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FOX THREE

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Editorial

FOREWORD

In the 20th issue of Fox Three,

Rafale International is proud to report on the status of the French Navy carrier air wing, a lethal and powerful strike force now composed of three squadrons of Rafale M naval omnirole fighters. Since entering operational service, the Rafale M has established itself as the World's leading carrier-borne fighter. The stringent French Navy requirements called for a versatile fighter capable of conducting the whole range of nuclear and conventional air-to-air and air-to-surface missions against the latest threats in a wide range of tactical environments. To package this kind of capabilities into such a compact aircraft required smart engineering: a host of new systems and technological innovations were introduced to ensure maximum combat efficiency and operational flexibility for the warfighter.

As demonstrated during countless operations, the exquisite Rafale M has become a key French Navy power projection tool. The battle-hardened fighter has successively taken part in combat operations around the world, thus proving to be a reliable and versatile combat asset.

The 'FOX THREE' Team

Summary

p.3/5



**THREE SQUADRONS
OF RAFALE M NAVAL
OMNIROLE FIGHTERS
NOW OPERATIONAL**

p.6/9



**TRAINED TO VERY HIGH
STANDARDS**

p.12/15



**FULLY INTEROPERABLE
RAFALE M**

p.16/19



**OPTIMISED FOR COMBAT
AVAILABILITY AT SEA**

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THREE SQUADRONS OF RAFALE M NAVAL OMNIROLE FIGHTERS NOW OPERATIONAL

The French Navy now has at its disposal a powerful, agile and flexible carrier strike wing composed of three Rafale M squadrons.

The Rafale M is undoubtedly the most advanced naval strike fighter in service anywhere. Designed from the outset for carrier operations, it has successfully been engaged in combat operations from the *Charles de Gaulle* nuclear aircraft-carrier in Afghanistan, Libya, Iraq and Syria. The versatile Rafale M excels in the full spectrum of missions, including air superiority/offensive counter air, fleet air defence/defensive counter air, pre-strategic and tactical reconnaissance, nuclear deterrence, destruction of enemy air defences, deep strikes, battlefield air interdiction, close air support, anti-ship strikes, buddy-buddy refuelling...



Optimised design

Compared to US super carriers, the *Charles de Gaulle* is smaller, with a shorter deck that imposed the development of an advanced aircraft that would guarantee particularly slow approach / landing speeds. To match this stringent requirement, Dassault Aviation came up with an aerodynamically advanced delta design fitted with canard foreplanes. The selected configuration offered the best compromise between minimum and maximum speeds, combat agility during a dogfight, and range and endu-

rance to strike targets far away. Even better, the Rafale M was fitted with thirteen hardpoints to carry a 9,500-kg weapon load, the largest combat load of any naval fighter. In flight, its performance is startling. It's got tons of thrust and loads of lift for maximum agility, as demonstrated at countless airshow venues since service entry. As a result, Rafale M air combat performance clearly exceeds expectations: it can accelerate and turn hard, and change altitude very rapidly to become unpredictable for the enemy. Specific features and low observable coatings have been introduced to significantly reduce

the Rafale's radar cross section, further lowering vulnerability. In an effort to minimise procurement / operating costs and decrease production and maintenance complexity, the naval Rafale M and its Rafale C and B air force counterparts all share an extremely high level of commonality. Their airframes, weapon systems, engines and subsystems are identical, differences being mainly restricted to the landing gear, to the arresting hook and to the introduction of a built-in foldable access ladder.

Global strike capability

Striking deep into contested airspace requires a platform able to operate effectively in medium to very high-level threat environments. The Rafale was designed with such a mission in mind as part of the French nuclear deterrence concept. When flying from the carrier, the Rafale M can strike a huge range of targets far inside hostile territories, either alone or as part of a multinational coalition. It can 'fling' long-range weapons such as the combat-proven Scalp

stealth cruise missile into warzones guarded by sophisticated enemy air-defence systems.

To increase the reach of carrier-launched strikes, the Rafale M can be refuelled by a land-based tanker or by another Rafale configured as a buddy-buddy tanker, thus giving all-out operational flexibility to the carrier air wing. For buddy-buddy refuelling missions, a Rafale can be fitted with four Mica air-to-air missiles, an in-flight refuelling pod and up to four drop tanks to maximise give away capabilities. The Rafale M is a combat-proven tool. It has been used

by the French Navy as a global combat asset, operating deep into Afghanistan, Libya, Iraq and Syria, demonstrating in action its operational effectiveness. Using a constantly expanding range of precision weapons, French naval aviators have destroyed an extremely large array of hostile positions, armoured vehicles, buried structures, guns and mortar emplacements, hardened aircraft shelters, cave entrances, including heavily defended targets in Libya.

