DASSAULT AVIATION

Airframer vision of the aircraft of the future

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

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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

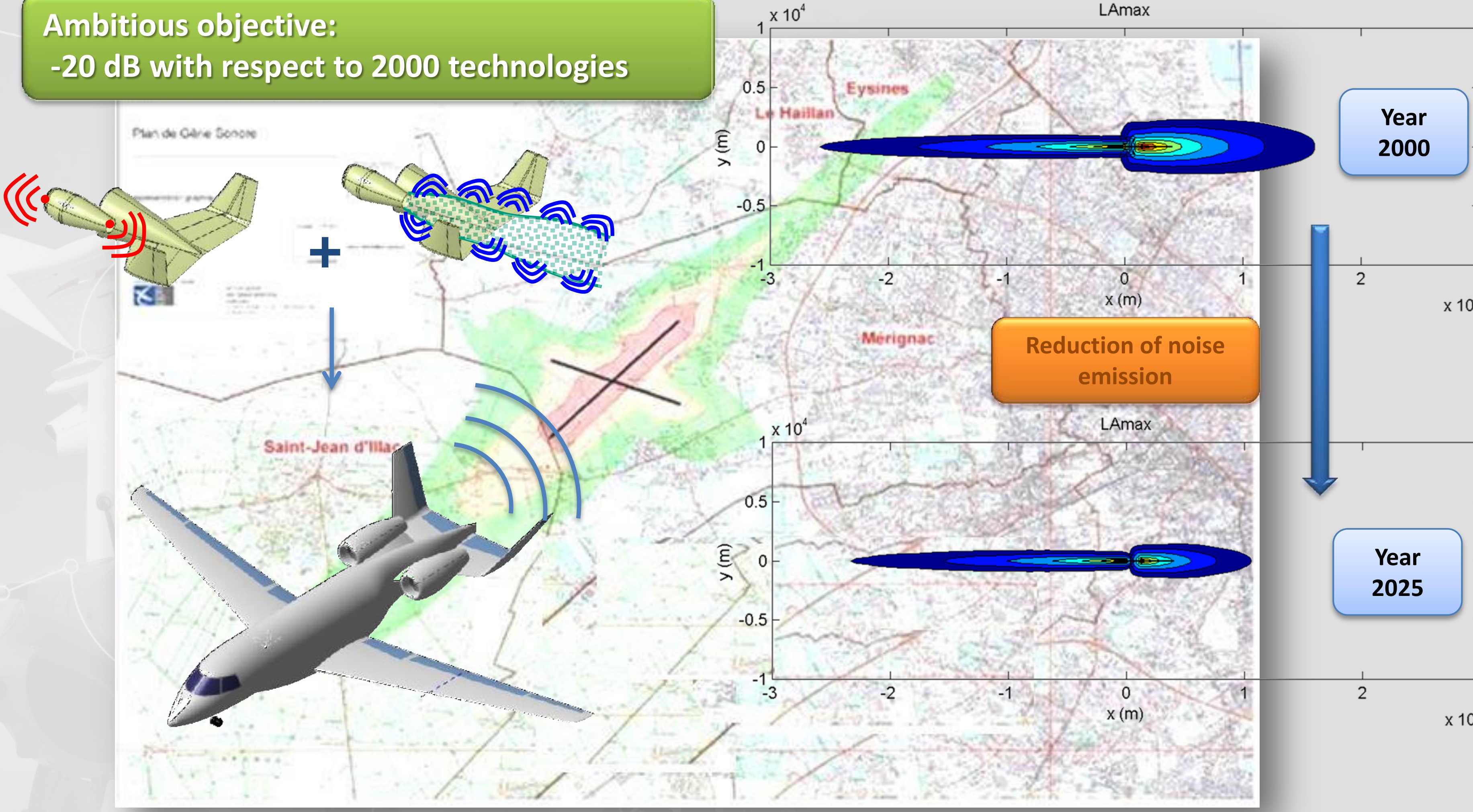
More electrical Falcon

- Dynamic management
- Consumption management

Eco-design

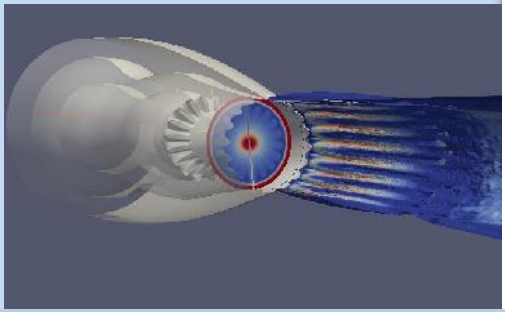
Greener Falcon: Noise reduction

Ambitious objective:
-20 dB with respect to 2000 technologies



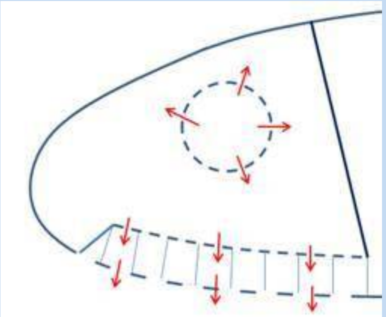
Greener Falcon: Noise reduction

Reduction of jet noise



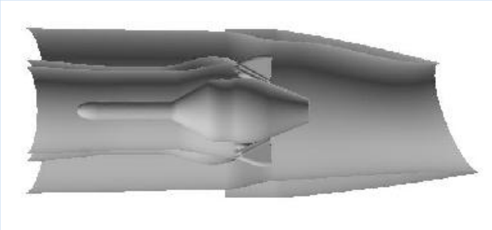
Chevrons

Reduction of fan front noise



Inlet lips

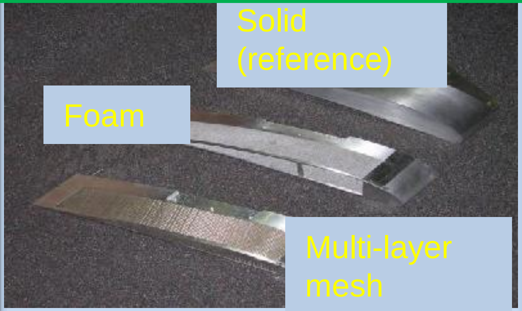
Reduction of fan back noise



