nEUROn : an international cooperation to enhance innovation

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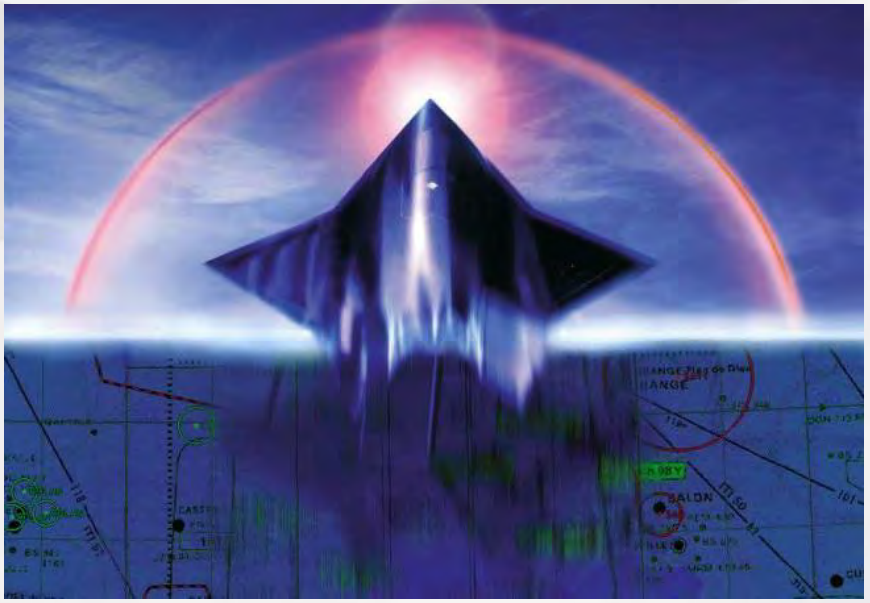
A project for the European defense industry

- **Development of strategic know-how**
  - Maintaining and reinforcing an advanced level of European know-how & key technologies
  - Mastering technologies – mainly stealth – for future European Combat Air System (manned or unmanned)
- **Cooperation scheme for future projects**
  - Experience & excellence
  - Best value for money
  - Clear lines of responsibility
  - Use of common PLM tools
- **UCAS technology demonstrator**
  - With challenging technical targets
  - Searching for technical innovation
  - While respecting cost & schedule



Main demonstration goals

Very low level signature (radar & infra-red)

Autonomous flight consistent with airworthiness regulation (similar to JAR23)

Air to Ground weapon delivery from internal bay

Automatic detection and recognition of re-locatable ground targets with airborne optical sensor without being detected

Program key milestones

- A French MoD initiative launched at Le Bourget 2003
- Six European partners
- Unveiled at Le Bourget 2005
- Contract award: February 2006
- Feasibility achieved: June 2007
- Engine run: December 2011
- First flight: December 2012
- LO measurement: March 2013
- Le Bourget presentation: June 2013

- Budget ≈ 400 M€

Clear lines of responsibility between governments & industries

Spain | Sweden | France | Italy | Greece | Switzerland

Strategic Board

Bilateral Inter-Governemental MoU's

Executive agency

DGA

Main Contract

Prime Contractor

Dassault Aviation

PM
TM

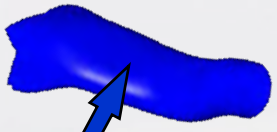
Sub Contracts

Casa (*) | Saab (*) | Thales | Alenia (*) | HAI (*) | Ruag (*)

(*) : MNSC = Main National Sub-Contractors

Airframe workshare based on demonstrated skills

Saab



Ruag

Dassault

HAI

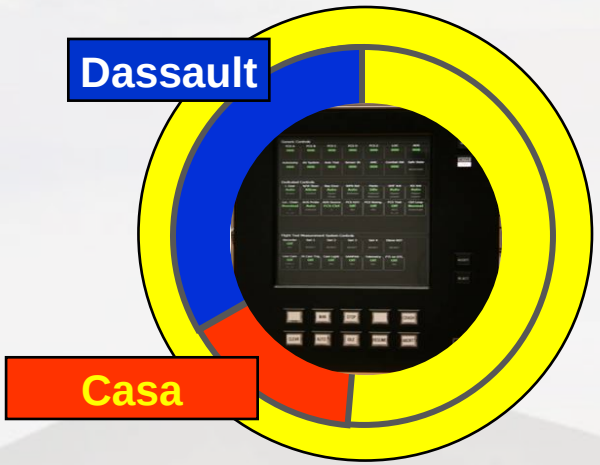
Casa

Alenia

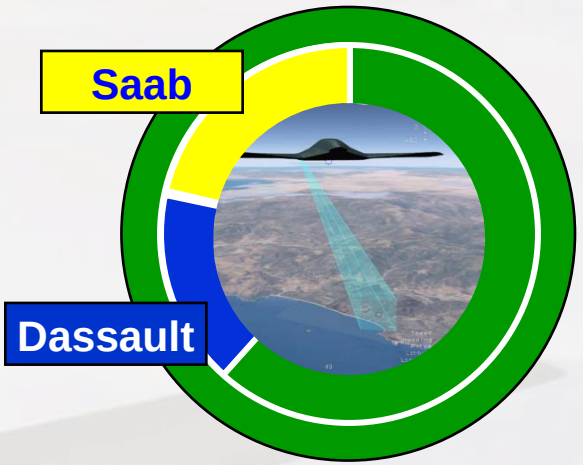
Systems & software workshare based on demonstrated skills

Flight Control System

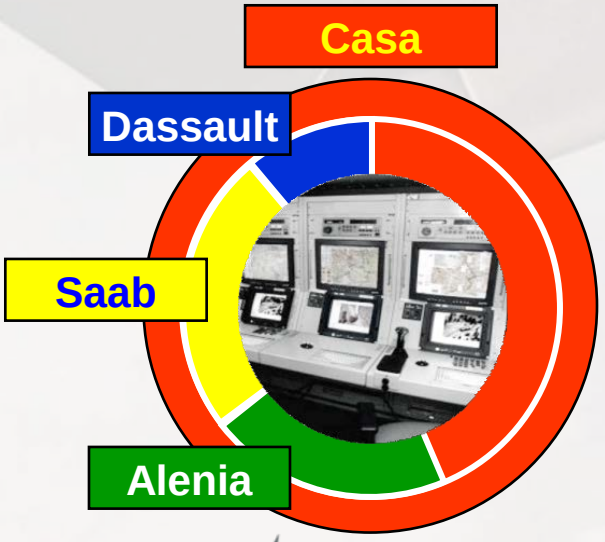
Avionics & VMS



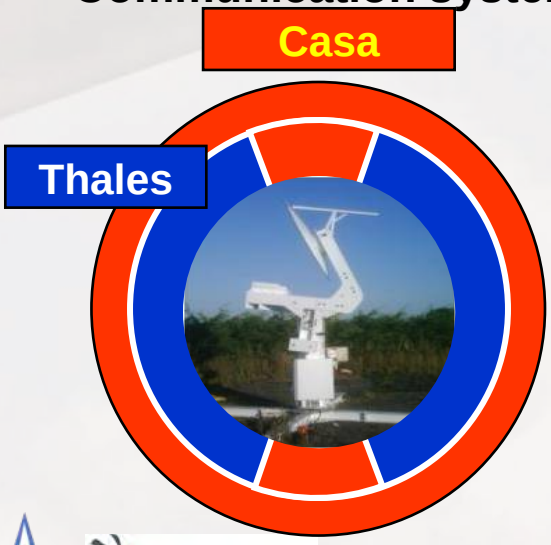
Mission Capability



Ground Control Station



Communication system



Large number of partners including government, industry & research centers

France

DGA

DASSAULT AVIATION

ONERA
THE FRENCH AEROSPACE LAB

SAFRAN
Turbomeca

Labinal
SAFRAN Group

THALES

Messier-Dowty
SAFRAN Group

Sweden

FMV

SAAB

VOLVO AERO

Italy

AleniaAermacchi
A Finmeccanica Company

Selex ES
A Finmeccanica Company

ASE

UTC Aerospace Systems
MICROTECNICA s.r.l.

Spain

EADS
CASA

Greece

Switzerland

RUAG

Others ...

