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RAFALE : **MULTINATIONAL SUCCESS**

From May 21 to June 2, 2001, the French Navy participated for the first time in a major training exercise with its state-of-the-art Dassault Aviation Rafale fighters. *Trident d'Or* (Golden Trident) was one of the largest international exercises ever

Charles de Gaulle, the French Navy flagship. With its embarked air-group, the *Charles de Gaulle* played a pivotal role in this event, carrying out air-defence, strike, combat SAR, and surveillance missions.

ning radar and the Spectra electronic warfare suite were extensively tested, and performed flawlessly. The Rafales were flown in various configurations, sometimes heavily loaded with external fuel tanks. To extend mission duration, the Rafales took advantage of the buddy-buddy refuelling capabilities offered by the carrier-borne Super Etendard Modernisé fighters. In-flight refuellings from French Air Force Boeing C-135FR Stratotankers were also performed. Additionally, French naval aviators demonstrated the Rafale hot refuelling procedure during the exercise. At the time of writing, seven Rafales had been delivered to the French Navy, and ten pilots had converted to the type. Deliveries are continuing, and, by mid-2002, Flottille 12F will be fully operational with a complement of 10 Rafales.

On May 18, 2001, Flottille 12F, the first Rafale naval fighter squadron, recreated at Landivisiau. Just a few days later, the unit deployed on board aircraft-carrier *Charles de Gaulle* with the first six Rafale pilots and their aircraft. During *Trident d'Or*, Flottille 12F personnel trained and evaluated the fighter's

held in the Mediterranean, involving warships from ten nations. Among the vessels taking part was the nuclear-powered aircraft-carrier

weapon system. They encountered AV-8B+ Harriers and F/A-18 Hornets, simulating interception profiles. Both the Thales RBE2 electronic scan-



SUSTAINING *THE EFFORT*

Capitalising on the Mirage 2000 impeccable track record, Dassault Aviation, Snecma and Thales have designed the Rafale omnirole fighter to offer unprecedented reliability, supportability, testability, sustainability and deployability levels. Customer and product support considerations have influenced the design of the aircraft from the outset, and the Rafale will undoubtedly set new reliability and maintainability standards.

Excellent supportability

Thanks to advanced technologies, the Rafale's supportability will be boosted by about 30 percent compared with that of the Mirage 2000. Dassault engineers have developed a very simple fighter with fixed air intakes and no dedicated airbrake, helping reduce maintenance requirements.

«The Rafale has been conceived for naval operations, and even the Air Force ground-based variants benefit from the naval characteristics: rugged airframe, excellent corrosion protection, and aircraft-carrier elec-

tromagnetic compatibility», explains Xavier Labourdette, International Support Manager. The Rafale has been built to last, and features a fully automatic, non-dedicated structural monitoring system which provides individual follow-up of airframe components, facilitating fatigue index surveillance throughout the 7,000 flying hour service life.

Fault detection is a key aspect of modern aircraft maintainability, and all Rafale systems are monitored in real-time by the IHUMS - Integrated Health and Usage Monitoring System - which ensures clean and unambiguous failure detection. This unique and fully automatic monitoring system helps reduce turnaround times by easing troubleshooting and repair, drastically minimising the need for ground support equipment. Testability targets call for a 95 percent fault detection, plus the ability to detect all safety-critical failures.

With the Rafale, Dassault has pioneered the use of revolutionary advances such as the

fully redundant, very high pressure (350 bar / 5,000 PSI) hydraulic systems and the variable frequency alternators which all boost reliability and safety. These advances have proved so successful that they have been adopted as standard by other aircraft manufacturers, and, for instance, they have been specified for the Airbus A380.

A single test bench capable of dealing with all electronic equipment has been developed, allowing specialists to determine which component in a Line Replaceable Unit (LRU) is defective. The first one is already fully operational with the French Navy. A similar bench has been selected for the Tiger and NH90 helicopters, and for the French E-2C Hawkeye. It is also the baseline for that of the French Army Leclerc main battle tank. The selection of the uprated Snecma M88-3 engine and of a state-of-the-art Active Electronic Scanning Antenna (AESA) for the Thales RBE2 radar also contributes to the overall improvement of aircraft reliability.



Unrivalled deployability



Stringent carrier requirements have had a positive impact on Rafale maintainability.