Canted inlet

Reduction of jet and turbomachinery noise

Reduction of flap noise



Porous flap edge

Various concepts based on shapes and flow handling

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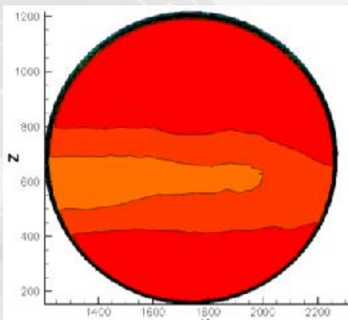
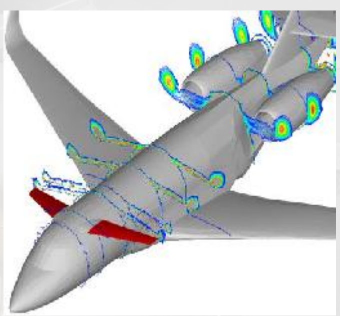
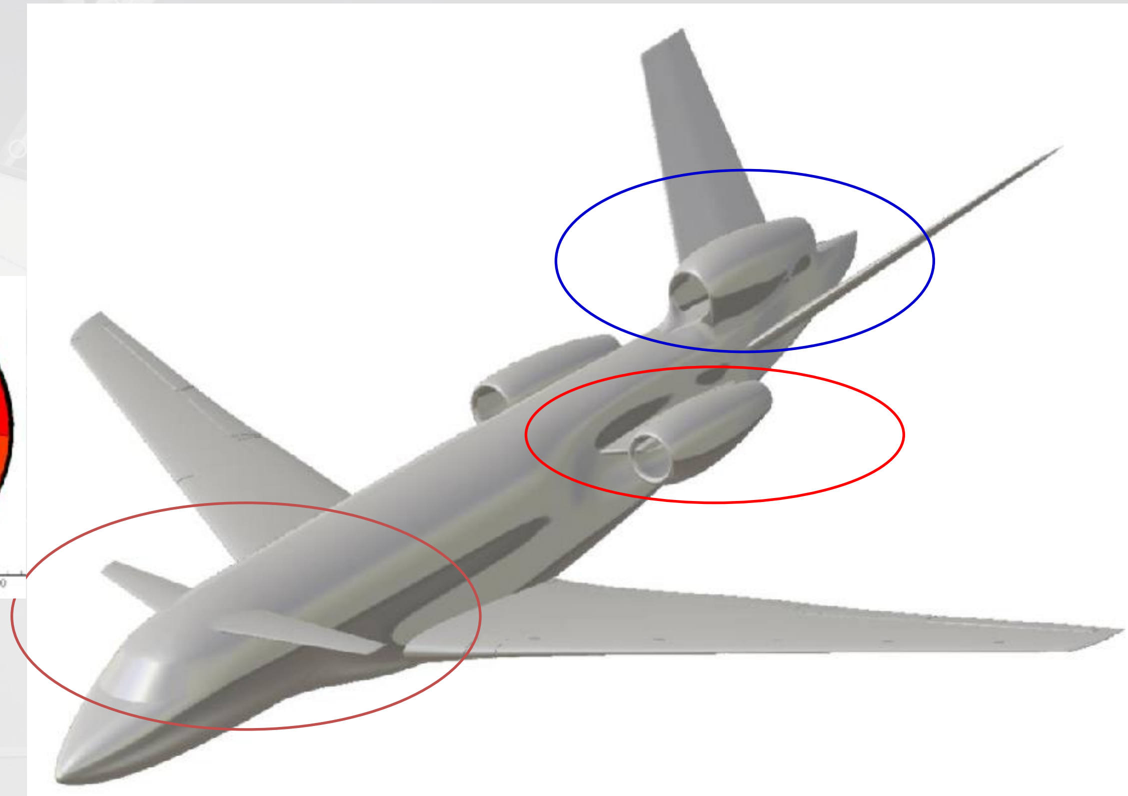
Greener Falcon: innovative configuration

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

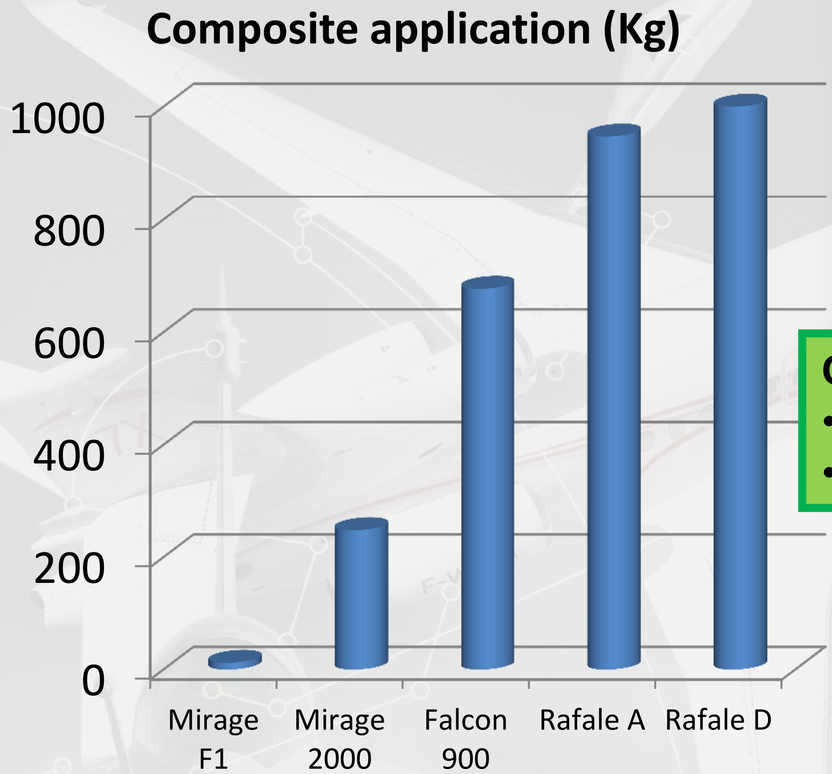






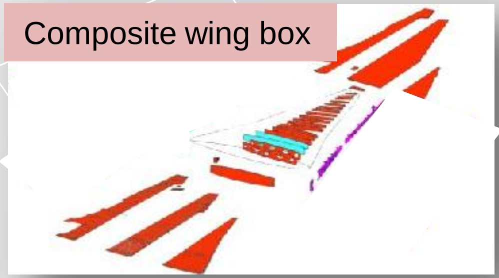
Reduced static margin

Efficient aircraft: Mass reduction



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

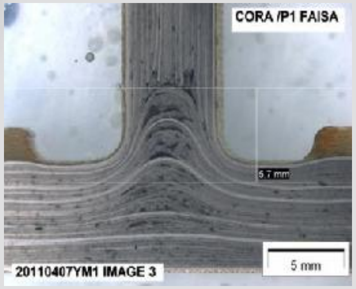
The increased part of composite materials impacts equipment installation rules



