

# ARCHIVED REPORT

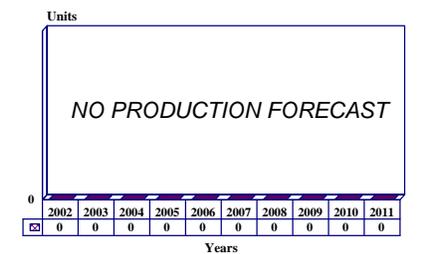
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## R.550 (Magic 1/Magic 2) - Archived 12/2003

### Outlook

- Production has ceased
- Magic is being offered for export in conjunction with Dassault's Mirage 2000
- New Magic orders are not expected to result in the production of all-new missiles
- Magic will remain on active duty beyond 2010
- Eventually, the Magic will be superseded by the new MICA-IR

10 Year Unit Production Forecast  
2002 - 2011



### Orientation

**Description.** Short-range air-to-air missiles.

**Sponsor.** French Ministry of Defense through the French Air Force.

**Contractors.** Developed and produced by Matra-Hachette SA, Matra Defense, Velizy-Villacoublay, France. Serial production is accomplished at Salbris, France.

**Major Subcontractors.** Artus SA (actuators), Bronzavia SA (seeker head nitrogen coolant), SFIM (gyros), Societe Anonyme de Telecommunications (SAT-IR seeker head), PROTAC (Richard and Romeo solid-propellant rocket motors), Souriau et CIE (electrical connectors), and Vibrachoc SA (shock absorbers).

**Licensees.** India and Matra BAe Dynamics could collaborate to design and manufacture a new short-range air-to-air missile. Furthermore, Matra has offered

a license to produce the Magic 2 in-country (see "Indian Magic" under **Worldwide Distribution**).

**Status.** The Magic 2 is in service and is operational with at least 17 air forces around the world.

**Total Produced.** Over 11,432 R.550 Magic 1 and Magic 2 missiles (including RDT&E units) were produced. A total of 8,290 Magic 1 and Magic 2 missiles were ordered, with about 7,900 delivered through December 1986. In early 1989, total orders for Magic missiles stood at 9,100 from at least 17 countries. By early 1990, 9,500 Magic missiles had been ordered.

**Application.** Close range, air-to-air dogfight missile deployed on a number of tactical aircraft, including helicopters.

**Price Range.** The unit price of the Magic 1 was placed at \$71,280 in FY87 dollars. The price of the Magic 2 is placed at \$93,600 in FY00 dollars.

### Technical Data

**Design Features.** The R.550 Magic 2 is capable of being fired from supersonic fighter aircraft during turns pulling over 8g. Most of the following data is for Magic 1, although differences for the Magic 2 are

indicated. Magic 2 is very similar to the Magic 1, but it does have a longer range (30,000 meters/16.19 nautical miles) and greatly enhanced seeker performance.

|                      | <u>Metric</u> | <u>US</u> |
|----------------------|---------------|-----------|
| <b>Dimensions</b>    |               |           |
| Length:              | 274.8 cm      | 9.02 ft   |
| Diameter:            | 15.7 cm       | 6.18 in   |
| Weight (Magic 1):    | 89 kg         | 195.8 lb  |
| Weight (Magic 2):    | 90 kg         | 198 lb    |
| Finspan (Canard):    | 47 cm         | 18.5 in   |
| Finspan:             | 66.8 cm       | 26.29 in  |
| <b>Performance</b>   |               |           |
| Speed:               | Mach 3        | Mach 3    |
| Range (min):         | <500 m        | <0.27 nm  |
| Range (max):         | >10,000 m     | >5.40 nm  |
| Maximum load factor: | 135g          | 135g      |

**Propulsion.** A Romeo (Magic 1) or Richard (Magic 2) butalane solid-propellant rocket motor, both with a 1- to 9-second burn delivering 2650daN impulse, are supplied by PROTAC.

**Control & Guidance.** Type AD3601 cryogenically (nitrogen) cooled passive infrared-seeking head, with a mechanical scan mechanism for target acquisition, produced by Societe Anonyme de Telecommunications. The gyroscope-stabilized autopilot, with independent stabilization in roll, pitch, and yaw, is produced by Matra. The canard aerodynamic control surfaces are electrically actuated.

