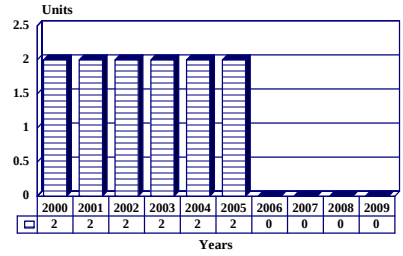
SPS-48E - Archived 5/2000

Outlook

- In service, ongoing logistics support
- SPS-48E refurbishment contract continues
- Selected for LPD-17



Orientation

Description. Long-range, 3D shipboard air surveillance radar.

Sponsor

US Navy
Naval Sea Systems Command (NAVSEA)
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Arlington, Virginia (VA) 22202
USA
Tel: +1 703 602 3381

Contractors

ITT Gilfillan
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Van Nuys, California (CA) 91409-7713
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Status. In service, ongoing logistic support continues. SPS-48E upgrades being completed.

Total Produced. Through 1999, an estimated 90 SPS-48(V) systems, including 45 SPS-48E New Threat Upgrade radars, had been produced. Production for the LPD-17 was beginning and refurbishment continues.

Application. The system is used on all aircraft carriers, most guided missile cruisers and destroyers, and amphibious command ships. It has also been installed at some land-based sites.

Price Range. Estimated unit cost is US$18 million (FY93 dollars).

Cost/price is estimated based on an analysis of contracting data, 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		
SPS-48C		
Antenna		
Weight:	2,014 kg	4,500 lb
Dimensions:	5.33 x 4.93 m	17.5 x 16.2 ft
Below decks		
Weight:	7,938 kg	17,500 lb
Dimensions (continued)		
SPS-48E		
Antenna		
Weight:	2,996 kg	6,600 lb
Dimensions:	5.48 x 5.18 m	17.9 x 16.9 ft
Characteristics		
SPS-48E		
Below decks		
Weight:	12,757 kg	28,100 lb
SPS-48F		
Antenna		
Weight:	1,125 kg	2,480 lb
Dimensions:	3.96 x 3.65 m	12.9 x 11.9 ft
Below decks		
Weight:	6,750 kg	14,884 lb
SPS-48E		
Power:	2.2 MW peak	
	33 kW average	
Frequency:	2.9 to 3.1 GHz	
Pulse width:	9 and 27 µsec	
PRF:	330 to 2,250 pps	
Range:	408 km	220 nm (5 m^2 target)
	231 km	125 nm (1 m^2 target)
	426 km	230 nm (low angle)
(Aircraft)	231 km	125 nm (1 m^2, Pd=0.5)
(Low-flyer)	31.5 km	17 nm (0.1 m^2, Pd=0.5)
Range resolution:	475.5 m	1,500 ft
Elevation coverage:	0° to 45° (search)	
	0° to 69° (track)	
Elevation accuracy:	1/6°	
Probability of detection:	0.5	
Probability of false alarm:	10^{-6}	
Scan rate:	15 rpm (4 sec)	
Altitude limit:	30,500 m	100,000 ft
Beam:	1.5° x 1.6°	
Polarization:	Vertical	
Planar array elements:	95	
MTBF:	> 650 hr	
MTTR:	15 min	

	Metric	**US**
SPS-48F		
Power:	660 kW peak	
	15 kW average	
Frequency:	2.9 to 3.1 GHz	
Pulse width:	3 µsec	
PRF:	1,250 – 2,000 pps	
Range:	278 km	150 nm (5 m^2 target)
	167 km	90 nm (1 m^2 target)
Scan rate:	7.5 or 15 rpm	
Altitude limit:	30,500 m	100,000 ft
SPS-48F (continued)		
Beam:	1.5^o x 1.6^o	
Polarization:	Vertical	
Planar array elements:	71	
MTBF:	950 hr	
Major units:	Digital Processor	
	Receiver	
	RF Amplifier	
	Driver/Final Amplifier	
	Final Converter	
	Final Modulator	
	Driver Modulator	
	Driver Converter	
	Auxiliary Detection Processor	
	Remote Maint. Datalink	
	Planer Array Antenna	
Pulse Doppler Upgrade		
Radar antenna height:	120 ft above MSL	
Target characteristics		
Radar cross-section:	$0.1m^3$	
Radial velocity:	Up to 3.0 Mach	
Probability of false alarm:	10^{-6}	
Probability of detection:	0.9	

