ARCHIVED REPORT

For data and forecasts on current programs please visit

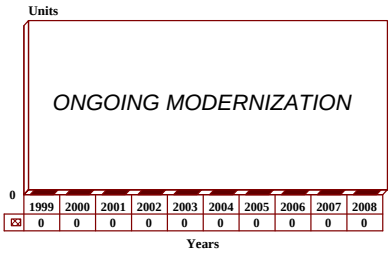
www.forecastinternational.com or call +1 203.426.0800

AWG-9/APG-71(V) - Archived 11/2000

Outlook

- Production has been completed, support continues
- Upgrades to the aircraft and avionics/flight control systems ongoing
- F-14 retirement planned in 2007

10 Year Unit Production Forecast
1999-2008



Orientation

Description. Airborne pulse-Doppler fire-control radar.

Sponsor

US Navy
Naval Air Systems Command
NAVAIR HQ
47123 Buse Road Unit IPT
Patuxent River, Maryland (MD) 20670-1547
USA
Tel: +1 301 342 3000

Contractors

Raytheon Systems Company
Sensors & Electronic Systems
PO Box 92426
El Segundo, California (CA) 90009-2426
USA
Tel: +1 310 334 1665
Fax: +1 310 334 1679

Status

AWG-9: In service, ongoing logistics support
APG-71: In service, deliveries complete, ongoing support

Total Produced. A total of 695 AWG-9 and 55 APG-71 radars were produced.

Application

AWG-9: F-14A/B
APG-71: F-14D

Price Range

AWG-9: US$2.5 million each
APG-71: US$3.0 million each

Technical Data

	Metric	**US**
Dimensions		
Antenna		
Slotted plane array:	14.2 cm	36 in
Weight:	590 kg	1,300 lb
Volume:	0.78 m^3	28 ft^3
Characteristics		
AWG-9		
Frequency:	8 to 12 GHz	
Peak power:	10 kW	
Average power:	7 kW (pulse-Doppler mode) 500 W (pulse mode)	
Pulse width:	0.4, 50 Φsec (pulse mode) 0.4, 1.3, 2.0, and 2.7 Φsec (pulse-Doppler)	
Range:	213 km	115 nm
Scan rate:	80°/sec (horizontal) 2 scans/sec (vertical)	
Tracking capacity:	Up to 24 targets simultaneously, with missile launches in rapid succession against six of these targets	
Target tracking alt:	50 ft to 80,000 ft, at speeds ranging from low subsonic to more than Mach 3	
Pulse-Doppler modes:	Pulse-Doppler Search (PDS) Range While Search (RWS) Track While Scan (TWS) Pulse-Doppler Single Target Track (PDSTT)	
Maximum antenna search:	8 bar pattern, 65 degrees to the left and right of the aircraft centerline	

APG-71

A digital version of the radar section of the AWG-9, it captures newer technology to enhance electronic countermeasures performance. The new system retained selected components from the AWG-9 and incorporated digital elements from the APG-70. Will incorporate non-cooperative IFF capabilities.

Range:	140 nm, bomber-sized target
Track:	24 targets simultaneously
Engage:	6 individual targets Track-while-scan capable
New modes:	Monopulse Angle Tracking Digital Scan Control Target Identification and Raid Assessment
Total units:	14
New units:	Programmable Signal Processor Radar Data Processor Analog Signal Converter

Design Features

AWG-9. The original F-14 weapon-control system is composed of the AWG-9 radar, computer, interface between AWG-9 and weapons, and the associated displays.

The radome and nose compartments contain the high-power pulse-Doppler radar processor. Missile auxiliaries are located behind the aft cockpit (Radar Intercept Officer, RIO), while the computer units are located below it. The RIO controls and displays include a

digital display (DD) unit and a tactical information display (TID) unit.

