ACT – TILT

A Major Step towards NICE-TRIP

Ph. Rollet, Eurocopter

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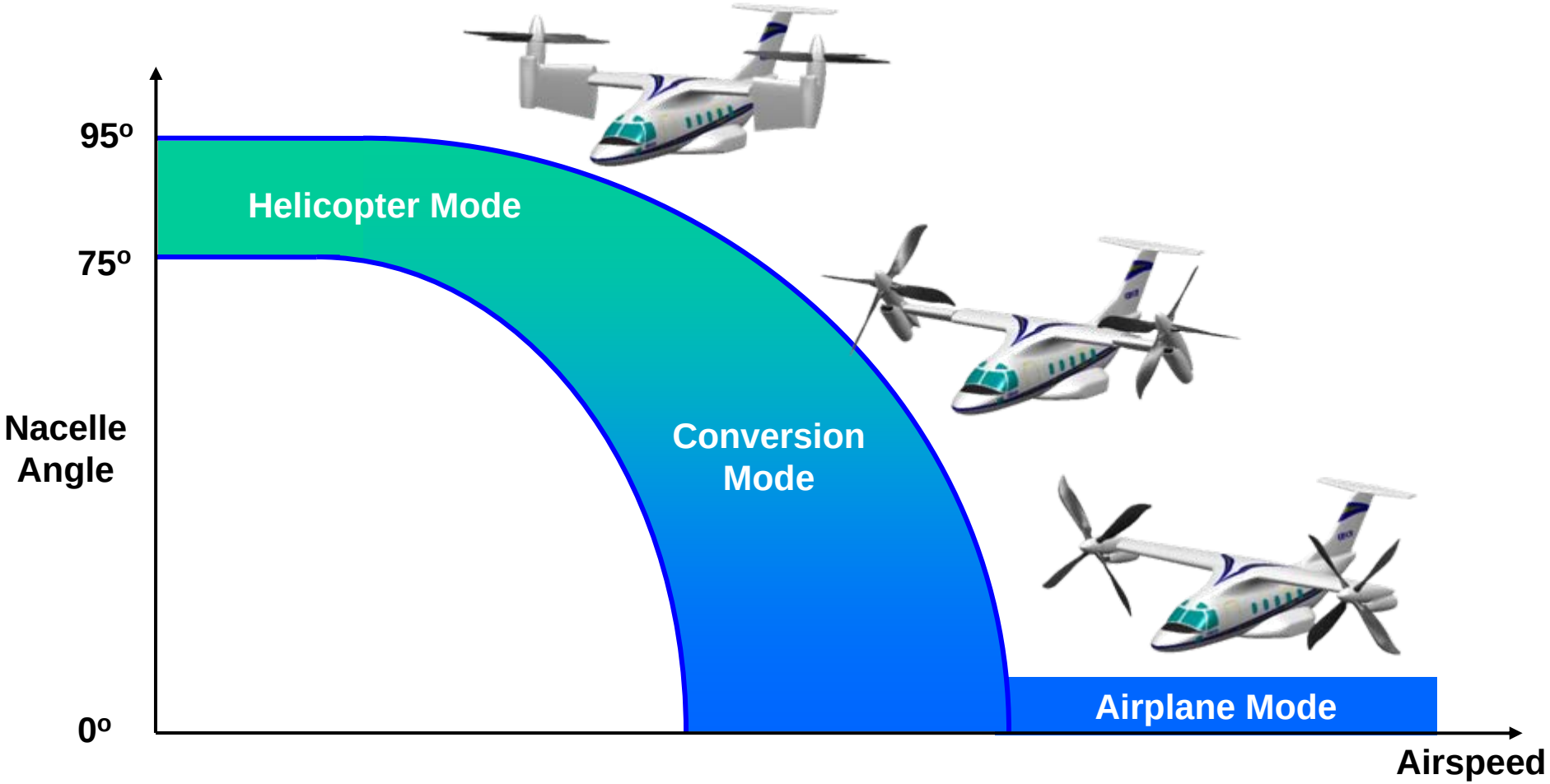
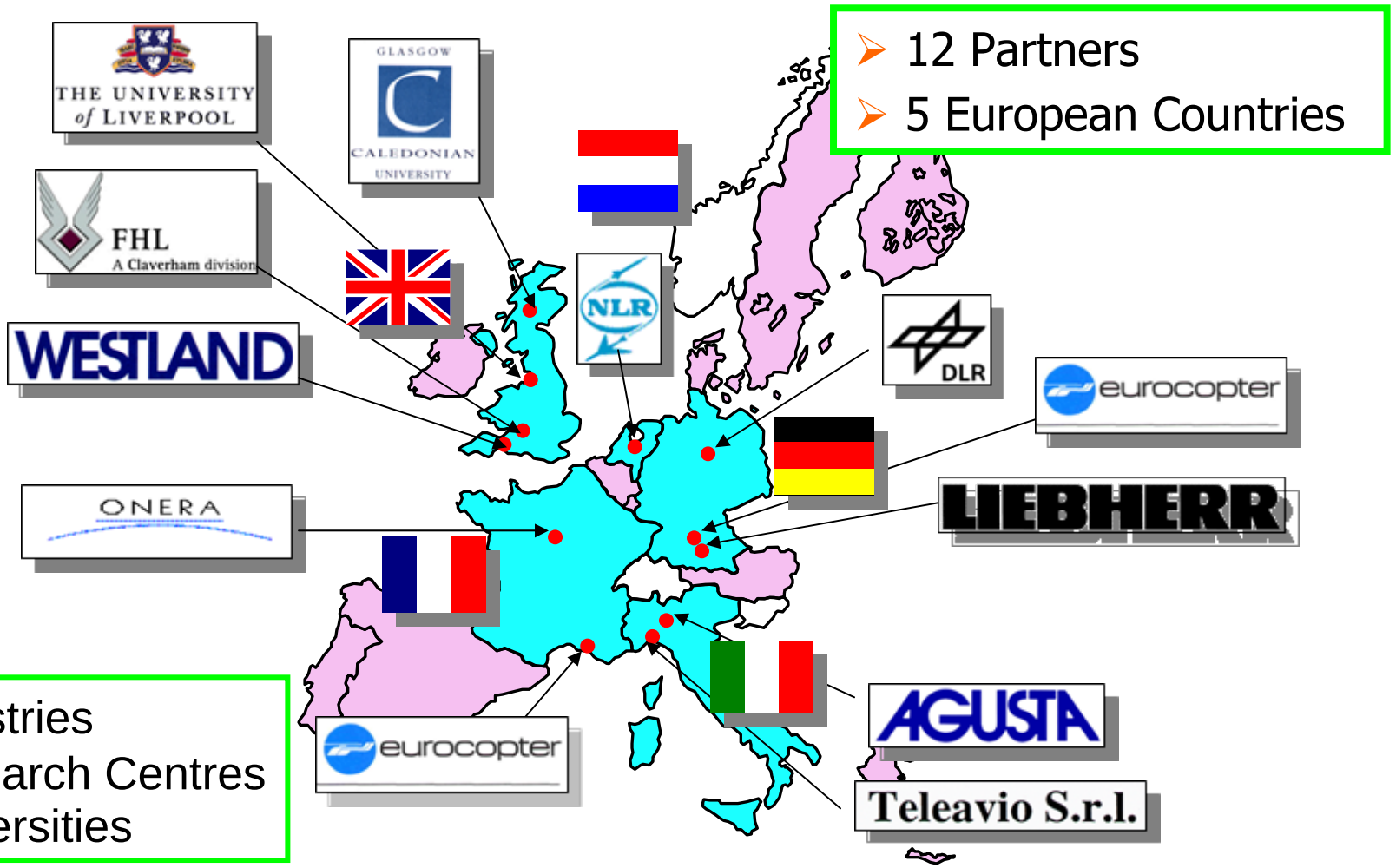
ACT-TILT Objective

