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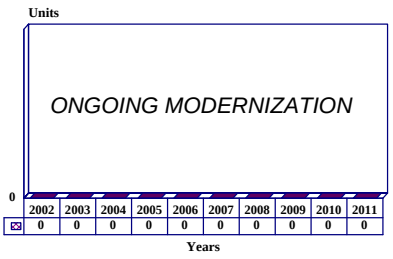
TPS-59(V) - Archived 09/2003

Outlook

- In service; TBM/CEC upgrades ongoing
- Radar to be certified as a CEC node and missile defense sensor
- Ongoing support
- Bahrain has requested one TPS-59(V)3

10 Year Unit Production Forecast
2002 - 2011



Orientation

Description. A land-based/long-range, 3D phased-array radar.

Sponsor

US Air Force
Electronic Systems Center
ESC/PAM
Joint Program Office
Hanscom AFB, Massachusetts (MA) 01731-5000
USA
Tel: +1 617 377 5191
Web site: http://www.hanscom.af.mil

US Navy
SPAWAR HQ
Space and Naval Warfare Systems Command
4301 Pacific Highway
San Diego, California (CA) 92110-3127
USA
Tel: +1 619 524 7000
Web site: http://www.spawar.navy.mil

Naval Sea Systems Command (NAVSEA)
1333 Isaac Hull Avenue SE
Washington Navy Yard, DC 20376
USA
Tel: +1 202 781 0000
Web site: http://www.navsea.navy.mil

US Marine Corps
Systems Command
2033 Barnett Ave Suite 315
Quantico, Virginia (VA) 22134-5010
USA
Tel: +1 703 784 5822
Web site: http://www.marcorsyscom.usmc.mil

Contractors

Lockheed Martin Corp
Ocean, Radar & Sensor Systems
Syracuse, New York (NY)
USA
Tel: +1 315 456 1554
Fax: +1 315 456 0130
Web site: http://www.lockheedmartin.com

Status. In service; ongoing logistic support and upgrades.

Total Produced. An estimated 21 TPS-59(V) radars were produced, including approximately nine for FMS orders. An estimated nine TPS-59M/34 radars have been produced.

Application. Long-range surveillance and ground control intercept sensor for the US Marine Landing Force in an amphibious environment, and support of TAOC-85 operations.

Price Range. Last known unit cost of the TPS-59(V) was estimated at US$12.6 million in FY83 dollars.

Price is estimated based on an analysis of contracting data and 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.

Technical Data

	Metric	**US**
Dimensions		
Antenna		
TPS-59(V)		
Height	9.2 m	30 ft
Width	4.6 m	15 ft
TPS-59M/34		
Height	5.8 m	19 ft
Width	4.6 m	15 ft
Weight		
System	12,700 kg	28,000 lb
Max package	2,360 kg	5,203 lb
Shelter dimensions		
Radar control group	2.2 x 37.3 x 22 m	87 x 147 x 85 in
Signal processor group	2.2 x 37.3 x 22 m	87 x 147 x 85 in
Characteristics		
Frequency	1.215 - 1.4 GHz 14% agile bandwidth	
Peak power		
TPS-59(V)	46 kW 54 kW (with upgraded 100 W peak power modules)	
TPS-59M/34	28 kW	
Average power		
TPS-59(V)	8.3 kW	
TPS-59M/34	5.0 kW	
Effective radiated power		
TPS-59(V)	270 MW	
TPS-59M/34	170 MW	
Probability of detection	90% 1 m^2 target within 200 nm	
Antenna beamwidth		
TPS-59(V)	1.7° (monopulse) 1.4° (low angle)	
TPS-59M/34	2.7° (monopulse) 2.2° (low angle)	
Antenna sidelobe reduction	55 dB	
Signal/clutter improvement		
Ground	53 dB	
Weather	33 dB	
Range		
TPS-59	7.4 to 556 km	4 to 300 nm
Accuracy (100 nm)	30.5 m	100 ft
Resolution (100 nm)	42.7	140 ft
TPS-59M/34	7.4 to 366 km	4 to 200 nm
Accuracy (80 nm)	30.5 m	100 ft
Resolution (80 nm)	42.7 m	140 ft

