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## Front sector optronics: a new targeting sensor for the Rafale F2

Jean-Luc Perrin

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# Front Sector Optronics: a new targeting sensor for the Rafale F2

Jean-Luc PERRIN<sup>1</sup>, DGA/DSP/STTC optronics department

## 1 ABSTRACT

Front sector optronics is an optronical sensor, which provides surveillance, tracking and identification of multiple targets to the aircraft system. This sensor is a multifunction sensor, which is located in the nose of the aircraft. It will be on the Rafale F2 standard, which will be delivered in 2005.

The paper will present the main operational advantages of FSO compared with the other sensors of the Rafale F2.

Technical characteristics of the FSO will be described and the key points of the design of the equipment (technology and software) in relation with the operational requirements will be presented.

The functions of the FSO will then be described, in particular the way the system or the crew, in association with other sensors uses them in order to designate the target to the weapons.

A summary of the latest flight tests on Rafale will be presented.

**Keywords:** Rafale, FSO, targeting sensor, IR

## 2 BACKGROUND OF THE PROGRAM

The Front Sector Optronics (FSO) program is the final step of studies that had been led by the DGA and achieved by THALES and SAGEM in the eighties, ASPIC, DIVA and ASPRO. These experiments validated the operational interest of the infrared (IR) and visible components of the FSO.

The DGA decided then to launch this program for the Rafale Aircraft.

### 2.1 The DIVA and ASPIC experiments

ASPIC was a pod designed to demonstrate the technical performance of IR surveillance. This pod has been integrated on a test-bench aircraft of the DGA and made several flights. This was the first trial that showed long-range detection performance. IR detection and tracking proved to be useful as a part of a discrete surveillance system.

DIVA was a visible camera, which had been integrated in the same test-bench aircraft as ASPIC and could comfort the use of a camera as an important tool for visual identification beyond pilot's visual range.

It was then stated that an optronical sensor could contribute to surveillance, tracking and identification in several wavebands.

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<sup>1</sup> [Sttc.optronique@cedocar.fr](mailto:Sttc.optronique@cedocar.fr); phone 33 1 45 52 45 93; fax 33 1 45 52 52 44 ; DGA/DSP/STTC/DT/OP 26 bd Victor 00457 Armées France.

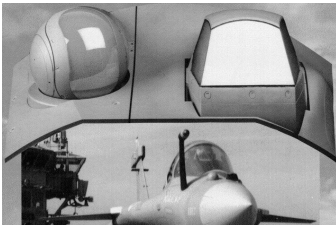
## 2.2 The ASPRO experiment

ASPRO was a study with existing optronical (ASPIC and ATLAS) and radar sensor (RDM radar). Its aim was to prepare the cooperation between optronics and radar in a weapon delivery system.

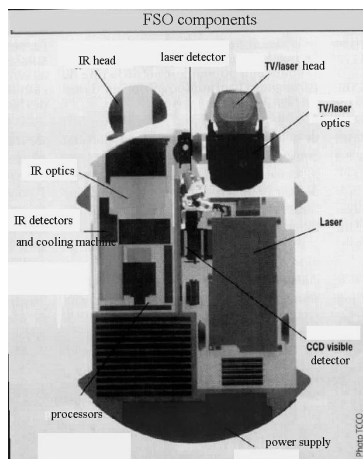
Following this study, it was decided in 1988, in the physical design of the radar, to free the necessary volume for FSO in the nose of the aircraft (88 liters). The precise specifications of FSO were built after a functional analysis of the operational requirements, which led to define the modes and functions that had to be developed.

## 3 DESCRIPTION OF FSO

The FSO is located in the front section of the Rafale Aircraft. Its location enables it to provide air to air and air to surface facilities to the weapon delivery and navigation system (WDNS).



The FSO has three main parts: the UIV (which is the infrared unit), the UIT (which is the visible unit) and the UGT (which contains the processing unit and is the interface with the WDNS). The geometry of FSO is optimized for the Rafale in order to fit the skin of the aircraft.



### 3.1 UIV

This unit contains the infrared sensors. The principle is to scan the line of sight in the space to achieve automatic detection and tracking several targets at the same time with a very good accuracy. This requires an accurate stabilization of the line of sight, especially in case of important vibrations and maneuvers. Several scan speed and scan area are available, in order to optimize detection range and field of view.

It enables as well night identification and navigation.

### **3.2 UIT**

This unit contains the visible sensor and the range finder using an eye-safe laser. It can detect and track several targets in the field of view.

The main point is a long focal length, which enables long-range identification, which requires high accuracy line of sight stabilization.

### **3.3 UGT**

This unit contains the processing units of the FSO, which make the target extraction and the high level processing, including data fusion of the plots. This generates an important data flow in the UGT. This led to a specific architecture of several single instruction multiple data (SIMD) elementary processors linked to central-units processors, which communicate with the high-level stage of processing. This unit is the interface of the FSO with the WDNS too.

