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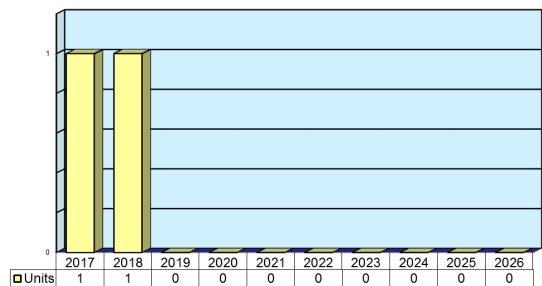
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EMPAR

Outlook

- Going forward, Italian FREMMs will specify Leonardo's Unimast, voiding any continued interest in the EMPAR from its primary customer
- Other NATO-aligned countries may purchase the EMPAR following the Algerian purchase
- Another Leonardo radar, the KRONOS, will take orders away from the older EMPAR

Unit Production Forecast
2017-2026



Orientation

Description. The European Multifunction Phased-Array Radar (EMPAR) is a multifunction, G-band (C-band), TWT-driven, phased-array radar. The EMPAR MFRA (Multifunction Radar Active) is marketed as providing the same function as an active phased-array system. The system is also known as the MM/SPY-790.

Sponsor

Delegation Generale pour l'Armement
10/14 Rue St. Dominique
F-75997 Paris Armees
France

Ministero Della Difesa
Office for Military Production
Palazzo dell'Esercito
Via XX Settembre 123
I-00100 Rome
Italy

Licensees. No production licenses have been granted.

Status. In production.

Application. EMPAR provides three-dimensional air surveillance and search, multiple tracking, and missile guidance functions simultaneously within a single masthead sensor. EMPAR can fulfill the radar portion of the Principal Anti-Air Missile System (PAAMS) and the Surface-to-Air Anti-Missile (SAAM) system.

Platform. The system has been specified for the Italian and French Horizon class frigates, the Italian FREMM (Bergamini class) frigates, Italy's *Conte di Cavour* aircraft carrier, and Algeria's *Kalaat Beni Abbès* BDSL (Improved San Giorgio class). The EMPAR system also is capable of providing target acquisition, target tracking, and missile guidance for the SAAM / SAMP missile system.

Price Range. EMPAR is believed to have a unit cost of between \$19 million and \$22 million, based on the known values of similar systems.

The EMPAR MFRA, a more advanced system, is believed to cost between \$25 million and \$29 million.

EMPAR**Contractors****Prime**

Leonardo Land & Naval Defense Electronics, (Selex ES)	http://www.leonardocompany.com , Piazza Monte Grappa, 4, Rome, Italy, Tel: + 39 06 41501, Fax: + 39 06 4131133, Prime
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Subcontractor

Mercury Computer Systems Inc, Corporate Headquarters	http://www.mc.com , 199 Riverneck Rd, Chelmsford, MA 01824-2820 United States, Tel: + 1 (800) 229-2006, Fax: + 1 (978) 256-3599 (Powerstream MP-510)
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Contractors are invited to submit updated information to Editor, International Contractors, Forecast International, 22 Commerce Road, Newtown, CT 06470, USA; rich.pettibone@forecast1.com

Technical Data**Specifications**

	<u>Metric</u>	<u>U.S.</u>
Air surveillance tracking range		
Normal	80 km	43.2 nm
Dedicated	150 km	91.0 nm
Radiating aperture	1.5 m x 1.5 m	4.9 ft x 4.9 ft
Antenna type	Passive phased array	
Azimuth scan angles	± 45°	
Elevation scan angles	± 60°	
Sidelobes	Better than -45 dB	
Transmitter type	Driven TWT	
Frequency	G-band	C-band
Number of antenna elements	2,200	
Rotation rate	60 rpm	
Peak power	120 kW	
Maximum number of tracks	300	
Tracking accuracy	3-5 mrad	
Maximum missile guidance	30	

Dimensions & Weights

Antenna group		
Dimension (h x w x d)	2.1 m x 2.2 m x 1.01 m	6.89 ft x 7.22 ft x 3.31 ft
Weight	2,500 kg	5,512 lb
Radome		
Diameter	5.0 m	16.4 ft
Weight	350 kg	772 lb
Below deck equipment		
Weight	6,000 kg	13,228 lb

Design Features. EMPAR is a passive phased-array radar operating in the G-band (C-band). It utilizes a central high-power traveling wave tube (TWT) transmitter, a two-stage super-heterodyne receiver, a fully adaptive array signal processor, and a digital pulse compressor. Design options include a single rotating array and back-to-back dual array and static array configurations.

