

MK 48 Mod 6AT



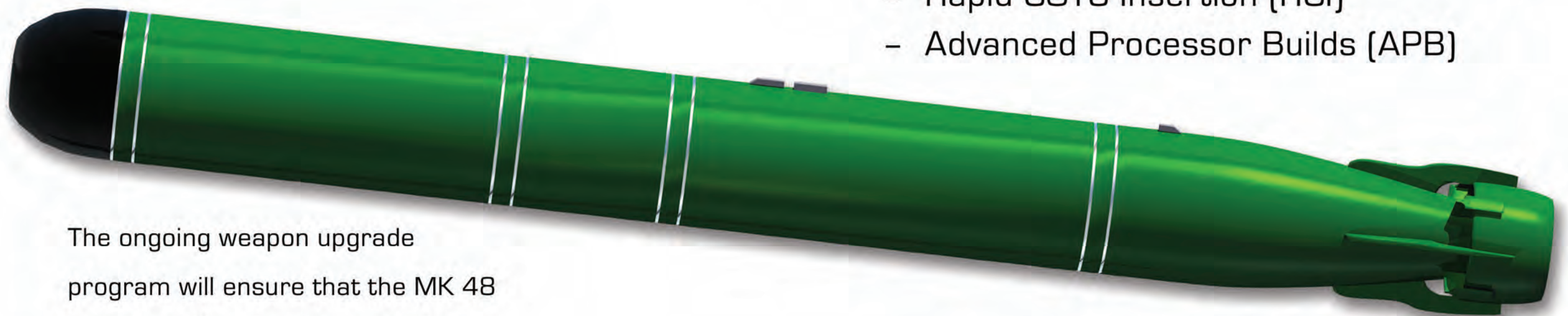
The MK 48 Mod 6AT (Advanced Technology) Torpedo is designed specifically to meet the emerging threat in the 21st century. By insertion of new technologies into the MK 48 Torpedo, via a continuous upgrade/modernization program, the U.S. Navy has produced a cost-effective, reliable, and easily supportable torpedo capable of exceptional performance in the littoral as well as blue water.

MK 48 Mod 6AT

- Operationally Effective
- Adaptable
- Cost Effective

World-class superiority maintained by ongoing:

- In-water testing and evaluation
- Performance upgrade and modernization programs
 - Rapid COTS Insertion (RCI)
 - Advanced Processor Builds (APB)



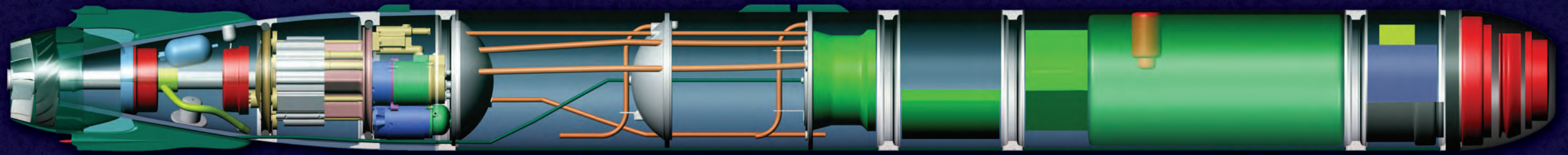
The ongoing weapon upgrade program will ensure that the MK 48 Torpedo will maintain superiority over all emerging threats.



MK 48

Mod 6AT

MK 48 Mod 6AT – Affordable and Effective



MK 48 Mod 6AT System Capabilities

- Low Doppler capability, programmable CCM
- Shallow water capability, bottom launchable
- Continuous improvements in hardware and software to grow additional capability
- Quiet
- Digital weapon programmable search and homing modes
- Wire guidance and salvo capability
- Supportable

Increased Weapon Effectiveness

Reduced Ownership Cost

ASW / ASUW Capable

Impulse or Swimout Launch Capable

Multiple and Selectable Warhead Fuzing Options

Continuous Software Block Upgrades

COTS Processors

Open Systems Architecture



- Hardware in-the-loop simulations: in excess of 20,000
- Digital simulations: in excess of 9,000,000

