RAFALE INTERNATIONAL

FOX THREE

N°6

Bucking the trend : *the lower, the better*

Recent conflicts have shown that most fight / bomber strike raids are now conducted with precision-guided weapons from medium or high altitude.
A variety of strike aircraft of diverse age, technology and performance level are generally involved in coalition operations. Capabilities vary widely between these platforms, and man-portable air defences are rightfully considered a formidable threat for all of them below 15,000 feet. Stand-off jamming is required, at the expense of tasking flexibility. However this is not always enough to avoid "blue" losses in the face of opponents operating SAMs with high altitude coverage and counter-stealth airspace surveillance...
At this point, theatre air commanders would probably dream of an aircraft with a hefty payload capability for smart weapons, immune to air defence systems. The aircraft must be survivable and operate on a "reasonable" budget...
Enters the Rafale. It is fully interoperable with coalition assets and procedures, and it is therefore totally capable of participating in strike operations, as required for political and diplomatic flexibility. Taking a closer look at the bird, we find an aircraft very close to the commander's dream.
The Rafale is fitted with a multi-sensor terrain-following system operating at the pilot's choice from the radar or from a digital terrain database : the RBE2 radar can detect even unreported obstruction and the digital terrain database does away with telltale emissions where total covertness is required. There is also a radar altimeter available in nap-of-the-earth flight over water or flat land. Data fusion is part of the system to cross-check the sensors before feeding their data to a flight path computation module whose development has been carried out per the exacting standards of safety-critical engineering. The relevant expertise does not come overnight and actually builds on the lessons learned of the Mirage 2000N and D in service with the French Air Force.
The terrain-following function integrated with the Rafale's flight control system actually flies the aircraft closer to the ground or the sea than would be reasonable for the crew flying in manual mode - and it does so with a demonstrated safety level even in blind weather. It remains a valuable help to the crew even when flying higher above ground level, allowing them to concentrate on other mission tasks without the burden -and energy-consuming anxiety - of maintaining terrain clearance during hi-speed / low-altitude legs. With its high thrust and low wing-loading, the Rafale is equally at ease flying at treetop height: its aerodynamics - delta wing and canards - is ideal for low-level agility and ride quality, and its canard foreplanes do not block downward visibility.
Flying low and fast in the clouds then becomes a real option : high altitude SAMs are no longer an issue since you fly under the radar coverage, and short range optically-guided air defences are powerless against a foe they cannot see. Other short range air defence systems can be dealt with by the Spectra EW suite capable of jamming and decoying. Speed is part of the game too, since air defence engagement zones are dramatically reduced against transonic targets, even in clear weather.

Advice to commander : next time, think twice before choosing your altitude option. Higher might not necessarily be better. The Rafale offers high AND low altitude options.

Data *fusion:* seeing through the 'fog of war'

In order to cope with the multifaceted threats of the 21st Century, Rafale aircrews rely on three essential systems to survive and achieve total battlespace dominance: a state-of-the-art multisensor suite, a smart data fusion management system and an advanced Man-Machine Interface (MMI).

Advanced MMI

Good situational awareness begins with a big and clear picture displayed on large, colour screens. For the Rafale omnirole fighter, Dassault engineers have designed the most modern Man-Machine Interface in service anywhere, introducing 21st Century technology to considerably reduce aircrew workload and to substantially improve situational awareness. The Hands On Throttle and Stick technology has been adopted to make function selections easier, and a Helmet-Mounted Sight and Display is on offer. To accelerate and facilitate information assimilation, the instrument panel of the Rafale cockpit is divided into one large Head-Up Display (HUD) and three colour multifunction screens: two touch-sensitive lateral displays, and a wide-angle, high-resolution head-level display collimated to infinity to enable the pilot to shift instantly from head-up flying to head-down mission monitoring without a need to refocus. In the two-seat Rafale variant, the front and rear cockpit displays can be operated in a tandem mode, which presents the pilot and the back-seater with the same information, or de-coupled so that crew members can carry out different tasks simultaneously, an obvious advantage during complex missions.

Multisensor technology

To carry out all its missions, the omnirole Rafale is equipped with a multisensor suite that

comprises the Thales RBE2 multimode electronic scanning radar, the Thales Front Sector Optronics (FSO) passive IR/TV/laser system and the Thales Spectra multi-spectral electronic warfare system, plus the infrared seekers of the Mica IR missiles. This combination of multiple sensors considerably enhances the probability of detecting hostile targets, including stealth aircraft. It also lowers the risk of fratricides.

