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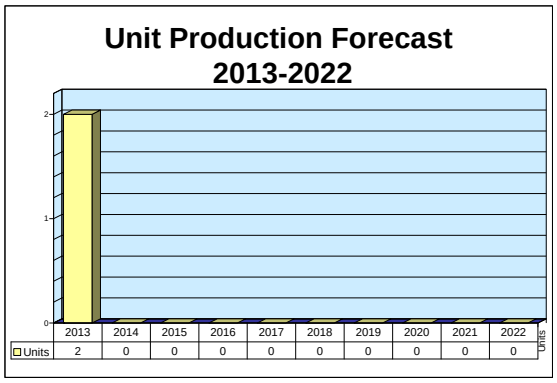
Volvo/GE RM12

Outlook

- Gripen NG replaces RM12 with General Electric F414G
- RM12 production expected to end early in 2013



Orientation

Description. Advanced-technology, two-shaft, low-bypass-ratio, augmented turbofan engine in the 18,000- to 20,000-lbst (80- to 89-kN) class.

Sponsor. The RM12 program has been sponsored by the government of Sweden through the Swedish Ministry of Defense and the Swedish Air Force.

Power Class. 18,100 lbst (80.5 kN) with full augmentation; 12,140 lbst (54.0 kN) dry. Power increase to 20,000 lbst (88.9 kN) possible.

Status. In production for Saab's Gripen fighter.

Total Produced. As of February 2013, an estimated 356 RM12 engines in all variants had been fabricated, including units for prototype aircraft flight testing.

Application. Single- and twin-seat light fighter/attack aircraft. Potential application in heavy fighter/attack aircraft. Current or proposed applications include the following:

Model Variant	Thrust Rating	Application	Units per Airframe
RM12	18,100 lbst (80.5 kN)	Saab-Scania JAS 39A/B	1
RM12C	20,000 lbst (88.9 kN) (a)	Saab-Scania JAS 39C/D	1

(a) Estimated maximum augmented thrust level.

Price Range. RM12, $3.3-3.5 million, estimated in 2013 U.S. dollars.

Competition. The major competition to the Volvo RM12 series comes from the GE Aircraft Engines F404, Eurojet EJ200, Snecma M88, and Klimov RD-33.

Contractors

Prime

Volvo/GE RM12

Volvo Aero Corp	http://www.volvoaero.com, Trollhättan, 461 81 Sweden, Tel: + 46 520 94000, Fax: + 46 8 555 05678, Email: volvoaero@volvo.com, Prime
GE Aviation	http://www.geaviation.com, 1000 Western Ave, Lynn, MA 01905-2655 United States, Tel: + 1 (781) 594-0200, Consortium Member

Subcontractor

Arkwin Industries Inc	http://www.arkwin.com, 686 Main St, Westbury, NY 11590-5018 United States, Tel: + 1 (516) 333-2640, Fax: + 1 (516) 334-6786, Email: rhultmark@arkwin.com (Fuel Distribution Valve)
Meggitt Sensing Systems	http://www.vibro-meter.com, 144 Harvey Rd, Londonderry, NH 03053 United States, Tel: + 1 (603) 669-0940, Fax: + 1 (603) 669-0931 (Vibration Monitoring System)
Moog Inc	http://www.moog.com, Jamison Rd, East Aurora, NY 14052 United States, Tel: + 1 (716) 652-2000, Fax: + 1 (716) 687-4457 (Afterburner Position & Fuel Control Servo Valve)
UTC Aerospace Systems	http://utcaerospacesystems.com, Four Coliseum Centre, 2730 W Tyvola Rd, Charlotte, NC 28217-4578 United States, Tel: + 1 (704) 423-7000, Fax: + 1 (704) 423-7002 (Accessory Drive System)
UTC Aerospace Systems, Electric Systems	http://utcaerospacesystems.com, 4747 Harrison Ave, PO Box 7002, Rockford, IL 61125-7002 United States, Tel: + 1 (815) 226-6000 (Air Turbine Starter)
Unison Industries, Norwich Operations	http://www.unisonindustries.com, 5345 State Hwy 12, PO Box 310, Norwich, NY 13815 United States, Tel: + 1 (607) 335-5000, Fax: + 1 (607) 335-5440 (Ignition Exciter)
Wyman-Gordon Investment Castings Inc	839 Poquonnock Rd, PO Box 999, Groton, CT 06340 United States, Tel: + 1 (860) 445-7421, Fax: + 1 (860) 449-8052 (Investment Cast Airfoil & Hardware)

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Technical Data

Design Features

Intake. Plane annular intake with fixed central bullet-dome spinner.

