium Assault Weapon (MAW). It is a short-range weapon needing only one soldier to fire.

The weapon consists of a tracker assembly and a discardable "packaged" missile. The missile has an unusual propulsion system consisting of 60 small rockets. The rockets are paired, with five such pairs making up a single longitudinal array along the missile's midbody. A total of six arrays are distributed evenly around the circumference of the midbody. These rockets provide thrust and stabilization, the latter in combination with three pop-out tailfins.

The missile uses Semiautomatic Command to Line of Sight (SACLOS) guidance with a Kollsman Infrared (IR) tracker following a flare in the missile's tail and bringing it to the gunner's line of sight. The original Dragon shaped-charge warhead was slimmer than the rocket section. Dragon Generation II has a full-diameter warhead.

DEVELOPMENT • The Dragon's initial operational capability was in 1971. Its series production ended in 1980. In January 1992, the US Army selected the Dragon II to serve as its interim short-range antitank missile until the Javelin (formerly the Advanced Antitank Weapons System-Medium/AAWS-M) is fielded in the late 1990s.

The Dragon is operated by the US Army and Marine Corps along with 10 other countries. Iraq is believed to have captured Dragons from Iran.

A major limitation of the Dragon is the SACLOS guidance. A Dragon gunner must remain exposed for approximately 16 seconds to obtain a hit. A 1990 Congressional Research Service report estimated that 33% of Dragon gunners would become casualties in a high-intensity war, This problem is not corrected in any of the improved versions. The Dragon has also been criticized for its inaccuracy.

The greatest limitation on Dragon III use, besides its still-modest maximum range, is its total weight of approximately 50 lb (22.5 kg). In practical use, the system's weight would prevent the operator from carrying any other equipment.

VARIANTS • B/B-77 (Swiss-made), Generation II Dragon, Generation III Dragon (USMC),

COMBAT EXPERIENCE • Although the Dragon was fielded with US Army and Marine Corps units in Operation Desert Storm, the rapid pace of the ground offensive in February 1991 meant that few Dragons were fired in combat. Some were used as "bunker busters" during attacks on machine-gun emplacements.

SPECIFICATIONS •

MANUFACTURER

McDonnell Douglas (original source)
Raytheon (second source)
Federal Aircraft Factory (Swiss license)

COMBAT WEIGHT 31 lb (14.1 kg)
round 25 lb (11.3 kg)
warhead 6 lb (2.72 kg)

DIMENSIONS

configuration packaged ready-round fiberglass tube containing missile with cylindrical body, 3 curved pop-out fins, 60 small sustainer rockets which both propel and control the missile

length tube: 3 ft 8 in (1.12 m)
rocket: 2 ft 5 in (0.74 m)

warhead diameter 4 in (101.6 mm)

PROPULSION
Hercules motor
2 stages: gas generator expels missile from tube; 60 small rockets, firing in pairs, propel and control the missile in flight

PERFORMANCE
speed: launch: 260 fps (79 mps); flight: 328 fps (100 mps)
max range: 1,094 yd (1,000 m)
minimum range: 71 yd (65 m)
warhead: conical shaped-charge

SENSORS/FIRE CONTROL guidance: Semiautomatic Command to Line of Sight (SACLOS) with Kollsman Infrared (IR) tracker following flare in missile tail

Hellfire (AGM- 114)

The Hellfire air-to-ground missile is the primary armament of several US attack/gunship helicopters. Although fielded as a laser-guided weapon, Hellfire accepts other guidance packages, including an Imaging Infrared (IIR) seeker, a Radio Frequency/IR (RF/IR) seeker, and a millimeter-wave seeker under development by Marconi Defense Systems.

The Hellfire can be launched in several modes. The Lock-On Before Launch (LOBL) has two modes. The first is ripple fire, in which several missiles are launched at one-second intervals at targets marked by different designators. The other LOBL mode-rapid fire-can be as fast as every eight seconds as the single designator shifts targets. Before Operation Desert Storm, this was the most common Hellfire sequence.

The missile can also be launched before its seeker locks onto a target. In this Lock-On After Launch (LOAL) mode, the missile will clear high or low obstacles (LOALH and LOAL-L) while seeking the coded laser designation, lock onto it, and dive on the target. Rockwell developed a hardened seeker that is more resistant to being misled by beam attenuation due to dust, smoke, and haze or by active countermeasures; production since 1991 included this seeker.

The missile is capable of 13-g turns at supersonic speeds.

DEVELOPMENT • The Hellfire evolved from Rockwell International's earlier Hornet missile program. The name Hellfire is a nickname derived from "helicopter-launched fire and forget." The missile's initial operational capability was in 1986. The US services plan to purchase at least 60,000 missiles over the life of the program.

The Hellfire is deployed on US Army Apache, Blackhawk, Kiowa Warrior, and Defender helicopters, US Marine Cobras, and Israeli Apaches. Additionally, Sweden began receiving a total of 700 antiship Hellfires in June 1987 to be operated as a portable coastal defense system mounted on a Swedish-built, single-rail tripod launcher. The Swedish RBS-17 weighs 108.5 lb (49.3 kg) and has a range of 5.4 nm (6.2 mi; 10 km). The Bofors delayed-action warhead penetrates the superstructure or hull of a ship before exploding. The system was successfully tested in October 1989, when a target boat 3.1 mi (5 km) offshore was hit four times out of four launches.

In October 1989, Rockwell received a $500,000, 16-month contract to study the missile's ability to shoot down helicopters and slow-moving (less than 100 mph, 160 km/h) targets. The missile would be carried by the RAH-66 Comanche (formerly LH) helicopter, complementing or replacing the Stinger missile. A proximity fuze would be developed for the AAH. The system was first tested in air-to-air firings in July 1990 with direct hits against aerial drone targets traveling 60 kts (69 mph; 111 km/h) at 600 ft (183 m) .

VARIANTS • AGM-114B (USN/USMC), AGM-114C (US Army), AGM-114D/F (US Army), AGM-114E/G (US Navy), RBS-17 (Swedish coastal variant), Brimstone (proposed RAF), Ground-Launched Hellfire-Heavy (GLH-H), Ground-Launched Hellfire-Light (GLH-L), Sea-Launched Hellfire, Longbow Hellfire.

COMBAT EXPERIENCE • In December 1989, 11 Apaches flew 200 hours of missions in support of the US military operation Just Cause to remove Panamanian leader General Noriega. The Army reported that seven Hellfire missiles were used against fixed targets, including General Noriega's headquarters, and all were accurate and effective.

Eight Apaches were used to attack early-warning radar sites in western Iraq on a round-trip of 950 nm (1,094 mi; 1,759 km) that opened Operation Desert Storm's air war. The mission, which cleared an attack lane for precision strikes, achieved complete surprise and within two minutes had scored 15 hits with Hellfire missiles. Hellfires were launched at one-to-two second intervals from as far off as 3.8 nm (4.3 mi; 7 km), the pilot switching his laser designator from one target to the next. Apaches fired an estimated 5,000 Hellfires and destroyed an estimated 500 tanks.

During the attacks against Iraqi Republican Guard formations that prepared the way for the ground war, one AH-64 hit and destroyed seven tanks with seven Hellfires. The 4th Battalion of the 229th Aviation Brigade was credited with 50 tanks in a single battle. Army OH-58Ds carried Hellfires during their antiship patrols; at least one Silkworm antiship missile launcher was destroyed by a Hellfire.

Marine Corps AH-1T and -lW Seacobra gunships fired 159 Hellfires during Desert Storm against tanks and observation and command posts.

Hellfires were also involved in accidental hits on friendly light armored vehicles and resulted in several US and British deaths. Subsequent improved recognition techniques reduced the risk of repeating such accidents.

SPECIFICATIONS •

MANUFACTURER
Rockwell International (primary)
Martin Marietta (secondary)

MISSILE WRIGHT
- *Laser variant* 100.9 lb (45.7 kg)
- *RF/IR, IIR* 105.6 lb (47.9 kg)
- warhead approx 18 lb (8 kg)

DIMENSIONS
- *configuration* thick cylinder, blunt nose with laser seeker window, small cruciform steerable foreplanes, low-aspect-ratio mainplanes at the rear
- length laser variant: 5 ft 4 in (1.63 m); RF/IR: 5 ft 8 in (1.73 m); IIR: 5 ft 10 in (1.78 m)
- *diameter* 7 in (178 mm)
- wingspan 1 ft 0.8 in (0.326 m)

PROPULSION Thiokol TX-657 reduced-smoke solid-fuel rocket (Navy designation is T773-3, Army motors designated M120E1)

PERFORMANCE
- speed Mach 1.1
- max range approx 4.3 nm (5 mi; 8 km)

WARHEAD high-explosive shaped-charge

SENSORS/FIRE CONTROL
- *missile* Laser seeker has Cassegrain telescope in hemispherical glass nose, giving the missile broad window coverage and enhancing its autonomous search capability
- Analog autopilot in production version; digital autopilot in development

target designation
TADS in AH-64 used by copilot to designate target itself or detect other designations and lock-on
AN/TVQ-l (G/VLLD) has range of 5,468 yd (5,000 m) against stationary target, 3,827 yd (3,500 m) against moving targets; designator weight is 28 lb (12.7 kg), total system weight is 51 lb (23.2 kg)
AN/PAQ-3 MULE uses AN/PAQ-1 laser and designator and AN/GSV5 rangefinder components; system weight is 37.5 lb (17 kg)

Javelin (AAWS-M)

The Javelin Advanced Antitank Weapons System-Medium (AAWS-M) is a man-portable antitank missile intended as a replacement for the M47 Dragon. Unlike the optically guided Dragon, the AAWS-M is an Infrared (IR) "fire and forget" system. It is a shoulder-fired missile coming in two parts: the disposable tube, which holds the missile, and the reusable Command Launch Unit (CLU) .

The missile is designed to attack the top of tanks where the armor is thinner. The missile climbs 330-660 ft (100-200 m) after launch. As the missile approaches the target, it dives at a 45" angle. If the target is protected from above, the operator has the option of selecting a direct-flight mode.

The warhead is a tandem shaped-charge for penetrating reactive armor. The first charge detonates the armor and the second penetrates the vehicle.

The AAWS-M is guided by an imaging Long-Wave IR (LWIR) seeker in the missile's nose using a staring focal-plane array. The array is a 64 X 64 configuration containing 4,096 IR detectors. A scanning focal-plane array with 240 detectors is used in the CLU; both arrays are made of mercury-cadmium-telluride (mercad). The CLU's Field of View (FOV) varies according to type of sight and magnification. Day sight FOV at four power is 3" X 4". The thermal sight's FOV at four power is 4" x 6"; at eight power it is 2" x 3".

The missile has a two-stage propulsion system. The first low-power motor ejects the missile from the tube. The missile glides for 15-20 ft (4-6 m) and then the main motor ignites. This allows the AAWS-M to be fired from inside a building or from a prone stance.

DEVELOPMENT • The Javelin's initial operational capability was originally planned for 1994 but was later put off until later in the decade, probably 1996 at the earliest. The first guided test firing was at Huntsville, Alabama, in April 1991.

In mid-1990, Martin Marietta selected Hughes Aircraft Co. as the second source for the IR focal-plane arrays. The original $169.7-million development contract was in 1989, but an Army review in March 1991 raised cost ceiling to $370 million.

Both the US Army and Marine Corps are scheduled to receive the missile.

In February 1989, the TI/Martin Marietta design was selected over two other designs, one by Hughes/Honeywell and one by Ford Aerospace.

SPECIFICATIONS •
MANUFACTURER Texas Instruments
Martin Marietta
COMBAT WEIGHT 41.9 lb (19.0 kg)
tube with missile 32.0 lb (14.5 kg)
missile 27.0 lb (12.2 kg)
CLU 9.9 lb (4.5 kg)

DIMENSIONS
configuration
cylinder with 4 folding control fins aft and 8 folding wings at midpoint
PROPULSION
Atlantic Research 2-stage motor system
1st, low-power, motor ejects missile from tube at 164 fps (50 mps)
2nd, main, engine then ignites for 4.5-5 sec and boosts missile to 1,804 fps (550 mps)
MAX RANGE approx 2,871 yd (2,000 m)
WARHEAD tandem, shaped-charge
SENSORS/FIRE CONTROL focal-plane-array IR guidance

TOW (BGM-71)

The US BGM-71 TOW (Tube-Launched, Optically Tracked, Wire-Guided) is the most widely distributed antitank guided missile in the world. It is fired from tripods, ground-combat vehicles, and helicopters.

