SEVENTH FRAMEWORK PROGRAMME

SIMULATION OF UPSET RECOVERY IN AVIATION

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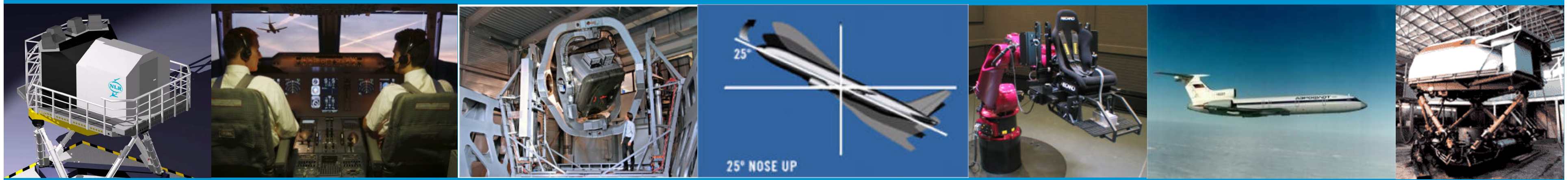


SUPRA – Simulation of UPset Recovery in Aviation

Project Overview

Dr. Eric Groen, Scientific Coordinator

SUPRA project

Funding scheme:	Collaborative Research
EU Call:	AAT-2008-RTD-1
THEME:	AERONAUTICS & AIR TRANSPORT
AREA:	Aircraft Safety

Objectives:

- Reduce aircraft accident rate with 80%
- Improve elimination of, and recovery from human error

SUPRA project

Consortium

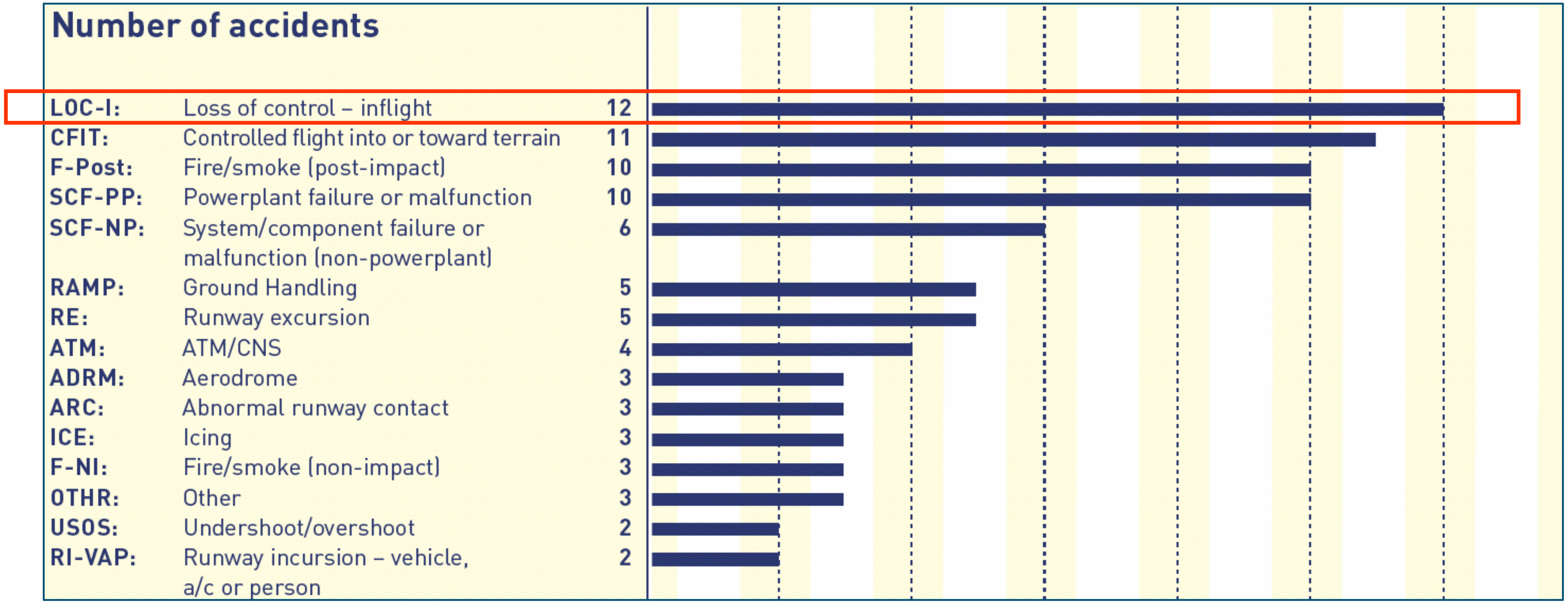
No.	Participant organization name	Country
1	TNO	Netherlands
2	NLR (National Aerospace Laboratory)	Netherlands
3	AMST Systemtechnik	Austria
4	BR&TE (Boeing Research & Technology Europe)	Spain
5	GFRI (Gromov Flight Research Institute)	Russia
6	TsAGI (Central Aerohydrodynamic Institute)	Russia
7	Dinamika	Russia
8	De Montfort University	United Kingdom
9	Max Planck Institute for Cybernetics	Germany

- Budget 4.9M€
- September 2009 –2012

Upset Recovery

The problem

- Loss-of-Control (LOC-I) leading cause of fatal accidents
- Unsuccessful upset recovery often contributing factor



