



## nEUROn : an international cooperation to enhance innovation

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Dimitri FELDMANN Ruag / Anders FORSBERG Saab



# A project for the European defense industry

- **Development of strategic know-how**

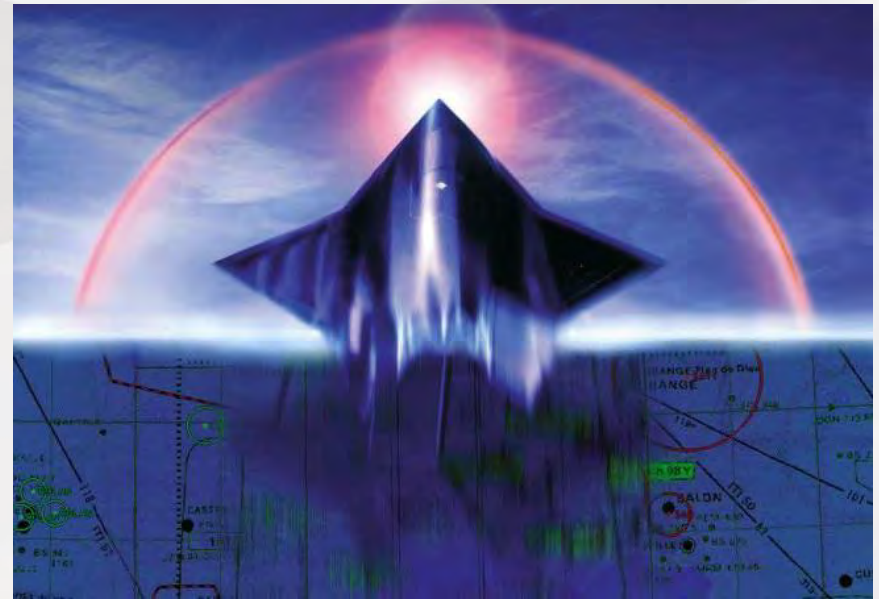
- Maintaining and reinforcing an advanced level of European know-how & key technologies
- Mastering technologies – mainly stealth – for future European Combat Air System (manned or unmanned)

- **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



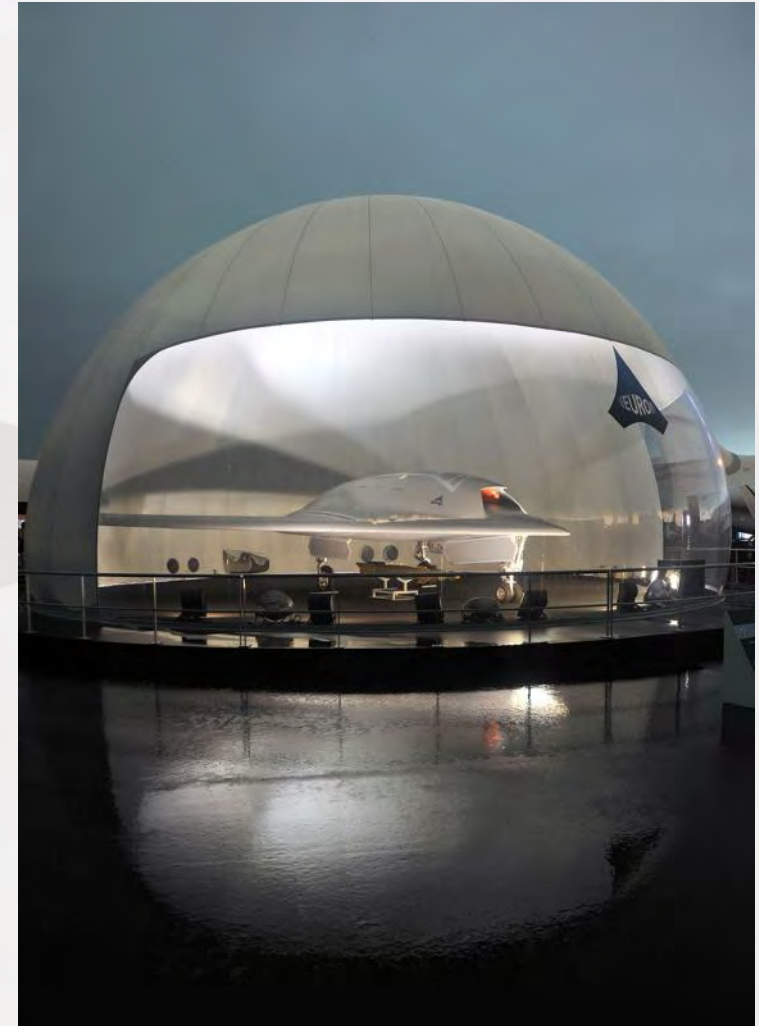
Automatic detection and recognition of re-locatable ground targets  
with airborne optical sensor without being detected





# 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  $\approx$  400 M€





# Clear lines of responsibility between governments & industries

Spain Sweden France Italy Greece Switzerland

Bilateral Inter-Governmental MoU's



Executive agency

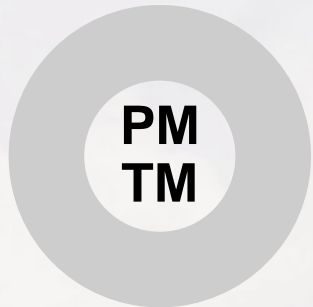


Main Contract

Prime Contractor

Dassault Aviation

Sub Contracts

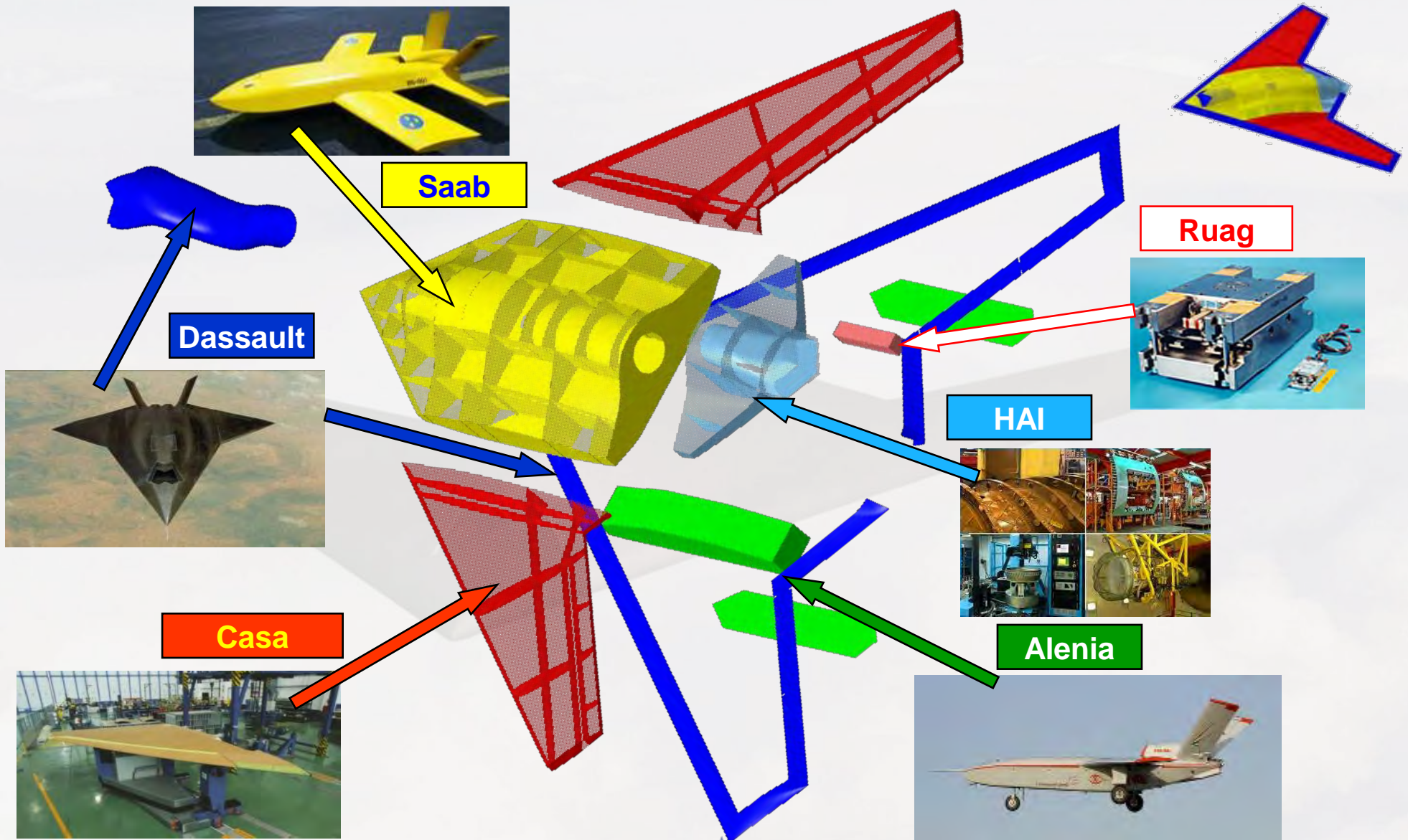


Casa (\*) Saab (\*) Thales Alenia (\*) HAI (\*) Ruag (\*)

(\*) : MNSC = Main National Sub-Contractors



# Airframe workshare based on demonstrated skills



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# Systems & software workshare based on demonstrated skills