Composite wing box

Industrial process assessment

Lightning protection experiments



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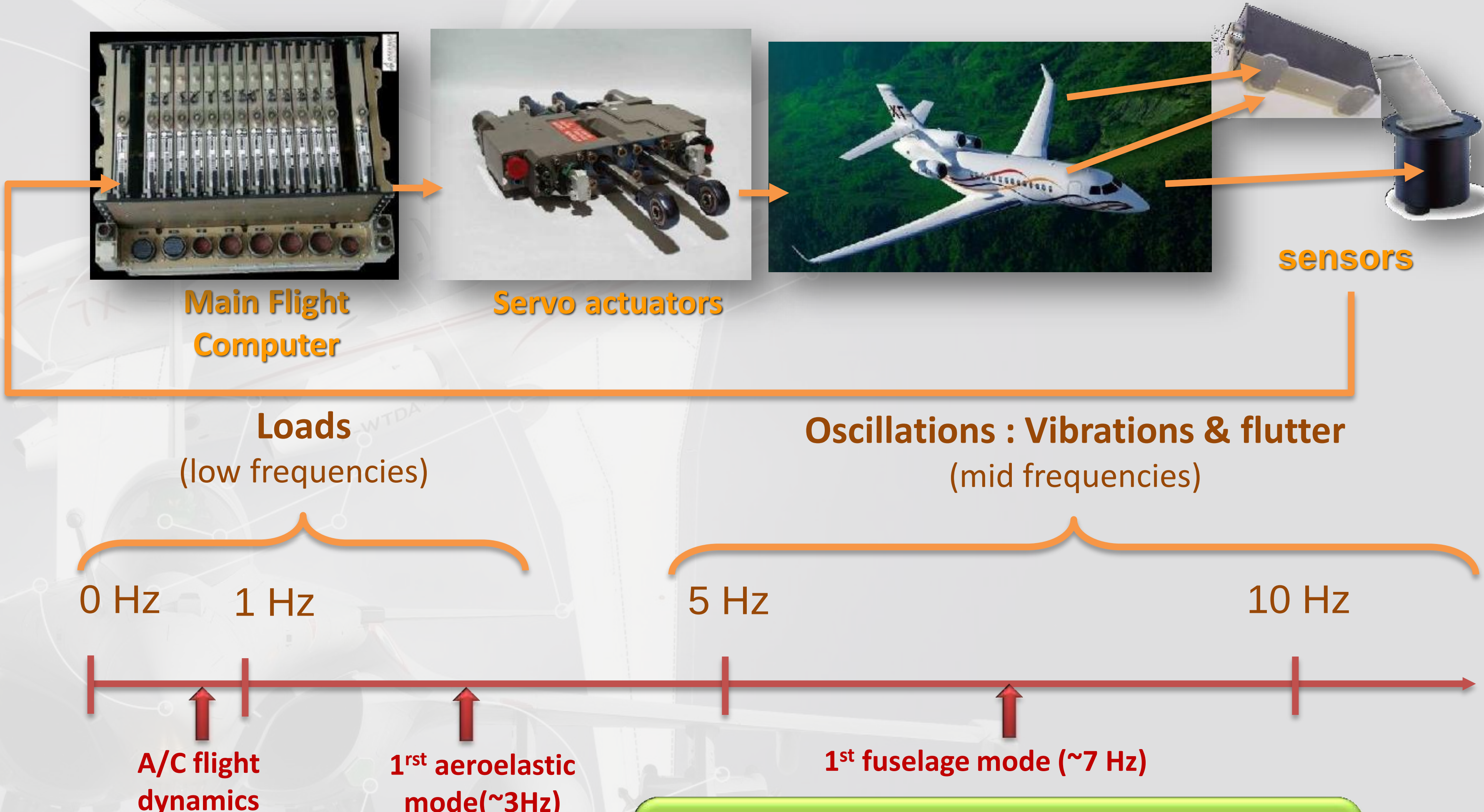
Efficient aircraft: Load and vibration control



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

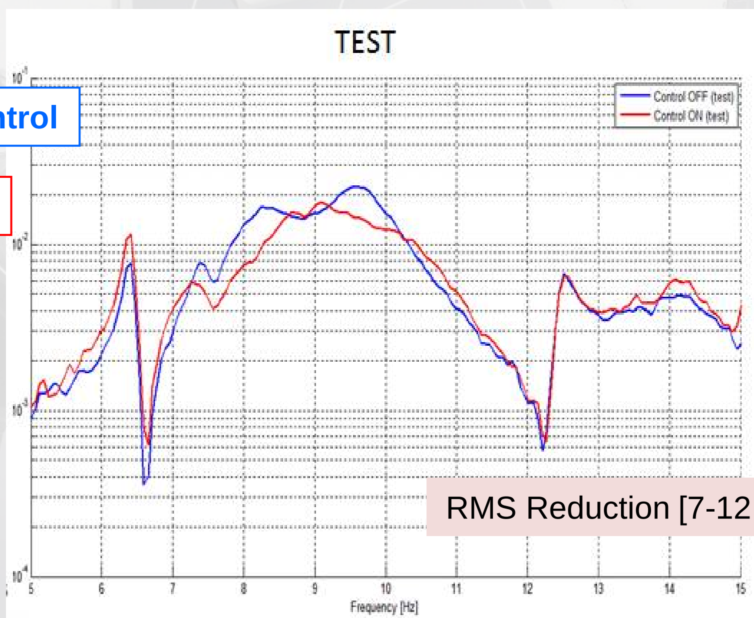
- ❍ Flight maneuvers
- ❍ Ground maneuvers
- ❍ Take-off and landing

Aircraft :

- Dynamic aeroelasticity
- Flight Control System

A/C responses

- ❍ Low frequency
  - Loads
  - Fatigue
  - Vibrations in turbulence
- ❍ Medium frequency
  - Local fatigue
  - Vibrations
  - Flutter



