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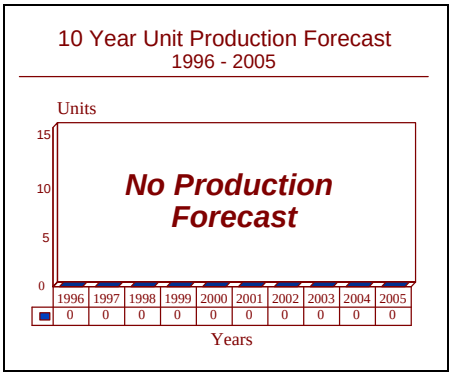
APQ-164(V) - Archived 11/97

Outlook

- In service; on-going logistics support
- No further production expected
- Conventional weapons, ECM upgrade now underway, may necessitate some radar software upgrades



Orientation

Description. Airborne, multi-mode, phased-array radar.

Sponsor
US Air Force
AF Systems Command
Aeronautical Systems Center
Wright Patterson AFB, Ohio (OH) 45433
USA
Tel: +1 216 787 1110

Contractors
Northrop Grumman Corp
Electronic Sensors & Systems Division
PO Box 17319
Baltimore, Maryland 21203-7319
tel: +1 (410) 765-1000
fax: +1 (410) 993-8771
USA
[formerly Westinghouse Electronic Systems Group]
(Prime)

Status. In service, ongoing support.

Total Produced. A total of 105 units were produced.

Application. B-1B bomber.

Price Range. Approximately US$ 6,000,000 each (est).

Technical Data

Dimensions	Metric	US
Weight:	570 kg	1,256 lb
Antenna:	55.9 X 111.8 cm	22 X 44 in
Characteristics		
Frequency:	8 to 20 GHz	
Reliability:	99% probability of completing a 15 hour mission	
Range Scales:	10, 20, 40, 80, 160 nm	
Azimuth scan:	✂ 10, ✂ 30, ✂ 60 degrees	
Patch size:	Selectable	
Range Resolution:	Selectable	

NAVIGATION/PENETRATION

High Resolution Mapping:	Provides a high-resolution synthetic aperture radar image of a ground patch
Real Beam Ground Mapping:	Provides precise inertial input for INS update or backup
Automatic Terrain Following:	Provides a range versus height profile of 10 nm path ahead of aircraft and inputs data to terrain following unit. Differentiates between rain, terrain, towers and interference
Manual Terrain Avoidance:	Operator controlled terrain avoidance
Mode Interleaving:	The radar performs other functions between terrain following/avoidance operations. TF scan rate determined by altitude, terrain characteristics, and aircraft speed

OPERATIONAL/WEAPON DELIVERY MODES

Velocity Update:	Functions as a Doppler navigator to input aircraft velocity information into standoff weapon computer
High Altitude Calibrate:	Provides extremely accurate altitude information above the 5,000 ft radar altimeter limit
Weather Detection:	Displays weather characteristics, especially rain areas. Circular polarization selection allows mission penetration without radar rain clutter
Beacon:	Decodes and displays airborne or ground beacon information
Rendezvous Mode:	Air-to-air radar search for tanker rendezvous. Overcomes short-range limits of beacon methods
GMTI/GMTT:	Ground-Moving Target Indicate/Ground Moving Target Track displays ground targets moving at greater than a set velocity

Design Features. The unique APQ-164 radar antenna contains 1,526 ferrite-type phase shifter/radiating elements. The complete system consists of the phased-array antenna, receiver/low-power RF, high-power TWT transmitter, microwave switching assembly, beam-steering control bus, signal processor, video signal processor, multiplex bus, and navigator's display. The system is dual-redundant, containing two sets of independent line-replaceable units, except for the antenna. One channel is operational with the other maintained in a standby mode.

The flat-plate, oval antenna incorporates electronic scanning by varying the frequency and phase of the transmitted signal fed to different parts of the antenna. The array uses dialectrically filled circular waveguide radiators with a dual mode ferrite circulator. The ferrite elements are too heavy for use in fighter aircraft, but suitable for applications onboard a bomber such as the B-1B, where the fulfillment of mission objectives takes priority over weight considerations.

Using a single antenna gives the APQ-164 radar the ability to emit a pencil beam which, in turn, provides the radar operator with the highest possible resolution, a characteristic especially valuable during terrain avoidance/terrain following. The antenna is tilted back 30^{o} from horizontal to provide a lower radar cross section to ground threat radars, part of the low-observability design of the B-1B.

The aperture phase can be adjusted to change the beam shape from pencil to cosecant-squared to vertical fan. Polarization can also be changed from vertical to one-sense circular. This can be done with a switchable Faraday rotor in conjunction with a ferrite quarter-wave plate.

The APQ-164 radar is unique in that the entire antenna can be rotated to three positions: its normal forward- looking position, or pointing to either side of the aircraft; thus, the system can function as a side-looking radar, particularly helpful for ground mapping or for supplying the aircraft with navigational updates. When pointing to the side, the radar coverage is from nose-on to about 105° back. This rotating feature of the radar, along with the system's advanced programmable system processor capabilities, ensures that the APQ-164 is capable of satisfying B-1B mission requirements.

