RTRA SMARTWING research axis & EMORPH EU project proposal

ONERA-DCSD activities : Real-time Flight Control Laws

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retour sur innovation

Outline

1. **DCSD research activities**

2. **Flight control**

3. **Some projects**
   - IMMUNE
   - AVISAC
   - DEVIS

4. **Proposal of RTRA Smartwing and EMORPH activities**

DCSD : Scientific competences & fields of activity

Control
Flight Dynamics

Artificial Intelligence
Robotics, Cognitive Sciences

Industrial and experimental applications

Design & **Performances**
air- & spacecraft

Operations of
air- & spacecraft :
autonomy, human factors,
control management architectures

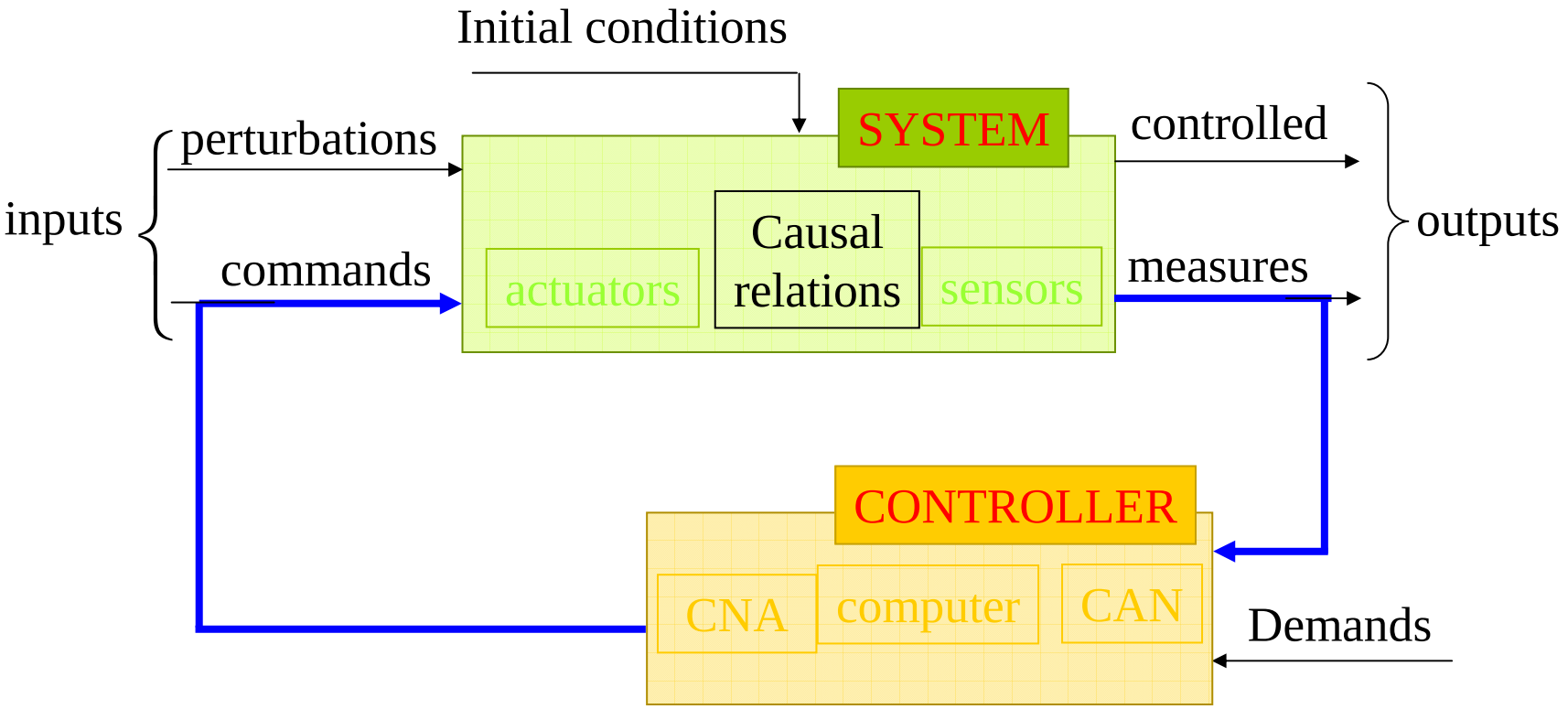
Methods & Tools
for
Guidance & **Control**