Six variants have been fielded. The Basic TOW has a 5-in (127-mm) diameter warhead, analog computer, and a 3,281-yd (3,000-m) range. Improved TOW (ITOW) added a telescoping standoff detonation probe. At launch, the two-section probe springs forward to provide the optimum distance between the armor and the exploding High-Explosive Armor-Piercing (HEAP) warhead. The TOW 2 has a three-section probe, a more powerful motor, and a 6-in (152-mm) diameter warhead. TOW 2A is similar to the TOW 2 except that it incorporates a tandem warhead to increase its effectiveness against reactive armor. The precursor warhead in the missile probe detonates the reactive armor, allowing the primary warhead to penetrate the tank.

The TOW 2B, a top-attack version, entered service in late 1992.

DEVELOPMENT • The initial operational capability for the TOW/BGM-71A was in 1970, ITOW/BGM-71C in 1982, TOW 2/BGM-71D in 1984, TOW 2A/BGM-71E in 1987, and TOW 2B/BGM-71F in 1992 (First Unit Equipped). Emerson Electric Co. builds the launcher, and Texas Instruments, digital guidance and the AN/TAS-4A night sight for TOW *2* retrofit. Over 500,000 TOWs have been built and are in service.

In January 1992, the Spanish joint-venture firm Guiado y Control (composed of Hughes and INISEL) won the Spanish Defense Ministry's $130-million contract to manufacture TOWs; additional orders were expected into the late 1990s.

In addition to the US Army and Marine Corps, over 36 other countries use the TOW missile. Although Brazil and Colombia are the only Latin American countries to receive the TOW, the missile is deployed extensively in countries in Europe, Asia, and the Middle East.

Many Western helicopters have been modified to fire TOWs. The Bell AH-1J, AH-1S, AH-1T, and AH-1W can carry TOWs as well as several versions of the McDonnell Douglas (formerly Hughes) 500MD, the MBB BO 105, Westland-Aerospatiale Lynx, Aerospatiale AS 350 Ecureuil, Agusta 109 Hirundo, and Al29 Mangusta.

ISSUES • The controversial arms sales to Iran disclosed in late 1986 included over 500 TOW missiles from Israeli stocks. The missiles were reportedly Basic TOWs. A November 1987 report claimed that a further 20,000 TOWs contracted for in late 1984 were not delivered when the $264 million letter of credit disappeared with the Iranian contact. In July 1991, the *Financial Times* of London reported that London branches of the troubled Bank of Credit and Commerce International (BCCI) were used to bankroll the clandestine sale of 1,250 TOW missiles worth $9.375 million to Iran in 1985.

No TOW motors were produced at the Hercules-managed Radford, Virginia, plant between May and December 1986, because of problems in cold-weather firing and crumbling propellant. The delay affected almost 11,000 TOW missile bodies. Full production capacity was reached again in mid-1987.

Two TOW missile explosions in September 1986 were unrelated to the Hercules propellant problem, having occurred because of stress corrosion in the motor cases of TOWs produced before 1986. A plastic coating on new motor cases was recommended as a preventative measure.

Soon after the TOW 2A was announced in 1987, evidence suggested that some Soviet tanks have stacked reactive armor, the first layer of which detonates the probe, leaving the inner layer to deflect the HEAT warhead. Another armor option would be a light layer of laminate armor over the reactive armor. The TOW 2B is expected to be able to defeat such measures by virtue of its depressed angle of attack from above.

VARIANTS • Basic TOW, Improved TOW, TOW 2, TOW 2A, TOW 2B, Further Improved TOW (FITOW) (British MoD funded), MAPATS (Laser TOW) (Israeli), Hughes wireless TOW.

Major airborne TOW system-variants are the M65 Airborne TOW, M65L Laser-Augmented Airborne TOW (LAAT), TOW Roof Sight (TRS), C-NITE (Cobra-NITE), HELITOW (for Danish and Italian helicopters).

COMBAT EXPERIENCE • The TOW missile was first used in May 1972 near Hue, South Vietnam, by US Army and Marine Corps infantry and airborne units. The success rate for helicopter gunship launches was claimed to be 65 direct hits out of 81 launches (80%).

Israeli forces fired TOWs in the 1973 Yom Kippur War and the 1982 invasion of Lebanon. The Moroccan Air Force has used TOWs against Polisario units in the Western Sahara. Iranian forces used TOWs against Iraqi tanks during the 1980-88 Gulf War.

In 1987, Pakistan used TOW 2s against Indian forces in the conflict over the glacier region.

In Operation Desert Storm, beginning January 17, 1991, TOWs were deployed by the US Army and Marine Corps as well as by the British, Royal Saudi, Egyptian, and Kuwaiti armies in far greater numbers than any other ground- or vehicle-based antitank missile. In the Marine Corps alone, 582 M220E4 TOW launchers were deployed with the 1st Marine Expeditionary Force (MEF) in Saudi Arabia. Another 96 launchers remained with troops embarked on landing ships in the northern Persian Gulf.

During preparations for the ground war, TOW-equipped Marine Corps LAV-25s were used for reconnaissance of Iraqi border positions, using the missiles as "bunker busters" as well as against armored vehicles. At the battle of Khafji, January 30-31, Saudi TOW-equipped M113s engaged tanks as well as hitting bunkers.

Marine Corps Cobras also figured prominently in the Marine-Saudi drive on Kuwait City. Four Cobras attacked through breaks in the oily murk and destroyed several tanks with TOWs. Altogether, 250 TOWs were fired by Marine Corps units.

SPECIFICATIONS •

MANUFACTURER

Hughes Aircraft (prime)

McDonnell Douglas (secondary)

WEIGHTS

on tripod launcher

Basic TOW: 173 lb (78.5 kg)

Basic with AN/TAS-4 night sight: 193 lb (87.5 kg)

TOW 2: 205 lb (93 kg)

weight in container
Basic TOW: 56.3 lb (25.5 kg)
ITOW: 56.6 lb (25.7 kg)
TOW 2: 62.0 lb (28.1 kg)
missile weight
Basic TOW: 41.7 lb (18.9 kg)
ITOW: 42.0 lb (19.1 kg)
TOW 2: 47.4 lb (21.5 kg)

WARHEAD
BGM-71A: 8.6 lb (3.9 kg)
TOW 2/-71D: 13.0 lb (5.9 kg)

DIMENSIONS
configuration
factory-sealed tube contains a cylindrical missile body; pop-out cruciform wings indexed 45” off line from cruciform rudders; 2 rocket exhausts at midbody; 2 guidance wire spools in tail
length prelaunch: 3 ft 10 in (1.17 m)
TOW 2, probe out: 4 ft 7 in (1.4 m)
diameter missile: 6 in (152 mm)
warhead Basic TOW, ITOW: 5 in (127 mm)
TOW 2: 6 in (152 mm)

PROPULSION
2 Hercules solid-fuel rocket motors
1st motor has short burn to allow TOW to clear tube
2nd motor sustains TOW flight until impact
TOW 2 motor provides 30% greater impulse than Basic TOW

PERFORMANCE
speed Mach OS-O.9
range (BGM-71D)
max: 4,100 yd (3,750 m)
minimum: 71 yd (65 m)

WARHEAD High-Explosive Armor-Piercing (HEAP) shaped-charge; ITOW and TOW 2 have extendable probes to enhance the hollow charge effect
ITOW probe length:
5 in (127 mm); standoff distance 15 in (381 mm)
TOW 2 probe length: 6 in (152 mm); standoff distance 21.25 in (540 mm)
penetration classified but TOW 2 is intended to penetrate any 1990s tank
rate of fire
3 launches in 90 sec

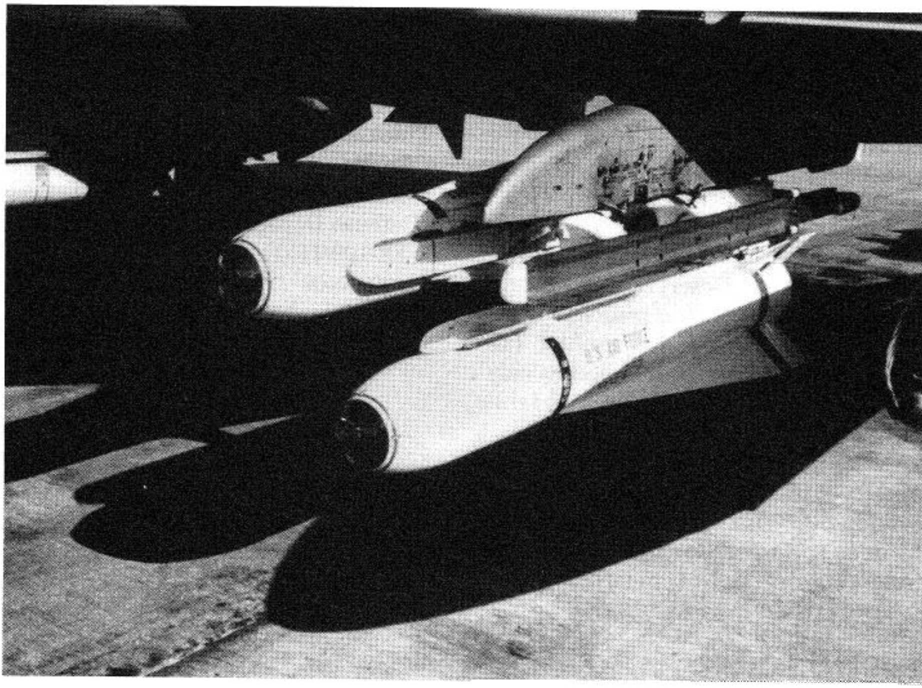
SENSORS/FIRE CONTROL
guidance: Semiautomatic Command to Line of Sight (SACLOS) wire guidance
automatic Infrared (IR) tracking of xenon or thermal beacon in missile tail
analog computer in Basic TOW
Texas Instruments dual digital programmable microprocessors in TOW 2
Texas Instruments AN/TAS-4 thermal night sight
Kollsman AN/UAS-12C thermal imager and missile guidance system for TOW 2
dual Thorn/EM1 optical/magnetic proximity sensor for TOW 2B

CREW 4

Maverick (AGM-65)

The Maverick is a precision-guided, air-to-ground missile configured primarily for the antitank and antiship roles. Six models of Mavericks have been developed. The AGM-65A/B/D variants have a shaped-charge warhead and are used as antitank weapons; these dive on the tank at an angle to hit the more vulnerable top armor. The AGM-65E/F variants have a larger blast/penetration warhead and are used in the land-attack and antiship role; the -65F’s terminal attack aims at the waterline of a ship.

In addition to the types of targets that can be engaged, the Maverick employs



Maverick AGM-65
U.S. GOVERNMENT DEPARTMENT OF DEFENSE

several different guidance methods. The AGM-65A/Bs are television-guided; the AGM-65C is laser-guided; the AGM-65D uses an Imaging Infrared (IIR) guidance system; the AGM-65E is the improved C model; and the AGM-65F combines the IIR seeker of the D model with the warhead and propulsion sections of the AGM-65E.

The Maverick is launched from a variety of fixed-wing aircraft and helicopters; the launch envelope varies slightly depending on warhead size.

DEVELOPMENT • The Maverick's initial operational capability was in 1972 for the AGM-65A, 1983 (AGM-65D), and 1985 (AGM-65E). The first test flights were in 1969. The AGM-65G completed its last test launch in October 1988. In August-September 1990, Hughes accelerated testing of the AGM-65D for launch from the AH-1W attack helicopter in response to the August 1990 Iraqi invasion of Kuwait. Final manufacture and delivery of missile (5,225 AGM-65Gs and 36 AGM-65Fs to the US Navy) was in April 1994.

In addition to the Maverick being deployed on various US Air Force and Navy fixed-wing planes and helicopters, the missile is used by 19 other countries in Europe, Asia, and the Middle East.

