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FPS-118 (OTH-B) - Archived 8/96

Orientation

Description. Very long-range strategic surveillance radar.

Sponsor
US Air Force
Electronic Systems Center
Hanscom AFB, MA

Contractors
Lockheed Martin Corp
Ocean, Radar and Sensor Systems
Syracuse, NY
(prime)

Aydin Corp
Computer Systems Division
Horsham, PA
(radar control & display system)

Continental Electronics
Dallas, TX
(transmitter subsystem subcontractor)

Digital Equipment Corp
Bedford, MA
(VAX Computers)

GTE Government Systems Corp
Communications Systems Division
Waltham, MA
(Communications equipment)

MITRE Corp
Bedford, MA
(engineering support)

SRI International
Remote Measurement Laboratory
Menlo Park, CA
(engineering support)

TRW Inc
Redondo Beach, CA
(software development subcontractor)

Status. In stand-down, caretaker status.

Total Produced. Two systems (six sectors) have been procured.

Application. Early warning of strategic bomber, air-to-surface missile or cruise missile attack on North America.

Price Range. According to the GAO, the procurement cost per sector was $177.7 million. There is an average $10 million military construction cost per sector.

Technical Data

Characteristics

Frequency range:	5 - 28 Mhz (six bands)
Power output:	1,200 W
Waveform:	FM/CW
Detection range:	500 - 1,800 nm
Basic detection format:	Range vs. time w/nested Doppler
Representation of data amplitude:	Intensity modulation (gray scale)
Height of receive array:	50 ft

Number of subarrays at transmit facility:	6
Number of subarray elements:	12
Length of receive antennas:	5,000 ft
Operating modes:	Normal, Interrogate and Interleaved
Surveillance area of normal mode:	30 degrees wide by 500 nm deep w/four contiguous 7.5-degree by 500-nm azimuth sectors
Number of bands for target location:	3
Beam width at receive facility:	2.5^o

Design Features. The Over the Horizon Backscatter (OTH-B) radar was designed to provide early warning of an attack on North America. The radars were deployed to detect penetrating subsonic and supersonic bombers as well as nuclear-armed cruise and air-to- surface missiles. The DoD also proposed that an OTH-B Central Radar be built to support drug interdiction efforts.

The Experimental Radar Station (ERS) in Maine, the first segment of the East Coast sector, formed the basis for the rest of the OTH-B system, and its features are shared by the other sectors, with some changes incorporated during construction of the later systems.

The OTH-B radar is bistatic, with separate receive and transmit sites about 100 miles apart. The 100-mile separation allows the use of 100 percent duty factor waveforms. It makes use of an FM/CW waveform instead of pulses to minimize radio frequency interference and eliminates the need for high peak power pulses. The two facilities are synchronized by the LORAN C navigation system. Computer control of the receive and transmit functions provides real time adaptation to ionospheric variations.

The 3,650-foot transmission array is comprised of six separate 12-element subarrays, each of which is optimized to cover a specific frequency band in the system's frequency range. Twelve 100 kW transmitters drive the subarrays, giving an effective radiated power of 100 megawatts with 1,200 kW actual output power.

The receiving antenna consists of a broadside array of fan monopole elements that pick up the signal returns. Digital processing results in three simultaneous beams that are step-scanned synchronously with the transmit beam. The signal processor resolves the data into range and Doppler cells and also provides such features as moving target indication, peak detection, parameter estimation, interference suppression, non- coherent integration, and range and Doppler resolution processing.

Bangor ANGB, Maine, houses the operations center which includes the radar control and display system for the East Coast radar system. Components include high resolution detection/tracking consoles, correlation and identification consoles, and a performance assessment console. The basic detection format uses range vs. time with nested Doppler.

OTH-B sites must be located in an electronically quiet area that is large enough to accommodate the massive antennas. The OTH-B radar system detects aircraft by sending high-frequency signals from its transmit antenna toward the ionosphere, the atmospheric layer extending from 50 to 250 miles above the earth's surface. The ionosphere then refracts the signals to the surface. Detection occurs when the transmitted radar signal "bounces off" the aircraft's surface, reflects off the ionosphere and returns to the receive antenna (backscatter). Signal processing refines the faint return signals by separating them from the clutter created by land and sea echoes.

