

RAFALE
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FOX THREE

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Editorial

In the 18th issue of Fox Free,

The Rafale Team is proud to report on the latest developments in the Rafale programme, including the deployment of the *Charles de Gaulle's* carrier strike group to the Persian Gulf to exercise with friendly forces: the US Navy, the Royal Saudi Air Force, the Qatar Emiri Air Force, the United Arab Emirates Air Force and the Greek Air Force.

The Rafale's military capabilities are on the rise too with the recent entry into service of the new Active Electronic Scanning Array (AESA) with the Aéronavale. Along with the new generation missile detector and the Front Sector Optronics-Improved Technologies, the AESA helps significantly increase the Rafale's combat efficiency on the battlefield.

The French Naval Aviation is now busy accepting back into service upgraded Standard F1 Rafales which have been brought to the latest F3 Standard to increase commonality between all aircraft delivered. This will help the French carrier air group transition to all Rafale force, a milestone that will be reached in 2016 when the last Super Etendard strike fighter is finally withdrawn from use.

The 'FOX THREE' Team

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HARD PUNCHING NAVAL STRIKE GROUP

The French Carrier Air Group (CAG) is a powerful, flexible and agile force now centred around the Dassault Aviation Rafale M omnirole fighter.

The Marine Nationale is, along with the US Navy and the Brazilian Navy, one of only three navies in the world equipped with CATOBAR (Catapult Assisted Take Off, Barrier Arrested Recovery) naval fighters.

Omnirole strike wing

The French Naval Aviation, the Aéronavale, is now fielding an ever increasing number of Rafales, a fighter which has brought new capabilities to the French CAG. Two Aéronavale Rafale M front-line squadrons, Flottilles 11F and 12F, are now fully operational with the twin-

engined combat aircraft. They take turns deploying on board the *Charles de Gaulle* nuclear-powered aircraft-carrier.

With the Rafale, the French CAG can carry out the full spectrum of offensive and defensive missions to support combat operations over land and sea: air-defence of the task force, air-superiority in a contested environment, destruction of enemy air defences, attacks of strategic

targets deep inside enemy territory, anti-ship strikes, battlefield air interdiction, close air support, pre-strategic and tactical armed reconnaissance, buddy-buddy refuelling and nuclear deterrence. Thanks to its very low radar cross section, the Rafale is ready to meet the anti-access and area-denial challenge, as demonstrated in Libya where the type was the first to operate at will over the country.





Enviably reputation

Since being declared operational with Flottille 12F in 2004, the Rafale M has earned an enviable reputation of combat efficiency and reliability. The type has been successfully engaged in combat operations in Afghanistan and Libya, logging thousands of flying hours, often in difficult conditions. In Afghanistan, the Rafales launched from the Arabic Sea flew countless close air support missions, performing shows of force and kinetic strikes with cli-

nical accuracy. They often fired their 30M791 30-mm cannon or dropped GBU-12 laser-guided bombs or Hammer (Highly Agile, Modular Munition Extended Range) precision weapons in support of troops in contact. In Libya, the French Carrier Air Group conducted high tempo operations against an elusive foe, using a wide variety of weapons, including Scalp cruise missiles. For over five months, Rafales, launched from the *Charles de Gaulle*, pounded enemy positions to protect civilians and stop forces loyal to Libyan Leader Muammar Gaddafi. With their

Pod Reco NG (new generation reconnaissance pod, also known on the export market as AREOS, for Airborne REconnaissance Observation System), they flew reconnaissance and non-traditional intelligence gathering missions. Even when operating in severe environments, at sea in the scorching heat of the Persian Gulf or in the freezing breeze of the arctic, the Rafale M's availability rates hover above 90% thanks to the dedication of the maintainers and to the type's inherent reliability, maintainability and supportability.