Fan. Three-stage axial fan, with variable first-stage stator. Solid titanium, wide-chord blades have been further strengthened against foreign object damage (FOD). Bypass ratio approximately 0.31:1. Fan airflow is increased by 10 percent over the F404-GE-400. Fan casing is chemically milled from aluminum.

Compressor. Seven-stage, axial-flow, high-pressure compressor driven by a single-stage turbine, with variable inlet guide vanes and variable Stage 1-2 stators. Overall pressure ratio of 27:1 at a mass flow of approximately 158 lb/sec (71.67 kg/sec). Discs, IN718.

Combustor. Single-piece, short annular combustor of smoke-free design, with dual ignition units and igniter plugs. Venturi swirlers employed. Turbine inlet temperature estimated to be 2,600°F (1,426°C). Fuel injector assembly has been provided by Coltec Industries.

Turbine. The single, axial, highly loaded HP stage features film- and impingement-cooling of the DSR80 blades and IN754 vanes. The single, axial LP stage is also cooled by bleed air from the compressor and has stator vanes brazed in pairs. Compared to the F404-GE-400, TIT has been increased 105°C. Discs are IN718.

Afterburner. Hydraulically actuated, convergent-divergent type. Nozzle area ratio about 1.6:1, with combustion in both core and bypass flows.

Accessories. Hydromechanical fuel control with a hydromechanical/digital electronic backup unit providing up to 90 percent of the former's capability. High-reliability geared fuel pump. Backup, aircraft-powered auxiliary ignition system. Integrated Drive Generator from Hamilton Sundstrand.

Bearings. Five main-shaft ball and roller bearings.

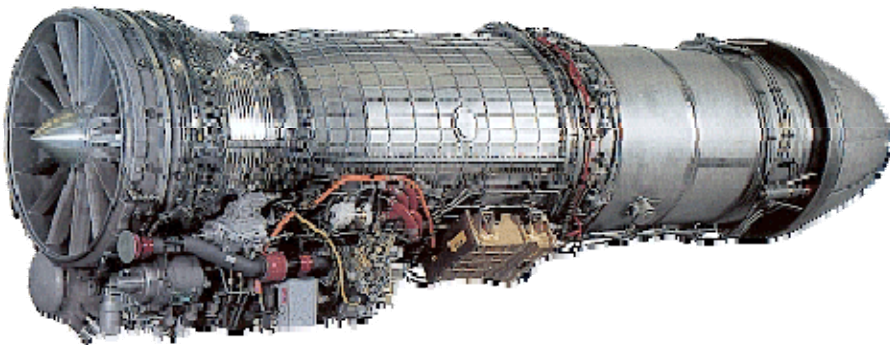
Dimensions

	Metric Units	U.S. Units
Length	4,040 mm	159 in
Diameter, max (a)	884 mm	34.8 in
Diameter, inlet	709 mm	27.9 in
Weight, dry	1,055 kg	2,325 lb

(a) With exhaust nozzle.

Variants/Upgrades

RM12. The RM12, developing 18,100 lbst (80.5 kN), equips series-production models of the Gripen. It was developed from General Electric's F404-GE-100. Control systems and materials were changed, and the afterburner's efficiency was significantly improved.



RM12

Source: Volvo

Program Review

Background. RM12 development work has been done by the General Electric Company (USA); GE Aircraft Engines, West Lynn, Massachusetts; and AB Volvo, Volvo Aero Corporation, Trollhättan, Sweden. Final assembly of the engine is done by Volvo in Trollhättan. GE Aircraft Engines is now a part of GE Transportation.