The OTH-B's beam can be steered from 500 nm to 1,800 nm offshore to track aircraft masked from ground-based, line-of-sight radars by the curvature of the earth's surface. This increased detection range is accomplished through the use of very high power and the transmission and return of signals on the high- frequency (HF) band.

There are three operating modes for each 60° OTH-B sector. The normal mode uses a step-scan technique to illuminate a 30° by 500-nautical-mile-deep surveillance area of the 60° azimuth sector. Four adjoining 7.5°- wide azimuth sectors are illuminated sequentially with four parallel receive beams being formed in congruence with each 7.5° sector.

The interrogation mode illuminates a single 7.5° range azimuth sector in order to supply extra detection energy and sharper range, velocity and azimuthal resolution. Finally, the interleaved mode combines the normal and barrier modes in order for system operators to be able to retain barrier surveillance while focusing on a particular target return.

The system uses vacuum tube technology in major portions of the radar. It uses flight plan comparison for target correlation and identification of potential hostile/unknown tracks.

Operational Characteristics. The system provided long-range, wide-area surveillance at all altitudes and at ranges of between 500 nm and 1,800 nm. These performance characteristics of the OTH-B system would increase warning time to help ensure the survival of retaliatory forces and provide decision time for the National Command Authority consistent with ballistic missile warning requirements. OTH-B increases attack warning time from 10 minutes to 90 minutes for supersonic aircraft and from 30 minutes to three hours for subsonic threats.

The Maine (East Coast) OTH-B site coverage pattern overlaps the eastern portion of the North Warning System (NWS). Northern Canada cannot be sufficiently covered by an OTH-B system because aurora borealis and electromagnetic disturbances in the upper atmosphere interfere with OTH-B signal propagation. The NWS, which is replacing the aging DEW line radar, was designed to complement OTH-B coverage and provide a continuous surveillance barrier around North America. The OTH-B system complemented PAVE PAWS and BMEWS early warning sensors.

The original Air Force plan called for the third and fourth systems to be located in the north central region of the USA and Alaska, respectively. A south-looking Central OTH-B would provide 120-degree coverage of the least protected area between the eastern and western radars, commonly referred to as the "skip zone." The Alaskan OTH-B would look southwest toward the Aleutian Island Chain. Plans for these sites have since been terminated.

Variants/Upgrades

There are no variants, although ongoing operational upgrades were planned.

Program Review

Background. In the early 1970s, the Air Force initiated development of an OTH-B system. General Electric was awarded a contract in 1975 to develop an experimental OTH-B facility (ERS). Testing began in 1980 and construction began in 1982.

The ERS's primary elements were a 4,000-ft transmitter and a 5,000-ft receiver array located in Moscow and Columbia Falls, Maine, respectively. The operations center was located at Bangor Air National Guard Base, Maine.

The radar's 60° coverage area included the North Atlantic commercial air routes and an area of significant aurora borealis activity. Thus, the ERS was tested against a large number of aircraft targets and with an ionosphere destabilized by the aurora. After the ERS successfully demonstrated its performance parameters it became the basis of the operational radar. The East Coast experimental radar system was upgraded in FY84 to a fully operational 60° sector.

The Air Force approved development of a West Coast system and began consideration of a south-looking OTH-B. Sites for the transmitter, receiver and operations center for the West Coast radar were selected. The transmitter site is near Christmas Valley, OR. The receiver is about 25 miles north of Alturas, CA, with the operations center at Mountain Home AFB, ID. Procurement of the second sector of the East Coast radar and preliminary planning for the Alaskan OTH-B also began in FY84.

In FY85, the software and hardware component testing for the radar was completed and installed at the site in Maine. Development Test and Evaluation of the initial operating 60-degree sector began. Special tests using this initial sector and other existing OTH radars were conducted to refine the understanding of OTH detection for the south-looking radar sectors and the sectors for surveillance of ocean areas to complement the East and West Coast radar systems.