The AWG-9 radar operates in a high-power pulse-Doppler mode for long-range target detection and tracking, multiple-target tracking and Phoenix missile attacks. A conventional pulse mode is available for air-to-ground mapping and ranging and short-range dogfight attacks with Sidewinder missiles and/or the M61 Vulcan cannon. The radar provides continuous wave target illumination for medium-range dogfights using Sparrow air-to-air missiles.

The planar-array antenna is mounted just forward of the high-power transmitter and sensitive receiver in the F-14's nose. Unique radar features include long-range target detection and tracking at all altitudes, large surveillance scan volume and automatic target acquisition in close-in dogfights. The AWG-9 computer correlates data from the radar and external sources for display and solves weapon attack equations.

In the track-while-scan operating mode, the computer generates up to 24 target track files while the radar scans. The computer performs navigation computations, gun and air-to-ground ballistic weapons computations, as well as a built-in self-test of both the AWG-9 and Phoenix missile system.

The digital display unit provides the RIO with radar target data while the tactical information display provides computer-processed target data. The 10-inch-diameter tactical information display presents target positions and tracks missile launch zones, datalink information, built-in test results and television sight unit display. Associated controls are used by the operator to enter data and commands into the system.

The missile auxiliary subsystem processes missile prelaunch data from the computer and radar. It provides the switching, signal processing and logic control to prepare and launch up to six Phoenix or Sparrow missiles and performs seeker positioning for up to four Sidewinder missiles.

APG-71(V). The AWG-9 was upgraded as part of an overall F-14 upgrade effort funded under project W1408 of PE#0205667N. The upgrade focused on increasing the Tomcat's operational capability and improving its reliability and maintainability.

The new radar, a digital version of the AWG-9, is similar to the Hughes APG-70(V) radar carried by the McDonnell Douglas F-15. It uses the same analog signal converter, programmable signal processor, and radar data processor. The APG-71(V) is composed of 14 line-replaceable assemblies rather than the 30 found in the AWG-9 Block IVA variant.

A much-improved, electronic counter-countermeasures capability for the F-14 is made possible by a low sidelobe antenna, a sidelobe-blanking guard channel to assist in raid assessment, a new digital programmable signal processor, and increased frequency agility. A new broadband radar master oscillator was added, and the system has a more flexible search pattern. The APG-71(V)'s digital scan control operates in a track-while-scan mode when activated by the pilot. Its monopulse angle tracking capability permits the location of targets precisely within the radar beam.

The radar transmitter, power supply and aft-cockpit Tactical Information Display (TID) were retained in the APG-71(V) system. New features include digital signal and data processors, a frequency synthesizer, revised antenna scan control, a digital display and a multi-channel receiver.

The APG-71(V) uses monopulse angle tracking and digital scan control. Processing speed was increased six-fold with the addition of a high-speed digital processor. The APG-71(V) has improved overland performance, a larger threat engagement zone, expanded velocity search coverage, programmable electronic countermeasures (ECM) and a raid assessment mode, all of which will enhance the look-down capabilities of the F-14D.

As a result of the integration between the two radar systems, a standard avionics module (SAM) was developed. The SAM can be installed in either radar, and permits the alternating of core modules in the system's programmable signal processor.

Operational Characteristics. The system uses inputs from the radar to establish target identities and priorities, processes data to establish the intercept geometry, develops launch envelope data, and monitors some of the aircraft's other avionics. The Tomcat's principal weapon is the AIM-54 Phoenix air-to-air missile.

The AWG-9 and APG-71(V) combine with the AIM-54 to form an airborne fire-control system that can track multiple targets simultaneously and launch six missiles at six different targets. While the launch range is classified, the system easily detects and tracks targets out to 100 miles. The radar incorporates a number of modes including velocity search, range-while-search, and track-while-scan.

The AWG-9 can also be used with the AIM-7E/F and AIM-9G/H/L missiles, the Advanced Medium-Range Air-to-Air Missiles (AMRAAM), and the M-61 20 mm cannon.