- Design a Flight Control System (FCS) for Civil Tilt-Rotor (CTR)



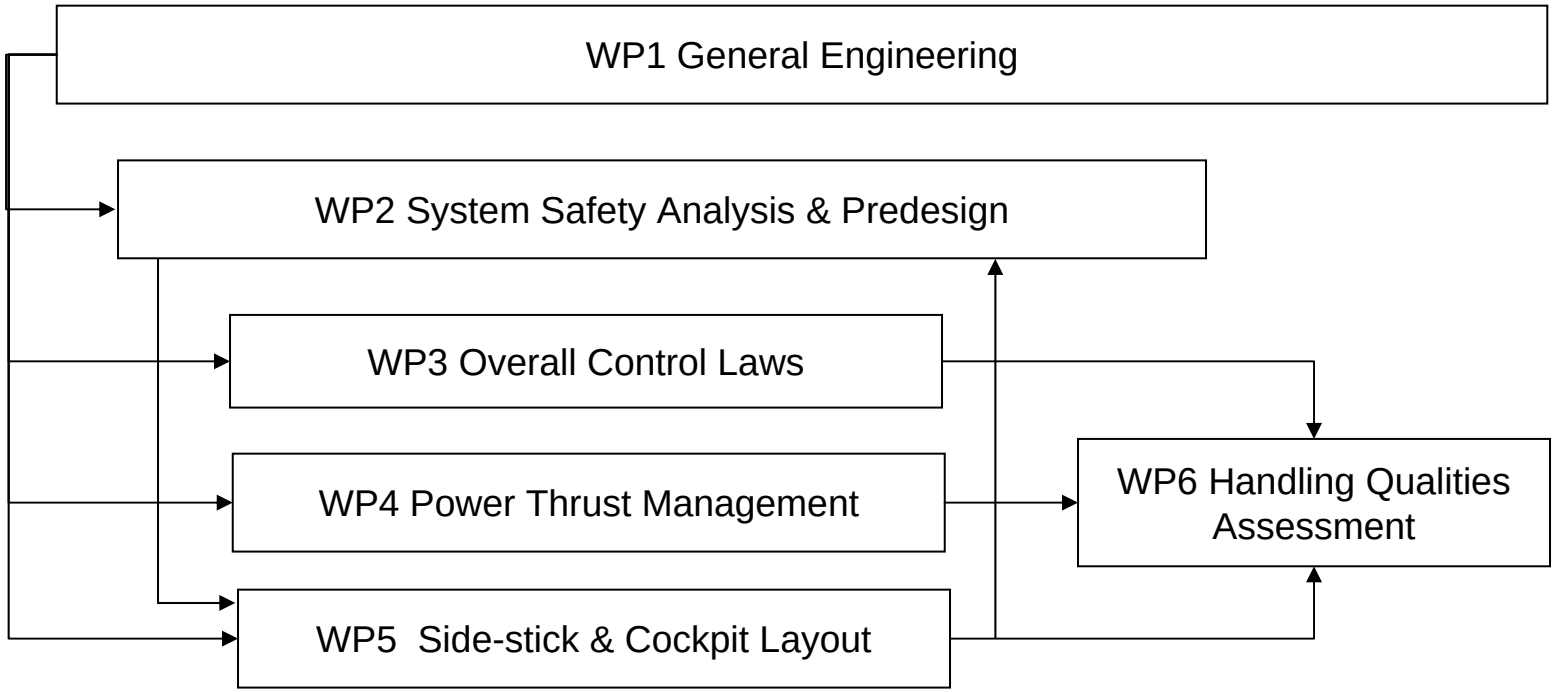
Partners

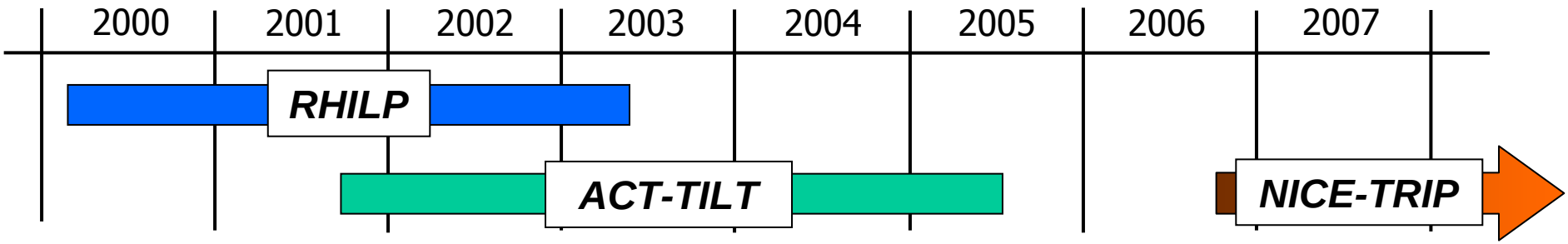


- 12 Partners
- 5 European Countries

- 7 Industries
- 3 Research Centres
- 2 Universities

WP structure and time scale





Linkages with other FP5 CTPs

Piloted Simulation & HQ requirements background

Flight Control System Definition

ERICA data package Control loads

Nacelle & Wing Actuators Loads & Dynamics

Validated aerodynamic data (after ACT-TILT completion)