Weapon Analysis and Simulation Facility

8,600 In-Water Mod 5/6 Exercise Firings Conducted

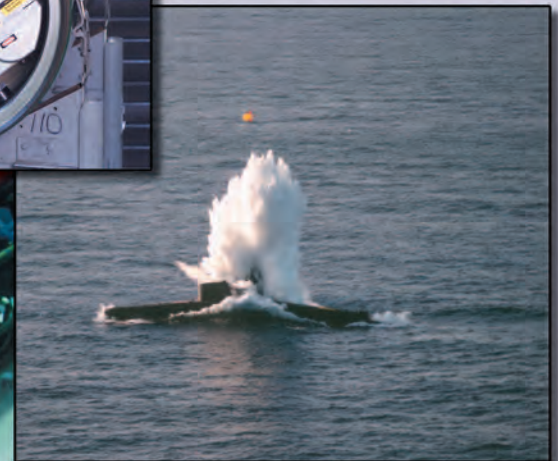
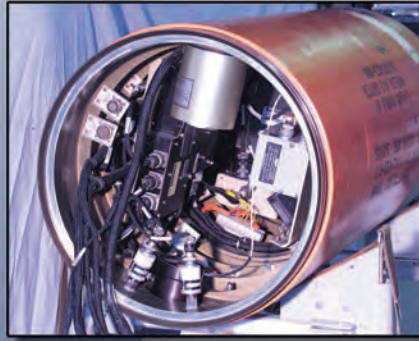


**Portable Torpedo Download System (TDS)
New Tactical Software
– ANYWHERE, ANY TIME –**



MK 48 Common Weapon Tester

Full-spectrum weapon systems support from development through operational deployment



ATE
automatic test equipment



THE U.S. NAVY TORPEDO TEAM . . .

MK 48 Mod 6 AT



NUWC Newport



NUWC Keyport



Raytheon



**For further information, contact the International
Business Manager at the Undersea Weapons
Program Office (PMS404)**

1333 Isaac Hull Avenue, Washington Navy Yard, Washington, DC 20376



MK 48 IN-SERVICE SUPPORT EQUIPMENT

The MK 48 In-Service Support Equipment (ISSE) encompasses all test and support equipment required for testing and turnaround of all MK 48 torpedo variants at the MK 48 Intermediate Maintenance Activity. The MK 48 ISSE is a mature equipment suite with a full complement of operational and maintenance manuals and drawings. Besides the MK 660 Mod 2 Automatic Test Equipment (ATE), the MK 48 ISSE hardware suite consists of the following test and support equipment:

MK 556 Mod 5 Cable Test Set (CTS)

Tests all MK 48 internal cable assemblies, as well as the external cables of test equipment used for torpedo comprehensive system testing on the ATE. The MK 556 CTS automatically tests cables for continuity, insulation resistance, and/or dielectric strength, as well as conducting high-speed analog/digital continuity tests.



MK 556 MOD 5 CTS

MK 23 Mod 1 Fleet Data Reduction System (FDRS)

Conducts data reduction and analysis on data extracted from MK 48 exercise section data recorders. The system produces instant hard-copy output of the weapon's critical data, as well as a data tape of weapon processor functions for postrun analysis and archive.



MK 23 FDRS



**MK 658
FDATS**

MK 658 Fuel Delivery Assembly Test Set (FDATS)

Tests the MK 48 Mods 5, 6 and 6AT fuel delivery assemblies and the MK 48 Mod 4 fuel pump. The system consists of a single cabinet containing the system controller, hydraulic pump, and fuel substitute reservoir.

MK 659 Steering Assembly Test Set (SATS)

Tests MK 48 steering assemblies. The system consists of a single cabinet containing the hydraulic adapter assembly and the system controller, which monitors feedback voltage to check the mechanical position of each control surface.



**MK 659
SATS**



**MK 562 Mod 3
CEHTS**

MK 562 Mod 3 Common Exercise Head Test Set (CEHTS)

Tests the MK 48 exercise sections and associated in-water run safety mechanisms. The system consists of two cabinets with an attached table for the system controller (personal computer). The system architecture maximizes the use of commercial-off-the-shelf hardware and open-system interfaces.

MK 525 Mod 3 Exploder Test Set (ETS)

Tests the functionality of MK 48 exploders. It consists of a suitcase controller with thermal printer and touch display.