The radar's long-range target detection capability makes it the logical choice for the F-14, which must engage

hostile targets as far as possible from the battle group. The system features an excellent look-down/shoot-down capability in heavy ground clutter, a critical capability if the fleet assets are to be protected from low-flying cruise missiles. The upgrades added significant medium-range, all-weather strike capability to the F-14.

Variants/Upgrades

APG-71(V). The digital follow-on to the AWG-9 on the F-14D. It is 86 percent common with the APG-70(V) central processor and 59 percent common with the digital radar processor.

F-14D. Improvements to the Navy F-14 squadrons were planned to make the aircraft capable of countering the projected threat through the year 2000 and beyond. The F-14D has increased capability in three major areas: new engines; new digital avionics; and the upgraded radar.

A Pre-deployment Update (PDU) program (primarily software) included air-to-ground ordnance delivery capability, full Link 16 capability, and radar/electronic counter-countermeasures (ECCM) improvements for the F-14D. The PDU program was created because of concurrent development of the F-14D and the common avionics and weapons. It implements the capabilities inherent in systems incorporated during the full-scale development (FSD) program and was a planned, integral part of the evolution of the F-14D aircraft.

F-14 weapons integration supports integration of electronic warfare (EW) improvements and correction of OPEVAL deficiencies. Funding is provided for various software upgrades such as Global Positioning System, and accommodates the realignment of Aviation Depot Level Repairables (AVDLR) from Major Range and Test Facility Bases to direct project funding.

Program Review

Background. The AWG-9 radar was originally developed for the Navy's F-111B. That program was canceled in 1968, and the AWG-9 was redirected toward the Grumman F-14A. The APG-71(V) was developed for the US Navy's F-14D tactical fighter. Although the Tomcat was designed to carry the AWG-9/Phoenix combination, the radar had evolved into a virtually all-new system by the time it was fitted on board the F-14.

F-14/AWG-9/Phoenix weapon system testing started in 1972, with the first Tomcat delivered to the Navy later that year. Initial operating capability (IOC) was reached in May 1973. The first export order for the AWG-9-equipped F-14 came in 1973 when Iran ordered 80 aircraft.

After the fall of the Shah of Iran, the DoD learned that the technology of the F-14 and AWG-9 had been compromised. The radar needed to be updated to counter Soviet jamming techniques instituted to exploit known AWG-9 capabilities. Target identification software was added to facilitate the employment of long-range missiles. This update equips existing F-14A and F-14A+ aircraft.

In FY89, the Pentagon made a limited production decision for 12 F-14D aircraft and continued avionics and radar hardware/software integration and development. Flight testing was performed to demonstrate ECCM improvements, mixed missile launch, fault isolation, TCS/ALR-67(V)/ASPJ operation, full radar mode operation, and additional live weapons firings.

The first F-14D production aircraft was delivered in FY90. The Bush administration, in its FY90/91 Budget Revision, recommended terminating the F-14D new manufacture and continuing the re-manufacture program. A major effort by the Long Island congressional delegation was able to forestall the Grumman production line shutdown until 1993.

In mid-1992, the Navy revealed that the F-14D was experiencing software and subsystem integration problems, which would probably have delayed deployment of delivered aircraft from 1993 as planned until some time in 1994. The Pentagon feared that a proposed congressional push in F-14 upgrades would introduce too much concurrency to the program.

There was no indication that the APG-71(V) was contributing to the problem.

The conference committee recommended termination of the F/A-14A/B upgrade and directed the Secretary of the Navy to convert existing F-14D aircraft into an F/A-14D with capabilities equivalent to the Air Force F-15E Strike Eagle, or to retire F-14s from service. The committee recommended authorization of US$158.3 million for procurement and US$171.4 million for F-14 research and development for this purpose.