RMS Reduction [7-12 Hz] = 22 %

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

Efficient aircraft: Ground control

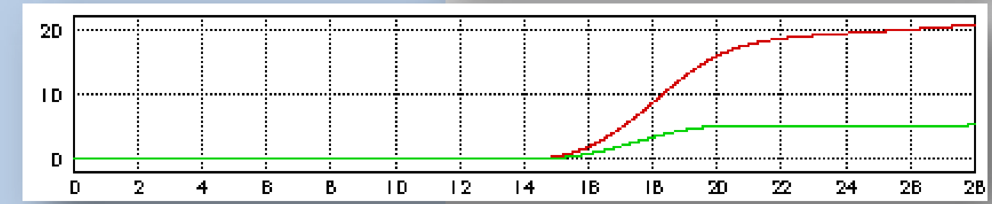
One of the example of the generalized control approach

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

Lateral excursion (m)



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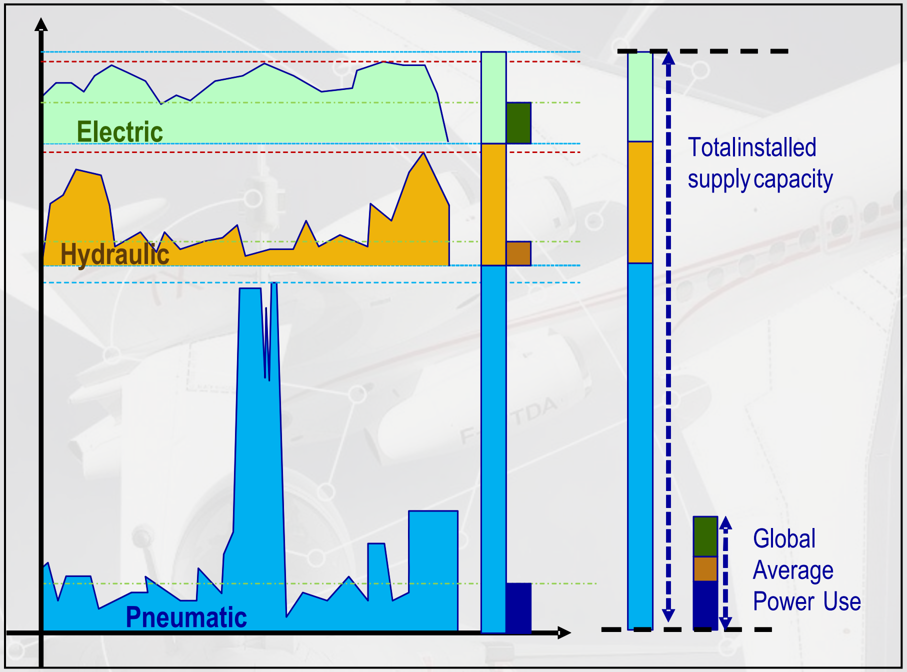
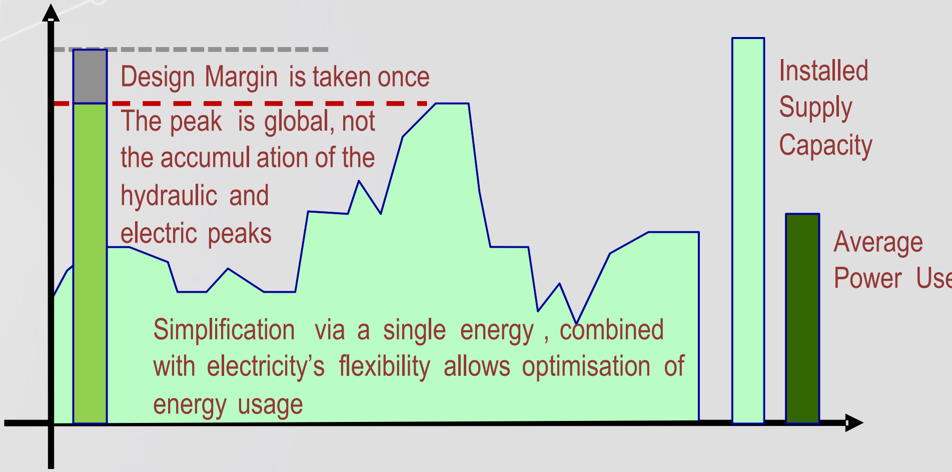
More electrical Falcon

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

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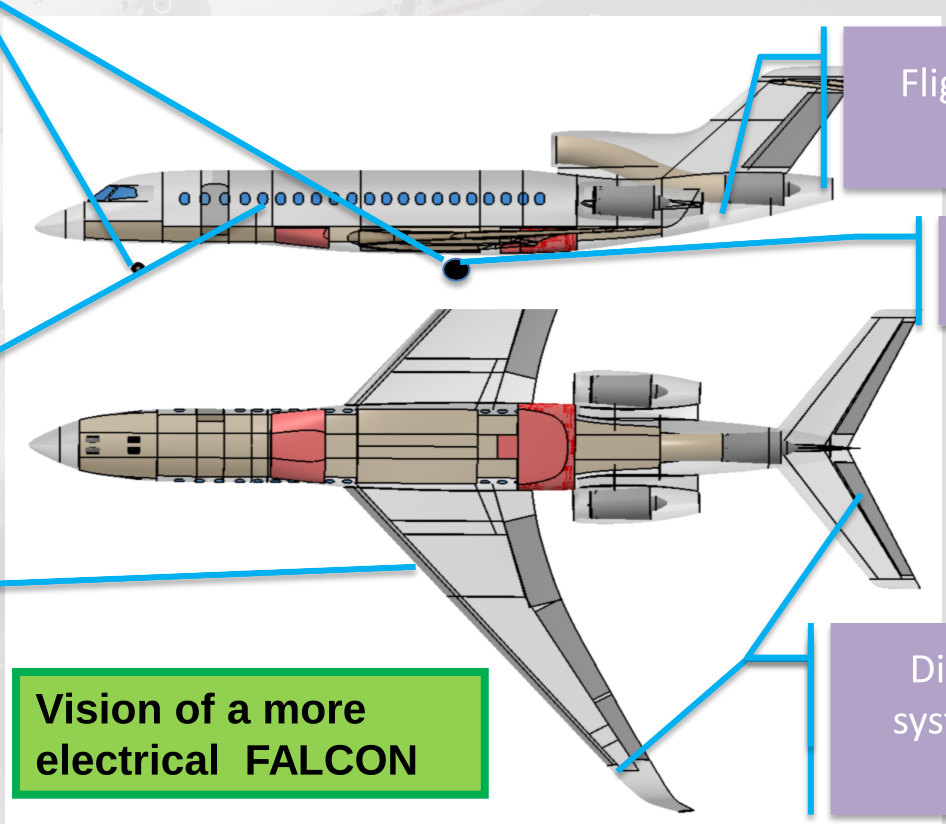
More electrical Falcon