## **4 MAIN CHALLENGES FOR DEVELOPMENT OF FSO**

### **4.1 A highly integrated and high performance sensor**

FSO combines in a limited volume the functions that usually would have taken place in the past in two different pods. To achieve this, new technologies were applied and the requirements of easy maintenance have been taken into account since the beginning of the project. Apart from optical integration, the main challenge was to implement on FSO hardware the algorithms that were formerly used on desk computers. The algorithms have been written in C and adapted for parallel specific computers for the low-level part (target extraction). Concerning the high level part (including data fusion) the hardware is based on off-the-shelf hardware.

The high level of performance required developing specific processing units to process simultaneously the pixels of the image and extracting the targets, even in complex background<sup>2</sup>

### **4.2 The covert part of a complex system**

FSO is one of the three main systems of Rafale along with the electronically steered beam array radar RBE2, and the self-protection system SPECTRA. This aspect and all the induced requirements have been taken into account since the beginning of the Rafale program, in common between DGA, French Air Force and French Navy. The latest example was the specification of the F2 standard, which has been ordered to the industry by the beginning of 2001.

Recent experiments demonstrated the capability of the Rafale to conduct covert interception with SPECTRA and FSO, without using radar.

### **4.3 A stringent environment**

The specifications of FSO concerning vibrations, navy requirements, EMI and optical performances are very tough. They were included in the specification at the beginning of the program, and first tests on aircraft carriers have demonstrated the capability of FSO to operate in this environment.

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<sup>2</sup> Experiments on Aircraft have demonstrated the capability of FSO to track targets even on complex backgrounds like clouds.

#### 4.4 An integrated logistic support (ILS) concept since the beginning

The design of FSO has taken into account the requirements of the Air Force and the Navy. The result is the accessibility of important elements and a modular design: UIV, UIT and UGT are three line replaceable units (LRU) and the main components of each of these LRU are SRU (shop replaceable unit).

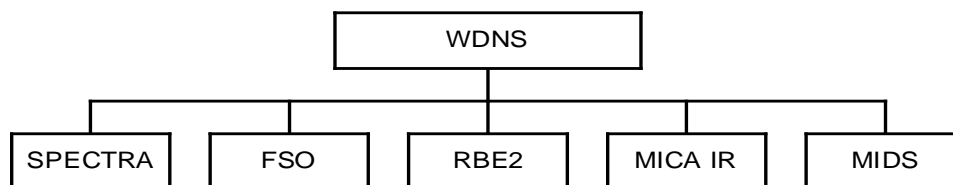
Concerning the maintenance concept, FSO benefits from the state-of-the-art:

- Full built in test
- Permanent maintenance status sent to the WDNS
- In-flight memorization of failures in the flight reports
- Download capability

Moreover FSO is fully compliant with LSA (logistic support analysis) standard and database production.

## 5 FUNCTIONS OF FSO

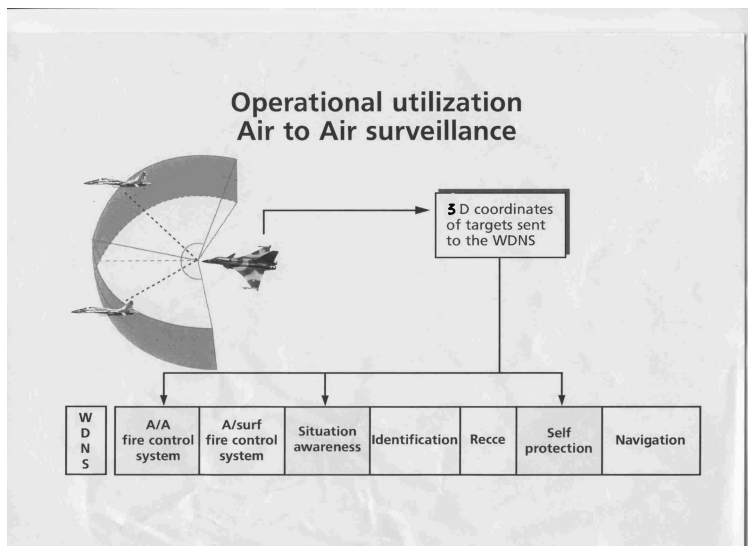
### 5.1 FSO and other sensors of the Rafale F2 Aircraft



In this figure we see the main sensors involved in targeting on the Rafale. This system design shows the central place of system and the functional equality of sensors, even if some have more operational background than others. The definition of the second standard for Rafale has been undertaken on a technical basis, to take benefit of all resources of each available sensor.

The French Navy and Air Force had several requirements that made of FSO one major sensor of the F2 standard:

System requirement	FSO Answer
➤ Multirole capability	Air to air, air to surface and navigation mode
➤ Electromagnetic Jamming resistance	Optronical multispectral sensor
➤ Stealthiness	Passive technologies (IR and visible)
➤ Accuracy	High stabilization et resolution optics
➤ Situation awareness	<ul style="list-style-type: none"> <li>➤ Wide field of regard and important field of view</li> <li>➤ High resolution sensor</li> <li>➤ Multispectral sensor</li> </ul>
➤ Multisensor capability	<ul style="list-style-type: none"> <li>➤ Full integration in the WDNS</li> <li>➤ Complementarity with MIDS, Radar, SPECTRA and MICA IR taken into account since the beginning of the development of FSO</li> </ul>
➤ Installation in limited volume	➤ High level of integration



This figure above details the different aircraft functions to which FSO contributes: fire control system (air to air and air to surface), situation awareness, identification, self-protection and navigation.