Program Element 0205667N F-14 Upgrade, Project E1408 provides for the development of improvements to the Navy F- 14 squadrons that will help them counter the projected threat through the year 2000 and beyond. The F-14D has increased capability in that it has a new engine, new digital avionics, and the upgraded radar. These changes yield significant improvements in capability and performance, as well as reliability and maintainability, and will facilitate the total integration and exploitation of related programs such as the Joint Tactical Information Distribution System (JTIDS) and Infrared Search and Track System (IRST). The Airborne Self-Protection Jammer (ASPJ) in the electronic warfare (EW) suite for the F-14D operational evaluation.

A Pre-deployment Update (PDU) program (primarily software) includes air-to-ground ordnance delivery capability, full Link 16 capability, and radar/ECCM improvements for the F-14D. The PDU program was created because of concurrent development of the F-14D and the common avionics and weapons. It implements the capabilities inherent in systems incorporated during the full-scale development program and is a planned integral part of the evolution of the F-14D aircraft. F-14 weapons integration supports integration of EW improvements and correction of OPEVAL deficiencies.

Funding is also provided for various software upgrades such as the Global Positioning System, and accommodates the realignment of Aviation Depot Level Repairables from Major Range and Test Facility Bases to direct project funding.

In FY96, the flight characteristics of the F-14 were improved, an effort prompted by a series of crashes. One change considered was converting to a digital flight control system. The budget request included US$232 million in F-14 modifications, with US$13.9 million for continued operation and maintenance of the F-14 tactical air reconnaissance pod system (TARPS). Responding to the Navy's continued reliance on TARPS, Congress agreed to authorize an additional US$2.6 million for TARPS upgrades.

In January 1996, an F-14D was reported to score three hits in the first three missile launches using the Medium PRF mode of the APG-71(V). The first two launches used an AIM-54C Phoenix missile, the third locked onto the target and launched a radar-guided Sparrow missile. It scored a direct hit.

Enhancements to the F-14 continued with the addition of infrared search-and-track (IRST) capabilities and night vision goggle compatibility. The IRST can operate in conjunction with the APG-71(V) or independently, depending on mission requirements. This gives pilots more all-weather, multimode options. It gives the aircraft a potential tactical ballistic missile detection capability. Also, using non-radar sensors alone enhances the stealthiness of an attacking aircraft.

In late 1997, the Navy began an effort to upgrade the Tomcat by replacing the control systems. Plans were developed to replace 200 flight control systems with GEC-Marconi Avionics Ltd digital flight-control systems to correct a history of out-of-control flight problems. Installation was to start in mid-1998.

In FY98 through FY00, funding concentrates on development and testing of a third PDU program.

In the July 8, 1999, *Commerce Business Daily*, the Naval Air Systems Command (NAVAIRSYSCOM) announced possible future requirements for engineering and technical services, training, maintenance, and material services during the engineering, manufacturing and development (EMD) phase of the High Power Device Test Set (HPDTS) or High Power offload to Consolidated Automated Support System (CASS). This support would include sustaining engineering in support of the AWG-9 Operational Test Program Set (OTPS), Microwave Transition Analyzer (MTA), Real Time Graphics Display (RTGD), enhancement of the current AWG-9 OTPS technical manual development effort, diagnostic enhancement of the current APS-137(V) OTPS effort and the enhancement of the current HPDTS training.

Additionally, the HPDTS test installation requirements include selective Consolidated Automated Support System RF station/HPDTS integration, delivery and installation, and engineering in support of additional software development and HPDTS First Article Test and technical evaluation requirements.

Funding

US FUNDING

	FY98		FY99		FY00(Req)		FY01(Req)	
	QTY	AMT	QTY	AMT	QTY	AMT	QTY	AMT
RDT&E (USN 0205667N F-14 Upgrade E1408	-	11.6	-	12.8	-	1.4	-	1.5

All US$ are in millions.

Recent Contracts

(Contracts over $5 million.)

