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Snecma M53 - Archived 7/2008

Outlook

- Dassault has withdrawn the Mirage 2000 from India's Multirole Combat Aircraft program; Mirage was sole application for Snecma's M53 engine
- Engine upgrade kits may be installed on significant number of existing Mirages in service with several air forces
- No engine production forecast, since it has effectively ceased

Orientation

Description. The M53 is a single-spool, low-bypass-ratio, augmented military turbofan engine in the 18,000- to 22,000-lbst (80- to 97.8-kN) class.

Sponsor. The Snecma M53 is sponsored by the French Ministry of Defense through the Armée de l'Air (French Air Force). The engine was privately developed by the prime contractor.

Power Class. 18,000-22,000 lbst (80.06-97.85 kN) with augmentation. Power of M53-PX3 to 22,640 lbst.

Status. Production for Dassault Mirage 2000-5 multirole fighter has ceased.

Total Produced. At the start of 2007, an estimated 700 M53 engines were built for Mirage aircraft.

Application. Multirole fighter/interceptor aircraft. Current or proposed applications include the following:

<u>Model Variant</u>	<u>Thrust Rating</u>	<u>Application</u>	<u>Units per Airframe</u>
M53-2	18,740 lbst (83.35 kN)	Dassault Mirage 2000 (prototype aircraft)	1
M53-5	19,850 lbst (88.29 kN)	Dassault Mirage 4000	2
M53-P2	21,400 lbst (95.18 kN)	Dassault Mirage 2000/2000C	1
		Dassault Mirage 2000-5/-5D/-9	1
		Dassault Mirage 2000N/-NK2/-D/-BR	1
		Dassault Mirage 4000 (engine replacement)	2
M53-PX3	22,640 lbst (100.7 kN)	Dassault Mirage 2000 Series (possible re-engining)	1

Price Range. Price is estimated at \$3.2-\$3.4 million in 2007 U.S. dollars for the M53-P2.

Competition. The major competition to the Snecma M53-P2 engine comes from the GE Aircraft Engines F404, Eurojet EJ200, Volvo RM12C/D, and, to a

limited degree, Snecma's own M88. While other engines are in the power band of the M53, including the Klimov RD-33 and the Rolls-Royce Pegasus 11-21, those engines do not actively compete against the M53 in aircraft engine competitions.

Contractors

Snecma M53

Prime

Snecma	http://www.snecma.com , 10, allée du Brévent, CE1420 Courcouronnes, Evry, 91019 France, Tel: + 33 1 69 87 09 00, Fax: + 33 1 69 87 09 02, Prime
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Subcontractor

Chromalloy Gas Turbine Corp	http://www.chromalloysatx.com , 4430 Director Dr, San Antonio, TX 78219-3299 United States, Tel: + 1 (210) 333-6010, Fax: + 1 (210) 359-5570 (Compressor Wheel)
Defontaine SA	http://www.defontaine.com , 3 Rue Louis Renault, BP 57, Saint Herblain, 44800 France, Tel: + 33 2 406 78989, Fax: + 33 2 406 78903 (Flash Butt Welded Rings)
Hellenic Aerospace Industry - Athens Office	http://www.haicorp.com , Athens Tower, 2-4 Messoghion Ave, Athens, 115 27 Greece, Tel: + 30 210 77 99 679, Fax: + 30 210 77 97 670, Email: marketing@haicorp.com (Exhaust Nozzle)
Malichaud Atlantique, (Antoine Marez)	http://www.malichaudatlantique.com , Z.I. of the sisters East St, Hubert-Pennevert, Rochefort, 17300 France, Tel: + 33 5 4682 1300, Fax: + 33 5 4687 5218 (LP Blade)
Ratier-Figeac	Route de Cahors, BP 2, Figeac, 46101 France, Tel: + 33 5 6550 5050, Fax: + 33 5 6534 2363 (Compressor Diffuser)
SNR Roulements Haute Precision	114, Route de Champ Argonay, Farçon, Pringy, F-74 370 France, Tel: + 33 50 65 3250 (Main Shaft Ball & Roller Bearings)

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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

Design Features

Intake. Front annular intake with pointed spinner.

Fan. Three-stage, titanium blade fan with bypass ratio of 0.35 (0.36 for the M53-P2). No inlet guide vanes.