Design Features. The SPS-48(V) is a three-dimensional, long-range air surveillance radar that is used to determine the range, azimuth and altitude of targets. It uses a sophisticated combination of mechanical azimuth scanning and electronic beam elevation steering to provide position and height information. The multiple beam elevation scans by changing the frequency of radio frequency energy fed to the frequency-sensitive planar array antenna. This produces a series of pencil beams which scan in the vertical. Stabilization of the radar antenna is accomplished electronically.

The radar transmits nine pulses of 3 µsec for each 6° of elevation coverage. Each pulse stream shifts upward covering from 0° to 45°. The multiple overlapping pencil beams result in high resolution and precise target position information. In the anti-jamming mode, the radar transmits a 27 µsec pulse with 3 µsec pulse compression. Random PRF jitter and beam sequencing eliminate mutual and friendly interference. Transmitter power is programmable and can be adapted to the volume of the area being searched.

The SPS-48(V) antenna system is similar in general appearance and operating principles to the SPS-52(V), although the SPS-48(V) is somewhat larger and there is only one "end plate" to the flat antenna array on the left side when facing the antenna. The scanner is square, compared to the SPS-52's oblong configuration. The SPS-48(V) has an identification friend or foe (IFF) antenna mounted at its upper edge, while the IFF is mounted at the lower edge on the SPS-52(V).

The SPS-48C introduced Moving Target Indication (MTI) to significantly increase a ship's combat systems' overall effectiveness and provide the capability to detect and track multiple air targets automatically. The SPS-48C was distinguished from the SPS-48A by the incorporation of an Automatic Detection and Tracking (ADT) modification that applied to all SPS-48s in service.

ITT's SPS-48 upgrade efforts resulted in the development of the SPS-48E for the Navy's New Threat Upgrade (NTU) program. This radar includes past enhancements as well as major improvements in video processing, jamming countermeasures, and tracking capability. The effort modified the antenna, receiver and control units, and replaced the transmitter, data processor and control consoles.

The SPS-48E was designed to improve the early detection of anti-ship missiles. Adaptive Doppler processing provides for rapid response to low- and high-flying targets, with low false alarm rates. The radar can supply positional information for mid-course guidance of the Extended-Range Terrier/Tartar and SM-2 missile systems. The result is essentially a new radar, and SPS-48(V)s already on ships are replaced entirely. The SPS-48E is installed on aircraft carriers and other new-build ships.

It features four scan modes, and only four controls are needed to operate the radar. The system gives higher elevation angle coverage, increased azimuth coverage, increased average power output, better reliability resulting from the use of solid-state components, and frequency and pattern flexibility to allow the defeat of electronics countermeasures (ECM) jamming while also detecting targets in conditions of heavy clutter.

The SPS-48E antenna was designed to function in very inclement conditions, including wind speeds of up to 75 knots, shock, vibration, ice loading of up to 22 kg/m^2, salt encrustation and temperature extremes ranging from 48° to +85° C. The NTU system has reduced the overall number of electronic components, simplified maintenance adjustments and enhanced the Built-In Test capability of the hardware. The Ultra-Side Lobe Antenna makes target detection possible in the presence of jamming.

The upgrades involve a number of components that vary by platform and can be divided into the following segments:

- The new Standard SM-2 Block II missile.
- Fire control engagement system modifications.
- Significant improvement to the SPS-48 and SPS-49 air search radars.