In FY86, the experimental radar became fully operational, and the initial 60-degree sector began operating in January. This sector demonstrated an ability to detect and track a single aircraft at ranges out to 1,850 miles. Automatic track correlation with enroute traffic reports from the Federal Aviation Administration and the international oceanic control areas was tested successfully. Testing demonstrated sector reliability. The second sector (first production sector) passed transmit subsystem and interference tests.

Planners determined that the OTH-B West Coast radar system configuration would detect and track adequately in the worst year of the eleven-year sun spot cycle and at all hours in the seven best years of the cycle. The Air Force began Environmental Impact Analysis for the Alaskan and Central Radar systems, and negotiated a procurement contract for the West Coast radar system. Work began in June.

During FY87, the initial sector was integrated with the second and third sectors to form the complete East Coast radar system, and extensive testing began. By the end of 1987 the entire system was operational and able to routinely detect aircraft at ranges of 2,000 miles, establish tracks, correlate the tracks with existing flight plans, display the information and perform an alert function on uncorrelated tracks. Tactical Air Command personnel were using the radar up to 12 hours each day, with the remaining time devoted to contractor work.

In FY88, the Air Force completed integration of the East Coast radar system sectors. The first two sectors of the East Coast radar reached 85 percent of total capability by January 1988. The East Coast radar could provide surveillance of the Atlantic from the coast of Labrador to Florida. The Air Force also procured the third and final sector of the West Coast radar system in 1988.

The Air Force began a Pre-Planned Product Improvement (P3I) program to evaluate cruise missile detection capabilities and explore techniques for reducing work force levels at OTH-B sites. This included the Small Target Test Program and studies of automated display processing, transmission beam steering techniques, ways to increase transmit-effective radiated power and longer integration periods.

On January 15, 1988, the Air Force began a program to use modified AQM-34M Vietnam-era drones to test the small target detection capabilities of the OTH-B System. Thirty simulated cruise missile flights were flown at altitudes ranging from 500 to 25,000 ft over the ocean between Puerto Rico and Bermuda.

According to the program director, the drones were flown 2,000 miles from the Maine-based transmit antenna to simulate the extreme range at which the proposed Central Radar System would operate.

During FY89, P3I efforts continued with promising developments implemented on one sector of the West Coast radar system. Tests allowed decision makers to determine if the modifications should be incorporated in all OTH-B radars. System improvements for small target detection continued, Developmental Test & Evaluation on the East Coast radar was completed, and the contract for the first sector of the Alaskan Radar was awarded. In December, the West Coast radar successfully tracked its first targets, an aircraft 939 miles from the radar. During the same test, multiple and crossing targets of opportunity were successfully tracked.

Also in 1989, Australian scientists reported that they had developed a technique to locate and track stealth aircraft through the wind turbulence created by their passage. Sophisticated software techniques would collect returns from the turbulence and interpret them into target detection and tracking information. It is known that bistatic sensors, such as OTH-B, threaten the "stealthiness" of the new low-observable aircraft being developed.

In FY90, the Air Force took control of the East Coast radar and began Operational Test & Evaluation activities. Full operational control of the system was to be turned over to the Tactical Air Command in 1991. New GE software demonstrated an ability to track surface ships effectively. The test used the East Coast radar for the demonstration.

A March 28, 1990, CBD notice indicated that the Air Force would issue an RFP during the first quarter of FY91 for the acquisition of the Central Radar. Plans were for a 36-month contract. Also in FY90, IOT&E of the East Coast radar began. It was completed in FY91.

The Department of Defense announced its intention to install a Central Radar system, justifying the $242 million expenditure as a tracking system for drug interdiction missions in the Gulf of Mexico area of operations. Congress rejected the request. In January 1991, the GAO released a report saying that the Central OTH-B radar could not be justified by either budget or operational considerations.

In the spring of 1991, the Air Force announced that it would cut back the operational schedule for the East Coast radar to eight hours per day, five days per week. National Guard and some civilian personnel would operate the system. The Air Force announced plans to mothball the West Coast system. In this status, the system could be brought back into operation within six months. Plans for the Alaskan System were canceled. The Air Force cited budgetary reasons for the actions. Industry observers suggested that technical problems may also have played a role.