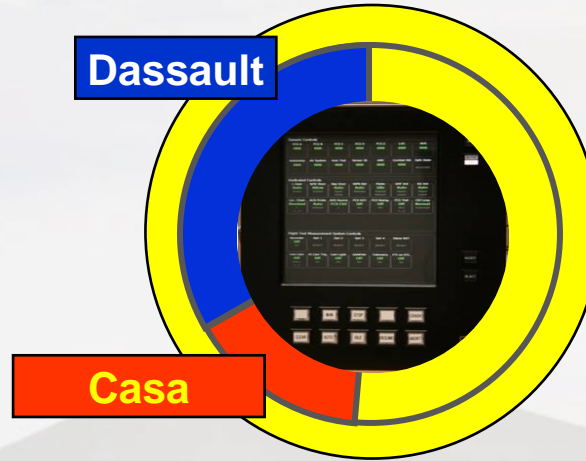
## Flight Control System

Dassault



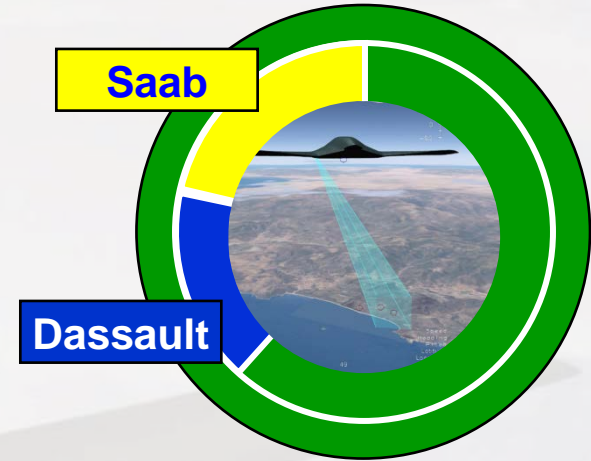
## Avionics & VMS

Saab



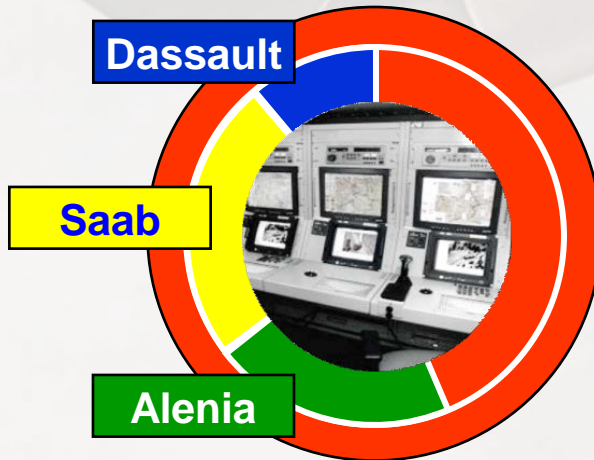
## Mission Capability

Alenia



## Ground Control Station

Casa



## Communication system

Casa





# Large number of partners including government, industry & research centers

**France**

DGA  
ONERA  
THE FRENCH AEROSPACE LAB  
Labinal  
SAFRAN Group  
DASSAULT AVIATION  
THALES  
SAFRAN Turbomeca  
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**

EAB

**Switzerland**

RUAG

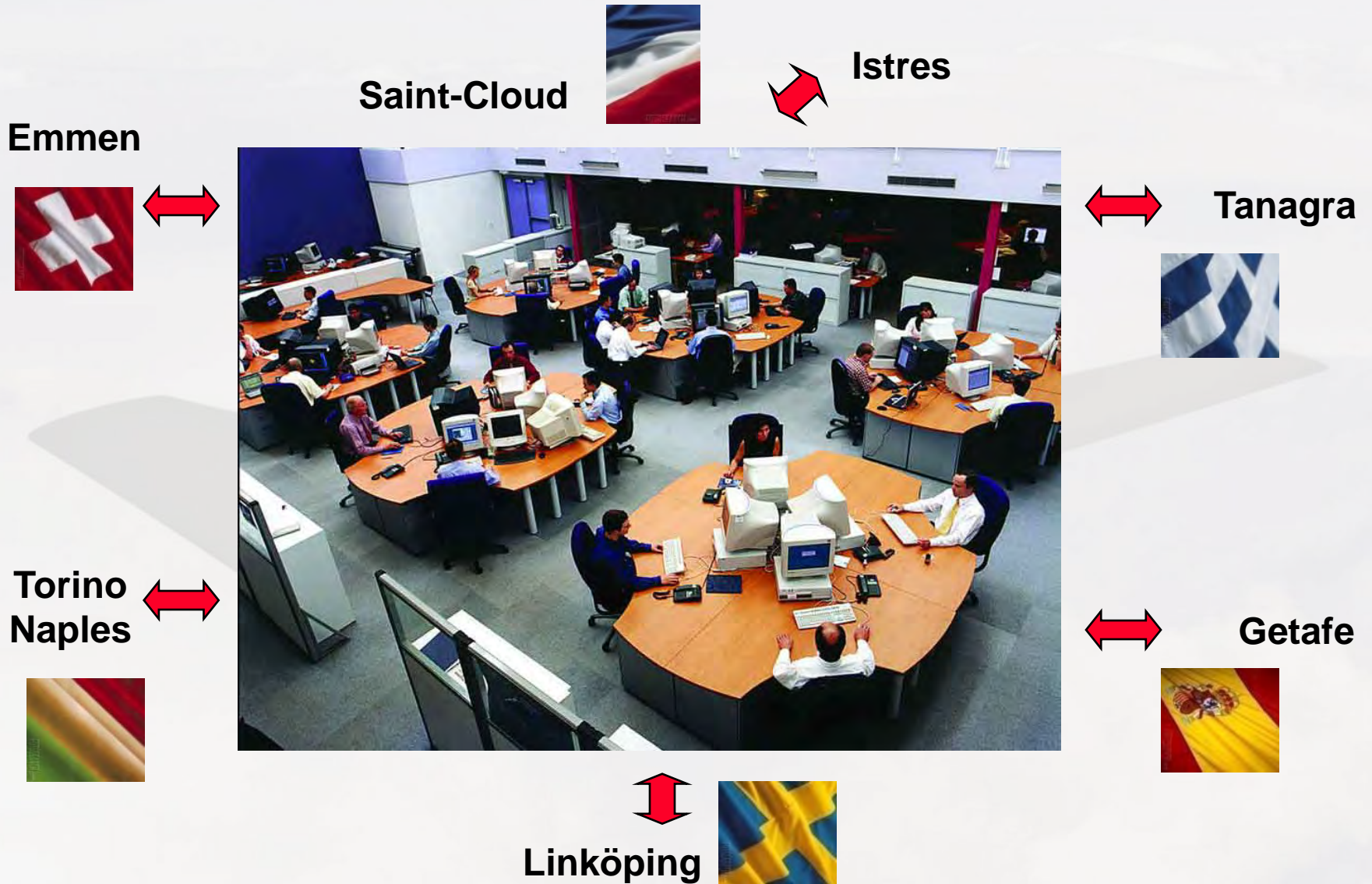
**Others ...**

Rolls-Royce  
AEROSONIC



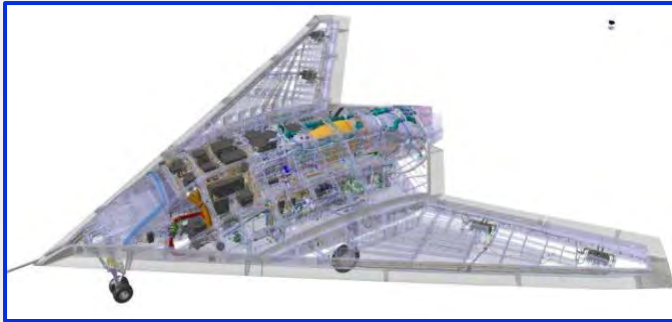


# Physical & virtual colocated workspace



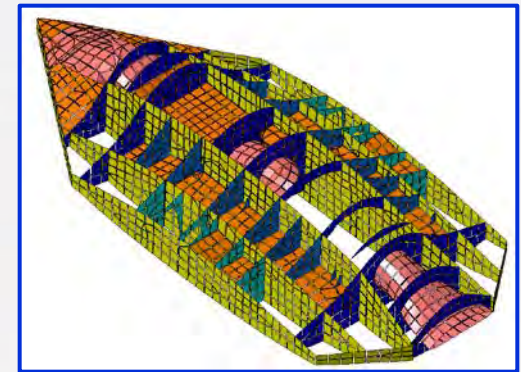


# Common IT system suit



Airframe & layout Design  
with CATIA v5

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



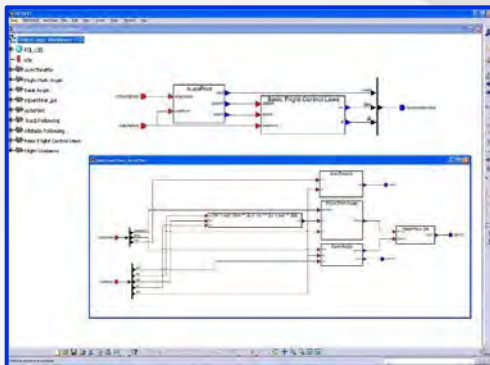
Structural Analysis  
with ELFINI  
and NASTRAN