Rolls-Royce

AEROSONIC

Physical & virtual colocated workspace

Saint-Cloud

Istres

Emmen

Tanagra

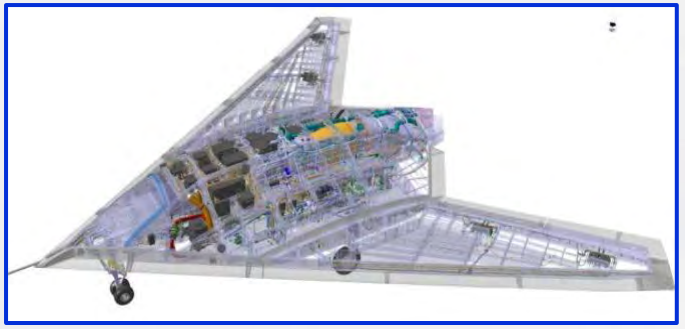
Torino
Naples

Getafe

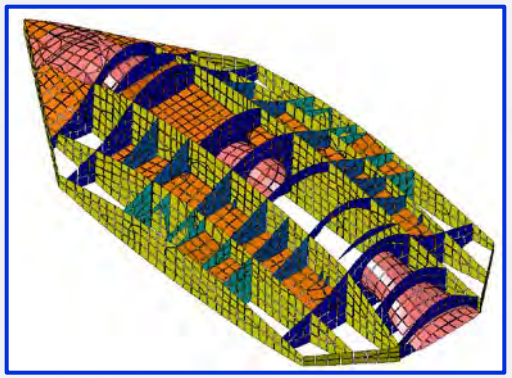
Linköping

Common IT system suit

outside of the collaborative area
(back office level only):
CFD, LO computation & tests



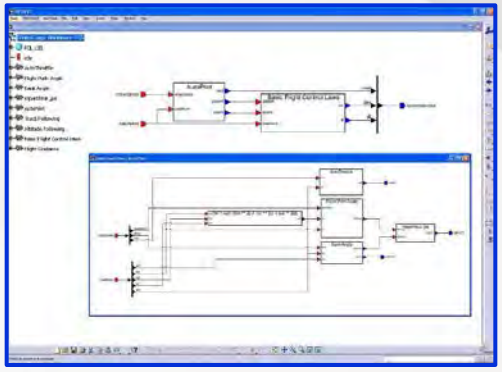
Aiframe & layout Design
with CATIA v5

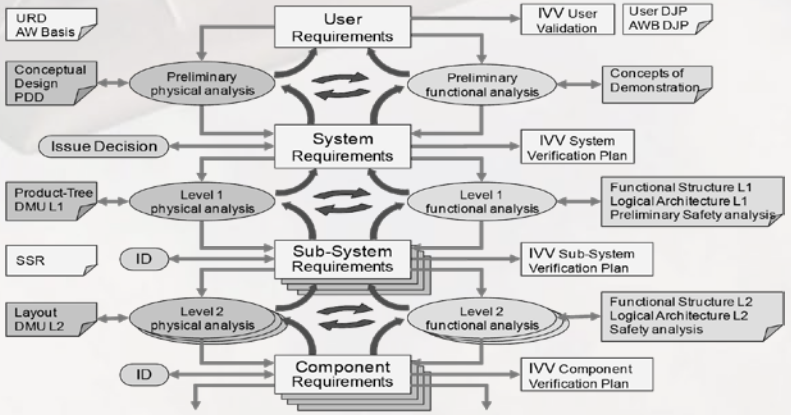


Structural Analysis
with ELFINI
and NASTRAN

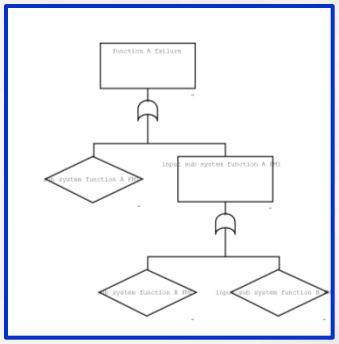
System Requirements
with PLM V6 experimental release
Program Documentation
with Documentum*
Change Management & Technical Events
with Sharepoint/NCM*

System Architecture
with PLM V6 experimental release

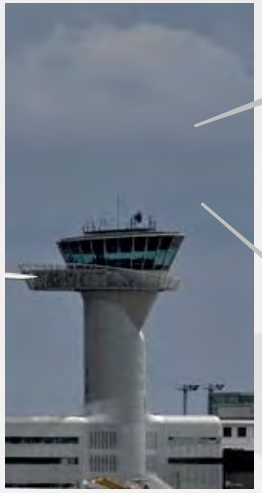




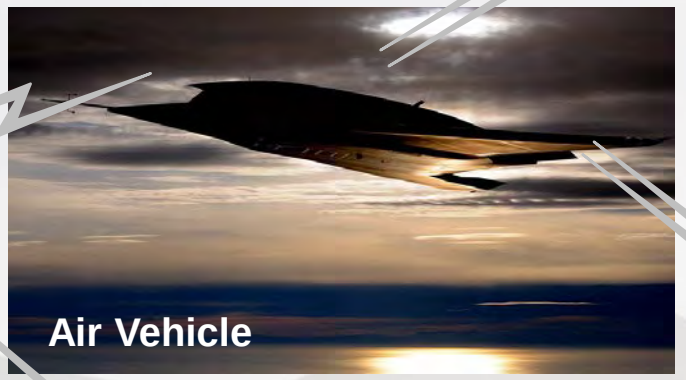
Functional Hazard Analysis (FHA)
with CECILIA



System components



ATC



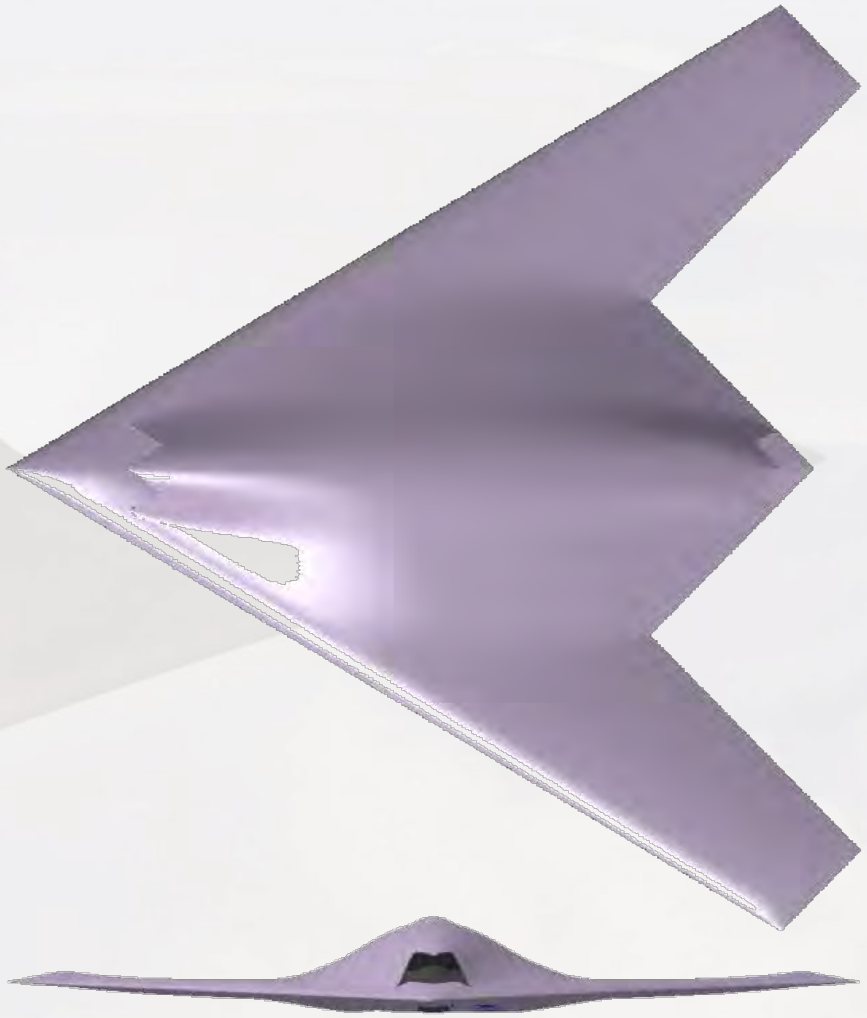
Communications

Ground Control Station

Flight Tests Room

Main Air Vehicle characteristics

- **Main characteristics:**
  - Fuselage length ≈ 9,3 m
  - Wing span ≈ 12.5 m
  - MTOW ≈ 7000 kg
- **Engine:**
  - RRTM Adour Mk951 hybrid
- **Main performance:**
  - Total mission duration ≈ 3 hrs
  - Max Mach ≈ 0.80+
- **VLO:**
  - Between 1/100 and 1/1000 of a legacy combat aircraft