Rotor Flapping Control Laws

Simulation models

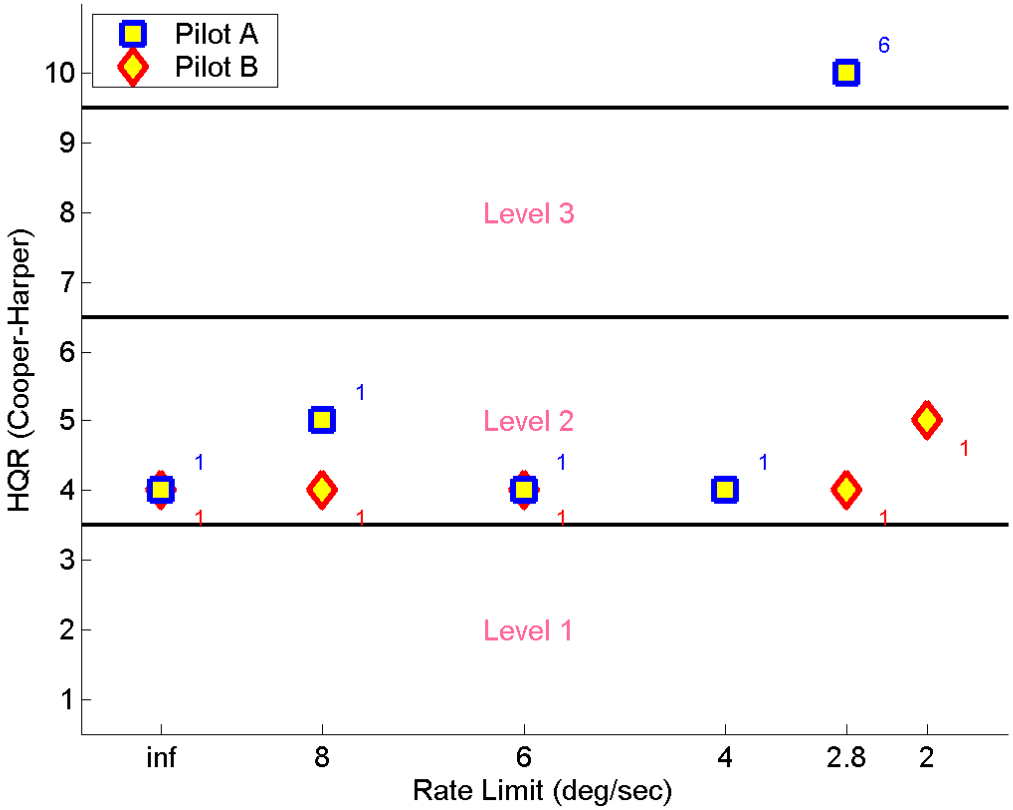
- F-XV15 Simulation Model
  - Based on XV15 public data
  - FLIGHTLAB™ simulation environment
  - Partially validated w.r.t. flight test data
  - Used in ACT-TILT as interim model for Handling Qualities studies (WP1.3)

- ERICA CTR Simulation Model
  - Based on AGUSTA data package
  - HOST, FLIGHTLAB, FMC, CAMRAD-JA simulation codes
  - Baseline CTR for ACT-TILT studies and final simulation trials