The Rafale's weapon system can also simultaneously deal with airborne and ground threats, a crucial advantage over the nearest competitors because pilots are now able to attack targets on the ground while engaging the enemy fighters presenting the greatest threat. For example, even with the radar in an air-to-surface mode, the FSO is fully capable of detecting and tracking hostile interceptors, and the pilot can instantly engage an emerging threat.

Silent intercepts can be conducted with the radar switched off, the FSO and the Spectra system then becoming the main sensors. It is worth noting that the FSO's laser supplies an accurate range-measurement, to provide the pilot with the 3D positions of the targets.

Smart data fusion

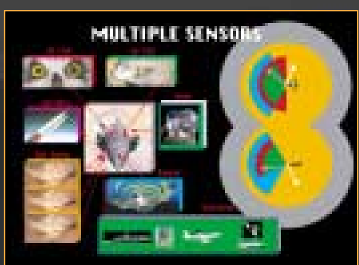
On the Rafale, there is no preferred sensor: the radar, the FSO, and the Spectra electronic warfare suite all contribute to situational awareness, and the data obtained from the different sources is fused into a single tactical picture shown on the central, head-level display, offering the pilot a clear image of the evolving tactical situation. Until now, pilots only had their brains to process the information obtained by their radars / eyes and to build a mental image of the evolving situation. With the Rafale, the system has taken over the processing role, considerably reducing workload, and allowing aircrews to devote more time to tactics management. The pilot now concentrates on the fight, not on the flight.

Sensors have inherent advantages and drawbacks: the passive FSO has excellent countermeasure resistance, and its angular resolution is better than that of the radar. On the other side, the radar is able to determine the target's position and velocity vector in all weather conditions. The Spectra suite can analyse enemy radar emissions to precisely identify an emitter. The powerful data fusion algorithms combine and compare the data gathered by all Rafale sensors, and accurately position and identify targets. It's much more than simple correlation as it gives the pilot an accurate and unambiguous tactical picture.

One of the key advantages of the system is its ability to identify and classify the type of target / threat, by using either the Spectra suite or the TV sensor of the FSO. When all tracks are positively identified, the system automatically creates a synthetic image with all enemy and friendly tracks shown in a clear and explicit way.

Off-board sensor can also contribute data to the integrated tactical air picture, via the datalink. Wingmen or AEW aircraft can feed their data to the leader's system, thus helping target-sorting and co-operation within the formation.

Multichannel target acquisition / tracking associated with smart sensor fusion is a key-enabler which will radically change the face of air warfare. This combination of multisensor technology and smart data fusion significantly increases mission success rates through enhanced crew awareness and improved aircraft survivability. With its multisensor technology, its advanced data fusion management system, and its remarkable Man-Machine Interface (MMI), the Rafale clearly stands in a category of its own and no other fighter in the world has such a wide array of systems at its disposal.



Right *on the Spots !*

The revolutionary AASM (Armement Air-Surface Modulaire, Modular Air-to-Surface Armament) was selected by the French Air Force and the French Navy in September 2000 to supplement their current inventory of laser-guided bombs and missiles, more than 3,000 AASMs being acquired for the Mirage 2000 and Rafale fighters. This unique weapon designed to destroy an adversary's best-defended target is already undergoing a comprehensive test programme for both the Rafale and the Mirage 2000. The first flights of a Rafale fitted with six AASMs were performed in 2003, and the weapon was subsequently tested on board French aircraft-carrier Charles de Gaulle when a Rafale was recovered at a weight of 15,7 tonnes (34,581 lb.) with six AASM bombs (plus empty 1,250 litre drop tanks), clearly demonstrating its huge 'bring back' capability. The first firings are now due to be conducted at the Cazaux Flight Test Centre in 2004.

A modular weapon

Designed and produced by Sagem, the AASM is a low-cost, all-weather, fire-and-forget weapon optimised for high-accuracy stand-off attacks.

Thanks to its fully modular architecture, the AASM can be utilised for a wide range of strike missions, offering unmatched destructive capabilities against soft or hardened targets. The weapon is divided into three major subsystems:
- the guidance kit at the front
- the warhead and fuse in the middle
- the range extension kit at the rear.

