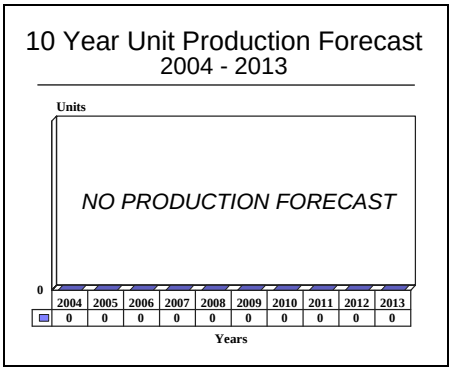
MPQ-53(V) (Patriot) - Archived 9/2005

Outlook

- Major upgrades in development and production; logistics support continues
- Phase III radar enhancement under way
- Performance of upgraded systems in Iraq reported good, with a few glaring missteps
- Target identification problems led to friendly fire incidents



Orientation

Description. The detection, guidance, and tracking radar for the Patriot air defense system. Operates against medium- to high-altitude aircraft and missile threats.

Sponsor

U.S. Army
Army Missile Command (MICOM)
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Redstone Arsenal
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USA
Tel: +1 205 876 4161
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Status. In service, upgrades and ongoing logistics support.

Total Produced. A reported 128 MPQ-53(V) fire units were produced for the U.S. Army and an estimated 26 units were produced in Japan. According to the U.S. DoD, the Army currently has 78 systems in its inventory.

Application. Tactical anti-aircraft, anti-ballistic missile defense sensor and guidance unit.

Price Range. Estimated cost is $2.5 million.

Contractors

Raytheon - Command & Control, http://www.raytheon.com, 1001 Boston Post Road, Marlborough, MA 01752-3789 United States, Tel: + 1 (508) 490-1000, Fax: + 1 (508) 490-2822, Prime

Technical Data

	Metric	U.S.
Dimensions		
Weight	35,870 kg	79,008 lb
Length	17.1 m	56.08 ft
Height	3.6 m	11.83 ft
Width	2.87 m	9.42 ft

	Metric	U.S.
Characteristics		
Frequency	4 - 6 GHz	
Range	68 km	37 nm
Detection sector	120 deg	
Engagement sector	90 deg	
Target capacity	50 simultaneous	
Missile control capacity	9 in final engagement	

Design Features. The MPQ-53(V) phased-array radar and associated processor are the heart of the Patriot system. It is a multifunction, electronically scanned radar mounted on an M-860 trailer and towed by an M-Engagement Control Center. A Hazeltine TPX-46(V)7 interrogator performs Identification Friend or Foe (IFF) target identification. The system includes a self-contained datalink to interface with the rest of the mobile defense system.

A new Patriot Information Coordination Central (ICC) allows the best system to be chosen for a particular threat and promotes efficiency by allowing one system to alert another to threats and coordinate a common defense against the threat. The ICC better protects friendly aircraft and provides more effective coverage of the sector. It also provides coordinated command and control to Patriot and HAWK air defense systems when they are operating in the same defense area.

The Patriot system was designed to operate under all weather conditions and to be capable of destroying maneuvering aircraft at all altitudes. It can guide several missiles to attack multiple targets simultaneously in a severe electronic jamming environment. Microelectronic technology has been applied to the system for purposes of reliability. Component standardization helps ensure a good system readiness record.

The MPQ-53(V) features a lens array using an optical feed. Sum and difference patterns are separately optimized with a monopulse feed. The aperture is round and uses nearly 5,000 ferrite phase shifters. Four-bit flux-driven non-reciprocal ferrite phase shifters and waveguide-type radiators are located at both apertures. The system has separate arrays for missile guidance and IFF.

The radar face is an immediately recognizable characteristic of the system. A large phased-array face dominates the upper portion of the antenna unit face. It performs both surveillance and tracking for the radar. Below it is a nearly circular, 5,000-element phase shifter, and below that are two smaller phase-shifter arrays of 50 elements each. A row of 18 rectangular boxes divide the antenna face roughly in half, with access boxes and two slightly larger planar arrays (250 phase shifters) below it. At least one planar array is for the command-guidance and receive links of the missile.