**MK 5 HYDRAULIC
FILLING UNIT**

MK 5 Hydraulic Filling Unit

Drains, evacuates, backfills, and pressurizes the MK 48 afterbody/tailcone hydraulic systems. It is also used for performing vacuum leak tests on various afterbody/tailcone group components. The system consists of a single cabinet containing a vacuum pump, hydraulic fluid reservoir and tank, and control panel.

MK 6 Fuel Tank Filling Unit

Drains, flushes, vacuum tests, and refuels MK 48 fuel tanks. The system consists of a single cabinet containing a vacuum pump, fuel trap, and control panel.



**MK 6
FUEL TANK
FILLING UNIT**

MK 576 Igniter Test Set

Measures igniter squib resistance accurately. The test set is a portable unit mounted in a weatherproof case.



**MK 576
IGNITER TEST SET**



DEU

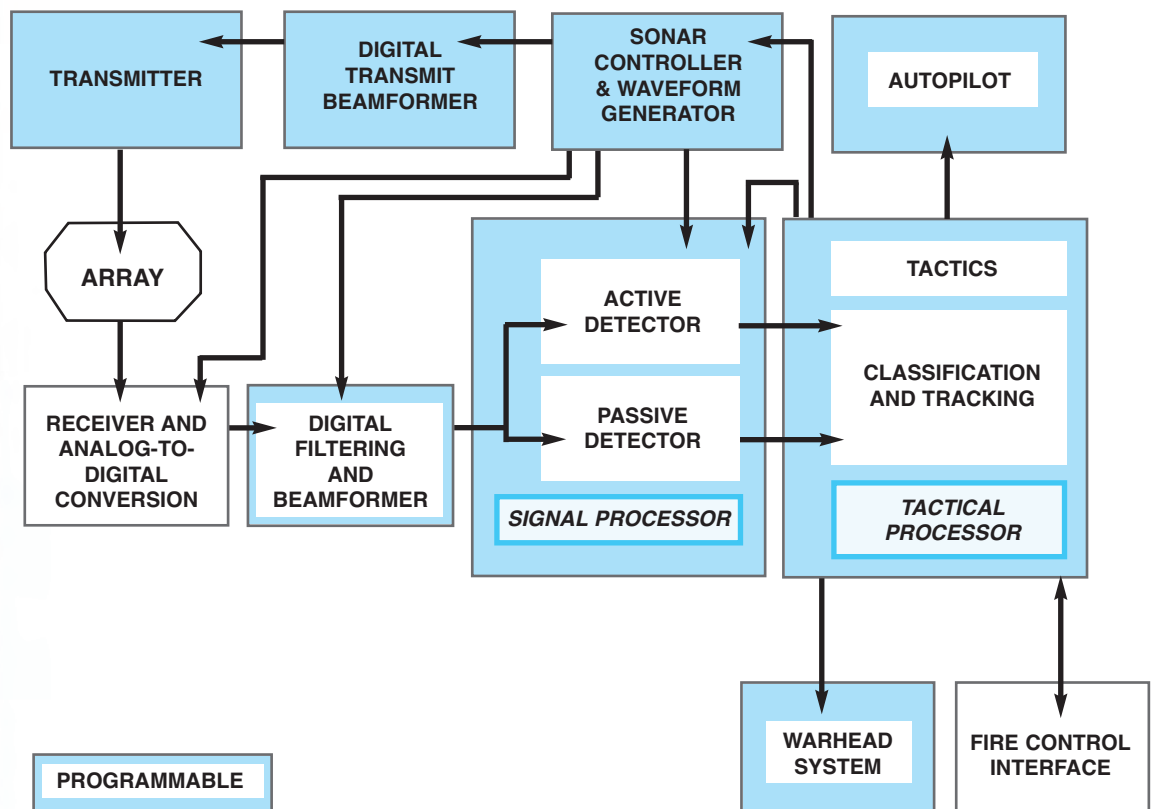
Data Extraction Unit (DEU)

Extracts in-water run data from all MK 48 exercise section data recorders. The system extracts the data and writes to removable media for subsequent data reduction and analysis using the MK 23 FDRS. The system consists of an equipment housing, that contains the system's personal computer controller, power supplies, and recorder interfaces mounted on a portable cart.