Expanding number of squadrons

All three French Navy fighter squadrons – Flottilles 11F, 12F and 17F shore-based at Landivisiau, in Brittany – are now equipped with an ever expanding fleet of Rafale M fighters. Flottille 12F was the first to convert to the Rafale, followed by 11F. Flottille 17F has just completed

the conversion from the Super Etendard which was withdrawn from use in 2016. It has now been declared fully operational on the Rafale.

The three units take turns providing two duty squadrons to the French carrier air group, the third squadron assuming the training role for new pilots in the meantime. Thanks to the Rafale's legendary ease of use and intuitive man-machine in-

terface, all French Navy pilots are trained to conduct all air-to-air and air-to-surface missions. Readiness is maintained at a very high level: at any given time, 24 Rafales stand ready to deploy on board *Charles de Gaulle* or to fly to a shore base for contingency operations.

Capabilities expansion

The French Ministry of Defence is constantly investing to guarantee the fighting relevance of all its Air Force and Navy Rafales and their ability to operate in contested battlespaces: software upgrades are introduced every two years on average, a required process for capabilities expansion. From early 2019, Air Force Rafale C and B fighters and their Navy Rafale M counterparts will be brought to the F3R standard that will permit the use of the Meteor ramjet-propelled air-to-air missile and of the Thales Talios next generation targeting pod. The AESA radar, the Spectra electronic warfare suite, the IFF, the datalink and other systems will also be upgraded as part of the F3R standard, thus offering robust

offensive and defensive capabilities to the French Navy. Work on integrating these new capabilities has now been completed, with service entry slated in the next few months.

Looking further ahead, Rafale M fighters will receive numerous new enhancements as part of the new Standard F4 which is being developed to meet the projected threats over the next two decades. Enhancements will include a helmet-mounted display, new cockpit displays, a new directional datalink to improve their connectivity, and multipurpose active electronic scanning planar arrays able to carry out numerous functions simultaneously: detection, jamming, electronic attack and communication. These planar arrays will rely on the latest Gallium Nitride (GaN) technology which

will offer extended operational ranges and reduced power and cooling requirements. A whole range of new, lethal weapons will be adopted, including the new Franco-British, multipurpose, stealth, stand-off Future Cruise and Anti-ship Weapon (FCASW) which will replace both the Scalp and the current AM39 Exocet.

From the start of its design process, the Rafale family was developed to easily incorporate new weapons, new sensors and new systems as part of spiral enhancements. Future variants will be even more survivable and networked for total interoperability with other French and foreign assets. Flown by competent and confident Aéronautique Navale pilots, Rafale M omnirole fighters will constitute a powerful strike force for the foreseeable future.



New Generation Mica missile for the Rafale

From 2026, all three Air Force and Navy Rafale variants will be equipped with the state-of-the-art Mica NG (New Generation) air-to-air missile for air-dominance missions. Two new versions of the fire-and-forget MBDA Mica NG, infrared and radar-guided, will be developed to supplant the current Mica IR and EM used for beyond visual range interceptions, dogfights and self-defence. They will be fitted with innovative seekers and rocket motors and will be resilient to US-imposed International Traffic in Arms Regulations (ITAR) to enhance their export potential. The two variants of the Mica NG will supplement the Meteor: while the ramjet propelled missile will be used for engagements at extreme ranges, the multipurpose Mica NG will prove its worth in a whole range of situations, from long-range interceptions to within visual range combat. Deliveries to the French Armed Forces will span from 2026 to 2031.



TRAINED TO VERY HIGH STANDARDS

French Navy Rafale pilots follow a rigorous conversion and training programme aimed at providing the highest level of carrier aviation flight safety and operational lethality.

After gaining their wings, Marine Nationale and Armée de l'Air pilots selected for the Rafale undergo conversion training at Saint-Dizier air base within Escadron de Transformation Rafale 3/4 'Aquitaine', a joint squadron with a pooled inventory of Navy Rafale M single-seaters and Air Force Rafale C single-seat and Rafale B two-seat variants.