Operational Characteristics. As the cornerstone of the B-1B's Offensive Avionics System, the APQ-164 radar system has several mapping and navigation modes to enable the bomber to fulfill its mission of nuclear and conventional weapons delivery. Of the four navigation modes, the primary function is high-resolution synthetic aperture radar mapping, reinforced with a real-beam ground-mapping mode that aids in identifying targets and feeding targeting data to weapons systems There is also weather and beacon capability to display ground-beacon returns over any radar image.

Terrain avoidance/terrain following modes are used extensively as part of the low-altitude penetration function. These modes create a profile of the terrain directly ahead of the bomber so that it can fly close to the ground without crashing in order to avoid, as much as possible, threat air defense radar detection. The radar can provide high resolution maps from 18.5 km^2 down to 1.1 km^2.

For weapons delivery, the APQ-164 provides a velocity update similar to a Doppler navigator, which generates velocity information for the inertial navigation system. There is also a ground moving target detection/track capability and a high-altitude altimeter for accurate measurement of height above ground.

Variants/Upgrades

There are no specifically identified variants. The Air Force began a Radar Signal Processor Upgrade effort in 1993/94. Enhancements capitalize on technology improvements to upgrade the performance of the radar. The plan provides for the following unit procurement schedule:

FY93	FY94	FY95	FY96	FY97	FY98
1	12	23	23	1	16 remainder TBD

A considered update to the system has been the incorporation of all solid-state, active-element phased-array technology, providing a system that would operate at higher frequencies and higher effective power. Northrop Grumman and Texas Instruments have developed the technology for the F-22.

Program Review

Background. The APQ-164 multi-mode phased-array radar system provides the B-1B bomber with data for navigation, penetration and weapons delivery, plus secondary functions such as air-to-air refueling, rendezvous, and guidance.

The system's technology was derived from the Electronically Agile Radar (EAR) and the Westinghouse APG-66 and APG-68 fire-control radars. The 39 in. diameter EAR, a phased-array radar developed in the early 1970s, contained 1,818 phase-shifter/radiating elements. The system was tested for five years with no appreciable degradation in antenna performance and required virtually no maintenance. The radar featured programmable signal processing.

According to industry sources, there is 47-percent parts commonality between the APG-68 and APQ-164. At least two of the B-1B's nine Line Replaceable Units (LRUs) and 47 percent of the sub-components are common with the F-16 radar. Using the Common Programmable Signal Processor, the Modular Low Power RF and Stable Local Oscillator saved an estimated US$ 350 million in development costs.

In December 1981, Westinghouse was awarded the contract for the B-1B radar. A year later the company decided to switch from conventional antennas for ground mapping and terrain avoidance to a single phased-array antenna.

In February 1984, the first radar was delivered for evaluation onboard the B-1A avionics test aircraft. The first production APQ-164 was delivered in March 1984. The last system was delivered in 1988.

Overall, the B-1B's Offensive Avionics System has performed at or close to performance specifications. In the terrain-following mode, the APQ-164 feeds data to the Automatic Terrain-Following System (ATF). The ATF suffered a high rate of unnecessary fly-ups in the past, with the system instructing the aircraft to pitch up fast even though there was no obstacle in its flight path. The Air Force refined the radar and automatic flight software.

On June 17, 1992, Secretary of the Air Force Donald B. Rice announced *"The Bomber Roadmap,"* the plan for the manned bomber in the changed world threat climate. With the bomber force freed from many of the demands of nuclear deterrence, the Air Force would concentrate on conventional capabilities and the rapid response to regional threats. Under the new plan, the B-1B would be either a penetration or standoff platform, adding mass and precision to composite strike packages. The B-1B will be assigned targets in low- to medium-threat arenas with the B-2 handling the toughest penetrating missions.

Through the end of the century, the B-1B will be upgraded and enhanced to accommodate the new missions with the majority of the funding and effort going toward improvements in the weapon systems, ECM, avionics, and communications systems. No significant radar upgrade plans were announced, although some upgrades may be included in avionics upgrades planned after FY94. The major thrust of the upgrades planned is toward integrating conventional weapons delivery systems, anti-jam voice radios, enhancing avionics computer systems, and making reliability and maintainability improvements.

In 1993, the Air Force announced that B-1Bs would be assigned to an Air National Guard unit. Through 1994, the Air Force and Pentagon had been debating the makeup of the bomber force. The number of B-1Bs assigned to reserve status has been an ongoing debate.

In the latter part of 1994, the Air Force conducted a special B-1B Operational Readiness Assessment to determine whether or not, with proper support, the bomber could meet its required operational rate. One squadron, operating with a properly established support system, demonstrated an 84.3 percent operational rate. Most of the problems were with general aircraft system maintenance.