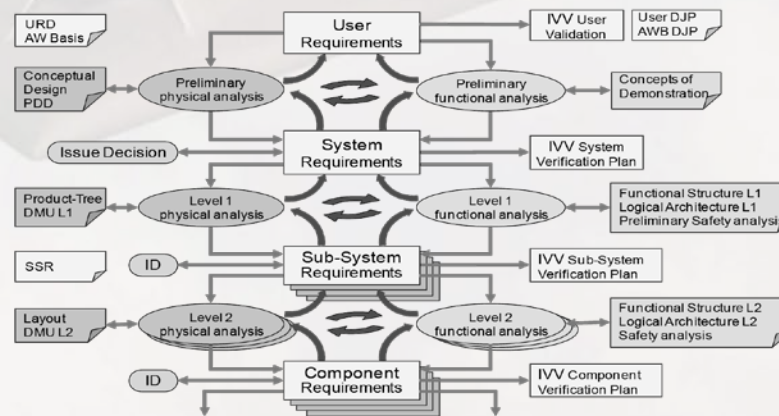
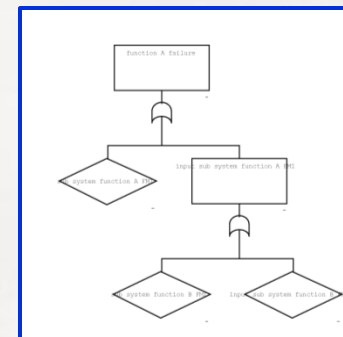
System Requirements  
with PLM V6 experimental release  
Program Documentation  
with Documentum\*

Change Management & Technical Events  
with Sharepoint/NCM\*

System Architecture  
with PLM V6 experimental release



Functional Hazard  
Analysis (FHA)  
with CECILIA

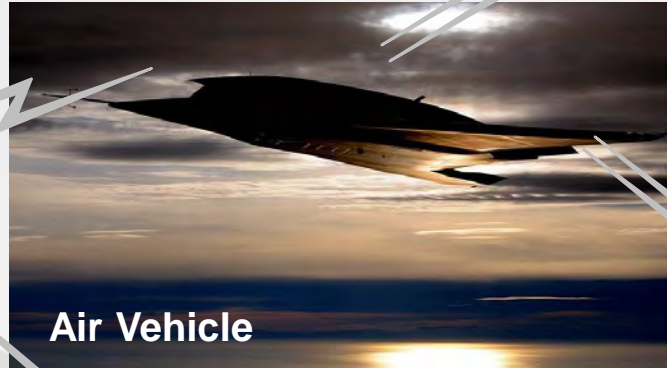




# System components



**ATC**



**Air Vehicle**



**Ground Control Station**



**Communications**



**Flight Tests Room**



# Main Air Vehicle characteristics

- **Main characteristics:**

- Fuselage length  $\approx 9,3$  m
- Wing span  $\approx 12.5$  m
- MTOW  $\approx 7000$  kg

- **Engine:**

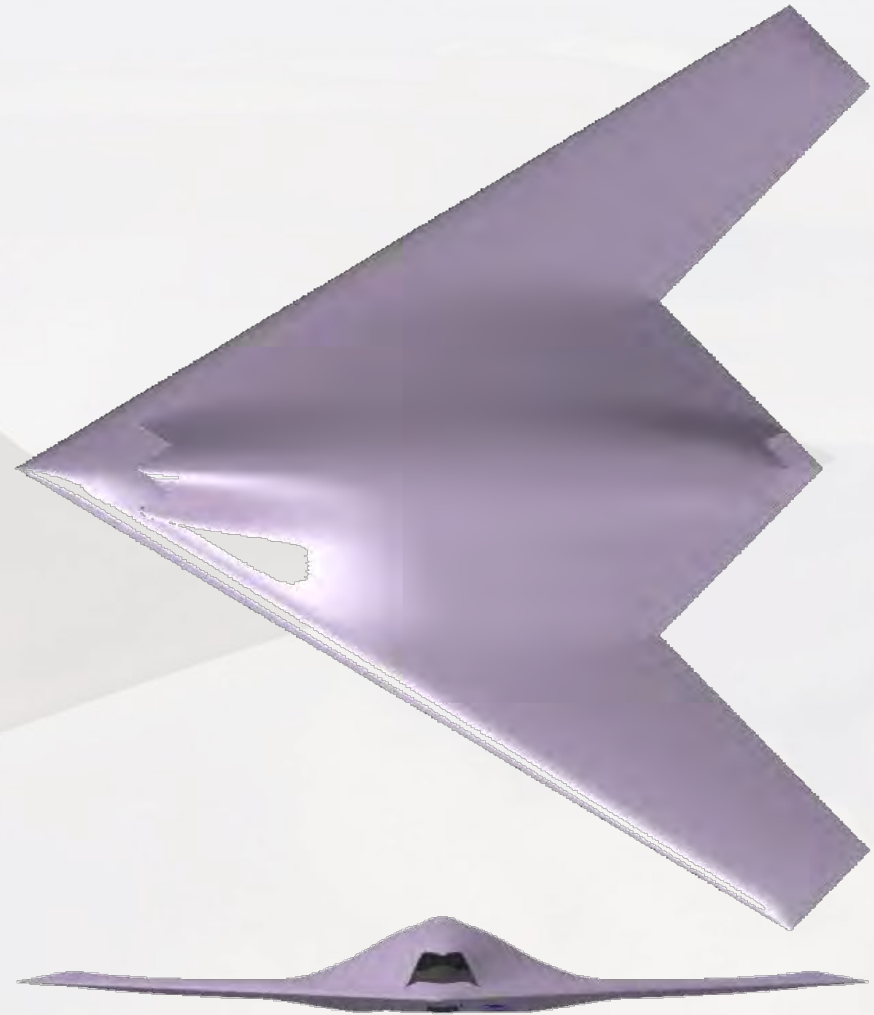
- RRTM Adour Mk951 hybrid

- **Main performance:**

- Total mission duration  $\approx 3$  hrs
- Max Mach  $\approx 0.80+$

- **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



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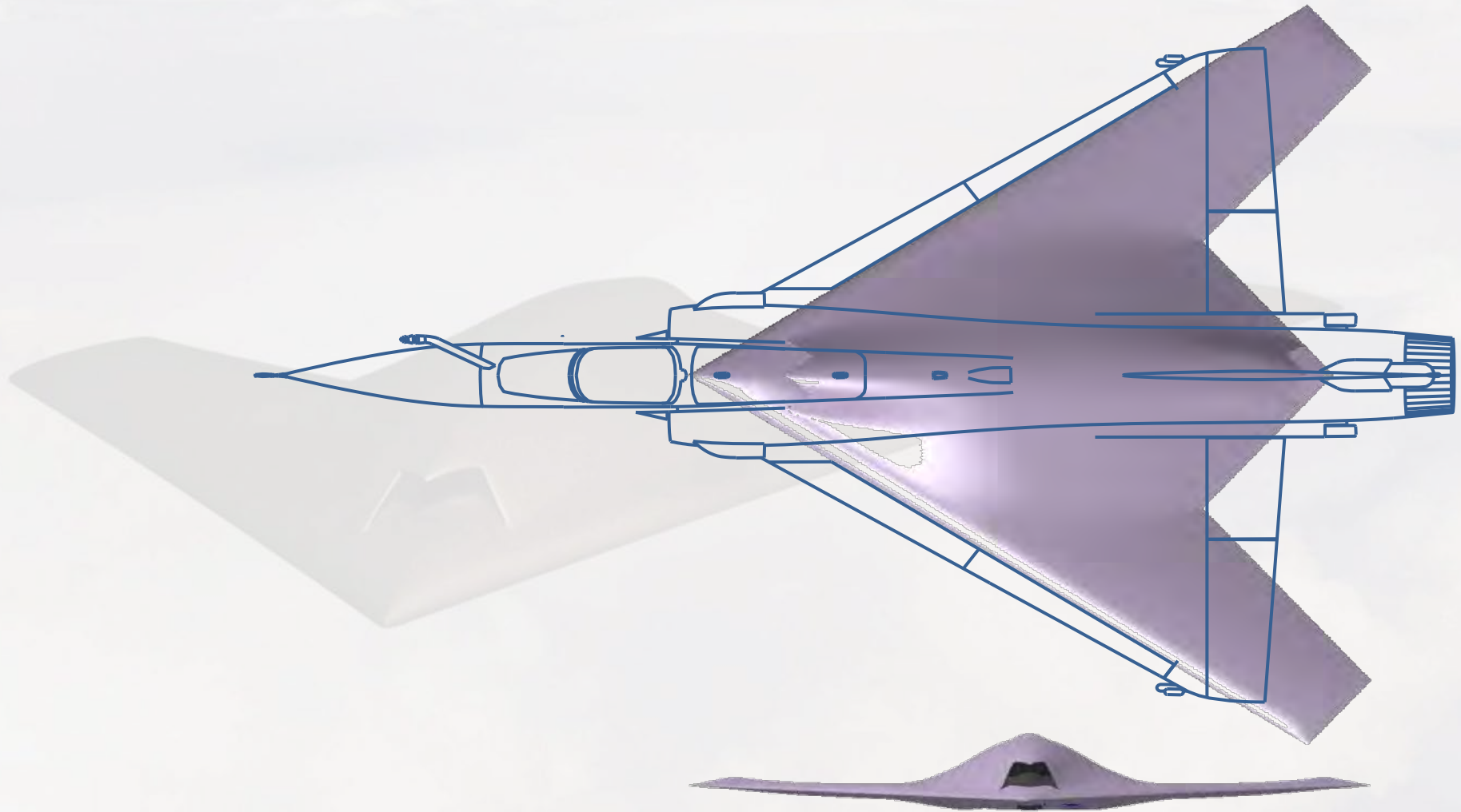