VARIANTS • AGM-65A (TV), AGM-65B, AGM-65C, AGM-65D, AGM-65E, AGM-65F, AGM-65G, Rapid Fire.

COMBAT EXPERIENCE • The first combat use of the Maverick was in Vietnam in January-February 1973, where targets were hit in 13 of 18 launches.

During the 1973 Yom Kippur War, Israeli aircraft fired 50 AGM-65s and scored

42 hits and five deliberate near misses (to disable, not destroy). Later Israeli combat use (up through March 1983) experienced 20 missiles hit for 20 targets engaged.

In a June 1975 border clash, Iranian aircraft fired 12 missiles, all of which hit Iraqi tanks.

More than 5,100 Mavericks were fired during Operation Desert Storm, making the missile the Air Force's principal tank-killing missile' during the conflict (although GBU-12 laser-guided bombs may have accounted for more armored vehicles).

An April 1992 official report on the conduct of the Persian Gulf War claimed an SO%-90% success rate (launch and guidance to target) for the TV and IIR Mavericks, and approximately 60% for the laser-guided variants.

SPECIFICATIONS •

MANUFACTURER
Hughes Aircraft (prime)
Raytheon (secondary)
Alenia (Italy, AGM-65D/G)

MISSILE WEIGHT
AGM-65A/B/D: 462 lb (210 kg)
65E/F: 637 lb (289 kg)
warhead AGM-65A/B/D: 125 lb (56.7 kg)
AGM-65E/F/G: 300 lb (136.1 kg)

DIMENSIONS
configuration Resembles an enlarged Falcon AAM (AIM-4) thick cylinder with rounded nose, cruciform extreme delta wings with rectangular control surfaces immediately behind
length 8 ft 2 in (2.49 m)
diameter 12 in (305 mm)
wingspan 2 ft 4.5 in (0.72 m)

PROPULSION
Thiokol TX-481 or TX-633 Z-stage solid-fuel rocket; Aerojet is second source
(Defense Department designation is SR-109-TC-1)

PERFORMANCE
speed between Mach 1 and 2
range (launch aircraft speed of Mach 0.9)
at approx 3,000ft *(914 m)* *launch altitude*
minimum; 2,000 ft (610 m)
max: 9 nm (10.4 mi; 16.8 km)
at 10,000ft (3,048 m) launch altitude
minimum: 5,000 ft (1,524 m)
max: 12 nm (13.8 mi; 22.2 km)
at 30,000ft (9,143 m) launch altitude
minimum: 3.5 nm (4.0 mi; 6.4 km)
max: 12.0 nm (13.8 mi; 22.2 km)
max with 300-lb (135-kg) warhead: 13.5 nm (15.5 mi; 24.4 km)
warhead type
conventional high-explosive
AGM-65A/B/D: shaped-charge
AGM-65E/F/G: blast/penetration

SENSORS/FIRE CONTROL varies by model

LAND-ATTACK MISSILES

AGM-130

The AGM-130 is a powered version of the US GBU-15 precision-guided modular glide bomb, which in turn evolved from the Mk 84 2,000-lb (907-kg) bomb. Commonality between the two weapons includes the TV seeker, body, and short-chord wings. Warheads for the GBU-15 are the Mk 84, a submunitions dispenser (SUU-54), or the more powerful BLU-109 (I-2000) unitary warhead.

In addition to its rocket motor, the AGM-130 differs from the GBU-15 in the provision of a digital autopilot and radar altimeter. The rocket motor extends the range of the AGM-130 up to three times farther than the GBU-15 under similar launch conditions.

The AGM-130 can be launched from low altitudes against high-value fixed targets. Its flight profile consists of a glide phase, a powered phase (after which the rocket separates from the missile), and a final glide phase. Midcourse corrections are passed through a jam-resistant data link that is an improvement over the GBU-15's AXQ-14. Targeting options can be Lock-On Before Launch (LOBL) or After Launch (LOAL), which provides for automatic tracking, or through joystick control by the weapons system operator on board the launch aircraft. The weapons systems officer can also update a locked-on AGM-130 during the flight.

GBU-15s have either a television (TV) (GBU-15 (V) 1/B) or Imaging Infrared (IIR) (GBU-15(V)2/B) seeker; the IIR seeker has 90% commonality with the AGM-65D Maverick IIR air-to-surface missile.

The AGM-130 serves as a standoff weapon for the F-4E, F-15E, and F-111F.

DEVELOPMENT • The initial operational capability of the GBU-15 (TV) was in 1983, the GBU-15 (IIR) in 1987. Air Force conducted nine initial operational test and evaluation launches, beginning in June 1989 and ending in January 1990. Eight of the nine launches were successful, with six scoring direct hits.

COMBAT EXPERIENCE • The GBU-15 was used effectively against Iraqi targets during Operation Desert Storm.

SPECIFICATIONS •

MANUFACTURER Rockwell International (prime)

MISSILE WEIGHT
GBU-15: 2,617 lb (1,187 kg)
AGM-130: 2,980 lb (1,352 kg)
warhead 2,000 lb (907 kg)

DIMENSIONS
configuration thick cylinders, with small cruciform foreplanes, and large rectangular mainplanes at the tail; AGM-130 has a strap-on ventral rocket
length GBU-15: 12 ft 10.5 in (3.92 m)
AGM-130: 12 ft 11 in (3.94 m)
diameter *(both)* 1 ft 6 in (460 mm)
wingspan *(both)* 4ft 11in(1.50m)

PROPULSION Hercules solid-fuel booster weighing 480 lb (218 kg) with 9 in (0.27 m) diameter

PERFORMANCE
max range GBU-15: 4.3 nm (5 mi; 8 km)
AGM-130: 26 nm (30 mi; 48 km)

WARHEAD Mk-84 conventional high explosive or SUU-54 explosive submunitions

SENSORS/FIRE CONTROL guidance: manual command through 2-way data link or automatic TV or IIR guidance through pre- or postlaunch lock-on

Army Tactical Missile System (ATACMS)

The US Army Tactical Missile System (ATACMS) is a long-range tactical missile for deployment in modified M270 Armored Vehicle-Multiple Rocket Launchers (AVMRL), which are already used for the Multiple-Launch Rocket System (MLRS) . The MLRS AVMRL is modified by changing the pods from two six-round to two M39 Missile/Launch Pod Assemblies (M/LPA) single-round units and updating the fire control software to Version 6. The Improved Stabilization Reference Platform (ISRP) provides more precise pointing, the Program Interface Module (PIM) allows the launcher and the missile to exchange more data, and the Improved Electronics Unit (IEU) gives better flexibility for processing types of munitions.

ATACMS is a semiballistic missile, with inertial guidance provided by a Honeywell H700-3A ring laser gyroscope system. Launch can be as much as 30” off axis, and the missile is steered aerodynamically by electrically actuated control fins during the descent, modifying the flight path from a ballistic parabola, Offsetting the launch angle and descending semiballistically complicates the enemy’s ability to trace trajectory back to the launch vehicle. Its disadvantage is that accuracy is less precise than a straightforward flight path would achieve.

The missile was deployed with an M74 warhead that dispenses 950 M42 Antipersonnel/Antimateriel (APAM) submunitions that are cast forward at a 45” angle over the target area, producing a 600-ft^2 (183-m^2) footprint. Effectively, 18 ATACMS would equal the impact of 792 155-mm artillery rounds.

DEVELOPMENT • The Desert Storm conflict resulted in rushing the operational test battery, being deployed to Saudi Arabia in late 1990. The original, tightly scheduled development contract was awarded in late March 1986. The first flight test was on April 26, 1988. The development test phase ended in December 1989 after 26 missiles had been fired. The operational test phase ran from March to June 1990.

Delivery of the first production missile to the US Army was in June 1990. A $66.4 million contract for the low-rate initial production of 104 missiles was awarded in February 1990. The $126.3-million contract for full-scale production of 318 missiles was awarded in November 1990. First delivery from this lot occurred in June 1991. Further $30.5-million-contract modification in June 1991 added 55 missiles and some LPAs.

When the development test phase ended in December 1989, only 26 of 35 planned test launches had been conducted. South Korea, Japan, Saudi Arabia France, Turkey, Italy, and Great Britain’ may purchase the ATACMS. Italy and France will participate in producing Block II warheads for the missile. ATACMS will also carry the brilliant antitank (BAT) missile as a submunition.

VARIANTS • Block II (follow-on warhead), Terminal Guided Warhead/TGW (US/German/French/British consortium), SADARM (Sense and Destroy Armor) submunition, Brilliant Antitank (BAT) submunition, AGM-137/MGM-137/TSSAM (Tri-Service Standoff Attack Missile).

COMBAT EXPERIENCE • The ATACMS was successful in Saudi Arabia during Desert Storm. More than 30 ATACMS missiles were launched against Iraqi fixed targets, mostly Russian-made SA-2 Guideline and SA-3 Goa missile launchers.

In at least one instance, 200 unarmored vehicles attempting to cross a bridge were also destroyed. According to official reports, all missiles hit, and destroyed or rendered inoperable, their targets, some of which were more than 54 nm (62 mi; 100 km) from the launch site.

SPECIFICATIONS •

MANUFACTURER Loral Vought

WEIGHT WITH BLOCK 1 WARHEAD 3,687 lb (1,672 kg)

DIMENSIONS

length **13** ft (3.96 m)
diameter **24** in (610 mm)

PROPULSION Atlantic Research 40,000-lb (18,144kg) static thrust solid-propellant rocket

MAX RANGE 81 nm (93.2 mi; 150 km)

WARHEAD M74 containing approx 950 M42 bomblets

SENSORS/FIRE CONTROL missile guided by Honeywell H700-3A ring laser gyro; overall ATACMS command and control managed by DEC MicroVAX computers

Multiple Launch Rocket System (MLRS)

The MLRS is a 227-mm system with tracked, self-propelled, launcher loader, disposable pods, and fire control equipment. The M270 Armored Vehicle-Mounted Rocket Launcher (AVMRL) consists of an M269 Launcher Loader Module (LLM) with two six-cell rocket Launch Pods/Containers (LP/C) mounted on an M993 carrier vehicle. Its mission is to bombard enemy field artillery and air defense systems as far as 20 mi (32 km) away. A full salvo of 12 227-mm ripple-fired rockets with the M77 submunition warhead will saturate a 60-acre (24hectare) area with 7,728 antipersonnel bomblets in less than one minute. Other warheads include the AT2 antitank

A Multiple Launch Rocket System (MLRS)
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mine dispenser and a Terminally Guided Warhead (TGW).

The M993 vehicle is a modified M2 Bradley armored personnel carrier. Above the tracks, the superstructure has an armored cab forward and the bulky traversable launcher behind. When traveling, the cab and launcher roofs form a flat roofline. The M269 LLM has a twin-boom crane for reloading the six-round LP/C that requires no personnel other than the three-man crew. (One crew member can serve the launcher from emplacement to departure if necessary.)

US MLRS batteries are served by three ammunition sections, each of which has six Heavy Expanded Mobility Tactical Trucks (HEMTT) towing a Heavy Expanded Mobility Ammunition Trailer (HEMAT); total capacity is 108 LP/Cs. British MLRS reloads come on Reynolds Broughton two-axle trailers carrying specially adapted flatracks.

The entire fire mission can be conducted from within the cab. The Norden fire control system can be programmed with three different fire missions, each with 12 aim points. The maximum rectangular target size for each aim point is 2,187yd X 1,094yd (2,000m x 1,000m), square target is 1,094 yd (1,000 m) square, and maximum circular target radius is 547 yd (500 m).

The Fire Control System's (FCS) ballistic computer calculates the necessary trajectories. Operation is semiautomatic, the FCS leading the crew through the sequence and automatically reaiming the system during ripple fire. The rrew ran also designate targets manually. The FCS can also accept inputs from other battlefield surveillance radars and sensors. The FCS also controls the loading and unloading of launch pods.

Version 9 fire control software was introduced in 1990 for the battery's Fire Direction System (FDS) that links the launchers to the Tactical Fire Direction System (TACFIRE). Version 9 permits an MLRS fire direction specialist to control launching in a Lance missile battery or to mix Lance and MLRS launchers. The FDS is now fielded at the platoon level, increasing flexibility and redundancy. In addition, the system can store four fire plans with up to 78 total targets and interact with the Airborne Target Handoff System (ATHS) on the OH-58D Kiowa and the Automatic Fire Control System (AFCS) developed for the M109A6 Paladin 155-mm self-propelled gun. Version 9 allows up to six firing units-platoons and batteries (depending on the size of the organization) -to mass their fires on a target.

