INNOVATIVE SHAPE AND CONTROL CONFIGURATIONS OF RAFALE INNOVATIVE DIGITAL DESIGN OF FALCON 7X

LECTURE FOR INNOVATION IN AERONAUTICS

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Innovative shape and control configurations of Rafale

Since the beginning, the specifications of the Rafale program have been very ambitious: alone, the new aircraft had to replace six different aircraft currently in operation in the French Army: Crusader and Super Etendard in the French Navy, Mirage 3 , Jaguar , Mirage F1 and Mirage IVP in the French Air forces.
It was mandatory to imagine a new configuration able to match both the navy specificities (low approach speed, catapult with low angle of attack, high vertical speed at deck landing) and the air specifications (agility, high Mach number flight, loading capacity, low level penetration and stealth level).

New Delta-Canard architecture for navy version.

Architecture studies converged on a new "delta-canard "configuration, statically instable, mastered by a full digital fly control system.
This configuration was already experimented by Dassault on the Super Mirage 4000, which was fitted with a fixed canard, switchable in case of fly control system failure.
On the Rafale, the canard becomes a primary pitch control surface, with full authority during all the flight.
The canard geometry (surface, profile and shape) and its location with respect to wing and air intakes were mitigated to optimize the interaction on wing's apex (lift increase +30%)

and to lower the interference with air intakes in supersonic.
For Air-to-Ground missions, the canard does not hide the down visibility of the pilot.

This configuration is designed to operate till the maximum lift, without any limitation.
The fly control system, with four digital independent channels, continuously master the required stability for each flight phase.
In approach phase, the canard is turning upward while the pitch control surfaces are down, acting as flaps.
This configuration adds a strong lift on the canard and on the pitch control surfaces that dramatically reduce approach speed on the carrier.
During the catapult phase, at the end of the deck, the digital fly control system automatically increases the angle of attack up to about 20 degres and stop the rotation, after one second, to reach the required lift for horizontal flight.
This digital fly control system pilots the thrust and the drag in approach mode: engine thrust is set a little bit higher than necessary , and the drag is produced by both canard and pitch control surfaces(at high frequency).
The pilot has just to tune the speed vector on the carrier target. In this mode, deck landing becomes very easy to achieve.
As the result of this innovative delta-canard combination, mastered by a full digital fly control system, the Rafale is the first delta-canard configuration to operate on aircraft

carrier worldwide, with a lower approach speed than the currently navy aircraft, in operation on carriers.

Revolutionary ventral air intakes

Air-to-Air missions (interception and dog fight) need both use of high angle of attack till maximum lift and high Mach number. Consequently, a thoroughly optimization of the air intakes has been undertaken to achieve the required behaviour for stationary and non stationary air flows, at high angle of attack and yaw, up to the limit of available maneuverability thanks to the delta canard configuration.

This air intake had also to operate up to a Mach number of 2 and match the stealth level required for the whole aircraft by the French authorities. The optimization, based on intensive aerodynamic computations and wind tunnel tests, converged on a very new design: air intakes protected at high angle of attack by a special shape of the front fuselage (like a boat stem) and the canard which interact on the air flow in front of the air intake. This stem is sufficient to protect also at high yaw angle and to guarantee an appropriate independence of both air intakes, in case of flame out of one engine.

This design, which features no movable devices (shock-cone, ramp) and no devices of boundary layer's suction, is the quite unique Mach 2 air intake of this type in the world.

Innovative Digital Design of Falcon 7X.

In the world market of business aircraft, the Falcon 7X of Dassault-Aviation made a breakthrough on three Key Technologies: aerodynamics, fly by wire and fully integrated digital definition on" virtual plateau".

Digital fly-by-wire (FBW) for business aircraft

The optimization of the Flight Control System

of the Falcon 7X led to a four channels architecture with full hardware and software segregation and an emergency mode (electrical) independent of FBW computers.

This system improves safety by introduction of limitations and flight envelope excursion protections, provides additional degree of freedom for aircraft architecture optimization, eliminates complex mechanical linkages and simplifies maintenance operations.

Moreover, it offers to the passengers a dramatic improvement of comfort during cruise when experiencing turbulence, at take off and in approach conditions.

The Falcon 7X is the first business aircraft in the world which can offer this technology to the customers.

Full Digital development on virtual Plateau

To give full satisfaction to our customers, the Falcon 7X had to be the best aircraft of its market segment in terms of performance, maintenance, availability and price.

To match these challenges, reaching a design which is globally optimized has to be favored; the optimization of each part corresponding to the cutting up of the product in work packages would be detrimental.

To this aim, the needed sharing of all the data between the industrial partners is necessary. For the Falcon 7X development, it has been ensured by a collective work in context on the same data base.

The first phase of the development started on a "physical plateau" where partners and Dassault Aviation teams worked all together at the same location, at the same time, during a whole year. They used the same methods: generalized computer design & production process with CATIA digital mock-up (DMU) and Virtual Product Management (VPM). The conclusion of this first phase was a Common Project from Dassault's preliminary design.

Then, the second phase took place to detail the design with 18 partners who had come back to their companies, all over the world. For this phase, Dassault-Aviation , with the help of Dassault-Systems, set up a "virtual plateau"

linked with a private optical high speed connection to the partner's companies.

Every day, the teams shared geometric data through the Digital Mock-Up and word development documentation.
The data where organized in configuration through the bill of materials with all the 3D models and the justification documents. The modifications were synchronized every day so that the engineers and technicians were assured to share an up-to-date data base.
The volume of data transfer represented a total design of the aircraft every month (50,000 parts, 2000 equipments and 200,000 fixations).
With this virtual plateau the real concurrent engineering turned up to reality. It was certainly the first full virtual design on an aircraft in the world. The result sets in a dramatic time reduction of final assembly and lay out work, a better quality and cost saving.
This full digital design (no more paper files) is the first in the world accepted and certified by American (FAA) and European (EASA) authorities.

Thanks:

I thank you very much for selecting me as recipient of the ICAS Award for Innovation in Aeronautics for 2010.
I am very proud to receive this award in the name of the Dassault-Aviation technical teams of Rafale and Falcon 7X programs which I had the pleasure to manage as chief engineer for twenty years.

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