An all Rafale air group

Under the latest plans, the replacement of the legendary Super Etendard Modernisé (SEM) strike fighter will be completed in 2017 when Flottille 17F, the last naval squadron still equipped with the SEM in France, is declared operational on the Rafale M. Flottille 17F conversion will begin in 2016 and, when the process is over, Flottilles 11F, 12F and 17F will each be equipped with at least 12 Rafales. The *Charles de Gaulle* will then deploy with two Rafale squadrons at a time. "Having two Rafale units on board instead of one Rafale and one SEM squadrons will help significantly increase operatio-

nal flexibility, says Captain Jean Judde de Larivière, Commanding Officer of the French Carrier Air Group. With a limited number of airframes, we constantly have to change configurations depending on the situation and on the missions to be carried out. With more aircraft of a single type, the pressure on the engineers will diminish as we will be able to keep a higher number of airframes in each configuration for air defence, precision attacks, anti-ship strikes, reconnaissance and buddy-buddy refuelling. Availability will rise even further and the carrier air group will become even more lethal and efficient. Supply chain and logistics management will be simplified. The spare parts inventory and the support equipment will be unified and we will

be able to reclaim some more space on the carrier for additional storage facilities. Having two Rafale squadrons will also boost our firepower against airborne, naval and surface threats. We will be able to strike targets from further away, engaging them with heavier, more powerful ordnance dropped by a highly survivable aircraft."

With the Rafale, the Marine Nationale now fields a naval fighter which is second to none and improvements are constantly being introduced to increase the design's effectiveness on the battlefield. Dassault Aviation and its partners are now busy developing the new F3R standard that will incorporate a large number of improvements, including the Meteor missile.

MISSION 'BELLEAU WOOD'

Named after a famous World War I battle, 'Belleau Wood' was a major deployment of a French Navy task force in the Indian Ocean. Centred around the *Charles de Gaulle* nuclear aircraft-carrier, it included a carrier air wing with ten Rafales and ten Super Etendards.

For the French Navy, the purpose of 'Belleau Wood', held in late 2013 / early 2014, was much more than showing the flag in a strategic area. The main goal of the operation was to bolster the already strong links that unite the French Navy and its partners in the region, including the US Navy. Since the mid-nineties, all Aéronavale fighter and E-2C Hawkeye pilots have undergone their advanced training in the USA, flying from Meridian, Corpus Christi and Norfolk naval air stations, and French Navy Rafale omnirole fighters had already performed cross-decks with, and operated from a large number of US Navy aircraft-carriers.

Total interoperability

For 'Belleau Wood', the *Charles de Gaulle* left France with a powerful carrier air group composed of ten Flottille 12F Standard F3 Rafale M omnirole fighters, ten Flottille 17F Super Etendard Modernisé strike fighters, two Flottille 4F E-2C Hawkeye airborne early warning aircraft, two French Air Force EC725 Caracal combat search and rescue helicopters, and two Dauphin and one Alouette III plane guard helicopters.

During 'Belleau Wood', the French task force closely cooperated with the USS *Harry S. Truman's* Carrier Strike Group 10 and Carrier Air Wing 3 (CVW 3) that were supporting operations in Afghanistan. In a high profile and highly symbolic joint effort, two US Navy F/A-18

Super Hornets flew from the deck of the *Charles de Gaulle* while two French Navy Rafales trapped and were catapulted away from the US flat top after a hot refuelling, thus demonstrating seamless integration between French and US carriers: procedures are common, expertise levels are comparable and aircraft are fitted with fully interoperable interfaces (catapult launch bars, arresting hooks and refuelling connectors). But even more important were the joint missions flown by the French and US navies in the Persian Gulf and in the Indian Ocean.



Complex missions

As part of the deployment, countless training missions were flown by French and US naval aviators: complex scenarios were rehearsed and numerous Combined Air Operations (COMAOs) were undertaken to test advanced tactics that could be used in a coalition. "We flew a large variety of training missions with our American friends, including air

combat search and rescue, close air support and long-range strikes, explains Captain Jean Judde de Larivière, Commanding Officer of the French Carrier Air Group.

the destruction of key targets deep inside a virtual country with Scalp cruise missiles 'launched' by Rafale fighters while F/A-18 Hornets and Super Hornets 'engaged' other targets. We also took advantage of the deployment to organise dissimilar air combat training, mainly 2 v 2 missions with Rafales against Hornets and Super Hornets. For the CSAR missions, the *Charles de Gaulle* launched its EC725 Caracal long-range helicopters while top cover was provided by French and US fighters.