The SYS-2 Integrated Automatic Detection and Tracking System was added to integrate the output of the SPS-48E and SPS-49(V) radars in order to provide a correlated track file to command systems.

The Pulse Doppler Upgrade improvements to the SPS-48E will modify the first and second stage transmitter, receiver synthesizer, processor and software. The transmitter becomes a single-stage, solid-state, high-stability 60W system. The receiver/synthesizer will contain a single-channel, wide dynamic range receiver and very stable synthesizer, a key to effective pulse Doppler performance. An adaptive resource manager in the radar processor will perform automatic waveform selection and associated interface functions. The SPS-48E modification package includes a digital processor, auxiliary equipment, software, transmitter, receiver, and Built-In Test and Auxiliary Detection Processors for CEC-designated combatants.

Operational Characteristics. The SPS-48(V) radar provides target position data to a variety of weapons systems, including the ship's standard missile, SM-2. Eight operating modes are available under computer program control.

The main application for the SPS-48E is surface ship anti-air warfare, and the upgrades enhance the ability to counter the latest hostile missile threats.

The SPS-48E features greatly reduced antenna sidelobes, doubled average transmitter power, adaptive energy beam management, snap-off/snap-on operation, a computer-driven control/display system, a solid-state transmitter, digital subsystem upgrades, improved signal processing, and improved tracking performance. The SPS-48E can automatically track hundreds of aircraft over a vast area.

The Pulse Doppler Upgrade will make it possible to track small radar cross-section targets such as cruise missiles over land and sea and in ducted clutter. This makes it possible to use the radar to control the skies over both the open ocean and shoreline. The SPS-48E will thus be suitable for littoral operations.

Variants/Upgrades

SPS-48C. The SPS-48C featured automatic detection and tracking and MTI (Moving Target Indicator) capability. The automatic detection and tracking feature was a significant enhancement of a ship's combat system that allowed for the automatic detection and tracking of multiple air targets.

SPS-48E. The SPS-48E was designed as a direct replacement for the SPS-48C, with all of the radar's components fitting in the same space as the SPS-48C. The antenna weighs 1,700 pounds more because of enhancements that improve sidelobe suppression and provide heavier protection of the sail itself. Vertical

coverage is increased and improved. Adaptive energy beam management and a three-mode, solid-state transmitter improve performance. Ongoing modification work has included the use of fiber-optic cables for SPS-48Es going on aircraft carriers.

SPS-48F. ITT Gilfillan developed a smaller, lighter version of the SPS-48E for the international market and as a possible replacement for the SPS-52(V) on LHA class ships. The system would be less expensive and more reliable, featuring a smaller antenna. The solid-state transmitter eliminates a final amplifier stage, reducing the output power and target detection range, and the system features embedded processors. It will be available in a ship- or land-based configuration.

Pulse Doppler Upgrade. This enhancement was designed to improve radar operation in the littoral environment. The upgrade improves the ability of the SPS-48E to detect small targets, such as cruise missiles, in severe clutter by increasing the subclutter visibility performance of the system. This improved performance is considered an integral part of ship self-defense and an important contribution to the effectiveness of the Cooperative Engagement Capability (CEC).

Solid-State Transmitter. This upgrades the transmitter areas of the SPS-48E radar with new high-power, solid-state components as a means of improving overall reliability, maintainability and operational availability.

Lightweight Antenna. Recent plans call for the development of a lighter replacement antenna for the SPS-48E.

The **AS-4305A/U** lightweight antenna subassembly is being introduced for monopulse IFF operations for add-on installation on the SPS-48E and SPS-49(V) surveillance radar antenna groups. It was developed as part of the OE-374/SPS-67(V) Antenna Group development. It features a lightweight honeycomb-laminate construction. The system has completed operational testing on the SPS-49(V).