DEVELOPMENT • The system's initial operational capability was in 1983, and it entered service in 1988. A year later, the Army awarded a five-year contract to the former LTV for the supply of 235 launchers and 127,000 rockets through 1995. The US Marines begin receiving their AVMRLs in 1995.

In December 1986, the Netherlands signed a $190-million agreement with the US government for 22 launchers, rockets, and spare parts. Its first units became operational in 1990.

In December 1987, the US government announced a 12-system sale to Turkey for $60 million. LTV (51%), EHY (34%), and MVKEK (15%) are shareholders in a program to produce 168 systems and 55,000 rockets over a lo-year period in a factory near Burda, Turkey.

A European Production Group (EPG) was established in 1981 with headquarters in Munich, Germany. The group was to produce MLRS systems for the nations in the consortium, Aerospatiale (France), RTG (Germany), Hunting Engineering (Great Britain), and SNIA BPD SpA (Italy). The first production contract was let on May 27, 1986. Aerospatiale began MLRS production for the EPG in October 1988; Wigmann is assembling German vehicles.

MLRS International Corp. (MIC), headquartered in London, England, is the marketing entity for all international sales. Vought Corp. (formerly LTV) owns

70% of the enterprise, with the EPG holding the other 30%.

The British (72 launchers), French (48 launchers), and Italian (22 launchers) armies have deployed their MLRS at the corps level. German MLRS is fielded in a nine-launcher battery composed of a four-launcher and a five-launcher platoon, two of which are assigned to each of eight division-level rocket artillery battalions. A US Army MLRS battery consists of nine AVMRLs.

Funding for Japanese production began in FY1991. As many as 150 launchers may be manufactured in Japan.

In addition to the US Army and Marine Corps, Bahrain, Japan, Netherlands, Saudi Arabia, and Turkey are or will be operating the US-produced MLRS

VARIANTS • XR-M77 Extended Range, AT2 (Germany warhead), Terminal Guided Warhead (TGW) , XM-135 Binary Chemical Warhead, SADARM (Sense and Destroy Armor) submunition, ABRS (shipboard).

COMBAT EXPERIENCE • Although the manufacturer claimed higher numbers, the official report on the conduct of the Persian Gulf War stated that 189 SPLLs had fired 9,660 rockets.

Most of the launchers were with US Army forces; the first US combat use came in mid-February as part of the preparation for the ground campaign. Generally, reports on the effectiveness of the weapon were very favorable, with a large percentage of Iraqi targets destroyed.

According to some reports, the rate of fire was described as "steel rain," allegedly coined by Iraqi soldiers to describe MLRS bombardments.

12 British MLRS launchers. fired over 2,500 rockets during Desert Storm. As evidence of the system's destructive power, the British noted an Iraqi brigade that began with 80 artillery pieces and lost only 20 to air attacks over a period of weeks. After the MLRS barrages, only seven pieces remained operable.

SPECIFICATIONS •

MANUFACTURER
FMC (AVMRL chassis)
Loral Vought (MLRS)
European Production Group (EPG) (see above)
Nissan Motors (Japan)

ROCKET ARMAMENT

number of cells 12
launcher elevation +60deg (+1,067 mils); rate 0.9" (15.5 mils)/sec
traverse +/-194" each side of centerline; rate 5deg/sec
rocket caliber 227 mm
weight rocket
Phase I: 677 lb (307 kg)
AT2: 568 lb (257.5 kg)
warhead
Phase I: 339.5 lb (154 kg)
AT2: 236 lb (107 kg)
rocket length Phase I: 12 ft 11 in (3.93 m)
diameter 9 in (227 mm)
max range Phase I: 19.9 mi (32 km)
AT2: 24.8 mi (40 km)
rate **ofjire** less than 1 min for 12 missiles

LAUNCH VEHICLE

weight combat: 55,536 lb (25,191 kg)
unloaded: 44,509 lb (20,189 kg)
launch pod: 5,004 lb (2,270 kg)
dimensions hull length: 22 ft 10 in (6.97 m)
width: 9 ft 9 in (2.97 m)
height: 19 ft 5 in (5.93 m) elevated, 8 ft 7 in (2.62 m) traveling
length of track on ground: 14 ft 2 in (4.33 m)

track width: 21 .in (530 mm)
ground clearance: 17 in (430 mm)

propulsion Cummins VTA-903 903-ins (14.8-liter) liquid-cooled 4stroke turbocharged V-8 diesel engine
General Electric I IMPT-500 hydromechanical transmission; 3 forward/1 reverse ranges (variable ratios)
max power: 500 hp at 2400 rpm
power-to-weight ratio 19.85 hp/metric ton

performance speed: 40 mph (64 km/h)
range: 300 mi (483 km)
fuel capacity: 163 US gal (517 liters)
obstacle clearance: vertical 3 ft 3 in (1 .0 m), trench 7 ft 6 in (2.29 m), fording 3ft 7in (1.1 m), gradient 60%

Sensors/Fire Control
Norden FCS
Bendix stabilization reference package/position determining system (SRP/PDS)

Crew 3 (section chief, gunner, driver); crew can fire entire load from cab and can reload MLRS without other help

Suspension torsion bar, 6 dual road wheels, front drive, rear idler, 2 shock absorbers, 4 return rollers

Vehicle protection
armor against small-arms fire on cab and louvers on windows
overpressure protection against Nuclear, Biological, and Chemical (NBC) warfare
electronics hardened against an Electromagnetic Pulse (EMP)

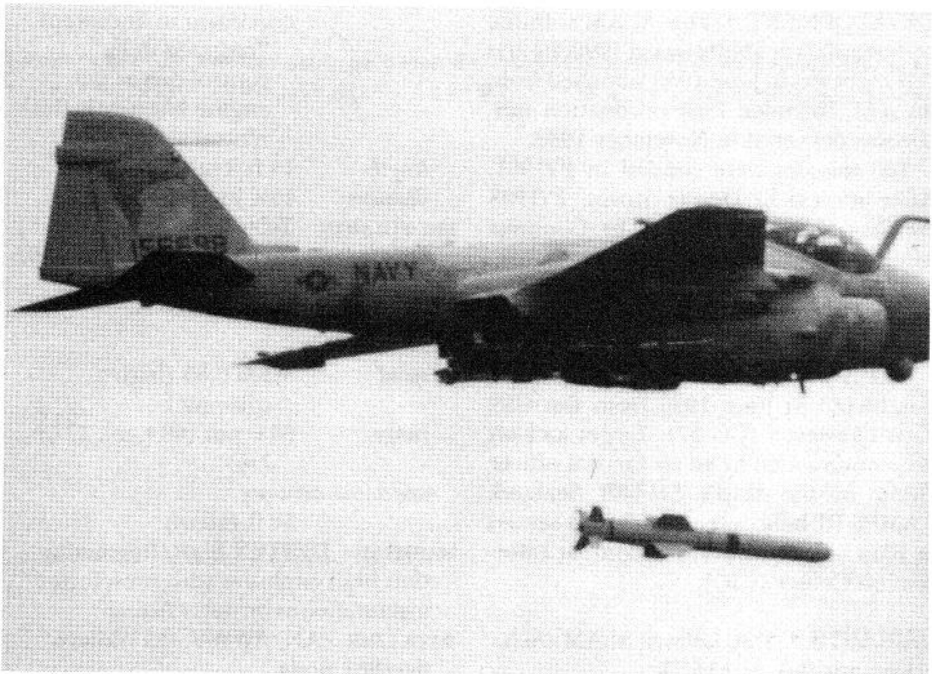
SLAM (AGM-84E- 1)

The Standoff Land-Attack Missile (SLAM) is an Imaging Infrared (IIR) seeker, man-in-the-loop-terminally guided missile that is a derivative of the AGM-84A Harpoon antiship missile. SLAM is launched from aircraft and surface ships against high-value targets while maintaining collateral damage and risk to the launch aircraft and aircrew. The SLAM was developed by integrating the existing assets of the AGM-84 Harpoon, the Hughes Maverick IIR seeker, the Collins Global Positioning System (GPS), and the Walleye data link.

SLAM is capable of two modes of attack: Preplanned (PP) missions against high-value fixed or relocatable land targets and Target of Opportunity (TOO) missions against ships at sea.

The SLAM shares common control, warhead, and sustainer sections with the Harpoon. Its navigational heart is the 12.5-lb (5.67-kg) Rockwell-Collins single-channel GPS receiver/processor that determines the missile's three-dimensional location within 52 ft (16 m) and its velocity within 0.65 fps (0.2 mps)

In addition to using Harpoon-common components, SLAM adopts the IIR seeker of the AGM-65 Maverick and the AN/AWW-9 (later replaced by the more reliable AN/AWW-13) data link of the AGM-62 Walleye. The full-duplex



SLAM
U.S. GOVERNMENT DEPARTMENT OF DEFENSE

datalinkoperates on one of eight transmit-and-receive frequency pairs, with the frequencies being widely separated.

Four missions (typically three PP and one TOO) can be loaded into the missile's Electronically Erasable Programmable Read-Only Memory (EEPROM) before takeoff, using a portable Prelaunch Data Memory Loader (PDML) . The PDML can store up to 16 sets of mission data (64 missions) for an eight-hour period before self-purge occurs. Transfer of mission planning data to the missile takes about five minutes. At the same time, the missile's GPS clock data is updated. The pilot / weapons controller chooses one of the four missions before launch.

After launch, the SLAM flies autonomously to the area of the target via its GPS-aided inertial system. At a preprogrammed point approximately one minute before impact, the seeker turns on and, because of GPS-aided navigation accuracy, should be looking directly at the target. The controller views the target scene and selects an aim point for the terminal phase via the SLAM's data link, and the missile flies autonomously to that point.

The missile can also be controlled from an aircraft other than the firing platform. Additionally, the SLAM provides the capability to attack targets of opportunity selected by scanning the missile's seeker at 4deg/sec.

The combination of an A-6E launching a SLAM and an A-7 pilot performing the locking-on was used during its first operational flights against Iraqi targets in January 1991. F / A-18 Hornets have also successfully launched and guided the SLAM.

The SLAM incorporates a fuze-wiring modification into the same warhead used in the Harpoon to allow for instantaneous detonation (for certain land targets) and delayed detonation (for ship targets).

DEVELOPMENT • The SLAM's initial operational capability was in 1990. Its first test flight was in June 1989 launched from an A-6E Intruder. First production missile was delivered in November 1988.

160 missiles were funded in FY1991. After success in Desert Storm, FYl993 funding was appropriated by Congress but not authorized.

The missile is used on A-6E Intruder, F/A-18 Hornet, F-16 Fighting Falcon, P-3 Orion, and B-52 Stratofortress.

The first ship-launched SLAM test was conducted in June 1990 from the USS Lake Champlain (CG 57). Target lock-on was commanded by an air tactical officer flying in the ship's SH-GOB Seahawk LAMPS III helicopter, which also served as data link for the ship's Combat Information Center (CIC).

VARIANTS • Ship Launch SLAM (SLS/cruise missile), SLAM-ER.

COMBAT EXPERIENCE • SLAMs were used during Desert Storm against Iraqi targets. Defense Department videos showed two SLAM strikes on a building, the second entering the hole made by the first. The SLAMs were launched from A-6E Intruders, but given midcourse corrections by A-7E Corsair pilots through the Walleye data link. Overall, seven SLAM missileswere successfully fired during the Persian Gulf conflict, even though the AWW-9 data link was very unreliable and required considerable maintenance.