# Multi-disciplinary technical challenges

- 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



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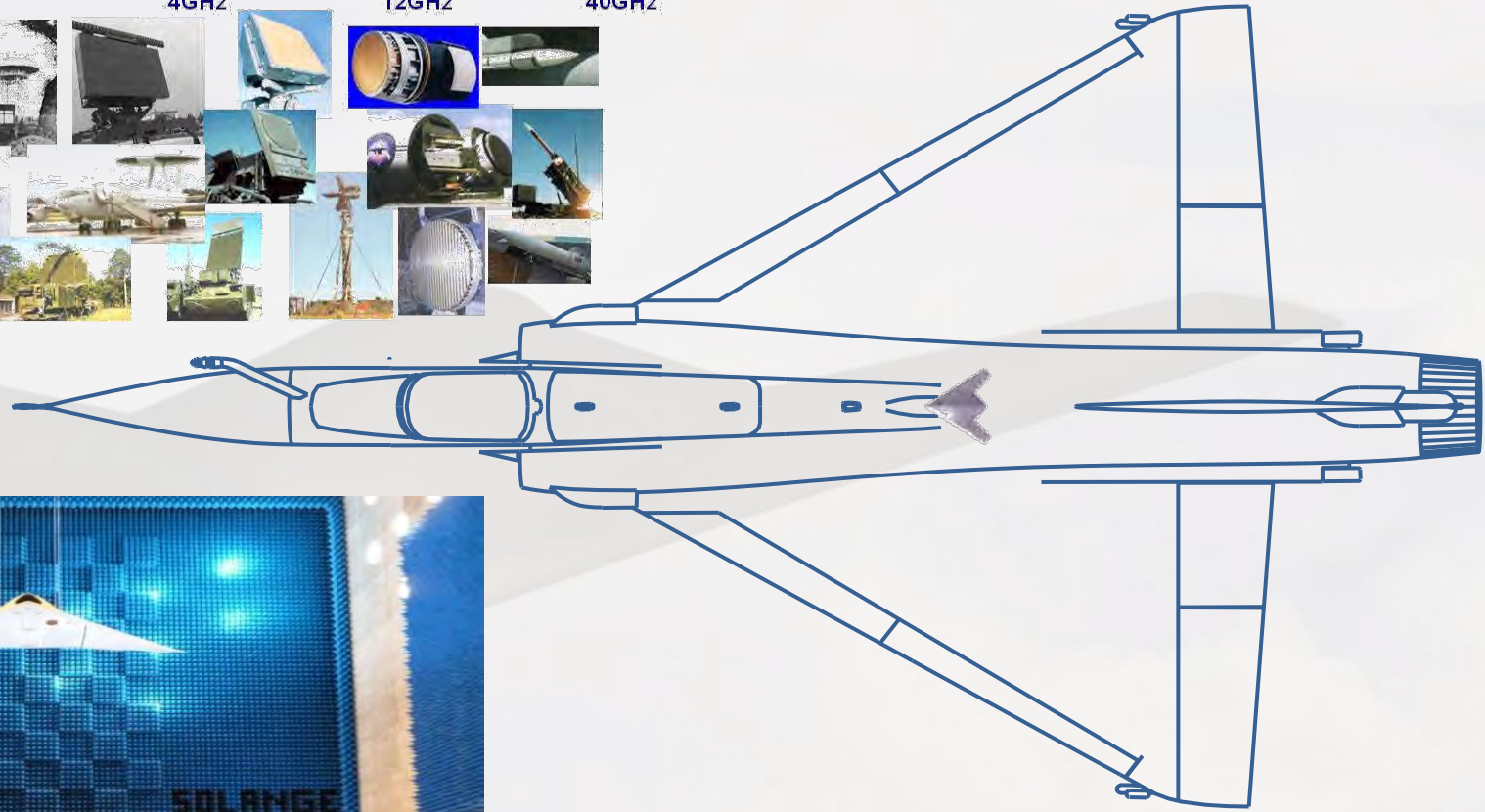
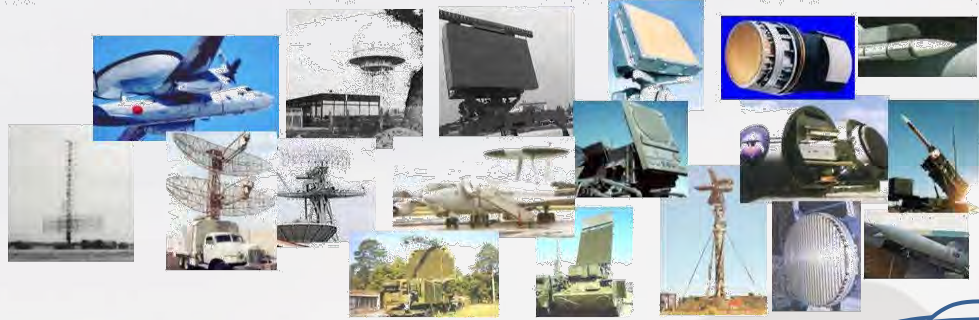
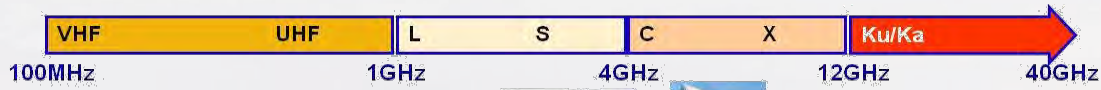
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# Comparison to legacy aircraft : LO view

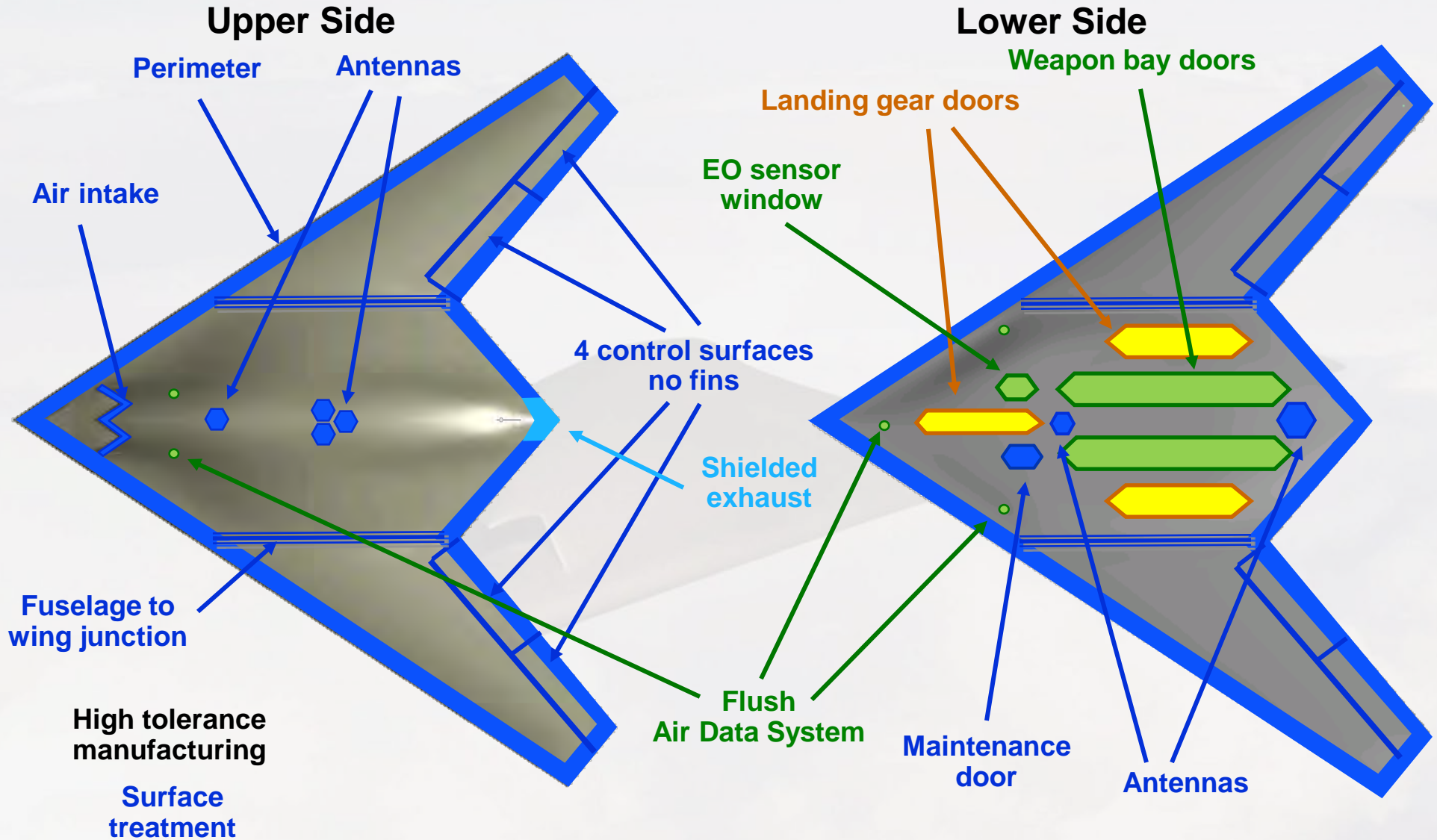
- As measured in Solange on a wide RF spectrum :