Methods & Tools
for
Supervision & **Decision**

Development of methods and tools

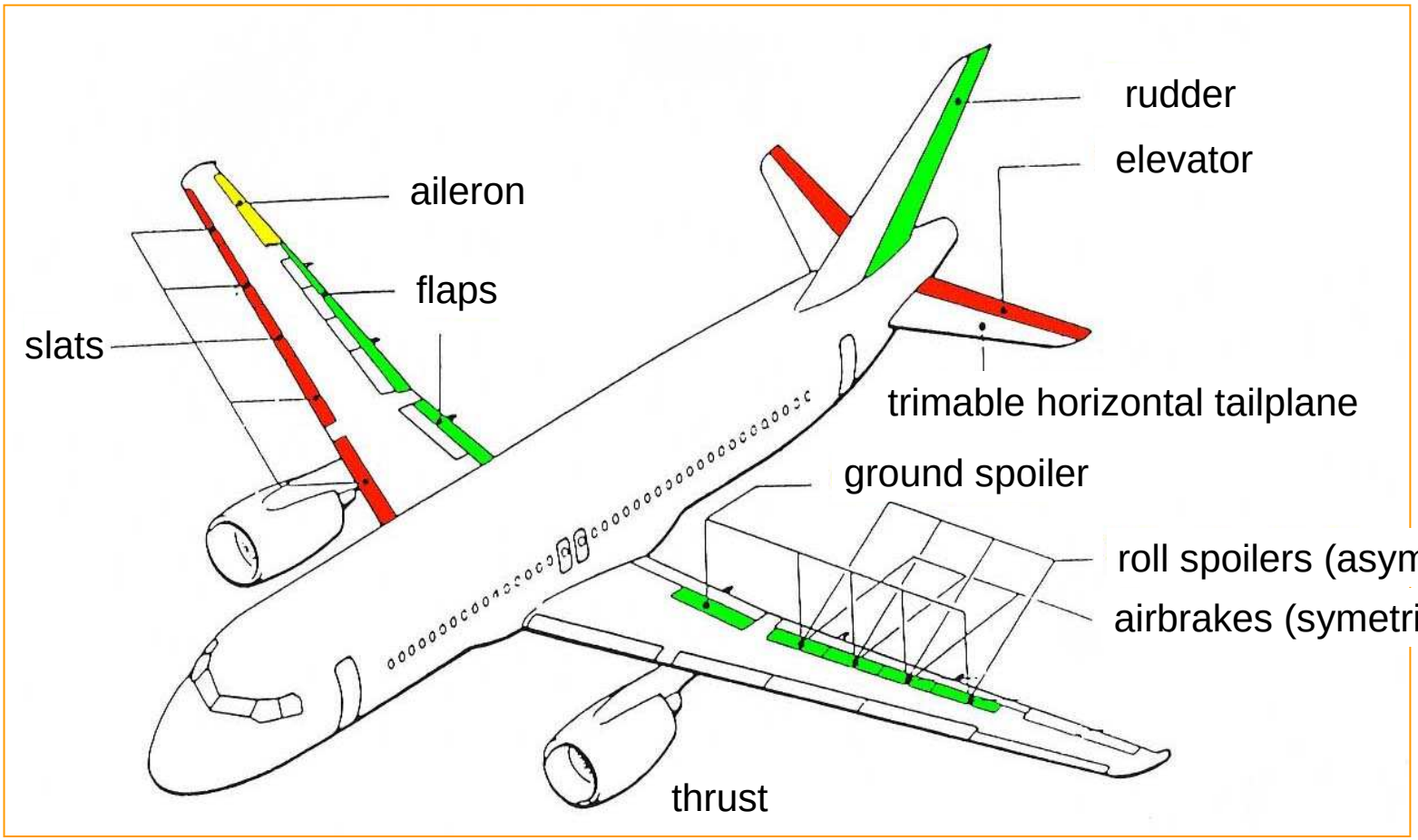
Experimental platform ACTION / ROSACE / ReSSAC

