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APG-70(V) - Archived 10/07

Outlook

- USAF announced competition between Raytheon's APG-63(V)3 or (V)4 and Northrop Grumman's APG-77 to equip the 224 F-15Es currently in service; competition to start late 2006, with victor announced in 2007
- APG-63(V)3 AESA version of the older radar with SAR capability considered to have better performance level than the APG-70(V)
- No further production is expected; if there are no new developments, this report will be archived as of 2007

Orientation

Description. Airborne, multimode pulse Doppler fire-control radar.

Sponsor

U.S. Air Force
AF Systems Command
Aeronautical Systems Center
ASC/PAM
Wright-Patterson AFB, OH 45433-6503
USA
Tel: + 1 (513) 255-3767
Web site: http://www.wpafb.af.mil

Status. In service, ongoing logistics support and software upgrades.

Application. The APG-70(V) is carried by the F-15E, AC-130U (APQ-180(V)), select F-15C/D aircraft, the F-15S, and the F-15I.

Price Range. The estimated average cost of a new APG-70 was $3.2 million when the system was in full rate production in the early 2000s.

Cost/price is estimated, based on an analysis of contracting data, other available cost information, and a comparison with equivalent items. It represents the best-guess price of a typical system. Individual acquisitions may vary, depending on program factors.

Contractors

Prime

Raytheon Space & Airborne Systems	http://www.raytheon.com/businesses/rsas, 2000 East El Segundo Blvd, El Segundo, CA 90245 United States, Tel: + 1 (310) 647-1000, Fax: + 1 (310) 647-0734, Email: SAS_Comms_PA@raytheon.com, Prime

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APG-70(V)

Technical Data

	Metric	U.S.
Dimensions		
Weight	251 kg	553 lb
Volume	0.25 m^3	9.0 ft^3
Characteristics		
Frequency	Selectable in the 8 to 20 GHz band	
PRF	Multiple	
Planar Array Antenna		
Gimbal axes	3	
Type scan	Mechanical	
Drive rate	140°/sec	
Field-of-view	120°	
Range		
Air-to-Air mode	185.3 km	100 nm
Automatic acquisition	152.4 m to 18.5 km	500 ft to 10 nm
Ground Map mode	+92.7 km	+50 nm
Resolution		
Ground Map mode	2.6 m @ 21.4 km	8.5 ft @ 20 nm
MTBF	80 hr	
LRUs	Receiver/Exciter Analog signal converter Transmitter Programmable signal processor Radar data processor Power supply Cockpit display and control equipment	
Operating modes	Automatic acquisition Super search (HUD frame) Boresight Vertical acquisition (auto/manual lock-on) Auto guns Track-while-scan Range-while-search (high/medium PRF) Velocity search (high PRF) Single target track Weapons delivery Real beam ground map Doppler beam sharpening Ground map Air-to-surface ranging Precision velocity update Fixed and moving ground track Beacon Sniff-passive/active Flood (dogfight)	
APQ-180(V) added modes	Fixed target track Ground moving target indication and tracking Projectile impact point position Beacon track Weather mode (for radar-directed firing under poor visibility conditions)	

Design Features. The APG-70(V) multimode pulse Doppler radar operates on a number of selectable frequencies within its operational band. A gridded high-power traveling wave tube along with digital signal processing combine with efficient mode and data management to permit operation over a wide range of

pulse repetition frequencies, pulse widths, and processing modes. This enhances system performance in an electronic countermeasures environment. Radar data are presented on four rear cockpit displays.

The APG-70(V) uses a programmable signal processor (PSP), which is a high-speed digital computer that adapts the radar to new weapons or tactics. The radar was designed for the F-15E Dual-Role Fighter, and includes VHSIC and U-series gate array technology. The HCMOS-II gate arrays have an effective channel length of 1.1 microns and a complexity up to 40,000 gates, and can operate at 25 MHz.

The radar provides greater ECCM capability than its predecessor, with a 73 percent increase in RF bandwidth. VHSIC tripled radar computational speed from 400 KOPS to more than 1.4 MOPS, allowing for less than 100-foot target separation discrimination in each dimension in the air-to-air mode. The APG-70(V) has the memory capacity of 1 million words – 10 times that of its predecessor. A radar reliability increase of 33 percent is coupled with a longer look-down detection range.

