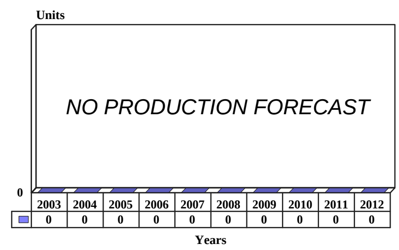
APG-66(V) - Archived 10/2004

Outlook

- In production and service; ongoing logistics support
- MLU upgrade kits boost performance to near APG-68(V) levels
- 23-year sustainment contract awarded

10 Year Unit Production Forecast
2003-2012



Orientation

Description. Airborne, coherent, multimode, digital fire-control radar.

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

Contractors
Northrop Grumman Corp
Electronic Systems Sector
PO Box 17319
Baltimore, Maryland (MD) 21203-7319
USA
Tel: +1 410 765 1000
Fax: +1 410 993 8771
Web site: http://www.northropgrumman.com

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

Total Produced. Through 2002, an estimated 2,434 radars and 595 MLU kits had been produced.

Application. Installed on F-16A/B, F-4EJ (Japan), AT-3 (Taiwan), A-4 Skyhawk (New Zealand), BAe Hawk 200 (UK), HU-25C (USCG), PBN BN-2T Turbo Islander (MSSA).

Price Range. Unit cost of the overall radar is approximately US$730,000. The unit cost for the mid-life upgrade kit ranges between US$225,000 and US$250,000. A complete aircraft MLU has been put at roughly US$12 million.

Price is 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.

Technical Data

	Metric	U.S.
Dimensions		
APG-66(V)1		
Weight	134.3 kg	296 lb
Volume	0.102 m^3	3.6 ft^3
Planar array antenna	75.3 x 48.8 cm	29.6 x 19.2 in

	Metric	**U.S.**
Dimensions		
APG-66(V)2		
Weight	115.9 kg	260 lb
Volume	0.097 m^3	3.43 ft^3
APG-66H		
Weight	107.7 kg	237 lb
Volume	0.082 m^3	2.91 ft^3
APG-66T		
Weight	98.4 kg	217 lb
Volume	0.08 m^3	2.91 ft^3
SASS/APG-66(V)		
Antenna	1 x 3 m	3 x 9 ft
APG-66SR		
Planar array antenna	129.5 x 80.6 cm	51 x 32 in

Characteristics	
APG-66(V)1	
Frequency	6.2 to 10.9 GHz
Range	80 nm (max)
Look-down	20 - 30 nm
Look-up	25 - 40 nm
MTBF	140 hr (demonstrated)
MTTR	5 min (flightline)
BIT	95% confidence
	98% fault isolation
Antenna azimuth scan	+/-10º, 30º, 60º
Elevation coverage	1, 2 or 4 bar
Range scales	10, 20, 40, 80 nm
Cooling	Air at 12 lb/min
LRUs	5 plus antenna
	Transmitter
	Low power RF
	Digital signal processor
	Computer
	Control panel
Electronic parts	9,600
APG-66(V)2	
Frequency	9.7 - 9.9 GHz
Pulse width	0.81 - 4µ sec
Range	
Look-down	24 - 36 nm
Look-up	29 - 48 nm
MTBF	> 210 hr
MTTR	5 min
LRUs	3 plus antenna
	Transmitter
	Low-power RF
	Signal data processor
Track-While-Scan	10 targets
AMRAAM multiple shot	6 target shots against 6 threats
Doppler beam shaping	64:1
Range scales	10, 20, 40, 80 nm
Elevation coverage	1, 2, or 4 bar +/- 60°

Characteristics

Antenna azimuth scan	+/-10°, 30°, and 60°
APG-66(V)2A	Detection and tracking range: +25% Reliability: +40% Weight: -16% Color display compatibility System operated by 1553 mux bus control (replaces current control panel, all APG-68(V)5 modes included)
Features	Full-scan Track-While-Scan (10 target) Two-target situation awareness mode multi-tracker Doppler beam sharpening mode (DBS) Improved electromagnetic interference protection Improved ground attack 4 to 1 improved ground map resolution AMRAAM datalink Six-shot AMRAAM mode CW illumination for AIM-7 and Skyflash MICA Improved false alarm rate Mux bus OFP loading
Air combat scan patterns	10° x 60° 30° x 20° 60° x 20° slewable Slewable boresight
APG-66H	
LRUs	3 plus antenna Transmitter Low-power RF Unit Signal data processor (new)
Track capacity	Eight simultaneous
SASS/APG-66(V)	
Frequency	9.7 to 9.9 GHz
Power	
Peak	20 kW
Average	200 W
PRF	500 Hz - 15 kHz
Pulse width	0.285 - 4µ sec
Max instr. range	80 - 160 nm
Detection	
Air/marine targets	120 nm
Ground moving target	60 nm
Antenna	
Elevation coverage	360º or sector scan
Polarization	+/-15º
Patterns	Vertical 0.75º azimuth
Rotation	2.25º elevation
Subclutter visibility	0.5 - 3 rpm
MTBF	750 hr