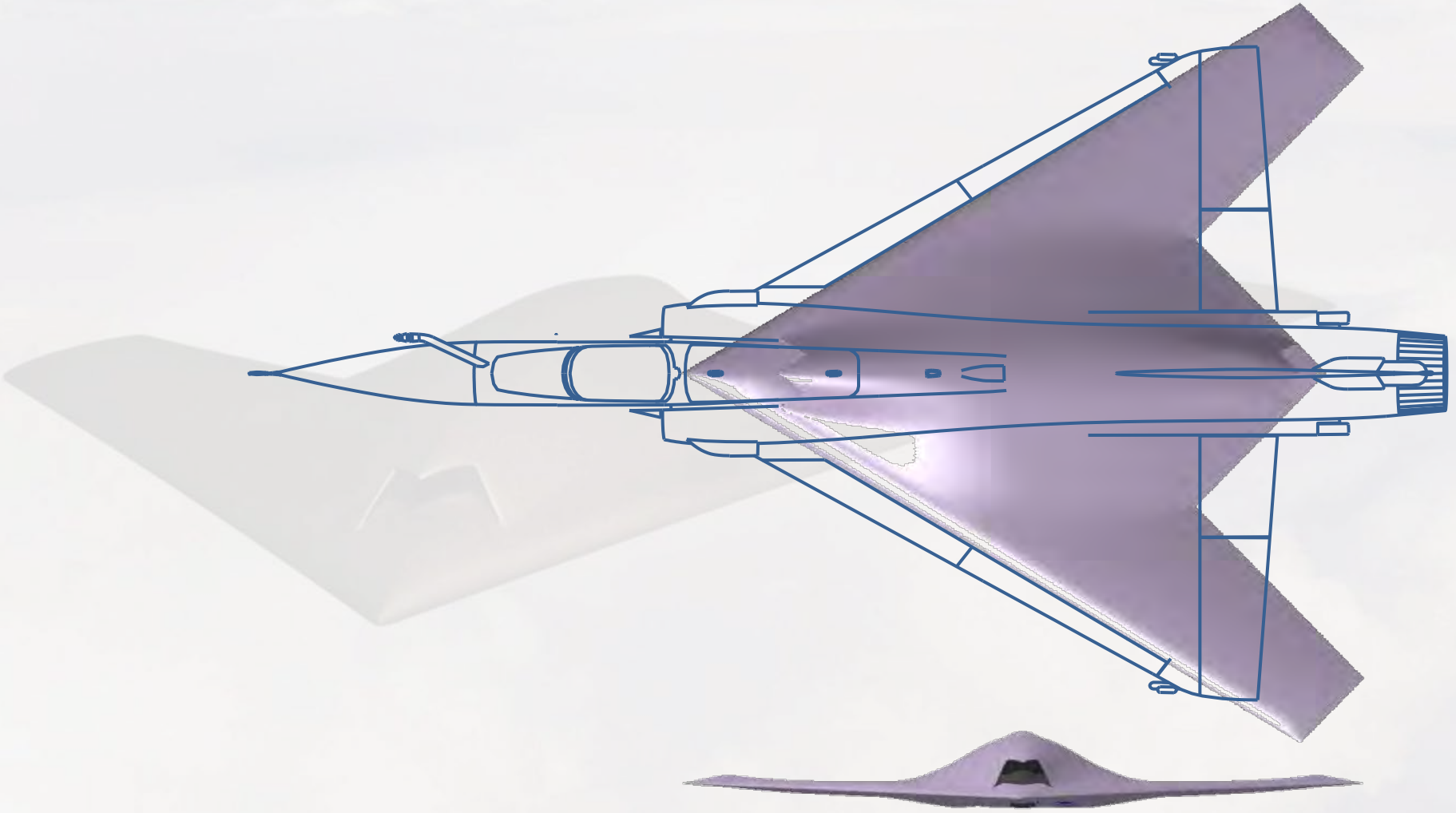
Main Ground Control Station characteristics

- **Deployable ISO 20 shelter**
- **All weather and demanding EM environment**
- **All subsystems seamlessly integrated in STANAG 4671 compliant architecture**
  - Redundant and certifiable DO 254 critical hardware
  - Critical software developed under DO178B Level C and RTOS
- **Integrated voice communication system with ATC, FLT and FTR**
- **Recording of critical data and all voice communications**

Multi-disciplinary technical challenges

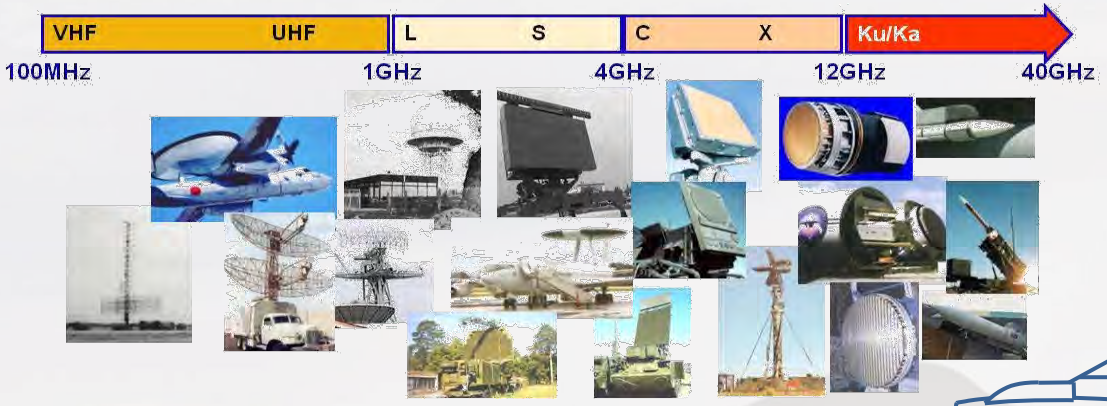
- LO & aerodynamic design (Dassault, Alenia, Saab & Ruag)
- Ground & flight tests (Dassault, HAI, Saab, Casa & Alenia)
- Control & monitoring (Dassault, Casa, Saab & Alenia)
- Internal Weapon Bay (Dassault, Alenia & Ruag)
- Exhaust system (Dassault, Saab, Volvo, HAI & RRTM)
- Propulsion integration (Dassault & RRTM)
- Sensor integration (Alenia, Selex & Dassault)
- Data-link (Casa, Dassault & Thales)
- Safety (Dassault, Saab, Alenia & Casa)
- Autonomy (Dassault, Saab & Alenia)
- FCS & LO ADS (Dassault & Alenia)
- - - -

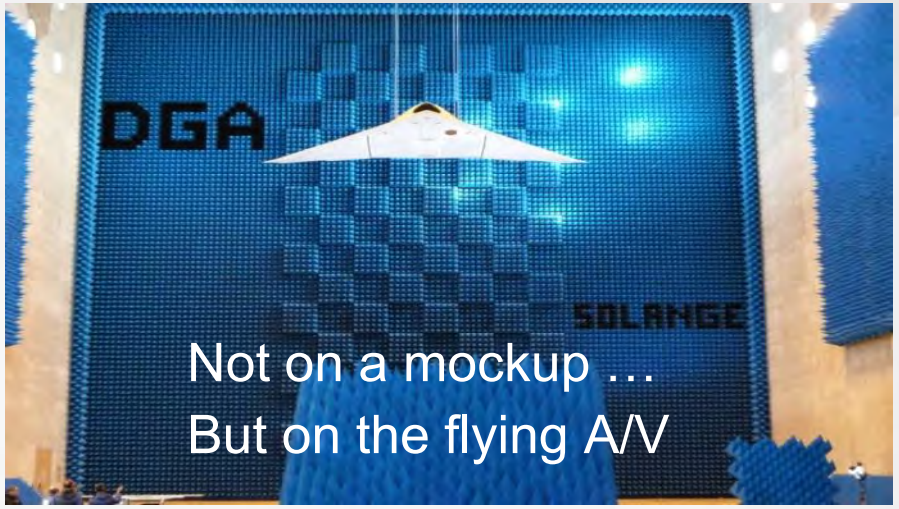
Comparison to legacy aircraft : classical view