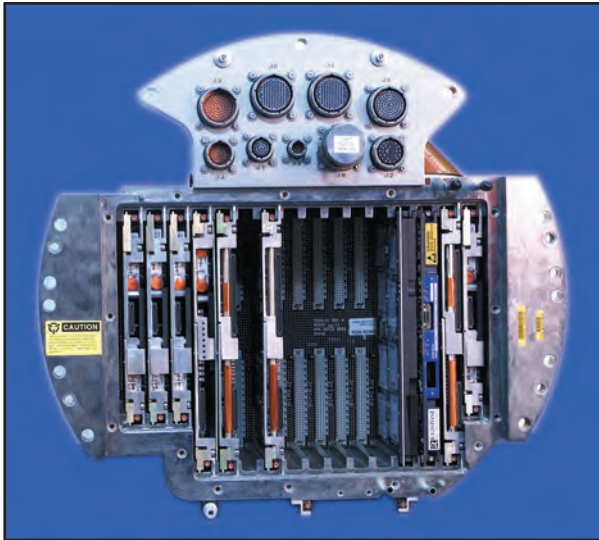


MK 48 Mod 6AT GUIDANCE & CONTROL

State-of-the-art open-systems architecture of the MK 48 Mod 6AT Guidance & Control (G&C) section has evolved from an original design using U.S. Navy standard processors (circuit card assemblies (CCAs)) to a full commercial-off-the-shelf (COTS) configuration. Two CCA boxes and two power supply assemblies have been merged into one card box assembly. The expandable open-systems architecture design uses an industry-standard data bus and communications. Spare expansion slots provide substantial signal processor upgrade possibilities. COTS signal and data processors provide significant reserve capacity.



- The MK 48 Mod 6AT G&C marries the capability provided by a low self-noise torpedo sonar array design with advanced sonar signal processing algorithms and weapon control tactics to provide exceptional torpedo operation and performance.



MK 48 Mod 6AT G&C CARD BOX

- The sonar signal processing functions provide target detection in adverse environments by using a combination of active and passive detection algorithms and passing each detection through multiple rejection algorithms to filter out nontargets.
- The weapon control processing functions track, map, classify, and calculate various target statistics, analyzed over multiple listening intervals to rank potential targets, edit out false targets, and pursue actual targets.
- The Autopilot Interface Controller function provides the primary control interface between the data processor and the propulsion section. It also provides the interfaces to the Inertial Measurement Unit, Depth Sensor, Warhead Electronics Subsystem, and Submarine Combat Control System.
- The Transmit Waveform Controller function provides a separate set of output signals for each of the transducer channels. It performs real-time generation of the acoustic pulse transmission structure including frequency changes, beam changes, and transmission envelope amplitude shading.
- Tactical software is downloaded into the torpedo by the automatic test equipment and is electronically erased at the end of run by the memory scuttle circuitry. The torpedo design allows for dockside/shipboard software upgrades using a portable Torpedo Download System.
- Torpedo tactical software was developed and evaluated using MIL-STD-498. NATO Standardization Agreement (STANAG) 4404 and MIL-STD-882 structured the safety architecture.



