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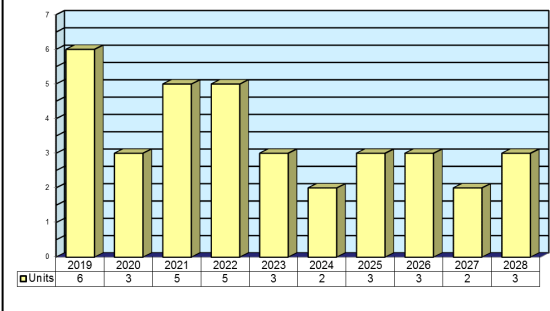
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Vixen

Outlook

- The Vixen possesses a blend of fire control and surveillance/tracking capabilities in a small package that is ideal for multimission light aircraft
- The U.S. could place additional orders to outfit border control and training platforms
- Orders by as-yet-unspecified customers are expected
- A Romanian conversion of an IAR-99 Technology Demonstrator could lead to further orders

Unit Production Forecast
2019-2028



Orientation

Description. Vixen is a family of active electronically scanned array (AESA) multimode (fire control, reconnaissance and surveillance, and target acquisition and tracking) radars for fighter, lead-in fighter trainer, surveillance, and interceptor/tracker aircraft.

Status. In production and service.

Application. The Vixen 500E has been fitted on the Cessna C-550 Citation interceptor/tracker aircraft. Other applications for Vixen radars include lead-in fighter trainers (LIFTs), light combat aircraft (LCA), and light reconnaissance and surveillance aircraft.

A variant of Vixen is part of the avionics package for the Saab Gripen NG (next-generation) fighter jet.

Price Range. The price of a Vixen radar varies based on the variant, quantity, and options ordered. A highly speculative range of \$1.9 million to \$2.4 million can be estimated. This range is derived from the only Vixen contract that has been announced.

In March 2009, a \$9.2 million contract was awarded to mount two Vixen 500E radars and associated mission management systems on Cessna C-550 Citations. However, this contract is thought to also have included options for two additional units.

The U.S. Navy awarded M7 Aerospace, an Elbit Systems company, a \$7.5 million contract in May 2016 to outfit the U.S. Naval Test Pilot School's Fairchild C-26 with the Vixen 500E. However, the contract likely includes overall electronics systems conversion and labor costs, which would lower the actual individual radar price.

Unit prices are generally higher for a small quantity buy and if additional options are included, such as user-specific software, installation, training, technical engineering support, logistics, and spares.

Vixen**Contractors****Prime**

Leonardo MW Ltd	http://www.leonardocompany.com , Crewe Toll, 2 Crewe Road North, Edinburgh, Scotland, United Kingdom, Tel: + 44 01313322411, Prime
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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**Vixen 500E**

	<u>Metric</u>	<u>U.S.</u>
Physical Characteristics		
Antenna Dimensions		
Height	429 mm	16.9 in
Width	496 mm	19.5 in
Depth	236 mm	9.3 in
Weight (Core LRUs)	86 kg	189.6 lb
LRUs	3 (5 with Optional Cooling & Navigational Units)	
Input Power	<3.4 kVA	
Cooling		
Antenna & Power Supply	Liquid	
Processor	Air cooled (liquid optional)	
Interfaces	Ethernet	
	MIL-STD-1553B (optional)	
Performance Characteristics		
Antenna Type	AESA	
Frequency	I-/J-band	X-band
Architecture	Solid state	
Scan Coverage	> +/- 60°	
Max Targets (Track-while-Scan mode)	20 targets	
SAR Resolution	<1 m	<3.3 ft
Reliability (MTBF)	>1,200 hr	
Operational Modes		
Air-to-Air Modes (Detect & Track)	Single Target Track	
	Track while Scan	
Air Combat Modes	Boresight	
	HUD Search	
	Sleuable Scan	
	Vertical Scan	
Air-to-Surface Modes (Detect & Track)	Ground Moving Target Indication	
	Sea Surface Search	
Mapping Modes	Real Beam Ground Mapping	
	Weather Mapping	
SAR Modes	Inverse SAR	
	Spot SAR (standard & high-resolution modes)	
	Strip SAR	

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Design Features. The Vixen 500E (E-scan) is a compact AESA radar. It combines fire control, surveillance and reconnaissance, target acquisition, and tracking and prosecution capability for air-to-air and air-to-surface arenas.