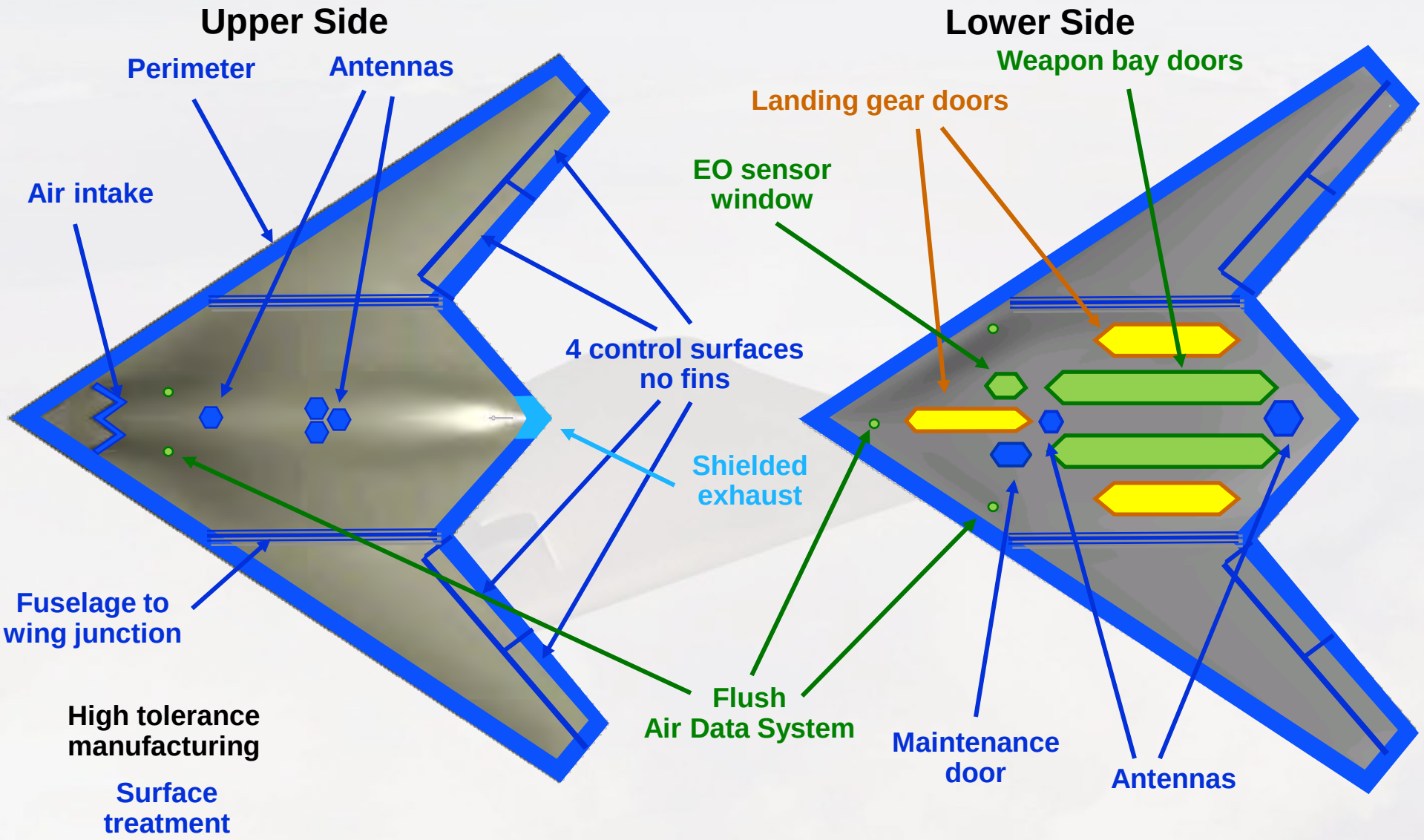
Comparison to legacy aircraft : LO view

- **As measured in Solange on a wide RF spectrum :**





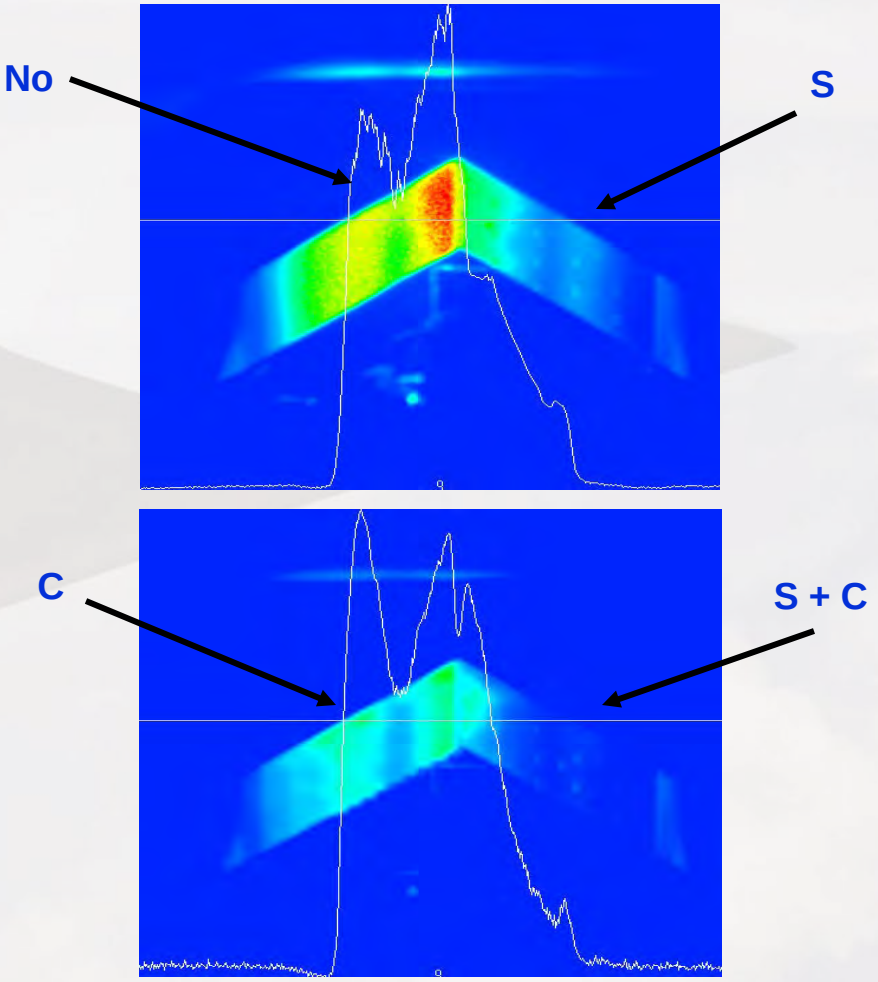
LO main treatments



LO coating … flavors

- **Built-in LO coating**
  - RCS treatment
  - IRS treatment

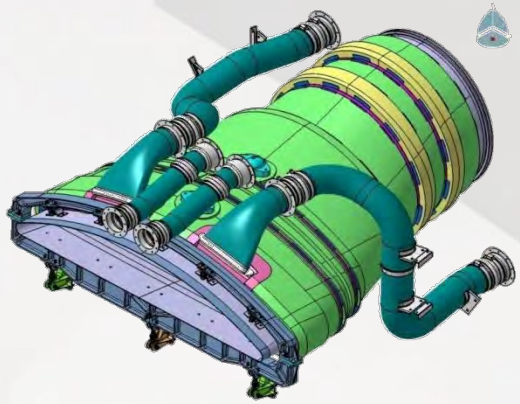
- **Shielded exhaust treatment**

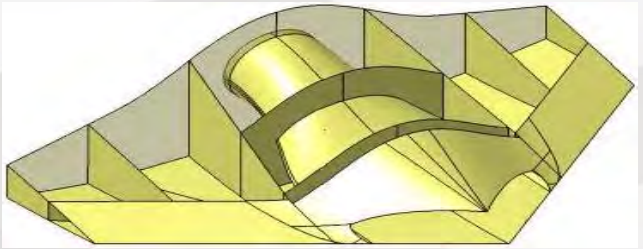


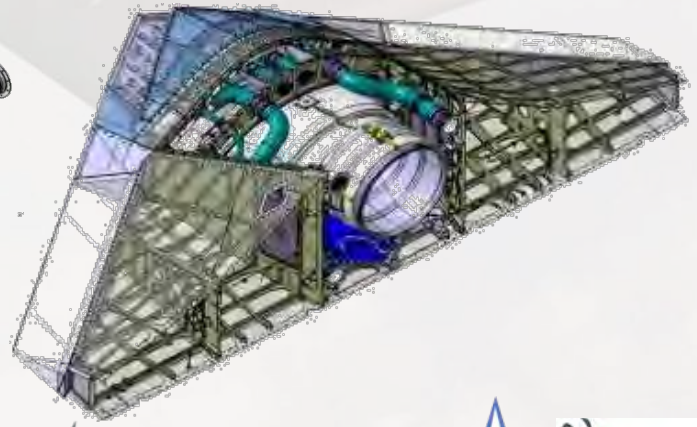
Exhaust System : design

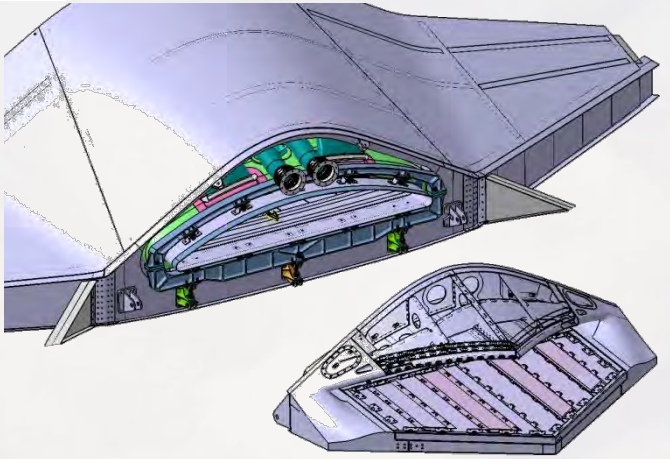
- **Architecture by Dassault**
- **Shaping by Saab & Volvo**
- **Structural design by HAI**

- **Multi-partners / multi-steps / multi-disciplinary optimization from preliminary ideas to detailed design**









Exhaust System : manufacturing

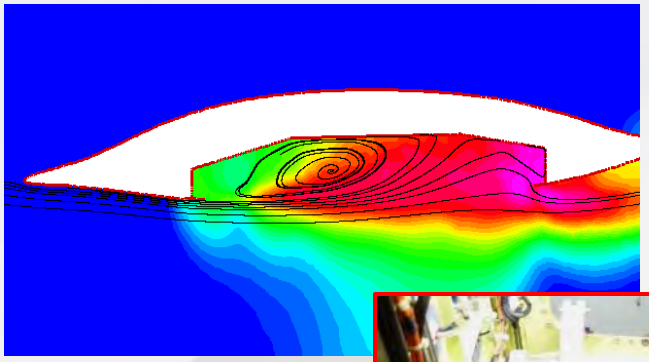
- **Manufacturing by HAI**
- **Application of innovative, advanced and challenging manufacturing processes such as:**
  - Rigorous Test Campaign
    - Material properties & Process characterization