Doppler Beam Sharpening produces high-resolution ground maps for targeting and navigation. It can produce imagery of ground targets several feet apart and at gazing angles below 0.5° using synthetic aperture radar technology.

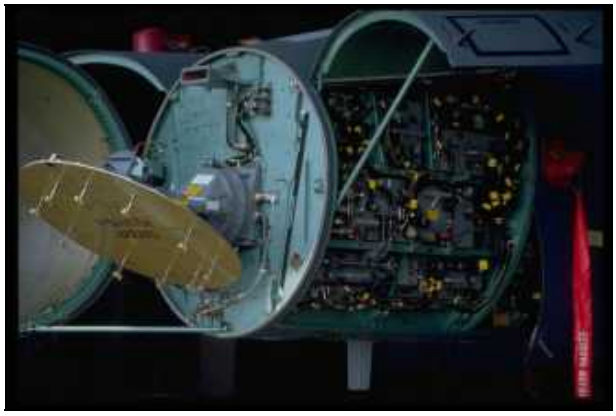
The radar has a planar array antenna gimbaled on three axes and six line replaceable units (LRUs). Four new LRUs were developed for the APG-70(V) and two were modified from the APG-63(V). The transmitter was also modified. The radar data processor has enhanced built-in test (BIT) and gate array technology, and the modified radar control panel is compatible with new radar modes. The high PRF filter band analog signal converter offers narrow-range bins for close target breakout, rear-aspect detection, and better ECCM.

The receiver/exciter has an increased RF bandwidth, a low-noise amplifier for greater detection range, and two-channel (track and search) processing. The PSP incorporates state-of-the-art gate array technology, increased memory, and rapid processing. BIT operates down to the module level, and modular software accommodates ECCM upgrades and mode expansion.

The PSP is capable of 34 million complex arithmetic operations per second. The use of a new software development tool, the Digital Software Integration Station, allows programmers to check out the PSP software package even before coding has been completed.

Operational Characteristics. To support its air-to-ground operations, the F-15E has a ground-mapping and terrain-following capability. Powerful hardware allows the APG-70(V) to carry out more sophisticated processing of incoming signals and to simultaneously execute complex operations, thus providing substantial operational advantages.

The APG-70(V) also provides raid assessment. It can distinguish between closely spaced targets at extended ranges and identify individual targets. The radar, when combined with the AMRAAM missile, gives a multiple-tracking and multiple-shot capability in the air-to-air modes. An improved raid assessment capability allows this feature to be used in tactical engagements. The APG-70(V)'s Receiver/Exciter is significantly more flexible than that in the APG-63(V); thus, the radar is agile in every dimension, including variable frequency, amplitude, sensitivity, and pulse repetition.



APG-70(V)

Source: Raytheon

Variants/Upgrades

APG-70S. This modified version for the Royal Saudi Air Force was "software de-tuned" to overcome software export concerns on Capitol Hill.

APG-180(V). The APQ-180(V) radar is a modification of the APG-70(V) radar. In addition to the standard APG-70(V) modes, it has fixed target track, ground moving target indication and track, projectile impact point position, beacon track, and a weather mode. The APG-70(V) antenna and analog signal processors were modified, and a new digital scan converter was added.

The APG-180(V) radar is carried by the AC-130U Specter gunship. U.S. Special Operations Forces operate this air-to-ground platform, equipped with a 105mm howitzer and 25mm and 40mm cannons.

Maintainability and parts availability problems with the APG-63(V) are leading to electronics component improvements that can be used in the APG-70(V).

Program Review

The APG-70(V) began its life as a modification to the APG-63(V). The APG-63(V) radar, which began development in October 1970, was modified into synthetic aperture configuration to permit the F-15 to carry out night and all-weather attacks on ground targets from standoff ranges. During FY82, designers successfully produced real-time, in-cockpit radar ground maps with resolution 10 times better than that of previous airborne tactical radar maps.

With modifications, the radar could produce ground maps at ranges in excess of 100 nautical miles, with resolution down to 8.5 feet (2.6 m). The mapping took place during flights of the F-15 Advanced Fighter capability demonstrator.

