Airframer vision of the aircraft of the future

What do airframers want from equipment makers in terms of leading edge technologies?

Bruno STOUFFLET
Vice-President R&T and advanced business
Aeronautics trends

- Upholding the high safety level of air transport
- Increased weight taken by environmental issues
- Aircraft becoming part/node of a network
  - ATM automatization
  - Information sharing (weather forecast, aircraft positions, ...)
  - Passenger systems (In-Flight Entertainment)
  - Maintenance services
- Increased demands for more open systems capable of evolution during life and free customization
- Increased importance of requirements linked to information system security
- More autonomous systems with high level of confidence
1-Five technological tracks

**Efficient aircraft**
- Weight reduction
- Generalized control

**Digital Falcon**
- Smart mission management
- Automation
- Connectivity

**Greener Falcon**
- Noise reduction
- Fuel Consumption reduction

**More electrical Falcon**
- Dynamic management
- Consumption management

**Eco-design**
Greener Falcon: Noise reduction

Ambitious objective:
-20 dB with respect to 2000 technologies

Reduction of noise emission
Greener Falcon: Noise reduction

- **Reduction of jet noise**
  - Chevrons

- **Reduction of fan front noise**
  - Inlet lips

- **Reduction of fan back noise**
  - Canted inlet

- **Reduction of jet and turbomachinery noise**

- **Reduction of flap noise**
  - Porous flap edge
    - Solid (reference)
    - Foam
    - Multi-layer mesh

Various concepts based on shapes and flow handling
Greener Falcon: innovative configuration

- Canard configuration
  - Flight qualities
  - Control strategies
  - Wake ingestion
  - Lay-out

Reduced static margin
Efficient aircraft: Mass reduction

The increased part of composite materials impacts equipment installation rules

Composite is adapted to innovative designs
- High span wings
- « U » empennage

Composite application (Kg)

- Mirage F1
- Mirage 2000
- Falcon 900
- Rafale A
- Rafale D

Lightning protection experiments

Industrial process assessment

Composite wing box
Efficient aircraft: Load and vibration control

A/C flight dynamics

1st aeroelastic mode (~3 Hz)

1st fuselage mode (~7 Hz)

Oscillations: Vibrations & flutter
(mid frequencies)

Loads
(low frequencies)

0 Hz

1 Hz

5 Hz

10 Hz

Take the full advantage of digital flight control system to control vibrations taking place in the aircraft using existing control surfaces
Efficient aircraft: Load and vibration control

**Aerodynamic solicitations**
- Turbulence
- Flow detachment

**Maneuvers**
- Flight maneuvers
- Ground maneuvers
- Take-off and landing

**Aircraft**
- Dynamic aeroelasticity
- Flight Control System

**A/C responses**
- Low frequency
  - Loads
  - Fatigue
  - Vibrations in turbulence
- Medium frequency
  - Local fatigue
  - Vibrations
  - Flutter

**Reduction of vibrations in cockpit during high Mach cruise in the frequency range [5-12Hz]**

RMS Reduction [7-12 Hz] = 22%
Efficient aircraft: Ground control

One of the example of the generalized control approach

**Multiphysics**
- Ground contact forces (tyres, dampers, gears)
- Aerodynamic forces

**Broad variability**
- Runway condition (grainy surfaces, contamination)
- Tyre condition (wearing, inflation, temperature)
- Transverse wind effect (high yaw, gust)
- Engine failure

**Various control means**
- Steering
- Aerodynamic control surface
- Differential braking

[Graph showing lateral excursion (m)]
More electrical Falcon

Shrink the gap between average power use and installed power

In a conventional architecture the average power use is about 7 times less than the total power supply capacity.

In an “all electrical” aircraft the ratio between installed power supply and average power use drops to 2.

Design Margin is taken once.

The peak is global, not the accumulation of the hydraulic and electric peaks.

Simplification via a single energy, combined with electricity's flexibility allows optimisation of energy usage.

Average Power Use

Installed Supply Capacity

Global Average Power Use

Total Installed supply capacity

Electric

Hydraulic

Pneumatic
More electrical Falcon

Progressive introduction of technologies

- **Expected benefits**
  - Dispatch rate, reliability
  - Mass reduction (not in a near future)

- **Design and development capacities**
  - Modelization and technological tests
  - Electrical and thermal benches for system tests

- Electrical operation of landing gears and steering
- Electrical bleed-less ECS
- Low power electrical ice protection

- Flight APU with power alternator
- Electrical operation of brakes
- Digital flight control system with electrical actuators

Vision of a more electrical FALCON
More electrical Falcon: Expectations & Challenges

- Clever choice of E-system operation and associated electrical architecture with optimization of the power losses
- Could require more equipment and space allocation compared to classical system pending E-choices, weight compromise including:
  - Heat thermal management
  - EMI/HIRF/Lightning protection aspects
  - PbW routing
- Implies more electronics, power conversion
  - Achievement of system failure rate objectives is a challenge
  - Reliability needs to be addressed in design phase, taking into account the product life
  - Power electronics and power conversion density shall continue to progress
Digital Falcon: Increase of operational flexibility

- A customized & innovative cockpit taking advantage of automatization, alleviating the work load
- A navigation and piloting system enabling an augmented operational flexibility
- 1+1 piloting mode, enabling rest (naps) in cockpit

A synthetic image elaborated from stored elements in an onboard data base (terrain, obstacles, pistes...)