    - Proof of manufacturing concept
    - Mechanical Calibration & Functional Testing
  - 5-axis machining and welding of parts possessing asymmetric shape and made of hard to process super-alloy and Ti alloy materials.
  - Development of specific heat treatment process
  - Hard plasma coating on high temp areas
  - Rapid prototyping of large Titanium Castings
  - **S**elective **L**aser **M**elting / **D**irect **L**aser **M**elting **S**intering, for flying prototype parts in Ti & Super-alloys
  - Sophisticated instrumentation installation & calibration
  - Achievement of tight control of manufacturing & assembly tolerances

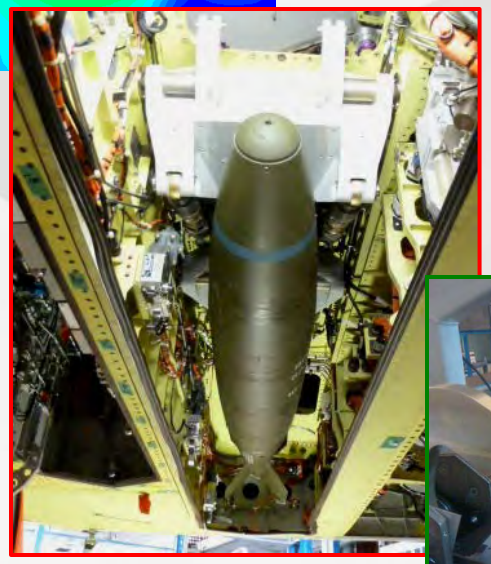
Exhaust design : ground test

- LO prediction by Dassault
  - Tests prepared by Dassault, RRTM & HAI
    - Tests performed by Dassault & RRTM

Weapon integration

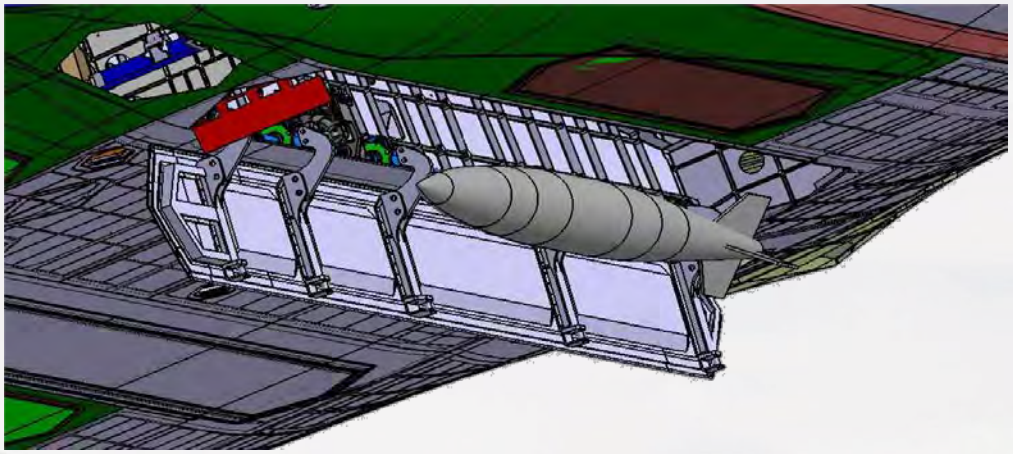
- WB architecture by Dassault
  - Weapon installation by Ruag
  - Weapon bay door and actuation by Alenia
  - Weapon firing tests by Dassault