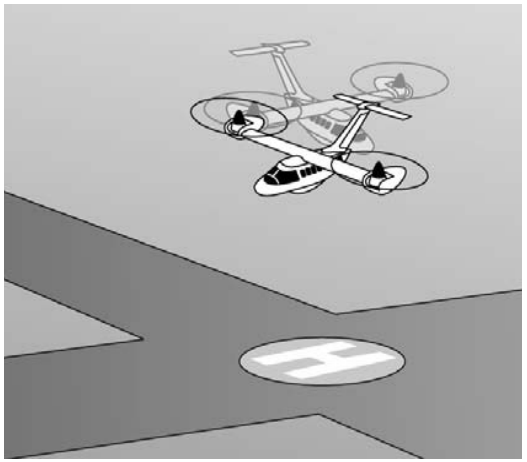
ERICA CTR: 10 T, 19 passengers

Preliminary HQ assessment

- Piloted simulations with F-XV-15 model for HQ criteria determination

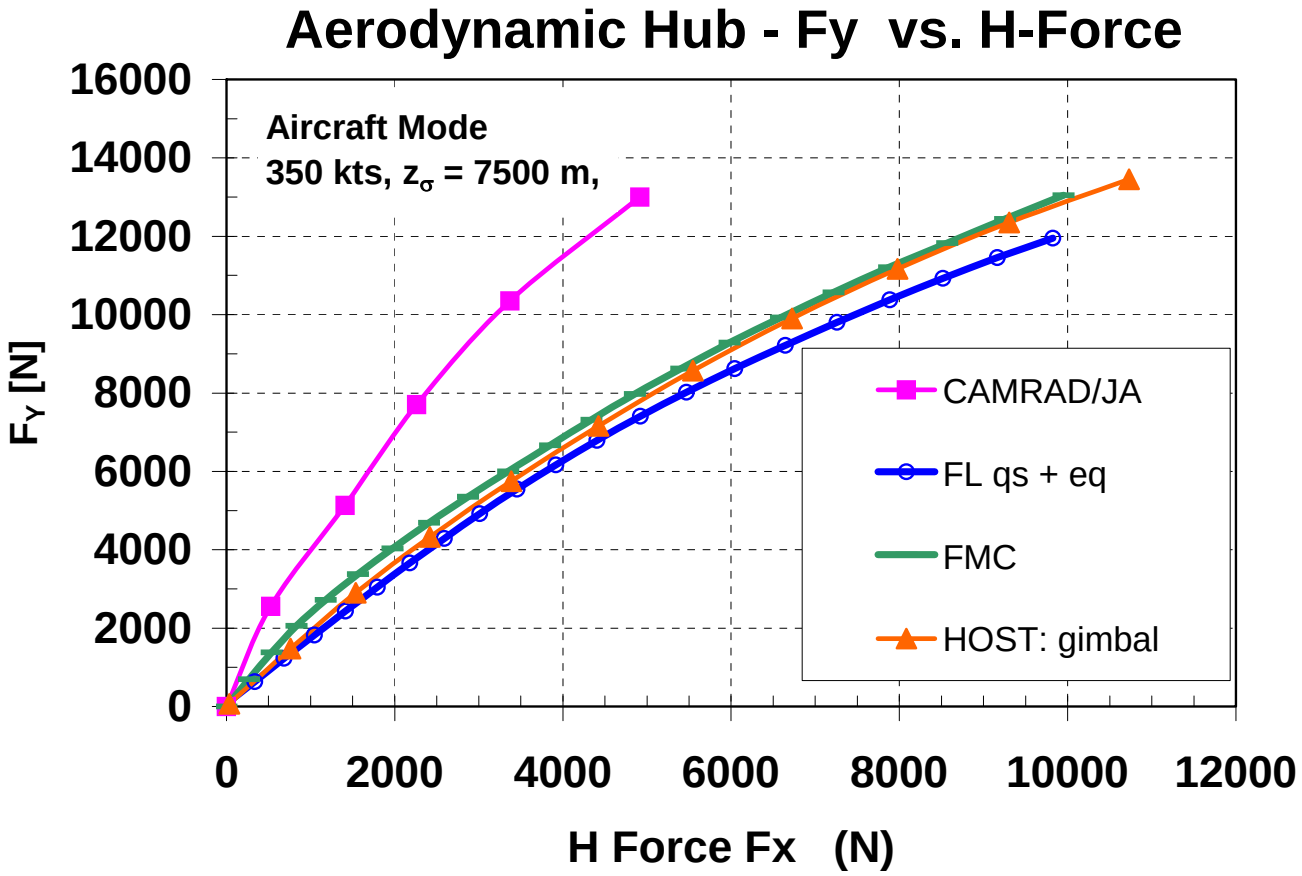


Hover turn



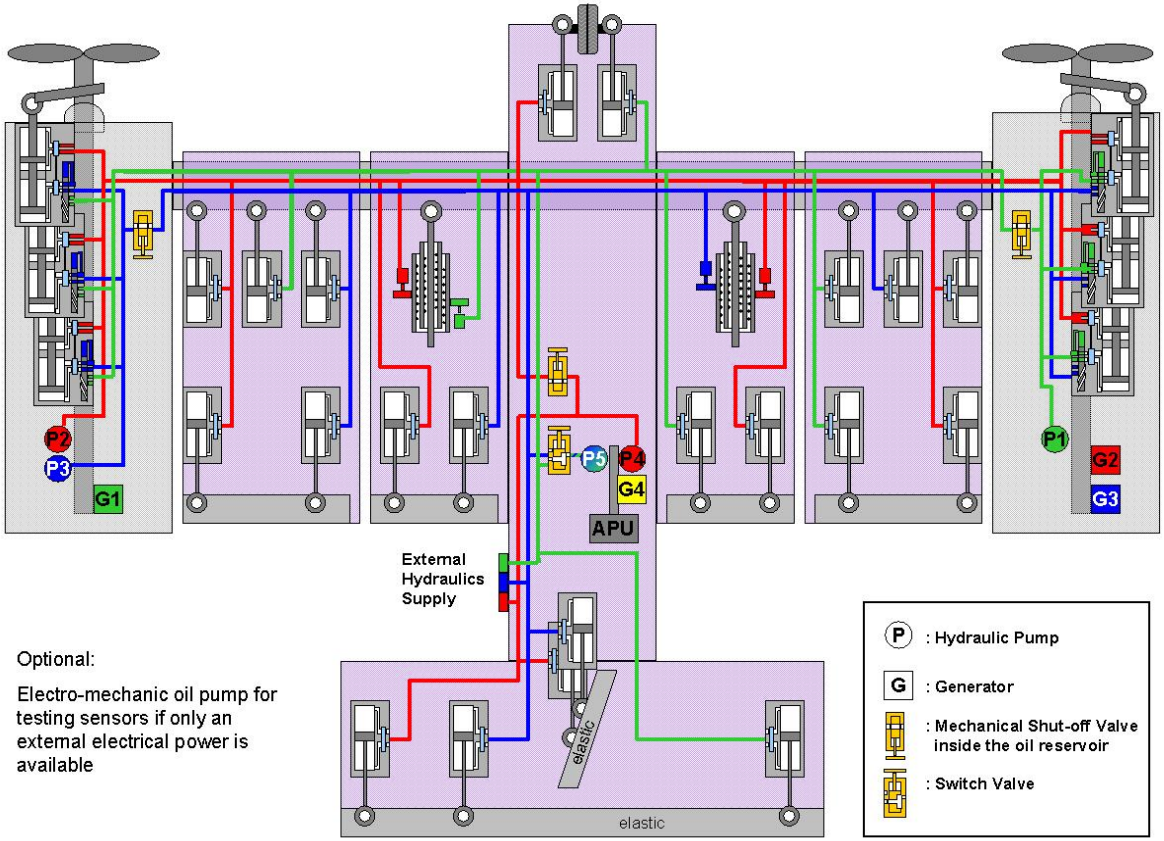
Flight mechanics codes

- Rotor forces prediction