Before an engagement, the radar is aligned to cover the most likely direction of attack. During an engagement, the beam is steered electronically in azimuth and elevation. The system has the ability to select and prioritize a single target from a mass formation based on a determination of the potential threat level.

The radar uses a track-via-missile (TVM) system to reduce cost. In semi-active missile systems, the radar illuminates an engaged target, and a seeker in the missile tracks the reflected energy from the target. The missile computes an interception course based on the bearing from its position to the target. In the Patriot TVM system, the missile relays this same bearing data to the engagement control station via the radar. The system's processors combine this information with the absolute positions of the target, the missile, and the velocity of the targets and generates tracking commands to guide the missile on the most efficient track to an intercept point. In the terminal phase, the missile's acquisition system acquires the target and relays information to the phased-array ground radar for final calculations.

The advantage of the TVM technique is that powerful ground-based processors are used for guidance. It is also difficult to jam – even if the tracking radar is receiving a jamming strobe, the Patriot missile can still receive missile-to-target bearing data from the TVM system for an intercept solution. The ground-based processors have sufficient computing power to resolve difficult jamming problems such as blinking jamming, where two aircraft in a formation jam alternately to frustrate home-on-jam modes.

Operational Characteristics. The Patriot missile is fired from mobile launchers. Each Patriot battalion has six Patriot fire units with quad launchers, also known as batteries. Each battery has two fire platoons outfitted with a total of eight quad launchers (which can be expanded to 16 if necessary), an MPQ-53(V) radar, an MSQ-104(V) engagement control station, an electric power plant, and an antenna mast group.

Patriot air defense systems are deployed in three-battalion brigade-size formations within the U.S. Army. Each battalion has up to eight batteries, each with two

fire platoons and four quad launchers. Each battery can be linked to up to eight fire sections, while each fire section (launcher) has four ready-to-fire missiles, for a total of 32 missiles in a battery, plus an additional 32 missiles for reload. Battery fire units equipped with eight quad launchers can be deployed independently on M814 vehicles within one kilometer of the datalink and radar.

MPQ-53(V) Patriot Radar

Source: Raytheon Systems Co

Variants/Upgrades

Although the Patriot was originally designed to counter aircraft threats, software modifications were implemented during the Persian Gulf War so the system could defend against Iraqi Scud missiles. Since then, Patriot has come to be thought of as an anti-missile system.

Patriot Radar Enhancement Phase III (REP III) and Patriot Classification, Discrimination & Identification Phase III (CDI-3). The Patriot Advanced Capability – 3 (PAC 3) system upgrade will be offered in kit form and retrofitted into operational systems. The upgraded batteries will be better able to defend against ballistic and cruise missiles. Among the changes will be a dual traveling wave tube transmitter and low-noise exciter. This upgrade doubles the average power of the radar, and adds a wideband capability for generating and processing high-range and medium-range resolution waveforms for target discrimination.

The April 2002 contract award (four REP III kits and four CDI-3 kits) would bring the total number of upgraded Patriot fire control units to 48.

Other ongoing upgrades and enhancements focus on improving the system's communications, which will also improve interoperability with other missile defense systems.

A series of enhancements and upgrades continue on both the missile and the command and control components. Among them are the Patriot Anti-Cruise Missile Upgrade Test Program IV; the Patriot/Hawk Phase III interfaces; the Patriot Classification, Discrimination, and Identification Phase III (CDI-3) modifications; and the Patriot remote launch communication enhancement upgrade.

Program Review

Background. The MIM-104 Patriot program began in 1963 as the Army Air Defense System 1970 (AADS-70), an attempt to develop a supplement to the MIM-23B Improved HAWK and a replacement for the MIM-14B Nike-Hercules missile system. An initial development contract was awarded to Raytheon in May 1967, and the program was renamed Patriot in May 1976.

The first operational Patriot battalion was deployed to Europe in November 1984 at Giessen, Germany. Another was deployed to Hanau. By 1992, the U.S. Army had 54 Patriot batteries deployed at nine sites in Europe. The German Patriots attained Initial Operational Capability in 1989.