Compressor. The three-stage fan is followed by a five-stage HP compressor, both sections on a single shaft. Pressure ratio is 9.0:1 at 10,200 rpm, 9.8:1 for the M53-P2. Air flow of 189.6 lb/sec (86 kg/sec) for M53-5; the M53-P2 has a mass flow of 207.2 lb/sec (94 kg/sec). No inlet guide vanes. Titanium rotor blades and discs.

Combustor. Single, annular combustor of smoke-free, pre-vaporizing design.

Turbines. Two axial turbine stages drive the combined fan and HP spool, which are on a single shaft. The two turbine stages are cooled.

Accessories. Accessory drives, front roller bearing and ball thrust bearing housed in mid-frame located between the fan and the compressor. For single-engine installation, the following options are available: an emergency lubrication system; an aircraft hydraulic system; an emergency drive or emergency fuel system; and a hydraulic system emergency drive. The control system includes a hydroelectronic control associated with an electronic computer designed by Elecma. Exhaust nozzles for M53 engines for Greek Air Force Mirage 2000 aircraft built in Greece by Hellenic Aerospace Industries (HAI).

Afterburner. Reheat duct fitted with a variable area multiflap nozzle. Afterburner fuel controlled by Elecma electronic fuel computer.

Dimensions. Approximate dimensions and weights of the Snecma M53-P2 are as follows:

	Metric Units	English Units
Length	5,070 mm	199.6 in
Diameter, maximum	1,055 mm	41.54 in
Diameter, inlet	796 mm	31.33 in
Weight	1,515 kg	3,340 lb

Performance. Approximate performance parameters of the M53-P2 are as follows:

	<u>Metric Units</u>	<u>English Units</u>
Thrust, with A/B	95.18 kN	21,400 lbst
Thrust, dry	64.49 kN	14,500 lbst
A/B SFC	58.643 mg/Ns	2.07 lb/hr/lbst
Unaugmented SFC	25.497 mg/Ns	0.90 lb/hr/lbst
Air Flow Rate	94 kg/sec	207.2 lb/sec
TIT	1327°C	2,420°F
Pressure Ratio	9.8:1	9.8:1
Bypass Ratio	0.36	0.36

Variants/Upgrades

M53-2. Early engine prototype variant, rated at 18,740 lbst (83.35 kN) with full augmentation. This variant powered the initial prototype units of the Mirage 2000. Qualified for French military aviation in April 1976.

M53-5. A follow-on to the M53-2, the M53-5 was the powerplant for early production-line versions of the Mirage 2000. Modified fuel delivery increases augmented thrust to 19,850 lbst (88.29 kN). Dry rating is 12,240 lbst (54.44 kN). This engine version also powered the prototype twin-engine Mirage 4000.

M53-P2. The M53-P2 is a further improved and uprated derivative of the M53 series, incorporating an improved LP compressor, enhanced turbine blade design, redesigned hot-end components, and advanced film and convection cooling and a new FADEC, giving a maximum reheated thrust of 21,400 lbst (95.18 kN) and maximum military thrust of 14,470 lbst (64.36 kN). Production began in January 1985. The service entry date was March 1987.

M53-PX2. This planned variant is aimed at extending the life cycle and reducing the operating cost of the M53. The changes are also intended to make the M53 better suited to throttling in tactical flying, as opposed to the sustained high supersonic speeds it was originally designed for. The PX2 offers a 2-3 percent fuel

consumption (SFC) reduction for greater range. The infrared signature is also to be reduced. New turbine airfoils will be incorporated. A streamlined product support structure similar to the U.S. Air Force's Integrated Product Support program (i.e., "just in time" product support and enhanced spare part inventory management) is an integral part of the cost reduction effort.

M53-PX3. Snecma has also been working on the M53-PX3, which incorporates advanced technologies from the M88 to significantly boost operability and lower costs.

The M53-PX3 will have a FADEC in a redundant layout. The engine will have an enhanced HPT and LPT, and thus offer longer parts life, in addition to greater turbine efficiency and temperature resistance. Those improvements are largely based on technologies developed for the M88 engine. Also available will be a six percent increase in takeoff thrust.

Snecma hopes to attain the M53-PX3 program engine qualification in 2006 and to begin initial deliveries of the retrofit kit in 2007. Customers would be limited to current operators of the M53, as complete engine production has ceased.