Characteristics

APG-66SR

Frequency	8 - 10 GHz
Range	78 nm (approx)
Beam width	1.8°
Coverage	360°
Range	60 nm (approx)
Simultaneous tracks	100
MTI gate	> 6 kt to < 53 kt

Design Features. The original APG-66(V) multimode fire-control radar was made up of five functional Line-Replaceable Units (LRUs). Each LRU had a self-contained power supply and was designed for maximum autonomy, logical function, and ease of maintenance with minimum interconnection.

In all current APG-66 radar systems, communication between the radar computer and the other LRUs is via a digital multiplex bus. A dedicated high-speed databus connects the radar computer to the digital signal processor, with the other LRUs communicating via a "party line" bus. Except for the control panel, all radar LRUs are mounted in the nose of the aircraft for easy accessibility from ground level.

The solid-state transmitter (except for a TWT final output tube) includes a solid-state grid pulser, high-voltage power supplies and regulators, and protection and control circuitry.

The pilot selects from among four of 16 available radar operating frequencies. The cockpit-mounted radar control panel controls the radar channel mode, range scale, scan width, and elevation bar scan. The F-16's avionics system can, in many circumstances, control some radar functions.

The low-power RF module includes a receiver protector, low-noise Field Effect Transistor (FET) amplifier, receiver, analog/digital converters, stable local oscillator, and the system clock generator. This LRU executes all necessary analog processing of the radar return signal and also supplies a frequency agility capability for certain air-to-surface modes. The digital signal processor handles clutter rejection and other radar signal processing.

The radar computer controls the APG-66(V)'s operating modes, commands the digital signal processor to embed symbols in the video output, carries out calculations, routes information to the fire-control computer, and interacts with other F-16 avionics systems and other radar LRUs while also directing all of the self-test and built-in-test features of the APG-66(V). The computer has 48,000 16-bit words of programmable, semiconductor read-only memory. The radar computer uses a serial digital databus (called digibus) to control all radar functions.

The nose-mounted planar array antenna is gimbaled in two axes. It supplies high-gain and low sidelobes over all scan angles.

The APG-66(V)2 is an enhanced version of the radar developed as part of the F-16 Mid-Life Upgrade Program and will become the standard APG-66(V). Key improvements are a 25 percent gain in detection and tracking range, a 40 percent improvement in reliability, and an overall 10 to 15 percent improvement in performance. Processing speed has been increased seven times with the addition of 20 times the non-volatile memory. A Doppler correlator reduces the false-alarm rate by classifying returns as either ground movers, weather, mutual interference, or sidelobe returns. The weight of the system is reduced by about 54 pounds (24.5 kg) and the radar is consolidated into three LRUs.

The update includes:

- A newly developed signal data processor fully programmable with an IBM PC
- A higher power and duty cycle transmitter
- Low-power radio frequency reliability and maintainability improvements for faster data throughput, greater sensitivity, and wider dynamic range
- Faster antenna phase shifters

The new design consolidates the functions of the radar computer and digital signal processor, reducing system volume 16 percent and system weight 18 percent, with 14 percent less dissipated power and 19 percent less cooling air needed. At the same time, it increases processing power six times and non-volatile memory seven times. Circuit board count drops from 45 to 14. The signal data processor uses advanced VLSI 32-bit floating point devices and modern programming language. Navigation and targeting lines of sight are generated simultaneously and can be steered independently.

The processor design includes options for operational mode growth. The enhanced radar was designed for multisensor processing, such as its combination with the Falcon Knight forward-looking infrared (FLIR) sensor.

Allowances are made for growth into the helmet-mounted sight (HMS) FLIR steering interface.

