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The **survivor**

THE FIRST OPERATIONAL *DEPLOYMENT IS A SUCCESS*

In the aftermath of the September 11, 2001 attack, the French authorities decided to support the American war effort against terrorist groups, and the aircraft-carrier Charles de Gaulle was sent to the Indian Ocean to participate in combat operations over Afghanistan. Equipped with Dassault Rafale

and they regularly practise dissimilar air-combat training against American fighters from USS Theodore Roosevelt and USS John C. Stennis and AV-8B+ Harrier IIs from Italian carrier Garibaldi. According to the pilots, the F-14 Tomcats, F-18 Hornets and AV-8B+ Harriers are no match for the Rafales: thanks to their high thrust-to-weight ratio, low wing loading, and extreme agility, the Rafales quickly gain the upper hand. On board the Charles de Gaulle, the pilots have a combat simulator at their disposal where they can train in a number of scenarios : catapult shots, carrier landings, navigation, and BVR combat. After the acceptance into full operational service of the Rafale fighter, the French Naval Aviation has gained unmatched air-defence capabilities, and, with its Rafales, Super Etendards, and E-2C Hawkeyes, the Charles de Gaulle's Air Group is among the most powerful air wings operating in the World.

at that time. However, Dassault and the Navy accelerated the upgrade programme, and we were soon able to increase the number of deployed fighters." In March 2002, the number of Rafales on board the aircraft-carrier had grown to seven. The reinforcement Rafales were sent directly to the Charles de Gaulle from continental France, and four in-flight refuellings were required on average. "Initially, we were a bit worried about landing on a carrier after a seven hour flight, but the Rafale's cockpit is very comfortable, allowing us to remain fully alert, and we experienced no problem at all", says Commander Planchon. Clearly demonstrating the Rafale's deployability, this long-range effort was a first for the French Navy. The seven fighters are equipped with two variants of the Snecma M88 turbofan, the M88-2 Stage 1 and the M88-2 Stage 4 which features increased time between overhauls.

With only a couple of serviceable, outdated fighters, the Taliban Air Force was not a threat, and there was no need to engage air-superiority assets over Afghanistan. As a result, the Rafales do not participate in full-scale operations over that country. They are nevertheless kept extremely busy,

fighters, Flottille 12F is the spearhead of the French carrier air group. "When the Charles de Gaulle left her home port in November 2001, we were caught in the middle of a comprehensive update programme, says Commander Denis Planchon, Officer Commanding Flottille 12F. This is the reason why only two Rafales were on board the vessel



When Quality *Comes First*

The Dassault Acceptance Team in Bordeaux-Mérignac, in south-west of France, is in charge of flight testing every aircraft coming out of the Dassault assembly lines, be it a Mirage 2000-5 Mk 2, a Rafale or a Falcon business jet. The purpose of the acceptance process is to check that a new aircraft is up to full specifications: thanks to this practice, any potential fault will be detected before the aircraft is delivered to the customer. Four Test and Acceptance Pilots undertake the numerous test sorties flown out of Mérignac. They are helped in their daunting tasks by highly qualified Test Engineers, Flight Test Engineers, and 'Inspecteurs Mécaniciens'.



A Test Engineer is responsible for a Standard F1 Rafale M from the moment it leaves the assembly line until it is delivered to the customer. He manages the acceptance programme, prepares the flights, briefs the Test Pilot, and supervises the sorties from the monitoring room. When the aircraft has landed, he debriefs the team, checks the recorded parameters, and ensures any fault is rectified by the maintenance specialists. The mission of the 'Inspecteurs Mécaniciens' - 'inspector engineers' - starts as soon as the Rafale leaves the assembly line. They are in charge of making sure the aircraft is trouble-free. The fighter is first tested in a hush test facility where the engines and the various components, including the weapon system, are thoroughly verified.

Dassault fully complies with the latest environmental protection laws, and the Thales RBE2 radar and Spectra electronic warfare suite are not cleared to emit while on the ground. The Snecma M88 reactors are run from idle up to full afterburner power, and the 'logics' of the electronic systems are tested. When this is completed, the aircraft is towed back to the assembly floor to undergo the 'debugging' process. The fighter is then jacked up for the security check, and all the systems are once again tested, including landing gear retraction. Every single access panel will be opened in search of any snag, such as forgotten foreign objects. The 'Inspecteur Mécanicien' and his team will then ready the aircraft (this is called the 'Security Inspection') for the first trial by a Test Pilot.

Ground run

The acceptance programme of a Rafale, a lengthy process spread over about a month, is divided into a ground run and three flights. The ground run commences half an hour before the planned start-up time, when the Test Pilot meets with the 'Inspecteur Mécanicien' and his team, and climbs into the cockpit. He totally trusts the engineers and, as a consequence, a pilot preflight check is not deemed necessary. A ground power unit is switched on for the system check during which the Test Pilot communicates with a Test Engineer sitting in the monitoring room, both making

sure everything goes according to the book. The switches in the cockpit are set to simulate a quick reaction alert, and the Rafale taxis out to the runway to accelerate to 30 knots in full dry power. Then, it returns to its starting point and accelerates, this time up to 90 knots with full afterburner selected, before applying the brakes. During this run, the pilot carefully monitors the Jx, the longitudinal acceleration of the aircraft. This helps ensure that the M88 turbofans are delivering their normal maximum thrust, and that they spool up in the required amount of time. When the aircraft

is back to the Dassault flightline, the engineers make certain the flight data recorder is working as it should be. The Test Pilot and the Test Engineer will then debrief, and the engineers will correct any fault.



First flight

This important mission is carefully planned by the Test Pilot, the Test Engineer, and the other members of the team. The sortie is followed by an air traffic controller who has undergone a special 'acceptance' training. His mission is to ensure the dedicated flight test airspace used by the aircraft is clear of any other traffic.