Program Review

Background. Development of the Snecma M53 began in 1967 under a program established to develop an engine suitable for the high-speed, high-performance multipurpose fighter and attack aircraft for the 1980s. Among the goals of the M53 development project were high specific thrust and low weight, structural integrity suitable for high speed (Mach 2.5), low SFC in low-altitude subsonic cruise flight, high reliability, simple design, and cost-effective maintenance. The M53 uses the experience and development technology

of the Snecma Atar, and experimental TF 106 and 306 engines. The resulting design is a single-shaft unit with the fan and compressor driven from the same shaft, unlike more conventional turbofans, which couple the fan to a low-pressure compressor. This arrangement is also referred to as a continuous-bleed turbojet, or "leaky turbojet," since the pressure ratio varies with the compressor shaft rpm.

The M53 is composed of 12 modules, including the afterburner and the exhaust nozzle variable-flap unit.

Snecma M53

The prototype was designed and constructed in 15 months, with bench testing occurring in 1970. Test flights were conducted in 1973 after a thorough testing phase using an Aerospatiale Caravelle testbed aircraft.

The M53-P2's extensive flight range – from unrestricted flight at very low speeds up to Mach 2.2 – makes it an ideal engine for modern combat missions. The M530P2 has logged more than 1.11 million flying hours (as of May 2005).

Snecma M53 Applications. The Snecma M53 has been tied to Dassault Aviation (formerly Avions Marcel Dassault-Breguet) Mirage 2000 aircraft, as follows:

Mirage 2000. The Mirage 2000 is a delta-wing, very high-performance, single-engine aircraft series, developed from experience gained during the Mirage III/5 projects. Powered by a single Snecma M53, the aircraft is capable of a maximum level speed of Mach 2.3 and a range with extra fuel tanks of 1,000+ nautical miles (1,852+ km). Deliveries of the production-standard aircraft with the M53-5 engine of 19,840 lbf (88.24 kN) have, since January 1985, given way to M53-P2-powered models.

French Procurement. Procurement of Mirage aircraft by France is: 2000B, 30; 2000C, 124; 2000D, 86; 2000N, 75. It received its last Mirage 2000 in 2001.

Export Orders. Export orders for the Mirage 2000 were slow to develop, but several nations eventually bought the aircraft. Export customers of the Mirage 2000 series included UAE (68), Egypt (20), Greece (55), India (59), Peru (12), Qatar (12), and Taiwan (60). Jordan previously ordered 10 aircraft, but could not consummate the contract. In addition, an order from Iraq for 50 aircraft was dropped due to the country's failure to make payments on earlier military contracts and because of its invasion of Kuwait.

Greek Participation. Greece's order of 40 Mirage 2000s was seen as a plus for the Greek armaments industry. Hellenic Aerospace Industries (HAI) was involved in work on the aircraft fuselage and wing sections, and helped fabricate parts for the fuselage, doors, and landing gear. HAI's engine division was involved in the assembly and testing of the approximately 50 M53-P2 engines. The first Greek-assembled M53-P2 was delivered to Snecma in April 1988.

In May 1989, it was announced that HAI had signed another agreement with Snecma to manufacture under license 235 exhaust nozzles for the French M53 powerplant used on the Mirage 2000 aircraft ordered by Greece. The five-year program was valued at

approximately GRD3,500 million (\$22 million), including development of the infrastructure.

Mirage 2000-9. The Mirage 2000-9 is similar to the 2000-5 model but with provisions for GEC-Marconi Hakim air-to-surface, precision-guided munitions and Matra BAe Dynamics Mica RF radar-guided, air-to-air missiles. That aircraft model, which also features Elettronica radar-warning receivers, was ordered by the UAE.

Brazilian Participation in Mirage Program. A Dassault-led French consortium bought into Brazil's Embraer in 1999, and Dassault proposed at that time a coproduction scheme for the Mirage 2000-5, with the aircraft being designated Mirage 2000BR.

The initial buy of the Mirage 2000 was planned at about 20 aircraft, with a possible ultimate requirement believed to be in the range of 70-120 aircraft.

Many analysts had called out the Mirage 2000 as the front-runner in the Brazilian competition, despite its Air Force having expressed a preference for the Sukhoi Su-35. However, Brazil has once again postponed a final decision and now appears more likely to go with an interim solution that may well involve either leasing available aircraft or acquiring used machines until, at some future date, a definitive re-equipment decision is made. In any case, Forecast International is no longer predicting the selection of the French fighter for Brazil's requirement.