In June 1981, GE Aircraft Engines and Volvo Flygmotor (now Volvo Aero Corporation) signed an agreement to undertake the joint development of a higher-thrust version of the F404-GE-400, with the new powerplant intended for the then-upcoming JAS consortium Model 2110 light fighter/attack aircraft. Sweden followed a pattern established with the RM8A/B in acquiring a manufacturing license for an existing engine and then adapting it. The resulting engine was the F404/RM12 (also referred to as the RM12).

Originally derived from the YJ101 turbojet engine (the engine for the aborted Northrop YF-17 project), the RM12 incorporates much of the design philosophy of the F404-GE-100. The RM12 incorporates all of the high-temperature materials of the F404 engine, including IN718, which replaces Rene 95 in compressor and turbine discs, and DSR80, which is incorporated into the DS turbine blades.

The engine effort involved minor modifications to the fan section. Although the original F404 provides much more FOD protection than previous-generation turbojet/turbofan engines, Sweden's peculiar requirements, such as the ability to operate from austere or damaged runways and unprepared strips, necessitated strengthening the fan module and increasing the size of the fan. In other work, the LP turbine materials were improved, airflow was increased by 5 percent, turbine inlet temperature was increased to 105°C, and an improved-efficiency afterburner was added.

Specific Swedish requirements that the GE/Volvo engine had to meet were: 1) SLS static performance at 18,000 lbst initially; 2) the installation of redundant control systems to meet single-engine requirements; and 3) greatly improved bird-strike capability.

Like the original F404, the RM12 is an easily maintained engine comprising six major modules: fan,

Volvo/GE RM12

high-pressure compressor, combustion chamber, high-pressure turbine, low-pressure turbine, and augmentor. The powerplant is also designed and produced with 13 borescope ports, nine of which are accessible without removing the engine from the airframe.

Specific development activities began in 1982 under a joint program of GE and Volvo, which share a 60/40 percentage split by value of parts. In the evolution of the RM12, Volvo participated in the engine's development, while GE had ultimate responsibility for engine design and development. In the production phase, Volvo produces approximately 30 percent of the engine's parts – Volvo buys 60 percent of the parts in kits from GE and then assembles the engine in Trollhättan. Volvo also supports Swedish operation of the engine. The value split on engine production is approximately 65 percent GE and 35 percent Volvo.

Testing under the First Engine to Test (FETT) program began in June 1984, followed in January 1985 by testing at Volvo. According to Volvo, flight-worthiness testing commenced in 1986; the flight-testing program began in 1987. Production-standard RM12s entered production in 1991, and deliveries began in 1992.

Volvo RM12 Applications

JAS 39 Gripen. The JAS 39A is the first production version Gripen intended to replace Viggen and Draken fighters in Swedish service. The first flight of the initial production aircraft occurred in September 1992; deliveries began in June 1993. A first group of deliveries (30 aircraft, including the JAS 39B prototype) occurred between 1993 and 1996; a second group of deliveries (110 aircraft, including 14 JAS 39Bs and 20 JAS 39Cs) began in 1996 and was completed in 2003.

The JAS 39B is the designation for a two-seat combat and operational conversion trainer variant. Parliamentary approval was granted in June 1992 for the second group of 110 aircraft as well as development of the two-seat version. The second group included 14 two-seaters.

Saab rolled out the JAS 39B prototype in September 1995; its first flight took place in April 1996. The initial production JAS 39B made its first flight in November 1996. Initial delivery of a production JAS 39B occurred in May 1998.

JAS 39C/D. In 1997, the Swedish Defense Materiel Administration (FMV) ordered a third group of 64 Gripens, including 50 single-seat aircraft and 14 two-seaters. Deliveries of those aircraft began in 2003 and were completed in 2007. The single-seat models have the designation JAS 39C, while the two-seat models have the designation JAS 39D.

In addition, the final 20 aircraft of Batch 2 were produced as JAS 39Cs.

The JAS 39C/D has in-flight refueling capability, new computer software, an onboard oxygen-generating system, full-color cockpit displays, a strengthened wing structure, and the ability to carry new types of pylons.