The long-range strikes constituted a typical example: we simulated



At times, up to twenty fighters, Hawkeyes and helicopters were involved in the strike or CSAR packages. For pre-strike and simulated battle damage assessment, we used the Rafale's new generation reconnaissance pod, a system which really impressed the Americans."

Live air-defence operations were conducted too, with French air-defence frigate *Forbin* protecting the USS *Harry S. Truman* while cruiser

USS *Gettysburg* provided close escort to the *Charles de Gaulle*. French and US combat air patrols (CAP) took turns to protect the joint task force, with French and US aviators using a common L16 datalink network for real-time command and control. Mixed patrols, composed of a Rafale and a Hornet (or Super Hornet), were also flown to 'share the burden': maintaining a permanent CAP above a fleet necessitates a large number of

aircraft and the two nations both contributed to a common pool of air defenders from which assets were drawn as required. Rafales and Super Etendards took the opportunity to refuel from Super Hornets configured as buddy-buddy tankers. Unfortunately, the administrative approval for US Navy Hornets and Super Hornets to tank from Rafales and Super Etendards fitted with refuelling pod was not granted on time.





Rafale M on board USS *Harry S. Truman*.





AESA IN FRENCH NAVY SERVICE

The first two Rafale M omnirole fighters fitted with an Active Electronic Scanning Array (AESA) are now fully operational with the Aéronavale at Landivisiau.

M39 and M40 are the first two Rafale M carrier-borne fighters drawn from the 4th production tranche. Like all Rafales produced since mid-2013, they are fitted with improved systems which help build up an unambiguous tactical picture, even at extreme range:

- AESA for the Thales RBE2 electronic scanning radar as a replacement for the PESA (Passive Electronic Scanning Array) which had been in service since 2004.
 - Détecteur De Missile de Nouvelle Génération (DDM NG, or new generation missile detector) for an even better survivability on the battlefield.
 - Front Sector Optronics-Improved Technologies (FSO-IT) for long-range visual identification of targets.
- The Rafale is the first European fighter equipped with the AESA breakthrough technology which has begun to change the face of air warfare. With the AESA, the omnirole fighter is now in a class of its own in Europe.



Operational evaluation

The AESA, DDM NG and FSO-IT all underwent an extensive test programme and a rigorous operational evaluation before being declared fully operational by the Armée de l'Air and the Marine Nationale.

In order to reduce costs, the evaluation was a joint effort between the French Air Force and the French Navy: a wide range of mission profiles were flown from Mont-de-Marsan air base by Armée de l'Air and Aéronavale

evaluators to test the new systems in challenging – but highly realistic – environments against a wide range of threats, including the nEUROn stealth UCAV demonstrator. Initially, AESA testing concentrated on air-to-air modes and functionalities. Results proved impressive, with the new radar antenna providing unprecedented detection and tracking ranges and improved angular coverage (from 60 to 70 degrees on each side), even when subjected to jamming and decoying. Tranche 4 Rafale M39 was delivered to the French Navy in October 2013 and remained

at Mont-de-Marsan for the joint evaluation until May 2014 when it was transferred to Landivisiau Naval Air Station. During the evaluation, French Navy pilots also tested the new array in air-to-surface modes against ground targets and ships at sea to check there was no performance regression in high resolution cartography and sea target search modes. Anti-ship strikes with the AM39 Block 2 Mod 2 Exocet missile remain a high priority for the Aéronavale and both RBE2 PESA and AESA variants offer outstanding capabilities against surface vessels.



Into naval service

The Aéronavale has decided to split its AESA-equipped fleet between its two front-line naval squadrons at Landivisiau instead of pooling them in a single unit. At the time of writing, M39 was serving with Flottille 12F while M40 had been allocated to Flottille 11F, allowing pilots of the two units to familiarise themselves with the AESA. "Compared with those of the PESA, detection and tracking ranges are significantly

improved, meaning that pilots flying an AESA-equipped Rafale will have a much better situational awareness in the air-to-air arena, explains Lieutenant Nicolas Mouis. *Enemy aircraft will be detected earlier, the situation will be assessed earlier, and decisions will be made earlier, leaving more time for the aircrews to engage or avoid the threats. The AESA is definitely a situation awareness builder and the Flottilles are busy exploring its capabilities to design new, advanced tactics. One obvious option would be to use an AESA-equipped*

Rafale as a mini-AWACS that would work in conjunction with PESA-fitted aircraft."