Operational Characteristics. In the air-to-air role, the APG-66(V) offers four modes of operation in all-aspect/all-altitude coverage:

- LOOK UP for search and tracking above the horizon
- LOOK DOWN for search and tracking below the horizon
- AIR COMBAT for automatic target acquisition in aerial dogfights
- AUTOMATIC for automatic selection of look-up or look-down modes

Either the pilot selects the operating mode or the fire control computer automatically selects the one appropriate to the situation. The pilot can select the automatic mode via a switch on the throttle grip. This action immediately configures the aircraft for a dogfight engagement.

For close-in combat, the automatic mode is selected, and the radar automatically acquires and tracks the first target it encounters while scanning the head-up display (HUD) field of view. In this mode, the radar provides the AIM-9 missile with pointing information. Provision has been made to provide illumination for the AIM-7 missile if desired.

In the air-to-surface role, nine modes of operation are available:

- MAPPING mode provides the pilot with an all-weather map of the ground area in front of the aircraft; ranges are selectable.
- EXPANDED mode centers an enlarged version (4:1) of the mapping mode on the tracking cursors.
- DOPPLER BEAM SHARPENING mode enhances the mapping mode for an 8:1 improvement in range and azimuth coverage.
- SCAN-FREEZE mode displays a frozen ground map and the aircraft's motion relative to the ground. The F-16's inertial navigation system provides aircraft movement data, while the radar transmitter can periodically update the map display.
- AIR-TO-GROUND RANGING mode provides real-time measurement of distance to a designated ground point; this mode enhances weapon delivery.
- BEACON mode is used for navigation and rendezvous with tanker or other aircraft.
- SEA-SURFACE SEARCH MODE (SEA 1) uses frequency agility technology for detection of ships in conditions up to sea-state four.
- SEA-SURFACE SEARCH MODE (SEA 2) provides a similar search in higher sea-states by using a narrow Doppler notch filter. This mode can also provide a moving target indicator capability for certain ground targets such as tanks.
- FREEZE mode freezes expanded and unexpanded air-to-ground displays at the moment the command is detected by the system, ceasing further RF emissions yet continuing to depict ownership position over the frozen map.

The APG-66(V)2 mid-life upgrade adds the following mode options:

- TRACK-WHILE-SCAN (TWS) mode provides high track quality information on up to 10 targets, as well as search information on a radar-controlled volume of +/-60°/+25°.
- FOUR-TARGET SITUATIONAL AWARENESS mode simultaneously tracks four targets positioned anywhere within the full +/-60° azimuth and elevation volume of the radar, optimized for AMRAAM and high kill probability.
- SITUATIONAL AWARENESS mode is a multi-track enhanced version of the Track-While-Scan mode combined with SAM to automatically provide optimum illumination of target formations while maintaining track on widely split formations.
- HIGH ACCURACY TRACK mode improves tracking by employing special techniques to reduce the effects of amplitude scintillation and glint.
- GROUND MOVING TARGET INDICATION (GMTI) mode utilizes coherent processing to detect small, slow-moving surface targets.
- MEDIUM DOPPLER BEAM SHARPENING mode provides increased azimuth sharpening and smaller range cells to 80 nautical miles.
- FIXED TARGET TRACK mode provides the capability to acquire and track either fixed ground targets or moving targets over the ocean or desert.
- SAM IN GROUND MAP mode allows low- to medium-resolution maps to be interleaved with the situational awareness mode.

The APG-66(V) was designed for single pilot operation. All combat-critical radar controls are incorporated into the throttle grip and side stick controller. The left console includes all other radar controls. The HUD and the radar display show air-to-air data.

APG-66(V)

Source: Northrop Grumman

Variants/Upgrades

The APG-66(V) radars in the USAF fleet received COTS (commercial off-the-shelf) processors produced by Mercury Computers. The RACE multiprocessor technology uses a Mercury 6U PowerPC AltiVec processor board with RACE++ architecture. This is the next-generation RACE switched fabric architecture that increases the aggregate bandwidth of RACE crossbars from 480 Mbps to 1 Gb.

APG-66(V)2 - Mid-Life Upgrade (MLU). The F-16A/B fleets of Belgium, Denmark, the Netherlands, and Norway are receiving upgraded avionics, including increased range and mode enhancements to their APG-66(V) radars. Modification kits were approved in 1993, with plans for upgrading 301 aircraft with the new radar kits. The MLU kit (ECP-170) consists of new antenna components, new low-power RF components, new rack hardware, transmitter kits, a new signal data processor, and a revised operational flight program.