MK 48 Mod 4 CHARACTERISTICS

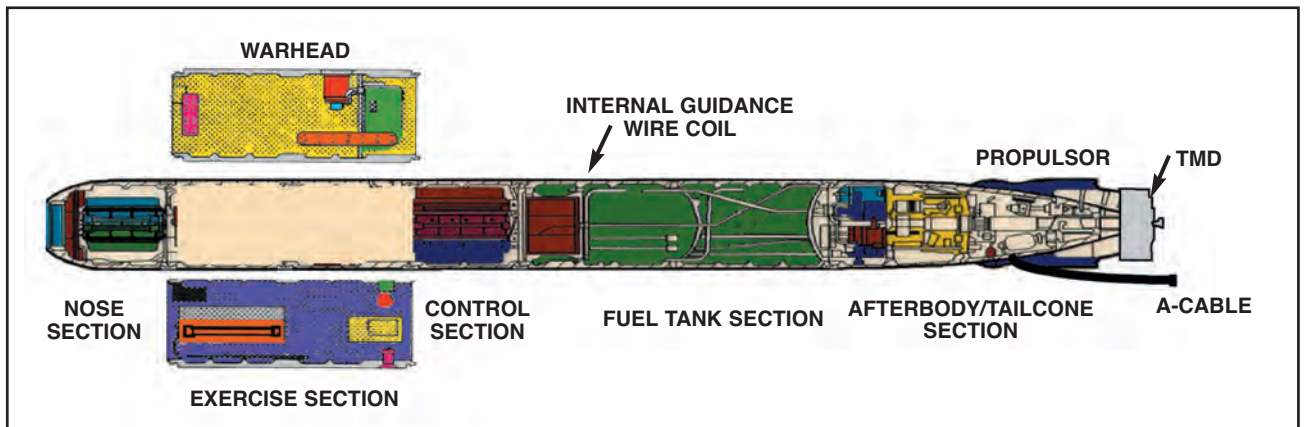
Currently deployed in the U.S. Submarine Force for anti-submarine and anti-surface warfare. Full support provided by the U.S. Navy.



MK 48 Mod 4

Operational

- Targets: All submarines and surface ships
- Depth Capability: Effective in the littoral and to full-depth capability of all world submarines
- Speed Capability: Effective against all submarines and surface ships
- Endurance: Effective against all submarines and surface ships
- Homing Capability: Active and passive homing with shallow-water and counter-countermeasure capability demonstrated in water
- In-Water Operability: Over 20,000 exercise and warshot firings by the U.S. Navy; superior in-water reliability demonstrated
- Sea State: Sea State 6+
- Launch Method: Impulse or swimout capable
- Wire Guidance: Provides target motion analysis (TMA) updates to weapon and telemetry data feedback to submarine; wire length supports operating range of weapon
- Wire Survivability: Torpedo-mounted dispenser (TMD) contains a flexible hose that ensures guidance wire integrity



MK 48 Mod 4 PHYSICAL LAYOUT

MK 48 Mod 4 Physical Parameters (nominal values)

MK 48 Mod 4 Configuration (Diameter = 53.2 cm (20.94 in.))	Length cm (in.)	Weight kg (lb)	CG (1) cm (in.)	CB (1) cm (in.)	Displacement (2) kg (lb)
Warshot	586.0 (230.7)	1553.1 (3423)	261.1 (102.8)	268.7 (105.8)	1158.6 (2553.5)
Warshot - Rack Stowage Configuration (3)	626.1 (246.5)	1684.7 (3713)	284.7 (112.1)	N/A	N/A
Exercise	586 (230.7)	1119.2 (2466.8)	291.1 (114.6)	270.3 (106.4)	1158.6 (2553.5)
Exercise - Rack Stowage Configuration (3)	626.1 (246.5)	1250.8 (2756.8)	321.3 (126.5)	N/A	N/A

(1) Center of Gravity (CG) and Center of Buoyancy (CB) are measured from the nose.

(2) Displacement is based on sea water with specific gravity of 1.025.

(3) Stowage configuration includes MK 10 Mod 0 TMD, A-cable umbilical, and nose and tail covers.



MK 48 Mod 6AT CHARACTERISTICS

The MK 48 Mod 6AT (Advanced Technology) is a software-driven, digital processor-based, heavyweight torpedo and the weapon of choice for anti-submarine and anti-surface warfare. The U.S. Navy guarantees its supportability through 2025.