The export version of the Gripen will be nearly identical to the JAS 39C/D.

The first prototype JAS 39 was presented in April 1987. The RM12-powered Gripen made its first flight in December 1988 in Linkoping, Sweden. The first production-standard Gripen made its initial flight on March 4, 1993.

In 1982, the Swedish Ministry of Defense awarded a contract to JAS for the development of five prototype aircraft and the first lot of 30 JAS 39 aircraft, with options for an additional 110. The Swedish Parliament approved the contract in May 1982.

In June 1997, Sweden ordered a third Gripen production batch composed of 50 single-seat aircraft and 14 two-seat aircraft. Those 64 aircraft were delivered between 2003 and 2007. With this order, Sweden had ordered a total of 204 Gripens.

At the 1995 Paris Air Show, British Aerospace Defence's Military Aircraft Division and Saab Military Aircraft sealed a long-anticipated alliance to develop, build, and market export versions of the Gripen. In November 1998, the South African government decided to acquire 28 Gripen combat aircraft, finally ordering them in December 1999. Deliveries began in 2008 and were completed in 2012.

In November 2001, the Hungarian and Swedish governments signed a Memorandum of Understanding concerning the lease by Hungary of 14 Swedish Air Force Gripens over a period of 10 years. Deliveries began in early 2006 and were completed by the end of 2007.

Note: *The current Gripen aircraft has a length of 14.1 meters (46.24 ft), a wingspan of 8.4 meters (27.56 ft), and a max T-O weight of 14 metric tons (30,864 lb). Its speed is supersonic at all altitudes.*

Timetable

Month	Year	Major Development
Jun	1981	Agreement signed with GE
Jun	1982	Development initiated/FSED
	1982-83	Component test (GE)
Jun	1983	Official development testing begins
Jun	1984	First Engine to Test (FETT) program at GE
Feb	1985	First full engine test (Volvo)
Jun	1985	Full-scale demonstration test
Mid-	1986	Flight-worthiness testing begins at Volvo
	1987	Flight testing begins at Volvo
Dec	1988	Prototype Gripen flight testing begins
Feb	1989	Gripen prototype crashes
May	1990	Resumption of flight test program
Early	1992	First production-standard RM12 delivered
Mar	1993	First flight of production-standard Gripen
Jun	1993	Swedish Air Force takes delivery of first Gripen
Dec	1999	South Africa becomes first Gripen export customer
Early	2006	Start of deliveries of 14 remanufactured aircraft to Hungary
	2008	First deliveries to South Africa
	2013	RM12 production expected to end

Worldwide Distribution/Inventories

As of February 2013, an estimated 356 RM12 turbofans had been built. Virtually all of the engines are in **Sweden**.

Forecast Rationale

Volvo's RM12 is forecast to end production for its sole application on the Saab Gripen fighter. The current Gripen is being replaced by the upgraded Gripen NG (next generation), and the new aircraft has replaced the RM12 with the higher-thrust GE F414 for increased performance and payload. It is expected that Volvo will support the installed engine fleet for current Gripen operators by providing module and parts support.

Saab is proposing the Gripen for upcoming fighter procurements in Brazil (36-130 aircraft), Bulgaria (8-16), Croatia (8-12), Denmark (30), Greece (30-60), Malaysia (18-36), the Netherlands (85), Romania (24), and Slovakia (14), among others. If Saab prevails in any of these contests, it will provide the new Gripen NG.

Other opportunities for Gripen sales may be found in Argentina, Bangladesh, Brunei, Canada, Colombia, Ecuador, Estonia, Mexico, Peru, Qatar, and Serbia. In addition, Saab could secure repeat orders from existing Gripen operators.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR UNIT PRODUCTION

Designation or Program	High Confidence				Good Confidence			Speculative			
	Thru 2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
Volvo Aero Corp												
RM12 Military <> JAS 39 C/D/Export												
	144	2	0	0	0	0	0	0	0	0	0	2
Total	144	2	0	0	0	0	0	0	0	0	0	2