EMPAR's modular design allows the system to grow using multiple array faces and incorporates "stretch" potential for future requirements. The rotating antenna consists of a corporate-fed, phase-phase scanning, planar array providing full azimuth coverage. A single pencil beam is formed in space and electronically scanned by the use of pin diode phase shifters. It is controlled from pulse to pulse by a beam-steering

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computer. The feed network provides two channels for monopulse beam formation.

The array is capable of scanning over a wide angle with low sidelobe levels. An electronic counter-countermeasures capability is provided by the inclusion of automatic frequency selection modes, jammer analysis and mapping, low antenna and sidelobe levels, and a frequency-agile mode, in addition to the use of narrow transmit and receive beams.

The radar management computer is responsible for all real-time task scheduling in EMPAR. Its roles include radar command and control, data handling, built-in test equipment (BITE) monitoring, and all external interfacing and communications.

Operational Characteristics. EMPAR is intended for autonomous and simultaneous, medium- to long-range air and surface surveillance. The hemispheric mission envelope takes in all surface and airborne targets and can display 300+ targets. It has the ability to track 168 priorities within the mission envelope and to acquire up to 50 targets simultaneously for prosecution within a local area defense system. EMPAR eliminates the need for several discrete systems to individually perform search correlation, acquisition, and tracking.

Variants/Upgrades

EMPAR MFRA. The EMPAR MFRA (Multifunction Radar Active) adds active electronic scanning capability to the EMPAR system.

MM/SPY-790. MM/SPY-790 is the official A/N designation of the EMPAR system.



European Multifunction Phased-Array Radar (EMPAR)

Source: Alenia Marconi Systems (now Leonardo)

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Program Review

Background. EMPAR was conceived for the NATO frigate radar system, and a system development consortium was formed in 1986. Conceptual disputes were the driving factor behind the program's collapse.

EMPAR Takes to the High Seas

Project Horizon/Orizzonte. In 1993, France, Italy, and the U.K. launched the Common New Generation Frigate (CNGF) program for a multirole ship designed for anti-air warfare. The new frigates were designated Project Horizon (Orizzonte).

Alenia (now SELEX Sistemi Integrati) was contracted to develop a G-band solution. The Italian Navy wanted an experimental single-faced phased array consisting of 2,500 elements to be installed on a Maestrale class frigate for trials. Extended field tests were completed in December 1993, and preparations were undertaken to transfer trials to the frigate ITS *Carabiniere*.

British Scrutiny. In early 1994, Britain debated using EMPAR for the CNGF program. The U.K. noted that program delays meant that the British Sampson radar would be available for the CNGF. The U.K. preferred Sampson because it would greatly increase the ship's capability with only a slight increase in cost.

Italy was displeased, as EMPAR was the only major Italian system in the program. The change also threatened the use of the French ASTER 30 missile system. France and Italy blocked the start of work until EMPAR was confirmed as the multifunction radar. Italy also threatened to drop out of the program entirely. In 1995, EMPAR was installed on the *Carabiniere*, and the testing trials were successfully completed by 1997.

France and Italy decided to go ahead with development of the Principal Anti-Air Missile System (PAAMS), setting up the EUROPAAMS joint venture for this purpose in 1997. British involvement in Project Horizon ended in 1999 due to its insistence on Sampson, along with other differences. PAAMS(E) was selected for the Franco-Italian Horizon frigates, and PAAMS(S) with Sampson was chosen for the U.K. Type 45 destroyers.

France and Italy Reduce Quotas. Originally, 12 British, six Italian, and four French ships were planned. However, the U.K. dropped out in 1999 and France and Italy reduced their quotas to two ships per nation.

The French first-in-class, *Forbin*, and the first Italian frigate, *Andrea Doria*, were launched in 2005. The *Chevalier Paul* was launched in 2006; the final Horizon frigate, Italy's *Caio Duilio*, was launched in 2007. All

four ships have been commissioned. Both countries have ended their Horizon programs and selected FREMM frigates for future needs.

Horizon's Demise, FREMM's Gain

In 2002, Italy signed a cooperative agreement with France to construct the Multi-Mission Frigate (MMF). At Euronaval 2004, France and Italy signed a Declaration of Intent for 17 FREMMs (Frégates Européenne Multi-Mission) for France and 10 for Italy.