Comprehensive syllabus

ETR 3/4 'Aquitaine' instructors are drawn from the two services, an obvious way of ensuring that combat experience is shared with the young airmen to broaden their combat skills at the earliest stage. The syllabus is split into six phases spread over seven months, with the sorties arranged by topics:

- Familiarisation, for initial conversion;
- Basic Fighter Manoeuvring / Air Combat Manoeuvring, to learn basic dogfighting tactics;
- Basic Fighter Interception, focusing on beyond visual range air-combat tactics;
- Navigation, to master the use of the Rafale's weapon system and of some of its air-to-surface weapons;
- Air policing, a training module dedicated to the tactics and

techniques required to intercept, identify and, if necessary, forcibly divert or even engage a hostile aircraft as part of the air-defence/air-policing/air-sovereignty mission;

- In-flight refuelling, a skill all fighter pilots have to master.

Advanced synthetic training aids, including full mission simulators, are widely used to reduce costs and confront the students with high fidelity combat scenarios. In fact, Rafale pilots practise their skills in a simulator at all stages of their career: for their first Rafale flight, their first solo, their yearly tests, for advanced training phases, for weapons and tactics training... At Saint-Dizier, the Armée de l'Air has at its disposal four Rafale cockpits while a further two are in service with the Marine Nationale at Landivisiau (a new training centre is due to open at Mont-de-Marsan in a not too distant future). These six cockpits can be modified from

an Air Force Rafale C single-seater configuration to a Navy Rafale M single-seater in about 30 minutes, with only a few black boxes to be changed. To simulate a two-seat Rafale B, two cockpits can be electronically coupled after a few changes limited to the side of the fuselage shapes and to the canopy. Missions are flown by trainees on both B and M aircraft, exploiting to the full the remarkably high level of commonality between all Rafale variants to ensure a high degree of standardisation among future Air Force and Navy aircrews. For optimum effectiveness, maintenance within ETR 3/4 'Aquitaine' is undertaken by a joint team of sailors and airmen. There again, commonality between the three Rafale variants is a decisive advantage, maintainers working indifferently on Air Force or Navy aircraft for added flexibility and improved availability.





Easy and intuitive to fly

After graduating from the joint Saint-Dizier squadron, new Rafale Navy pilots go to Landivisiau naval air station, in western France, where they follow an additional, maritime-oriented syllabus. The Rafale is so easy and intuitive to fly that all carrier landings by Navy trainees are conducted in the Rafale M single-seater. In the past, French Super Etendard pilots had to wait to gain experience before being qualified for carrier landings at night. With the advent of the Rafale, all this has changed, and night traps are now conducted much earlier in their career, up to the point that all newcomers straight from flying school will now be qualified to operate at night from the *Charles de Gaulle* right from the beginning. Aircrews are also trained to fly with night vision goggles (NVGs) at a much earlier stage, thus improving the ability of the French carrier air group to operate round the clock, taking advantage of the night to catch foes by surprise, during resupply operations for instance. NVGs have been used extensively by French Rafale aircrews in combat.

As part of the continuation training to maintain currency and improve proficiency and tactical efficiency in demanding scenarios, Navy pilots frequently use the advanced simulator operational at Landivisiau. During her 2017/2018 refit/mid-life update, a Sogitec simulator was installed on board carrier *Charles de Gaulle*. This was needed to ensure that there is no discontinuity in the training for the full spectrum of missions that can be flown by the Rafale: when pilots are deployed, they tend to focus on one type of mission only, with the risk of having eroded skills in other roles. The availability of the simulator on board the carrier will minimise this issue.



Weapons/tactics training

The Rafale carries a wide spectrum of guided weapons, including the GBU-12 Paveway II, GBU-22 and GBU-24 Paveway III laser-guided bombs, the SBU-38, 54 and 64 versions of the Hammer (Highly Agile, Modular Munition Extended Range) family of precision weapons, the AM39 Block 2 Mod 2 Exocet anti-ship missile, the Scalp cruise missile and the Mica IR/EM air-to-air missiles which will be supplemented by the Meteor from early 2019. To maintain proficiency,

pilots spare no effort: weapons/tactics training is pushed to unprecedented levels thanks to a rigorous tactical preparation and thanks to the use of the advanced simulators. Navy Rafales routinely visit firing ranges to work with forward air controllers and carry out firing runs with their 30-mm cannon and their precision weapons. To cut costs, aircrews can rely on the Laser-Guided Training Round (LGTR) to replicate the release and guidance sequences of laser-guided bombs. A few selected pilots are also cleared to operate the ASMP-A (Air-Sol Moyenne Portée-Amélioré) nuclear missile, requiring further, highly specific training.