As Magic is a short-range missile, target acquisition is visual, with the nitrogen-cooled seeker head warning the pilot when lock-on has been achieved. No provision is made for slaving the seeker head to the aircraft fire control radar. The seeker head is sensitive to both infrared and CO<sub>2</sub> emissions, capable of detecting targets head-on with infrared and at angles of up to 80 degrees with CO<sub>2</sub> emissions, and also capable of independent target detection. The warhead is armed 1.8 seconds

after launch, giving a minimum engagement distance of 0.3 kilometers (984 ft), but more typical ranges are 2.5 kilometers (3.97 mi) at medium altitude and 10 kilometers (6.25 mi) at high altitude.

**Launcher Mode.** Airborne launch from pylons or wingtip racks aboard a variety of fighter/attack aircraft. Both Magic 1 and Magic 2 can use the same launchers as the AIM-9 Sidewinder. (See separate report.) Aircraft currently compatible with Magic include the Alphajet, Mirage III, Mirage 5, Mirage 50, Mirage 2000, Mirage F1, Hawk, Jaguar, Sea Harrier, Super Etendard, MiG-21, MiG-23, F-5, F-8, A-4, and F-16; other types are possibly operating this missile as well. The F/A-18 Hornet is also being made compatible with the R.550.

**Warhead.** Both Magic 1 and Magic 2 employ a pre-fragmented warhead produced by Thomson-Brandt, with a contact and infrared proximity fuze that has an effective radius of about 5 meters. The warhead weighs about 13 kilograms (28.6 lb), with a charge weight of 12.5 kilograms (27.5 lb). Giat Industries has developed a new warhead for the Magic 2.

## Variants/Upgrades

There are two versions of the Magic: the [R.550 Magic 1](#), the original Magic air-to-air missile; and the [R.550 Magic 2](#), a greatly enhanced version of the R.550 that is 100 percent interchangeable with the Magic 1.

For additional information, please see the pertinent entries under the **Program Review** section.

## Program Review

**Background.** Matra began development of the R.550 Magic air-to-air missile in 1968 as a private venture, designing it specifically for the Mirage F1. The French government began funding the program in 1969 and the first R.550 Magic 1 was in-service in 1975. The missile has since been cleared for use by the Mirage III, Mirage 5, MiG-21, and MiG-23 (with India), F-8E, A-

4, Jaguar International (to carry Magic missiles on overwing pylons), Sea Harrier, Hawk, Super Etendard, and also the Mirage 2000 series. It has also been adapted to the AerMacchi MB.326K, and Matra has demonstrated the missile with helicopter applications. A Messerschmitt-Bolkow-Blohm Bo.105 helicopter fitted with Magics was exhibited at the 1978

Farnborough Show, and in the late 1970s a joint Matra/Northrop study validated the application of wingtip-mounted R.550s to the F-5E. Saudi Arabia's F-5 fighters are thus equipped.

Magic 2/F-16. Matra, under a \$10 million contract, adapted the Magic 2 missile to the F-16 Fighting Falcon. There are over 15 F-16 operator nations worldwide, accounting for more than 1,600 aircraft, a potentially lucrative market for the Magic 2. Matra is expected to offer the missile to F-16 users who are unable to acquire more advanced short-range AAMs, and as a possible replacement for existing AIM-9 Sidewinder stocks.

The first launch of a Magic 2 from an F-16 took place on May 12, 1989. Operational trials on the F-16 were completed in February 1990 with the firing of a Magic 2 at 20,000 feet (6,100 m) over the North Sea at Mach 1.3 at 8.7g at the limits of the F-16 envelope. The standard F-16 configuration will be four R.550 Magic 2s per aircraft on wingtip and underwing stations. Turkey is said to have expressed an interest in arming its F-16 fighter fleet with the R.550 Magic 2.

Magic 2/F/A-18. Another agreement between Matra and McDonnell Douglas covers the marketing of the F/A-18 fighter with the R.550 Magic 2 air-to-air missile. Matra is considering a similar program for the BAe Hawk and Panavia Tornado.

New SRAAM. France is interested in procuring a new short-range air-to-air missile for its Mirage 2000 fighters. A request for proposals for the Missile d'Auto-protection et de Combat Rapproché (MACR) will be issued before the end of 2002.

According to sources, the MACR will replace the R.550 Magic but not the new MICA-IR. The MICA-IR, along with the medium-range MICA-EM, will still be carried by the Rafale and the latest version of the Mirage 2000.