In April 1984, the Pentagon began to modify the Patriot as an anti-missile missile for defense against Soviet tactical missiles. The program was titled Anti-Tactical Missile, or ATM, but was called the PAC (Patriot Anti-Tactical Missile Capability) upgrade series. Phase I of this program upgraded the Patriot software to enable the MPQ-53(V) to track tactical missiles. Phase II upgraded the missile and demonstrated its capabilities against a tactical target.

Software changes added specialized tactical ballistic missile (TBM) tracking algorithms to go along with anti-aircraft versions. This modification made it possible for the Patriot missile to knock incoming missiles off course, but not destroy them. This version was called the PAC 1 system.

PAC 2 focused on further software improvements and modifications to the missiles, which enabled Patriot to protect an area approximately 30 by 30 kilometers. The upgrade added software that allowed for the interception of steep-diving ballistic missiles, incorporated a new missile fuze, and optimized the anti-missile warhead.

Additional improvements to the PAC 2 included a series of upgrades to the radar, missile, and fuze to increase the area the Patriot is able to defend. A radar shroud was also installed around the back of the Patriot's fire control radar to prevent interference from other radars. The improved 185-pound warhead and a new fuze provided both self-defense and asset defense. All Patriot fire units received the TBM engagement capability. This modification enabled the Patriot to destroy TBMs, but not necessarily detonate the warhead. PAC 2 modification packages were incorporated into the system in 1989.

PAC 2 missiles were extensively used during Operation Desert Storm. In the Persian Gulf War, the Patriot intercepted over 30 Iraq SS.1 Scud (and other indigenously modified) missiles. The rate of success was originally claimed to be 100 percent, but evidence makes an accurate determination impossible. The reported Patriot success rate has varied from a high of 80 percent to a calculated low of 9 percent. After the Gulf War, debating the pros and cons of Patriot's performance became great political sport.

In December 1997, the Ballistic Missile Defense Organization (BMDO) announced the successful test of a PAC 3 missile at the White Sands Missile Range, New Mexico. This was the second of two development flight tests for the upgraded missile. It would be followed by 16 intercept tests against a mix of ballistic and cruise missile targets. A September 1999 test cleared the way for a PAC 3 LRIP decision.

On June 12, 1998, the U.S. DoD announced the possible sale to Israel of Patriot missile system equipment, including three MPQ-53(V) radar sets, three MSQ-104(V) engagement control stations, three M983 tractors, nine M931A2 trucks, and government-furnished equipment, trailers, and transporters. Also included were modification kits, generators, shop and tool equipment, spare and repair parts, support and test equipment, personnel training and training equipment, quality assurance team technical support, and related elements of logistics support. The estimated cost was $73 million.

On June 16, 1998, Raytheon Systems Company announced that it had been awarded a $141 million contract to upgrade ground equipment associated with the German Air Force Patriot Air Defense System. This would bring the German Patriot units, considered the backbone of German ground-based air defenses, to the latest Patriot Phase III ground configuration, equivalent to fielded U.S. Patriot units.

The direct sale, three-year contract was issued by the Federal Republic of Germany and included upgrade kits for seven Patriot radars, spares, system-level test equipment, technical assistance, and training. Raytheon was to provide the upgrade kits and technical assistance to SI Sicherungstechnik GmbH & Co KG (formerly Siemens) for installation into the radars. The contract included a follow-on option for additional upgrade kits that was to be awarded in June 1999 at an additional value of $71 million.

Germany and the United States were to establish a joint air defense unit made up of 500 troops armed with Patriot, HAWK, and Roland air defense missile systems. The German-American unit was reportedly to be modeled on the Franco-German armored brigade and would be available for deployment with international peacekeeping missions.

On November 9, 1999, it was announced that the Republic of Korea had requested a significant weapons procurement valued at $4.2 billion. The request included 14 MPQ-53(V)s, 14 MSQ-104 engagement control stations, 76 launching stations, 31 antenna mast groups, 616 MIM-104D missiles, and a variety of other systems.

