

# CUSTOMER SUPPORT: A MISSION-READY AIRCRAFT WITH LOW OPERATING COSTS

## Rafale: designed for easier operation and maintenance

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Logistical support for the RAFALE was designed on the strength of lessons learned with the MIRAGE 2000, endowing the RAFALE with its predecessor's excellent reliability.

Right from the start of the development phase, the French Ministry of Defense imposed very stringent 'integrated logistics support' (ILS) requirements for the RAFALE program. Concurrent engineering, bold technological choices, and Dassault Systèmes CATIA software produced an ILS system that not only met but exceeded these high supportability standards.

**Selected from a range of unique and innovative features, the following examples demonstrate the advances in reliability, accessibility, and maintainability brought by the RAFALE.**

- More than 20 years of experience on the MIRAGE 2000 has proven the effectiveness of the integrated testing in the Weapon Delivery and Navigation System (WDNS). Accordingly, for the RAFALE we decided to extend integrated testing to all aircraft systems. **Thanks to the accurate diagnoses that integrated tests provide, they allow targeted flight line replacements to be made**, down to electronic circuit boards and specific components.
- **Human factors engineering conducted with CATIA** was used to ensure easy access to components in aircraft bays, meaning that flight line maintenance operations can be carried out by a single technician. This also helped reduce the risk of error and the duration of these operations.
- **A centralized armament safety system** has made it possible to dispense with conventional end-of-runway safety pin removal operations, clearly reducing the risk of error and accident in weapon implementation and allowing for unbeatable rearming times that increase overall 'turnaround times' (TAT).
- Using CATIA results in highly precise mechanical assemblies, which in turn allow the gun, head-up display (HUD) or radar to be replaced **without long boresighting operations**.
- With the M88 engine, **it is no longer necessary to perform checks on an engine test bench** before reinstalling an engine on an aircraft. The M88's groundbreaking design means that the engine can be changed within an hour.

- To allow the RAFALE the greatest possible autonomy during deployments, it requires only **minimum ground support equipment**:
  - Its On-Board Oxygen Generation System (OBOGS) eliminates the need for liquid oxygen re-fills, so the associated ground support equipment for the production and transportation of oxygen are no longer needed.
  - The optronics are cooled by a closed-loop nitrogen circuit, which overcomes the need for a dedicated nitrogen supply chain.
  - Its built-in auxiliary power unit (APU) makes engine start-up possible without a ground power unit.
  - All ground support equipment is compact or foldable, so that it can be transported by air. It does not require external power. In addition, only two types of carriages are needed for all armament loading and unloading.

All of these maintainability features, which were validated from the development phase by French Navy and Air Force support specialists, have demonstrated their reliability in combat during various operations. This ease of maintenance means that technicians can be trained quickly: Rafale conversion training and aircraft support was organized for export clients within a matter of weeks, **providing them with the operating and training autonomy they need to successfully deploy a fleet.**

In Mérignac, a center set up as a training squadron, and equipped with up-to-date teaching resources based on digital information retrieved from the CATIA digital mock-up, is in service to train clients, technicians and pilots.

## An affordable, high-tech fighter

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**Its outstanding reliability has drastically simplified maintenance for the RAFALE.**

- Its unique maintenance concept results in a **lighter maintenance schedule**, requiring fewer man-hours and a smaller team of technicians.
- **The RAFALE does not have to leave its operational base for maintenance purposes.** Unlike other types of fighter aircraft, the RAFALE airframe and engine no longer require time-consuming and costly periodic preventive inspections.
- **With more than 3,600 logged flight hours on the “fleet leaders”, no structural parts have been changed**, proving the robustness of the airframe and the maintenance concept.
- **With its 21 modules, the architecture of the M88 engine is a perfect example of this maintenance philosophy:** all maintenance and repairs can be performed simply by sending modules or individual parts to the central shop or to the manufacturer. **No run-up checks** or balancing are necessary before returning the engine to service.
- Systems that can impair reliability were eliminated from the RAFALE very early on in the design phase, for example:
  - airbrakes,

- the moving parts of air intakes,
- constant speed drive (CSD) for AC generators,
- the refueling probe deployment and retraction mechanism.

**This significantly reduces the spare inventory, man-hours, and ground support equipment required.**

Rafale deployments have confirmed that specialized infrastructures are unnecessary, even in cases of intensive use: maintenance can be performed outdoors or in a temporary shelter.

- **A focus on standardization in the design phase** also minimized the number of different spare parts needed:
  - the same part is used in different locations on the aircraft. Thanks to precision mechanical manufacturing, which eliminated the need for fitting and boresighting operations when installing airframe components, it is easier to install a part in the different locations in which it is used.
  - Whenever possible, left-hand and right-hand components such as foreplanes, FCS actuators, etc. are identical.
  - Miscellaneous parts such as screws and electronic modules have also been designed with a view to standardization.
- **Special attention has been paid to accessibility.** For example, the side-opening canopy facilitates replacement of the ejection seat, so that it can be removed by two technicians in just ten minutes.
- **The RAFALE does not require any external test equipment on the flight line:** all of the test systems are integrated, so technicians can run checks on the aircraft itself if need be, thereby boosting its deployability and the speed of diagnoses.
- DASSAULT AVIATION has extensive experience in corrosion protection for carrier-based aircraft (SUPER ETENDARD) and marine patrol aircraft (ATLANTIC 1/ ATLANTIQUE 2), which has allowed it to develop effective protection techniques. **The RAFALE therefore features some of the most advanced corrosion protection solutions**, which also helps drive down operating costs.
- All of these advantages allow DASSAULT AVIATION to make firm promises about the availability of fleets for air activities, over several years (typically 10).
- Just as the use of innovative approaches and tools made it possible to turn the Rafale into a benchmark aircraft in terms of performance, operational capability and support, the DASSAULT AVIATION teams favor and constantly implement innovations for the benefit of current fleets, and to produce the aircraft of the future and its support.

## **“Combat proven”: operational proof**

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From 2006 to 2011, French Air Force and Navy RAFALE fighters engaged in a number of combat missions in Afghanistan, where they proved highly effective. The modular air-to-ground weapon

(AASM) "Hammer", laser-guided bombs, and the 30 mm gun were employed on many occasions with remarkable precision.

In 2011, French Air Force and Navy RAFALE fighters were successfully engaged in coalition operations over Libya. They were the first fighters to operate over Benghazi and Tripoli, and performed the entire spectrum of missions for which the RAFALE was designed: air-superiority, precision strikes with the AASM, deep strikes with SCALP cruise missiles, intelligence for the ISTAR mission (Intelligence, Surveillance, Tactical Acquisition and Reconnaissance), and Strike Coordination And Reconnaissance (SCAR) fire support. During the Libyan conflict, hundreds of targets – tanks, armored vehicles, artillery emplacements, fuel and munitions stores, command centers and air-defense systems (SA-3 Goa and SA-8 Gecko fixed and mobile SAM launchers) – were hit with devastating accuracy by RAFALE aircrews.

From the beginning of 2013 to September 2016, French Air Force RAFALEs were engaged in missions in Africa, helping destroy enemy logistics infrastructure and support friendly troops in contact.

Since 2015, French Air Force and Navy RAFALEs have been actively engaged in strikes against hostile forces in Iraq and Syria alongside our coalition allies, based in the Near and Middle East.

Since early 2019, the Rafale has been back on the African theater of operations (Chad), carrying out reconnaissance missions as part of Operation Barkhane.