In the FY97 Defense Authorization conference, Congress addressed the B-1B Conventional mission upgrade program. The Pentagon requested US$ 84.4 million for bomber modifications and US$ 220.9 million for research and development. The conferees authorized an increase of US$ 82.0 million to the procurement request for B-1B modifications as follows:

US$ 25.0 million to accelerate competitive procurement of PGM; and

US$ 57.0 million to procure conventional bomb modules.

The conferees also agreed to an increase to the budget request of US$ 8.3 million for defensive systems upgrade program

The conferees said that they were discouraged by the slow pace of conventional PGM integration for the B-1B. Although additional funding was provided in FY96 to accelerate arming of the B-1B bomber force with Joint Direct Attack Munitions and other PGM capability, the conferees said that they were not aware of any significant progress toward this objective. Their funding action was taken to correct this.

The FY97 Defense Appropriations bill was more uncertain. The House recommended a US$ decrease of US$ 13 million in R&D funds; the Senate recommended a US$ 8.3 million increase. A conference to work out the differences was pending.

Funding

US FUNDING

	FY94		FY95		FY96		FY97 (Req)	
	QTY	AMT	QTY	AMT	QTY	AMT	QTY	AMT
RDT&E (USAF)								
PE0604226F B-1B								
4143 Conventional Weapons Upgrade		48.4	-	73.2	-	162.6(a)	-	161.2

RDT&E	FY98		FY99		FY00		FY01	
(USAF estimate)	QTY	AMT	QTY	AMT	QTY	AMT	QTY	AMT
4143 CW Upgrade	-	126.1	-	132.4	-	99.9	-	60.2

NOTE: None of these funds are specifically earmarked for APQ-164 upgrades, although some enhancements and integration work are part of the upgrade. Congressional interest is increasing the pace of funding for the overall B-1B upgrade effort.

(a) The FY97 Defense Authorization recommended increasing this amount to US$ 220.9. The FY97 Appropriation would have to be decided in conference.

All US$ are in millions.

Recent Contracts

Contracts over $5 million.

Contractor	Award ($ millions)	Date/Description
Westinghouse	8.1	May 1995 — FFP contract to upgrade four radar test benches for the B-1B aircraft. Complete May 1999

Timetable

	1974	Development of Electronically Agile Radar begun, with the resultant technology used to develop the APQ-164
	1980	Air Force authorized Westinghouse to develop an improved APG-66, designated APG-68, from which portions of the APQ-164 are derived
	1981	Westinghouse awarded contract to build the APQ-164, a radar using conventional antennas for ground-mapping and terrain-avoidance/terrain clearance
	1982	Westinghouse proposed and the Air Force agreed to a switch to a radar with a single phased-array antenna
Mar	1984	First APQ-164 production radar delivered
May	1984	APQ-164 evaluated onboard Westinghouse-owned BAe 1-11 testbed aircraft
Jul	1984	Evaluation of APQ-164 onboard B-1A test aircraft
Aug	1984	Westinghouse awarded production contract for 92 radar systems
	1985	Full-scale production
	1986	First B-1B squadron began active duty
	1988	Last APQ-164 delivered to Rockwell
Jun	1992	Bomber Roadmap released (future force plans)
	1993	Processor upgrades begun
	1994	B-1B ORA

Worldwide Distribution

This is a **US** only program.

Forecast Rationale

The APQ-164 radar performs adequately for the B-1B, since software improvements eliminated the fly-up problem that troubled earlier operations. Some technology developed for this radar has found its way into the next generation of aircraft, with engineers incorporating APG-68 and APQ-164 features and hardware into the APG-77.

The B-1B's new mission has a heavy emphasis on conventional weapons delivery, which means that the radar will be adequate for some time to come. Without the strategic deep penetration requirement, the bomber will not be as dependent on very low-level terrain- following tactics as the original concept called for. This reduces the need for advanced radar upgrades in the future. Possible avionics enhancements may include minor software upgrades to the APQ-164.

The B-1B upgrade effort, and Congressional concern, has focused on the B-1B's defensive ECM equipment and the bomber's history of maintenance problems. None of the concerns involve the APQ-164, but the system is a bystander and is impacted by decisions regarding overall funding. The Operational Readiness Assessment showed what could be done with adequate support, making a good case for proper funding in the future. Capitol Hill attention in FY96 and FY97 have put the upgrade process into motion. Criticism and complaint is being replaced by funding and pressure for action.

The bulk of the conventional weapons upgrades involve changing the aircraft's carry and delivery systems, but some interface and mode enhancement for the APQ-164 must be considered likely. Most of the effort can be accomplished with software changes.

APQ-164 radar production is complete, although there is an ongoing logistics requirement for operational equipment and limited upgrades.

The demonstrated reliability of the radar system's components reduces the parts support needed to keep the equipment operational. There is no market for new systems, but the concept and technology have been used in newly developing systems for the next-generation aircraft, enhancing the component and sub-component market.

Ten-Year Outlook

No further production planned.

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