Initial service introduction of the AESA was extremely smooth: "The beauty of the system is that pilots do not really need any specific training to use the new radar array as the controls to operate the AESA remain the same, insists Commander Martinot, Flottille 12F Commanding Officer. For the moment, the first two aircraft are dedicated to air-to-air training but they will be sent at sea for the next Charles de Gaulle deployment."

Meteor in 2018

The entry into service of the Meteor ramjet-propelled missile later this decade will allow the outstanding detection and tracking capabilities of the AESA to be used to its full extent. Designed and produced by MBDA, the Meteor will offer unmatched interception capabilities at extreme range, from sea level to very high altitude, against a wide array of airborne targets: fighters, airborne early warning aircraft, tankers, unmanned aerial vehicles, helicopters and cruise mis-

siles. With its ramjet propulsion, the Mach-4 Meteor will retain excellent endgame manoeuvrability against agile targets such as hostile fighters. Its active radar seeker provides true fire-and-forget capabilities and the Rafale will be equipped with a fighter to missile datalink. Initial Meteor testing, including envelope expansion for traps and catapult shots from the *Charles de Gaulle* have already been carried out and the programme is on track for service entry in 2018. By design, the Rafale can carry four Meteors under the fuselage and wings in addition to four Micas. The French Armed Forces chose,

as an initial implementation, to carry two Meteors under the rear lateral fuselage hardpoints.

With the delivery of the first Tranche 4 Rafales, the Marine Nationale now fields the latest variant of the Rafale omnirole fighter. In all, 60 Tranche 4 Rafales have been ordered for the French Air Force and the French Navy. Thanks to the advent of the AESA technology, the Aéronavale pilots will be able to use advanced tactics to defeat the most lethal threats around and to rapidly achieve air supremacy.



Rafale M testing

In order to clear the Rafale M for naval operations, the type underwent extremely thorough testing on land bases and at sea, on board French aircraft-carriers *Foch* (now *São Paulo* in Brazilian Navy service) and *Charles de Gaulle*. During the trials, test pilots and engineers checked that advanced catapulting and carrier landing modes developed to increase safety and decrease aircrew workload behaved as advertised. Today, trials campaigns are still regularly organised from the deck of the *Charles de Gaulle* to test at sea the latest standards of the Rafale. The AESA, the DDM NG and the FSO-IT were among the latest systems that went through extensive tests to make sure they could withstand the violent shocks associated with carrier landings and catapult shots.



MODERNISING THE STANDARD F1 RAFALES

Dassault Aviation has now delivered back to the Ministry of Defence the first of ten Rafales to undergo an extensive modernisation programme.

The first ten Rafales, M1 to M10, were delivered to the French Navy in a fairly basic configuration called F1 Standard, without the full omnirole capabilities introduced later. These aircraft, only capable of undertaking air-defence / air-superiority missions, were produced to replace the outdated F-8 Crusader. To bring them to the latest operational standard, an industrial upgrade programme had to be implemented, and a contract was awarded to Dassault Aviation in late 2009.

Common standard

As the French Navy did not want to operate two very different variants of the Rafale, a modernisation programme of the F1's weapon system was needed to bring the whole fleet to the common, omnirole F3 Standard capable of undertaking the full spectrum of combat missions. This is a comprehensive upgrade and each aircraft is fitted

with a new Spectra electronic warfare/self-defence suite, an updated RBE2 radar, new cockpit displays, a brand new electrical harness, a Modular Data Processing Unit (MDPU) composed of line-replaceable modules, and upgraded weapon pylons fully compatible with the latest air-to-surface and air-to-air weapons. As usual, cost was one of the key drivers for the modernisation programme. This is the reason why the ten modernised fighters retain the

PESA (Passive Electronic Scanning Array) radar, albeit in a massively upgraded form that supports a large number of air-air and air-to-surface modes, including terrain following. Like all Standard F3 aircraft, they are nevertheless fully capable of accepting the Active Electronic Scanning Array (AESA) now operational on the Rafale, a major improvement that will facilitate the Rafale fleet management.