A variety of other enhancements are being considered or are under development. They include ADP/BIT mod kit improvements, remote maintenance capability, and Theater Missile Defense operation with reverse track capabilities. Cooperative Engagement Capability improvements continue, including providing additional processors to accommodate CEC networking. Much of the work is being accomplished through field-change installations.

Program Review

Background. The Navy and ITT Gilfillan began developing the SPS-48(V) air search radar in 1959. The Navy was concerned that the SPS-39(V) three-dimension air search radar range was too short when detecting targets for the Talos surface-to-air missile. The SPS-48(V) underwent sea trials in 1964, and the first operational SPS-48(V) entered service in 1965. It has been deployed ever since.

The SPS-48A modification kit added a moving target indicator (MTI) capability and was fielded in 1968. The next major upgrade was the SPS-48C during the early 1970s. The SPS-48C incorporated the Automatic Target Detection and Tracking System (ADT).

During the late 1970s, the Navy became concerned that its missile cruisers would be unable to cope with the expected air threats of the 1990s. The Navy awarded ITT Gilfillan a US$17 million contract in 1978 for development of the New Threat Upgrade (NTU), an upgraded radar that was designated the SPS-48E.

During FY82, land-based testing and first-phase, at-sea operational testing for the SPS-48E were completed. In FY83, operational tests were completed, production approved, and an SPS-48E was installed aboard the destroyer USS *Mahan* (DDG-42) for sea trials. The NTU included a solid-state transmitter, advanced digital receiver and signal processor, improved resistance to ECM, increased azimuth accuracy and computerized control of several functions that had previously been performed manually.

The SPS-48E also introduced Adaptive Energy Management, which would automatically allocate radar time and power in response to jamming. Another feature of the SPS-48E was the Integrated ADT (IADT), which integrated the inputs from the SPS-48E and the SPS-49(V)5 two-dimensional air search radar.

During FY84, development and testing of the SPS-48C receiver/processor improvements was completed. Also during FY84, ITT Gilfillan received about US$131.3 million in SPS-48(V) contracts. The major FY84 contract award was US$94 million received by ITT in July 1984 as an increment to the production contract. This increment called for two SPS-48C systems for new aircraft carriers and eight SPS-48E systems for retrofit to operational Navy ships.

Hardware design and computer program changes for the CGN/NTU continued during FY85. CGN/SM-2(V) computer programming changes resolved problems found during land-based programming. Fire control

modifications and installation documentation for the CGN/NTU also were completed.

The USS *Mahan* completed NTU trials in early FY85. In mid-1986, the Navy began overhauling the cruiser USS *Biddle* (CG-34), which would be the first ship to receive an operational NTU system.

SPS-48E deliveries began in FY86. The Navy continued IADT development for aircraft carriers and continued adapting computer programs and system documentation for integrating the baseline CG/SM-2 and NTU combat systems in Terrier ships. FY86 also saw the design/development of performance modifications to the NTU combat system and the Digital Fire Control System Upgrade for improved reliability, maintainability and availability.

CGN/SM-2 (MR) Block I combat system DT/OT testing was completed in FY86, and deficiencies identified during operational testing of the CGN/ SM-2(MR) Block I combat system were corrected. Since that time, efforts have concentrated on upgrading the SM-2 system, along with the various components which make up the weapon system.

By FY93 time, two aircraft carriers equipped with the SPS-48E joined the Fleet. The Navy continued retrofitting the SPS-48E to aircraft carriers undergoing Service Life Extension Program (SLEP) upgrades. Plans were to retrofit SPS-48E to most ships with the SPS-48C.

The Navy evaluated the Low Elevation Detection Improvement field-change kit in FY92 and awarded a contact for 19 such kits. Congress added money to the FY93 appropriation for radars to be retrofitted to amphibious assault ships and transitioning the LEDI kit to production.

An announcement in the August 1994 *Commerce Business Daily* said that the Naval Sea Systems Command intended to sole-source a contract with ITT for the cost-plus-fixed-fee research and development of a Pulse Doppler Upgrade to the SPS-48E. An award was made in February 1995.