The F-16 MLU adds an enhanced mission computer, improved datalinks, and an automatic target handoff system, as well as navigation and cockpit improvements. The enhancements to older Block 10 and Block 15 F-16A/B aircraft bring them up to a standard close to that of new-production Block 50 F-16s. Plans call for making this the standard APG-66(V) radar. Other users, including Portugal and possibly Singapore, will procure the upgrades.

An upgraded version of the processor, the modular mission computer (MMC), has been developed for the MLU and is being installed in F-16 Block 40/50 aircraft to replace the general avionics computer (GAC).

APG-66(V)3. MLU radars are being supplied to Taiwan for up to 150 F-16A/B aircraft. They are suitable for the less-capable AIM-7 Sparrow air-to-air missile.

APG-66(V)5. This version is carried by the two AEW radar-equipped P-3B aircraft used by the US Customs Service for drug interdiction patrols.

APG-66J. The APG-66(V) radar was slightly modified to give the F-4EJ the capability of carrying the Advanced Medium-Range Air-to-Air Missile (AMRAAM), and provides Japanese F-4EJs with a look-down/shoot-down capability and other air-to-air and air-to-ground mode improvements. Plans called for modification of 100 aircraft.

APG-66(V) ADF. In 1986, the USAF selected a modified F-16A as the new air defense fighter (ADF) to be flown by all 11 Air National Guard units assigned to the air defense mission. A total of 270 F-16As were transferred to the ANG units starting in early 1988.

Adding a continuous wave illuminator to the radar's antenna made it possible to illuminate targets for the AIM-7 Sparrow missile. The improved ADF is scheduled to carry the AIM-120 AMRAAM.

The aircraft includes interface units compatible with the new Infrared AIM-9 Sidewinder, as well as an AIM-20/AIM-7 dual-mode launcher. The radar software was updated to improve the radar's ability to detect and track small airborne targets such as cruise missiles.

APG-66Z. In February 1987, New Zealand awarded a contract for 22 APG-66(V) radar systems to equip two squadrons of A-4 aircraft.

The APG-66Z retained the air-to-air modes, but incorporated a maritime search-and-track capability for the A-4 mission. The radar has a smaller antenna diameter because of space limits. Smiths Industries was responsible for avionics integration, which included a HUD, a multifunctional display, and an ALR-66 radar warning receiver.

APG-66H. In 1991/92, British Aerospace selected this variant of the APG-66(V) as the radar fit for the

Hawk 200, a single-seat fighter version of the Hawk trainer. To fit the Hawk, designers reduced the number of LRUs to four by combining the digital scanner processor and computer into a single data processor. The radar has multiple air-to-air and air-to-ground modes. It features significant commonality to the standard APG-66.

The Hawk 200 was aimed at the light fighter market. Saudi Arabia is believed to have been the first recipient of the Hawk 200 as part of a large aircraft order with the United Kingdom. Over 170 Hawk 200 aircraft are expected to be built in the near future.

APG-66T. This is a smaller and lighter variant that was created for the F-5 retrofit market, in particular for Thailand’s F-5 program. The RTAF originally planned a second phase to its upgrade program that would include a radar update. Structural problems with many F-5s precluded any significant upgrade funding by the RTAF. The US Navy has tested the coherent, multimode radar successfully on USN F-5F aircraft for use in aircrew training operations against a modern, sophisticated radar.

Taiwan has decided to modernize its entire fleet of 50 indigenous AT-3 trainers to make them attractive to potential export customers as a ground attack aircraft. The upgrades will extend the life of the AT-3s by another 15 years. The AT-3 would be the first fighter/trainer exported by Taiwan. The APG-66T would be part of the upgraded avionics. Reports are that one unidentified customer is interested in at least 20 of the aircraft.

SASS/APG-66(V). An APG-66(V) radar can be mounted under the small aerostat surveillance system (SASS), a 31-meter, helium-filled balloon. The sensors are used primarily along suspected drug smuggling routes. When deployed at 2,500 feet, SASS provides roughly 15,000 square miles of coverage. The antenna is stabilized relative to the horizon.

The unmanned balloons can provide up to 14 days of continuous coverage between maintenance intervals. Power cables and fiber-optic signal/control lines are part of the mooring tether. The system is typically tethered to a ship or trailer.