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

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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

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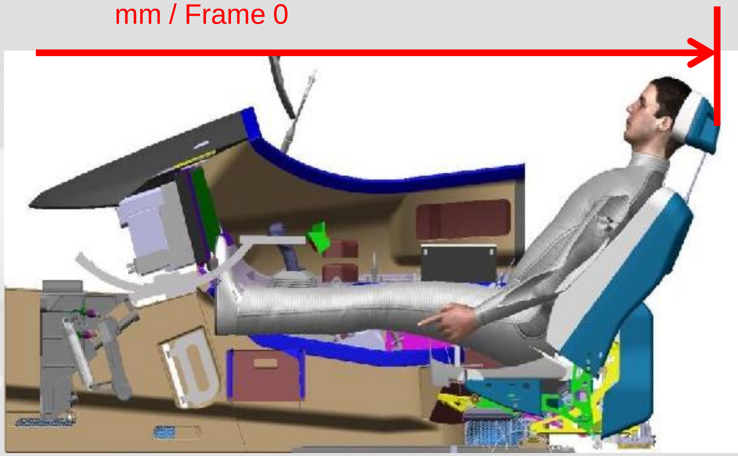
Digital Falcon: Increase of operational flexibility

FALCON 50

FALCON 900EX EASy



- 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
…

Digital Falcon: Increase of operational flexibility

Two complementary PILOT VISION enablers for more OPERATIONAL CREDIT

Enhanced Flight Vision System (EFVS)

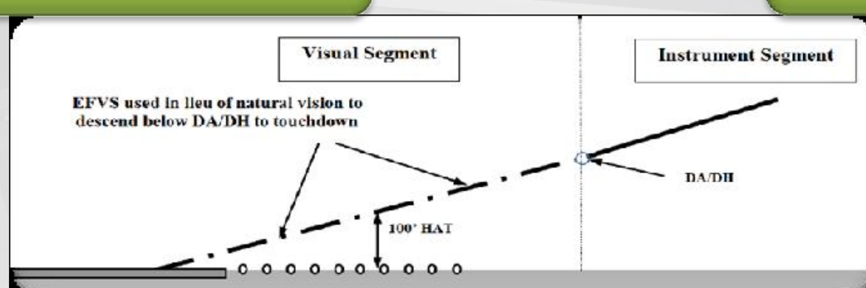
Extends the visual segment below DA/DH by providing in HUD Sensor Vision of the runway before natural vision

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

OPERATIONAL CREDIT
Lower Decision Height by 50ft



At CAT1 airport, by CAT1 crew

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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)

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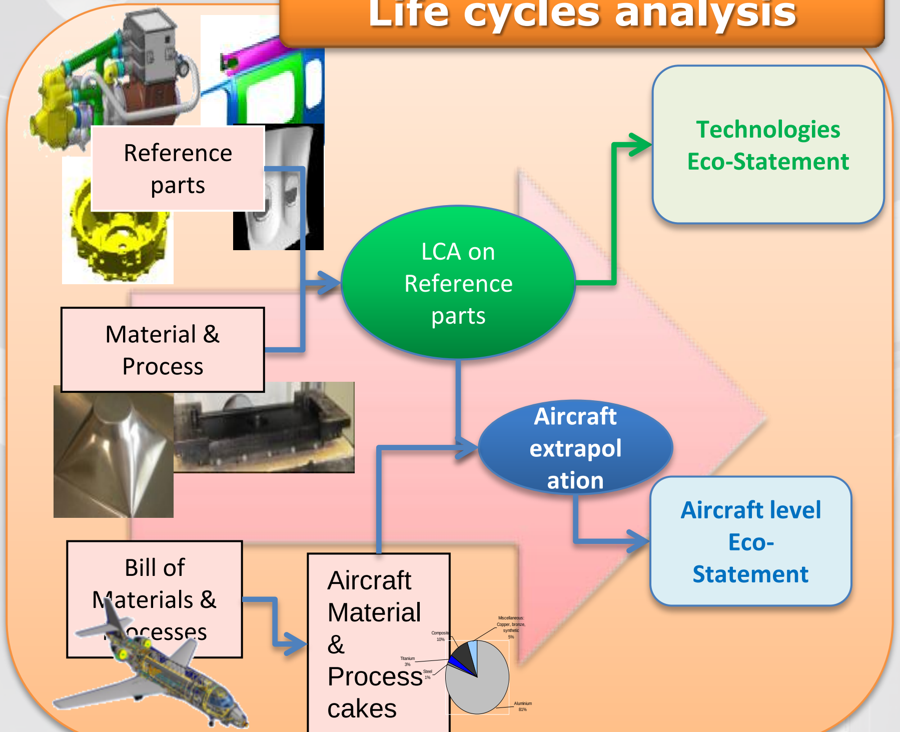
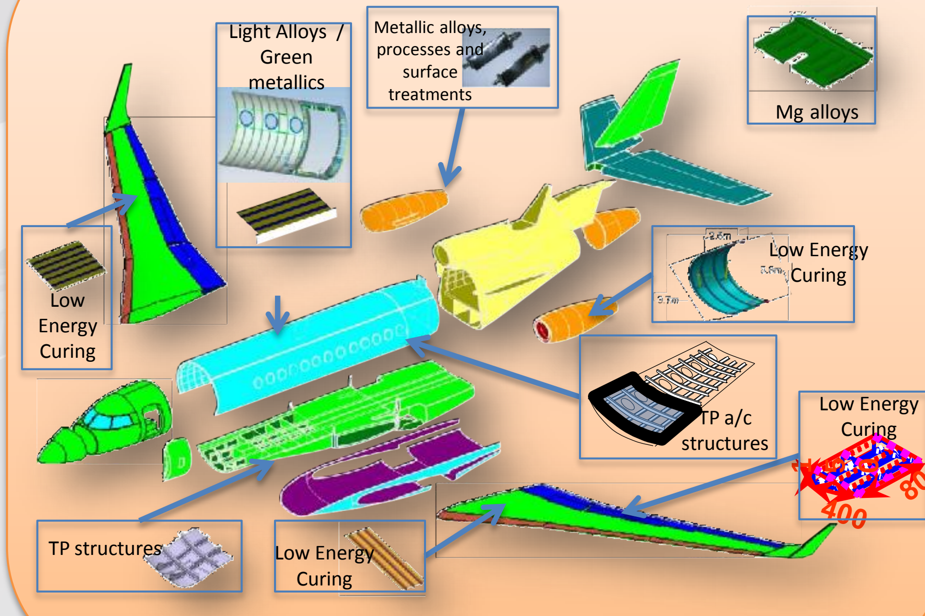
Eco-design