	Metric	US
Characteristics (continued)		
Height	100 Kft	
TPS-59(V)		
Accuracy (100 nm)	305 m	1000 ft
Resolution (100 nm)		1.7°
TPS-59(V)3		
Instrumented Range	740 km	400 nm (0.1 m² tgt
Altitude	152.5 m	500,000 ft
TPS-59M/34		
Accuracy (80 nm)	457.5 m	1,500 ft
Resolution (80 nm)	2.7°	
Azimuth coverage	360°	
Scan rate	6 or 12 rpm	
Accuracy		
TPS-59(V)		
Accuracy (100 nm)	3 mrad	
Resolution (100 nm)	3.4°	
TPS-59M/34		
Accuracy (80 nm)	3.5 mrad	
Resolution (80 nm)	2.5° (max, two-target resolution)	
Elevation		
TPS-59(V)	-1° to +18°	
TPS-59M/34	-2° to +20°	
Sidelobes, off-axis	-55 dB (median)	
MTBF	>1,000 hr	
MTTR	< 40 min	
Availability	0.999	
Assembly time		
TPS-59(V)	1 h	
TPS-59M/34	30 min	
Disassembly time	0.5 h	
Wind operation		
Normal	50 kt max	
Degraded	75 kt max	
Survival (lower array)	100 kt max	
Transport	120 kt max	
Wind & ice load (degraded operation)	75 kt with up to 3.5 lb ice per ft^2	
IFF Subsystem		
Modes	1, 2, 3A, C	
Elevation coverage	50°	
Azimuth beamwidth	<7° (half-power points)	
Peak power	2 kW	
Prime power		
TPS-59(V)	90 kW	
TPS-59M/34	75 kW	

Design Features. The TPS-59(V) system is a phased-array tactical radar designed to provide long-range surveillance for the Tactical Air Operations Center (TAOC-85 or TYQ-23(V)). The radar has a solid-state transmitter and a rotating planar array antenna. The displays and processors are housed in two standard S-280 military shelters that include a UYK-7(V) general-purpose digital computer and three 45 kW diesel generators.

The antenna uses 54 identical row/feed networks, 27 power supplies, and a digital signal processor to control the beam pattern and process the returned signals. The smaller TPS-59M/34 uses 34 identical row/feed networks and 17 power supplies. The low-level

transceivers include power supplies, transmitters, preamplifiers, phase shifters, duplexers, and logic control circuitry. There is one column feed assembly and one monitor feed assembly in the TPS-59(V). There are three and one, respectively, in the TPS-59M/34. The feeds distribute power vertically on the antenna scanning the elevation plane.

During operation, the self-erecting array antenna rotates mechanically in azimuth while a pencil beam electronically scans in elevation from 0° to 19°. This is the key to the radar's 3D capability. The scanning covers the specified surveillance volume in a raster-scan pattern.

Two basic surveillance waveforms are used: one for the short-range interval (5.5 to 185 km) which requires 11 pencil beams, and another for the long-range interval (from 185 km to the limits of coverage) which requires eight pencil beams.

The system was designed to counter the effects of multi-path propagation. For optimal system performance, a special weather mode adjusts energy management and processing every five minutes according to weather conditions.

Three trailer assemblies carry the system. The radar can be transported by helicopter, 2.5 ton truck, C-130 aircraft, rail, or seagoing vessel.

Upgrade kits improve the overall detection and processing of the system. The enhancements feature full monopulse processing, programmable beam coverage, improved electronic counter-countermeasures (ECCM), and programmable digital data interfaces. The high-power transmitter was designed to illuminate small targets along with advanced clutter and chaff rejection. The improved processing makes "one hit" position determination possible, along with flexible data hand-off.