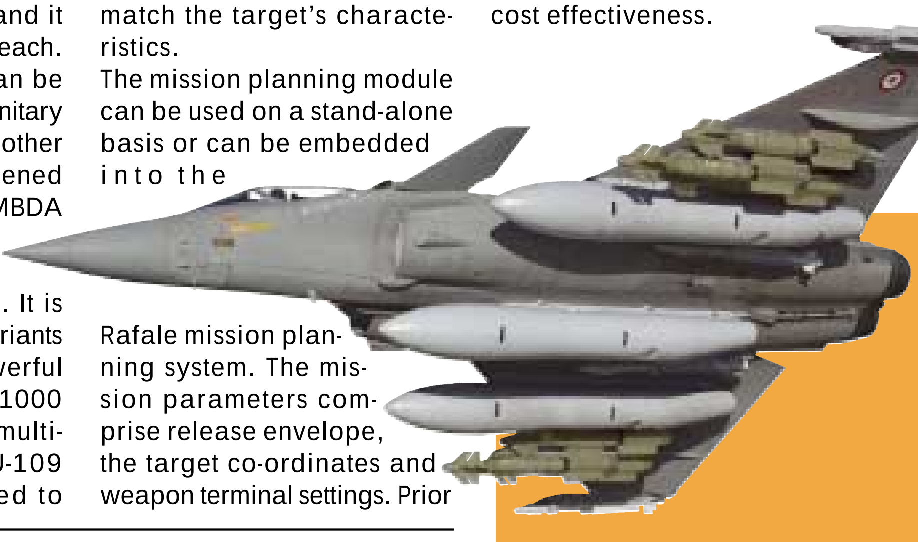
Recent advances in the fields of navigation and optronics technologies have allowed Sagem engineers to design a highly accurate weapon, a crucial advantage when collateral damages must be avoided. Depending on the tactical situation, the required precision, and the importance of the target, the Air Force commanders can choose between two types of state-of-the-art guidance kits :
- a combined Inertial Measuring Unit / GPS receiver navigation system for all-weather attacks with a 10 m class accuracy
- a combined Infrared Imaging seeker / Inertial Measuring Unit / GPS receiver for day and night attacks with metric precision.

The low-cost IMU / GPS receiver would be the main guidance system in most cases. In the event the AASM is unable to receive GPS signals after launch for any reason, the IMU will provide rate and acceleration measurements which the weapon will develop into a navigation solution.
For even greater accuracy, the affordable infrared imaging seeker is a key subsystem. It uses autonomous target recognition algorithms to locate its target, no operator intervention being required. This seeker also ensures exceptional resistance to GPS signals unavailability or jamming, and target coordinates errors can be compensated.

Stand-off engagement capability

For very long distance engagements, the AASM is equipped with a bolt-on tail unit / range extension kit which comprises a solid rocket motor and flip-out wings. Ranges

exceed 50 km for a high-altitude release or 15 km for a low-level firing, and even more significant is the capability to engage targets at high off-boresight angles: the Rafale does not have to overfly the target to carry out its attack with deadly accuracy, and it can safely remain out of reach.
The 250 kg warhead can be either a general purpose unitary munition (Mk 82, or any other similar types) or a hardened penetrator (BLU-111, or MBDA Bang / CBEMS series optimised for storage on board aircraft-carriers). It is worth noting that other variants with heavier, more powerful warheads weighing up to 1000 kg such as the Mk 84 multipurpose bomb or the BLU-109 penetrator are planned to engage targets requiring more destructive power or deeper penetration.
The AASM is a 3 m long weapon that weighs 340 kg. Up to six can be carried by a Rafale on two triple stores adaptors. Six widely separated targets to be attacked in a single pass, with a full 90 degrees off-boresight capability. For maximum terminal efficiency, the AASM angle of impact can be adjusted to match the target's characteristics.
The mission planning module can be used on a stand-alone basis or can be embedded into the Rafale mission planning system. The mission parameters comprise release envelope, the target co-ordinates and weapon terminal settings. Prior to bomb release, the guidance kit will be fed with aircraft position, velocity and altitude data through the store-station interface.
For the AASM, Sagem has chosen the "Wooden-round" concept, and the weapon can be left unattended for many years until it is used.
The AASM fulfils the warfighter's most stringent requirements in terms of attack accuracy, destructive power and cost effectiveness.