Life cycles analysis



Demonstrations of components



Green technologies & processes

Applications

REACH Regulation

Certification ISO 14001

Company Environmental Policy

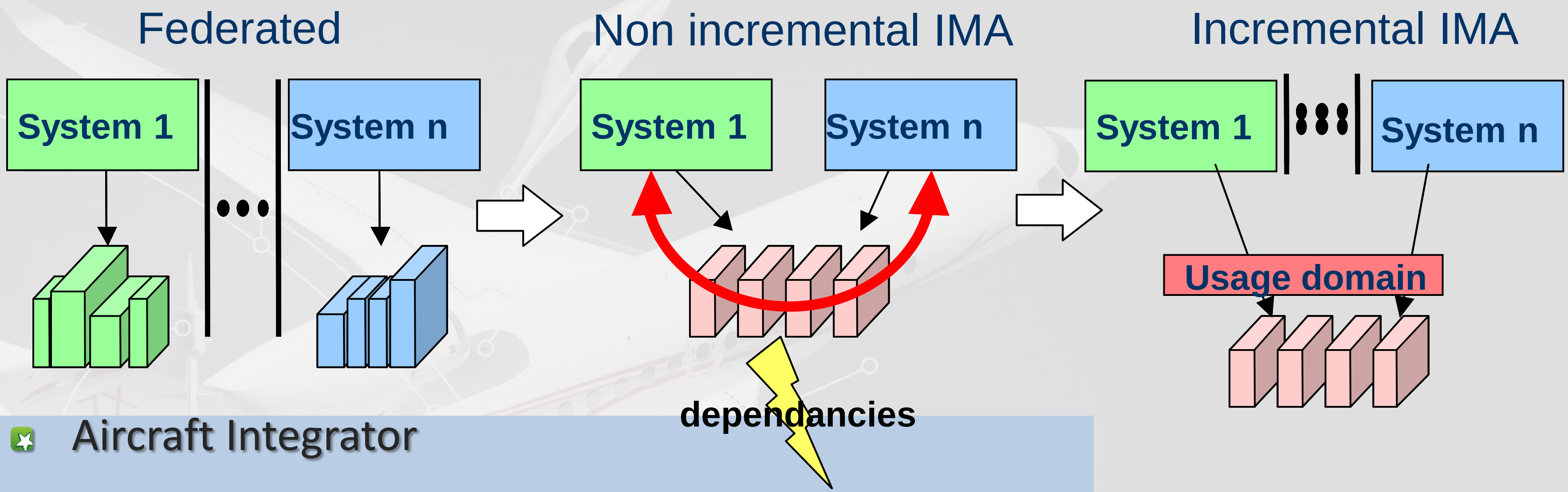
Falcon paintings without chromates

2-Evolutions of interfaces between OEM & supplier

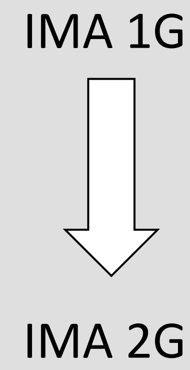
- Shifting of the interfaces
- Redefinition of the different respective roles

Modular avionics
Conformal antennas
Multifunction sensors
Functional structures (ex. pre-wired composites)
More integrated propulsion system

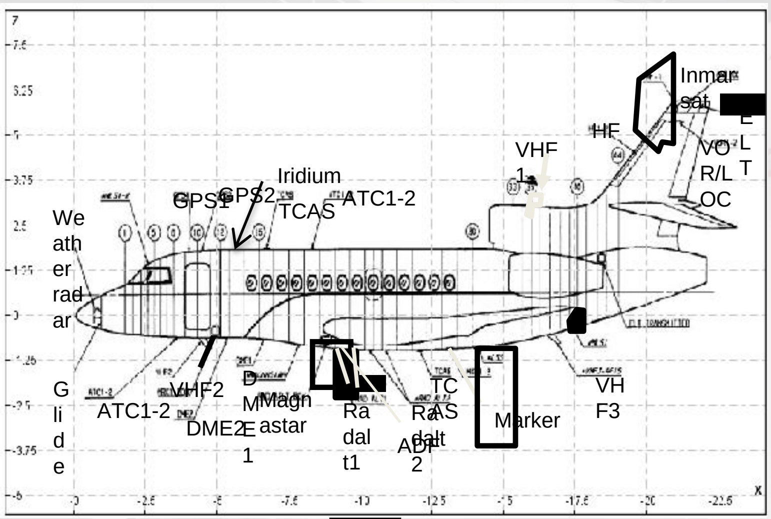
Modular avionics: A recomposition of the roles