In February 1996, the Navy announced that it intended to issue a solicitation for integration of the SPS-48E radar with the SYS-2(V) Integrated Automatic Detection Tracking System (IADT) and for integrating the SPS-40E Radar with the SYS-2(V) IADT. The specifications for the computer systems were: Motorola Power PC Model, MVME 1604-023, 133 MHZ; CPU, MPC 604; Memory Dram 32 Mbyte; Memory Flash 1 Mbyte; Memory Cache 256 Kbyte; Ethernet Interface; SCSI Interface; Graphics Output; Four Serial I/O; One Parallel I/O.

The acquisition of Motorola personal computers was considered essential to the government's requirements, precluding consideration of a product manufactured by another company. The intended Motorola source had the only verified and validated hardware which could execute the existing tactical software. Therefore, the acquisition would be on a sole-source basis.

In December 1996, the Navy awarded the contract for the LPD-17 next-generation amphibious ship to an alliance led by the Avondale Shipyard, New Orleans, Louisiana. The SPS-48E was chosen by ship designers for use on up to 12 ships. The radar will be integrated with what the Navy plans to be its most sophisticated command and control system yet.

In a September 1997 *Commerce Business Daily,* the Naval Sea Systems Command announced a pending solicitation for the development, fabrication, testing and delivery of one SPS-48E Solid State Transmitter (SST) Upgrade EDM. Plans were to select ITT Gilfillan on a sole-source basis.

This was followed up by a November 1997 *Commerce Business Daily* announcement by the Naval Research Lab of technical analysis, evaluation and consulting support for the development of improvements to the SPS-48(V) SST. A 24-month performance period was anticipated.

On December 5, 1998, NAVSEA awarded a US$7 million contract to ITT Gilfillan for design of the SST Upgrade engineering development model (EDM).

In a November 23, 1999, *Commerce Business Daily,* Naval Sea Systems Command announced a pending issue of orders for a period of up to three years under a new Basic Ordering Agreement (BOA) with ITT Industries, ITT Gilfillan Division, for engineering services and support for the SPS-48(V) radar system.

In February 2000, ITT Gilfillan announced that it had received an award for three upgrade kits, the refurbishment of three systems, and related efforts. This extended the refurbishment contract to 12 systems for LHA, LHD, and CVN class ships. ITT said that it expected to support efforts through 2025.

Volume Search Radar (VSR). In May 1997, the US Navy issued a Research and Development Sources Sought announcement in the *Commerce Business Daily* seeking concept papers for a new Volume Surveillance Radar (VSR) that was under consideration by the Navy. A concept paper was requested from companies qualified to design, construct, and test the VSR.

The VSR is to replace the SPS-48(V) and SPS-49(V) series radars and would typically be installed on non-AEGIS ships. One of the new radar's missions will be

to track threats such as aircraft, missiles, unmanned air vehicles (UAVs), and helicopters with rapid hand-off to engagement systems. Other missions would include situational awareness and air traffic control, IFF and fire finding. These mission goals were considered desirable, if not a cost driver.

The DD-21 Program Office considers both radars part of the next-generation ship's sensor suite and crucial to the air dominance mission of the ships. A development/ production plan has not been completed, but it can be assumed to parallel the Multi-Function Radar (MFR) effort, since the two will complement one another. The MFR will provide search, detect, track, and weapon control functions, enabling the amount of manpower on the ships to be dramatically reduced. Life-cycle costs are to be lower than with today's radar suites of multiple systems. Plans are to achieve a higher level of force protection and greatly enhance a ship's defense capability against all threats envisioned in the littoral environment.

Funding

Funding is now from ship construction lines.

Recent Contracts

(Contracts over US$5 million.)

