RAFALE INTERNATIONAL

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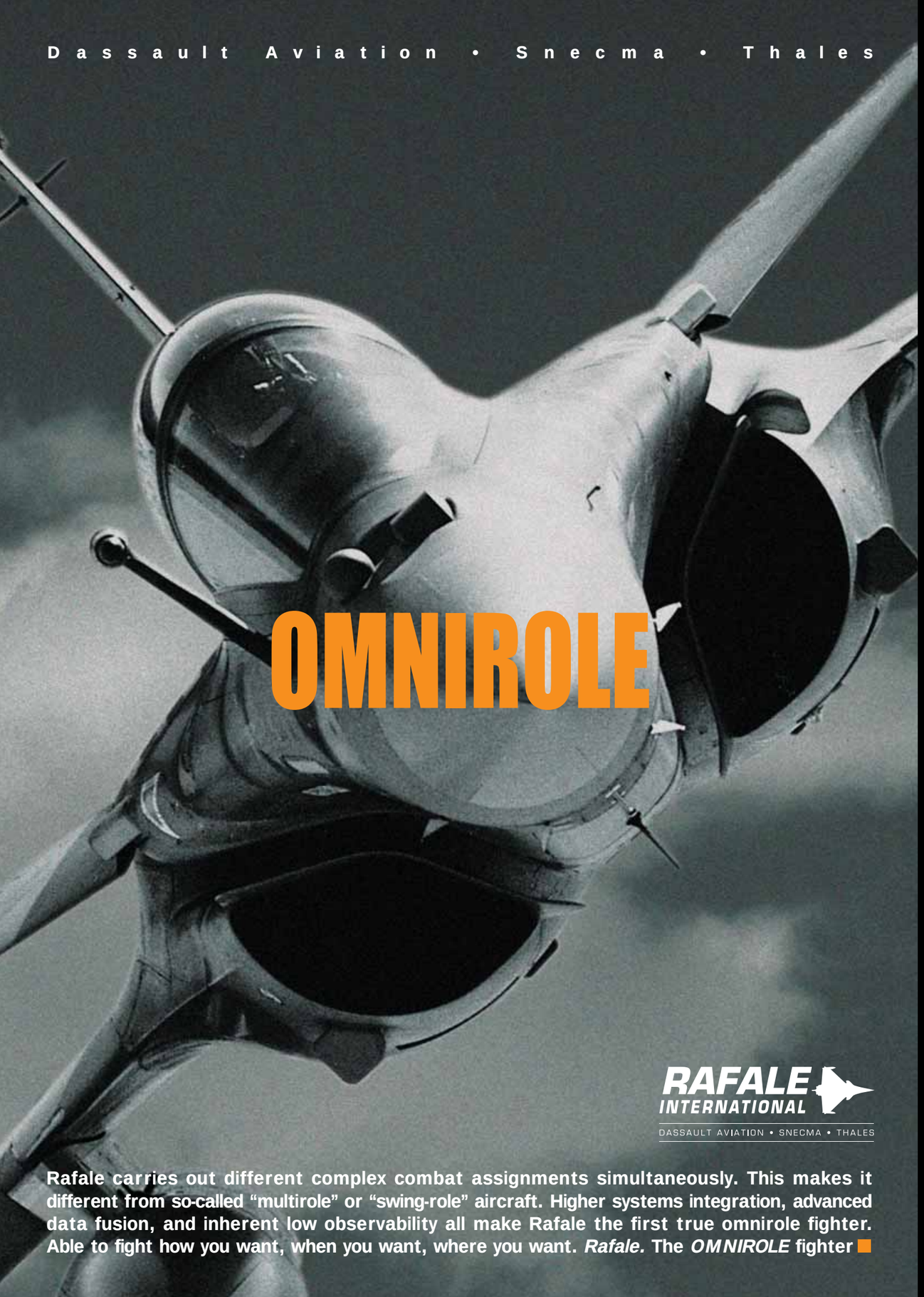
N°14



OMNIROLE

RAFALE INTERNATIONAL

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Rafale carries out different complex combat assignments simultaneously. This makes it different from so-called “multirole” or “swing-role” aircraft. Higher systems integration, advanced data fusion, and inherent low observability all make Rafale the first true omnirole fighter. Able to fight how you want, when you want, where you want. *Rafale.* The *OMNIROLE* fighter

Editorial

The Rafale programme is rapidly moving forward with new variants of the avionics and of the M88-2 engine being introduced to satisfy the most stringent requirements. At the same time, the range of weapons and of external targeting and reconnaissance pods the omnirole fighter can carry is being considerably expanded. Dassault, Snecma and Thales are always keen to develop close ties with the customer, and acquiring the Rafale is a strong commitment towards autonomy and independence.