India and the Mirage: Will She or Won't She. The Mirage 2000-5 was viewed by many as the favorite for a 126-unit fighter requirement of the Indian Air Force, competing against the Lockheed Martin F-16, Boeing F/A-18, Saab JAS 39 Gripen, and the MiG-29. More recently, India has increased the planned buy to 200 aircraft, primarily in order to split the order between two manufacturers.

The Indian Air Force reportedly favors the Mirage 2000 but the government does not wish to exclude Russia, its primary supplier, and the U.S. is also making a determined push as relations between New Delhi and Washington continue to thaw.

Originally, India was insisting that 108 of the 126 aircraft be built under license by Hindustan Aeronautics in India. It is safe to assume that the bulk of the increased (200-unit) buy will also be produced or assembled locally.

Russia recently sweetened its bid, offering India the redesignated MiG-35, a production variant of the improved MiG-29OVT demonstrator that appeared at the Moscow Air Show in August 2005.

Snecma M53

In the early months of 2006, Dassault announced that it was withdrawing the Mirage from the running in the MRMCA program. It cited the cost of keeping the soon-to-be-dormant production line open as it waited for the Indian government to select an aircraft for the program as the major factor in its decision. As the

Mirage was the only application for the M53, engine production has effectively ended.

Snecma M53 Engine Refits. Approximately 100 Mirage 2000s worldwide have been refitted with the M53-P2 variant.

Timetable

<u>Month</u>	<u>Year</u>	<u>Major Development</u>
	1967	Design initiation
Feb	1970	First bench test
Jul	1973	First flight in a Caravelle testbed aircraft
Jun	1974	Type qualification for the Mirage F1-E installation
Dec	1974	First flight in F1 made
Dec	1976	M53-5 maximum thrust test (20,000 lbst with A/B)
Jul	1977	Official 50-hour certification program of M53-5
Mar	1978	M53 initial flight on Mirage 2000
Mar	1979	First flight of Mirage 4000
Jan	1983	M53-P2 flight test aboard Mirage 2000 prototype
	1984	Start of Mirage 2000 deliveries to French Air Force
Late	1985	M53-P2 becomes production-standard model
	1987	Mirage 4000 fitted with M53-P2 engines
Early	1988	French Mirage 2000 refitting program begins with M53-P2
Jul	1991	M53-P2s log first 100,000 flight-hours (-P2 and -5 at 200,000 hours cumulative)
2H	1992	Dassault donates the prototype Mirage 4000 with M53-P2 engines to the Le Bourget Museum of Air and Space
Jan	1993	Sale of 60 Mirage 2000-5s to Taiwan made official
	1999	The M53 passes the mark of 780,000 flying hours
	2001	Final Mirage 2000 delivered to French Air Force
May	2005	The M53 passes the mark of 1.11 million flying hours
	2006	French Mirage 2000/M53 production ends
	2007	M53-PX3 retrofit kits possibly ready for delivery

Worldwide Distribution/Inventories

At the start of 2007, an estimated 700 Snecma M53 engines were built, of which about 640 were still in service in the inventories of **Egypt, France, Greece, India, Peru, Qatar, Taiwan, and UAE.**

As of early December 2005, Forecast International estimated that the worldwide distribution of the Mirage 2000 aircraft was: Egypt (19), France (252), Greece (46), India (48), Peru (12), Qatar (11), Taiwan (57), and UAE (61).

Forecast Rationale

In early 2006, Dassault announced that it was withdrawing the Mirage from India's MRMCA competition in favor of promoting its more advanced Rafale fighter. As the Mirage was the sole application for Snecma's M53 engine, production has effectively ceased. The IAF may add to its existing Mirage fleet by acquiring aircraft second hand, but not in great enough quantities to keep the new aircraft production line going.

Upgrades for Existing M53 Fleet

There is a significant number of Mirage fighters in service with several air forces for Snecma to successfully market engine upgrade kits. Snecma may find its PX2 and PX3 upgrades popular with air forces seeking to extend the service life of their Mirages as a more cost-effective solution to purchasing new aircraft.

Snecma M53

Ten-Year Outlook

No engine production forecast, since it has effectively ceased. Therefore, the ten-year chart has been eliminated.

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