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

Bilateral Inter-Governemental MoU’s

Executive agency

Prime Contractor

Main Contract

Sub Contracts

Strategic Board

PM TM

Spain  Sweden  France  Italy  Greece  Switzerland

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

(*) : MNSC = Main National Sub-Contractors

ICAS 2014
Airframe workshare based on demonstrated skills

- Dassault
- Saab
- Casa
- HAI
- Alenia
- Ruag

ICAS 2014
Systems & software workshare based on demonstrated skills

Flight Control System
- Dassault
- Alenia
- Casa

Avionics & VMS
- Saab

Mission Capability
- Alenia

Ground Control Station
- Casa
- Dassault

Communication system
- Casa
- Thales
- Alenia
- Saab

ICAS 2014
Large number of partners including government, industry & research centers

France
- DGA
- ONERA
- SAFRAN Turbomeca
- Labinal SAFRAN Group
- Thales
- Messier-Dowty SAFRAN Group

Sweden
- FMV
- Saab
- Volvo Aero

Italy
- Alenia Aermacchi
- Selex ES
- UTC Aerospace Systems

Spain
- EADS CASA

Greece

Switzerland
- RUAG

Others...
- Rolls-Royce
- AEROSONIC
Common IT system suit

- **Aiframe & layout Design**
  - with CATIA v5

- **System Architecture**
  - with PLM V6 experimental release

- **System Requirements**
  - with PLM V6 experimental release
  - with Documentum*

- **Program Documentation**
  - with Documentum*

- **Change Management & Technical Events**
  - with Sharepoint/NCM*

- **Structural Analysis**
  - with ELFINI and NASTRAN

- **Functional Hazard Analysis (FHA)**
  - with CECILIA

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

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ICAS 2014

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System components

- Communications
- Air Vehicle
- Ground Control Station
- Flight Tests Room

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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:

  Not on a mockup …
  But on the flying A/V
LO main treatments

**Upper Side**
- Perimeter
- Antennas
- Air intake
- Fuselage to wing junction

**Lower Side**
- Weapon bay doors
- Landing gear doors
- EO sensor window
- Shielded exhaust

- 4 control surfaces no fins
- Flush Air Data System
- Maintenance door
- Antennas

High tolerance manufacturing
Surface treatment
LO coating ... flavors

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

- Shielded exhaust treatment

![Image of a drone with LO coating flavors]

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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
  - **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

Computation in black
Flights in blue and red

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Combat capability: system integration

Avionics

E/O Processor (EOP)

Mission Controller (MC)

GCS Control Box

Sensor Bay

Weapon Bay

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IR sensor & optical window

- Flush installation for LO purpose
  - LO integration
  - Field of View optimization
  - Integrated image processing and recording
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
French: Rennes Solange, Istres Test Centre
Italian: Decimomannu Air Base, Perdasdefogu Test Range
First flight

2012, 1st December at dawn
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

<table>
<thead>
<tr>
<th></th>
<th>France (Istres)</th>
<th>Sweden (Vidsel)</th>
<th>Italy (Perdasdefogu)</th>
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<td>Flight domain: weapon bay closed</td>
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<td>Mission sensors tests</td>
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<td>Weapon release</td>
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<td>Mission experimentation</td>
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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

nEUROOnist = member of the nEUROOn family
Human adventure

- A greater outcome than the sum of its parts

nEUROnists at work
**Summary**

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

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Thank you for your attention!