Enjoy!

Summary

PEMA2M Photos : DASSAULT AVIATION - S. RANDÉ, V. ALMANSA, A. PARINGAUX, F. ROBINEAU, K. TOKUNAGA, H.P. GROLLEAU / SIRPA AIR - A. JEULAND / Snecma - Eric Drouin THALES / Airbus Military. Print: Imprimerie Moutot 2009.

M88: MORE THRUST THAN ENOUGH

Snecma (a SAFRAN Group company) is currently working on a more powerful variant of the acclaimed M88-2 turbofan, a state-of-the-art engine which powers the Rafale omnirole fighter.

The Rafale was conceived as a swing-role fighter capable of carrying out an extremely wide range of missions. As a result, the M88 engine had to comply with stringent requirements: it had to be compact and was designed to excel at low and high levels. Moreover, engine response to pilot throttle movements had to be instantaneous. *"The M88 is an innovative powerplant with a very high thrust to weight ratio, an extremely low fuel consumption in all flight regimes, and a very long life*, explains Michel Caunes, Snecma M88 programme Director. *As of October 2009, 75 production Rafales powered by M88 engines had been delivered and development and production engines had logged more than 100,000 functioning hours."*

High level of performance

To provide the required amount of thrust while keeping fuel consumption within given limits, Snecma engineers had to come up with innovative solutions to ensure that performance levels complied with the extremely demanding French power and durability requirements. Consequently, the M88-2 incorporates advanced technologies such as integrally-bladed compressor disks, called 'blisks', low-pollution combustor, single-crystal high-pressure turbine blades, ceramic coatings, revolutionary powder metallurgy disks, and composite materials. Additionally, the M88 has been optimised so that its small infrared signature does not compromise the Rafale's overall IR signature, and its non-polluting, smoke-free emissions make the aircraft more difficult to detect visually than older designs.

The M88-2 powerplant is rated at 10,971 lb dry and 16,620 lb with afterburner. It is equipped with a fully-redundant Snecma FADEC (Full Authority Digital Engine Control) which allows it to accelerate from idle to full afterburner in less than three seconds. Thanks to the FADEC, the M88-2 engines give the Rafale stunning performance: carefree engine handling allows the throttle to be slammed from combat power to idle and back to combat power again anywhere in the flight envelope. The compressor utilises a three stage low pressure fan, and a six stage high pressure compressor. Peak engine temperature is 1,850 K (1,577 °C) with a pressure ratio of 24.5:1, and, at maximum dry power, specific fuel consumption is in the order of 0.8 kg/daN.h, increasing to 1.7 kg/daN.h with afterburner.

Modular engine

Reducing the costs of ownership and improving performance have always been obvious targets for Snecma and the M88 has been designed to achieve the optimum combination of operational readiness and reliability. To facilitate rapid repair and maintenance in harsh conditions and minimise spares holdings, the engine is divided into 21 modules, interchangeable without a need for balancing and re-calibration. Some of these modules can even be changed without taking the engine out of the Rafale airframe, and a M88 can be removed and replaced in under an hour. Even more significant is the fact that, after maintenance, there is no need to check the turbofan in a test bench before it is installed back on the aircraft. The M88 is the only engine of its kind that can be returned to service after changing modules without requiring a new ground acceptance test – all what it needs is a simple leak test. As a direct consequence, the French Air Force has decided not to procure any dedicated test bench for the M88. Since entering service, the M88-2 has undergone a number of improvements and M88-2 Stage 4 engines are currently being delivered.

M88 ECO and TCO technology programs

The M88 was designed as a totally modular engine with a lot of built-in growth potential. In the last couple of years, Snecma has been extremely active, testing new hardware to increase engine life, reduce costs and demonstrate that higher thrust levels could be achieved.

From 2003 to 2007, during the M88 ECO programme, Snecma engineers tested new technologies to demonstrate that they could increase even further the life of some components to diminish operating costs. In all, more than 4,000 Total Accumulated Cycles (TACs) were logged by the test engine during endurance trials. The engine was also rated up to 20,000 pounds of thrust to demonstrate that this level of power could be achieved with a limited amount of modifications.