The TPS-59(V)3 uses modernized computer hardware and is highly sensitivity: it can detect a 0.1 m² target at 400 miles. The system's sensitivity and software enhancements make it possible for the radar to track ballistic missiles in flight and report their location in real time, estimating launch and impact points. The system is also being modified to provide inputs to the Navy's Cooperative Engagement Capability (CEC) system.

Operational Characteristics. The TPS-59(V)'s capability to provide detection of up to 500 targets per scan, its 3D positional accuracy, and various console readouts and controls enable it to function autonomously in the buildup or backup ground control intercept role.

With the TAOC, the USMC can control all air, anti-air warfare and air defense operations within a 100- to 300-nautical-mile sector. In conjunction with the TPS-32(V) radar and TPS-63(V) 2D, short-range radar, the TPS-59(V) is interconnected to the command and control center it supports.

Because of the radar's large power aperture, frequency band, and solid-state receivers, the TPS-59(V) is capable of long-range detection of low radar cross-section (RCS) targets. Both radars perform well in rejecting weather and surface clutter, and both offer a look-down capability. They feature automatic data processing with scan-to-scan correlation and data transfer. The radars use a variety of sophisticated interference rejection techniques.

A series of upgrades are under way to improve the ability of the TPS-59(V) to function in an anti-missile capacity. Better detection and improved target processing should make it possible for battlefield commanders to better detect missile attack in time to do something about it. The upgraded radar will be able to be linked by radio to an MSQ-124(V) air defense communications platform which will relay target information to HAWK batteries. This will give the Marine Corps an inherent, though limited, point defense capability for its expeditionary forces. This capability, in turn, will provide a defense against short-range theater missiles that cannot be engaged by either Patriot or AEGIS.

The Corps has decided to keep the TPS-59(V) radar, but possibly get rid of the HAWK. The missiles are difficult to deploy and have never actually been used in combat by the Marines. Instead, it will depend on the Navy and Army for actual battery protection, using its own sensors as inputs to Patriot and AEGIS, and is investigating interfaces with the HUMRAAM (AMRAAM missiles mounted on a HMMWV).

Developers have been actively working with industry and evaluating techniques for interfacing the radar with the Cooperative Engagement Capability net through the Land Mobile CEC System (LMCS). As part of this effort, a joint task force exercise was conducted in 1998 which made actual TPS-59(V) inputs to a CEC relay net. The goal is to incorporate the TPS-59(V)3 in a tactical ballistic missile detection network. This network would have three modes of operation: Normal (air-breathing targets), Theater Missile Defense, and Combined.

Variants/Upgrades

The following five derivatives of the basic TPS-59(V) have been developed for various applications:

- The fixed 3D long-range (450 km) radar, which uses a 7.3 x 7.3 meter array with row/feeds 50 percent longer than the original TPS-59
- The medium-range (225 km) transportable 3D radar, which uses a 4.3 x 4.9 meter antenna and has a five-track capability
- The long-range (370 km) 2D fixed radar, which uses a 3.7 x 6.1 m antenna and vertical row/feeds (unlike the horizontal original TPS-59) and has a track-while-scan processing capability
- The medium-range (55 km) limited-sector 2D radar, which uses a 3.7 x 1.5 meter antenna with vertical row/feeds, and provides an inertialess scan of 120 degrees and has a track-while-scan processing capability
- A shipboard long-range (370 km) 2D radar, which uses a 4.6 x 2.3 meter antenna that is contained within a 9.2 meter diameter radome

TPS-59(V)3. This is the latest upgrade, which incorporates tactical missile defense features. Eleven upgrade kits are being produced and will be added to fielded radars over the next two years. The following capabilities are to be incorporated:

- Long-range detection of TBM targets
- Cueing to missile defense systems
- Launch and impact point prediction
- Improved air surveillance

The TPS-59(V)3 features software and hardware upgrades which enhance the ability of the radar to detect and track tactical ballistic missiles as well as air-breathing threats. It was jointly developed by the US Marine Corps and Ballistic Missile Defense Organization.