Air-to-air search models, sea modes, map modes, and weather detection modes are used in the aerostat configurations. The display uses a high-resolution graphics monitor, presenting both artificial video, PPI format, and various display aids. The SASS can be linked to other nodes, such as JSTARS ground station modules or a SASS remote sensor monitoring system. Although there were problems keeping aerostat radar pickets in the air during some weather conditions, the Department of Homeland Security has expressed renewed interest in the concept.

APG-66SR. An APG-66(V) mounted on the nose of a Northrop Grumman/Pilatus Britten-Norman Ltd Multi-Sensor Surveillance Aircraft (MSSA). The radar is combined with a WF-360 infrared imaging system to produce a platform for international/maritime surveillance. It is aimed at the international security market and can be used for both military and law enforcement missions. It features a larger planar array, 360-degree coverage and a maritime surveillance mode. Range performance is increased about 30 percent because of the new antenna.

The first order for one aircraft came from Turkey, which had an option for four more. The program was terminated in 1993.

Loiter time, low cost, and simple operation were key selling points for the MSSA. The aircraft can loiter for six to seven hours and can operate with as few as two crew members. Operational modes included air-to-air, mapping, moving target indicator, and weather avoidance.

ARG-1. The nomenclature of the APG-66(V) for the Argentinian A-4 upgrade.

Program Review

Background. The APG-66(V) radar was developed specifically for the largest international coproduction aircraft program in history, the F-16. The radar design emphasized simplicity and eliminated hydraulics, rate and roll gyros, and bulky components. The result was a modular, solid-state radar with multiple operating modes and excellent jamming resistance.

The APG-66(V), developed from the Westinghouse WX-200, was designed to be the fire control radar for AIM-7 Sparrow and AIM-9 Sidewinder missiles. In FY86, the Operational Capability Upgrade (OCU) developed a datalink from the aircraft’s computers to the APG-66(V). Better countermeasures for the radar were also developed. FY87 efforts expanded memory to enhance the radar’s electronic counter-countermeasures (ECCM), while in FY88 engineers improved the APG-66(V) to give it greater ECCM capabilities and increase its effectiveness in air-to-air combat.

Surveillance Applications. The US Customs Service operates Cessna Citation IIs equipped with APG-66(V)s. Five modified Citation II business jets were put in service to perform high-speed interception of suspected drug-smuggling aircraft. The Cessnas are also equipped with a fixed forward-looking infrared (FLIR) detection system, and include operators for both the radar and the FLIR system.

The Customs Service purchased eight modified Piper Cheyenne IIIs in 1986 and exercised an option for eight more in 1987. As their mission was long-endurance surveillance, the aircraft were equipped with additional nacelle fuel tanks for seven-hour flights. The aircraft had larger noses to fit the APG-66(V), and were configured to carry a night vision system.

The US Coast Guard installed the APG-66(V) in nine HU-25C Falcon twin-engine jets deployed for drug interdiction surveillance.

In June 1993, the Republic of Turkey had plans to purchase the first MSSA aircraft for border surveillance and emergency response, and had options for four more aircraft. Delivery was scheduled for August 1993. In April 1994, however, the contracts were put on indefinite hold for budgetary reasons.

The test aircraft was tried as a surveillance platform during the Branch Davidian standoff in Waco, Texas, in March 1993. The situation did not lend itself to effective use of the MSSA, company sources said.

In 2001, the US Coast Guard announced that it would upgrade the APG-66(V) radars in its nine HU-25C drug-intercept aircraft. The enhancements would increase detection range, reduce false targets, lower the failure rate, and reduce size and weight. Other enhancements include better control display units, improved electro-optical sensors, and further aircraft upgrades. The last aircraft will report to the Miami (Florida) CGAS in early 2002.

Mid-Life Upgrade. The U.S., Belgian, Danish, Dutch, and Norwegian air forces agreed to jointly develop and implement a major upgrade of up to 533 Block 10 and Block 15 F-16A/Bs. The original cost estimate for the effort was US$2 billion and covered improving the mission computer and datalinks, installing an automatic target handoff system, and upgrading the APG-66(V), as well as making other navigation and cockpit improvements.

A three-year, US$370 million project was launched to develop the improvement kits needed, with the planned production phase running from 1996 to 2000. The Northern NATO nations saw the update as necessary to keep their fleets effective through 2020. (Retrofit planning had been initiated in FY92 and the mission computer upgrade for Block 50 aircraft started.)