A decisive advantage

In order to reduce fabrication costs and cycles from contract signature to delivery, Dassault Aviation has pioneered new design and production methods for the Rafale. The widespread use of digital technology for the development considerably simplified the elaboration of digital blueprints that were later transferred to production plants. For production engineers, the advent of the automated conception with the Dassault Systems Catia 3D tool meant that new production methods could be adopted. Everybody – from the design office to the production engineers working in Dassault Aviation’s factories – utilises a common, unique digital reference that greatly facilitates production. Huge investments in new tooling were made to reduce costs and increase flexibility: state-of-the-art automated produc-

tion machines being introduced to fabricate parts for both the fighters and the Falcon business jets. With these machines, the level of production accuracy has been boosted to unprecedented levels. This means that parts taken from one aircraft will fit another, without any adjustment or modification as was common practice on previous aircraft. The sweeping changes introduced for the Rafale programme have

helped streamline manufacturing techniques. Such is the success of this process that they are progressively being adopted by the rest of the world, from automotive companies worldwide to most major aircraft manufacturers. Obviously, the advent of the digital blueprint has had a major, positive impact on the Rafale F1 to F3 modernisation programme.





Joint effort

The Rafale F1 modernisation is a successful joint industrial effort involving Dassault Aviation, Thales, the French Navy and the Clermont-Ferrand military air engineering centre which specialises in third line depot repair and maintenance.

Rafale M10, the first aircraft to be modernised (in fact the last Standard F1 to be produced), served as a prototype and benchmark for the comprehensive upgrade programme. It was dismantled by Navy personnel at Landivisiau Naval Air Station and its main components were dispatched to the various plants involved: Clermont-Ferrand, in Central France, for the first stage of the fuselage

rework, Biarritz, in the south-west of France, where the fins were worked on, and Martignas, close to Bordeaux, for the update of the wings.

In Clermont-Ferrand, the old electrical harness and all the pipes of the fuel, hydraulic and air-conditioning systems were removed. The fuselage was overhauled and brought up to the latest production F3 standard that includes a number of modifications to extend the life of the aircraft. For the French MoD personnel there, the learning curve was quite steep since they had never worked on Rafales before, but they did a superb job, providing a product that was 100% compliant with the agreed requirements. In January 2013, M10's fuselage was handed back to Dassault Aviation for delivery to

the Argenteuil plant, near Paris, where it was brought back to full F3 Standard. The F3 electrical harness was installed and new fuel, hydraulic and air-conditioning systems were fitted, bringing the fuselage to exactly the same level as a brand new one fresh from production.

After a 600-km road trip, M10's fuselage was injected back onto the assembly line at Mérignac, near Bordeaux, for final assembly and acceptance testing. There, it was treated as a new aircraft, but with more than 50% of its components supplied by the Navy. This modernisation process took 33 months for the first airframe, but this should decrease to 26 months for the last one as more and more experience is gained by all MoD and Dassault personnel involved.

Instrumented test aircraft

Discussions are now being held to decide whether Rafale M1, the first production naval aircraft which had been used for testing by Dassault Aviation and the French Flight Test Centre, will be modified for more trials or be brought to front-line F3 standard.

Prototype M02 is currently used for all naval testing, but transforming M1 into a F3 flying test bench would be ideal to ensure that one instrumented carrier-capable airframe remains operational post 2020, once M02 is withdrawn from use.

The delivery of M10 to the French Navy has kicked out a process that will help accelerate the transition of the French Car-

rier Air Wing to an all Rafale fleet. Under the latest plan, two modernised aircraft will be delivered in 2014, followed by three in 2015, four in 2016 and the final one in 2017, then bringing to an end a major industrial effort. That very same year, Flottille 17F, the last Super Etendard naval squadron, will have completed its conversion onto the new type.



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 ■