TPS-59M/34. A version of the basic radar with a downsized antenna and slightly different operational characteristics. It can be set up more quickly. Nine systems have been ordered by an unidentified (probably FMS) customer.

FPS-117(V). This is the solid-state fixed-site derivative of the TPS-59 and is similar to the GE 592 radar supplied to the UK in mobile form and to Belgium for a fixed site installation.

GE 592. This is the export version of the TPS-59.

Program Review

Background. In FY71, contracts were awarded to GE, RCA, and Sperry for TPS-59(V) development. In late FY72, GE received a US$6.9 million contract that included delivery of an engineering development model (EDM) for testing. In 1980, the Navy awarded a fixed-price-incentive multiyear contract for procurement of the TPS-59(V) radar. The award obligated funds to procure 11 systems for the Marine Corps and four for Egypt. Additional foreign sales included one radar for Belgium in FY79. The British Ministry of Defence ordered two versions based on the TPS-59(V) for Buchan, Scotland and Benbecula in the Outer Hebrides. The FY84 program focused on TPS-59(V) improvements. TPS-59(V) improvement efforts continued in FY85 and contract were awarded that supported the overall TPS-59(V) radar program.

In FY89, development of was begun an energy management, track-while-scan, ground control interface upgrade to the TPS-59(V). In addition, plans were made to develop an anti-radiation missile defense system for the radar, and to complete development of proposed electronic counter-countermeasure (ECCM) enhancements.

Tactical Missile Defense Upgrade. In 1992, the Marine Corps began looking for ways to incorporate the TPS-59(V) and HAWK missile into a battlefield anti-tactical ballistic missile (ATBM) defense system. This effort grew out of experiences with Iraqi Scuds in the Persian Gulf. The effort ran in conjunction with the Ballistic Missile Defense Office programs and tapped some BMD funding.

The Ballistic Missile Defense Office worked with the Marine Corps to develop a method of providing cueing data to the HAWK and other interceptor systems via the Joint Tactical Information Distribution System (JTIDS) and the Air Defense Communications Platform (ADCP).

A requirements document for the HAWK upgrade was completed by the end of FY94. Integration and test efforts began during FY95. The upgraded radar underwent live-fire testing at the White Sands Missile

Range, cueing HAWK firings at ranges of 32, 57, and 81 miles.

As part of BMDO PE#0603872E, Joint Theater Missile Defense, TPS-59(V) received funding from the Cueing and Netting project and the Ballistic Missile/C^3I concept projects. The overarching objective of the cueing and netting task was to enable the TPS-59(V) to accept external cues from, and pass cues to, different theater sensors in order to facilitate TBM identification, location and tracking.

In FY97, the system's hardware and software was modified to enable the system to accept an external cue and conduct developmental testing of cueing and netting capability. In FY98, an operational demonstration of TPS-59(V) external cueing was performed and infrared and radar data were fused to improve impact point predictions and to reduce the size of the impact ellipse.

A May 15, 1998, *Commerce Business Daily* announced that a sole-source contract was to be awarded to Sensis Corporation to design and produce seven production-level Theater Missile Defense System Exerciser (TMDSE)-capable TPS-59(V)3 Radar Environmental Simulators (RES). The contract would include options for four additional systems and provisions for upgrading the RES prototype to a production-level configuration. The first TMDSE was expected to be delivered in the first quarter of FY00, with the remaining units to be delivered a year later.

In February 1999, following a series of successful tests, the Marine Corps began discussions with the Navy on how to certify the TPS-59(V) as a Cooperative Engagement Capability (CEC) node.