In July 2000, a Patriot PAC 3 missile successfully intercepted and destroyed a cruise missile at the White Sands Missile Range.

In February 2001, Israel and the U.S. completed a successful proof-of-concept demonstration of a combined Arrow-Patriot missile defense system. The two-tiered system would use Arrow as the long-range component, with Patriot used for close-in defense. Important to the test was the successful interface of communications between the Arrow Green Pine L-band radar and Citron Tree fire control system and the MPQ-53(V) and MSQ-104(V) engagement control station.

The tests were the joint effort of the Israeli Air Force and U.S. Army. The unfunded program proved to be technologically feasible, but some policy issues needed to be worked out.

In the 2003 war to oust Saddam Hussein from Iraq, Patriot batteries performed well, actually intercepting 12 Iraqi missiles launched against Kuwait and U.S. units at the beginning of the war. This was a significantly improved performance compared to the First Persian Gulf War in 1991, when after-the-fact analysis gave Patriot a poor score, with the hit rate down significantly from the original estimates. The hit-to-kill missile seemed to perform well.

There were two major glitches when batteries locked-on to and fired at a British Tornado GR4, killing the crew. A lock-on of a returning U.S. F-16 resulted in the aircraft firing a HARM missile, damaging the radar. A cause had not been announced at the time of writing, but one possibility may be that a bit of legacy software allowed the sensor to accept the slower aircraft as a valid target – a possible throwback to the original mission of the system.

PE#0203801A, Missile/Air Defense Product Improvement Program. The Army is involved in the PAC 3 upgrade program under the Patriot Product Improvement Program, Project 036. Although most of the changes focus on new, more capable missiles, radar enhancements were originally contracted in FY96. Many of the radar changes can be accomplished with software, but the overall Patriot system is being upgraded through a series of individual materiel changes.

The Patriot Product Improvement Program upgrades the Patriot system through a series of individual materiel changes culminating in the attainment of the Patriot Advanced Capability – 3 (PAC 3) system. The communication upgrades improve the Patriot's above and below battalion communication equipment. These changes eliminate Patriot-peculiar communications equipment and improve Patriot's interoperability between systems and the armed services.

The Remote Launch Communication Enhancement Upgrade (RLCEU) Link 16 Phase 1 and Post Deployment Build 5 (PDB 5) were initiated in FY00. Under RLCEU Link 16, the hardware required for Link 16 terminal and communications processing equipment to receive and process the Link 16 Joint Data Net information is being developed and tested.

PDB 5 will improve system capability against advanced threats (theater ballistic missiles and air-breathing threats) in all environments, including clutter and intense electronic countermeasures. The program objective is to define the software changes necessary to enhance system capabilities against advanced TBM and cruise missile threats.

Other areas addressed are interoperability improvements (cooperative engagement capability interface, cueing, and a Tactical Data Information Link direct to the fire unit), PAC 3 ground software improvements, Classification Discrimination & Identification Phase III (CDI-3) enhancements, and on-line diagnostics. This system supports the Legacy to Objective transition path of the Transformation Campaign Plan (TCP).

From FY03 on, The Patriot Product Improvement Program plan provides for the upgrade of the Patriot System through individual materiel changes culminating in the attainment of the PAC-3 System. The Program will define and implement software changes necessary to enhance system capabilities against advanced air breathing threat, tactical ballistic missile, and cruise missile threats. Recapitalization development efforts address mode vs Identify Friend or Foe (IFF), launcher and design improvements. Single Integrated Air Picture (SIAP) continues efforts associated with Block 0 improvements were initiated in FY03.

Acquisition Strategy. The design objective of the Patriot system was to provide a baseline system capable of modification to cope with the evolving threat. This alternative minimizes technological risks and provides a means of enhancing system capability through planned upgrades of deployed systems.

The Patriot program consists of two interrelated acquisition programs, the Patriot growth program and the PAC 3 missile program. Growth program

modifications are grouped into configurations that are scheduled to be fielded in the same time frame.