Italy selected EMPAR, while the French FREMM will receive the Thales Herakles radar. In May 2006, the Organisation Conjointe de Coopération en Matière d'Armement (OCCAR) awarded a contract that authorized the start of the first two Italian FREMM frigates. The Italian frigates are being built by Fincantieri.

SAAM and PAAMS Testing

In early 2002, an EMPAR-supported Surface-to-Air Anti-Missile/Italian Navy configuration (SAAM/IT) successfully completed the first qualification firing of its ASTER 15 naval missile. The launch was conducted from Italy's trial vessel ITS *Carabiniere* and resulted in a direct target hit at 7 kilometers at an altitude of 1,000 meters. A successful second trial was performed in June 2002, and the third trial launch was carried out in December 2002. The EMPAR-equipped SAAM/IT acquired, tracked, and destroyed two close targets equipped with jamming devices.

In May 2006, the first successful PAAMS qualification firings took place on *Carabiniere*. This trial demonstrated the three main parts of a PAAMS(E) outfit for the first time: EMPAR, MBDA's Sylver A50 launcher, and the ASTER 30 air defense missile. EMPAR picked up an incoming Mirach subsonic target at approximately 35 kilometers and 23,000 feet and guided the ASTER 30 to a direct hit. Eurosam stated that the target represented an attacking aircraft with strong electronic countermeasures.

A year later, in May 2007, the final PAAMS(E) qualification firing was successfully completed. The firing profile represented an air defense frigate fitted with the PAAMS(E) system defending a consort ship attacked by two subsonic missiles flying at very low altitude. The first target was intercepted by a simulated ASTER 30, and the second target was intercepted and directly hit at medium range by an ASTER 30.

EMPAR***Conte di Cavour***

EMPAR is part of the SAAM/IT system that equips the Italian vertical/short takeoff and landing aircraft carrier. The carrier, the *Conte di Cavour*, was commissioned in 2008.

Competition Limits Sales

Thales. In December 2006, the Royal Danish Navy selected Thales Nederland to supply its APAR/SMART-L radars for its three new patrol vessels. The active phased-array radar (APAR) has been integrated with Raytheon's Evolved SeaSparrow Missile and long-range Standard Missile-2 (SM-2), while the SMART-L has embedded growth potential for Tactical Ballistic Missile Defense with the Standard Missile-3 (SM-3).

BAE Systems. The new ARTISAN 3D radar was selected for the U.K. Royal Navy's Medium Range Radar program. A team led by BAE Systems will supply radars for the majority of the current surface fleet and for the Future Aircraft Carriers.

Almaz-Antey. According to a May 2008 *Military Procurement International* report, the Turkish SSM Undersecretariat for Defense Industries was launching a competition to procure at least four batteries of ballistic missile defense systems. In September 2008, *MPI* reported that Turkey would purchase three surface-to-air missiles from Russia's Almaz-Antey. It is unclear if this purchase fulfills all of the needs of the Turkish Air Force.

Kongsberg. Finland's Ministry of Defense is replacing the country's 18 Russian-built Gadfly missile systems with the Norwegian Advanced Surface-to-Air Missile System (NASAMS) made by Kongsberg.

French FREMMs. In 2008, the Kingdom of Morocco ordered one FREMM frigate from DCNS, taking advantage of synergy with the French program.

Italy's FREMM Program Underway

In May 2006, the start of the first two Italian FREMM frigates was authorized. In February 2008, Italy formally ordered its second batch of FREMMs. This order reportedly involves three land attack ships and one anti-submarine warfare ship, bringing the class total to six vessels. The keel was laid for the third Italian FREMM in September 2010.

Active EMPAR

According to a paper presented at the 2010 Institute of Electrical and Electronics Engineers International Symposium on Phased Array Systems and Technology, SELEX SI had worked on a technology upgrade to the EMPAR known as Active EMPAR. Active EMPAR features AESA technology, greatly enhancing capability and reliability.

Development of the AESA version began in 2008 and was completed in 2011. Now called the EMPAR MFRA (Multifunction Radar Active), the AESA variant equips all Italian-variant FREMM ships.

Contracts/Orders & Options

<u>Contractor</u>	<u>Award (\$ millions)</u>	<u>Date/Description</u>
Eurosam	1.9	Sep 2000 – Initial production contract for the PAAMS program, which includes production of the first two production EMPAR systems for the new French and Italian frigates.