MLU Background. In FY93, the MLU kit production contract was awarded, and a kit was installed in an aircraft for trial verification. After debate, the European nations decided in June 1993 to continue with the MLU program.

Original purchase estimates were Belgium, 110 (reduced to 48); Denmark, 61; the Netherlands, 170 (reduced to 136); and Norway, 56.

From May 17 to June 3, 1994, the capabilities of the APG-66(V)2 were demonstrated to other possible European buyers in Spain and England. This followed demonstrations in Holland and Norway for the four MLU members mentioned above. The idea was for the customers to use the radar in the actual northern European environment in which their aircraft would operate. It gave the company an opportunity to show customers that at the mid-design point the radar was operating according to specifications.

During the field trials on a BAC-1-11 test aircraft, the APG-66(V)2's performance surpassed expectations; it was possible to demonstrate the radar in the high electromagnetic interference environment of the Netherlands and in the high clutter environment of the fjords of Norway. According to company officials, the demonstration radar doubled range detection, reduced false alarms by a factor of 10, and simulated six AMRAAM shots. Ground mapping was improved and demonstrated out to 80 nautical miles, and the buyers had the opportunity to see the full-color display.

In demonstrations to other potential buyers, engineers emphasized design maturity and growth potential. The upgraded radar's performance was nearly that of the APG-68(V) installed in the F-16C/D, and it permitted use of the AMRAAM with a smaller, lighter radar system – both excellent selling points.

In 1994, Taiwan decided to procure the MLU radar with its purchase of up to 150 F-16A/Bs. The RoC originally wanted the APG-68(V), but accepted the APG-66(V) once the MLU performance was demonstrated. The contract was computed to be worth up to US$195.8 million, and production extended from 1996 through 1999.

The US originally planned to upgrade 130 older F-16s in service with the Air National Guard and Air Force Reserve. But in mid-1992, the US indicated that it was seriously considering dropping out of the Mid-Life Upgrade Program because the enhanced aircraft would be nearly the same standard as the Block 50 airframes going into service. The US update decision was made more definite with a plan to continue purchasing Block 50 F-16C/Ds equipped with the APG-68(V) through 1996 or later.

The US decision became a political issue, since it could increase cost by an estimated US$3 million to US$4 million per aircraft. But (then) Secretary of Defense Les Aspin announced his support of the upgrade plan in

1993. This support stemmed in no small part from the European decision to continue. Instead of upgrading all A/B aircraft, the USAF would incorporate the new MLU mission computer in up to 223 Block 50 C/D aircraft. A decision on backfitting the computer into Block 40 aircraft was deferred.

Other Upgrades. In December 1993, the Naval Air Warfare Center announced its intention to issue a sole-source contract for the upgrade of 14 APG-66(V) multi-mode radar systems. The effort would IFF and software changes. According to the announcement, the upgrade would cover both antennas and the signal data processor. The Navy also announced that it intended to purchase six complete APG-66(V) radar systems, including antennas, signal data processors, transmitters, racks, and interconnecting cables.

In 1994, Portugal purchased 20 new F-16A/Bs under the Peace Atlantis program.

In October 1996, the APG-66(V)2 successfully completed its Developmental Test and Evaluation at Leeuwarden Air Base in the Netherlands. Nine test missions, in both air-to-air and air-to-ground modes and including 17 radar sorties, were flown in 37 flight hours. The tests concentrated on air-to-air testing using low-altitude look-up and medium-altitude look-down modes over terrain of varying clutter. Reports indicated that the radar's performance exceeded specifications. Operational Test and Evaluation flight plan development began immediately.

In the FY97 Defense Authorization, the US Air Force was authorized to purchase six new Block 50 F-16s. This supported the service's final decision to acquire new aircraft instead of upgrading older airframes with the MLU. The decision was an economic one based on the amount of life left in the airframes, not shortcomings of the update itself. Many newer Block 40 F-16s could receive upgraded avionics, but they are not nearing the end of their flying hours.

In a February 1997 *Commerce Business Daily*, the Naval Research Laboratory announced plans to award a contract to Northrop Grumman to provide flight services support for testing of the APG-66(V) radar for the F-16 fighter. The effort would evaluate the F-16 in an at-sea Fleet test environment.

In November 1997, the DoD announced that Portugal had requested 20 MLU modification kits for its F-16A/B aircraft. With spares, training, and support, the value of the procurement could total US$185 million.

