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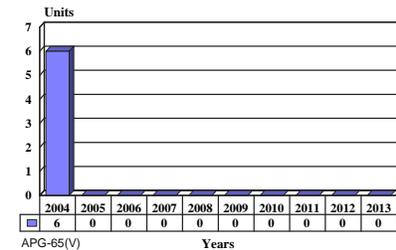
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APG-65(V) - Archived 10/2005

Outlook

- In service; ongoing logistics support
- Production ending for AV-8B Harrier II Plus for USMC and FMS
- Upgrades planned through the life of system

10 Year Unit Production Forecast
2004 - 2013



Orientation

Description. Airborne, multimode fire control radar.

Sponsor

U.S. Navy
 Naval Air Systems Command
 NAVAIR HQ
 47123 Buse Road Unit IPT
 Patuxent River, Maryland (MD) 20670-1547
 USA
 Tel: +1 301 342 3000
<http://www.nawcad.navy.mil>

Total Produced. Through 2003, an estimated 1,532 units had been produced.

Application. F/A-18C/D, CF-18, EF-18, AV-8 II Plus, F-4E/F.

Price Range. Approximately US\$1.2 million each.

Price is estimated based on an analysis of contracting data and other available cost information, and on a comparison with equivalent items. Individual acquisitions may vary, depending on program factors.

Status. In service, in production, ongoing logistics support.

Contractors

Raytheon Space & Airborne Systems, <http://www.raytheon.com/businesses/rsas/index.html>, 2000 East El Segundo Blvd, PO Box 902, El Segundo, CA 90245 United States, Tel: + 1 (310) 647-4519, Fax: + 1 (310) 647-0734, Email: pway@raytheon.com, Prime

Technical Data

	<u>Metric</u>	<u>U.S.</u>
Dimensions		
Weight (excluding rack)	154 kg	340 lb
Total System	260.4 kg	560 lb
Volume (excluding antenna)	0.126 m ³	4.5 ft ³
Antenna (diameter)	71 cm	28 in

Characteristics

Frequency	8-12 GHz
Range	>60 nm
PS	7.2 million operations per sec
RDP	General-purpose radar data processor with a 250K, 16-bit word bulk storage disc memory
A/D Converter	1.3 MHz (air-to-air) 8 MHz (air-to-ground)
Operating Modes	Velocity search (high PRF) Range-while-search (high/medium PRF) Track-while-scan (maintains 10, displays 8) Single target track Gun director Raid assessment HUD (boresight and vertical acquisition modes with automatic lock-on) Terrain avoidance Precision velocity update Ground target track (fixed/moving) Sea surface search Air-to-surface ranging Real beam ground mapping (long-range) Doppler beam sharpened patch Doppler beam sharpened sector Look-down/shoot-down
Antenna	Low sidelobe planar array Direct electric drive
LRUs	TWT transmitters (2) Receiver/exciter Radar data processor (RDP) Programmable signal processor (PSP)
MTBF	120 hours

Design Features. The APG-65(V) is an all-digital, multimode radar designed for both air-to-air and air-to-ground combat missions. It was the first radar to incorporate a single programmable digital signal processor having both air-to-surface and air-to-air capabilities. Until then, bombing or air-combat operations were controlled by hardwiring the radar controllers for either one mission or the other.

Totally conflicting operational requirements for the bombing and combat modes had to be accommodated, and a small antenna used because of limits imposed by the F/A-18 nose design. In addition, the radar had to share the nose with the aircraft's gun, necessitating heat and vibration protection.

The system was designed to reduce pilot workload during all phases of both missions. During air-to-air operations, the APG-65(V) provides total visibility against airborne targets at all aspects, at any altitude, and through all target maneuvers. It is designed to accommodate the F/A-18 head-up, hands-on throttle-and-stick (HOTAS) operation.

Advanced digital and analog technology makes the radar resistant to many electronic countermeasures (ECM) threats. All modes incorporate highly automated electronic counter-countermeasures (ECCM) features. Field upgrades of the radar's ECCM were made through software in the signal and data processors. It is possible to quickly adapt the system to changing threats.

The APG-65(V) has six standard modes for the F/A-18C/D during air-to-surface navigation and attack missions. High-resolution modes previously unavailable in tactical aircraft, combined with other radar modes, make possible long-range surface mapping of fixed, moving, and sea-surface targets.

This detection and tracking capability allows the pilot to cue other sensors such as a forward-looking infrared (FLIR). A long-range, real-beam ground-mapping mode can be used to identify large terrain features, using pulse-to-pulse frequency agility to smooth scintillation. Long-range capabilities come from a combination of pulse compression and low pulse repetition frequency (PRF). Doppler beam-sharpened modes achieve better definition.