Configuration groupings are convenient for managing block changes of hardware and software and are not performance-related groupings. However, incremental increases in performance will be determined for each configuration in order to provide benchmarks for configuration testing and for the development of user doctrine and tactics.

Funding

U.S. FUNDING

	FY03		FY04		FY05(Req)		FY06(Req)	
	QTY	AMT	QTY	AMT	QTY	AMT	QTY	AMT
RDT&E (U.S. Army)								
PE#0203801A Missile/ Patriot Product Improvement								
036 Patriot PIP	-	39.3	-	46.5	-	31.7	-	16.7
	FY07(Req)		FY08(Req)		FY09(Req)		FY10(Req)	
	QTY	AMT	QTY	AMT	QTY	AMT	QTY	AMT
036	-	10.8	-	11.1	-	11.3	-	TBD

All $ are in millions.

Recent Contracts

(Contracts over $5 million)

Contractor	Award ($ millions)	Date/Description
Raytheon	70.7	Jan 2002 – Delivery order as part of a $376,384,358 cumulative total CPAF contract for FY02 Patriot engineering services for Israel, Germany, Saudi Arabia, the Netherlands, Japan, Kuwait, Greece, Taiwan, and the NATO Maintenance and Service Agency. Completed in FY02. (DAAH01-99-C-0028)
Raytheon	48.7	Apr 2002 – Mod to FFP Radar Enhancement Phase III (REP III) and Classification, Discrimination & Identification (CDI-3) contract. To be completed November 2005. (DAAH01-95-C-0446)
Raytheon	5.2	Apr 2003 – Mod to FFP contract for FY03 radar enhancement. Completed December 2003. (DAAH01-95-C-0445)
Raytheon	6.2	May 2003 – Mod to CPAF contract for FY02 engineering services for Patriot. Completed January 2004. (DAAH01-00-C-0028)
Raytheon	8.6	Aug 2003 – Mod to FFP contract with prospective price re-determination requirements for antenna elements for Patriot missile radar. To be completed September 2008. (DAAH17-03-D-0020)

Timetable

Month	Year	Major Development
May	1967	Contract awarded to Raytheon
May	1974	Engineering development begins
Oct	1978	Final DT/OT Phase II testing initiated
Jan	1980	DT/OT Phase II testing completed
May	1980	Production decision
Sep	1980	NATO announces Patriot to replace Nike/Hercules

Month	Year	Major Development
Aug	1982	First Patriot unit activated
Oct	1983	The Netherlands becomes first export customer
Dec	1983	U.S.-West German Patriot/Roland deal made
Apr	1984	Patriot confirmed for ATM role
Late	1984	Patriot first deployed in Germany
	1985	IOC
	1989	PAC 1 first deployed to Europe
	1990-91	PAC 1 and PAC 2 deployed to Saudi Arabia
	1991	Patriot deployed to Operation Desert Storm
Aug	1996	Contract awarded for Patriot anti-cruise missile upgrade, Phase II
Feb	1998	Anti-cruise missile upgrade completed
3Q	FY98	PAC 3 contractor DT&E
1Q	FY00	Start of PDB-5 software improvements
3Q	FY00	PAC 3 FUE
4Q	FY01	PDB-5 software improvements completed, PAC 3 Missile FUE
Feb	2001	Joint Arrow-Patriot proof-of-concept demonstrations
Feb	2002	Patriot Radar Enhancement III completed
1Q	FY02	Initiation of PAC 3 Evolutionary Block Upgrades
1Q	FY03	PAC 3 Missile Block 02 production DAB
3Q	FY04	DAB IPR PAC 3/MEADS Combined Program
4Q	FY04	PAC 3 Missile Block 04 production
4Q	FY05	PAC 3 Missile IOC
4Q	FY07	PAC 3 Missile Block 06 production DAB

Worldwide Distribution

Egypt. In March 1999, the U.S. approved the sale of the Patriot system to Egypt to upgrade its air defense systems. The systems would be the latest PAC 3 ground equipment.