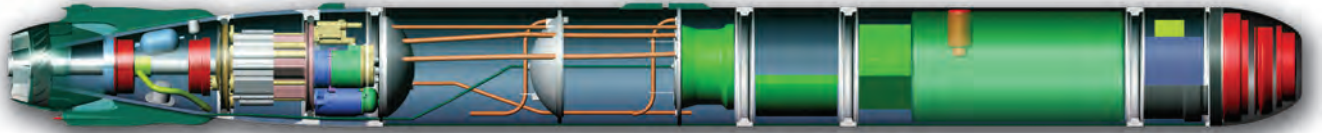


MK 48 Mod 6AT

Operational

- Targets: All submarines and surface ships
- Depth Capability: Effective in the littoral and to full-depth capability of all world submarines
- Speed Capability: Effective against all submarines and surface ships
- Endurance: Effective against all submarines and surface ships
- Homing Capability: Active and passive homing with superior shallow-water and counter-countermeasure performance demonstrated in water; search volume rates exceed 1.6 billion cubic meters per second
- In-Water Operability: Over 8600 Mod 5/6 exercise and warshot firings by the U.S. Navy; superior in-water reliability demonstrated
- Sea State: Sea State 6+
- Stealth: Undetectable prior to homing acquisition
- System Architecture: Commercial-off-the-shelf electronics in open-systems architecture allow rapid software upgrades and hardware technology improvements for timely tactical enhancements
- Launch Method: Impulse or swimout capable
- Rapid Launch Capability: Weapon ready immediately after application of warm power; when matched with wire guidance and superior active search, allows instant attack with minimal target solution

- **Wire Guidance:** Provides target motion analysis (TMA) updates to weapon and telemetry data feedback to submarine; wire length supports operating range of weapon
- **Wire Survivability:** Torpedo-mounted dispenser (TMD) contains a flexible hose that ensures guidance wire integrity



MK 48 Mod 6AT WARSHOT

MK 48 Mod 6AT Physical Parameters (nominal values)

MK 48 Mod 6 Configuration (Diameter = 53.2 cm (20.94 in.))	Length cm (in.)	Weight kg (lb)	CG (1) cm (in.)	CB (1) cm (in.)	Displacement (2) kg (lb)
Warshot	586.2 (230.8)	1691.5 (3728.1)	252.1 (99.3)	267.0 (105.1)	1166.6 (2571.3)
Warshot Stowage Configuration (3)	626.4 (246.6)	1823.1 (4018.1)	276.1 (108.7)	N/A	N/A
Exercise	586.2 (230.8)	1125.3 (2480.1)	290.1 (114.2)	267.0 (105.1)	1166.6 (2571.3)
Exercise Stowage Configuration (3)	626.4 (246.6)	1256.8 (2770.1)	320.7 (126.3)	N/A	N/A

(1) Center of Gravity (CG) and Center of Buoyancy (CB) are measured from the nose.

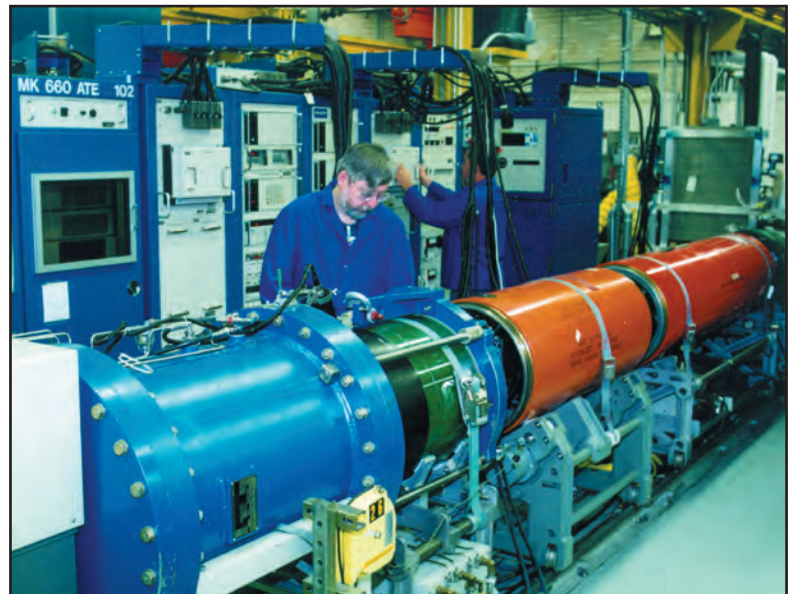
(2) Displacement is based on sea water with specific gravity of 1.025.

(3) Stowage configuration includes MK 10 Mod 1 TMD, A-cable umbilical, and nose and tail covers.



MK 660 Mod 2 AUTOMATIC TEST EQUIPMENT

The MK 660 Mod 2 Automatic Test Equipment (ATE) performs full-up automatic comprehensive system testing of all Torpedo MK 48 variants in an All-Up-Round (AUR) torpedo configuration. It is the “workhorse” test equipment in the U.S. Navy’s Intermediate Maintenance Activities (IMAs) and supports numerous additional testing evolutions, including factory acceptance testing, proofing, periodic maintenance, group testing, and weapon turnaround/ conversion activities.