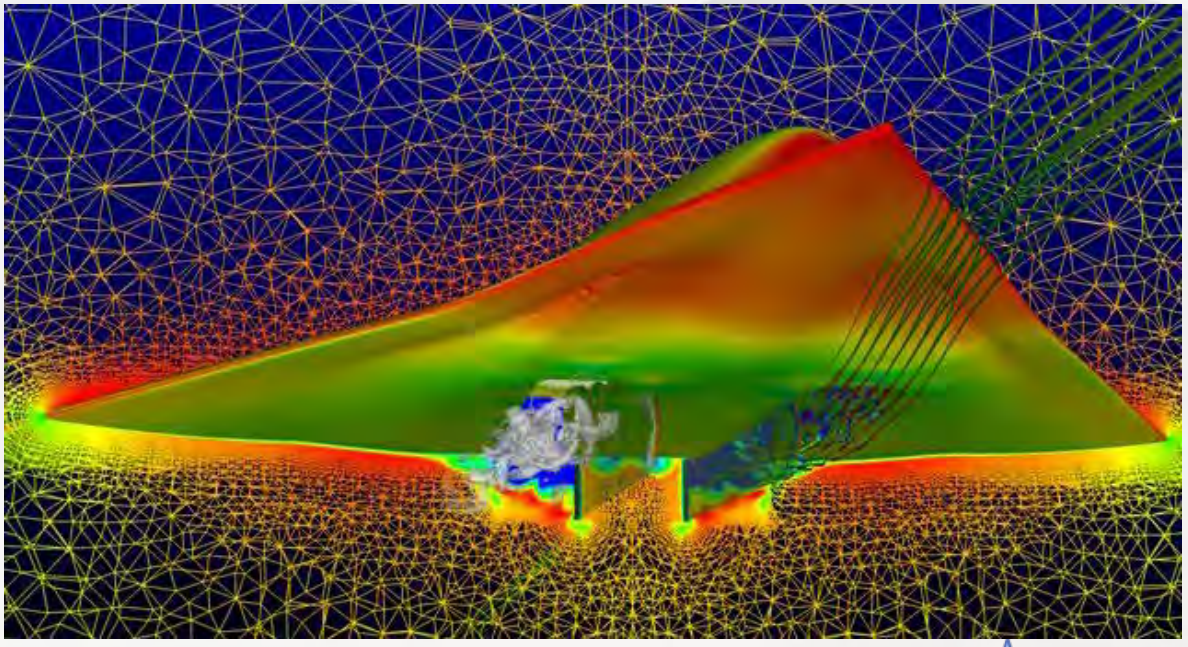


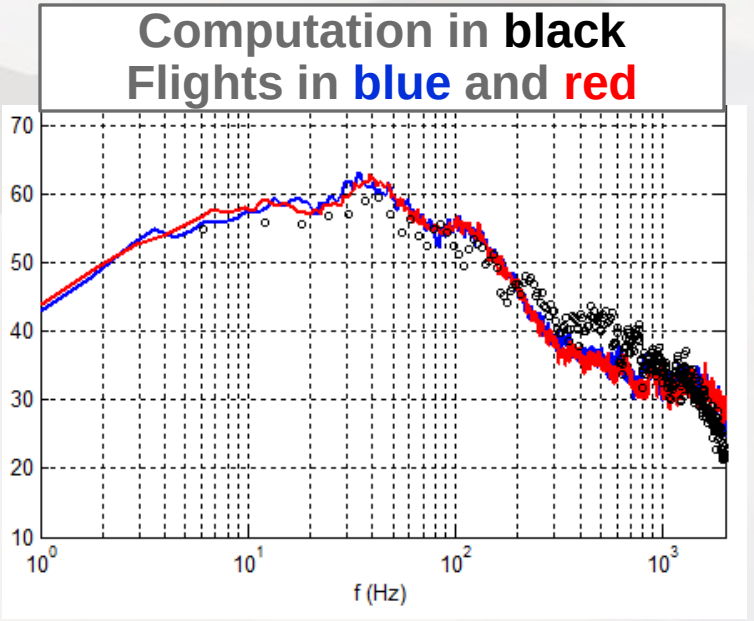


Weapon Bay aeroacoustics field

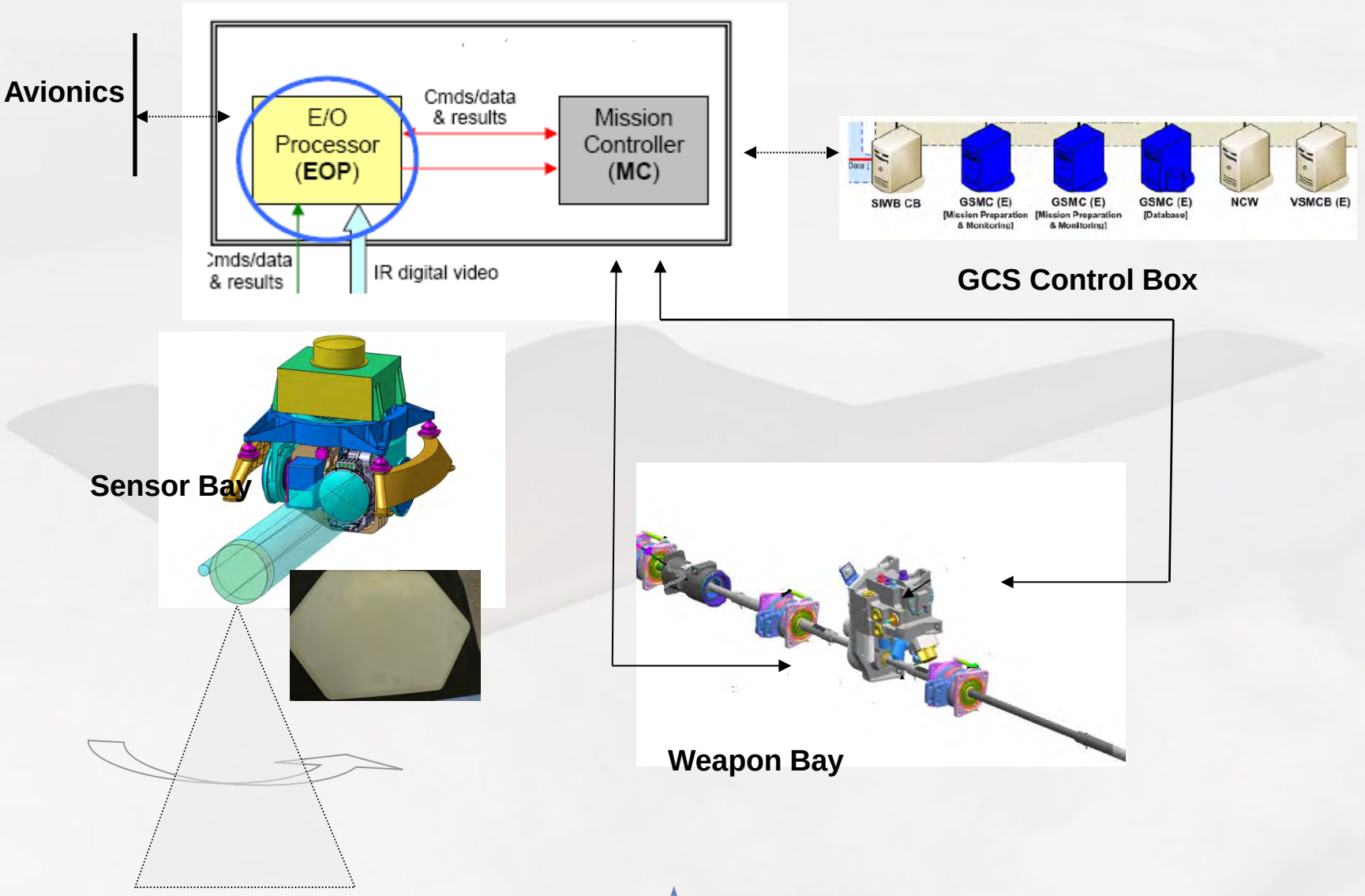
- **Design process by Dassault**
  - Initial shaping
  - Aeroacoustics loads prediction
  - Wing Tunnel Tests
  - Shaping update
  - Flight Tests