Germany. In December 1983, after a protracted period of negotiations, the United States and Germany reached agreement for the modernization of German air defenses. The U.S. Army Missile Command signed a $3 billion contract with the Federal Republic of Germany in July 1984 to provide an elaborate network of Patriot and Roland missiles over 10 years. The first Germanized version of the Patriot was handed over to the Luftwaffe on June 15, 1989. The main differences between the U.S. and German systems were the command and control systems, IFF equipment, and vehicle and shelter mountings. (Then) West Germany procured a reported 36 fire units. Germany is upgrading its units to PAC 3 ground unit configuration.

Greece. The Greek government approved the procurement of four Patriot batteries. The systems would be the latest PAC 3 ground equipment.

The **Netherlands.** The Netherlands purchased the Patriot for its No. 3 and No. 5 Guided Missile Groups, with two Patriot and four HAWK fire units per group. The Netherlands has four fire units, each with five launchers. Deliveries were made, and the final unit reached operational status in April 1990.

Japan. After several years of vacillation, Japan decided in 1983 to license-produce the Patriot to upgrade its air defenses. In 1985, Mitsubishi Heavy Industries, which was already license-producing the MIM-23 HAWK, was selected to co-produce the Patriot. Work was completed at MHI's Komaki North Plant in 1986. The plant has since been renamed the Nagoya Guided Missile and Propulsion Systems Works, and is part of Nagoya Aircraft Works.

Japan purchased 26 Patriot fire units to replace its aging MIM-14B Nike-J air defense systems, with two of the fire units (10 launchers) being used for training purposes. At one time, Japan was contemplating the purchase of as many as 84 Patriot fire units, but this figure was revised downward because of high cost.

Although all fire units were to be delivered by FY91, the system was not fully operational until FY95. According to Japanese sources, the Japanese were considering developing their own surface-to-air missile system as the eventual replacement for the Patriot. Cost, however, would be a major consideration.

Because of concern over North Korean missile developments, Japan decided to seek an anti-tactical ballistic missile (ATBM) system. It has been looking for a near-term system based on existing weapon systems, and decided on upgrading its Patriots to the PAC 3 configuration, and interfacing them with its Navy's AEGIS assets. This is the result of a long-term U.S.-Japan Ballistic Missile Defense (BMD) working group.

Kuwait. Kuwait awarded Raytheon a $327 million contract for the provision of 210 Patriot PAC 2 missiles and five (maybe eventually 20) fire units. Deliveries commenced in mid-1995. Kuwait lost most of its air defense missile systems during the Iraqi invasion of 1990. The overall value of this contract could eventually grow to $450 million, with additional awards for logistical and engineering support, test equipment, and support hardware. However, financial shortfalls are expected to cause some rescheduling.

Israel. Israel purchased four Patriot batteries equipped with PAC 2 missiles. This acquisition cost approximately $350 million. Israel had been leasing a pair of fire units from the United States for evaluation. Eventually, as a result of the Gulf War, the United States and the Federal Republic of Germany transferred at least two full Patriot air defense batteries to Israel to counter Iraqi SS.1 Scud missile attacks.

The transfer of these batteries helped fuel a debate concerning how Israel intends to fulfill its future air defense needs. Rumors have suggested that the Israelis plan to downsize their Arrow anti-tactical ballistic missile system for a test launch using the Patriot launcher and avionics. Israel has strongly denied such plans, and has said that it is in the process of determining whether it has a military requirement for a system such as the Patriot. It requested the possible sale of three additional units in June 1998.

Saudi Arabia. Saudi Arabia purchased six Patriot fire units in December 1990. The Bush administration requested that Congress allow the sale of the Patriot to Saudi Arabia in light of the Iraqi invasion of Kuwait. The Bush administration proposal included eight Patriot air defense fire units (one additional fire unit for training and another as a maintenance float), 384 missiles, and 48 launchers for $984 million, but congressional opposition reduced the number of Patriots sold to six. In 1991/92, the United States allowed Saudi Arabia to purchase an additional 13 Patriot fire units and 758 missiles as part of the second phase of this sale. The Saudis received the first batch of eight fire units in 1993.

Italy. Italy is an identified user of the Patriot.