This first mission is a flight envelope sortie during which the aerodynamic performance and behaviour of the fighter are checked. After a full reheated takeoff during which the acceleration (Jx) is again

monitored, the fighter climbs nearly vertically to 10,000 feet, and the pilot performs tight turns in the two flight control modes available: 'air-air', with no limits, and 'weapons', simulating a load of drop tanks or ordnance (with reduced g, angle-of-attack and roll rate limits). The autopilot and the airbrakes are then verified, and the pilot enters 360 deg turns to automatically calibrate the magnetometer. At the end of the last turn, the Rafale starts climbing again in full dry power up to Flight Level 360. The pilot levels off at

36,000 feet, checks the altitude hold mode of the autopilot, and verifies again the agility of the fighter in the two flight control modes. Full afterburner is then selected to accelerate from Mach 0.7 to Mach 1.4 before easing back the throttle to decelerate to Mach 0.8 and climb up to Flight Level 500 where the air-conditioning and pressurisation systems are checked. Manoeuvring aggressively all the way down, the pilot descends to FL330 where he makes tight turns to decelerate to 110 knots to initiate an engine test during which he slams the throttle open from idle to full afterburner power to ensure that the M88s are trouble-free. Then, the throttle is brought out of afterburner, and the pilot descends down to FL200 where he tests the slow speed and high alpha flying qualities of the Rafale before cycling the undercarriage. The descent is continued down to 2,000 feet where the Test Pilot checks the anemometric data while accelerating from 250 to 450 knots. After a few minutes of low-level flight to analyse the ride quality and the precision of the navigation equipment, the one-hour long mission is concluded with an ILS approach to Mérignac.



Second and third flights

The second sortie is also a flight envelope mission during which the Rafale reaches Mach 1.6 at 36,000 feet. The Rafale M is cleared for hands-off sea-surface following, and this dedicated mode is checked during the second sortie.

The third mission is a 'système' flight during which the fighter's combat capabilities are fully tested. The sortie is divided into two parts. For the first one, the Standard F1 Rafale M is accompanied by an Alpha Jet which acts as an exercise target to check the performance of the RBE2 radar. Also flown by a Test Pilot, the Alpha Jet flies an extremely accurate profile, and the RBE2 acquires its target in various conditions using the different

radar modes: look up, look down, air-combat and interception. Targets of opportunity, generally Armée de l'Air fighters operating out of Cazaux Air Base, are acquired in the Search While Scan mode. For the second part of the sortie, an Air Force Mirage 2000C uses its RDI radar to check the Rafale's radar-warning receiver and jammer. When Standard F2 Rafales are delivered, weapon system testing will be expanded to include air-to-surface armament modes.

In the highly competitive market of the combat aircraft, everything has to be done to

ensure that the customer is satisfied, and the acceptance process represents the best way of checking the quality of the end product. Dassault's 'know-how' is not limited to the Mirages and Rafales, and the Falcon business jets are also built and tested in exactly the same rigorous way.



THE *SURVIVOR*

Survivability is the key to modern air-warfare, and the Rafale fighter is well equipped to slip undetected through dense air-defence networks and survive, even against the latest threats.

Avoid Detection

The French fighter is definitely a 'low-observable' aircraft, and its systems will set new standards in terms of low-observability and survivability. Every effort has been made by the engineers to minimise its infrared and radar signatures. The objective was not to make the aircraft undetectable or to match the Radar Cross Section (RCS) of the F-117 or B-2, but to significantly reduce the detection and tracking range of hostile air-defences. Accordingly, the airframe has been carefully shaped to cut down its RCS. Other signature reduction measures include state-of-the-art Radar-Absorbing

Materials in various areas of the airframe, 'sawtooth' edges on the foreplanes, on the flaperons, and on some access panels and doors, specially treated canopy, plus 'double-S' shaped air-intake ducts to hide the engine compressor faces. Thanks to the Hot Spot treatment, infrared signature is minimised, and the Snecma M88 turbofans have been optimised to limit infrared detectability.

Dodge the Threat

But low-observability is definitely not the only way to boost survivability. As radar and radio emissions can betray the position of a fighter, the designers have adopted for the Rafale a wide range of unique passive sensors and missiles: the passive Front Sector Optronics used in conjunction with the long-range, infrared-guided Mica IR missile gives Rafale pilots unprecedented capabilities, allowing totally silent interceptions to be performed, especially when accurate targetting data is received via a datalink. Additionally, radar emissions can be carefully controlled, and emission limitations can even be programmed on a data transfer cartridge before the mission.

The Rafale is fitted with a discrete terrain avoidance/following system optimised to improve survivability while flying at extremely low altitude and very high speed. For threat avoidance,

the Thales Spectra electronic warfare suite is capable of accurately localising and targetting enemy radar emitters (both surface-to-air and airborne systems). Lethality zones, determined by Spectra according to the performance of the air-defence weapon types detected and the local terrain, are displayed on the colour tactical screens, enabling the aircrew to avoid dangerous areas without being detected.

Survive damages

The 'fail-safe' concept has been implemented to simultaneously increase redundancy and reduce vulnerability: the dual redundant hydraulic and electric systems ensure maximum safety, even if combat damages have been inflicted to the aircraft. The advanced fault management system can automatically reconfigure the fly-by-wire control system if a control surface is damaged. When used in conjunction, all these advanced redundancy and signature reduction technologies significantly increase the Rafale's effectiveness and survivability. In the not too distant future, other refinements might be introduced, such as a new system to shroud external weapons to reduce radar cross-section, the stealthy shapes being ejected before weapon release. Alternatively, tube-launched and 'cocooned' missiles could also be adopted.

Rafale measurements in anechoic chamber.



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