System design

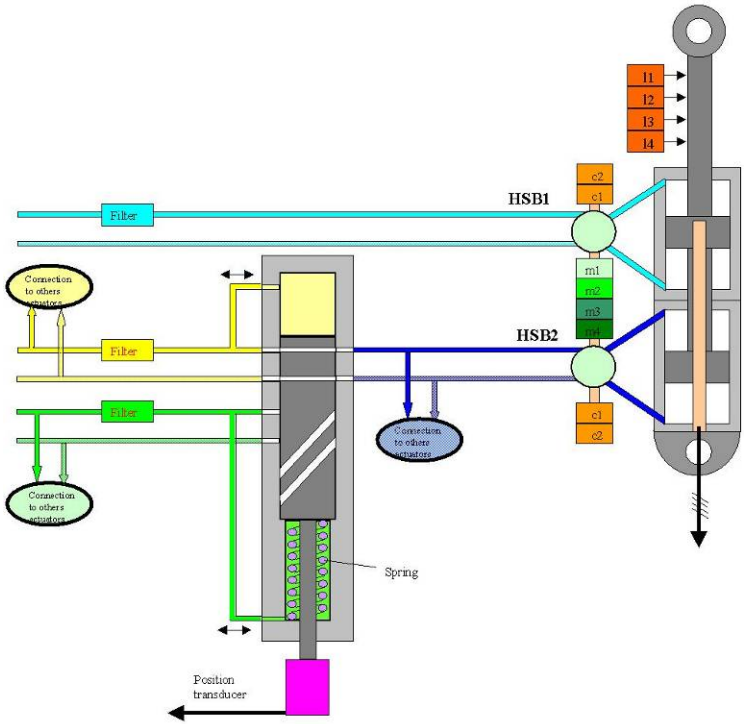
- Location of actuators and generators



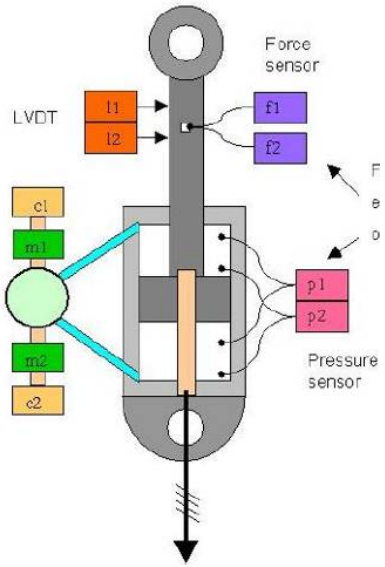
Sub-systems specification

Actuators specification

Duplex tandem actuator for rotors



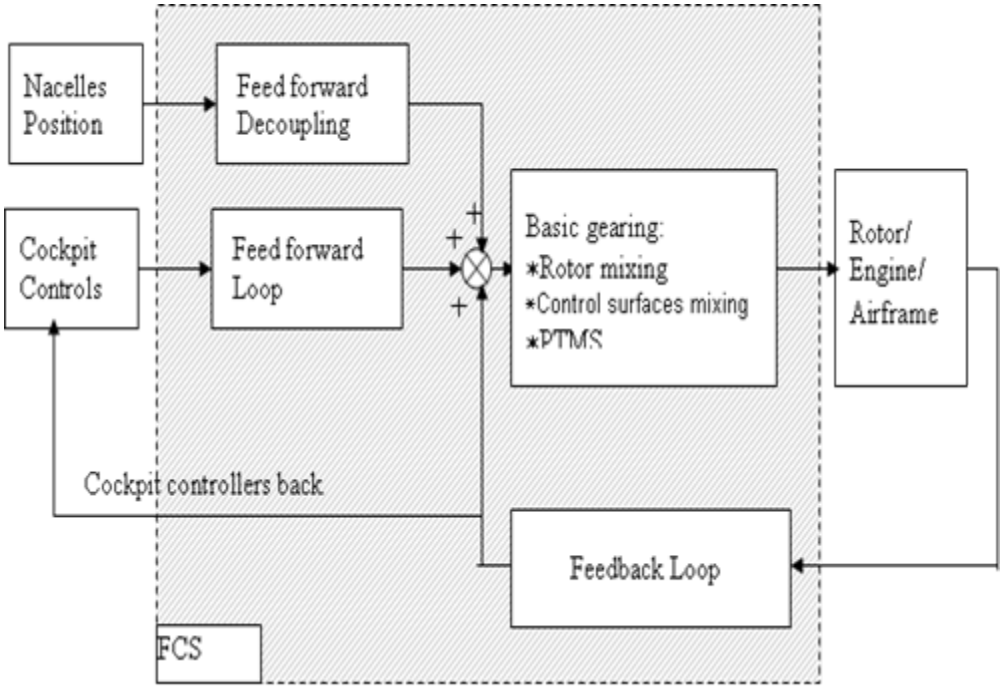
Simplex actuator for aerodynamic surfaces