In December 1997, an MLU-upgraded APG-66(V)2 was involved in the first AIM-120 AMRAAM launch from a Danish F-16 assigned to the F-16 Combined Test Force at Edwards AFB, California. The radar performed very well during the entire test, demonstrating the integration of AMRAAM with the MLU configuration.

In late 1998, Portugal signed a Letter of Offer and Acceptance to acquire an additional 25 F-16A/B aircraft from existing USAF inventory under the Peace Atlantis II program. The aircraft would be removed from U.S. storage and shipped to Portugal where the modifications, including structural upgrades and the installation of MLU kits, would take place between 2001 and 2003. The Peace Atlantis II effort was valued at US$286 million. The Portuguese Air Force then said it was considering upgrading other F-16s with the MLU; the DoD recently announced that Portugal has requested 20 MLU kits.

In February 1999, Lockheed Martin received authorization to execute an option for 18 additional F-16A/B mid-life upgrade kits for the Belgian Air Force. The US$46 million addition was to begin in March 2002 and be completed in June 2003. The kits would be installed by SAVCA in Belgium.

A March 1999 *Commerce Business Daily* announcement reported that the United States Customs Service intended to negotiate a sole-source contract for four complete APG-66(V)2 upgrade kits plus spares. The radar systems would be integrated into four US Customs Service aircraft with an upgraded antenna system, an IFF interrogator, and a commercial off-the-shelf (COTS) processing and display system. The contract would include an option for four additional radar upgrade kits.

A June 1999 *CBD* announced that the US Coast Guard intended to procure 12 AGP-66(V)2 mid-life upgrade kits for installation on nine HU-25 aircraft and to upgrade two test benches.

At the Paris Air Show in June 1999, Northrop Grumman announced that it had been awarded three separate contracts for APG-66(V)2 MLU kits plus spares. Collectively, the contracts would provide 45 radar kits to the Belgian Air Force, 25 kits to the Portuguese Air Force, and two kits the USAF. Completion of the contracts was set for early 2002.

A July 1999 notice announced that New Zealand would lease 28 existing F-16A/B aircraft for five years. The aircraft would be similar to international versions, but the announcement made no mention of an MLU upgrade.

A July 2000 notice from the Pentagon officially notified Congress that Portugal had requested the sale of 20 MLU modification kits for its F-16s. Estimated cost was put at US$100 million. This would be the production phase follow-up to the EMD effort.

In February 2002, the US Air Force awarded Northrop Grumman a firm fixed-price, time and material and cost reimbursement no-fee contract valued at up to US$487 million for engineering services and technical support for the F-16 APG-66(V) and APG-68(V) radars for a sustainment period of 23 years. The program is known as FALCON 2020 Radar. The effort would support both U.S. and Foreign Military Sales needs. Plans are for the F-16 to be in service at least through 2020.

FALCON 2020 provides flexible terms and conditions, making it easier for the DoD to contract with suppliers. Actual disbursements will depend on customer needs and available funding. The 16 countries participating are Bahrain, Belgium, Denmark, Greece, Israel, Jordan, Korea, the Netherlands, Norway, Portugal, Singapore, Taiwan, Thailand, Turkey, Venezuela, and the United States.

Funding

U.S. FUNDING

	FY02		FY03		FY04(Req)		FY05(Req)	
	QTY	AMT	QTY	AMT	QTY	AMT	QTY	AMT
RDT&E (USAF)								
PE#0207133F								
F-16 Sqdn (total)	-	107.0	-	81.6	-	87.5	-	99.9

Note: This effort covers a variety of upgrades and enhancements.

All US$ are in millions.

Recent Contracts

(Contracts over US$5 million.)

Contractor	Award ($ millions)	Date/Description
Northrop Grumman	5.9	Mar 2000 – Contract for supplies and support line items for USCG APG-66(V) upgrades. (DTCG23-00-C-EA9133)
Northrop Grumman	487.0	Feb 2002 – FFP time and material cost reimbursement no-fee contract to provide for engineering services and technical support of the F-16 APG-66(V) and APG-68(V) fire control radar sustainment for a 23-year period. The Air Force can issue delivery orders totaling up to the maximum amount, although requirements may necessitate less than the amount approved. (F42620-01-D-0076)

