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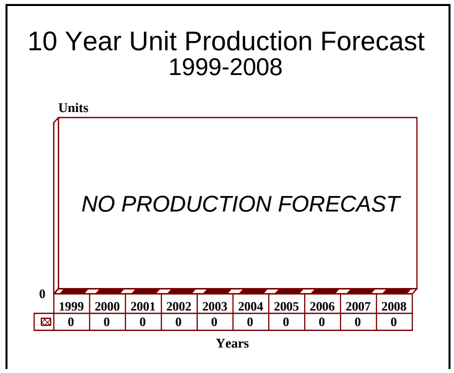
SPS-49(V) - Archived 5/2000

Outlook

- Ongoing logistics support and upgrades
- Systems in service will support a spares market into next century
- Medium PRF upgrade will be sought after for many years



Orientation

Description. Shipborne 2D air search radar.

Sponsor
US Navy
Naval Sea Systems Command (NAVSEA)
2531 Jefferson Davis Hwy
Arlington, Virginia (VA) 22202
USA
Tel: +1 703 602 3381

Contractors
Raytheon Systems Company
Sensors & Electronic Systems
1001 Boston Post Rd
Marlborough, Massachusetts (MA) 01752
USA
Tel: +1 508 490 1000
Fax: +1 508 490 2822

Status. In production, ongoing logistics support and upgrades.

Total Produced. An estimated 228 units have been produced.

Application. These radars are installed aboard a variety of US and allied capital ships.

Price Range. Estimated at US$3.7 million per ship set.

Technical Data

	Metric	US
Dimensions		
Antenna		
SPS-49(V)1		
Weight:	1,456 kg	3,210 lb
SPS-49(V)5		
Weight:	1,425 kg	3,165 lb

	Metric	**US**
Dimensions:	7.3 x 4.3 cm	24 x 14.2 ft
Rotating clearance (diameter):	8.7 m	28.4 ft
Below deck weight		
SPS-49(V)1:	6,255 kg	13,791 lb
SPS-49(V)5:	6,325 kg	14,004 lb

Characteristics

SPS-49(V)1

Power:	280 kW peak 10 kW average
Frequency:	851 to 942 MHZ
Pulse width:	125 µsec
PRF:	280/800/1000 pps
Range:	250 nm
Altitude limit:	150,000 ft
Beam:	3.3° X 9°
Polarization:	Horizontal
MTBF:	+300 hr

SPS-49(V)5

Power:	360 kW peak 13 kW average
Frequency:	850 to 942 MHZ (fixed or agile)
Pulse width:	125 µsec (83:1 compression) or 2 µsec
Minimum range:	0.5 nm
Range accuracy:	0.03 nm
Scan rate:	6 or 12 rpm
Azimuth beamwidth:	3.4°
Azimuth accuracy:	0.5°
MTBF:	>600 hr
MTTR:	<0.5 hr
Mechanical stabilization:	± 25° roll
IFF antenna:	AS-2188 mounted on beam

Design Features. The SPS-49(V) is an all solid-state 2D search radar with a klystron final amplifier. The antenna is stabilized relative to the horizon, making low-altitude detection possible in most sea states. True or relative antenna azimuth information is provided to the ship's radar switchboard in one-speed synchro format together with time-aligned video and trigger information. This can be distributed throughout the ship. The antenna is mechanically stabilized.

The system includes automatic target detection using pulse Doppler techniques and clutter maps to enhance target detection in a clutter environment. It has a state-of-the-art electronic counter-countermeasures (ECCM) capability as well as up-to-date adaptive Digital MTI (DMTI) and Constant False Alarm Rate (CFAR) receivers for reliable detection in clutter conditions. It is compatible with standard shipboard displays.

Every production system undergoes a minimum of 150 hours of continuous testing in a shipboard simulated environmental chamber. This accelerated maturing of each system helps eliminate failures once the system is deployed.

The double curved antenna reflector provides 28.5 dB gain with csec^2 shaping and low sidelobes. Line-of-sight stabilization keeps the antenna beam aligned with the horizon. A characteristic fan-shaped feed horn is underslung in front of an open-mesh, orange-peel parabolic antenna. The fully coherent, solid-state driver and klystron amplifier chain provide the peak power. Stability is emphasized for improved pulse Doppler processing. It can be PRF staggered and is frequency agile.

A triple-conversion receiver provides image rejection and freedom from spurious responses. Two complete channels are provided for the main and sidelobe blanking channels. The radar features built-in redundancy switches so the sidelobe channel can be substituted for the main channel in case of failure. Dispersive delay lines are used in both channels to generate and receive the chirp pulse compression signal. A new state-of-the-art, crystal-controlled stable frequency synthesizer is used for frequency stability and allows instantaneous random frequency selection. There is a four-loop coherent sidelobe canceler system.