Candidates to meet the MACR need to include the MICA-IR, along with BGT's IRIS-T and Raytheon's AIM-9X Sidewinder. The MACR could enter service as early as 2007.

Missile Models. There are two models of the R.550: Magic 1 and Magic 2. As of January 1987, 8,290 R.550 missiles in both versions had been ordered, about 75 percent of these for export. By early 1990, this figure had risen to more than 9,500 units.

R.550 Magic 1. The R.550 is similar to the AIM-9 Sidewinder in its overall dimensions, but features a unique double canard layout with a set of movable canard control surfaces directly behind and in line with the cruciform fixed surfaces. The movable canards are electrically operated with the angle of attack variable by

up to 20 degrees. Matra designed the R.550 to use the same launcher as the Sidewinder, which the R.550 has replaced in several air forces. The fact that Magic does not require additional black boxes or other equipment, and the fact that the aircraft need not return to the factory for installation has been a major factor in the missile's success. The missile's warhead contains 6 kilograms of explosive and is at the rear of the missile to provide stabilization.

Matra replaced the Cassegrain system typically used in the optics of infrared-homing heads with a system in which the sole moving part is a low-inertia, primary plane mirror. This has resulted in a rapid scanning rate for the missile. A failure of many infrared-homing missiles is that they have been prone to track false targets in the background terrain. Matra has reportedly greatly reduced this tendency, following lengthy studies of Magic's modulator and signal processor.

Magic can be launched from an aircraft maneuvering at up to 6g, and has a range from 500 meters (1,640 ft) to over 10,000 meters (5.40 nm). The maneuvering limit is 30 to 35g. No minimum airspeed exists, but the upper limit is 365 mps (700 kt).

Magic 2. Matra developed a greatly enhanced version of the R.550 missile, designated Magic 2, in the 1980s. The new Magic, while improved in both reliability and performance over the original missile, remains 100 percent interchangeable with the now-designated Magic 1. Magic 2 incorporates further-refined aerodynamics, advanced electronics, and digital signal processing, a new multi-element seeker head with greater sensitivity, and increased airframe load factors. The Magic 2 possesses an all-aspect attack capability and general performance said to be superior to the AIM-9M Sidewinder. Some reports state that the missile's new seeker head possesses 80 to 100 times greater sensitivity than the original, and is capable of being slaved to the aircraft's fire control system. Serial production of the Magic 2 began in February 1985.

Magic 2 is so tactically flexible that it is considered two missiles in one. In the integrated operational mode, the missile receives target information as well as flight parameters from the launch aircraft. In this manner, the missile can be used to its maximum effective range; after launch, it is fully autonomous. In the autonomous operational mode, the missile can acquire and track the target while still on the launch pylon; no information is received from the launch aircraft. This latter mode is ideal for dogfight situations. The capability of integrated operation with onboard target designation and fire control equipment means that both day and night engagements can be successfully made at very short, short, and medium ranges. The new seeker is

also understood to be more resistant to countermeasures.

Performance is also improved, with the maneuvering limit raised to 50g. Target detection can now be made

at distances greater than the range of the missile itself (about 10 kilometers), enabling a fire-first advantage over an adversary.



R.550 MAGIC 2

Source: French MoD

## Funding

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Deliveries of Magic 2 missiles to the French Air Force are proceeding, but future funding is somewhat in doubt. The French Ministry of Defense had been requesting an additional 3,000 Magic 2 missiles in its FY95 budget, but funding shortfalls may have postponed or prevented altogether the issuance of any procurement contract. Some examples of prior year funding for the Magic are as follows:

FY81 – French Air Force funding included FRF21 million for Magic 1 procurement, FRF20 million for production preparations for Magic 2, and FRF60 million for Magic 2 development. French Navy funding totaled FRF24 million for procurement.

FY82 – French Air Force funding included FRF5 million for Magic 1 procurement, FRF136 million for procurement of Magic 2, and FRF37 million for Magic 2 development. French Navy funding totaled FRF12 million.

## Recent Contracts

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No specific information is available concerning Magic contract awards.