# LO main treatments





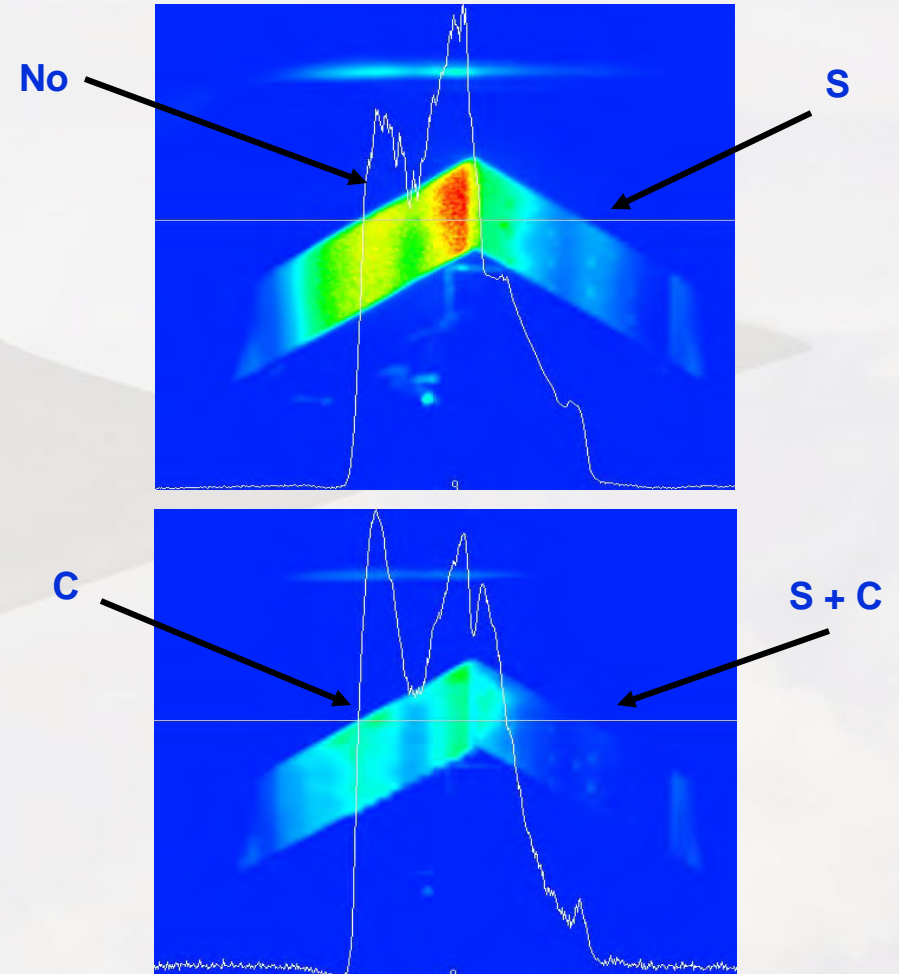
# LO coating ... flavors

- **Built-in LO coating**

- RCS treatment
- IRS treatment



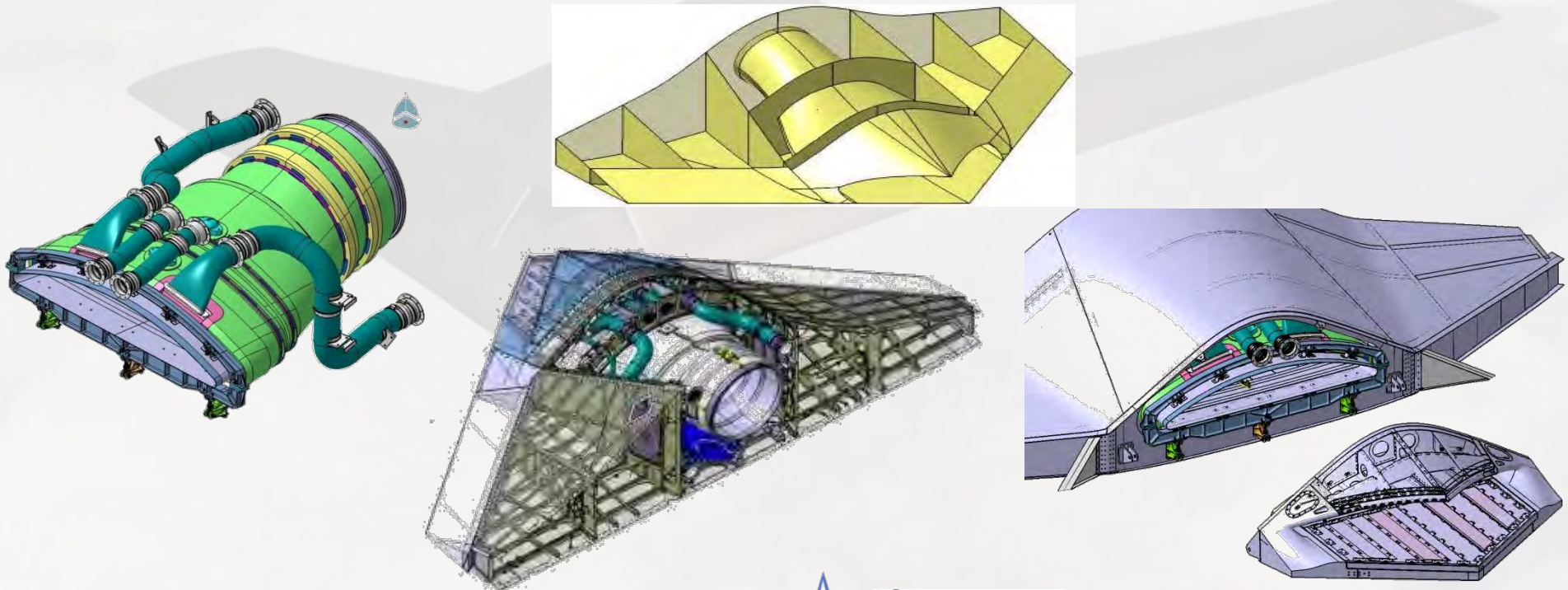
- **Shielded exhaust treatment**





# 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**



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# 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
  - **Selective Laser Melting / Direct Laser Melting Sintering**, for flying prototype parts in Ti & Super-alloys
  - Sophisticated instrumentation installation & calibration
  - Achievement of tight control of manufacturing & assembly tolerances





# Exhaust design : ground test

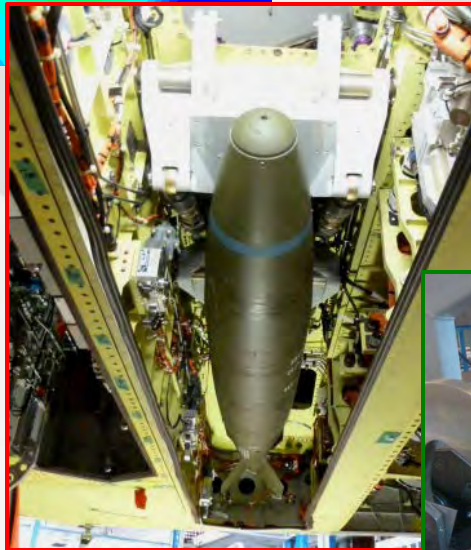
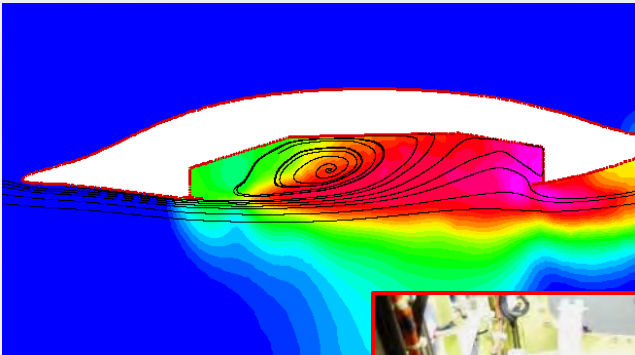
- LO prediction by Dassault
  - Tests prepared by Dassault, RRTM & HAI
  - Tests performed by Dassault & RRTM