FULLY INTEROPERABLE RAFALE M

Since entering service, French Navy Rafales have routinely operated as part of multinational coalitions, demonstrating total interoperability with foreign assets in the air, on the ground and at sea.

There has been a strong push for interoperability within NATO for quite a while and the Rafale is a logical outgrowth of that trend. The twin-engine fighter is fully compliant with all NATO Stanags (standard agreements). As a result, it is optimised for joint, multinational operations and can readily accept foreign weapons. With its NATO-compatible encrypted radios and its Link 16 datalink it can seamlessly plug into allied command and control networks. Thanks to the ROVER (Remotely Operated Video Enhanced Receiver) system, Rafale pilots can instantly share targeting imagery with forward air controllers on the ground to shorten the amount of time taken to destroy a target during a TIC (Troops In Contact) event.

At sea

Interoperability extends to aircraft-carrier operations: the Rafale M is fitted with the very same launch and recovery systems as all US Navy fixed-wing aircraft, making it totally compatible with all US-built catapults and arresting gear

systems. Equally important is the fact that it is fully compliant with the most stringent electromagnetic compatibility rules for safe operations on board a foreign carrier.

On board the *Charles de Gaulle*, the Rafale M shares the deck space with US-built E-2C Hawkeye airborne early warning

aircraft flown by Flottille 4F. They operate as part of hunter killer teams, performing network centric offensive and defensive operations in conjunction with other French and allied assets, including fast jets, helicopters and surface vessels.





Close cooperation with the US Navy

French Navy Rafales frequently operate from US Navy super carriers, helping pilots maintain carrier landing currency and qualifications when carrier *Charles de Gaulle* is in dry dock and/or in refit. Since 2002, countless cross deck exercises have been carried out, with Rafales performing touch and goes or traps on US flat tops while American F/A-18 Hornets and Super Hornets visited the French flagship in return. In July 2008, during the *Charles de Gaulle's* first nuclear refuelling and overhaul, six Rafales and two E-2C Hawkeyes spent a week on board USS *Theodore Roosevelt*

(CVN-71) off Norfolk, Virginia. Ten years later, in May 2018, during the *Charles de Gaulle's* second refit/mid-life upgrade, a full squadron of twelve Rafales accompanied by a single Flottille 4F Hawkeye deployed on USS *George H. W. Bush* (CVN-77) for two weeks, replacing on board the vessel a squadron of F/A-18 Hornets. On top of the carrier landing qualification needed by French pilots to maintain currency, French and US naval aviators flew a large variety of training missions, replicating a whole range of realistic combat scenarios. Operating alongside F/A-18E/F Super Hornets, EA-18G Growlers, E-2C Hawkeyes and MH-60S Seahawks of Carrier Air Wing 8 (CVW-8), the French Rafales flew demanding training

scenarios. Air-to-air missions were flown, including 4 v 4, 6 v 8 and 8 v 8 engagements to rehearse advanced beyond visual range interception tactics. Rafales and Super Hornets flew either together as part of mixed forces, or against each other. Using common procedures, all Blue Air assets shared the very same Link 16 network, thus boosting tactical efficiency and lethality. Both offensive counter air operations, to simulate a push to obtain air superiority over a hostile land, and defensive counter air missions, in defence of the carrier task force, were carried out. Some Rafales were fitted with AESA (Active Electronically Scanned Array) for maximum detection and tracking ranges.

Complex air-to-surface missions

During the deployment on board USS *George H. W. Bush*, Rafale pilots flew a wide range of air-to-surface missions against simulated ground and naval targets, refining their tactics when flying in mixed formations with US Navy fighters. Rafales rehearsed anti-ship attacks against US

Navy surface combatants, simulating the firing of AM39 Block 2 Mod 2 Exocet missiles after performing a very low-level ingress in radar and radio silence, targeting information being provided by a Hawkeye via Link 16. A Combat Search and Rescue (CSAR) package comprising twenty Rafales, Super Hornets, Growlers and Seahawks under the control of the French Hawkeye was also launched to fictitiously recover

a 'downed' pilot behind enemy lines.