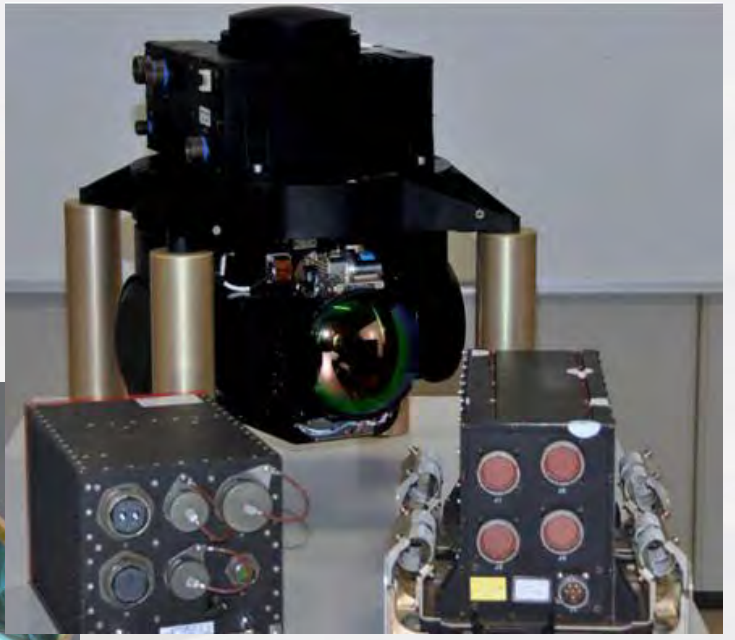


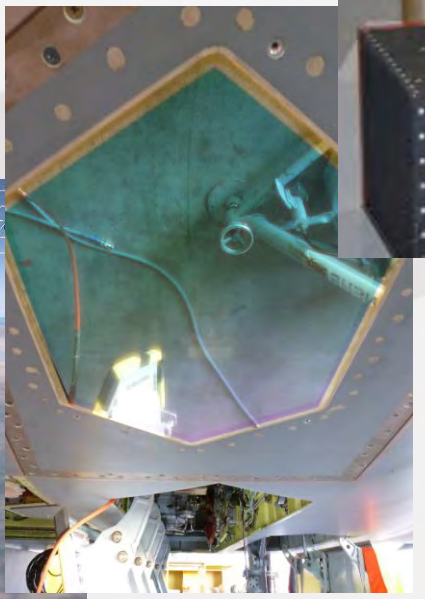
Combat capability : system integration



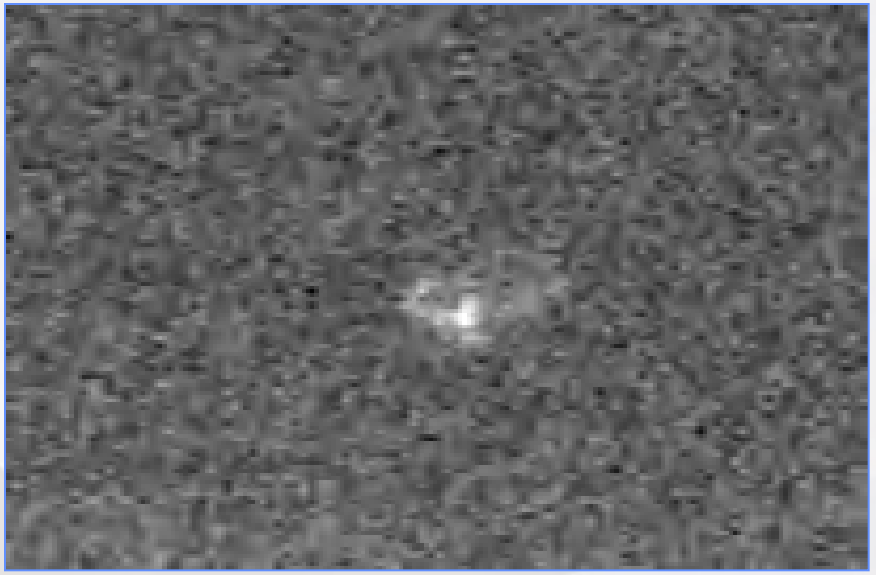
IR sensor & optical window

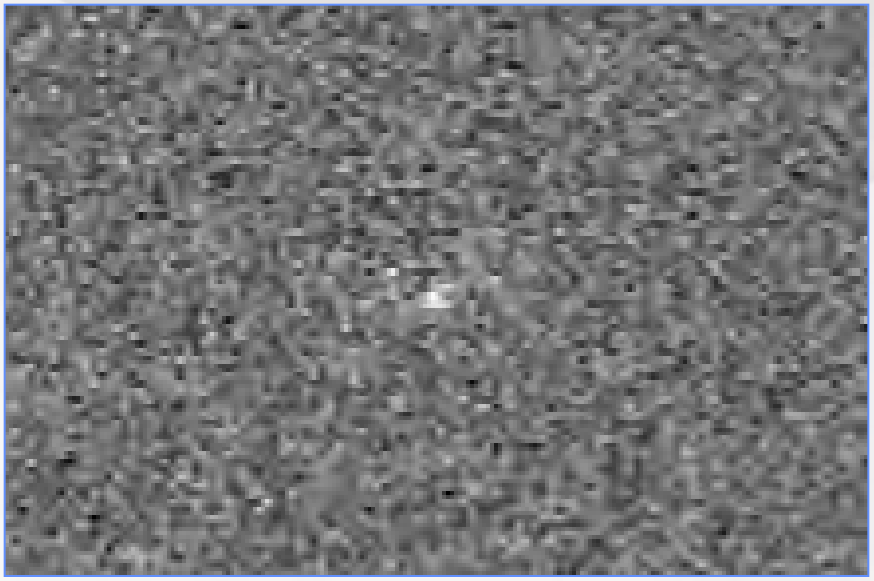
- **Flush installation for LO purpose**
  - LO integration
  - Field of View optimization
  - Integrated image processing and recording





Detection & recognition performance assessment





Estimation of detection and recognition probability by means of large sets of synthetic images produced considering all relevant information

scenario as well as technology related

Monitoring & control principles

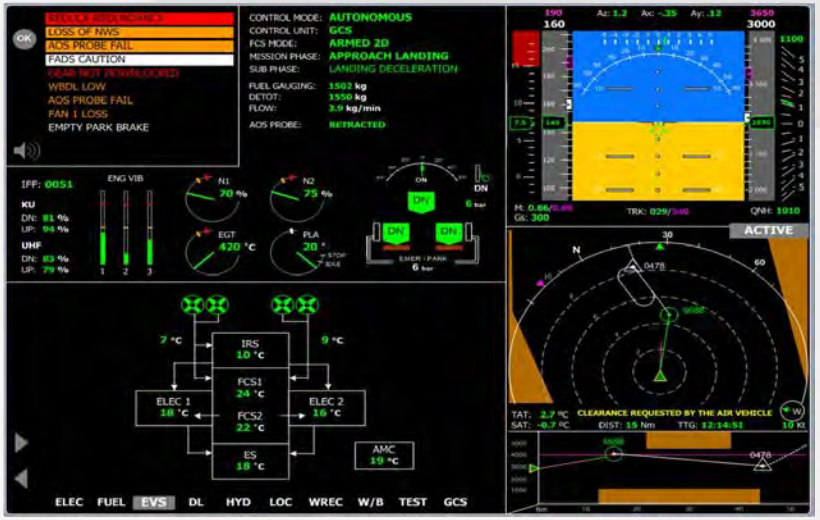
- **Ground Control Station**
  - With 2 operators connected to Air Traffic Controllers
  - Supervised autonomy

- **Fully automatic flight management**
  - Engine control, automatic taxiing, take-off and landing
  - Automatic 4D flight plan following
  - Always under operators control for engine starting, taxiing, take-off, approach, target validation, firing authorization, …
  - And with potential operators intervention for real-time flight plan modification, ATC orders, recovery procedures, …

- **On-board autonomy**
  - In-flight auto re-planning in case of new target / threat provided by C4I through the GCS

Vehicle control / Operator in the loop

- **On board**
  - Automatic Flight Management
    - Taxi, ATOL
    - 4D Flight Plan
  - Autonomy
    - Loss of data links
    - Authorized area check
    - Holding patterns
    - Recovery procedures