In the past 30 years, the French Armed Forces have participated in countless operations far from their national support infrastructure, gaining considerable experience in forward

deployments. As a direct result, the French requirement for the Rafale called for significant built-in deployability and self-supportability, and Dassault and its partners have taken advantage of their undisputed know-how to develop a fighter with an extremely low logistic footprint. This is a crucial advantage which will prove less constraining for strategic airlift assets as only four C-130 Hercules loads are necessary to carry equipment and spares for 20 Rafales for 30 days. For example, no integral engine test cell is required for the M88 turbofans. Additionally, thanks to unrivalled manufacturing and assembly techniques, there is no need to check equipment boresighting after replacement, and no complex external testers are required for Flight Line or Organisational level maintenance.

For self-supportability, the Rafale is designed to require the minimum of ground support equipment: it is equipped with an on-board oxygen generation system, and with a closed-loop cooling fluid system

for on-board coolanol and nitrogen circuits. The built-in auxiliary power unit provides electrical power until the engine-driven generators come on line.

For future operators, the Rafale's unmatched reliability, maintainability and testability will ensure an extremely high availability, allowing sorties to be conducted at a sustained tempo for extended periods of time. Full scale in-country maintenance will be carried out by customers, and the local industry will benefit from technology transfers: French authorities have already approved source codes transfers, and even radar cross section reduction material will be maintained locally. The electronic warfare suite can be programmed by indigenous experts, and new weapons can be easily integrated. This facilitates transparent decision making process and support through the life of the aircraft.

Unmatched Affordability

An extremely reliable and easily maintainable fighter invariably translates into considerably lower maintenance costs. Numerous maintenance/support aspects contribute to the Rafale's incredibly low life-cycle costs:

- There is no complete airframe or engine depot level inspection required throughout the aircraft service life, and only specific components such as Shop Replaceable Units (SRUs) are returned for maintenance/repair. This is a remarkable achievement that will reduce the amount of time during which the aircraft is not available. The same philosophy applies to the M88 turbofan composed of 21 modules, interchangeable without needing full balancing and re-calibration. For maintenance and repair, only modules or parts are returned to the depot/manufacture.

- The minimum spare part requirements allow a reduction in spares inventory, and the very high commonality between variants minimises the number of spare items. Similarly, changing, at flight-line level, printed circuit boards within a LRU instead of replacing the LRU itself lessens the need for complete spare units (radar, Spectra, modular computers).

- The fighter is extremely reliable, and easy to maintain and repair, ensuring reduced manning levels (minus 30 percent compared with the Mirage 2000), and lowered mechanics training requirements. For instance, the side opening canopy facilitates ejection-seat removal.

VOICE **MAGICS**

Compared with earlier generation systems fitted to other fighters, the Rafale's Man-Machine Interface has been tuned to considerably reduce aircrew workload. One of the most innovative choices made by Dassault Aviation is the introduction of the combined Voice, Throttle and Stick (VTAS) system which drastically eases

data entry and systems selections.

«As an alternative to using manual methods, the direct voice input technology allows the pilot to activate data entry functions, and select non-safety-critical modes», explains Philippe Rebourg, Dassault Chief Test Pilot for Military Aircraft. «In some demanding combat scenarios, manual actions can prove painfully slow, and the voice command system increases overall effectiveness: the pilot does not have to look into the cockpit any more. That enables him to focus on the mission and on systems operation.»

Developing such an advanced tool was a challenge since the various speech recognition algorithms had to cope with the noises of the cockpit environment as well as with the stress and the high g-loads that can affect pilots' voice. But Dassault and Thales engineers overcame all hurdles, and two production Rafales, two-seaters B301 and B302, are currently equipped with the direct voice input system. «These two aircraft allow us to push development even further», says Philippe Rebourg. «Numerous foreign test pilots have evaluated the system, and they all praise its efficiency: word recognition rates are better than 95 percent, and, depending on the custo-

mer's requirements, the system boasts a vocabulary of between 50 and 300 words. The response time is extremely short (less than 200 ms), and critical voice command selections are confirmed by visual feedback.» Display management, navigation tasking and mode switching are even quicker. A typical example is radio and navigation aids selection: a single pressure on a button on the throttle activates the voice input system, and, with chosen code words, the pilot can instantly reprogram the flight-plan or select various autopilot modes or radio/IFF frequencies.

«As an added bonus, the voice command system proves also extremely useful by reducing high pilot workload during emergency situations», says Gérard Dailloux, Dassault Flight Safety Vice-President.

The direct voice input system will be available on export Rafale Block 05s, and, although Dassault has mainly concentrated on the Rafale so far, it could be adopted at some stage on the Mirage 2000-5 Mk2 and on the future Falcon 7X long-range business jet, helping reduce cost by increasing series production.



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