SPECIFICATIONS •
MANUFACTURER Douglas Missile Systems
COMBAT WEIGHT 1,366 lb (619.5 kg)
warhead section 500 lb (226.8 kg)
DIMENSIONS
configuration thick cylinder with rounded nose, cruciform trapezoidal wings at midbody, cruciform in-line swept "cropped delta" control fins at tail; engine has nearly flush ventral air intake
length 14 ft 8 in (4.47 m)
diameter 13% in (343 mm)
PROPULSION Teledyne Continental 660-lb (299-kg) static thrust CAE-J402-CA400 turbojet sustainer burning JP-10 fuel
PERFORMANCE
speed Mach 0.85 (high subsonic)
range 60+ nm (69+ mi; 111+ km)
midcourse accuracy 52 ft (16 m)
WARHEAD DESTEX blast/fragmentation high explosive with preselected instantaneous or delay fuzing
DATA LINK AN/AWW-9, -13 Walleye datalink pods
SENSORS/FIRE CONTROL
on-board midcourse guidance unit
Rockwell Collins (R-2387/DSQ-51) Global Positioning System (GPS) receiver
IBM digital computer
Smith's or Northrop 3-axis attitude reference assembly
Honeywell AN/APN-194 short-pulse radar or Kollsman Frequency-Modulated Continuous Wave (FMCW) altimeter
terminal homing through AGM-65F Maverick Imaging Infrared (IIR) seeker (using -65G centroid-biased software developed to attack large targets) and Harris Corp. AGM-62 Walleye data link (RT-1608/DSQ-51)

Tomahawk (BGM-109)

The Tomahawk is a long-range cruise missile for both surface and submarine launch against both surface-ship and land targets. It was subsequently adapted for land launch as the US Gryphon Ground-Launch Cruise Missile (GLCM) as part of the US Intermediate-Range Nuclear Forces (INF) that were deployed in Western Europe.

Initially known as the Sea-Launched Cruise Missile (SLCM), the Tomahawk's principal roles are antiship (TASM), land attack with a conventional warhead (TLAM-C), and land attack with a nuclear warhead (TLAM-N). All versions operate at very low altitudes and have a radar cross section of approximately 10.76 ft^2 (1 m^2). The missile is sealed in its launch canister at the factory and can be treated as a "wooden round."

Both TLAM versions have an inertial guidance phase using a Litton P-1000 inertial platform and Litton LC-45/16/C computer, after which the missile's accuracy is updated using the McDonnell Douglas Electronics AN/DPW-23 Terrain-Contour Matching (TERCOM). TERCOM measures actual land contours with its on-board radar altimeter and compares them to stored digitized profiles. The profile's land area shrinks as the missile nears its target. TERCOM is also used to update the TERCOM-Aided Inertial Navigation System (TAINS).

While TLAM-N uses inertial and TERCOM guidance alone, TLAM-C uses a Loral Digital Scene-Mapping Area Correlator (DSMAC) as it nears the target for still greater accuracy. DSMAC correlates the optical view of the target area—obtained with a Fairchild Weston Schlumberger Charge-Coupled Device (CCD) sensor—with digitized target maps, refining the missile's terminal flight. For night flights, the DSMAC can flash a strobe light when needed.

Target map updating involves relatively simple DSMAC reprogramming. Either Tomahawk version can fly preprogrammed evasive flight paths between guidance updates; a "Flex-Targeting" upgrade, which permits retargeting during flight, has been tested.

The antiship Tomahawk is fitted with a modified Harpoon active radar seeker. The missile flies a preprogrammed profile at sea-skimming height for most of its flight. When the missile nears the target's estimated position, the active radar seeker takes over. The latest antiship variant is reported to have a reattack mode.

The missile's great versatility and adaptability are based largely on having been constrained to the size of the standard 21-inch (533-mm) submarine torpedo tube. Later US submarines have 12 vertical-launch tubes for Tomahawks. The submarine-launch canister is made of stainless steel.

On board US Navy surface ships, the Tomahawk is launched from the four-missile Mk 143 Armored Box Launcher (ABL) or from the Mk 41 61-cell Vertical-Launch System (VLS). The ABL is deck-mounted and elevates hydraulically to 35° in 35 seconds to fire. As in the submarine-launched versions, a TRW Thrust Vector Control (TVC) system steers the missile during the first 15 seconds of flight.

The VLS combines weapons launcher and magazine and occupies the same below-decks volume as the 44-missile magazine of the older twin-rail missile launchers. In 1984, the Navy reported in congressional testimony that the nominal "load-outs" were 26 Tomahawks (6 TLAM-N) in the Bunker *Hill* (CG 52) and *Aegis* cruisers and 45 (two TLAM-N) in the Spruance-class destroyer VLS. Tomahawk load-outs for Operation Desert Storm were believed to be much higher in some ships.

DEVELOPMENT • The missile achieved initial operational capability in 1982 for TASM in surface ships, 1983 for TASM in submarines, 1984 for TLAM in surface ships, and 1987 for TLAM-N. On September 27, 1991, President Bush announced that all tactical nuclear weapons would be removed from US Navy surface ships and attack submarines. The order included all TLAM-Ns, which were placed in storage.

The 1,000th Tomahawk was delivered to the Navy by McDonnell Douglas on July 10, 1991. The missile is deployed on US Navy submarines, cruisers, and destroyers. Hughes became sole-source producer in 1994.

VARIANTS • BGM-109A/TLAM, BGM-109B/TASM, BGM-109C/TLAM Block IIA, BGM-109D/TLAM Block IIB, BGM-109E/TASM, BGM-109F/TLAM, BGM-109G/GLCM, Block III/TLAM, Block IV.

COMBAT EXPERIENCE • During Desert Storm, 264 BGM-109Cs (unitary warhead) and 27 BGM-109Ds (cluster bombs) were launched from the battleships *Missouri* and *Wisconsin*, several cruisers and destroyers, and at least two submarines, mostly in the early days of the war.

An analysis of Tomahawk results suggested that 85% of the 242 target aim points were hit. The United States suggested that two missiles may have been shot down.

Tomahawks attacked Iraqi targets twice more in 1993. The January attack directed 45 missiles against nuclear facilities (one hit a hotel instead). In June, 20 of 23 launched hit the Iraqi intelligence headquarters; three others landed in a residential area.

SPECIFICATIONS •

MANUFACTURER

'Hughes (prime)

McDonnell Douglas Missiles (secondary)

WEIGHTS

VLS, loaded: approx 255.7 short tons (232 metric tons)

VLS, empty: approx 129 short tons (117 metric tons)

ABL: 55,000 lb (24,948 kg)

missile 2,650 lb (1,202 kg)

booster 550 lb (249 kg)

capsule 1,000 lb (454 kg) for submarine launch

warhead 1,000 lb (454 kg) TASM

DIMENSIONS

configuration torpedo-shaped fuselage with ventral pop-out turbofan intake, pop-out wings and tail surfaces

length missile: 18 ft 2 in (5.54 m)
booster: 2 ft (0.61 m)

diameter 21 in (533 mm)

wingspan 8 ft 8 in (2.64 m)

PROPULSION

Atlantic Research 6,000-lb (2,722-kg) static thrust solid-fuel booster that burns for 12 sec

Williams Research F107-WR-400 600-lb (272-kg) static thrust turbofan sustainer

PERFORMANCE

speed 331-496 kts (381-571 mph; 613-919 km/h) or Mach 0.50-0.75

cruise altitude 50-100 ft (15-30 m)

max range BGM-109B: more than 250 nm (288 mi; 464 km)
BGM-109C/D: approx '700 nm (806 mi; 1,297 km)
BGM-109A: approx 1,350 nm (1,555 mi; 2,500 km)

WARHEAD conventional high-explosive in TASM; nuclear 5-150-kiloton W80 in TLAM-N

ACCURACY

Circular Error Probable (CEP)

TERCOM: less than 100 ft (30.5 m)

TERCOM + DSMAC: approx 33 ft (10.0 m)

GUIDANCE

Ships with Mk 143 ABL have AN/SWG-2 weapons control system

Ships with Mk 41 VLS have AN/SWG-3 weapons control system

Submarines have Mk 117 fire control system

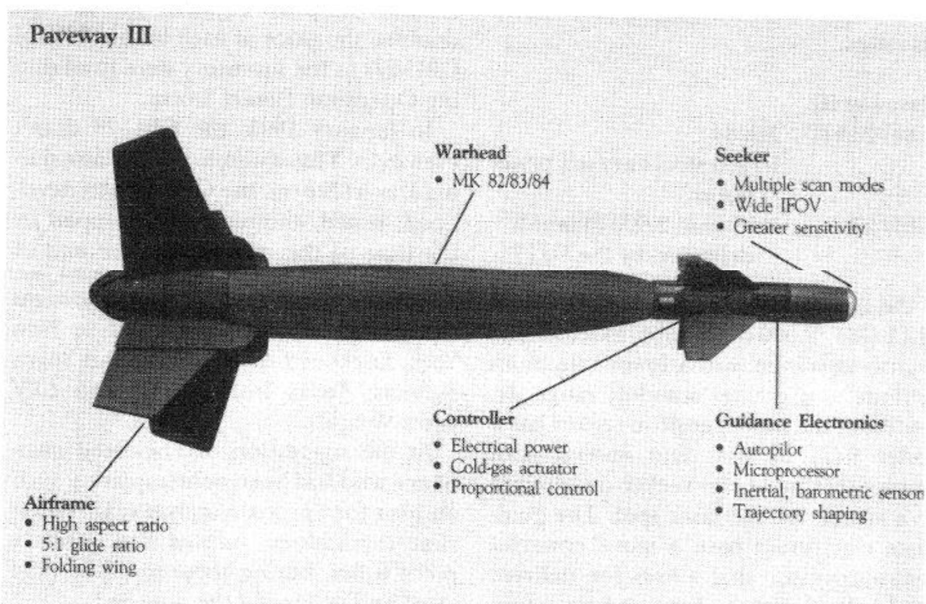
TASM: inertial; terminal is active radar homing (similar to Harpoon)
TALM-C: inertial; terminal is Terrain Contour Matching (TERCOM) with Digital Scene-Mapping Area Correlator (DSMAC); Block IIA has a preselectable pop-up terminal maneuver
TLAM-N: inertial and TERCOM

Paveway Bomb Series (GBU-)

The Paveway II and III unpowered Precision-Guided Munitions (PGM) are based on the Mk 80 series low-drag general-purpose unguided bombs originally developed in the 1950s. The Mk 82 500-lb (227-kg) is the smallest of the three, followed by the 1,000-lb (454kg) Mk 83 and the 2,000-lb (907-kg) Mk 84. This bomb series also formed the basis for the Destructor air-dropped bottom sea mines used extensively during the Vietnam War.

The first of the Paveway series of Laser-Guided Bombs (LGB) were originally given KMU designations but were later redesignated GBU. Paveways increased the standoff distance for attacking aircraft while improving bombing accuracy, which was unacceptably low. Using a spot seeker tuned to the 1.064-micron wavelength of the widely deployed Neodymium: Yttrium-Aluminum-Garnet (Nd:YAG) laser, Paveways entered service in Vietnam in the late 1960s. (25,000 Paveways were dropped for 18,000 targets claimed destroyed.)

In fundamental configuration and operation, these bombs have changed little since Vietnam. Each Paveway has several elements; from nose to tail they are: detector assembly, computer section, control section, the bomb itself, and the pop-out wing assembly. All are designated GBU-, the designation changing depending on bomb size and Paveway generation:



Paveway III
TEXAS INSTRUMENTS

Paveway II

GBU-10E/B	Mk 84
GBU-12E/B	Mk 82
GBU-16C/B	Mk 83

(British l,OOO-lb Mk 13/18 bombs are similar to the GBU-16.)

Paveway II detector assemblies have a small seeker that swivels on a universal joint and has an annular ring that aligns it in the slipstream; it does not scan independently. The optical silicon detector staring array behaves analogously to a monopulse semiactive radar-homing seeker. The array is subdivided into four parts that receive reflected laser energy. A computer analyzes the relative reflection strengths and sends steering commands to the Airfoil Control Group system to the control fins. The fins operate on a full-on, full-off ("bang-bang") gas-operated system, adjusting the bomb's flight path until the reflections are equal in all four quadrants, thus refining its descent on the target. The pop-out rear wings stabilize the bomb and extend its range.

Paveway III

GBU-24A/B	Mk 84	
	I-2000 steel-encased penetrator	
GBU-27	steel-case 2,000-lb bomb delivered by the F-l 17	

Paveway III GBU-24 Low-Level LGB (LLLGB) 2,000-lb bombs expand the launch envelope with a lower minimum altitude and greater standoff range.' In addition, the more sensitive seeker has a wider field of view and several scan modes that move the seeker on gimbals in a search for the laser spot. The guidance electronics have a more powerful microprocessor that allows for delivery mode (level, loft, or dive) and trajectory shaping (to achieve the best terminal angle).