Further upgrades planned for the Rafale will ensure that the fighter will remain fully interoperable with allied assets for the foreseeable future. Networking of the fighter with friendlies will be progressively improved to guarantee effective communication and targeting to maintain the advantage over potentially hostile nations.





OPTIMISED FOR COMBAT AVAILABILITY AT SEA

Since entering service, the Rafale has proved to be an easily supportable and maintainable combat platform and the carrier-borne Rafale M variant is no exception.

The deck of an aircraft-carrier is a harsh, salt-laden, wind-swept environment for combat aircraft which have to be serviced and repaired, day and night, in sometimes difficult conditions such as inclement weather during blue water operations. For this reason, Dassault Aviation engineers have designed the Rafale M to be highly reliable and easily maintainable, with judiciously positioned panels to ease component access and black boxes replacement.

A sturdy airframe

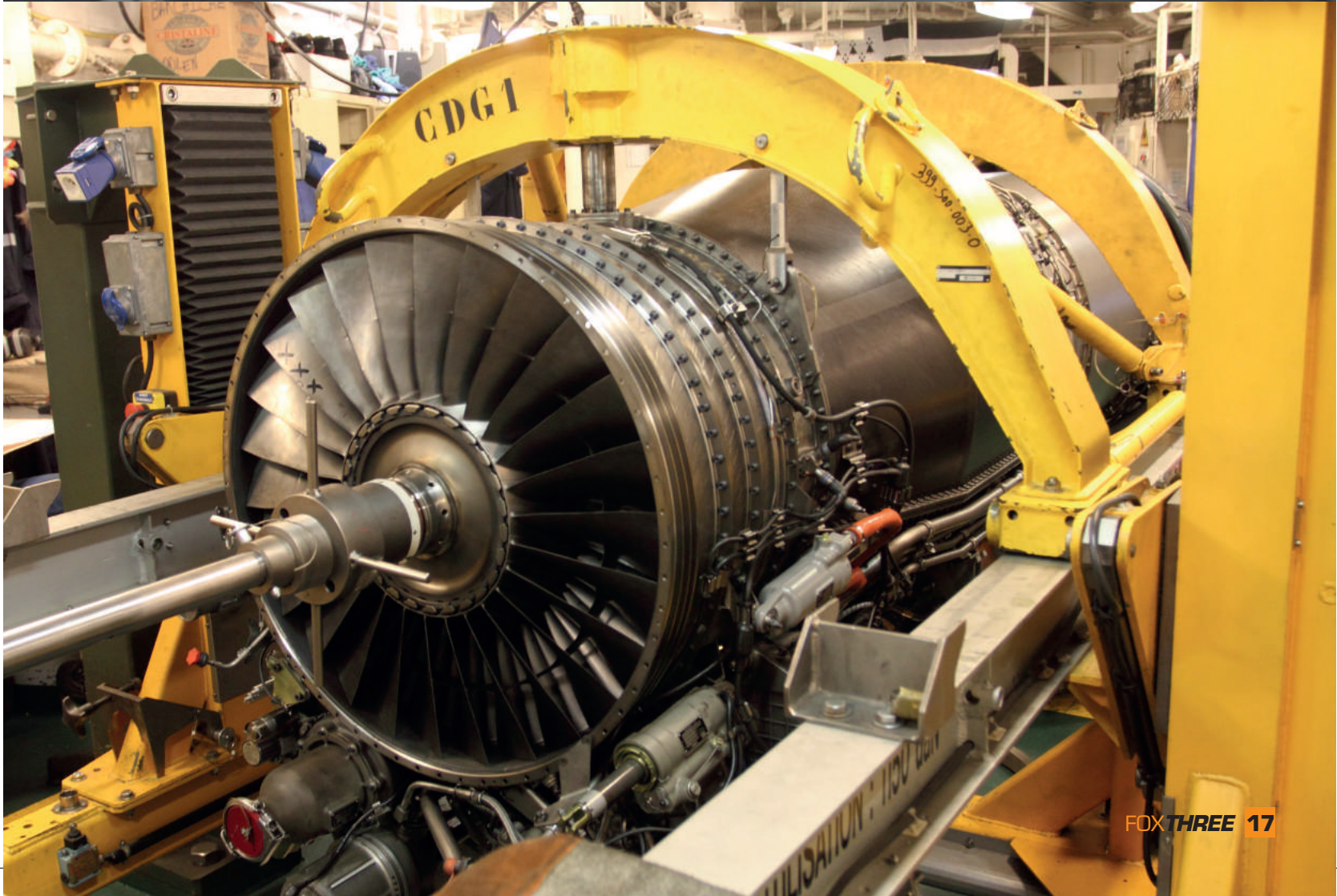
You just need to look at the Rafale's massive landing gear to understand how strong its airframe really is. The fighter was carefully designed to fit the necessities of carrier operations while ensuring a long service life. Its structure was optimised to absorb the violent shocks and loads associated with