The signal processor receives main and sidelobe channel inputs, digitizing them and feeding into sidelobe blanking and interference cancelers. The main channel is processed to provide clutter suppression in a five flight information region (FIR) filter pulse Doppler processor with false alarm control. This is followed by the provision of high-resolution clutter maps, video integration and detection thresholding. The output is usually made up of digital target reports. An optional Track-While-Scan processor can be added. There is also automatic on-line fault monitoring and fault isolation.

The Radar Set Control allows for manual selection of the radar operating mode, scan rate, emission controls, ECCM features and fault monitoring. Normal operation is from a set in the Combat Information Center, although a functionally identical unit is part of the equipment in the radar room.

The SPS-49(V) search radar was upgraded under the Navy Radar Surveillance Equipment program, PE#0604508N. The SPS Improvement Program project sought to improve the quality and reliability of SPS radar systems, including the SPS-49(V). Plans included development of a Medium PRF Upgrade (MPU), the development of tracker enhancements for the automatic detection and tracking (ADT) variant, and the resolution of production and technical problems. The Navy's SPS improvement efforts have been moved to PE#0604755N, Ship Self Defense, which does not currently address specific SPS-49 efforts.

Many improvements were tied to the New Threat Upgrade Combat System, which is an anti-air warfare program designed to counter the latest missile threats. The program addressed three principal components: improvements to the SPS-48(V) and, as previously indicated, SPS-49(V) search radars, including the addition of the SYS-2(V) to integrate the outputs of the radar to a ship's overall weapons control system; engagement system modifications; and a new SM-2 (ER) Block II missile.

Operational Characteristics. The SPS-49(V) can acquire fast targets at altitudes up to 150,000 feet in clutter, bad weather, and active or passive countermeasures environments. The radar's narrow beam and line-of-sight horizon-stabilized capabilities provide excellent low-altitude target acquisition in all sea states.

The SPS-49(V) provides range and bearing data as a backup to a 3D radar. Aboard CG-47 class guided missile cruisers, the SPS-49(V) is tied into the AEGIS weapon system as a supplement for the ship's SPY-1 radar for target detection and attack functions.

Improvements have concentrated on efforts to improve the way ships use the data from all of its sensors, fusing more effective own-ship and Cooperative Engagement Capability (CEC) information into a comprehensive situational awareness for all ships in a battle group.

Variants/Upgrades

There are seven variants of the original SPS-49 to meet individual platform requirements. The most common are:

SPS-49(V)1 is the original system carried by the Perry class frigates.

SPS-49(V)2 is the New Threat Upgrade version for cruisers.

SPS-49(V)3 is a Canadian variant with an embedded tracker. It is carried by the Halifax class cruisers.

SPS-49(V)5 provides enhanced ECCM processing and automatic target detection capability. This version has a higher peak power, 360 kW.

SPS-49(V)6/7 also possess an automatic target and detection capability and is installed aboard AEGIS-equipped platforms.

SPS-49A(V)1, **Medium PRF Upgrade (MPU)**. The MPU improvement to the SPS-49(V) doubled the range and improved performance against small targets in sea clutter. It also enhanced performance in an electronic countermeasures environment. Innovations included new wave forms and signal processing coupled with improved subclutter visibility for increased detection of small, fast targets near or over land.

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).

Program Review

Background. The SPS-49(V) was first operational on the first Oliver Hazard Perry class frigate in 1977. During FY78, Developmental and Operational testing was completed and the ATD effort initiated. The identification, friend or foe (IFF) antenna development began in FY79. R&D efforts in FY80 continued work on automatic target detection for the SPS-49(V) radar.

In FY81, land-based testing of the SPS-49(V) ADT began. During FY82, SPS-49(V) ATDM development was completed, as was land-based testing. The first phase of at-sea operational testing of the automatic target detection modification (ATDM) was completed. During FY83, SPS-49(V) ATDM operational testing ended. In FY84, development of the wideband solid-state transmitter for the SPS-49(V) began. Raytheon was awarded a US$76 million contract in May 1984 from (then) Paramax Electronics Inc for the Canadian Halifax class frigate program.

During FY86, the Navy commissioned six ships that would be equipped with the SPS-49(V) radar. The Radar Surveillance Equipment program's SPS improvement project saw the continuation of development of a wideband solid-state transmitter, and the development of an integrated automatic detection and tracking (IADT) capability for the FFG-7 Perry class frigates. In FY88, the Navy investigated the development of low sidelobe antennas for the SPS-49(V) along with other possible upgrades.

The Navy completed evaluating the Medium PRF Upgrade (MPU) in FY91. In January 1994, a solicitation for engineering and technical support for the development of the MPU was released. In addition, improvements to the AEGIS ADT variant and to the CEC and Ship Self Defense System (SSDS) programs were developed. It would be a three-year contract.