The midcourse autopilot is gyro-referenced (to establish its position relative to "up" and "level") and uses barometric sensors to determine the rate of descent. Texas Instruments claims that in the dive mode, the pilot only has to "place the target in the windscreen and " 'pickle.' " The control system introduced proportional control with infinite fin-angle positioning in place of the bang-bang method. At the tail, much larger wings confer a glide ratio of 5:l on the bomb.

GBU-24A/B Penetrators are the LLLGB with the BLU-109/B I-2000 warhead that has a hardened case and delayed fuze to greatly increase effectiveness against concrete bunkers and hardened aircraft shelters. In tests, the I-2000 penetrated up to 3 in (76 mm) of steel plates and 6 ft (1.83 m) of concrete.

GBU-27/B is a 2,000-lb penetrator with smaller wings and radar-absorbing materials delivered by the F-1 17A, and guided by a specially modified Paveway III guidance kit that ensured its accuracy. According to press reports, the kit has doubled the price of each bomb. 60% of GBU-27s in the inventory were used during Operation Desert Storm.

In January 1991, the GBU-28 didn't even exist. This is significant because during Desert Storm, the GBU-28 was developed, tested, shipped, and dropped by the time of the cease-fire at the end of February. The remarkable 17-day ad hoc effort combined the Air Force Systems Command, Watervliet Arsenal in New York, Lockheed Aeronautical and Space Systems, Texas Instruments, and LTV (now Vought).

At the suggestion of Lockheed engineers, who had been contemplating such an idea for approximately a year, Watervliet remachined surplus 8-in artillery piece tubes, boring them to 10 in (254 mm) and reshaping the outside.

As the casing took shape, Texas Instruments modified its GBU-27 Paveway III laser-guided-bomb guidance kit to account for the altered ballistics of the more cylindrical shape and greater weight of 4,700 lb (2,132 kg). Tests showed that the bomb could penetrate 100 ft (30.5 m) of earth or more than 22 ft (6.71 m) of concrete. (In the concrete test, the sled-driven bomb crashed through the 22-ft-thick slab and continued for another half mile before stopping.)

The bombs were then rushed to Eglin AFB, Florida, to be filled with 650 lb (295 kg) of explosive, a process so compressed that the bombs hadn't completely cooled before they were flown to Saudi Arabia. A total of 30 GBU-28s were made.

DEVELOPMENT • Initial operational capability for Paveway I was in the late 1960s. Paveway II went into production in 1977; Paveway III entered service in 1987.

In FY1988, the unit cost of a 2,000-lb hard target bomb was $12,686; in FYI992 the cost had dropped to $11,608. As of 1991, a standard "dumb" bomb cost roughly $2 per pound. A Paveway II costs between $10,000 and $15,000 depending on the length of the production run. Paveway 111s cost approximately $40,000-$50,000.

VARIANTS • In addition to the variants listed above, three other members of the Paveway III family were proposed but not produced: GBU-21 (2,000-lb weapon), GBU-22 (500-lb, began development but not produced), GBU-23 (l,OOO-lb USN development variant).

COMBAT EXPERIENCE • During Desert Storm, 7,400 tons of precision-guided munitions were dropped on Iraqi targets. Most of the unpowered weapons were Paveways. In the official conduct of the Persian Gulf War report issued in April 1992, the totals were given as:

- more than 2,500 GBU-10
- more than 4,500 GBU-12
- more than 200 GBU-16 (virtually all by USN aircraft)
- almost 2,000 GBU-24/-27; 1,600 were penetrators

The US Air Force described how F-1 11s using GBU-12s destroyed 150 armored vehicles per night. Most of the large LGBs were GBU-10s although hardened targets were reserved for the GBU-24 with the I-2000 warhead, the GBU-27, which was delivered solely by the F-l 17 Stealth fighter, and GBU-28. 60% of GBU-27s in the inventory were used.

Two GBU-28s were dropped by two F-1 11F Aardvarks on a command and control bunker in Baghdad only days before the cease-fire. One missed its mark (because of faulty laser spotting); the other penetrated, destroying the bunker and reportedly killing several Iraqi military leaders.

The US Navy reported delivering 202 GBU-1 Os, 216 GBU-12s and 205 GBU-16s. An additional 611 LGB kits were fitted to other bombs. The British Royal Air Force reported dropping 1,000 LGBs.

SPECIFICATIONS •

DIMENSIONS

length GBU-10: 14 ft 2 in (4.31 m)
GBU-12: 10 ft 11 in (3.33 m)
GBU-28: 18 ft 9 in (8.42 m)

bomb diameter
GBU-10: 1 ft 6 in (457 mm)
GBLJ-12: 10 3/4 in (273 mm)
GBU-28: 1 ft 4 1/2 in (368 mm)

control fin span
GBU-10: 2 ft 7 1/4 in (794 mm)
GBU-12: 1 ft 5 2/3 in (448 mm)

wingspan GBU-10: 5 ft 5 in (1.67 m)
GBU-12: 4ft 4in (1.32m)

AIRBORNE TARGETING PODS

AN/AAS-33 TRAM	A-6E Intruder
AN/AAS-37 IR detection set	OV-1 OD Bronco
AN/AAS-38 laser designating	F/A-18 Hornet
AN/ASQ-153 Pave Spike	British Buccaneers
AN,'AVQ-14 LANTIRN	F-15E Eagle F-16A/C Fighting Falcon
AN/AVQ-26 Pave Tack	F-l 11 Aardvark
Mast-Mounted Sight	OH-58D Kiowa Warrior
TADS/PNVS	AH-64 Apache
ATLIS	French Jaguars
TIALD	British Tornados

GROUND-BASED DESIGNATORS

AN/PAQ-1 handheld laser target designator
AN/PAQ-3 Modular Universal Laser Equipment (MULE)
AN/TVQ-2 Ground/Vehicular Laser Locator Designator (G/VLLD)

Other aircraft such as the AV-8B Harrier, the A-10 Warthog, and the British Jaguar that did not have-laser designators used their laser spot seekers to deliver LGBs against remotely marked targets.

GBU-15

The GBU-15 precision-guided modular glide bomb is based on the original Pave Strike GBU-8, which was used to great effect in the latter part of the Vietnam War. The weapon comprises a television (TV) or Imaging Infrared (IIR) seeker, warhead adapter section, warhead, fuze adapter, short-chord wings, and data link. Warheads for the GBU-15 are the Mk 84, a submunitions dispenser (SUU-54), or the more powerful BLU-109 (I-2000) unitary warhead. Midcourse corrections are passed through a jam-resistant AN/AXQ-14 data link.

Targeting options can be Lock-On Before Launch (LOBL) or After Launch (LOAL), which provides for automatic tracking, or through joystick control by the weapons system operator on board the launch aircraft. GBU-15s have either a TV (GBU-15(V)1/B) or IIR (GBU-15(V)2/B) seeker; the IIR seeker has 90% commonality with the AGM-65D Maverick IIR air-to-surface missile.

DEVELOPMENT • The initial operational capability for the GBU-15 (TV) was in 1983 and for the GBU-15 (IIR), 1987. In April 1989, the General Accounting Office criticized Rockwell for overstating prices on 13 material items by almost $5.6 million under a $114 million contract awarded in January 1984. Rockwell denied the criticism, arguing that although it had inadvertently failed to disclose some data, the contracting officer had not relied on Rockwell's information, an allegation denied by the contracting officer.

VARIANTS • GBU-15-I (with BLU-109 I-2000 penetrator warhead), AGM-130.

COMBAT EXPERIENCE • GBU-15s were delivered to F-15Es and F-11 1s during Operation Desert Storm, primarily to use against targets that were likely to be heavily defended or offering good contrasts to permit effective lock-on by the TV or IIR seekers. A typical GBU-15 payload was two weapons and a data link pod. A typical strike was flown at night using the IIR seeker, with a launch altitude between 10,000 and 23,000 ft (3,048-7,010 m).

To counter low visibility caused by bad weather, GBU-15s were dropped above the clouds but only locked onto their targets after they glided below the cloud deck.

The GBU-15s were effective against bridges, chemical plants, building complexes, command facilities, mine entrances, and bunkers and were also used to destroy the opened oil valves that were letting oil flow into the Persian Gulf. In the oil-manifold closure mission, one aircraft launched the missile, but a second one controlled it until impact.

SPECIFICATIONS •

MANUFACTURER Rockwell International

MISSILE WEIGHT **2,617** lb (1,187 kg)

warhead **2,000** lb (907 kg)

DIMENSIONS

configuration thick cylinder, small cruciform foreplanes, large rectangular mainplanes at the tail

length 12 ft 10% in (3.92 m)

diameter 1 ft 6 in (460 mm)

wingspan 4ft 11 in (1.5 m)

PROPULSION GBU-15 is unpowered

PERFORMANCE

max range **4.3-22.6** nm (5-24.9 mi; 8-40km), depending on launch altitude

WARHEAD Mk-84 conventional high explosive or SUU-54 explosive submunitions

SENSORS/FIRE CONTROL guidance: manual command through Hughes AN/AQX-14 P-way data link or automatic TV or IIR guidance through pre- or postlaunch lock-on

NAVAL MINES AND TORPEDOES

NAVAL MINES

The US Navy lays mines principally from aircraft and submarines. There are no surface minelaying ships in the fleet, and very few ships are fitted for minelaying. Attempts to replace the mines described below have met with little success. Several programs begun in the 1980s and early 1990s, the most promising a joint effort with Great Britain, were canceled when funding fell short and mines sank to their usual low priority. Remote Control (RECO) by acoustic signal has been developed for Captor and Quickstrike mines.

Mk 52

The Mk 52 is a modified 1,000-lb (454kg) aircraft bomb deployed as an aircraft-laid bottom mine. Mods vary principally in their firing mechanism; in fact, most combinations of pressure, acoustic, and magnetic triggers were deployed: Mod 0 pressure, Mod 1 acoustic, Mod 2 magnetic, Mod 3 pressure-acoustic, Mod 4 pressure-magnetic, Mod 5 magnetic-acoustic, Mod 6 pressure-acoustic-magnetic, and Mod 11 seismic-magnetic.

It was rated as capable of detecting a submarine moving at three knots. Arming delays ran from one hour to 90 days and the mine could count up to 30 ships before detonating. It could also turn itself off between ship passages and self-sterilize at the end of its useful life.

DEVELOPMENT • The US Long-Range Mine Program began in 1948, with production of the Mk 52 getting under way in 1954 and testing starting in 1956. The weapon didn't achieve initial operational capability, however, until 1961. German production followed. Some may still be in service, although it is known that Mods 1 and 4 have been withdrawn.

COMBAT EXPERIENCE • Mk 52s were laid by US aircraft in North Vietnamese waterways as part of the late-1972 "Christmas offensive" mounted to persuade the government to return to end-of-war negotiations.

SPECIFICATIONS •

WEIGHT 1,130 (Mod 1) to 1,235 lb (Mod 6) (513-561 kg)
warhead 595 lb (270 kg) of conventional HBX-1

DIMENSIONS
length 5 ft 1 in (1.55 m)
diameter 19 in (477 mm), 2 ft 9 in (0.84 m) over fins

MAX DEPTH 150 ft (45.7 m) (Mods 1, 3, 5, 6); 600 ft (183 m) (Mod 2)

SENSORS AND DETONATORS
Mod 1 acoustic
Mod 2 magnetic
Mod 3 pressure-magnetic
Mod 5 acoustic-magnetic
Mod 6 acoustic-magnetic/pressure
Mod 7 dual-channel magnetic
Mod 11 magnetic-seismic

Mk 55

The Mk 55 is the 2,000-lb bomb analogue to the Mk 52 and functionally resembles it. Many of the components were interchangeable.

DEVELOPMENT • Initial operational capability was in 1961. Probably still in service.