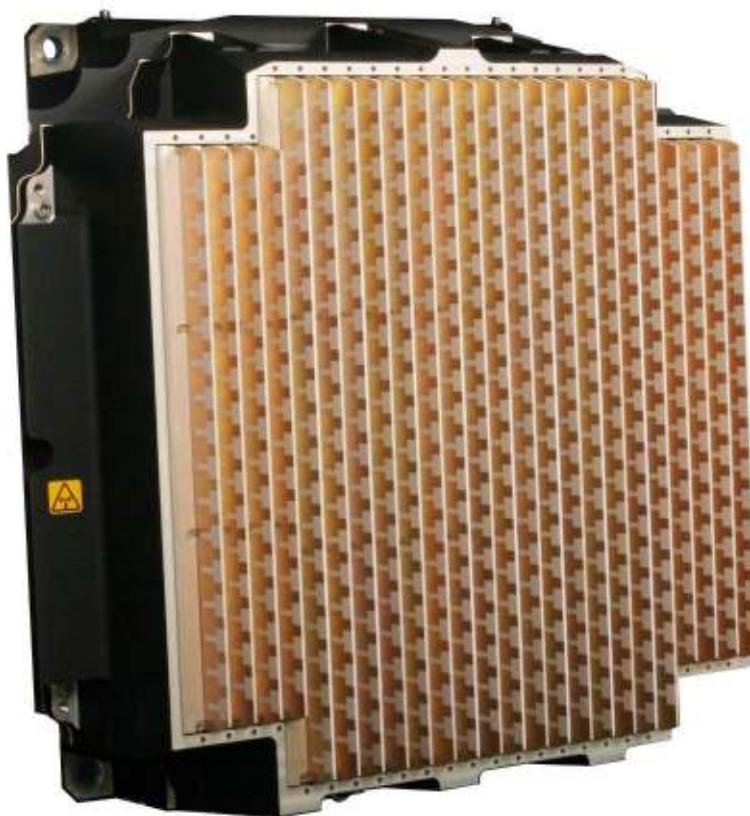
Air-to-air modes include track while scan and single target track. Air combat modes include head-up display (HUD) search, vertical scan, slewable scan and boresight. Air-to-surface modes include real beam ground map, sea surface search and track, synthetic aperture radar (SAR) map, ground moving target indicator (GMTI), beacon interrogation, and inverse SAR imaging freeze. Additionally, the unit can perform ground mapping and weather mapping duties.

The Vixen 500E has three major line replaceable units (LRUs), including a processor/receiver and an AESA antenna.

Notably, as a solid-state AESA unit, the Vixen 500E does not require any interconnecting wave-guides. Also, the impact of future obsolescence is minimized by the use of commercial off-the-shelf-based processor cards with an open architecture and a software abstraction layer. This design enables hardware to be replaced without significantly impacting the radar software.

Two optional LRUs are also available for the Vixen 500E package: a navigation unit and a cooling unit. These can be customized for the chosen platform's needs.

The use of multiple transmit/receive modules gives the Vixen operative robustness so that performance degrades with damage, rather than the radar suddenly ceasing to operate.



The Vixen 500E's AESA

Source: Selex ES

Vixen

Variants/Upgrades

Vixen 500E. The Vixen 500E is a compact, lightweight AESA radar for fighter and lead-in fighter trainer aircraft.

Vixen 1000ES/Raven ES-05. The Vixen 1000ES is produced under a collaborative program of SELEX Galileo (now Leonardo), Saab Microwave, and

Saab Aerosystems. It has been designed especially for the Gripen E/F (Gripen NG) fighter jet.