Control laws

- Designed to provide Level 1 Handling Qualities in all modes of operation (helicopter, conversion, airplane)

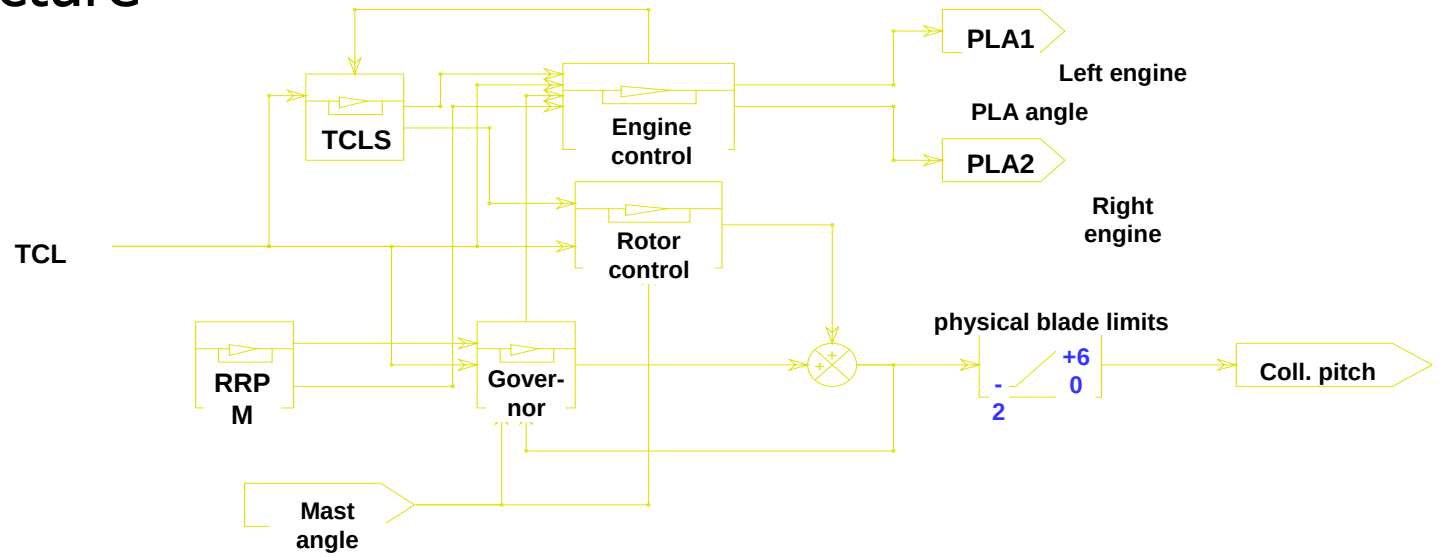
- Control inputs
  - stick deflection
  - feed-forward control
  - feedback loop
    - attitudes
    - rates
    - accelerations
    - long. and vertical speeds
    - rotor & engine parameters



Power Thrust Management

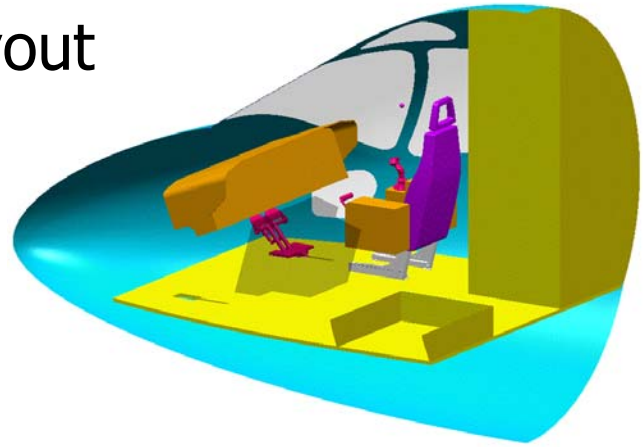
- Designed to provide adequate power / thrust response in all modes of operation:
  - Torque command (turboprop-like) with collective pitch feedforward to achieve helicopter-like response in helicopter mode