SPECIFICATIONS •
WEIGHT 2,039-2,128 lb (925-965 kg)
warhead 1,269 lb (576 kg) of HBX-1
DIMENSIONS
length ***6*** ft ***7*** in (2.09 m)
diameter ***23.4*** in (594 mm)
MAX DEPTH ***150*** ft (45.7 m) (Mods 3, 5, ***6), 600*** ft (183 m) (Mods 2, 7)
SENSORS AND DETONATORS
Mod 1 acoustic influence
Mod 2 magnetic influence
Mod 3 pressure-magnetic
Mod 5 acoustic-magnetic
Mod 6 acoustic-magnetic/pressure
Mod 7 dual-channel magnetic
Mod 11 magnetic-seismic

Mk 56/Mk 57

The Mk 56 is an aircraft-laid, moored US mine which was specifically designed for use against high-speed, deep-operating submarines. The Mk 56 has a nonmagnetic, stainless-steel case and is fitted with a magnetic firing mechanism. The Mk 57, launched by submarines, has a fiberglass casing.

DEVELOPMENT • Mk 57 achieved initial operational capability in 1964, the Mk 56 following in 1966.

SPECIFICATIONS •
WEIGHT ***2,135*** lb (968 kg); Mk 57 2,059 lb (934 kg)
warhead ***357*** lb (162 kg) of HBX-3; Mk 57 340 lb (154 kg)
DIMENSIONS
length Mk 56: 9 ft 5 in (2.87 m)
Mk 57: 10 ft 8 in (3.25 m)
diameter Mk 56: 23.4 in (594 mm) body
Mk 57: 21 in (533 mm)
MAX DEPTH ***1,200*** ft ***(366*** m) , also adjustable from 30-480 ft
SENSORS AND DETONATOR magnetic dual-channel using total field magnetometer as detector

Mk 60 Captor (encapsulated torpedo)

The Mk 60 Captor is the US Navy's principal antisubmarine mine. Each Captor mine consists of a container that contains a threat analyzer and acoustic signature library, a Mk 46 Mod 4 Antisubmarine Warfare (ASW) torpedo, and an anchor. Captors are laid in a barrier pattern in deep water by aircraft or submarines; preferred drop points are straits and other "chokepoints."

As the container descends, it pays out the anchor, which drops to the seafloor. The container finds its preset surveillance depth and "floats" vertically at the upper end of its tether. Using a passive acoustic sensor, the Captor detects moving submarines while ignoring surface ships.

When the mine has established the submarine target's bearing, Captor begins active tracking using Reliable Acoustic Path (RAP) sound propagation. As the target comes within range of the torpedo's seeker, the container fills with water. The flooding is controlled in a way that tilts the canister to an angle 30" from the vertical. The torpedo is released, finds its own search depth, and searches with its passive acoustic homing seeker.

Despite its ability to be remotely activated and its "fire and forget" search and attack system, the Captor's punch is relatively light. This lack of explosive power concerned many in the US Navy during the days of Soviet submarine growth. A Captor would probably succeed in disabling or destroying most likely submarine targets, however.

DEVELOPMENT • Development of the Captor concept began in 1961; production started in March 1976 after several years of trials. The weapon achieved initial operational capability in 1979.

Produced by Goodyear Aerospace (now a division of Loral, Inc.), Akron, Ohio. Last authorization came in FY1986 at a unit cost of $377,000. Budget constraints cut Captor procurement in FY1985-87 from a planned 1,568 to 450. Total procurement fell short of the 4,109 originally stated as a requirement.

A modification program was planned but has not been funded.

SPECIFICATIONS •
WEIGHT 2,321 lb (1,053 kg)
warhead 98 lb (44 kg) high explosive
DIMENSIONS
length 12 ft 1 in (3.68 m)
diameter 21 in (533 mm) mine, 12.4 in (324 mm) Mk 46 torpedo
MAX DEPTH 3,000 ft (914 m)
MAX DETECTION RANGE 3,281 ft (1,000 m)
SENSORS AND DETONATOR passive acoustic monitoring switching to active once target is identified as submarine; monitoring is not continuous but turns on and off according to programmed schedule

Mk 62 Quickstrike

Quickstrike aircraft-laid bottom mines were converted from Mk 80 series bombs. They succeeded the Destructor series of conversions that were used to mine North Vietnamese harbors and rivers.

A Quickstrike conversion includes installation of a modular arming kit containing an arming device, fitting an explosive booster, and Mk 57 magnetic-seismic or Mk 58 magnetic-seismic-pressure Target Detection Devices (TDD). (Mk 70 and Mk 71 TDDs replaced Mk 57/Mk 58s in production in the mid-1980s.)

The Mk 62 is a modified Mk 82 500-lb (227-kg) bomb.

DEVELOPMENT • Began in the mid-1970s to replace the Mk 36 Destructor, achieving initial operational capability in 1980. Plans called for production of almost 40,000 TDDs, but only a small fraction was actually funded.

SPECIFICATIONS •
WEIGHT
fixed conical *tail* 531 lb (241 kg)
low-drag tail 570 lb (259 kg)
warhead 192 lb (87 kg) of H-6 explosive
DIMENSIONS
length 7 ft 5 in (2.25 m)
diameter 10.8 in (274 mm)
MAX DEPTH 300 ft (91.4 m)
SENSORS AND DETONATOR Target Detection Device TDD Mk 57/58 or TDD Mk 70/Mk 71, magnetic-seismic or magnetic-seismic-pressure firing mechanism

Mk 63 Quickstrike

Successor to Mk 40 Destructor series conversion of 1,000-lb (454kg) bomb. Few of these seem to have been procured.

SPECIFICATIONS •
WEIGHT
fixed conical tail 985 lb (447 kg)
low-drag *tail* 1,105 lb (501 kg)
warhead 450 lb (204 kg) of H-6 explosive
DIMENSIONS
length 9 ft 5 in (2.86 m)
diameter 14 in (356 mm)

Mk 64 Quickstrike

Successor to the Mk 41 Destructor, a modified Mk 84 2,000-lb (907-kg) bomb.

SPECIFICATIONS •
WEIGHT 2,000 lb (907 kg)
DIMENSIONS
length 12 ft 8 in (3.83 m)
diameter 18 in (457 mm)

Mk 65 Quickstrike

Although considered part of the Quickstrike series of bomb-to-mine conversions, the Mk 65 aircraft-laid bottom mine is substantially different from the Mk 84 2,000-lb (907-kg) bomb that is the basis of the Mk 64 and 65. The Mk 65 has a thin-walled mine-type case and several modifications to the arming mechanism, nose, and tail.

DEVELOPMENT • Production contract awarded to Aerojet Tech Systems, Sacramento, California, in April 1982. Achieved initial operational capability in 1983. 4,479 were produced under FY1983-86, FY1988-89 funding, very close to the 4,500 originally planned.

SPECIFICATIONS •
WEIGHT 2,390 lb (1,083 kg) including warhead with HBX explosive
DIMENSIONS
length 9 ft 2 in (2.8 m)
diameter body 20.9 in (530 mm), across fins 29 in (734 mm)
MAX DEPTH 300 ft (91.4 m)
SENSORS AND DETONATOR Target Detection Device TDD Mk 58/Mk 71 combination sensor, variable influence (magnetic-seismic-pressure)

Mk 67 SLMM

The Submarine-Launched Mobile Mine (SLMM) adapts a Mk 37 heavy torpedo to a self-propelled torpedolike mine that submarines can launch covertly into inaccessible waters. SLMM can also operate as a shallow-water bottom mine against surface ships.

The SLMM consists of a modified Mk 37 Mod 2 electrically powered torpedo with the wire guidance equipment removed and warhead replaced by a mine. The electronics are similar to those of the Quickstrike series. Honeywell Marine Systems proposed an Extended SLMM incorporating the NT-37E torpedo, but this was not developed.

DEVELOPMENT • Development began in 1977-78 with plans to produce 1,729 mines by the mid- to late 1980s. Delays in development and chronic funding problems pushed the service introduction date to 1992. By then only 889 had been produced under SLMM funding, although others may have been converted using torpedo refurbishment dollars. The prime contractor is Dewey Electronics of Oakland, New Jersey.

SPECIFICATIONS •
WEIGHT
overall 1,759 lb (798 kg)
warhead 529 lb (240 kg) of Mk 13 explosive
DIMENSIONS
length 13 ft 5 in (4.08 m)
diameter 21 in (533 mm)
MAX DEPTH approx 328 ft (100 m)
SENSORS AND DETONATOR Target Detection Device TDD Mk 71 combination sensor, variable influence (magnetic-seismic-pressure)

TORPEDOES

NT-37

The NT-37 medium-weight torpedo is an extensively reworked Mk 37 torpedo that is in service with several navies. It can be launched from surface ships or submarines. Alliant has offered several versions of the NT-37, including the digital NT-37E and the analog NT-37F.

The NT-37E proved to be too expensive for most prospective retrofit candidates. The costly strap-down guidance system provides more precision than the torpedo needs to get close enough for its terminal homing system. Therefore, Alliant claims that the NT-37F, which upgrades the analog system with gimballed gyros, achieves nearly the same performance and is more reliable than earlier Mk 37s while avoiding the expense of the digital system.

VARIANTS • NT-37C was developed in the early 1970s as an upgrade of the older Mk 37 torpedo. An Otto-fuel piston motor like that of the Mk 46 replaced the Mk 37's electric motor and battery. NT-37D used the NT-37C motor and replaced vacuum-tube acoustic technology with a solid-state acoustic processor system designed to improve antiship capability as well as doubling acoustic performance against submarine targets.

NT-37E replaces vacuum-tube analog guidance and control with strap-down solid-state digital equipment using Xylog processors and inertial navigation. Fitted with two-way communications link through the guidance wire. Improvements doubled the active detection range and nearly doubled the passive range. Reliability and logistical support also upgraded.

NT-37F was introduced in 1990 as a less expensive retrofit of Mk 37s. Original control system replaced by upgraded analog system controlled by computer having Intel 80186 processors; senses drift of less than one knot. After launch and immediately before turning on its homing sensor, the NT-37F takes background noise readings of itself and surrounding medium and can adjust seeker sensitivity accordingly.

The designation NT-37F is trademark-protected.

DEVELOPMENT • NT-37C/D kits developed and manufactured by Northrop Corp. from 1968 to 1980, achieving initial operational capability in 1974. The NT-37E/F developed by Honeywell Marine Systems (later Alliant Techsystems) in Everett, Washington. The NT-37E seeker was first tested in 1980, full kit tested in 1982-83.

Not in service in US ships but has replaced Mk 37 in several other navies. Canada, Norway, Peru, and Taiwan operated earlier NT-37 torpedoes; Israel (in 1986), Netherlands, and Taiwan also procured NT-37Es. Egypt (1991) was the first customer for the NT-37F.

SPECIFICATIONS •

WEIGHT wire-guided 1,653 lb (750 kg), free-running 1,415 lb (642 kg)
warhead 331 lb (150 kg)

DIMENSIONS
length wire-guided 14 ft 9 in (4.51 m), free-running 12 ft 7 in (3.85 m)
diameter 19 in (485 mm)

WARHEAD conventional high explosive

GUIDANCE solid-state acoustics designed to improve anti-surface-ship capability; solid-state, computer-driven guidance and control (NT-37E is strap-down digital, NT-37F is analog with gimballed gyros); three search patterns: straight run (antiship), straight run with acoustic reattack, snake and circle, active for ASW, passive for antiship

POWERPLANT 90-hp thermochemical rotary piston cam motor using liquid monopropellant (Otto) fuel

SPEED 2 speeds selectable, max range 9.7 nm (11.2 mi; 18 km)

Mk 46 lightweight torpedo

The Mk 46 is the most widely deployed 12.75-in (324mm) lightweight torpedo for use against submarines by helicopters, aircraft, and surface ships; it is also fitted in the Captor deep-water mine.

Development of the Mk 46 in the late 1950s as a successor to the Mk 44 addressed a design goal of a lightweight torpedo to counter nuclear-propelled submarines. Speed and range demands led to the substitution of a chemical-fuel motor in place of the Mk 44's battery-powered electric propulsion. The solid-fuel motor in the Mk 46 Mod 0 was not successful. The much more numerous Mod 1 (6,608 produced) is driven by a motor fueled by a liquid monopropellant.