Feedback control of a dynamic system



Flight dynamics

Control inputs (A320) : thrust and control surfaces



Flight dynamics

Measurements

- **longitudinal motion**
  - angle of attack
  - airspeed
  - flight path angle or pitch angle
  - pitch rate
  - load factor nx
  - load factor nz
  - vertical position (altitude)
  - longitudinal position
- **lateral motion**
  - sideslip angle
  - roll rate
  - yaw rate
  - roll angle
  - load factor ny
  - lateral position
- **environment**
  - static pressure
  - temperature
- **morphing control surface**
  - chordwise deflections of the surface

Perturbations

- **external**
  - wind
  - turbulence
- **internal**
  - friction
  - electrical resistance
- **parameter uncertainties**
  - aerodynamic coefficients
  - mass
  - inertia

Global objectives

- Control, guidance & management systems are a main issue during the design and development process of air- & spacecraft

Global objectives :

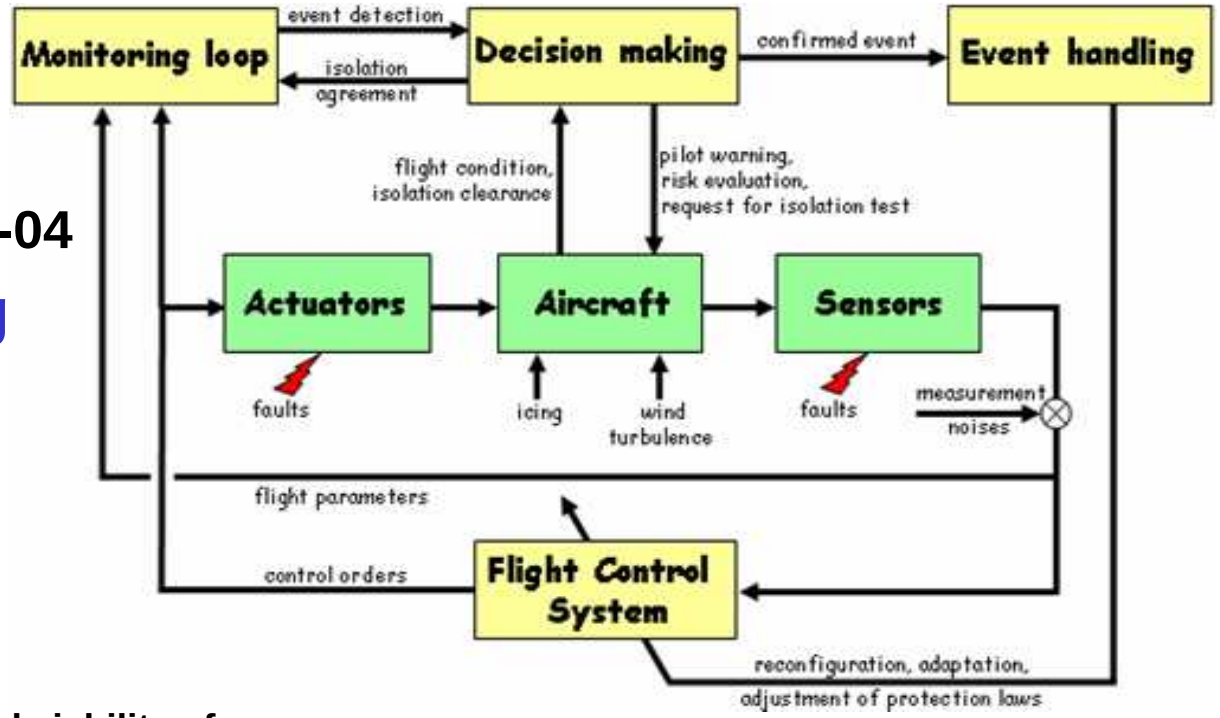
1. Safety and certification
2. Complexification of systems and of the performance criteria
3. Increasing automatisation of the control & management functions
4. Improvement of the design
5. Extension of air- & spacecraft performances