MK 660 MOD 2 ATE

The MK 660 Mod 2 ATE consists of seven cabinets of primarily commercial-off-the-shelf (COTS) hardware. Additional supporting hardware includes an Inertial Measurement Unit (IMU) for Torpedo MK 48 Mods 5, 6, and 6AT, a Gyro Test Table for earlier variants, and an electrical-mechanical afterbody group section.

The MK 660 Mod 2 provides a mature and expandable test system capable of meeting the immediate and long-term requirements of the Torpedo MK 48 Program.

MK 660 Mod 2 System Capabilities:

- Performs comprehensive system testing of the Torpedo MK 48 (all mods) in either the exercise or warshot AUR configuration.
- Provides simulated swim scenarios for verification of weapon safety features.
- Performs functional stand-alone testing for the guidance and control section, IMU, warhead, and electrical power system.
- Downloads torpedo operational software including memory scuttle capability.
- Performs automated self-test and system calibration verification (ATE suite includes MK 125 Mod 0 Calibration Console).
- Has full complement of operational and maintenance manuals and drawings.
- Features flexible configuration as a single- or dual-rail system.
- Converts from a MK 48 Mod 6AT test configuration to a MK 48 Mod 4 test configuration in less than 2 hours.

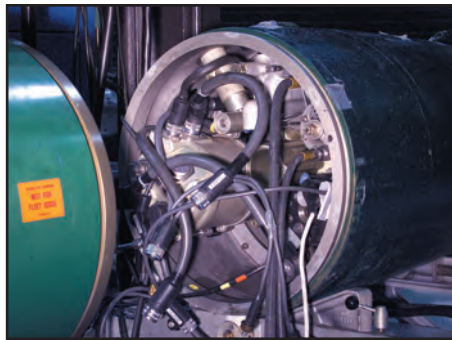
MK 660 Mod 2 ATE Performance Parameters

Throughput (number of torpedoes)	> 230/yr
ATE Mean Time Between Mission Critical Failures ($MTBMCF_{ATE}$)	> 100 hr
ATE Mean Corrective Maintenance Time ($MCMT_{ATE}$)	< 3 hr
Torpedo Mean Corrective Maintenance Time ($MCMT_{Torp}$)	< 3 hr
Availability (A_O)	> 0.93

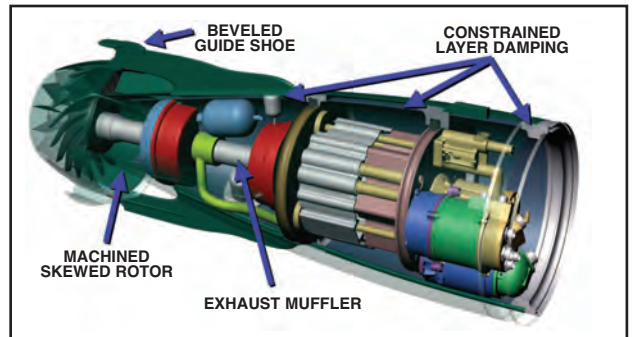


MK 48 Mod 6AT PROPULSION SYSTEM

The MK 48 Mod 6AT Propulsion System is an extremely robust, safe, and reliable open-cycle propulsion system providing very high and variable speeds, long endurance, and both shallow- and deep-depth operation. It incorporates a number of sound-isolation techniques and mechanisms that mitigate energy transmission to the hull and sea water, resulting in a low radiated noise signature with reduced detectability.