Contractor	Award ($ millions)	Date/Description
Raytheon	8.1	Oct 1998 – Not-to-exceed ceiling price order for four antenna assemblies and two microprocessors in support of APG-71(V) radar on the F-14. To be completed Oct 2001. (N00383-98-G-001A)

Timetable

Month	Year	Major Development
	1968	Engineering development of AWG-9 begun
	1970	First EDM AWG-9 delivered to US Navy
	1973	Production initiated of AWG-9
	1984	Digital modifications to AWG-9 initiated
	1984	Memory modifications to AWG-9 begun
	1986	APG-71 Engineering Development Models delivered
Jan	1988	F-14D radar flight tests begun
		Memory update to AWG-9 completed
Sep	1989	Scheduled delivery of first production APG-71
Mar	1990	Delivery of first F-14D to Navy
FY	1991	Start of F-14D remanufacturing program
Feb	1991	Termination of remanufacturing program
	1993	Last APG-71 deliveries
	1993	Final F-14D remanufactured, original planned deployment
	1994	Deployment of F-14D
	1995	APG-71 production line shutdown begun
Jun	1998	Installation of digital flight controls to begin
	2007	F-14D retirement planned

Worldwide Distribution

The only foreign operator of the F-14A was **Iran**. None are operational.

Forecast Rationale

The AWG-9, F-14, and AIM-54C Phoenix combination is a potent air-to-air fighting system and has provided the US Fleet with its air superiority fighter. Tomcats have proven themselves capable in testing, training, and limited combat, although a history of control problems plagued the venerable old airplane from the beginning. The system can engage and attack targets from outside the effective range of many adversaries.

Unlike the F-15 and F-16 radars, the AWG-9s did not have an opportunity to prove their capability in combat during the Persian Gulf War. Assigned fleet combat air patrol duties, they were never challenged by Iraqi fighters. Saddam's air force was destroyed (or had moved to Iran) and never attempted to attack naval assets, so it never engaged the F-14s. However, the commonality of components and architecture with the APG-63/70(V) radars, which did perform very well in the Gulf, indicates that the F-14 capability would have been similarly effective. The Tomcats maintained 24-hour combat air patrol stations throughout the war, validating the reliability of the F-14 in a combat arena.

The APG-71(V) radar enhanced the F-14's performance in an ECM environment, and the digital system has better multimode characteristics. Improved capabilities include the ability to counter new fighters with look-down, shoot-down weapons systems and beyond-visual-range air-to-air missiles. The radar is fused with the Tomcat's IR/EO sensor system.

The APG-71(V) programmable ECCM performance can counter most of the newer threats, and features new modes such as digital scan control and monopulse angle tracking, as well as target identification and raid assessment. It offers non-cooperative target identification and has better overland performance than the AWG-9. The APG-71(V) is slightly smaller and lighter.

Proposed upgrades included an inverse synthetic aperture capability, enhanced look-down, shoot-down capability over land, and a 15 to 20 percent increase in detection and acquisition range in the air-to-air environment. Additional capabilities could be added – including ground moving target indication and tracking.

A congressional push to convert existing F-14D aircraft into an F/A-14D, with capabilities equivalent to the Air Force F-15E Strike Eagle, made the APG-71(V) the critical system on the aircraft. The key to successful ground attack is the radar. With its APG-70(V) commonality and ability to benefit from and use basic F-15 software, the APG-71(V) will be the key to successful improvements.

Production has been completed. The DoD ended production of new F-14D aircraft in 1993. The Navy originally planned to remanufacture over 200 F-14As into the F-14D, but that figure was cut back significantly. It is adding digital flight controls to reduce many of the control (and thus crash) problems of the past.

Future F-14D remanufacturing possibilities were eliminated for a variety of reasons, eliminating future procurement of the APG-71(V). Improvement of the air-to-ground capability of the Tomcat may prompt a series of operational upgrades of existing systems. Although the hardware will not require much change, software upgrades can be expected to continue.

The Tomcat will continue to carry the air-to-air mission until the F/A-18E/F enters the Fleet. The Navy will gradually see the ground-to-air mission of the Hornet increase until the F-14Ds are phased out and leave the decks of carrier battle groups.

Ten-Year Outlook

No further production expected.

* * *