In FY83, an APG-63(V)-equipped F-15 mapped an area of 10 square miles at a distance of 150 nautical miles (277.9 km). The U.S. Air Force awarded a four-year contract to add upgraded air-to-air capabilities to the APG-63(V), forming a baseline for what would become a dual-role fighter. The Preliminary Design Review of the upgraded radar was conducted in June 1983.

New Radar Given APG-70 Nomenclature

The U.S. Air Force initiated an Adaptive Agile Radar ECCM concept development for airborne interception, fire control, navigation, weapon delivery, and A/A missile radars in FY84. The USAF accepted the F-15E in February 1984, transitioning to the newer sensor that was re-named the APG-70(V).

In November 1987, Hughes Aircraft Co received a $58 million contract from Rockwell International to develop and produce a modified APG-70(V) radar for the Air Force's AC-130U gunship. The gunship radar was expanded to include five additional modes to complement the high-resolution ground mapping and air-to-ground weapon delivery features. The system had fixed target track, ground moving target indication and track, projectile impact point position, beacon track, and a weather mode. Designers modified the existing radar's antenna and analog signal processors, and added a digital scan converter.

The original F-15E procurement funding ended in FY91, with the final aircraft delivered in FY93. Continued F-15E composite developmental test and evaluation flight testing took place from January 1991 through December 1995. This included the integrated performance of all F-15E systems, including the APG-70(V) and electronic warfare systems.

Saudi Purchases Approved, but "De-tuned"

The U.S. approved a Saudi Arabian purchase of F-15 aircraft in December 1992. In May 1993, Saudi Arabia contracted for 72 F-15S aircraft. Congressional opposition blocked approval of a full-up radar, so the software in the F-15S is de-tuned to give Saudi Arabia's APG-70s lower performance than their American counterparts. The first two aircraft were delivered in November 1995, and deliveries continued at a rate of one per month. The order included 12 spare radar units.

The Saudi design effort featured the Advanced Design for Quality Avionics Systems (ADQAS) concept, which was developed in the Eagle Century program.

The process was described as a disciplined design and manufacturing technique that emphasized concurrent engineering, integrated product development, key characteristics, parts characterization, tolerance and margins, and test verticality. ADQAS was called an end-to-end process that covered all aspects of development from concept inception to field support. In the past, avionics design was driven by performance requirements, and cost was a secondary consideration. Avionics systems developed under ADQAS should

yield, according to developers, an order of magnitude improvement in reliability and supportability.

In 1996, the Air Force embarked on studies to evaluate the inclusion of an active array into operational radars. The study contract ran for one year and included a Phase I feasibility study. The effort used the APG-70(V) as a base radar for the program, with a prototype planned for demonstration sometime in 1998.

The first Israeli Air Force F-15I successfully completed its first flight in September 1997. The aircraft was known in Israel as the Thunder. Israeli F-15s also were equipped with a de-tuned APG-70(V).

A February 1998 *Commerce Business Daily* announcement solicited engineering services to support the APG-70(V) Operational Flight Test program, which would include support for the development of a Non-Cooperative Target Recognition (NCTR) mode.

In an April 2001 edition of the *Commerce Business Daily*, the F-15 System Program Office announced plans to define those contractor tasks needed to provide engineering services related to the reliability and maintainability of the APG-63(V) and APG-70(V) radars, among other tasks. The effort would include "bad-actor failure" investigations, material improvement project (MIP) tasks, hardware/software design tasks, first articles support, FMS actions, and parts investigations.

F-15E to Receive New Radar

In June 2005, the U.S. Air Force began a study to identify potential sources to support an F-15E Radar Modernization Program (RMP). Officials anticipated the award of two separate contracts. The first contract would be for execution of the System Development and Demonstration (SDD) phase of the F-15E RMP. Major tasks would include design, development, full weapon system integration, and test of a radar system that would meet requirements documented in the Capability Development Document (CDD), into the F-15E Weapon System. The Joint Requirements Oversight Council had approved the Capability Development Document (CDD) for the F-15E Radar Modernization Program.

The document noted that there are presently 224 USAF F-15E aircraft in service worldwide. The current radars are, on average, 22 years old and are experiencing problems in reliability, diminishing manufacturing sources, and increasing radar sustainment costs. The goal of the F-15E Radar Modernization Program (RMP) is to affordably upgrade the F-15E radar system to significantly improve reliability, maintainability, and supportability (RMS), maintain APG-70 operational capability, and lay the groundwork for future network-centric warfare requirements.