ONERA – DLR Project IMMUNE (2006-2009)

IMMUNE

ONERA-DLR CTARP FMS-04

Intelligent Monitoring and Managing of UNexpected Events



Objectives :

Demonstration of the capability and viability of :

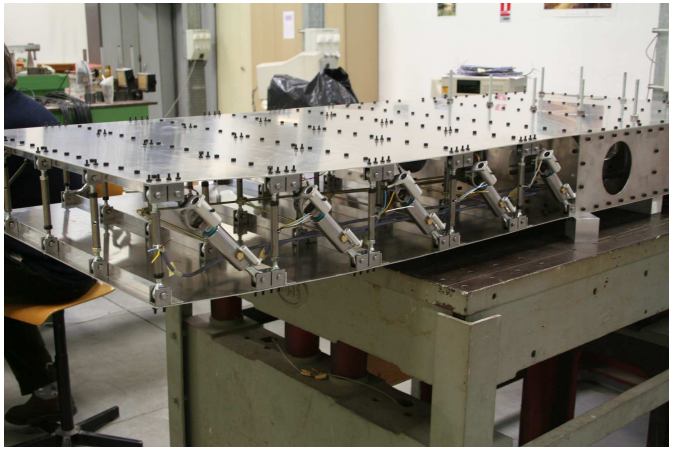
- **intelligent monitoring (fault detection, isolation and estimation)**
- **managing (decision what to do)**
- **fault handling (fault monitoring & fault tolerant control, pilot information)**

…of unexpected events during flight with the aim to improve safety and autonomy and to increase flight envelope margins.

Project AVISAC (2005-2008)

Objectives and main realisations

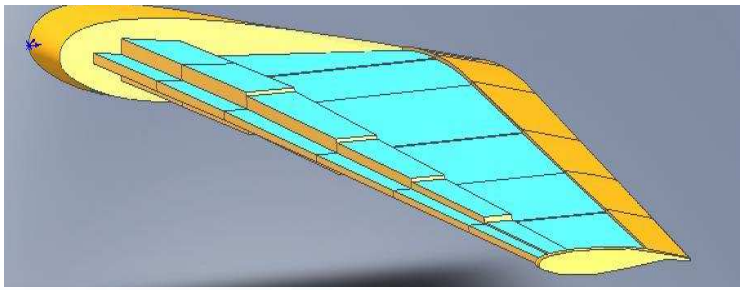
- **Answer to the question of the interest of active flexibility**
  - propose pertinent concepts
  - numerical and experimental validations
  - optimisation of a wing with « active flexibility »



demonstrator active structure

- **Produce advances in the belonging scientific fields**
  - Design of innovative structures
  - Design of a flexible wing
  - knowledge and modelling of aeroelastic phenomena

tool VoilSoup, then MDO



Project DEVIS (started in 2011)

Demonstrator of a wing with innovative actuators

- All electrical aircraft with several distributed electrical actuators instead of mechanical drives
- Composite Aircraft (with flexible hinge) : coopération SME Protoplane
- Wing loading alleviation
- Control and Reconfiguration of distributed actuators

Proposal of activities in RTRA Smartwing - Dynamorph and EMORPH

1. Shape feedback controller design

- In order to obtain the optimal shape given by the aerodynamists in **real time** for all flight conditions while the wing is subject to external perturbations, modelling errors, etc. in cooperation with Laplace
- Three steps (low frequency, high frequency and hybrid version) as proposed in **Dynamorph**
- **Open** and **Closed** loop control design at **control surface level**

2. Flight control evaluation

- In the case of a morphing control surface, we propose to evaluate the **impact of this morphing device on an existing control law** (for example the one of IMMUNE) in terms of performances due to a control surface efficiency loss
- Evaluation in terms of handling qualities and autopilot performances at **A/C level**

Proposal of activities in RTRA Smartwing - Dynamorph and EMORPH

3. Use of the wing demonstrator DEVIS

- In the case of a morphing control surface, **this control surface could be compared to the classical control surface** on the DEVIS demonstrator (compatibility aspects!)
- Comparison in terms of control surface efficiencies at **A/C level**