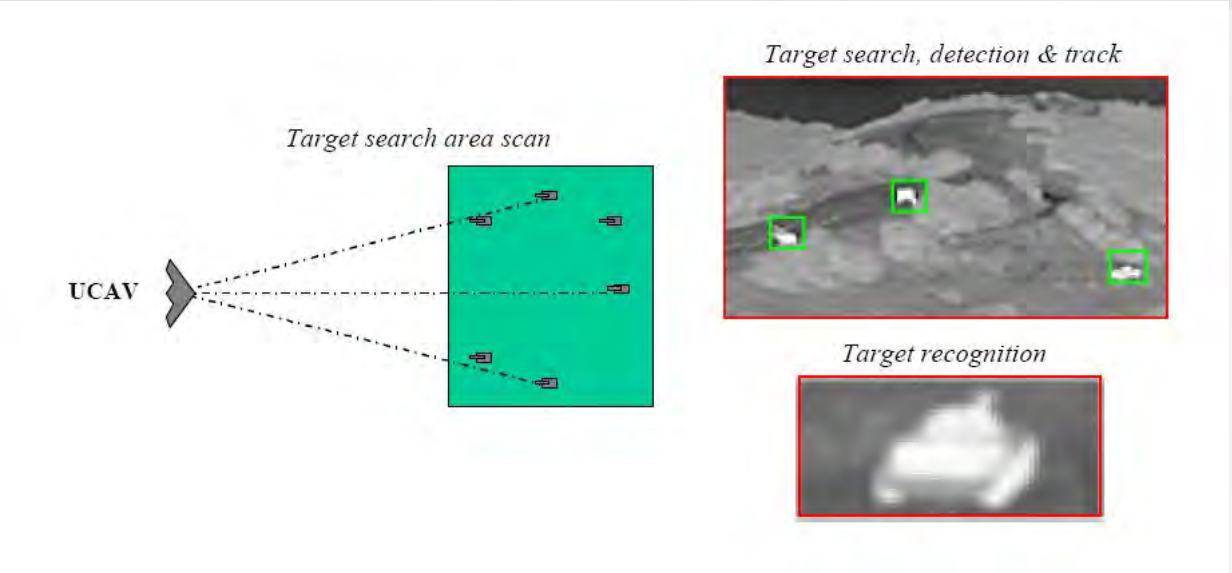


- **Operators**
  - ATC
  - Clearances
    - Engine start
    - Taxiing
    - Take off /Landing
  - Supervision & monitoring
  - Flight management
    - Flight plan
    - High level modes (speed ,track ,slope)
  - Recovery procedures

No stick / no throttle

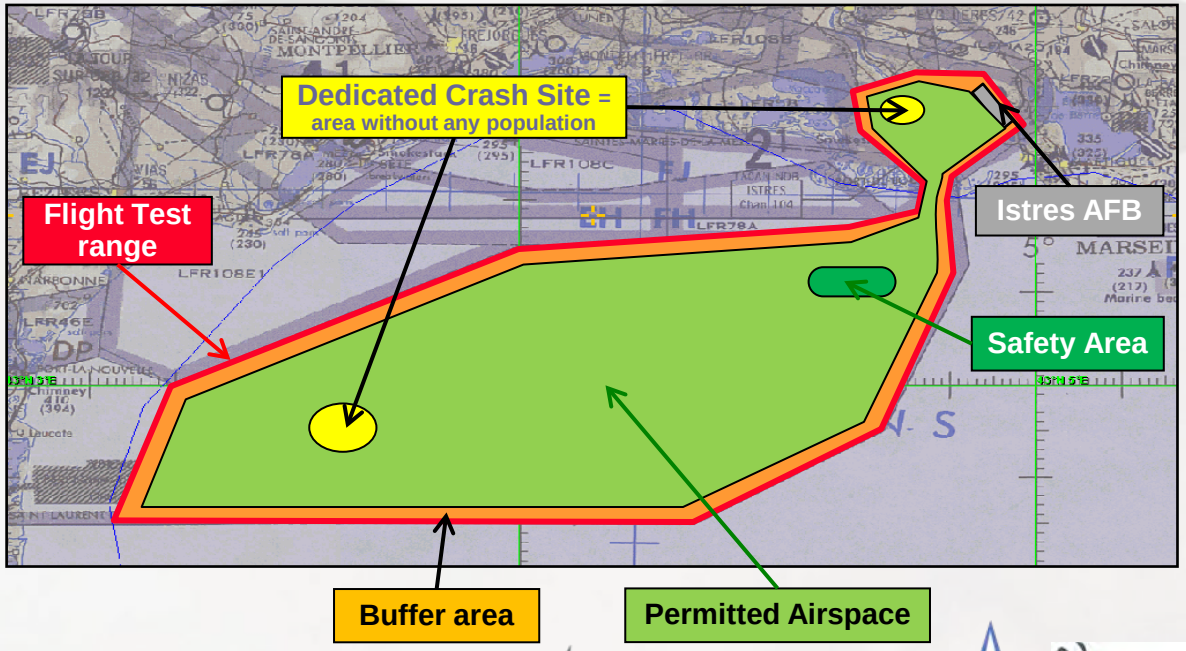
Mission control / Operator in the loop

- **IR reconnaissance system capable of high resolution on operator-selected PoIs or automatically captured high-contrast tracks**
  - Ground images transmitted through real-time data-link to GCS operator
- **Autonomous recognition and attack system**
  - Recognized target image transmitted through real-time data-link to GCS operator
  - Target confirmation and firing authorization by GCS operator



Airworthiness

- **Demanding Airworthiness Basis close to JAR / FAR 23**
  - Key issues = safety analysis & software development assurance level
- **Same process than Military Certification**
- **Very low probability of exiting from Test Area**
  - Under operator interfaces by Casa
    - Autonomous Permitted Airspace Manager by Saab



- ATOL routes & contingency routes by Dassault

Safety of flight

- **First flights in Istres AFB located in a populated area**
  - Low probability of system failure causing an uncontrolled crash
  - Manual & automatic recovery procedures

- **Manned & unmanned flight**

Safety linked to bird strike

- **Specific case of LO Perimeter**
  - Dedicated Wing Tunnel Tests after bird strike

  - Flight control demonstrated for all bird strike location

Main tests location

Sweden :
Vidsel Test Range

France :
Rennes Solange
Istres Test Centre

Italy :
Decimomannu Air Base
Perdasdefogu Test Range

First flight

Flight domain : Weapon Bay closed

- **Two levels of requirements from Customer**
  - [Mandatory] level
  - [Objective] level
- **Level demonstrated in flight > 400 kt ~ [Objective]**
  - Mach > 0,7
  - Nz > 3

Flight domain : Weapon Bay opened

- **Two levels of requirements from Customer**
  - [Mandatory] level
  - [Objective] level
- **Level demonstrated in flight >> [Mandatory]**
- **Aeroacoustics loads by Dassault**

- **WB doors & commands by Alenia**

- **Internal webs by Saab**

IR reconnaissance mission flights

- **Development flight in progress**

Coming flight tests campaigns

	France (Istres)	Sweden (Vidsel)	Italy (Perdasdefogu)
First flight	Done		
Flight domain : weapon bay closed	Achieved		
Flight domain : weapon bay open	Achieved		
Mission sensors tests	In progress		Δ
LO flight tests	Launched	Δ	Δ
Weapon release		Δ	
Mission experimentation			Δ

Human experience

- **Sensible project and person management : person, not people or "resources"**
- **Sensitive to :**
  - Partner company skills and weaknesses
  - Flexibility and changing requirements
  - Fuzziness of a dynamic, evolving system
  - Able to exploit individual skills
- **Inviting, collaborative, transparent.... to the point of accepting some apparent inefficiency in order to foster excellent relationships**
- **Group / team working mentality**
- **Respect & not sub estimating**
- **Sharing personal experiences**

nEUROnist = member of the nEUROn family

Human adventure

- A greater outcome then the sum of its parts

nEUROnists at work

Summary

- Addressing technical challenges
  - Implementing innovative cooperation
    - Implementing cooperative innovation
      - Getting valuable results


A project for the European defense industry

- **Development of strategic know-how**
  - Maintaining and reinforcing an advanced level of European know-how & key technologies
  - Mastering technologies – mainly stealth – for future European Combat Air System (manned or unmanned)
- **Cooperation scheme for future projects**
  - Experience & excellence
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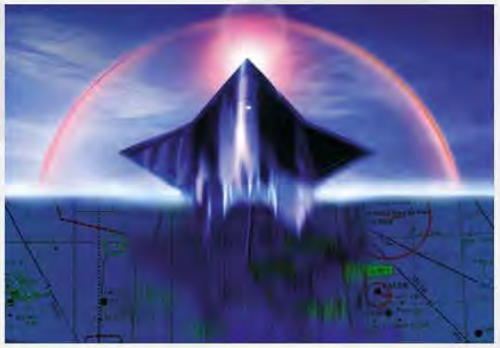
  - Searching for technical innovation
  - While respecting cost & schedule






Thank you for your atttention !