The plan is to leverage existing Commercial off-the-shelf/Government off-the-shelf (COTS/GOTS) radar systems technology from already developed systems (examples include F/A-18E/F (APG-79), F/A-22 (APG-77), and F-35 (APG-81)). By emphasizing reuse and integration of existing technologies, the F-15E RMP approach will keep the program development risks low and development costs at a fraction of similar fighter radar improvement programs.

This upgraded radar will be an important component of Combat Identification (CID) and Theater Air and Missile Defense (TAMD) Families of Systems.

Significant News

USAF to Replace F-15E Radars – The U.S. Air Force has announced that it will hold a competition to decide which company will supply new radars to replace aging APG-70s for the F-15E Strike Eagle. The match will pit Raytheon, with its APG-63(V)3 or (V)4 versus Northrop Grumman, with its APG-77, which now equips the F-22. The competition is expected to begin in late 2006, with the victor chosen in 2007. (*Flight International*, 9/05)

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Timetable

Month	Year	Major Development
	1970	APG-63(V) development begins
	1984	APG-63(V) upgrade becomes APG-70(V)
Dec	1984	APG-70(V) CDR
Mid-	1986	Digital upgrade modifications completed

APG-70(V)

Month	Year	Major Development
Dec	1986	F-15E first flight
Jun	1987	First APG-70(V)-equipped F-15E delivered
Nov	1987	APG-70(V) chosen for AC-130U gunships
	1989	F-15E IOC
Jul	1994	First AC-130 delivery to AF active unit
Nov	1994	First APG-70S delivered
	1995	Active array antenna (AESA) introduced
Sep	1997	First flight F-15I
Nov	1997	First F-15I delivery
	2000	Congress adds funds for five aircraft to prevent production line shutdown
Feb	2001	Korea announces possible selection of F-15K with AESA APG-63(V) radar
	2004	Last current USAF F-15E delivery
Jun	2007	Current contract for repair support assemblies complete
	2007	Decision on new radar competition expected
	FY10/11	LRIP for Radar Modernization Program

Worldwide Distribution / Inventories

The **U.S.** carried the APG-70(V) on 214 of its F-15E and 42 of its F-15C/D aircraft.
Saudi Arabia carries the APG-70S on its F-15S aircraft.
Israel installed the APG-70(V) on 25 of its F-15I aircraft.

Forecast Rationale

The APG-70(V) is a venerable radar, which has proven invaluable during many combat operations. It is easy to use and considered particularly effective at delivering laser-guided bombs. It combines a ground-mapping capability with an air-to-air radar. Ground mapping proved effective in locating Iraqi targets during the Persian Gulf War. The F-15E interfaced effectively with JSTARS on a variety of missions, especially Scud hunts.

APG-70 Nearing End of Life Span

Despite this track record, the U.S. has announced plans to replace this aging version with a new radar, and so the APG-70's life will be coming to an end. By 2007, the U.S. Air Force is expected to announce a winner in a competition between Northrop Grumman's APG-77 and Raytheon's APG-63(V)3 or (V)4. Production of the new radar will begin late in this decade, with full-rate production well under way within 10 years.

Israel and Saudi Arabia to Keep APG-70s

Israel and Saudi Arabia will most likely keep their APG-70s in service longer than the U.S., preserving some maintenance opportunities despite the loss of the American market. However, new sales of Raytheon's APG-63(V)1s through (V)4s radar family will likely block the market for the APG-70. The APG-63(V)3 AESA version of the older radar, with SAR capability, has a performance level that is considered better than the APG-70(V). Retrofits are being considered, but funding will be a major consideration.

Furthermore, in some cases, buyers are opting for other aircraft, especially new versions of the F-16. Cost can be a problem for the F-15, with users able to acquire new, capable F-16s for roughly half the cost of an F-15E. In addition, the F-15 has been dealing with image issues – it is viewed as an "old bird" by some buyers. All of these factors are affecting the marketability of the Eagle.

Ten-Year Outlook

No further production is expected. If there are no new developments, this report will be archived as of 2007.

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