catapult shots and carrier landings: this allowed launch loads, which run through the nose landing gear, and arrestment loads, transmitted via the tailhook, to be efficiently distributed through the aircraft structure to minimise fatigue and wear and tear.

The materials used to build the new fighter were carefully selected to reduce corrosion, a perennial hurdle for carrier-based aircraft.

The airframe itself is rather compact for an aircraft offering such large fuel and weapon payloads: this facilitates on-deck handling and aircraft placement and spotting, maintains carrier elevator capacity and carriage, and allows for satisfactory hangar height clearance for below deck storage and maintenance.







Ease of maintenance

Thanks to its innovative maintenance concept, the Rafale can be easily maintained while on board carrier vessels. Dassault Aviation engineers smartly introduced a number of advanced features to shorten downtimes. For example, the fighter is fitted with a side opening canopy to facilitate ejection seat removal and installation, a traditionally time-consuming operation which requires the canopy to be removed on other fighter types. Its engine intakes are fixed, helping reduce maintenance requirements and the type is not equipped with a

dedicated airbrake, relying instead on control surfaces deflection to significantly increase drag and obtain a braking effect.

The Rafale's low maintenance requirements, its low logistical footprint and its high availability rates are obvious advantages for operations at sea: a higher number of sorties can be generated with a low number of airframes, smaller teams of maintainers, and smaller inventories of spare parts. In turn, this minimises manpower requirements and carrier size, or allows more fuel, more food and more ammunition to be loaded onto a carrier vessel for a given displacement, thus improving combat endurance and resilience

at sea. Moreover, reduced spares requirements also diminish the pressure on the logistics supply chain and shorten the amount of time needed for replenishments at sea by supply ships and/or fleet replenishers, a phase during which the carrier is more vulnerable to attacks and during which fixed-wing aircraft cannot be launched or recovered. For customers already operating the Rafale Air Force versions, the very high commonality between variants minimises the number of spare items required, helping further bring down operating and sustainment costs.



Integrated monitoring system

The Rafale incorporates a very sophisticated integrated Health and Usage Monitoring System (HUMS) which permits maintenance to be fully optimised and operating costs to be kept under tight control. It achieves this objective by acquiring, analysing, and storing structural and engine stress and usage data. The large amount of data is acquired by countless sensors strategically positioned inside the airframe and by monitoring multiple parameters on the aircraft's

data buses. Real-time analysis examines this data for significant structural load and engine events. The data is stored on a removable cartridge aboard the aircraft. This cartridge can be read by a dedicated processing station on board the carrier: user-friendly displays provide maintenance technicians with 'on condition' maintenance diagnostics, greatly reducing aircraft turnaround times and trouble-shooting delays. The collected data is also used for usage trending, long-term aircraft structural fatigue data accumulation, and to compile airframe/engine parts life usage/warranty information.

The HUMS also drastically minimises the need for ground support equipment.

The Rafale M's impeccable operating record is a testimony to the ease of maintenance of the fighter. The aircraft is fully mature, easy to maintain, repair and support, with outstanding availability rates as demonstrated during all recent combat operations. Since service entry, thousands of combat missions have been logged with remarkable regularity.

PIT STOP

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Maintaining operational combat readiness can be expensive. It's why Rafale is designed to be fully, quickly serviceable by a reduced ground crew. Compare that to the maintenance requirements of other late-generation fighters. And then carefully calculate the impact Rafale's better design can have on your total life-cycle costs and dispatch reliability. Rafale. A generation ahead. Rafale. The **OMNIROLE** fighter ■

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