This variant has now been redesignated the Raven ES-05 and is covered in a separate report in Forecast International's *Airborne Electronics Forecast* and *Radar Forecast*.



The U.S. Customs and Border Protection Lot IIIB C-550s carry the Vixen 500E.

Source: U.S. Customs and Border Protection

Program Review

Investor Day

Finmeccanica (now known as Leonardo) first reported on the Vixen 500E radar at its Investor Day in November 2006. Investor Day is an event held on average once a year with top management from the group's operating companies.

U.S. Says No to South Korea

Aviation Week reported in August 2007 that the U.S. had refused to allow South Korea to fit the Vixen 500E radar to its Korea Aerospace Industries FA-50 aircraft.

According to the report, the U.S. exercised its rights under an agreement whereby the FA-50's ability must remain below that of the U.S. F-16 fighter. The result is that the FA-50 is less attractive than the F-16 on the export market.

U.S. Customs Order

The U.S. Customs and Border Protection (USCBP) agency awarded the first contract for the E-scan Vixen radar. Finmeccanica announced in March 2009 that it had been awarded a \$9.2 million contract from TKC Aerospace to upgrade the CBP Cessna C-550

Vixen

Citation Tracker aircraft with the Vixen 500E intercept radar and associated mission management system. This contract was for the first two radars and mission management systems, with options for additional systems to upgrade the remainder of the fleet.

SELEX reported that the Vixen 500E radar is a forward-looking, fixed array mounted in the nose of the Citation that will allow the pilot to detect and track aircraft of interest.

Defense News reported that, according to SELEX officials, an order for two more radars would be placed. Afterwards, the company believed an additional 10 orders could be placed for a mix of Vixen and Seaspray radars.

Defense News reported that the first radar was expected to be delivered in late 2009 and the second in early 2010.

Introducing the Vixen 1000E

In March 2009, Saab announced that Saab and SELEX Galileo had entered an agreement to cooperatively develop an AESA radar for the Gripen NG program. The system, which was initially aimed at Brazil's fighter program, signified the beginning of a long-term collaboration between two Saab business units – Saab Aerosystems and Saab Microwave Systems – and SELEX Galileo.

The jointly developed AESA radar is based primarily on the SELEX Galileo Vixen AESA radar but also utilizes functionality from the Saab PS-05/A radar and other programs of the two companies. After beginning life as the Vixen 1000E, this radar is now known as the Raven ES-05 and is being used in the Gripen E/F (Gripen NG) fighter jet.

Vixen 500E Cleared for Operation

Following the completion of operational test and evaluation (OT&E) flight trials in August 2012, the Lot IIIB USCBP C-550 Citation platform was cleared for operational duty.

TKC Aerospace performed the Lot IIIB modifications to the C-550s, including the addition of a Vixen 500E radar, an MX-15 EO/IR ball, and an air intercept mission management system. The company, as of December 2013, had received four modification orders from the CBP agency, with allowances for six options.

Going forward, enhancements to the Lot I, Lot II, and Lot III C-550s could improve the aircraft to the Lot IIIB configuration. One of the Lot IIIB variant's distinguishing features is the addition of the Vixen 500E, meaning Leonardo could gain further orders if the older aircraft were updated.

As of December 2018, no plans had been made to modify the earlier aircraft, but the award of a contract for this purpose is not improbable.

Contracts/Orders & Options

<u>Contractor</u>	<u>Award (\$ millions)</u>	<u>Date/Description</u>
SELEX Galileo	9.2	Mar 2009 – TKC Aerospace contract to mount two Vixen 500E radars and associated mission management systems on U.S. Customs and Border Protection Cessna C-550 Citation Tracker aircraft. The contract has options for additional systems.
M7 Aerospace	7.5	May 2016 – An FFP contract to perform modifications on the U.S. Naval Test Pilot School's C-26 aircraft. The modification installs an ISR upgrade and the Vixen 500E radar.