Rafale pushes *BVR fight at extreme !*

In order to quickly achieve total air-dominance, a concept of multi-layer offensive / defensive air-to-air weapons has been chosen for the Rafale omnirole fighter, allowing all known and future air-threats to be engaged from extreme long range to extreme short range. To carry out its air-defence / air-superiority missions, the Rafale relies on a wide range of advanced air-to-air weapons: Meteor missiles for very long-range engagements, Mica RF and Mica IR multirole missiles for long-range to short-range scenarios, and a powerful 30 mm gun for close-in dogfights. With such a wide array of weaponry, hostile fighters, strike bombers, cruise missiles, unmanned aerial vehicles and helicopters will all be easily defeated.

Integrating the Meteor to the Rafale

Thanks to the involvement of the Rafale integration team in support of missile development from the very beginning, Meteor qualification on the Rafale is definitely a low-risk undertaking. Preliminary aeromechanical integration work has already been completed, and a series of wind tunnel tests have now been conducted. This first stage of the comprehensive trial programme was a total success. Functional integration (fire control) is not expected to be a major hurdle either: the Mica and the Meteor both operate in the same way, and the Rafale's fighter-to-missile datalink is already fully capable of accepting the new missile. Up to four Meteors can be carried by a single Rafale, two under the aft lateral fuselage pylons and two under wing store stations. Obviously, the capability to carry Mica missiles will remain unchanged, especially for the infrared-guided Mica IR variant mounted at the wingtips and under the outboard wing rails.

Ramjet propulsion

The Meteor is a Pan-European multinational programme officially launched in December 2002 when MBDA was awarded a development and production contract by the British Defence Procurement Agency on behalf of the governments of six European countries. The Meteor is a highly flexible, long-range, agile air-to-air missile which provides a comprehensive operational capability in the most complex combat scenarios. The weapon can engage air targets autonomously by using its state-of-the-art active radar seeker by day and night, in all weathers and in dense electronic warfare environments.
The rear section of the missile comprises the Bayern Chemie / Protac boron-filled, solid propellant, throttleable, ducted ramjet motor which is one of the principal elements of the missile's success. Thanks to the ramjet propulsion, high-speed is maintained throughout the engagement and the motor offers

variable thrust levels to match the target's hard manoeuvres. The Meteor's ramjet motor system offers ranges in excess of 100 km and speeds of more than Mach 4. Even when launched from extreme stand-off ranges, the missile has enough kinetic energy in the end-game to defeat fast and hard manoeuvring targets such as highly-agile, fifth generation fighters. Its vastly expanded no-escape zone significantly enhances the Rafale's lethality at long ranges. Moreover, high-value assets such as tankers and early warning aircraft can be engaged at very long ranges too, boosting even further the fighter's overall combat efficiency.

Advanced active radar seeker

Terminal guidance is provided by an active radar seeker design based on proven technologies borrowed from the MBDA Aster

surface-to-air and Mica air-to-air missile programmes. In June 2003, Thales and MBDA signed an agreement to jointly develop an improved derivative of the AD4A seeker already in service on the Mica and Aster missiles. Mid-course guidance will be provided by a fighter-to-missile datalink until the active seeker acquires the target, the missile then becoming autonomous. Alternatively, the Meteor can be fired without using mid-course update, allowing the Rafale to immediately turn away to deny the enemy aircraft any firing possibility.
Following extensive wind tunnel testing, a wingless aerodynamic configuration has been chosen for the Meteor: MBDA has concluded that the selected airframe configuration is the optimum solution to fulfil the required performance characteristics. The controls and aerodynamics principle incorporated by MBDA will result in a missile which has a very high turn rate and which, at the same time, maintains the performance of its ramjet propulsion system thanks to a constant ram air supply. The Meteor missile will therefore have the level of manoeuvrability and speed needed to achieve the demanding end-game performance to intercept even the most agile air targets.
To ensure total target destruction, the missile is equipped with both proximity and impact fuses and with a powerful blast fragmentation warhead that is detonated at the optimum point to maximise lethality.
With the acclaimed Mica IR and RF missiles, the Rafale is already equipped with superior weapons, but the advent of the Meteor will further improve the fighter's outstanding combat efficiency: the Meteor offers enhanced all-round kinematics performance and a higher kill probability to ensure unequalled combat efficiency, even against the most modern hostile fighters.