Operational Characteristics. For surface attack missions, the APG-65(V) has a high-resolution surface mapping feature that can be used with land- or sea-search modes for moving or stationary targets. A terrain avoidance mode is used for low-level penetration missions, and an air-to-surface ranging mode is available for the accurate delivery of both guided and unguided munitions. A specialized sea-search mode enables the APG-65(V) to acquire and track ship targets in any sea state.

Some of the operational features are:

- A VELOCITY SEARCH mode yields maximum detection range capability against nose aspect targets because of the high PRF used. This mode provides velocity and azimuth information.
- A TRACK-WHILE-SCAN mode maintains 10 track files, and displays eight. It can provide advanced missiles, such as the AMRAAM, with a fire-and-forget capability, as well as simultaneous engagement of multiple targets.
- The RANGE-WHILE-SEARCH mode can detect all-aspect targets by using both high and medium PRF



APG-65(V)

Source: Ratheon

waveforms. The high PRF mode incorporates FM ranging; the medium PRF uses range gate processing.

- A RAID ASSESSMENT mode expands the region centered on a single tracked target for increased resolution in the target vicinity and radar separation of closely spaced targets.
- Three automatic short-range AIR COMBAT MANEUVERING modes, boresight (BST), vertical acquisition (VACQ), and gun acquisition (GUN ACQ), provide automatic acquisition of maneuvering targets from ranges of 500 feet to 5 nautical miles. A WIDE ACQUISITION (WIDE ACQ) mode automatically acquires targets out to 10 nautical miles.
- A short-range GUN DIRECTOR mode uses pulse-to-pulse frequency agility to reduce target scintillation during tracking.

Pilots are impressed with the radar's look-down/shoot-down capability. This characteristic generated a significant FMS market for retrofits into older aircraft.



AB-8B Harrier

Source: BAE

Variants/Upgrades

The United States and Canada developed a major upgrade to the APG-65(V) radar. Designers enhanced the radar's ability to perform in an increasingly hostile electronic countermeasures environment. The bandwidth, and the processing speed of the radar signal processor (RSP), were increased. New radar data

processing (RDP) hardware increased throughput speed and expanded memory.

APG-65(V)/Harrier II. The antenna diameter was reduced to about 23 inches, and the system components distributed around the aircraft, to accommodate differences in the aircraft's physical design.

Program Review

Background. The F/A-18 program was approved for full-scale development in December 1975. (Then) Hughes was selected to produce the APG-65(V) radar in August 1976.

The first flight of an F/A-18 with the radar controlling gun operation took place in summer 1980. Operational evaluations were in August 1982, and Initial Operational Capability was then achieved.

In April 1985, Germany selected the Hughes APG-65(V) for the F-4F Improved Combat Efficiency (ICE) program. The first fully functional aircraft flew in 1990 and deliveries began in April 1992.

In February 1988, McDonnell Douglas and British Aerospace announced that they would begin full-scale development (FSD) of the long-awaited radar-equipped version of the McDonnell Douglas/British Aerospace AV-8B, the Harrier II Plus. This came less than a month after a U.S. Marine Corps decision to approve an operational requirement for a radar-equipped Harrier. It selected the APG-65(V) radar for the effort.

Spain and Italy joined a tri-national agreement with the U.S. on production of the advanced Harrier with APG-65(V) radars. Italy acquired 16 AV-8B and 2 TAV-8B aircraft, taking delivery of its first Harrier II in

April 1994. Spain had a requirement for 13 Harrier II Plus.

The U.S. procured 24 new aircraft and re-manufactured 72 standard Harriers to the II Plus standard. Initial aircraft were delivered to the Marine Corps in April 1993. In May 1994, McDonnell Douglas received funding for the first four remanufactured Harriers. The first flight of a remanufactured Harrier took place in January 1996.

Raytheon Technical Services, as the designer and Original Equipment Manufacturer (OEM) manufacturer of the APG-65(V)/APG-73(V), is considered the only source with the required technical expertise and knowledge to provide Contractors Engineering Technical Services (CETS) of the equipment. This has been contracted and should run through September 30, 2008, if all options are exercised.

The United States, Italy, Spain, and the United Kingdom have signed a memorandum of understanding to create a joint program office to manage Harrier post-production, spare parts procurement, and upgrades for ten years.

Funding

	<u>U. S. FUNDING</u>							
	<u>FY03</u>		<u>FY04</u>		<u>FY05 (Req)</u>		<u>FY06 (Req)</u>	
	<u>QTY</u>	<u>AMT</u>	<u>QTY</u>	<u>AMT</u>	<u>QTY</u>	<u>AMT</u>	<u>QTY</u>	<u>AMT</u>
Production (USMC)								
AV-8B	-	5.8	-	12.4	-	4.7	-	TBD
AV-8B Mods	-	58.6	-	57.4	-	20.8	-	TBD

All US\$ are in millions.

Recent Contracts

(Contracts over US\$5 million.)