A NEARTIP (Near-Term Improvement Program) and Mod 6 refit program began in the early 1980s to counter the loss in acquisition range due to introduction of anechoic hull coatings and to improve shallow-water capability. NEARTIP features an improved sonar transducer and a digital guidance and control system with correlation channel and second gyro; engine improvements included a slower search speed for greater range and lower self-generated noise.

Compared to the Mk 44, the Mk 46 is faster, dives deeper, and has approximately twice the range.

VARIANTS • Mk 46 Mod 2 (3,344 produced for Foreign Military Sales/FMS customers) had improved Electronic Counter-Countermeasures (ECCM) logic.

Mk 46 Mod 4 is used in the Captor mine, which is laid in geographic chokepoints and lies dormant until activated. Operating autonomously, the torpedo's seeker tracks ship noises and leaves the special capsule when a target is within range.

NEARTIP total of 4,922 kits was procured for the US Navy; refitted torpedoes were designated Mk 46 Mod 6. FMS production totaled 311.

Mk 46 Mod 5 are new-manufacture torpedoes with NEARTIP features that were first authorized for US Navy in the late 1970s as an interim measure (575 produced). As development of the Mk 50 Advanced Lightweight Torpedo (ALWT) hit delays, an additional 4,205 Mk 46 Mod 5 were authorized from FY1983 to FY1987. 1,278 were produced for FMS sales.

DEVELOPMENT • Aerojet Electra Systems Co. of Azusa, California, developed and produced both the Mod 0 and Mod 1. The Mk 46 achieved initial operational capability in 1966 for the Mod 0 and 1967 for the Mod 1. Honeywell Defense and Marine Systems of Everett, Washington (which became Alliant Techsystems, Inc., in September 1990), captured the later production contracts, completing the last Mod 1 in 1971 and the last of 23,000 Mk 46s in the mid-1990s. License production by Mitsubishi in Japan began in 1982.

Alliant also produced the Mk 46 Mod 2, Mod 5, and NEARTIP update kits. The last US Navy funding was authorized in FY1987, but FMS continued for almost another decade.

A list of aircraft and surface-ship classes that do ***not*** carry the Mk 46 would be far shorter than the list of those that do.

SPECIFICATIONS •

WEIGHT 508 lb (230 kg)
warhead 95 lb (43 kg)

DIMENSIONS
length 8 ft 6 in (2.59 m)

diameter 12¾ in (324 mm)
WARHEAD conventional PBXN-103 high explosive
GUIDANCE active/passive acoustic homing; capable of repeated attacks using "snake-search" method
POWERPLANT 5-cylinder cam engine with Otto liquid monopropellant fuel; contra-rotating propellers
SPEED 45 kts; max range 5.9 nm (6.8 mi; 11 km); max depth classified (greater than 984 ft/300 m)

Mk 48 heavyweight torpedo

The Mk 48 is a heavy, wire-guided, long-range, antisubmarine and anti-surface-ship torpedo that succeeded the Mk 37. The Mk 48 is generally considered the most advanced torpedo in Western naval inventories. Still, in the late 1970s advances in Soviet submarine capabilities reduced its margin, leading the Navy to begin the Advanced Capability (ADCAP) program led by Hughes.

The Mk 48 is divided into five component groups. The nose group contains the sonar and homing equipment; next are the warhead, control (with gyro, command, and power units), and fuel tank groups. The fuel tank also holds the command wire dispenser. The afterbody/tail-cone group consists of the engine and steering surfaces. The all-digital Mk 48 Advanced Capability (ADCAP) is virtually a new torpedo, possessing much greater "intelligence," speed, and range.

Following launch, the submarine performs a wire-clearance maneuver and the torpedo heads to a preselected "enable point." At the enable point, the acoustic search program guides the torpedo in a programmed search for the target. Once the target is acquired by the torpedo's sonar, the Mk 48 maneuvers to lock-on and accelerates to intercept.

The ADCAP effort suffered cost growth and delays during the first few years due in part to Hughes' inexperience in developing torpedo sensors as well as a continuing, and increasingly pessimistic, reassessment of the Soviet nuclear submarine threat. Each reassessment resulted in demands for more of every parameter.

For example, the Mk 48 Mod 4 interim ADCAP variant entered production at an accelerated rate in 1978 to take advantage of improvements in performance, active and passive acoustic search range, anti-surface-ship capability, and ease of operation studied. The later "Near-Term" Mod 5 ADCAP upgrades existing torpedoes to Mod 4 with a Hughes Aircraft electronically steered, higher-powered active sonar and a larger fuel supply.

Meanwhile, the "Full-Up" ADCAP continued development, spurred by continuing improvements in Soviet submarines. Further expansion of the operating envelope, higher fuel delivery rates and greater fuel capacity, further improvements in acoustics and electronics, thicker shell, speed increased to more than sixty knots were the result. The Hughes Guidance and Control subsystem has two computers, signal processor, digital-based, electronically steered active sonar, and Inertial Measurement Unit (IMU). It is capable of acoustic homing on fast-moving targets in shallow water and strong thermal gradients. Unfortunately, program delays continued as the Navy and Hughes played catch-up while tests to existing versions hit their inevitable snags.

US Navy apprehensions about the growing quality of Soviet submarines persisted right up to the moment of the Soviet Union's collapse. Almost overnight, that collapse alleviated the urgency of ADCAP development, and production withered.

VARIANTS • Mk 48 Mod 1 was the product of Gould (formerly Clevite Corp. and later Westinghouse) and Naval Surface Warfare Center at White Oak, Maryland, which began work on this variant in 1967. Propelled by a piston (swashplate) engine with a different acoustic homing system from the Mod 2. Mod 1 entered production in 1972.

Mk 48 Mod 3 was provided with TELECOM (Telecommunications) two-way communications link that transmits 14 torpedo parameters once per second through the wire guidance path Major production variant.

Closed-Cycle Advanced Capability Propulsion System (CCACPS) was a Product Improvement to the ADCAP torpedo with a propulsion system based on the Mk 50's Stored Chemical Energy Propulsion System (SCEPS). Full-Scale Development (FSD) was planned to start in March 1989 but was delayed several times and eventually canceled.

DEVELOPMENT • Development began in the early 1960s. The Ex-10 RETORC (Research Torpedo Configuration) turbine-propelled torpedo was the joint experimental project of Pennsylvania State University Applied Research Laboratory and Westinghouse Electric that began in the early 1960s. This led to the Mk 48 Mod 0/2 turbine-propelled variants; the Mod 2 lost in competition with Clevite's Mk 48 Mod 1, with the latter achieving initial operational capability in 1972. Production versions built by Westinghouse (formerly Gould, Inc.) Naval Systems Division in Cleveland, Ohio, and Hughes Aircraft Company in Forest, Mississippi.

Plans for 320 ADCAP torpedoes per year fell afoul of program problems as well as the diminution of the Soviet submarine threat. Until FY1992, production featured firm-fixed-price competition between Westinghouse and Hughes Aircraft Co.'s Undersea Weapons Division in Buena Park, California.

Beginning in FY1992, the production rate was reduced to minimum sustainable level for just one manufacturer. Hughes emerged the victor of a "winner take all" competition to produce 324 torpedos over a five-year period.

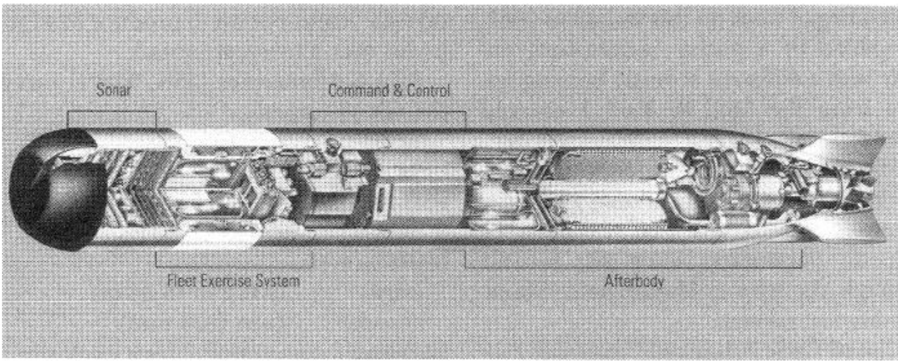
All US submarines (SSN/SSBN) carry the Mk 48 torpedo.

SPECIFICATIONS •
WEIGHT *3,450* lb (1,565 kg)
warhead *650* lb (295 kg)
DIMENSIONS
length 19 ft 2 in (5.84 m)
diameter 21 in (533 mm)
WARHEAD conventional high explosive (PBXN-3)
GUIDANCE can be launched as free-running or wire-guided free-running; active or passive acoustic search and terminal homing
POWERPLANT 500-hp axial-flow, gas-piston (swashplate) pump-jet using Otto II monopropellant (nitrogen ester and Hydroxylamine Perchlorate/HAP oxidant) liquid fuel
SPEED 55 kts max; max range at 55 kts, 20 nm (23 mi; 37 km); range at 40 kts, 27 nm (31 mi; 50 km); max depth *2,500* ft (760 m)

Mk 50 lightweight torpedo

The Mk 50, formerly known as the Advanced Lightweight Torpedo (ALWT), is the successor to the Mk 46 for use by fixed-wing Antisubmarine Warfare (ASW) aircraft, helicopters, and surface ships. The Mk 50 is constrained by the need to stay within the Mk 46's weight and dimensions as well as having to fit within the length and width of the S-3A Viking's weapons bay. In addition, the Mk 50 will be carried in the Vertical Launch ASROC antisubmarine rocket launcher. (It was also to have been the conventional payload for the canceled Sea Lance ASW missile.)

Compared to the Mk 46, the Mk 50 is faster and will dive to a greater maximum depth. Its passive/active seeker can generate multiple, selectable transmit-and-receive beams and home on its target



Mk 50 Advanced Lightweight ASW Torpedo
ALLIANT TECH SYSTEMS

from twice as far away as the Mk 46. The AN/AYK-14 on-board, programmable, digital computer analyzes signal returns in real time and provides mission control, navigation, and target detection and tracking.

The larger warhead was designed by the Naval Surface Warfare Center. The propulsion system is a closed, Rankine-cycle engine that uses a lithium-sulfur hexaflouride reaction to generate steam. The Mk 50 also has better countermeasures resistance and lower radiated noise than the Mk 46.

An earlier version of the ALWT was known as the Barracuda; the current Mk 50 logo shows the fish, but the name is not often used and is not official.

The Mk 50's size and weight constraints worried many late-1980s Western analysts who regarded the improving Soviet nuclear submarine fleet with increasing trepidation. Despite the real improvements in speed and operating depths, the Mk 50's warhead seemed too small to threaten the double hulls of Soviet boats. Use of a directed-energy warhead similar to the shaped charge found in antitank missiles would enhance performance, and development was believed to be under way.

VARIANTS • Mk 51 was the McDonnell Douglas/Raytheon entry in the 1979 "swim-off" with Honeywell/Garrett. (Gould/Hughes, Westinghouse offered a third contestant, but theirs was not selected for the swim-off.) Powered by silver-oxide electric battery (General Electric) and fitted with Raytheon side-looking linear or flank arrays.

DEVELOPMENT • Development began in August 1975. Alliant Techsystems (formerly Honeywell Underseas Systems Division) in Hopkins, Minnesota, is prime contractor. Westinghouse in Baltimore, Maryland, was selected as second source in May 1987; Martin Marietta supplies the command-and-control system for Westinghouse team.

Alliant and Westinghouse both received initial production contracts, but funding slipped in later years.

The Mk 50 was to replace the Mk 46 in many Western navies, but its cost seems likely to limit foreign sales.

SPECIFICATIONS •
WEIGHT 800 lb (363 kg)
warhead approx 100 lb (45.4 kg)
DIMENSIONS
length 9 ft 6 in (2.9 m)
diameter 12¾ in (324 mm)
WARHEAD conventional warhead; a directed-energy (shaped-charge) warhead has been considered

GUIDANCE active and passive acoustic homing with multiple selectable transmit/receive beams; directed by AKY-14 programmable digital computer

POWERPLANT Garret Pneumatic Systerns Stored Chemical Energy Propulsion System (SCEPS) using a closed cycle steam turbine driving a pump jet

SPEED 50+ kts; max depth more than 1,968 ft (600 m)