# Weapon integration

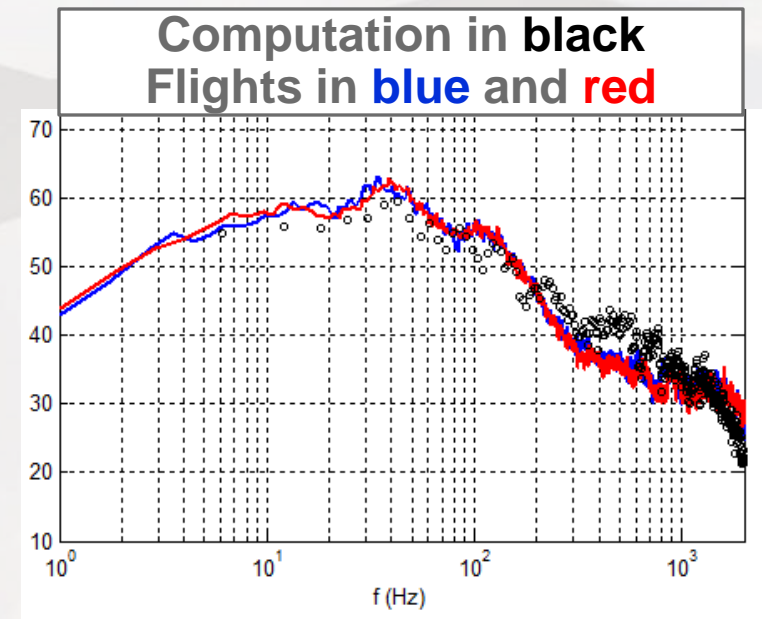
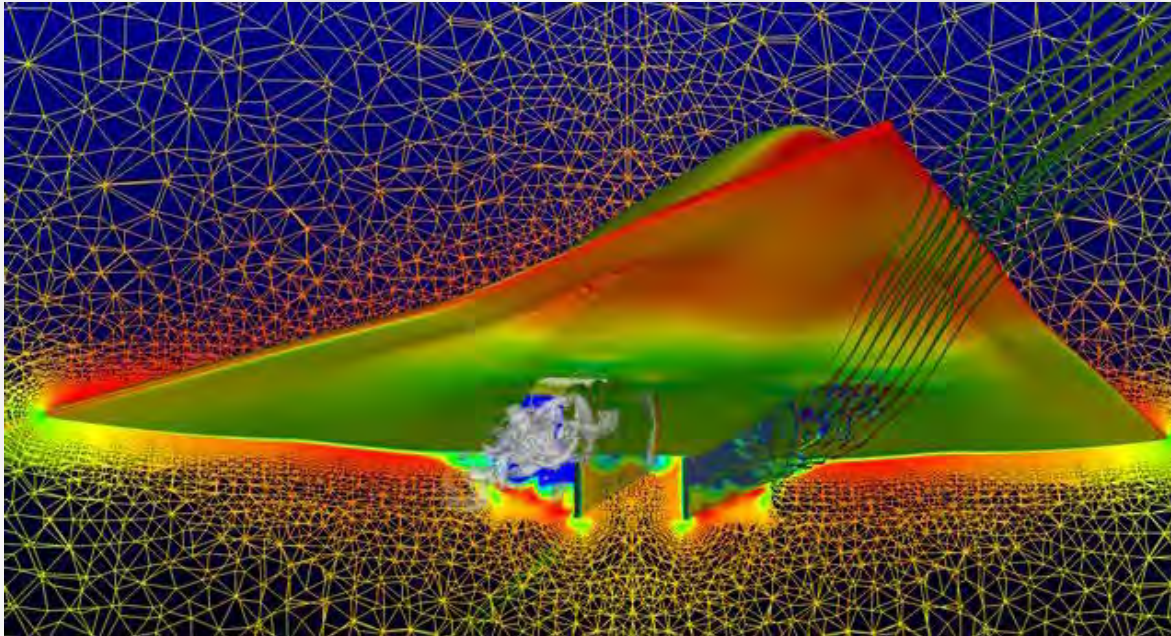
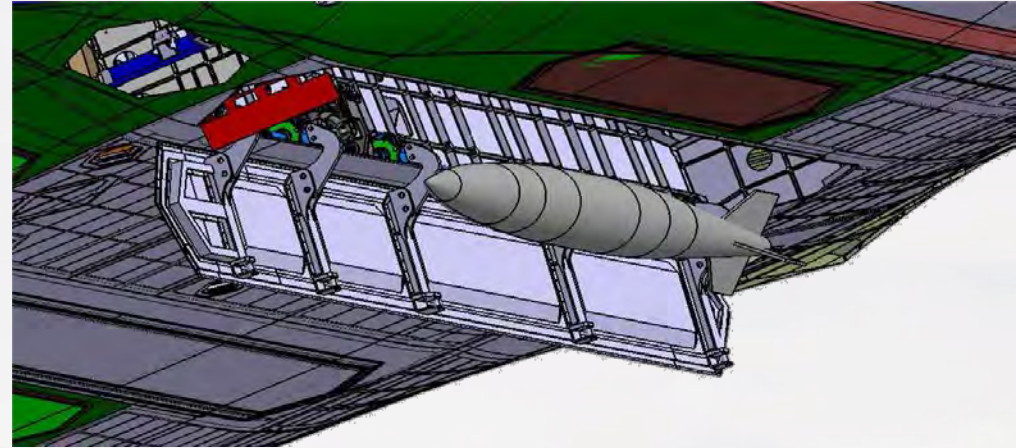
- **WB architecture by Dassault**
  - **Weapon installation by Ruag**
  - **Weapon bay door and actuation by Alenia**
  - **Weapon firing tests by Dassault**





# Weapon Bay aeroacoustics field

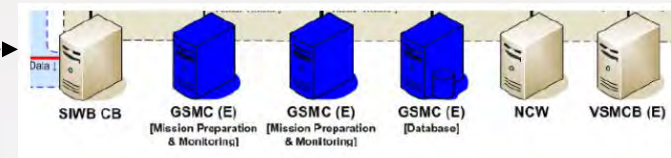
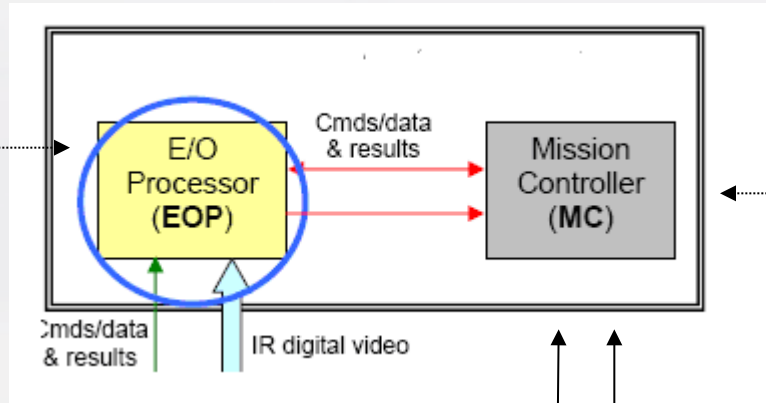
- **Design process by Dassault**
  - Initial shaping
  - Aeroacoustics loads prediction
  - Wing Tunnel Tests
  - Shaping update
  - Flight Tests





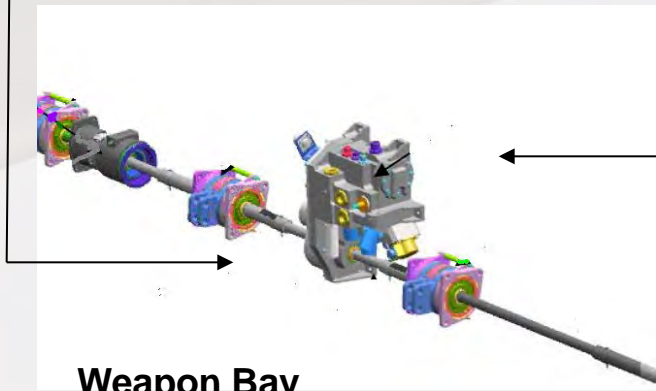
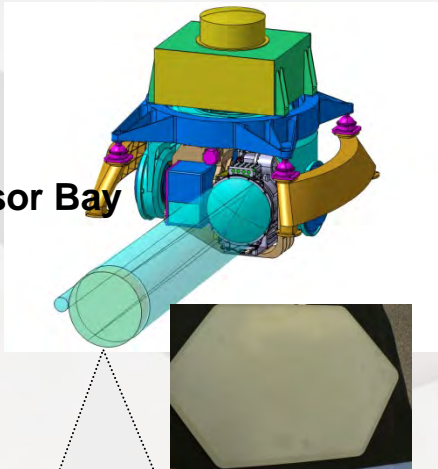
# Combat capability : system integration

Avionics



GCS Control Box

Sensor Bay



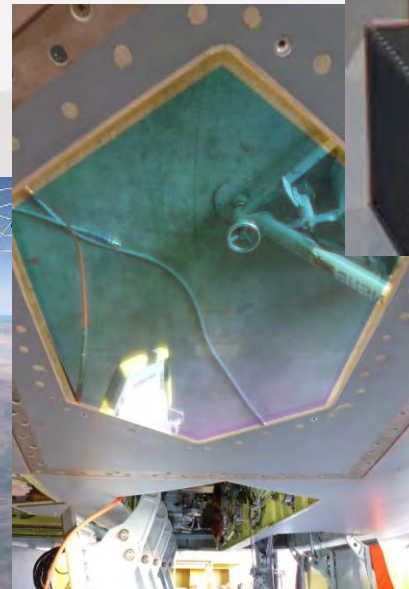
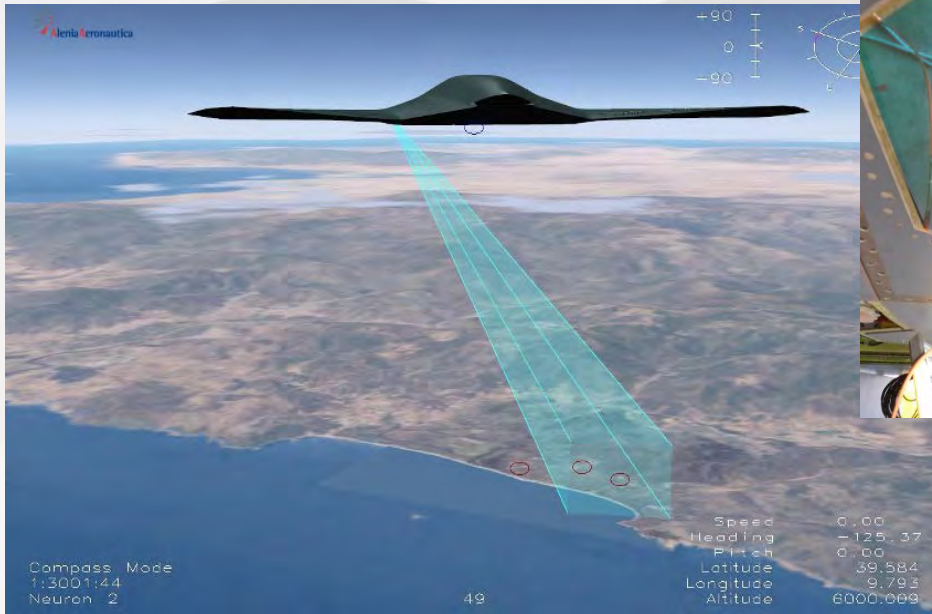
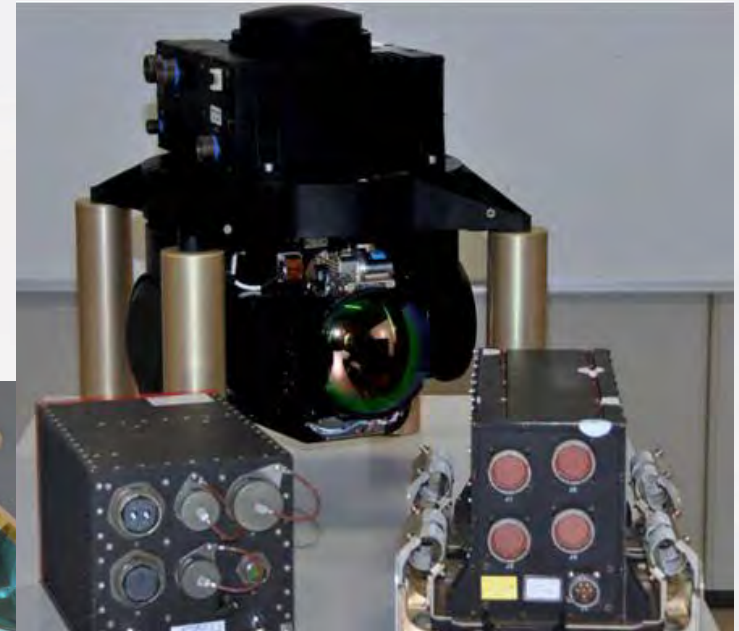
Weapon Bay