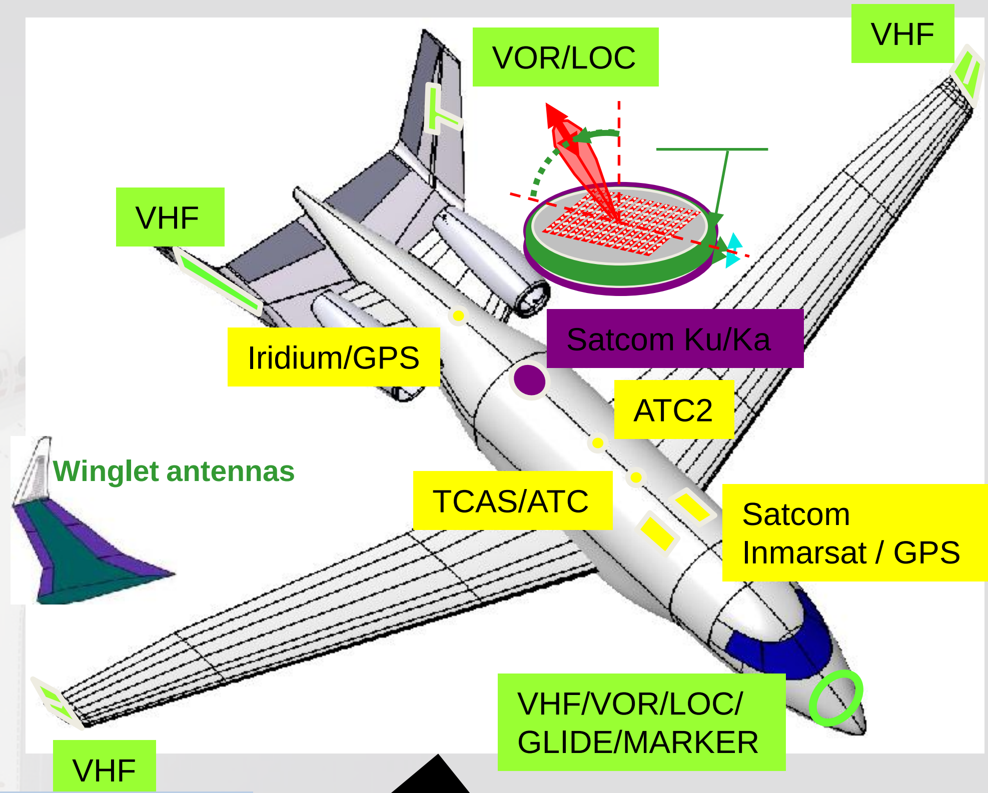


- Aircraft Integrator
- Responsible of ATAxx system
- Responsible of IMA (ATA42) system
  - Conduct IMA process
  - Allocate shared resources
  - Define and qualify configuration tables
- Platform supplier
  - Develop and qualify IMA platform
  - Provide usage domain, tools and associated supports
- Application provider
  - Develop, integrate and qualify applicative software associated to ATAxx system functions



Conformal antennas



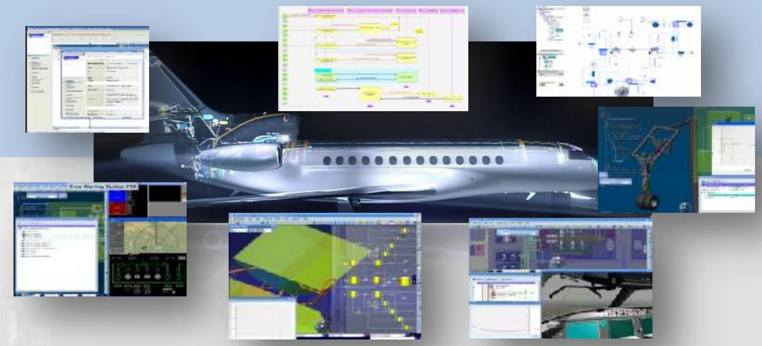


Divide by 2 the number of antennas

Radiating elements become part of the structure

3-Validation by models

- More and more, review and validation processes involves 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/supplyer

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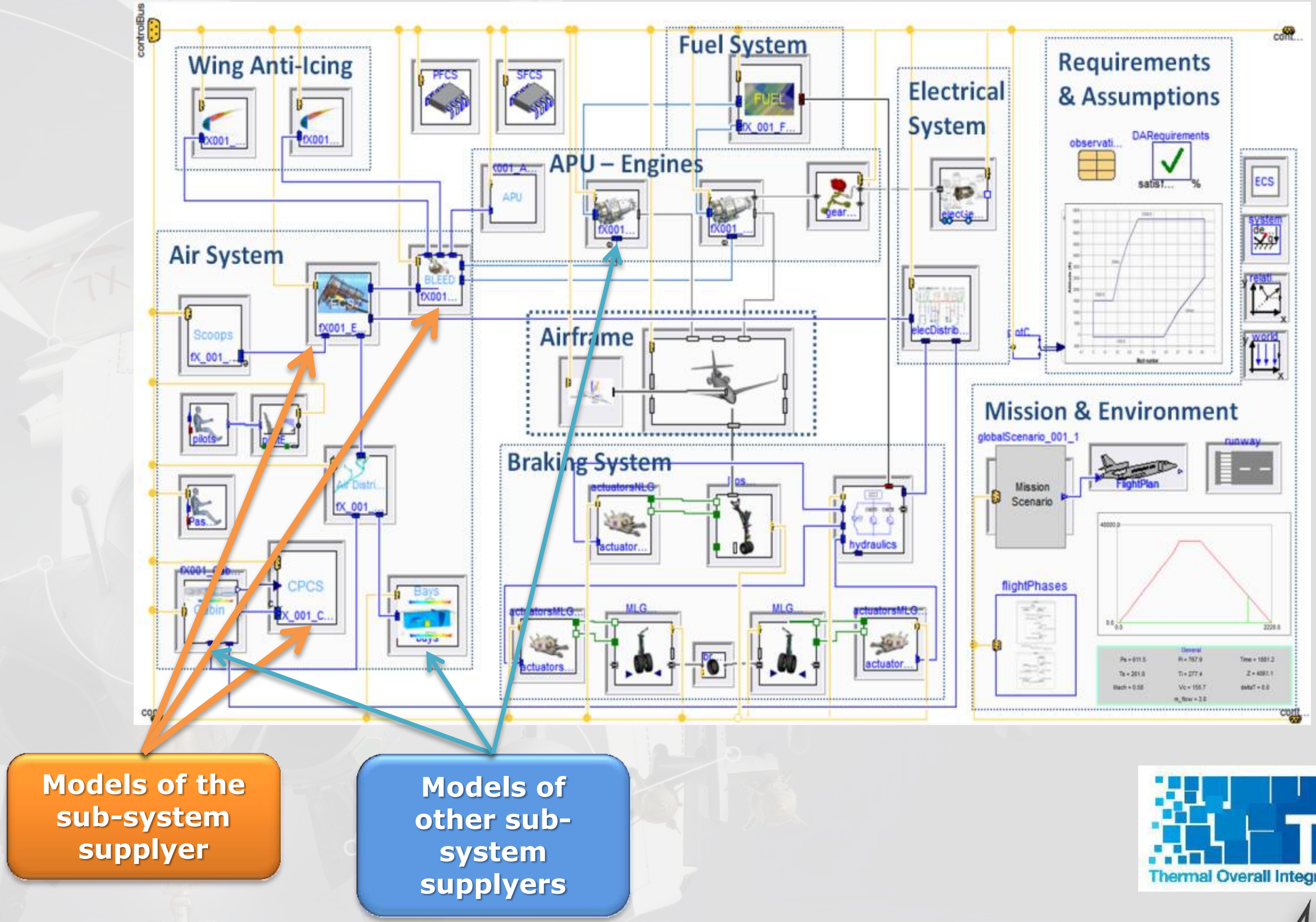
Validation by models