ERIC **GERARD**

The Rafale is regularly displayed at major airshows around the world by Dassault Aviation test pilot Eric Gérard.

After high school, Eric joined the French Navy in 1975 and was awarded his Naval Aviation Fighter Pilot Wings in 1978. The following year, he gained his carrier-qualification.

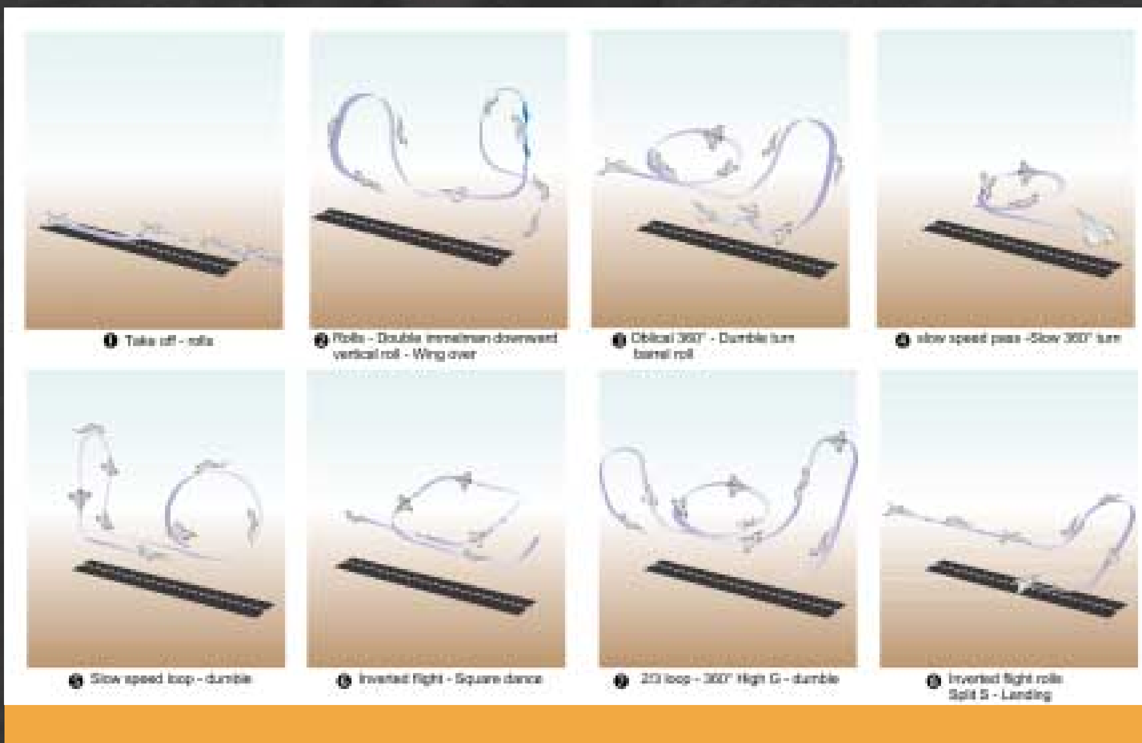
From 1979 to 1987, he flew Super Etendard strike fighters from Hyères and Landivisiau naval air stations, and from the *Foch* and *Clemenceau* carriers, successively flying with Flottilles 17F and 14F.

He was then selected to become a test pilot and graduated from the EPNER, the prestigious French Test Pilot School, in 1988. While serving with the French Flight Test Centre, Eric was involved in various projects, including the Super Etendard Modernisé, the Mirage 2000 and the Rafale flight test programmes.

In 1991, he was recruited by Dassault Aviation to take part in the Mirage 2000-5 development effort and in the Rafale carrier trials. In July 1999, he became the first pilot to trap a fixed-winged aircraft on the nuclear aircraft-carrier *Charles de Gaulle*.

During his career, he was successively awarded the French National Defence Medal, the Lebanon Campaign Medal and the French Aeronautical Medal. Eric is now credited with over 5,200 flying hours.

IN FLIGHT **DISPLAY**



PEMA2*b* - Photos F. Robineau - Dassault Aviation - K. Tokunaga.

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