Tactile screens
Vocal command
Data Bases management
Communication means ...

FALCON 50
FALCON 900EX EASy
Digital Falcon: Increase of operational flexibility

Two complementary PILOT VISION enablers for more OPERATIONAL CREDIT

Enhanced Flight Vision System (EFVS)
Extends the visual segment below DA/DH by providing in HUD Sensor Vision of the runway before natural vision

Synthetic Vision Guidance System (SVGS)
Extends the instrument segment below DA/DH by providing Synthetic Vision & guidance cues

OPERATIONAL CREDIT
EFVS to land down to RVR 300m / 1000ft

At CAT1 airport, by CAT1 crew

OPERATIONAL CREDIT
Lower Decision Height by 50ft
Digital Falcon: Increase of automation

Automation to be introduced in the four major pilot activities

- **Aviate**
  - Increase the authorities of automation to perform in all external conditions and resilience to all known degraded modes

- **Manage**
  - Increase automation level in each system as much as possible and reduce multisystem cascading effects by improving the resilience of the global architecture

- **Navigate**
  - Secure the aircraft flight path regarding external hazards such as terrain, obstacles, weather, traffic, ...

- **Communicate**
  - Develop a robust and secured architecture but open enough to accept new services (SSI challenges)
Eco-design

Life cycles analysis

- Reference parts
- Material & Process
- Aircraft level Eco-Statement
- Aircraft extrapolation
- LCA on Reference parts

Demonstrations of components

- Technologies Eco-Statement
- Metallic alloys, processes and surface treatments
- Low Energy Curing
- Light Alloys / Green metallics
- Mg alloys
- TP a/c structures
- TP structures
- Low Energy Curing
- Low Energy Curing

Green technologies & processes

- Bill of Materials & Processes
- Aircraft Material & Process cakes
- Composite 10%
- Miscellaneous: Copper, bronze, synthetic 5%
- Titanium 3%
- Steel 1%
- Aluminium 81%

Applications

- REACH Regulation
- Certification ISO 14001
- Company Environmental Policy
- Falcon paintings without chromates
- Company Environmental Policy

References

- Parts
- Bill of Materials & Processes
- Aircraft Material & Process cakes
- Life cycles analysis
- Eco-statement
2-Evolutions of interfaces between OEM & supplier

- Shifting of the interfaces
- Redefinition of the different respective roles

- Modular avionics
- Conformal antennas
- Multifunction sensors
- Functional structures (ex. pre-wired composites)
- More integrated propulsion system
Modular avionics: A recomposition of the roles

- Aircraft Integrator
  - Responsible of ATAxx system
  - Responsible of IMA (ATA42) system
    - Conduct IMA process
    - Allocate shared resources
    - Define and qualify configuration tables

- Platform supplier
  - Develop and qualify IMA platform
  - Provide usage domain, tools and associated supports

- Application provider
  - Develop, integrate and qualify applicative software associated to ATAxx system functions

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**Federated**

- System 1
- System n

**Non incremental IMA**

- System 1
- System n

**Incremental IMA**

- System 1
- System n

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IMA 1G

IMA 2G
Conformal antennas

Divide by 2 the number of antennas

Radiating elements become part of the structure
More and more, review and validation processes involve architecture modelling for verification that the milestones are passed.

Thus, model exchange will play an essential role in the contractual relationship between OEM and suppliers.

This approach has already been used in Dassault Aviation to select an Enhanced Flight Vision System on the basis of evaluation of performances in synthetic environments.

Interoperability Standards (STEP AP242, Modelica, ...) Balanced approach OEM/suppliers
Validation by models

Evaluation of architecture alternatives of thermal management system
Digital continuity from design to manufacturing encompassing realistic simulations in configured context (multidisciplinary design, active immersion, design review, maintenance scenario, …)
A global PLM based on an integrated system approach is the next frontier.

The exploitation of massive data to extract behaviour for maintenance purposes or knowledge of operations takes advantage of the breakthrough brought by Big Data.

A “new” supply chain appears in the game.

It raises the issue of data ownership and user right amid customer, operator, OEM, supplier, third party, ...
Digitalization: Product standpoint

**Operation domain**
- Generalization and functional enrichment of Electronic Flight Bags (EFBs)

**Maintenance domain**
- Retex process and statistical analysis of data
  - signal processing, estimation techniques, identification of dynamical systems, machine learning, data mining
- Signalization, diagnostics and fixings
  - Dysfunctional modeling and analysis of monitored parameters
- More autonomous systems

**Cabin domain**
- A digital environment at the highest standard considering connectivity, friendliness, content, real time information, ...

Cybersecurity
Openness
Even if the trend is no longer to install an equipment with its own computer and software but to integrate a sub-system in a comprehensive system, it is expected that suppliers do not forget the basics of their core skills:

- Identification of failure modes
- Robustness validation
- Comprehensive vibration, shock, lightning tests for qualification of equipment

OEMs are expecting that suppliers maintain their capacity to assess the maturity of their product (beyond the TRL increment R&T journey).