Timetable

<u>Month</u>	<u>Year</u>	<u>Major Development</u>
Nov	2006	Finmeccanica reports on the Vixen 500E radar at its Investor Day
Aug	2007	U.S. prevents Vixen 500E sale to South Korea
Mar	2009	SELEX Galileo awarded Vixen 500E contract to support USCBP aircraft
Aug	2012	Vixen 500E-carrying C-550 enters service with the USCBP
Dec	2013	Iraq orders 24 FA-50s equipped with the Vixen 500E
Aug	2017	Romania places contract for integration of Vixen 500E on board an IAR-99 technology demonstrator

Vixen

Worldwide Distribution/Inventories

The U.S. Customs and Border Protection agency and the U.S. Navy have purchased the Vixen 500E. The air forces of Iraq, Romania, and the United Arab Emirates have purchased the Vixen 500E for fighter/trainer jets.



A U.S. Naval Test Pilot School C-26 Aircraft received the Vixen radar under a 2016 contract.

Source: Wikimedia Commons, Peter Bakema

Forecast Rationale

The Vixen 500E is a highly capable radar in an atypical package. While the radar has the fire control options of a fighter-specified radar, it is optimized for the advanced SAR and ground and sea tracking modes of a surveillance radar. Additionally, the radar's size is scaled for lighter aircraft, not the larger platforms in which a system with these kinds of mission capabilities is typically found.

These features make for a system that is more capable than many other offerings in its cohort. The negative aspect is that the added fire control feature set has resulted in a price that is higher than that of most of the Vixen's surveillance radar competitors.

Many of the Vixen 500E's potential customers will end up purchasing either a dedicated fire control radar or a surveillance radar. Its advanced features and the resulting cost inflation make the radar overqualified for many of the procurement programs for which it could be considered.

However, for military users that can afford the Vixen 500E or have a need for a light aircraft with superb multimission capabilities, the radar is a good option.

Iraq has selected the radar for its Korea Aerospace Industries (KAI) FA-50 fighters/trainers – the Vixen

winning the award over the IAI Elta ELM-2032 specified by South Korea.

While Iraq is utilizing more of the Vixen's fire control features, in the U.S., surveillance and tracking capabilities are the focus. On board USCBP C-550s and the Navy test school's C-26, the Vixen functions as a long-distance cueing system for EO packages, the focus being primarily on reconnaissance.

Probably looking at the Vixen 500E as both a fire control and surveillance option, in August 2017, the National Institute for Aerospace Research in Romania placed an order to integrate the radar on board an IAR-99 technology demonstrator. The contract could lead to further orders from the Romanian government in order to outfit its fleet of 18 IAR-99s with the radar. Additionally, the contract could be part of a plan to market the IAR-99 as a Vixen-carrying dual attack and surveillance platform abroad.

Going forward, further orders by as-yet-unspecified customers are likely, albeit in low numbers.

One potential customer is the USCBP. At present, the Vixen 500E has only been selected for the Lot IIIB C-550s, but earlier Lot III variants could be upgraded in the future. Moreover, additional Lot IIIB C-550s could be ordered if any of the final six options on the original contract are exercised.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR UNIT PRODUCTION												
Designation or Program		High Confidence				Good Confidence			Speculative			
	Thru 2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Total
Leonardo MW Ltd												
Vixen 500E <> Iraq <> Air Force <> FA-50												
	18	6	0	0	0	0	0	0	0	0	0	6
Vixen 500E <> United States <> Government Agency <> C-550												
Note: Speculative Option Exercise												
	0	0	1	2	2	1	0	0	0	0	0	6
Vixen 500E <> Worldwide												
	2	0	2	3	3	2	2	3	3	2	3	23
Subtotal	20	6	3	5	5	3	2	3	3	2	3	35
Total	20	6	3	5	5	3	2	3	3	2	3	35