Timetable

<u>Month</u>	<u>Year</u>	<u>Major Development</u>
Oct	1982	Prefeasibility study conducted
Oct	1985	NFR-90 feasibility study evaluation completed
Jul	1986	EMPAR consortium announced
Jun	1989	Eurosam (FAMS) consortium formed
Oct	1989	Britain withdraws from NFR-90
Dec	1989	RN selects FAMS as next air defense missile
Jan	1990	NFR-90 collapses
Jan	1993	Project Horizon inaugurated
Dec	1994	Factory Acceptance Tests completed

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<u>Month</u>	<u>Year</u>	<u>Major Development</u>
Jan	1995	Shipborne sea trials performed on the ITS <i>Carabiniere</i>
	1997	Validation trials completed
	1998	First air defense Horizon frigate ordered for France
Aug	1999	Contract (\$1.9 billion) to EUROPAAMS SAS for PAAMS
Sep	2000	Eurosam receives order for first two production PAAMS
Feb	2002	First qualification firing of Italian EMPAR-equipped SAAM/IT
Mar	2002	France, Italy, and U.K. sign agreement for production of seven PAAMS, two of which will be EMPAR-supported
Mar	2005	First Horizon frigate, <i>Forbin</i> , launched for France
Oct	2005	First Italian Horizon frigate, <i>Andrea Doria</i> , launched
Nov	2005	First FREMM contract signed, for eight Herakles-equipped French ships
May	2006	Italy authorizes contract for first two Italian EMPAR-equipped FREMMs
Jul	2006	<i>Chevalier Paul</i> launched at DCN's Lorient shipyard
Oct	2007	Fourth and final Horizon frigate, <i>Caio Duilio</i> , launched
	2009	<i>Caio Duilio</i> delivered to Italian Navy
	2014	First non-European EMPAR delivered, for the Algerian <i>Kalaat Béni Abbès</i> BDSL
	2017	Estimated delivery of the eighth EMPAR for the Italian FREMM program
	2018	EMPAR production could end

Worldwide Distribution/Inventories

Algerian Navy	One EMPAR for the <i>Kalaat Béni Abbès</i> BDSL, an improved version of the Italian San Giorgio class.
French Navy	Two on its Horizon class frigates.
Italian Navy	One prototype has been installed on the Navy frigate <i>Carabiniere</i> for the evaluation program. In addition, two have been installed on the Horizon class frigates and one on the <i>Conte di Cavour</i> aircraft carrier. Italy is also installing EMPAR on its FREMM frigates.

Note: France utilizes Thales' Arabel radar on its Land SAAM systems and Thales' Herakles radar on its FREMM frigates. Both radars are manufactured in France.

Forecast Rationale

The EMPAR program is nearing the end of its production life. While the program marked a major milestone in 2014 with the delivery of the first EMPAR-equipped ship to a non-European country, Algeria, the Italian Navy – the radar's primary user – is selecting other options for its own fleet. Moreover, Leonardo, the EMPAR's manufacturer, has released a successor radar, the AESA-equipped KRONOS.

Future Italian FREMM (Bergamini class) ships will use Leonardo's Unimast integrated mast. Since Italy has chosen the Unimast to replace EMPAR on board its FREMMs, it is very unlikely to select the radar for any other ships going forward.

EMPAR could potentially find another market abroad. The Algerian sale was a major coup for the Leonardo sales team. Algeria could order a second vessel in the *Kalaat Béni Abbès* class. Additionally, Algeria's selection of the EMPAR may encourage other NATO-aligned countries to select the radar.

At this time, a second Algerian *Kalaat Béni Abbès* class ship has been tentatively forecast. However, due to the uncertain nature of sales to any other country and the waning support for EMPAR in its home market, no further sales have been forecast. Still, an additional EMPAR order is not beyond the realm of possibility.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR UNIT PRODUCTION												
Designation or Program		High Confidence				Good Confidence			Speculative			
	Thru 2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total
Leonardo Land & Naval Defense Electronics												
EMPAR MFRA <> Algeria <> Navy <> BDSL (San Giorgio-class) LPD												
	1	0	1	0	0	0	0	0	0	0	0	1
EMPAR MFRA <> Italy <> Navy <> FREMM												
	7	1	0	0	0	0	0	0	0	0	0	1
Subtotal	8	1	1	0	0	0	0	0	0	0	0	2
Total	8	1	1	0	0	0	0	0	0	0	0	2