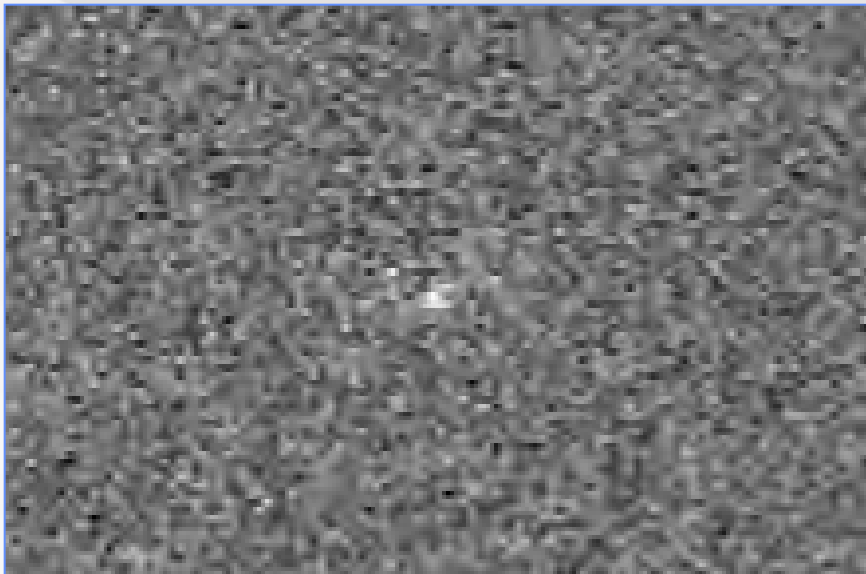
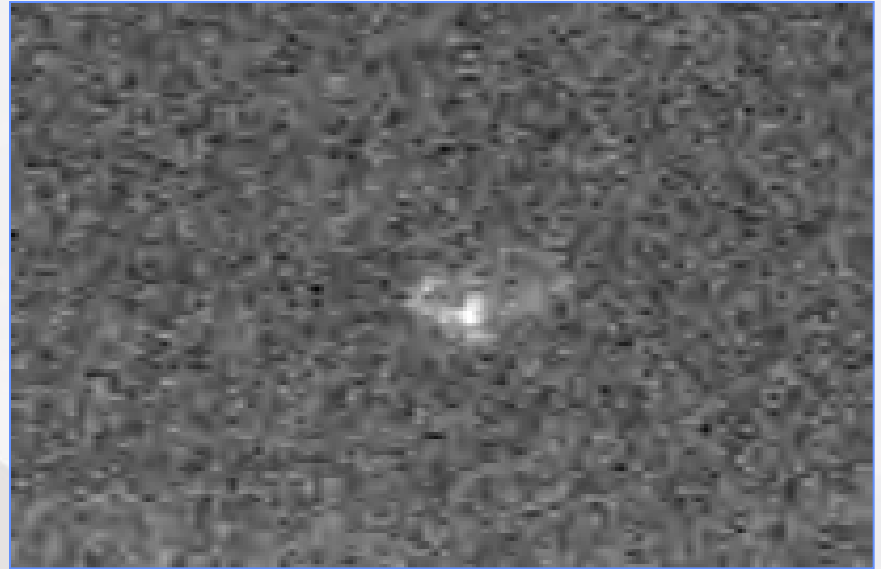
# IR sensor & optical window

- **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



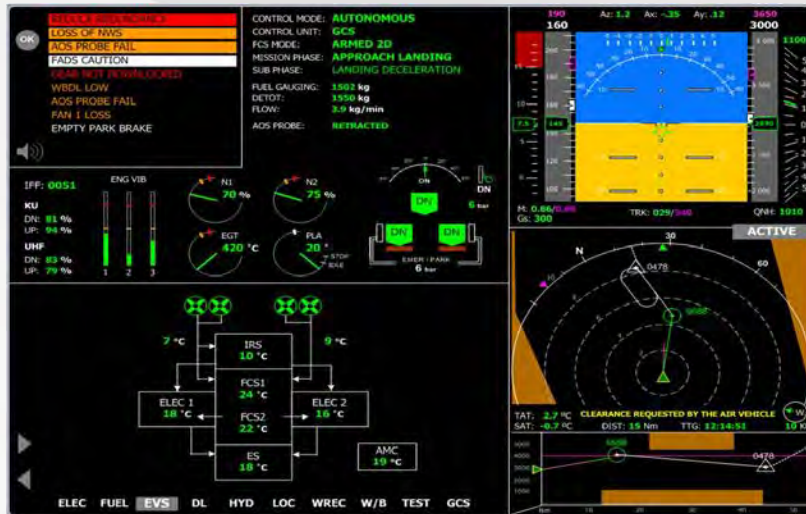
# Vehicle control / Operator in the loop