Launched in 2008, the M88 TCO (Total Cost of Ownership) programme was initiated to further improve engine durability and bring support costs down. Capitalising on the ECO project, Snecma was able to upgrade the high-pressure compressor and the high-pressure turbine of the M88-2: cooling is ameliorated and stronger components have been introduced, boosting durability by up to 50%. Life expectancy between overhaul has been considerably expanded for a number of modules, helping further minimise the impact of planned maintenance on engine availability. The First Engine To Test (FETT) ran for the first time in September 2009 and the first TCO pack for M88 engines will be delivered to the French Armed Forces in 2011.

Uprated engine

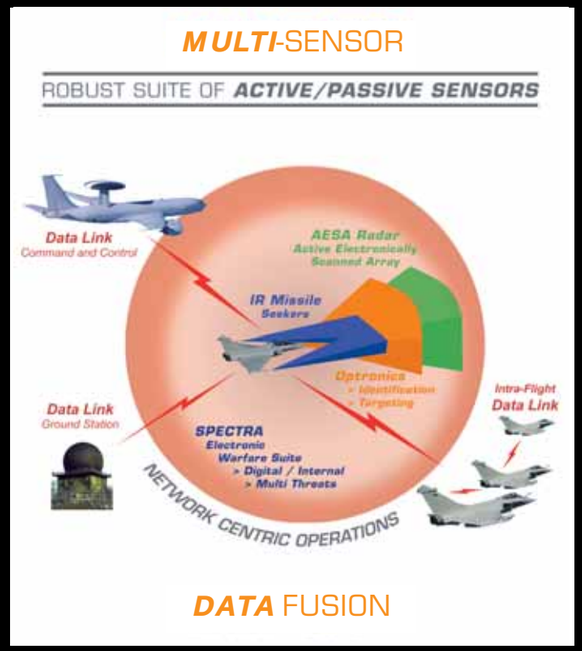
For Air Arms requiring more power for enhanced combat agility and improved performance in very hot weather, Snecma is considering the development of a variant of the M88 which will be rated at 20,000 lb with afterburner. The staged approach has had a very good impact on commonality between variants: *"since the M88 programme was launched, one of our objectives was to regularly introduce new technologies that could reduce the engine's operating costs, increase its dispatch reliability and increase its thrust,* explains Michel Caunes. *The successive M88 ECO and TCO technology programs allow us to progressively reduce risks and limit associated costs. We have managed to retain a very high degree of commonality between the M88-2 TCO and the uprated engine. Compared with the M88-2 TCO, the uprated turbofan will require less than 20% new parts, including a redesigned low-pressure compressor for a higher airflow. In fact, we will have to alter only two of the 21 modules. This is quite an achievement which will enable us to keep costs within acceptable limits. The M88-2 and the new engine will remain fully interchangeable, but the introduction of the new type will impose the adoption of slightly enlarged air-intakes to allow for the higher airflow."*

With the new uprated engine, the Rafale omnirole fighter will prove even more competitive in terms of thrust-to-weight ratio at combat weight. The fighter will be able to take off at maximum weight in a very short distance, even in the most demanding weather conditions, at high altitude, in the heat of the desert. Climb rate, acceleration, sustained turn rate will all be massively improved, bringing the Rafale's combat effectiveness to unprecedented levels.

NOWHERE TO HIDE

For the Rafale omnirole fighter, Thales has provided the most advanced sensors and integrated avionics suite ever designed for a combat aircraft. It comprises the RBE2 electronic scanning radar, the Front Sector Optronics, the Spectra electronic warfare suite, the Damocles targeting pod and the AREOS[1] reconnaissance system, all supplied by Thales.

All the Rafale's sensors are closely integrated and all data is automatically fused to massively reduce pilot workload and significantly increase tactical effectiveness. *"Our goal was to avoid saturating the pilot*, explains Jean-Noël Stock, Thales Rafale Programme Director. *This smart data fusion significantly increases mission success rates through enhanced crew awareness and improved aircraft survivability. This is a crucial advantage over our competitors."*



AESA[2]

From the outset, the French Armed Forces have adopted an innovative electronic scanning radar for the Rafale fighter. Electronic scanning radars have numerous advantages over legacy mechanically steered types: they scan the sky much more quickly, they allow targets to be tracked outside the selected search volume and their radar modes can be interleaved.