By early 1994, an estimated two pre-production units had been built for evaluation and testing. These upgrades are slated for DDG-93, CV/CVN, Amphibious Assault, AEGIS cruisers and FFG-7 class ships.

In December 1994, the US Naval Systems Command awarded Raytheon Equipment Division a production contract for US$48 million to definitize a previously awarded letter contract to produce the next-generation long-range air surveillance radar, a Foreign Military Sales (FMS) contract for the current-generation surveillance radar, and modification kits and spares. Raytheon would produce the first production unit of the next-generation SPS-49A(V)1 radar; two SPS-49(V)5 radars for Taiwan under the FMS program; nine MPU modification kits; and spares for the US, Taiwan and Canada.

In February 1995, the Navy announced that it intended to solicit five MPU kits, two SPS-49A(V)1 Test Fixtures, MPU spares, tech-manual revisions, and technical documentation and data. The requirement contained an option for four MPU kits, spares, integration and data. The contract was awarded in November.

A July 1996 solicitation notice was issued for an estimated two SPS-49A(V)2 radars, three SPS-49A(V)1 mod kits, three SPS-49A(V)2 mod kits, an SPS-49A(V)1 to SPS-49A(V)2 conversion kit, manufacturing production start-up, field engineering services and support, a technical data package, technical documentation, technical manuals, item orders and data. Also solicited was an FY98 option for five SPS-49A(V)2 mod kits, along with ancillary support and interim spares.

In February 1997, the Navy announced a requirement for SPS-49A(V)1 radar modification kits and applicable support effort items including interim and INCO spares, field engineering services, item orders and associated technical data for use in FY97 through FY99. The FY97 through FY99 requirements were for both mod kits and applicable support effort/items. Twelve mod kits and applicable support items would be needed in FY97, seven in FY98, and six in FY99.

In 1998, Australia embarked on a significant upgrade to its FFG-7 frigates. Although many of the ships' systems will be replaced, the SPS-49(V) air search radars installed on the ships will be retained.

Volume Surveillance Radar. The US Navy released a May 13, 1997 *Commerce Business Daily* Research and Development Sources Sought announcement for concept papers for a new fleet Volume Surveillance Radar (VSR) from companies qualified to design, construct and test the VSR. The concept paper would be followed a April 15, 1997, industry briefing at the Naval Research Laboratory (NRL).

The VSR would replace the SPS-48(V) and SPS-49(V) series radars on non-AEGIS ships. One of the new radar's missions will be to track threats such as aircraft, missiles, ultra-light 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 goals were considered desirable, if not a cost driver.

The tentative radar coverage requirement is 360° degrees in azimuth, 70° in elevation, and 120,000 feet in height, and with an instrumented range of 250 nautical miles. The VSR would have to be capable of operating in a littoral environment contaminated by land, sea, precipitation, bird, large discrete and other clutter as well as by hostile radiated signals.

Guidelines for radar supportability were a mean time between failure (MTBF) goal of 5,000 hours, with full built-in-test down to the LRU level with local maintenance and radar set control panel. It would have to be Battle Force Tactical Training (BFTT) system compatible and supported by minimal manning. Ruggedized commercial off-the-shelf (COTS) equipment should be used where possible and documentation and logistics would have to meet a tailored MIL-STD. Flexibility would be a key issue, and the largest anticipated antenna size and weight would be needed so the effect on ship construction could be determined. Modular construction to accommodate a changing COTS environment would be considered.

The Navy said it was interested in having an engineering development model of the VSR ready for installation by the year 2003 with production beginning in 2005, with a cost goal of US$10 million per system (in FY97 dollars).

On February 4, 1999, the USS *Arthur W. Radford* collided with a Saudi Arabian container ship off the Virginia coast. The *Radford* was calibrating the instrumentation for the composite mast it will be testing. There was significant damage. Although the *Radford* is not directly involved in the VSR program, some of its findings on composite mast/ship radar cross-section technology would be used by Navy planners to develop and evaluate concepts and requirements for the volume surveillance radar program. A significant delay in resuming the tests could impact the VSR schedule.

Funding

US FUNDING

	FY98		FY99		FY00(Req)		FY01(Req)	
	QTY	AMT	QTY	AMT	QTY	AMT	QTY	AMT
Procurement (USN)								
SPS-49(V)	-	12.8	-	1.0	-	2.2	-	-

All US$ in US millions.