Timetable

Month	Year	Major Development
Nov	1975	FSED contract awarded
Jun	1977	Initial production models delivered
	1980	AMRAAM integration contract begins
Jul	1984	Japan's improved F-4EJ prototypes flown
Jan	1985	US Navy selects APG-66(V)-equipped F-16Ns for its aggressor aircraft
May	1985	Westinghouse awarded contract by US Army for APG-66(V)-equipped Aerostat
Jun	1986	Completion of delivery of APG-66(V)-equipped Cheyenne IIIs WX-100 radar based on APG-66(V), Japan begins retrofitting F-4EJ APG-66(V) upgrade
Feb	1987	Japan begins retrofitting F-4EJs; Westinghouse awarded contract to provide radar for New Zealand A-4s
Apr	1987	First deliveries of F-16N
Feb	1992	FSD of MLU begins, MLU SDR
	1993	MLU PDR
1Q	FY94	MLU hardware CDR

Month	Year	Major Development
Sep	1994	Award for MLU (301 NATO) update kits
Nov	1994	Taiwan selects APG-66(V)3 for F-16A/Bs
1Q	FY95	MLU CDR
3Q	FY95	Start of MLU DT&E
	1995	MLU in-flight trial verification
Jan	1995	APG-66 (ARG-1) selected for Argentinean A-4 upgrades
Aug	1996	MLU DT&E complete
	FY97	First MLU kit deliveries
Jan	2000	MLU production (NATO) complete
	FY02	MLU retrofit complete (current contracts)
	2020	Projected life of F-16

Worldwide Distribution

The F-16A/B is the primary platform for the majority of APG-66(V) radars now in service. The aircraft are operated by:

Argentina. Selected for installation on 36 refurbished A-4s; to be called the ARG-1
Belgium. 132 F-16A/B (MLU)
Denmark. 63 F-16A/B (MLU)
Egypt. 45 F-16A/B
Indonesia. 12 F-16A/B
Japan. 110 F-4E/J Phantom IIs
Netherlands. 184 F-16A/B (MLU)
New Zealand. 20 A-4 Skyhawks. Will lease 28 F-16A/B Block 15 aircraft to replace selected A-4s
Norway. 59 F-16A/B (MLU)
Portugal. Requested 20 modification kits and plans to acquire more for an added 25-aircraft purchase
Singapore. 6 F-16A/B
Taiwan. Planning to install the radar on 30 more AT-3 fighter/trainers for the export market. Twenty reportedly already installed on AT-3s
Thailand. 18 F-16A/B
Venezuela. 24 F-16A/B
United Kingdom. Installed on Hawk 200 aircraft
United States. Used on the Coast Guard's HU-25C Falcon and the Customs Service's Piper Cheyenne surveillance aircraft. The APG-66(V) also equips the F-16N, the Navy's aggressor training aircraft

The APG-66H:

Indonesia. 16 Hawk 200
Malaysia. 18 Hawk 200
Oman. 12 Hawk 200
Spain. Interested in a system similar to the MSSA model for its Guardia Civil
Turkey. Ordered 1 to 4 MSSA aircraft, then put the contract on hold

Forecast Rationale

The APG-66(V) multimode radar is used throughout the world, and this radar has been something of a baseline for many uses. It has found life on platforms other than the F-16, and was picked for several retrofit programs, including programs in Japan and Argentina. As this radar is the standard for much of the world's military air power, a variety of upgrades and adaptations make the APG-66(V) a true multimode, multimission sensor. The mid-life upgrade (MLU) improved the operational capabilities of the radar significantly by increasing its processing power.

The full MLU will not be accomplished on older USAF F-16s because the cost of new Block 50 aircraft was worth the extra expense (US$20 million for a new

Block 50 versus US$12 million for a complete upgrade); the aircraft that would have been upgraded already had upwards of 4,000 hours flying time on their airframes. A Block 10 or 15 F-16 upgraded with the MLU became a Block 20 aircraft.

The MLU reduced the objections many FMS purchasers had to F-16A/B aircraft. Taiwan’s acceptance of the aircraft with MLU kits instead of a full APG-68(V) showed the positive impact the upgrades had in the marketplace. The large number of aircraft in service guarantees a very healthy spare and repair parts market for some time to come.

The APG-66(V) will continue to expand its retrofit and modernization potential with several differing aircraft applications. The MLU performance enhancements make the radar very attractive to nations that cannot or will not purchase the F-16C/D. Installing a kit brings the radar’s performance nearly up to that of the APG-68(V), the selling point for Taiwan, which wanted the APG-68(V) for its 150 new F-16s.

Ten-Year Outlook

No further production expected.

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