## Timetable

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| <u>Month</u> | <u>Year</u> | <u>Major Development</u>   |
|--------------|-------------|--|
| Early        | 1967        | Feasibility studies initiated  |
|              | 1969        | Development initiated  |
| Jan          | 1972        | First successful engagement of turning target                        |
|              | 1973        | Full-scale engineering development; first air launch from Mirage III |

| <u>Month</u> | <u>Year</u> | <u>Major Development</u>                          |
|--------------|-------------|---|
|              | 1974        | Flight evaluation by French Air Force             |
|              | 74-75       | Initial production deliveries                     |
|              | 1975        | Operational status                                |
| Dec          | 1976        | Production at 100 per month                       |
|              | 1978        | R&D on Magic 2 initiated                          |
|              | 1983        | Continuing production of Magic 1                  |
| Feb          | 1983        | First flight of Magic 2                           |
| May          | 1983        | Magic 2 unveiled at Paris Air Show                |
| Late         | 1984        | Magic 1 production terminated in favor of Magic 2 |
| Feb          | 1985        | Magic 2 IOC                                       |
| Nov          | 1989        | Production continued                              |
|              | 1990        | Magic 2 F-16 operational trials complete          |
|              | 2000-2001   | Production concluded                              |

## Worldwide Distribution

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The Magic has been an excellent export item for France, with about 75 percent of total production being exported. This trend is forecast to continue with the Magic 2. Among the recent customers for the R.550 Magic 2 have been **Jordan** and **Venezuela**. Amman ordered the Magic 2 as part of a FRF1 billion (\$175.2 million) contract for armaments systems for its new Mirage 2000s. Although no R.550 procurement total was given, the estimated number of missiles purchased has been placed between 120 and 200 units. This delivery may still be suspended due to Jordan's support of Iraq during Operation Desert Storm. Venezuela purchased the R.550 under a \$100 million contract, as part of an overall air force modernization program.

In mid-1984 it was reported that **Argentina** had received supplies of R.550 Magic missiles for fitting to their ex-Israeli A-4 Skyhawk aircraft. It was revealed in early 1987 that Libya had supplied the missile to the Argentinian Air Force during the Falklands conflict. This was the first reported use of the Magic on the Skyhawk, which could prove an interesting indicator for further sales of the weapon. This would be of interest to other countries that use the aircraft and have a requirement for an air defense capability at minimum cost, such as Indonesia and Singapore.

**Chile** is interested in acquiring new combat aircraft and air-to-air missiles. However, this purchase has been put off indefinitely due to the Asian economic crisis. The financial problems in Asia have resulted in a downturn in revenues from copper exports for Chile, leading to the decision to postpone new fighter purchases. Among the aircraft offered to Chile are Boeing's F/A-18 Hornet, Lockheed Martin's F-16, Dassault's Mirage 2000, and Saab's JAS 39 Gripen.

The **Philippines** is interested in acquiring new combat aircraft as part of its air force rebuilding effort. Various aircraft have been under consideration, but no specific decision has been reached. Among the aircraft examined by Manila were ex-Belgian Air Force Mirage 5s (which would be equipped with the Magic), ex-French Air Force Mirage F1s, South Korean F-5s, Israeli Kfirs, South African Cheetahs, and US-built F-16s. Eventually, the Belgian Mirages were transferred to Chile to replace its Air Force's older Hawker Hunters.

In 1994, **Qatar** announced its intention to acquire the Mirage 2000-5 to replace its aging Mirage F1 fleet (numbering 12 aircraft), which will be transferred to Spain. The Qatari Mirage 2000-5s will be armed with the R.550 Magic 2 and MICA-Active. The MICA and Magics will be purchased under a separate FRF1.5 billion (\$280 million) agreement.

In 1992, **Taiwan** (Republic of China) purchased 60 Mirage 2000-5 fighters and an unspecified number of R.550 air-to-air missiles as part of a deal worth an estimated \$3.6 billion. This announcement came just over two weeks after Taipei signed for 150 F-16A/B fighters. The French deal included the procurement of about 1,000 R.550 Magic and MICA air-to-air missiles. Deliveries of the aircraft commenced in 1996. Taiwan is the launch customer for the Mirage 2000-5.

Eastern Europe Market. Eastern Europe represents an all new market for Western defense firms. Various countries have expressed an interest in Western-built fighter aircraft and their accompanying air-to-air missiles including

Poland, Hungary, and the Czech Republic. Sales to Eastern Europe could generate additional orders for such current generation air-to-air missiles as the Magic 2.