Recent Contracts

(Contracts over US$5 million)

Contractor	Award ($ millions)	Date/Description
Raytheon	49.6	Apr 1994 – FFP contract for production of SPS-49 radars and auxiliary hardware. Combines purchases for USN (53.14%), Taiwan (29.75%), and Canada (17.11%). Completed Aug 1997. (N00024-94-C-5614)
Raytheon	9.4	Nov 1995 – Modification of previous contract for production of five MPU kits and two SPS-49A(V)1 test fixtures. Contains an option for four MPU kits plus spares, integration, and data. Completed March 1999. (N00024-94-C-5614)
Raytheon	14.1	Apr 1997 – FFP letter contract for 12 SPS-49A(V)1 modification kits with integration as well as field engineering service support. To be completes Jan 2000. (N00024-97-C-5200)
Raytheon	9.1	Dec 1997 – Basic ordering agreement for repair parts for the Sidewinder Missile, SPS-49 Radar System, NATO Sea-Sparrow, and WSC-6 Communications System. Completed Dec 1997. (N00104-93-G-A050, Order 0004)

Contractor	Award ($ millions)	Date/Description
Raytheon	8.7	Dec 1997 – Time and materials contract for repair parts for the Sidewinder Missile, SPS-49 Radar System, NATO Sea-Sparrow, and WSC-6 Communications System. Completed Dec 1998. (N00104-98-G-A400)

Timetable

Month	Year	Major Development
	1975	Advanced version evaluated
	1977	Enters service
	1981	SPS-49(V) radar improvement program begun as part of New Threat Upgrade Program
	1982	First phase of at-sea operational testing of SPS-49(V) automatic target detection modification completed
	1983	Operational testing completed. Production approval given for SPS-49(V) automatic target detection modifications
	1984	Development of wideband solid-state transmitters for SPS-49(V) begun
	FY87	Competitive development of SPS-49(V) solid-state transmitter begun
	FY88	Full-scale engineering development of solid-state transmitter begun
Mar	1988	Westinghouse and Raytheon awarded contracts for Phase 1 of solid-state transmitter (SSTX) program
	FY89	Full-scale development of SSTX discontinued
	FY91	MPU evaluation completed
	FY93	MPU pre-production start, testing begun
	FY99	End of current MPU contract
	2003	VSR engineering development model ready to install
	2003	Possible VSR production start
	2040	Expected life of SPS-48E in the Fleet

Worldwide Distribution

Australia. The SPS-49(V)2 is standard fit on the country's FFG-7 class frigates.

Canada. The SPS-49(V)5 forms part of the electronics fit for the Canadian Patrol Frigate class, of which two batches of six ships have been ordered. The first ship was delivered in early 1990. The second batch of six was delivered by 1996.

New Zealand. The SPS-49(V) is carried on ANZAC frigates.

Spain. The SPS-49(V) is standard fit onboard the country's FFG-7 class frigates.

Taiwan. The SPS-49(V) is being fitted onboard the modified FFG-7 class frigates being built by the Taiwanese. Present planning calls for a total of eight.

Thailand. Carries the radar on its Type 25T class ships.

US. The following ships are equipped with the SPS-49(V): all active aircraft carriers; the CG-47 Ticonderoga class (equipped with the SPS-49(V)6, although later models may be equipped with the (V)7 variant) cruisers; DD-963 Spruance class; FFG-7 Perry class; LHD-1 Wasp class amphibious assault ships; and LSD-41 Whidbey Island/Modified Whidbey Island class dock landing ships.

Forecast Rationale

The SPS-49(V) is a rotating, 2D search radar that provides a ship additional defense time by acquiring small, fast-moving targets at long range. It is fitted to a variety of large warships, including active aircraft carriers, the CG-47 Ticonderoga class AEGIS cruisers, the FFG-7 Perry class destroyers and LSD class landing ships. It will not be carried by the LPD-17 next-generation amphibious ship.

Few SPS-49(V)-equipped ships were built past the mid-1990s, but there is an ongoing upgrade program to improve existing systems and extend service life.

The Medium PRF Upgrade helps meet the need for protection from small, low-flying missile threats, increasing the sensitivity of the radar in detecting and tracking these low-observability threats in sea clutter and ECM environments. Although it is still based on older technology, the SPS-49 performs its job well.

The AEGIS radar is the prime sensor for the next-generation guided missile cruisers and destroyers. This eliminates the need for SPS-49(V) radars on these ships. Future combat ship designs will probably follow the sophisticated AEGIS concept; reducing the radar signature precludes the use of large, rotating antennas. The selection of the SPS-48E for the LPD-17 shows, however, that the Navy is not going to install AEGIS on ships that do not need this sophisticated a weapons control capability. But the SPS-49(V) was not selected for these ships, and is probably not going to be picked for other new construction vessels either.

The US requirement has been met with completed production contracts. Most navies interested in providing good anti-air surveillance systems have considered it for their fleets, but budget-induced slowdowns in shipbuilding have reduced the expected rate of procurement over the remainder of the reporting period.

The large number of units in service will support a significant spare and repair parts market though the turn of the century and beyond. An active improvements and upgrade effort can also be expected. Once proven and made available, the Medium PRF Upgrade could become a sought-after enhancement for those with the radars.

Ten-Year Outlook

No further production expected.