Evaluation of architecture alternatives of thermal management system



Thermal Overall Integrated Concept Aircraft

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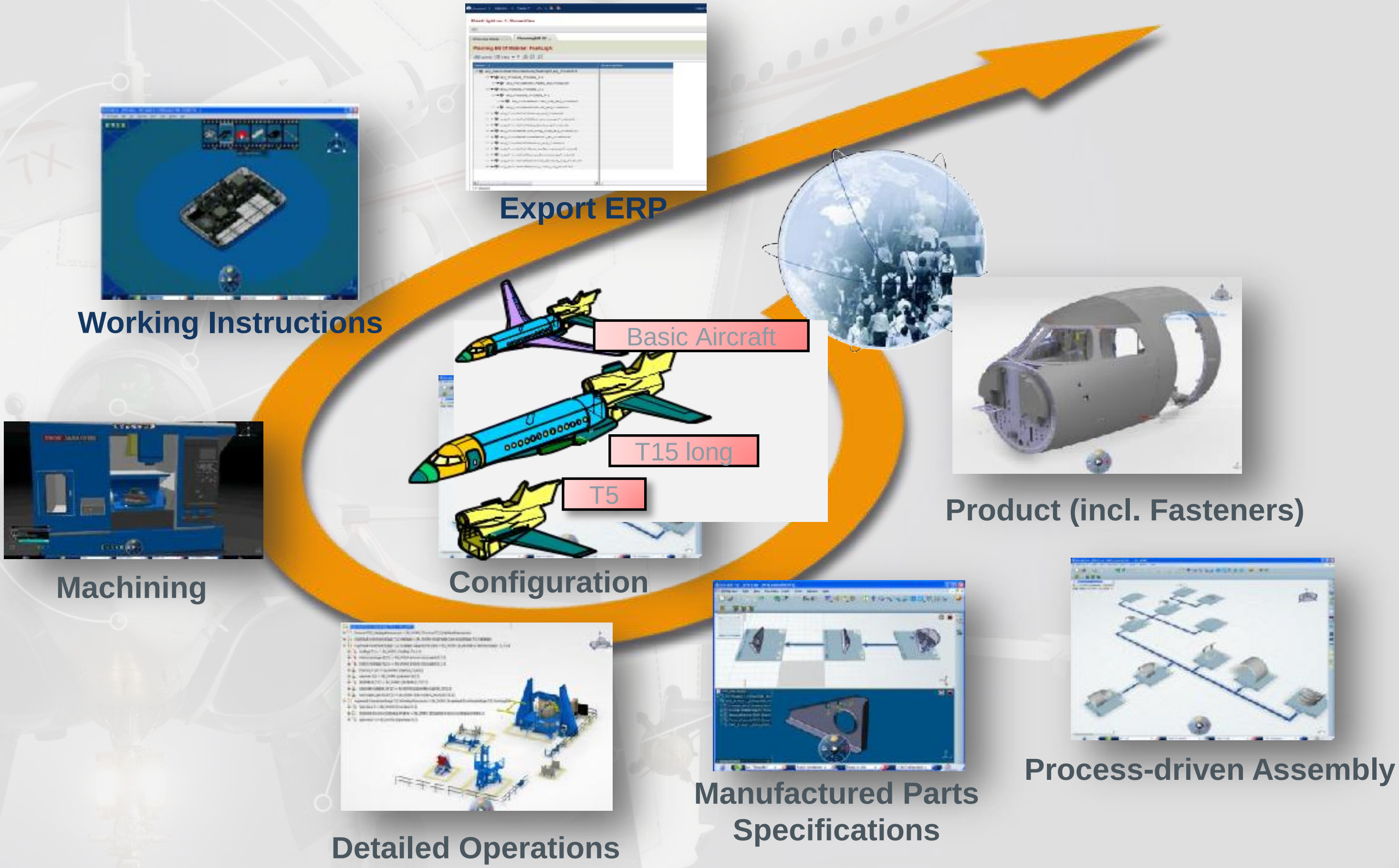
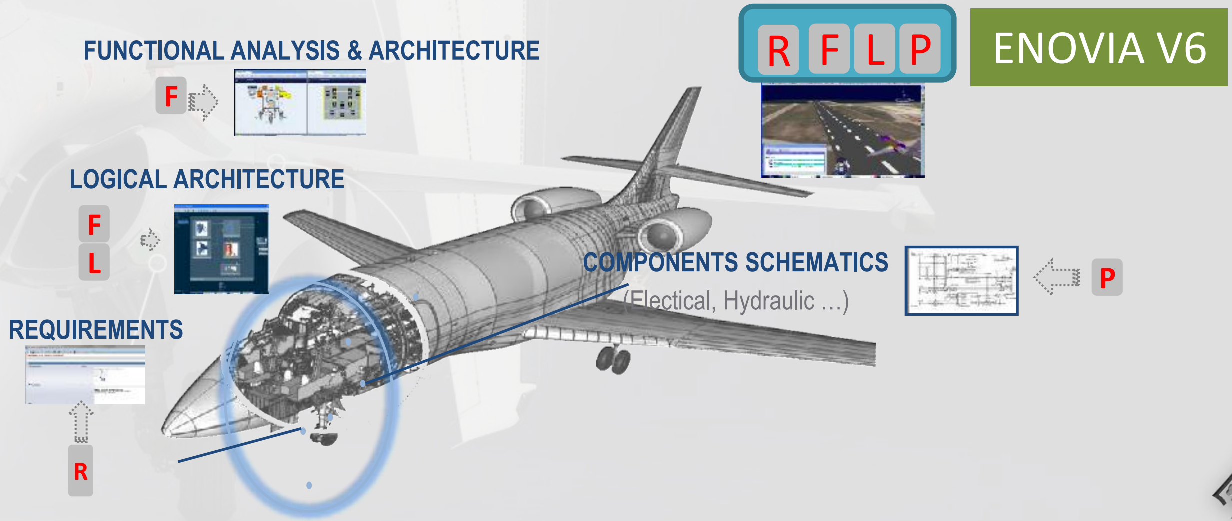
4-Digitalization

Digital continuity from design to manufacturing encompassing realistic simulations in configurated context (multidisciplinary design, active immersion, design review, maintenance scenario, …)



Digitalization: Some statements

- 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, …



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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
Openess

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5-Final statements

Development of future products

- 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)