<u>Contractor</u>	<u>Award (US\$ millions)</u>	<u>Date/Description</u>
McDonnell Douglas	5.6	Apr 2001 – Delivery order under a basic ordering agreement for repair of various systems, including the APG-65(V). Completed October 2001. (N00383-98-G-010H)
Raytheon Co	12.4	Sep 2003 – Delivery order against previously awarded basic ordering agreement for seven Phase I retrofit kits for the APG-73(V) for the F/A-18 aircraft for the USMC, and Australia (one) under FMS. This delivery also covers the non-recurring re-design of two obsolete gate arrays and a roll-up engineering change proposal for retrofit change proposals for the APG-65 radar. Complete January 2005. (N00383-01-G-100A)

<u>Contractor</u>	<u>Award (US\$ millions)</u>	<u>Date/Description</u>
Raytheon Co	10.2	Sep 2003 – Delivery order against a previously issued basic ordering agreement for the procurement and installation of four ECP-583 upgrade kits to upgrade the APG-65(V) radar to the next-generation APG-73(V) radar for the F/A-18E/F. In addition, this contract provides for the procurement of two micro-switch parts for assembly of the APG-73(V). Complete August 2005.

Timetable

<u>Month</u>	<u>Year</u>	<u>Major Development</u>
Nov	1975	Full-scale development
Mar	1983	Full production approved, IOC
Dec	1990	Contract awarded for AV-8B radar development
	1992	Scheduled delivery of APG-65(V)-equipped USMC AV-8B Harrier II Plus
Apr	1992	First German ICE APG-65(V)-equipped F-4 delivered
Sep	1992	First flight, Harrier II Plus
	1993	Planned completion of ICE program
Mar	1993	First flight, production Harrier II Plus
Jun	1993	Delivery of first APG-73 to the USMC
	FY94	First remanufactured AV-8B procured
	FY96	First remanufactured AV-8B delivered
Jul	1997	Last Harrier II Plus delivered to Spain
Nov	1997	Last Harrier II Plus delivered to Italy
	FY03	Scheduled last delivery of remanufactured AV-8B (current contracts)

Worldwide Distribution

Australia. Carried on 73 F/A-18s, to be replaced by the APG-73(V).

Canada. Carried on CF-18 aircraft.

Germany. Installed the radar on its fleet of F-4Es.

Italy. Procured 18 AV-8B Harrier II Plus aircraft.

Spain. Carried on 71 EF-18s and will be installed on 13 AV-8B Harrier II Plus.

United States. The radar for USMC F/A-18 fleet. The radar is being installed on 72 AV-8B Harrier II Plus aircraft. The Marines once expressed an interest in buying an additional 26 remanufactured Harriers.

Forecast Rationale

The major platform for the APG-65(V) radar and its upgrades has been the F/A-18C/D. The radar performs both air-to-air and ground-to-air missions well, making separate systems and aircraft unnecessary. During combat, the pilot can switch to the air-to-air mode, engage in a dogfight, and return to the air-to-ground mode with little or no mission disruption.

However, after five generations of hardware and software upgrades the processor reached the limits of its capabilities, so a new radar, the APG-73(V), replaced the APG-65(V) radar on new F/A-18s. The APG-73(V) uses many APG-65(V) components, primarily replacing the processors and power supply.

The final production and procurement supports the AV-8 Harrier II Plus, the radar configuration of the V/STOL (vertical/short-take off and landing) aircraft, and some combat spares. U.S. F/A-18C/D production transitioned to the APG-73(V), but not all FMS aircraft will be equipped with the new radar, and there are no plans to upgrade the AV-8B to the APG-73(V).

The radar-equipped Harrier II Plus has a dual-purpose mission as military maritime patrol and anti-ship aircraft, expanding international procurement possibilities. Since FY95, all new-production Harrier II Plus production has been for the international market. Deliveries of new-production Harrier II Plus aircraft ordered by the U.S., Italy, and Spain have been

completed. Spain took delivery of its last new Harrier II Plus in July 1997, and Italy took delivery of its final Harrier II Plus in November 1997.

The radar forecast includes an estimate for wartime spares unit production. A Harrier replacement will be available when the STOVL version of the F-35 Joint Strike Fighter (JSF) becomes operational.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR PRODUCTION

Designation	Application	Thru 03	High Confidence Level				Good Confidence Level				Speculative			Total 04-13
			04	05	06	07	08	09	10	11	12	13		
APG-65	AV-8B HARRIER II PLUS (FMS) (VARIOUS)	50	6	0	0	0	0	0	0	0	0	0	0	6
APG-65	Prior Prod'n:	1398	0	0	0	0	0	0	0	0	0	0	0	0
APG-65(V)	Prior Prod'n:	84	0	0	0	0	0	0	0	0	0	0	0	0
Total Production		1532	6	0	0	0	0	0	0	0	0	0	0	6