In November 1999, the Pentagon announced that the Egyptian government had requested that five of its TPS-59(V)2s be upgraded to the TPS-59(V)3 configuration. The modification would consist of procuring and installing five TPS-59(V)3E Theater Missile Defense modified shelters, five array modification kits, and command and control shelter interfaces. The project was estimated to cost US$85 million. A contract was awarded in December 1999.

In May 2000, Lockheed Martin Naval Electronics & Surveillance Systems announced that it had been awarded US$7.5 million in incremental funding from the US Marine Corps for further upgrades to the TPS-59(V)3 radar. This brought funding for this effort to a total value of US$46.8 million. An Integrated Product Team will work with the Marine Corps and its supporting agencies to make multiple improvements in the radar to lower the cost of owning the system, address issues of parts obsolescence, and improve the radar's capabilities.

In April 2001, Egypt awarded a US$16 million contract to refurbish eight TPN-59M/34 radars.

In a May 2002 *Commerce Business Daily*, the Marine Corps Systems Command released a Broad Agency Announcement for Slotted Waveguide Technology (SWAT), Solicitation Number: M67854-02-R-2038. The Radar Systems Program Office of the United States Marine Corps, Marine Corps System Command (MCSC), Battle Space Management and Air Defense Systems Product Group Directorate, was soliciting proposals for the development of slotted waveguide technology toward producing a radar system that utilizes the D-band (1,215-1,400 MHz) in the detection of multiple targets in range, azimuth, and elevation from a single coherent dwell (monopulse). This new system will replace the current Marine Corps long-range, solid state, three-dimensional (range, bearing and target altitude), ground-based surveillance radar that operates in the D-band.

The Slotted Waveguide Technology covered by this BAA is not limited to any specific radar system but may include the TPS-59(V)3. The development and testing of prototype systems using this technology will be a two-phased effort. Phase I will consist of build and test activities. Phase II will be a sole-source follow-on effort that will culminate in the development and demonstration of a full-scale development model.

The primary components of the current system are a modular, mechanically rotated, phased-array antenna, an electronics shelter, a power distribution box, and a decoy system. The TPS-59(V)3 operates in three modes: Air Breathing Targets, Theater Ballistic Missile, and Combined. The new 3D long-range radar is to be employed by the Tactical Air Operations Center (TAOC), along with the Tactical Air Operations Module (TAOM) in its role as the Anti-Air Warfare (AAW) agency of the Marine Air Command and Control System (MACCS) of the Marine Air-Ground Task Force (MAGTF). The 3D long-range radar is the MAGTF's primary means of detecting, identifying, tracking, and reporting on all aircraft and missiles within the MAGTF's area of responsibility.

The new radar must provide the MACCS with a real-time display of all air activity and must be rugged enough to support a wide range of tactical operations in all types of weather and terrain conditions. It must provide anti-air warfare units with sufficient advanced warning and target information to allow for threat evaluation and responsive action, including air raid warning of targeted forces and neutralization of the threat. The radar must provide air controllers with a

precise, true air picture of sufficient quality to conduct close control of individual aircraft under a wide range of environmental and operational conditions. The logistical footprint of the radar system must be reduced as technology permits. Downsizing is the key to improved transportability and reduced setup time. In the case of TMD operations, the radar must have the capability, in the interim, to disseminate target information to the Air Defense Communication Platform and to the Marine Corps and Joint Services by way of a common digital datalink. The mature system must also provide target information to the Marine Corps Surface-to-Air Missile (SAM) batteries.

In support of its TMD role, the sensor must improve target processing capabilities and survivability. Offerors are encouraged to use teaming to leverage existing production programs. They in addition must be familiar with the USMC operational environment, including the detection and tracking of complex theater ballistic missiles.

In June 2002, the Defense Security Cooperation Agency notified Congress of a possible Foreign Military Sale of one TPS-59(V)3 to the government of Bahrain. In addition to the radar, the procurement would include one Air Defense Communication Platform, spare and repair parts, publications, training, technical assistance, and logistics support. The total value of the contract could run up to US$40 million.