## ● 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



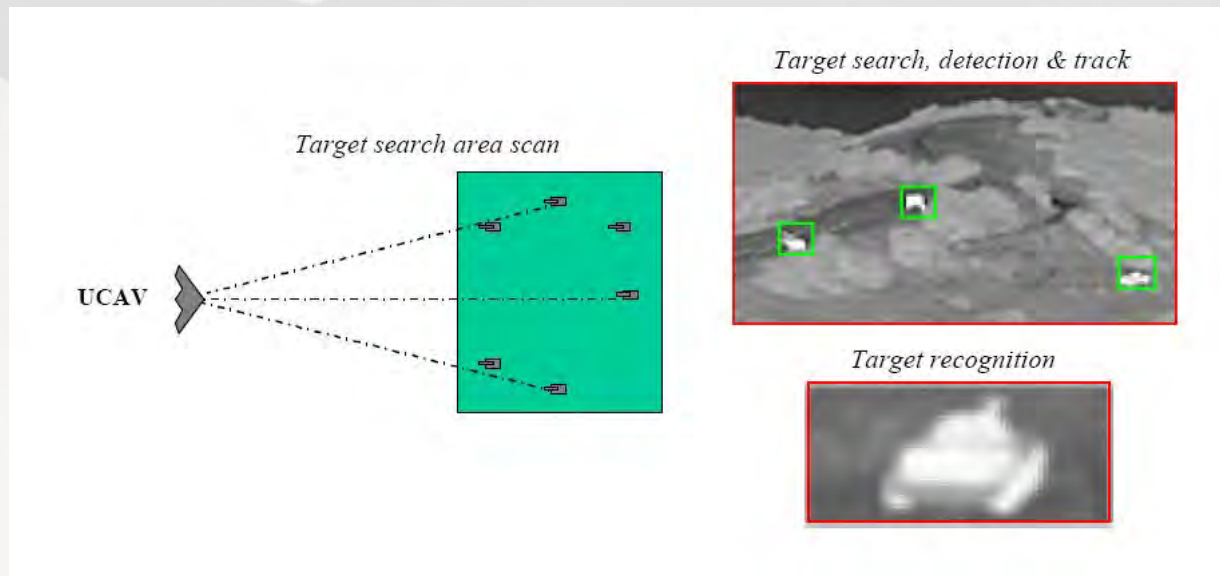
## No stick / no throttle



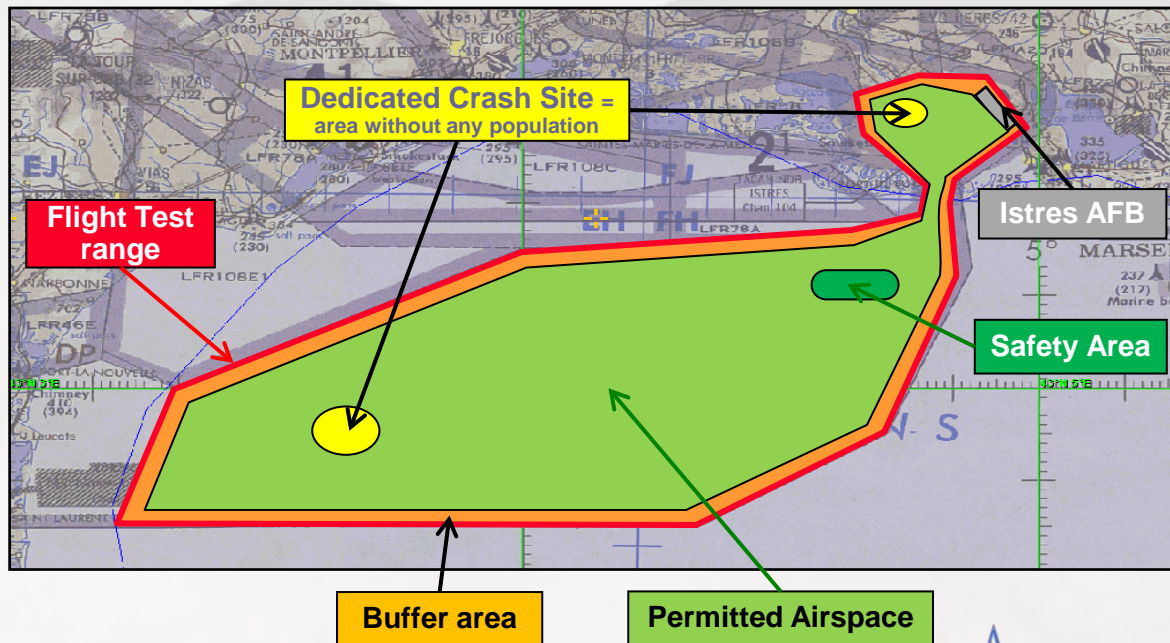


# Mission control / Operator in the loop

- **IR reconnaissance system capable of high resolution on operator-selected Poles 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



- **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

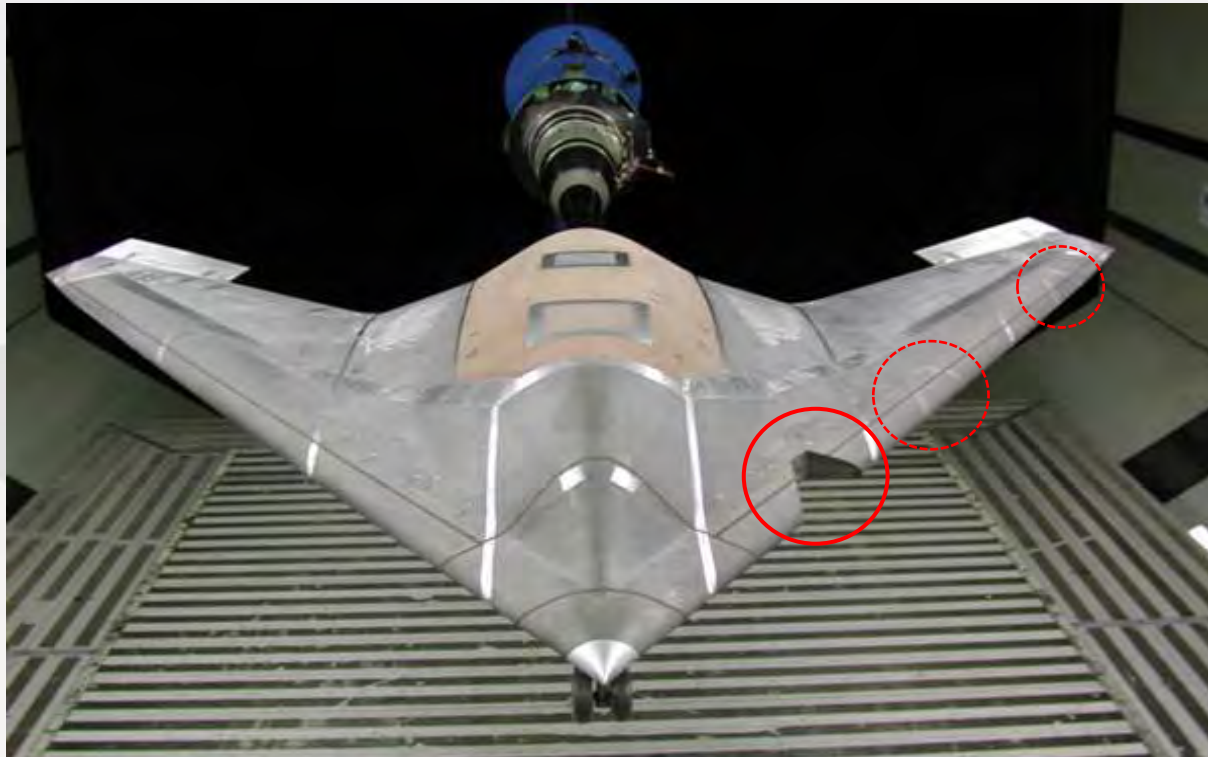


- **Manned & unmanned flight**



# Safety linked to bird strike

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

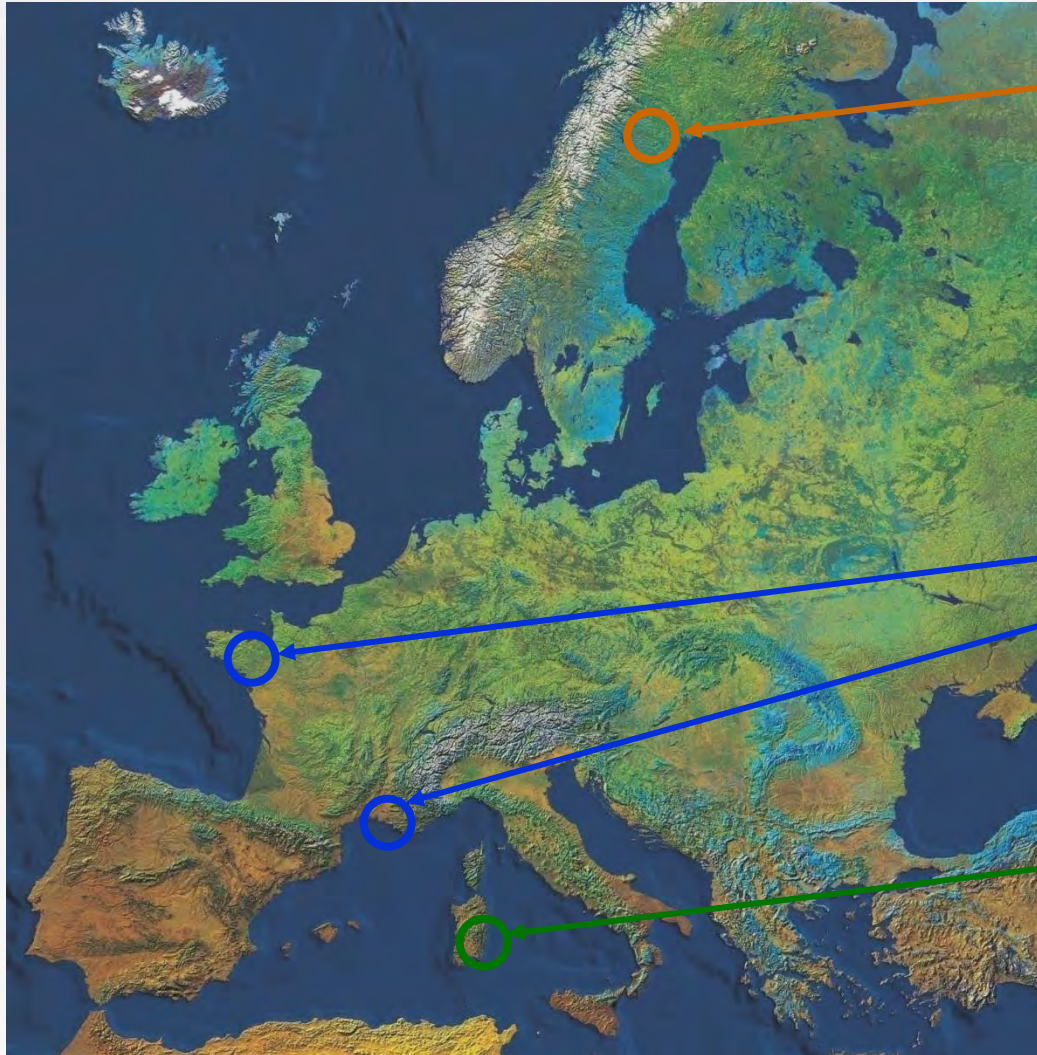


- Flight control demonstrated for all bird strike location





# Main tests location



**Sweden :**  
Vidsel Test Range

**France :**  
Rennes Solange  
Istres Test Centre

**Italy :**  
Decimomannu Air Base  
Perdasdefogu Test Range



# First flight



**2012, 1st December at dawn**

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# 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**

**nEUROn = member of the nEUROn family**





# Human adventure

- A greater outcome then the sum of its parts



# nEUROnists at work

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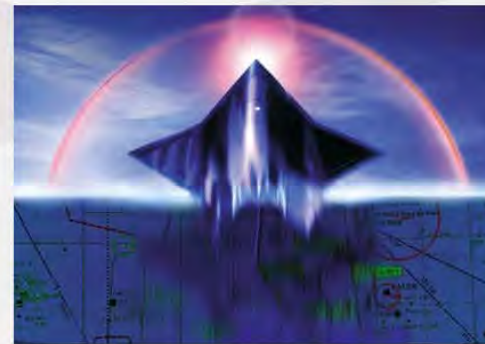
# Summary

- 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
  - 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



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# Thank you for your attention !



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