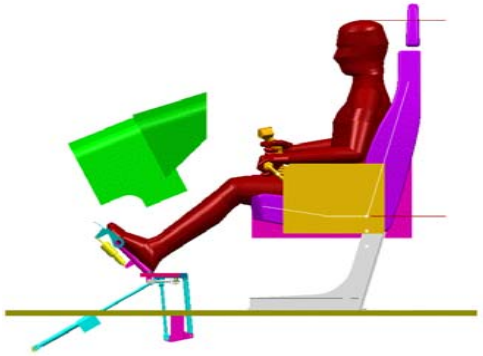
- System structure



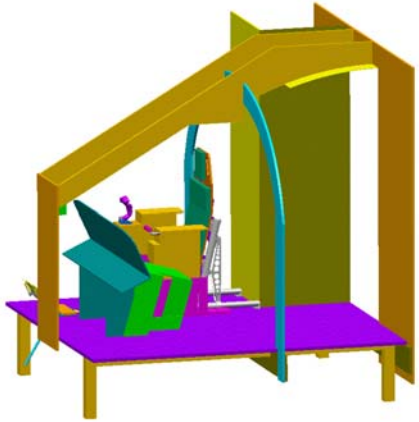
Cockpit definition

- Cockpit layout





- Mock-up design and manufacturing

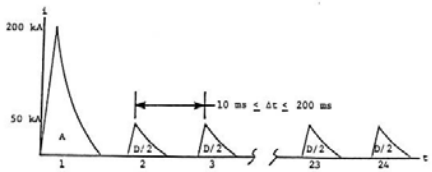


Cockpit controls

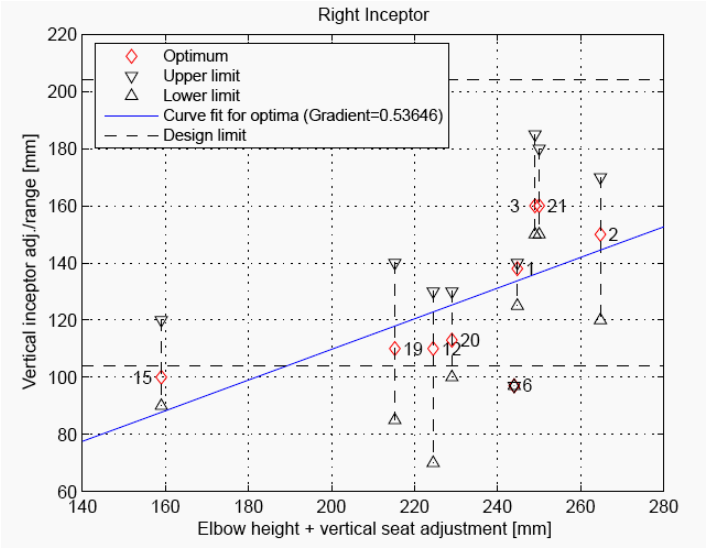
- Side-stick studies
  - Survey of existing side-sticks
  - Study and specification of active side-stick for CTR

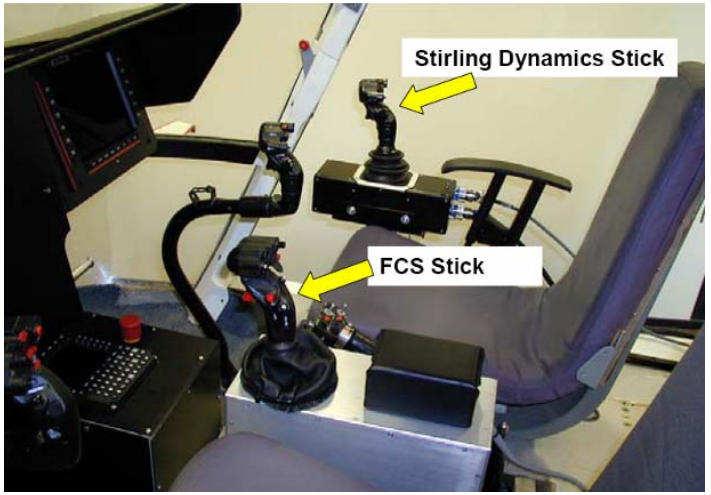






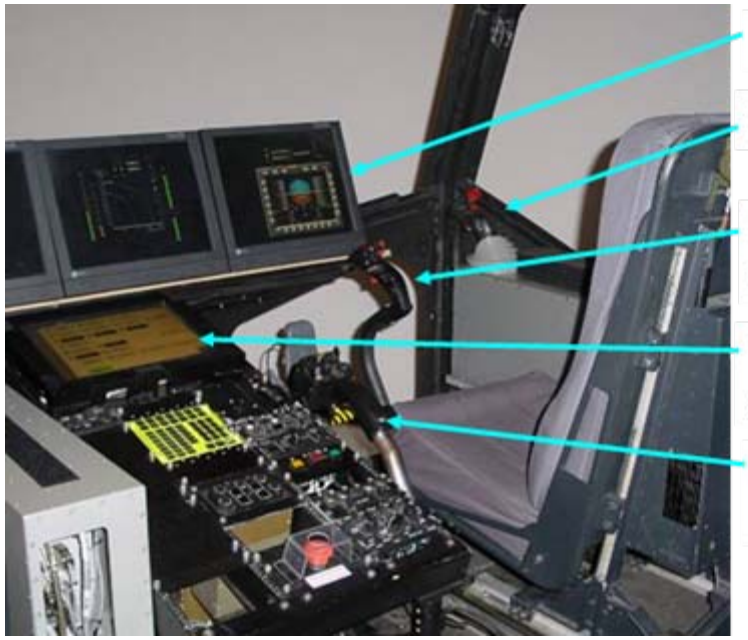
- Ergonomics assessment and simulator investigations