The first Rafales were all fitted with a passive antenna and Thales and the French Military are now switching to active electronic scanning array technology. *"In the late nineties, we thought there were some risks involved going straight to the AESA and this is why we chose the PESA[3] for the first Rafale standards,* stresses Jean-Noël Stock. *The active array is made up of solid-state GaAs transmit/receive modules which can steer and reposition the radar beam at very high speed in any direction. The new radar variant also incorporates a new data processing unit and a strengthened structure to cope with the higher weight of the AESA. In terms of performance, detection range is increased by considerably more than 50% and the radar can look in many directions at the same time, offering significantly enhanced tracking capabilities. Angular coverage in azimuth is improved and very small targets with lower radar cross section such as cruise missiles could also be detected. Furthermore, AESA radars are inherently more reliable and cheaper to maintain."*

The AESA demonstrator first flew in 2002 and, since then, hundreds of flight hours have been logged to support the development effort. On top of that, the AESA has been successfully evaluated by a number of potential customers. A European production line for T/R modules has been set up and, at the time of writing, six development AESAs had been delivered and three pre-series AESAs were in production, with first deliveries to Dassault Aviation planned for 2011.

Passive interception

The Rafale is the only fighter equipped with an integrated system optimised for target identification and battle damage assessment at stand-off distances. The Front Sector Optronics is composed of a powerful TV sensor to identify targets and to determine the number of hostile aircraft within an incoming raid, and of an eyesafe laser rangefinder for telemetry. When used in conjunction with the long range Mica IR missile, the FSO allows entirely passive interceptions to be carried out without radar emissions. In the air-to-ground mode, the FSO is used to accurately determine target coordinates before attacking with precision weapons such as the AASM (Air-to-Surface Modular Armament) or LGBs (Laser Guided Bombs). A new generation infrared sensor for passive search and track of airborne targets and for night identification could be integrated into the FSO at a later stage. Such an infrared sensor operating in the 8 to 12 µm band has been fielded in the French Air Force F2 Standard Rafales, and an updated variant working in the 3 to 5 µm band is being studied for the future growth of the FSO. The FSO has been in service since 2005 and is now combat proven.






SPECTRA

The Spectra[4] multi-spectral, totally integrated electronic warfare suite is designed to ensure efficient electromagnetic detection, laser warning, missile approach warning using passive IR detection technology, jamming and chaff/flare dispensing. Three-dimension direction-finding accuracy is excellent, and the time taken for signal identification is extremely short. Its very high processing power gives outstanding detection and omni-directional jamming performance through active antennas, optimising the response to match the threat, even in a multi-threat environment. The location and types of systems detected by Spectra can be recorded for later analysis, giving Rafale operators a substantial built-in ELINT capability.

AREOS

For both strategic and tactical reconnaissance missions, the French Armed Forces have adopted the Thales System Reco NG (new generation tactical reconnaissance system) for the Rafale. *"This high-tech, day and night equipment can be used in a wide range of scenarios, from stand-off distances at very high altitude down to very high speed and extremely low-level,* enthuses Jean-Noël Stock. *To shorten the intelligence gathering cycle and accelerate the tempo of operation, the pod is fitted with a datalink which allows high resolution images to be transmitted back to the military deciders in real time."* Since July 2009, the System Reco NG has been undergoing qualification testing / operational evaluation at Mont-de-Marsan Air Base, with entry into service planned for early 2010. This very advanced system is now offered on the export market under the AREOS designation.

(1) AREOS: Airborne REconnaissance and Observation System
(2) AESA: Active Electronically Scanned Array Radar
(3) PESA: Passive Electronically Scanned Array Radar
(4) SPECTRA: Self-Protection Equipment Countering Threats of Rafale Aircraft

Damocles

In modern warfare, the ability to detect, localise, identify and engage ground targets at stand-off distances is a real necessity. This is why the Rafale is now being fitted with the Thales Damocles targeting pod. The new infrared (3rd generation staring array detector) and laser technologies chosen for the Damocles provide extended detection and recognition ranges, permitting laser-guided armament to be delivered at substantially greater ranges from higher altitudes, considerably reducing the aircraft's vulnerability to short/medium-range air-defence systems.
In mid-2009, the French MoD issued a contract for the Mastrid (Multi-context Airborne System for Target Recognition and IDentification) demonstrator to ensure that new capabilities will be available for the Damocles XF (eXtended Features) from 2012. With the Mastrid project, a new high-definition TV sensor optimised for short-range engagement and a new software to boost the resolution of the IR sensor will be developed and test flown.

With such a large suite of advanced sensors and a direct access to datalink networks, the Rafale is a key contributor to the common tactical air picture. The ongoing improvements to its sensor suite will further increase the combat effectiveness of an already revolutionary aircraft

GLOBAL **REACH**

With its outstanding endurance, its in-flight refuelling capability and its very long-range stand-off weapons, the Rafale omnirole fighter is extremely well equipped to strike distant, well-defended, deeply buried hardened targets.