South Korea. Fears of missile attack from North Korea have prompted a desire for Patriot battery protection of key cities and other potential targets. The government requested 14 PAC 3 systems, including MPQ-53(V) radars, as part of a major weapons request.

Switzerland. Switzerland is considering the purchase of a new air defense missile system to satisfy its year 2000 requirements. The system would replace its current inventory of Bloodhound surface-to-air missiles. The Swiss plan has not been finalized, but possibly includes the MIM-104 Patriot, ADATS, and a surface-to-air version of the AIM-120 AMRAAM.

Taiwan. The Republic of China uses PAC 2 versions of Patriot, but is considering upgrading to the ERINT missile when it becomes available.

Turkey. Turkey may yet ask the United States to sell it the Patriot, and remains on the list of potential customers. Six to 10 Patriot batteries could be sold to Turkey.

United Arab Emirates (UAE). The United Arab Emirates announced an intention to eventually procure a longer range air defense system with an ATBM capability. No specific decision has been made concerning this system, although European, Russian, and American weapons are being offered. The Russians announced their intention to market the S-300PMU1 to the UAE, and the Patriot is being offered. France could attempt to offer an alternative. The systems would provide an air defense capability for the country's six army brigades.

United Kingdom. The United Kingdom was thought to be a potential Patriot customer because it was planning to deactivate the Bloodhound Mk 2 surface-to-air missiles in service since 1964. It was interested in an off-the-shelf weapon system, but nothing available had the desired capability against advanced ballistic missiles. Anything it could procure would be obsolete or nearly so when installed. Instead, the U.K. opted for developing a new tactical ballistic missile defense, possibly through a pan-European effort, within 15 years.

Forecast Rationale

Battlefield forces can count on being threatened by tactical ballistic and cruise missiles. Even rudimentary, inaccurate, and ineffective weapons can hold sophisticated forces at risk and cause general anxiety in a theater of operations. In the Persian Gulf War, Saddam Hussein's Scud missiles sometimes did not hit the country they were aimed at, let alone their target, but they generated fear, and significant resources were used for Scud hunts. A few chance, disastrous hits compounded this fear.

North Korea's ballistic missile development program is causing anxiety in Japan. The AEGIS system was picked as the basis of the island nation's protection, and the Japanese Navy is fielding four AEGIS destroyers. The Japanese military also decided to upgrade its systems to the PAC 2 configuration and may even step up to the PAC 3 system. Upgraded Patriots would be integrated into a self-protection net of both sea- and land-based missile defenses.

The focus on new, more advanced equipment will prompt many nations to invest in new developments. But this is contingent on affordability, schedule, and export approval. The Patriot's lack of 360-degree coverage, limited low-altitude cruise missile detection, and inability to protect from some surface-to-surface missiles will be a limiting factor. Mobility can also be an issue. Achieving full 360-degree protection (six batteries – one battalion) takes a major airlift effort.

The fielded system re-capitalization effort, which began in FY02, will turn back the clock on system components to 0 hours and 0 miles.

The performance of the system in Operation Iraqi Freedom was much improved over the record achieved in the Persian Gulf War. Hit-to-kill proved to be a better technology, and the tracking and missile control was better. Nine kills were attributed to the system.

The unfortunate friendly-fire incidents were thought to be exceptions to an otherwise effective performance. After-action reports revealed unexpected equipment and operational problems. The IFF performance on one aircraft was a problem, and full automatic operation made it impossible for operators to intervene and prevent the deadly accidents. Too many units operating in close proximity and operating in an autonomous mode because the operators had taken shelter in response to a mortar attack were cited. A recommendation was not to operate in full automatic.

Patriot is the only operational battlefield anti-missile system available to allies today. A new missile protection system is needed, and nations are reluctant to spend money for the older equipment. Instead, some may opt to invest in a new system. MEADS (Medium Extended Air Defense System) is the planned replacement, but will not be available for several years. MEADS will have its own radar, so changes in that program will have little or no impact on the MPQ-35(V).

Ten-Year Outlook

No further production is expected.

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