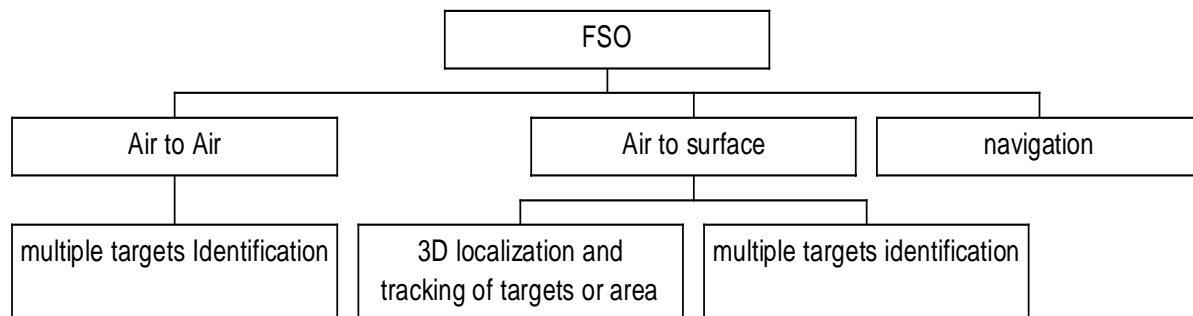
As an example let us detail a ground target attack:

- while penetrating, the crew uses the RBE2 and FSO to survey air targets above; FSO can simultaneously provide accurate localization of way points that enable the update of the inertial navigation system;
- approaching the estimated position of the target, the crew uses a radar ground map to designate the target, which is accurately localized by FSO; while FSO is tracking the ground targets, the crew uses a radar air surveillance.
- The WDNS can then deliver an air to ground ammunition using the coordinates coming from a data fusion of data coming from FSO and RBE2. This example shows clearly the joint use of radar and FSO. This illustrates that FSO can simultaneously provide different functions with its IR and TV channels.

This is a good example of joint use of sensors by the Rafale.

## 5.2 Contribution of FSO

Let us detail the FSO part of this figure



The location of FSO enables it to provide air to air and air to surface capabilities. Its central place in the front of the aircraft does not hide targets on a particular side in most of operational cases.

Design of FSO was led by the notion of functions (surveillance, identification,...) and not by the hardware design of the sensor. For example surveillance uses the UIT as well as the UIV; identification can require the UIT for long range and the UIV for short range. This requirement in the design of FSO led to a central processing unit UGT, which can drive both parts of the sensor. For example the designation to the UIT of a target detected by the infrared part does not have to transit through the entire aircraft system: the aircraft system needs only to designate the number of the target. The internal designation of target is an important advantage in case when a target is close to escape the fire area of the weapons before identification.

The electronically beamed steered radar can process surveillance and tracking at the same time. The requirement of simultaneous surveillance and tracking was applied to FSO, and the crew can track a ground target and still have discrete surveillance for situation awareness.

## **6 FIRST RESULTS OF OPERATIONAL FLIGHT TESTS**

Testing FSO in its operational environment was an important part of the development of the sensor. Several prototypes were scheduled since the beginning. The first one allowed confirming the model mechanical environment specified. Then other prototypes demonstrated the capability of FSO to operate in its mechanical environment with real targets and real atmosphere. Along with these tests, electromagnetic impulsion (EMI) tests were carried out to demonstrate the ability of FSO to dialog with the aircraft system and to process targets designation from other sensors.

The Year 2000 was a very important period for FSO: the sensor participated in the joint integration work that led to an advanced version of the future F2 Rafale standard. Unlike RBE2 or SPECTRA, which have been integrated for the first standard, FSO will be for the first time in the second one. Unless this “functional youth”, FSO was able to perform 52 flights.

These tests demonstrated the ability of FSO to work in common with other sensors from Rafale: for example the ability of FSO to track ground targets coming from an accurate radar designation

FSO demonstrated its ability to detect and track several targets at range compatible with the delivery of air to air weapons.

In counter air missions, target counting at range similar to radar was observed.

The flight tests of the advanced version of the future F2 Rafale standard demonstrated the coherence of the aircraft system, and the important contribution of FSO to the aircraft functions.

## **7 CONCLUSION**

FSO has now demonstrated its ability to work in common with other sensors like SPECTRA and RBE2 inside a complex system like the Rafale. From this experience we can be confident about the basic performances of the equipment.

FSO program is a successful development of a multirole capacity multiplier that will provide the Air Force and Navy with an outstanding operational advantage in the range of missions assigned to them.