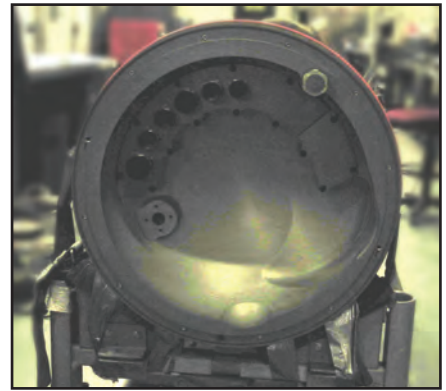
AFTERBODY SECTION



TORPEDO QUIETING UPGRADE
AFTERBODY/TAILCONE

Propulsion System Hardware

- Six-cylinder, hot-gas piston engine, fueled by Otto Fuel II monopropellant, directly drives a high-efficiency pumpjet propulsor. Propulsion system performance and reliability demonstrated in over 8600 submarine-launched firings.
- All energetic components (fuel, igniter, start grain, squibs, and thermal battery) have undergone safety testing and have been "Approved for Service Use" by the U.S. Navy.
- Propulsion system requires no onboard maintenance, monitoring, or environmental control. Fleet-issued weapons have a minimum 5-year shelf life.
- Both impulse and swimout launch capable.
- Rapid propulsion system startup and weapon control recovery allows launch in any water depth.
- Noise mitigation techniques include forcing function reductions, exhaust muffling, hull damping, and low-noise pumpjet propulsor, all of which significantly reduce weapon-radiated noise and detectability.
- System design provides for safe recovery of exercise weapons by either surface vessels or helicopters.



FUEL TANK

Otto Fuel II

- Blended monopropellant based on an energetic nitrate ester.
- Extremely stable, low fire hazard, noncorrosive, and insensitive to handling shock.
- Extensively tested so that safety and handling hazards are thoroughly understood and easily controlled.
- Safety and performance aspects greatly exceed other torpedo fuels currently in use.
- Excellent storage characteristics:
 - 10 years in torpedo fuel tank without maintenance
 - 75-100 years in controlled general storage
- No surveillance required on board submarine.



MK 48 Mod 6AT WARHEAD SYSTEM

The MK 48 Mod 6AT Warhead System consists of the MK 107 Mod 1 Warhead, MK 22 Mod 1 Warhead Electronic Sensor, and MK 21 Mod 3 Exploder. It is the U.S. Navy's most advanced warhead for heavyweight torpedoes. The system has been in service since 1982 and has performed with no safety incidents.



**MK 48 ADCAP
WARHEAD SYSTEM**



SINK EXERCISE

MK 48 Warhead System Effectiveness -- Proven Through Demonstration

- Extensively tested in ship sink exercises and service weapons tests.
- Large bulk charge warhead.
- Multiple fuzing modes.
- Proven capability against all submarine types and hull material designs.
- Highly effective against major surface combatants.

MK 107 Warhead Safety-Certified and Final Type-Qualified

- Warhead aluminum shell is loaded with 295 kg (650 lb) of PBXN-105—the safest, most tested, and most powerful underwater explosive ever produced for the U.S. Navy.
- Service life for MK 107 warheads loaded with PBXN-105 is more than 60 years (shelf life exceeds 100 years) with no special maintenance.
- Qualification testing included temperature, shock, vibration, thermal and humidity cycling, 30-day storage at 0° F and 140° F, and 40-foot drop test.
- Meets the requirements of NATO Standardization Agreement (STANAG) 4333, "Underwater Munitions, Principles for Safe Design" and STANAG 4187, "Fuzing Systems – Safety Design Requirements." Certified for Hazards of Electromagnetic Radiation to Ordnance (HERO).
- Approved for Service Use by Naval Sea Systems (NAVSEA) Weapon Systems Explosive Safety Review Board.

MK 22 Warhead Electronic Sensor Operating Features

- Multimode firing system.
- Serial firing string.
- Digital circuitry and noise immunity for fire command.

MK 21 Mod 3 Exploder Mechanism Operating Safety Features

- Microprocessor internal design.
- Rigid-flex circuitry and card cage construction (passes 1000-g shock test).
- Multimode firing system.
- Sequential arming; no single point of failure within firing train.
- Electrical and mechanical lockout of firing capacitors; complete own ship safety circuits.
- Requires sequential postlaunch events for warhead detonation: velocity sensor switch closure to unlock the exploder mechanism, enable point and target acquisition signals from the warhead relay assembly, and serial fire signal for detonation.

SEA 21 POWER



MK 48 Mod 6AT **ASW/ASUW WEAPON OF CHOICE**

This brochure is provided for information only and does not constitute a commitment on behalf of the US Government to provide additional information and/or sale of the system.