In FY91, the West Coast radar was put into full stand-down/caretaker status. Termination of the Alaska Radar System was completed.

Reacting to changes in the strategic threat climate, the Air Force decided to place the OTH-B East Coast system into "warm storage." The radar would not be available for daily operational use. Estimated cost for maintaining the system in "warm storage" would be $5 to $7 million per year. A complete shutdown of the system would cost an estimated $420 million for environmental clean-up.

This caused a conflict with National Oceanic and Atmospheric Administration (NOAA) researchers who wanted to use the radar for research on weather prediction. The system is effective in measuring the choppiness of the ocean surface, a reliable measure of wind speed and direction. Critics of the storage move claim that an extra $5 to $7 million per year would allow NOAA to perform its research and make it possible to use OTH-B for counter-drug missions. Funding for NOAA was a problem. Researchers failed to receive 1994 money for the proposed OTH-B use.

Funding

US FUNDING

	FY92		FY93		FY94		FY95	
	QTY	AMT	QTY	AMT	QTY	AMT	QTY	AMT
RDT&E (USAF)								
PE0102417F	-	9.8	-	8.0	-	4.0	-	0
Production (USAF)								
OTH-B	-	68.0	-	0	-	0	-	0
MILCON	-	11.0	-	0	-	0	-	0

All $ are in millions.

Recent Contracts

No recent DoD contracts over $5 million recorded.

Timetable

	1946	Idea for OTH radar first postulated
Nov	1973	OTH-B system definition completed
Mar	1975	Award for prototype OTH-B facility
Dec	1976	Program restructuring initiated
	1980	Testing of Maine OTH-B facility began Agreement signed with Australians for exchange of OTH data.
Jun	1982	Award for full-scale development
	FY84	Began upgrade of experimental OTH-B East Coast radar to a fully operational 60^{o} sector
	FY86	Upgrade of experimental radar system to fully operational configuration completed
Jun	1986	Construction of West Coast system began
Dec	1986	Contract for West Coast radar system
Aug	1987	Sites selected for Alaskan system
Feb	1988	USAF accepted West Coast radar system operations center at Mountain Home AFB (ID)
	FY88	Completed integration of East Coast system sectors. Procured the third and final sector of the West Coast radar system.
Jan	1989	Alaskan system RFP released. Scheduled start of construction of Central system.
Mid	1990	Scheduled award of contract for the Alaskan radar system

Dec	1990	West Coast radar transferred to the Air Force
	FY90	IOT&E on the East Coast radar
	FY91	OTH-B FY91 funds rescinded. Reduced operating schedule for East Coast radar and "mothballing" of West Coast radar announced. FY92 funding zeroed
	FY93	Originally scheduled full operational capability for the complete OTH-B system.
Oct	1994	The East Coast system goes into "warm storage."

Worldwide Distribution

Japan The Japanese Government announced that it intended to purchase an OTH-B system from the US. But concerns over Tactical Ballistic Missile Defenses have since overcome this project. Japan is seeking other ways to provide missile protection.

Australia The USA had a project agreement with Australia for the exchange of OTH-B research data. The Australians have an operational system (Jindalee) radar for the Royal Australian Air Force. They would procure three additional systems.

Forecast Rationale

The Over-the-Horizon Backscatter Radar has been directly affected by the end of the Cold War. The radar was considered one of the most cost-effective surveillance systems available on a cost-versus-area-scanned basis, and testing reports indicated that the system could perform its mission effectively. The very low probability of ICBM or SLBM attack by the former Soviet Union has made the system an unwanted expense for the Department of Defense.

Although NOAA found research uses for the system, and the radar was somewhat effective for counter-drug operations, no one was willing to come up with the money to continue to operate the system beyond October 1, 1994.

The longer the equipment remains inoperative, the more out-of-date the hardware and software becomes, lessening its operational applicability. For all practical purposes, the OTH-B is being shut down. The "warm storage" option is just a way to avoid having to spend an estimated $420 million in cleanup costs.

Ten-Year Outlook

It will take an estimated $5 to $7 million each year to maintain the radars in "warm storage."

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