Contractor	Award ($ millions)	Date/Description
ITT	7.0	Dec 1997 – FFP contract for the design, fabrication, and testing of a Solid-State Transmitter (SST) Upgrade engineering development model (EDM) as a proof of concept under the SPS-48E radar program. Was scheduled to be completed Dec 1999. (N00024-98-C-5200)
ITT	7.0	Mar 1998 – FFP CPFF contract option for the upgrade and refurbishment of one SPS-48E radar field change kit that will support the refurbishment of two SPS-48E radar systems. Other options awarded are for field engineering services and support. To be completed Sep 2000. (N00024-97-C-5233)
ITT	13.7	Feb 2000 – Award for three sets of upgrade kits, refurbishment, and related efforts. (N00024-97-C-5233)

Timetable

Month	Year	Major Development
	1970	Initial development
	FY76	SPS-48C procurement initiated
	1983	SPS-48E production begins
	1986	Delivery of SPS-48E variants commences
	FY88	Investigation/advanced development of upgrades, improvements to in-service air search radars such as the SPS-48
	1993	Radar refurbishment efforts begin
	1995	Planned completion of LEDI field-kit production
Dec	1996	LPD-17 contract awarded, SPS-48E to be installed on all ships
Dec	1997	Solid-State Transmitter upgrade development contract award
May	1997	Announcement of search for replacement radar, the Volume Surveillance Radar (VSR)
Dec	1999	Completion of Solid-State Transmitter upgrade development
	2003	VSR EDM to be ready for installation
	2003	VSR EMD delivery possible
	2040	Expected life of SPS-48E in the Fleet

Worldwide Distribution

Presently in service with **US Navy** only. The following are known installations of SPS-48(V)s: CGN-36 to 37; CV-63 to 67; CVN-68 to 76; CVN-65, DDG-993 to 996; LCC-19 and 20. (SPS-49E is being installed under SLEP programs now under way.) The LHD-1 Wasp class will be fitted with SPS-48Es. The CVN-76 and LPD-17 will be fitted with this radar.

Forecast Rationale

The SPS-48(V) is a powerful, three-dimensional, air search naval radar. The original system and its follow-on variants saw combat service during the Vietnam War, a variety of limited conflicts, and the Persian Gulf War. ITT and the Navy have continued to update the radar. The SPS-48E and the New Threat Upgrade (NTU) program incorporate the latest hardware/ software technology and were designed to meet most of the anti-air warfare combat demands of the 1990s. The Pulse Doppler Upgrade enhances the radar's ability to detect small, low-flying, anti-ship missiles over both open sea and the coastline. This is a critical change, given the Navy emphasis on operations in the littoral environment. The Solid-State Transmitter Upgrade capitalizes on new component technology and design to improve the reliability and maintainability of the radar.

Congress has confidence in the system, and the push to retrofit aircraft carriers and amphibious assault ships with the SPS-48E boosted the Navy's plan by authorizing reprogramming of funds and adding money to appropriations bills. The missile threat to the Navy afloat, especially during operations in the littoral zone, is an important planning and budget issue. Fleet protection is of major interest to congressional appropriators.

The development of the Volume Search Radar for the next-generation guided missile cruisers and destroyers eliminates the need for SPS-48E radars on these platforms. Selection of the SPS-48E for the LPD-17 shows, however, that the Navy does not currently plan to install it on ships that do not need such sophisticated or expensive capability, although there has been talk of backfitting the Multi-Function Radar and Volume Search Radars on the LPD-17. This would be an expensive project, and has a low likelihood of implementation.

The large number of radars in service and their constant use will support a significant spare and repair parts market over the next several years.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR PRODUCTION

			High Confidence Level				Good Confidence Level				Speculative			
Designation	**Application**	**thru 99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**Total 00-09**
SPS-48E	LPD-17 (USN)	1	2	2	2	2	2	2	0	0	0	0	12
SPS-48(V)	Prior production	90	0	0	0	0	0	0	0	0	0	0	0
Total production		91	2	2	2	2	2	2	0	0	0	0	12