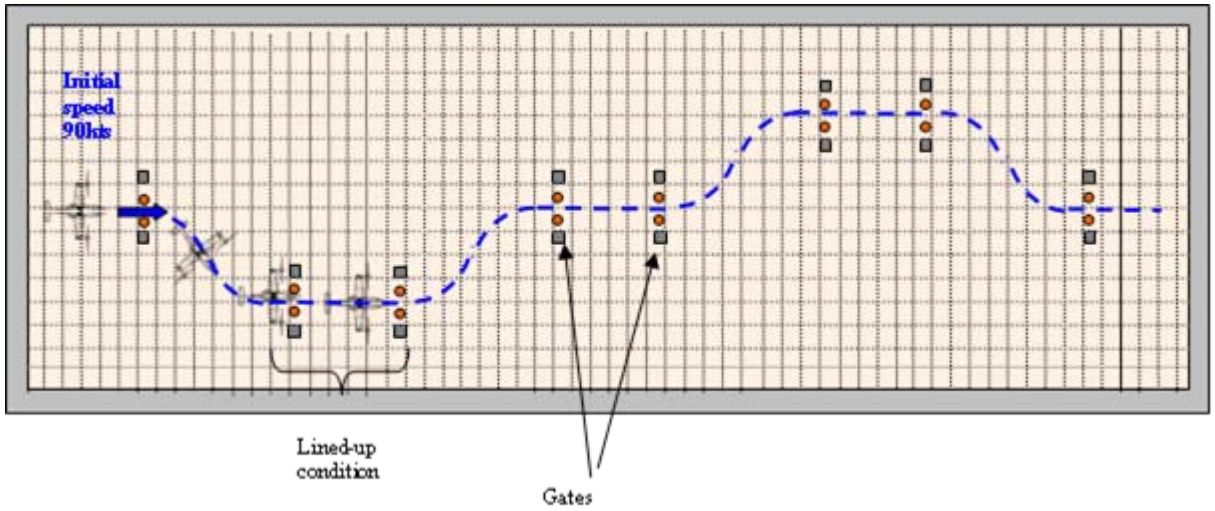
Flight simulators

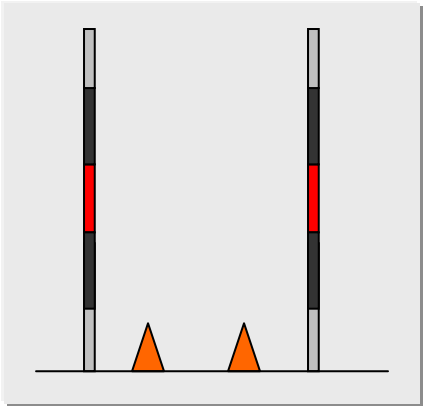
- 6 simulation facilities have been used in ACT-TILT:
  - University of Liverpool (Heliflight), NLR (HPS), Eurocopter (SPHERE), Eurocopter Deutschland, DLR, Westland
- SPHERE simulator preparation for final HQ assessment



Test manoeuvres

- Definition of 16 test manoeuvres for CTR HQ assessment
  - Example: Fast lateral jinking in helicopter mode

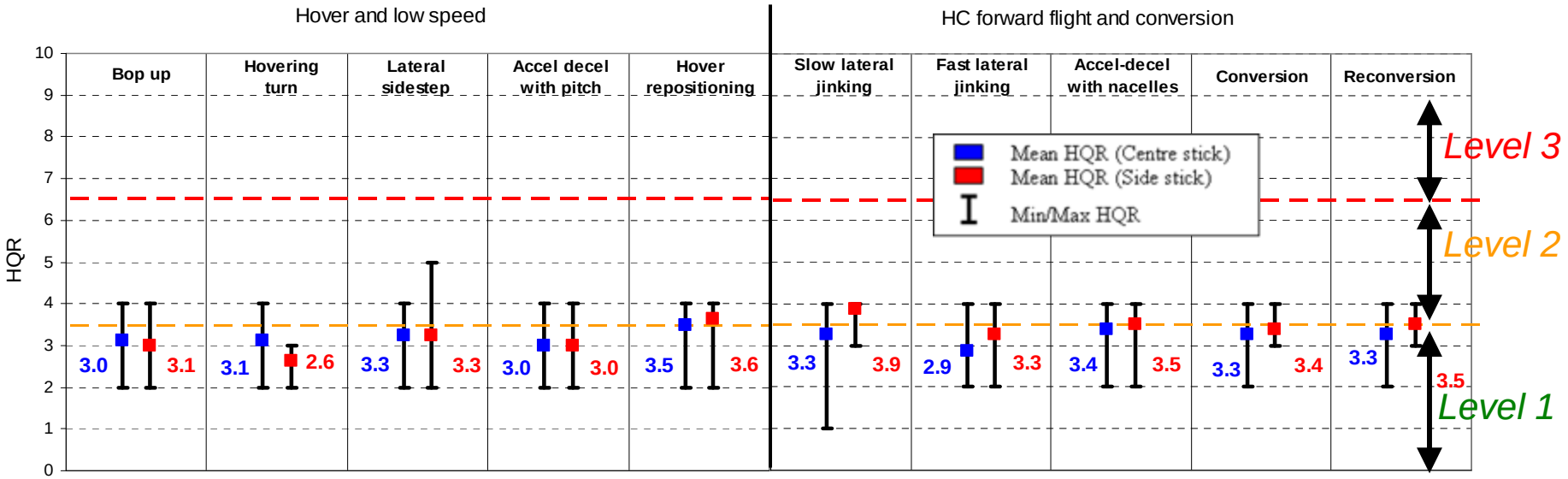




	Desired	Adequate
Maintain heading within pair of gates	± 10°	± 15°
Maintain roll attitude within pair of gates	± 5°	± 10°
Maintain lateral position within pair of gates	± 3m	± 6m
Maintain speed	± 5kts	± 10kts
Maintain height	± 8ft	± 25ft

Level 1 HQ final demonstration

- Assessment of the 16 test manoeuvres by 8 test pilots
  - Both with conventional stick and side-stick



All mean HQRs within Level 1 range (≤ 3.5)

Conclusions (1/2)

- The ACT-TILT project delivered 10 major results related to Tilt-Rotor flight control system design:
  - Level 1 Handling Qualities criteria for a civil tilt-rotor
  - Improved flight mechanics models for tilt-rotor, including ERICA configuration specific features (movable tip wing)
  - Definition and safety analysis of Flight Control System (FCS) for a civil tilt-rotor, in particular for the ERICA configuration
  - Optimised control gearings for the ERICA tilt-rotor configuration, including open loop tiltable outer wing control
  - Active (closed loop) control laws providing Level 1 Handling Qualities for civil tilt-rotor, in particular for the ERICA configuration

Conclusions (2/2)

- Cont'
  - Carefree Handling features (Structural Load Alleviation, Envelope protection) compatible with HQ level 1 active control laws
  - Power Thrust Management System (PTMS) for civil tilt-rotor, in particular for the ERICA configuration
  - Requirements of primary controls (i.e. active side-stick) for use in a tilt-rotor cockpit
  - Assessment of aircraft Handling Qualities in piloted simulation with both a conventional inceptor and a side-stick
  - Defined applicability of in-flight simulation in support of tilt-rotor demonstrator development
- All these results represent a significant gain in Tilt-Rotor knowledge that could be exploited in further European Tilt-Rotor activities, in particular in NICE-TRIP