The **Czech Republic** is said to be on the verge of buying the R.550 Magic 2. So far, no procurement order has been placed. The actual first sale of the Magic to a Eastern European country was to **Romania** in early 1996. Romania purchased several hundred Magic 2 missiles to outfit its MiG-21 and MiG-23 fighters. These aircraft are being upgraded by IAR in cooperation with Elbit of Israel.

Indian Magic. India has asked Matra to help design and manufacture a new short-range, infrared-guided air-to-air missile. The system could be based on the French R.550 Magic 2, but if a new missile is developed it is more likely that it will use MICA-IR technology. The new missile would be produced in India. So far, additional information is scarce on the India-Matra missile deal. However, Matra has offered India a license to manufacture the Magic 2. This is seen as a possible alternative to the development of a new MICA-based air-to-air missile.

**User Countries.** While Matra has not identified all its customers, it is known that in addition to **France** (Magic 1 and/or 2 onboard Air Force Mirage F1C, Mirage III, Mirage 5, Mirage 2000, Jaguar, Rafale fighters; and Navy F-8 Crusader and Super Etendards), the following countries have either operated or ordered the R.550: **Argentina** (A-4 Skyhawk), **Australia** (Mirage III), **Belgium** (Mirage 5), **Republic of China** (Magic 2 on Mirage 2000-5), **Ecuador** (Mirage F1, Jaguar S), **Egypt** (Mirage 5, MiG-21), **Greece** (Mirage F1), **India** (Magic 1 and possibly Magic 2 on MiG-21, Jaguar, Sea Harrier, Mirage 2000), **Iraq** (Mirage F1, MiG-21), **Jordan** (Mirage F1), **Kuwait** (Mirage F1), **Libya** (Magic 1 on Mirage F1), **Morocco** (Mirage F1), **Oman** (2 Jaguar S squadrons), **Pakistan** (Mirage III, Mirage 5), **Qatar** (Magic 2 on Mirage 2000-5), **Romania** (Magic 2), **Saudi Arabia**, **South Africa** (Magic 1 on Mirage F1), **Spain** (Mirage F1), the **United Arab Emirates** (Abu Dhabi on Mirage 5), and **Venezuela** (Magic 1/2 on Mirage III).

## Forecast Rationale

Although production has been concluded, the R.550 Magic missile is still being offered for export in conjunction with the Mirage 2000. A possible near-term customer for this combination is Brazil.

Brazil has been offered a full-up Mirage 2000 production line if it selects this aircraft to meet its future fighter requirements. Such a deal could stimulate interest in the licensed fabrication of Magic, although Brazil could opt to arm its new Mirage 2000s with its indigenous MAA-1 Piranha short-range AAM.

Also, certain Eastern Europe countries could be interested in the Mirage 2000 to replace their aging inventories of Soviet-built fighters. So far, the

Mirage 2000 has yet to win any customers in this region and the prospects for the R.550 securing significant sales in Eastern Europe are slim.

While success in one or more of these competitions could see new orders placed for Magic, it will not result in the production of all-new missiles. Instead of the Magic, MBDA's main marketing focus is now the new MICA-IR.

No further production of the Magic missile is anticipated unless a major order is placed that cannot be fulfilled with missiles from existing French stockpiles. Nevertheless, the Magic will likely remain on active duty throughout the decade and possibly even beyond.

## Ten-Year Outlook

### ESTIMATED CALENDAR YEAR PRODUCTION

| Missile            | (Engine) | High Confidence Level |    |    |    | Good Confidence Level |    |    |    | Speculative |    |    | Total 02-11 |   |
|--------------------|----------|-----------------------|----|----|----|-----------------------|----|----|----|-------------|----|----|-------------|---|
|                    |          | thru 01               | 02 | 03 | 04 | 05                    | 06 | 07 | 08 | 09          | 10 | 11 |             |   |
| MATRA BAE DYNAMICS |          |                       |    |    |    |                       |    |    |    |             |    |    |             |   |
| R.550/1            | ROMEO    | 7241                  | 0  | 0  | 0  | 0                     | 0  | 0  | 0  | 0           | 0  | 0  | 0           | 0 |
| R.550/2            | RICHARD  | 4191                  | 0  | 0  | 0  | 0                     | 0  | 0  | 0  | 0           | 0  | 0  | 0           | 0 |
| Total Production   |          | 11432                 | 0  | 0  | 0  | 0                     | 0  | 0  | 0  | 0           | 0  | 0  | 0           | 0 |