The Rafale has been designed as a very compact, high-tech fighter capable of carrying a huge external load of fuel tanks and missiles. In fact, it can carry more than 15,000 kg of kerosene and weapons, quite an accomplishmentor an aircraft weighing less than 10 tonnes empty.

Scalp

For long-range attacks of high-value, heavily defended targets, the French Armed Forces have selected the Scalp cruise missile of the MBDA Scalp / Apache / Storm Shadow / Black Shaheen family. The Rafale's normal combat load is composed of two Scalps, four Mica air-to-air missiles and three 2,000-litre drop tanks. The Scalp can be released at very low level, with the Rafale flying in terrain-following mode to avoid detection. With its fuel-efficient Microturbo engine, this 'intelligent', stealth weapon can navigate autonomously at high subsonic speed towards the target which will be clearly identified by its onboard infrared sensor: automatic target recognition algorithms compare the actual scene with the memorised scene, identify the designated target, and accurately select the impact point in order to hit with very high precision. To maximise its military effect, the Scalp is fitted with a remarkably powerful Broach tandem warhead which can defeat heavily protected bunkers.

Buddy-buddy tankers

With their 4,700 kg of internal fuel, single-seat Rafales boast an impressive range which can be massively extended by up to five external drop tanks (three 2,000-litre and two 1,250-litre fuel tanks) under five wet hardpoints, four under the wings and one under the fuselage. Range can be further increased thanks to air-to-air refuelling and the Rafale can refuel from a wide range of tankers: A330 MRTT, Boeing 707, Il-78 Midas, KC-135, KC-130, VC-10... It can also be fitted with a buddy-buddy refuelling pod under the centreline pylon, and French Navy Rafales routinely refill the tanks of other Rafales and

of Super Etendard fighters, extending their reach from the *Charles de Gaulle* carrier. Buddy-buddy tankers could also prove really useful in a high threat environment, their six Mica air-to-air missiles giving them considerable firepower for self-defence (and even to escort a strike package).

Combat-proven AASM

For simultaneous attacks of multiple targets, the Rafale can ripple fire up to six AASM (Armement Air-Sol Modulaire, Modular, Air-to-Surface Armament) stand-off precision weapons in one pass to strike six different impact points with clinical precision. Designed by Sagem, the AASM is composed of a GPS / INS / IR imager guidance kit at the front, a bomb body (general purpose or penetration) in the centre, and a rocket motor at the rear. The extremely advanced AASM can be released from very high or very low levels, and its powerful controls allow it to manoeuvre aggressively to engage distant, off-boresight targets. Up to six AASMs can be carried by a single Rafale, plus four Mica air-to-air missiles and three 2,000-litre drop tanks.

Météor

For air-defence / air-superiority missions, the Rafale is already equipped with the outstanding Mica air-to-air missile capable of performing both short-range dogfight combats and long-range interceptions. For engagements at even longer distances, the Rafale will soon be armed with the MBDA Meteor air-to-air missile. The new, ramjet-propelled Meteor will offer a no-escape zone several times greater than that of today's missiles. This extremely fast missile - Mach 4+ - is designed to retain sufficient energy at end game to defeat hard manoeuvring targets. When fitted to the Rafale, the new Meteor missile will create a formidable combination of weapon / sensor / airframe. The French Ministry of Defence has recently reaffirmed its support to the programme, and it has been officially announced that a first batch of 200 Meteors will be ordered for the Rafale as part of 2010 defence procurement budget.

On top of the Scalp, the AASM, the Mica IR / RF, the Meteor and its internal 30 mm gun, the Rafale is cleared to carry the AM39 Exocet antiship missile and the GBU-12 / 22 / 24 laser guided bombs, and the French Armed Forces are seriously considering the adoption of rockets in the near future. With such a wide range of weapons, the Rafale has now become the most powerful strike fighter ever designed, a tool that will deter aggression.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INDEPENDENCE
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RAFALE
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When a single country makes your aircraft from nose to tail, you know exactly what you're getting into. Rafale is not subject to multinational controls. It also offers unrestricted access to key weapon systems technologies, spare parts, and know-how. Rafale offers superior operational effectiveness and failsafe worldwide support, yet isn't delivered wrapped in red tape. Or with strings attached. *Rafale.* The *OMNIROLE* fighter