Funding

Recent radar funding is from Operations & Maintenance accounts.

Recent Contracts

(Contracts over $5 million.)

Contractor	Award ($ millions)	Date/Description
Lockheed Martin	58.7	Dec 1999 – FFP contract to upgrade five Egyptian TPS-59(V)2 radars to a tactical ballistic missile configuration under FMS. To be completed Feb 2003. (M67854-00-C-2049)

Timetable

Month	Year	Major Development
	1972	First development contract awarded
	1976/77	USMC acceptance testing begins
	1980	Production contract
	1985	Delivery of 10 TPS-59 radars to NAVELEX
	1985/86	USMC/USAF complete operational testing
	1989	Initial Operational Capability of TAOC-85
3Q	FY94	ADCP requirements document due
	FY95/96	R&D into missile defense upgrades
	FY96/97	Missile defense upgrade procurement
Dec	1999	Modification studies completed; contract awarded to upgrade five Egyptian TPS-59(V)2s
	2001	Egyptian TPS-59M/34 upgrades contracted
Feb	2003	Egyptian upgrades to be completed

Worldwide Distribution

Belgium. One GE 592 system was delivered to Belgium in 1979.

Egypt. Egypt has eight TPS-59M/34 radars, which are to be refurbished. Five TPS-59(V)2s are to be upgraded to (V)3 configuration.

Middle East. Nine systems were delivered to an unnamed Middle East country.

Taiwan. Unknown number of GE 592 radars.

UK. Two GE 592 radars were supplied to the UK.

US. Deployed with US Marine Corps in support of ground control intercept and TAOC-85 operations.

Forecast Rationale

The primary US Marine Corps tactical air control radar, the TPS-59(V), was used as the design foundation of the FPS-117(V), and is undergoing significant upgrades to enable it to be a part of a tactical ballistic missile warning system. Long-range radars are not usually replaced for long periods once they become operational, so changes in the processing and ECCM features have kept the TPS-59(V) updated to perform its assigned missions.

The TPS-59(V)-equipped TAOC-85 is used for integrated air defense and en route air traffic control. It also provides real-time tactical air data for agencies outside the Marine Corps, and supports amphibious units through Marine Amphibious Force-sized operations.

Tactical battlefield radars such as the TPS-59(V) are no longer the primary battlefield sensors. They can be used as gap-fillers or for air traffic/flow control and coordination.

Efforts are ongoing to improve the radar's ECCM capabilities and its ability to detect and track low radar cross-section targets. This is an important step toward providing frontline forces with a carry-along anti-missile capability. Designers are improving the way radar data can be used, including combining the radar with missile interceptors to create an interim defense for frontline units from tactical ballistic missiles, such as Scuds.

The TPS-59(V) will be around for a long time. The downsized TPS-59(V)M/34 system is readily mobile, an important capability in today's fast-moving combat arena. As an interim missile protection system, the TPS-59(V)/ HAWK combination was planned to accompany battle units to areas where Scud or other tactical missile attacks are a consideration. Current projects are integrating the radar into an overall joint protective net, with Patriot and AEGIS serving as the actual missiles.

The Joint Task Force Exercises have proven the validity of the TPS-59(V) as part of the CEC network. Radar data can be used to extend a battle group's air defense capability inland, and the TPS-59(V) need not be slaved to the HAWK. The system uses a variety of equipment, including an aerostat communications relay platform. A major USMC effort is under way to certify the radar as an operational CEC node. This will make it possible for the radar to be recognized as a valid input to the CEC network, and allow the Marine units operating it to share the information available from the CEC links. The Marine Corps is pleased with the performance and service of the TPS-59(V)3.

The forecast does not yet include an estimated production date for the TPS-59(V)3 for Bahrain. It is possible that it will be a refurbished system coming from depot stock, depending on the outcome of contract negotiations.

Ten-Year Outlook

Production of one more system for Bahrain is possible.

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