Upset Recovery

The problem

- LOC-I accidents in Russian states:
  - 1994: A-310 (stall, upset, spatial disorientation)
  - 1995: Tu-154 (upset, spatial disorientation)
  - 2000: Yak-40 (stall at takeoff)
  - 2001: Tu-154M (stall at approach for landing)
  - 2002: Il-86 (upset, stall after takeoff)
  - 2005: An-24 (stall at approach for landing)
  - 2006: A-320 (spatial disorientation, upset)
  - 2006: Tu-154M (deep stall)
- Russian Center for Upset and Stall Training (Interstate Aviation Committee)

ЗАМЕСТИТЕЛЬ ПРЕДСЕДАТЕЛЯ
МЕЖГОСУДАРСТВЕННОГО
АВИАЦИОННОГО КОМИТЕТА

Upset Recovery

The problem

- Airline pilots trained to *avoid* upset situations
- Recognized need for (simulator) training
- Simulator training cost-effective and safe

However, current FFS inadequate:

- Aerodynamic models
- Motion envelope (in particular G-load)

SUPRA project

Main objective

- To develop advanced flight simulator technologies for teaching airline pilots to detect and recover from upset conditions

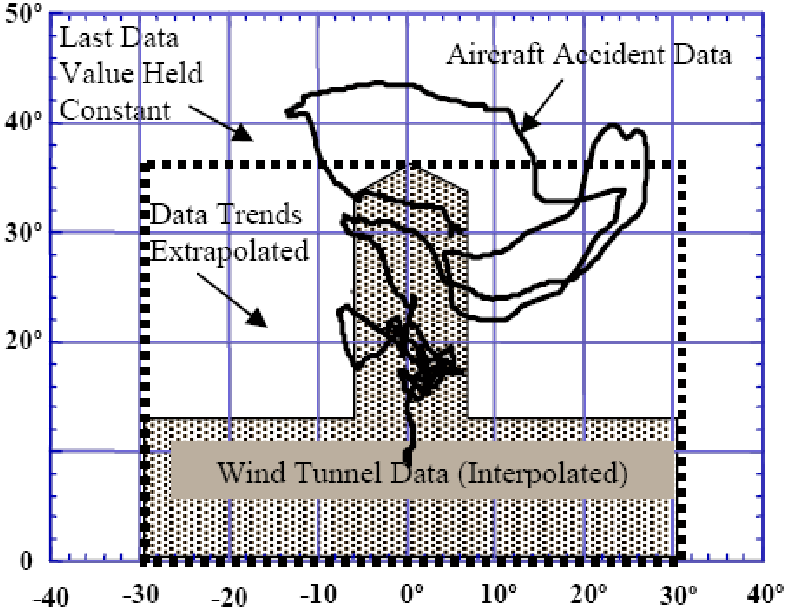
Research activities

- Definition of relevant upset conditions
- Aerodynamic modeling
- Pilot perception modeling
- Motion cueing algorithms
- Final experimental evaluation

Aerodynamic modeling

Baseline aerodynamic models

- Limited to standard flight envelope



(Cunningham et al. 2005)

Aerodynamic modeling

Baseline aerodynamic models

- Limited to standard flight envelope

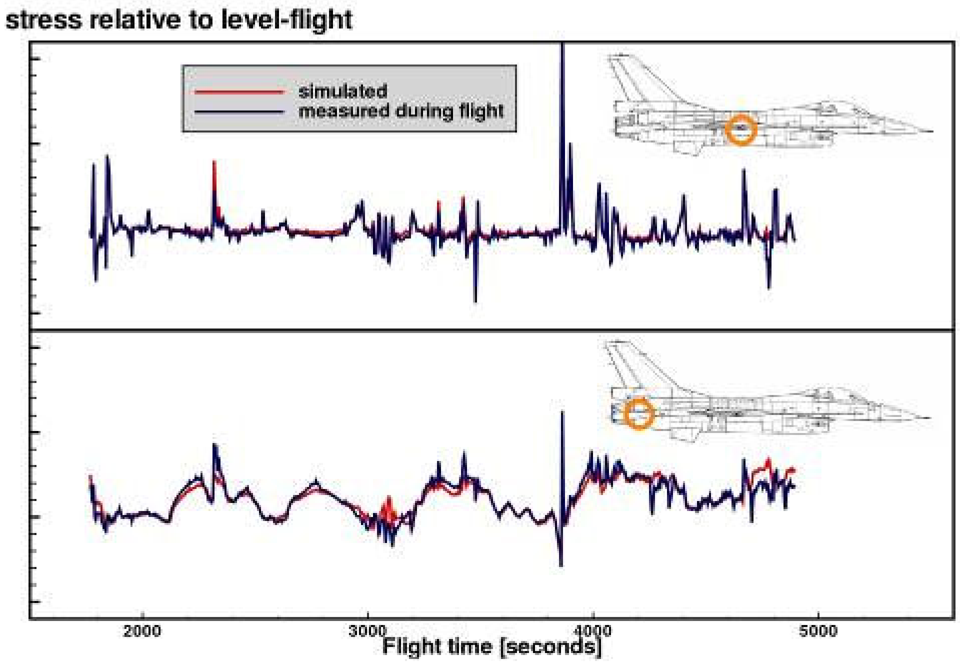
Required extensions

- Non-linear aerodynamics at high AoA, angular rates
- High load deformations at high incidence
- Dynamic hysteresis
- Validation versus dynamic wind tunnel and flight tests

Aerodynamic modeling

Computational Fluid Dynamics

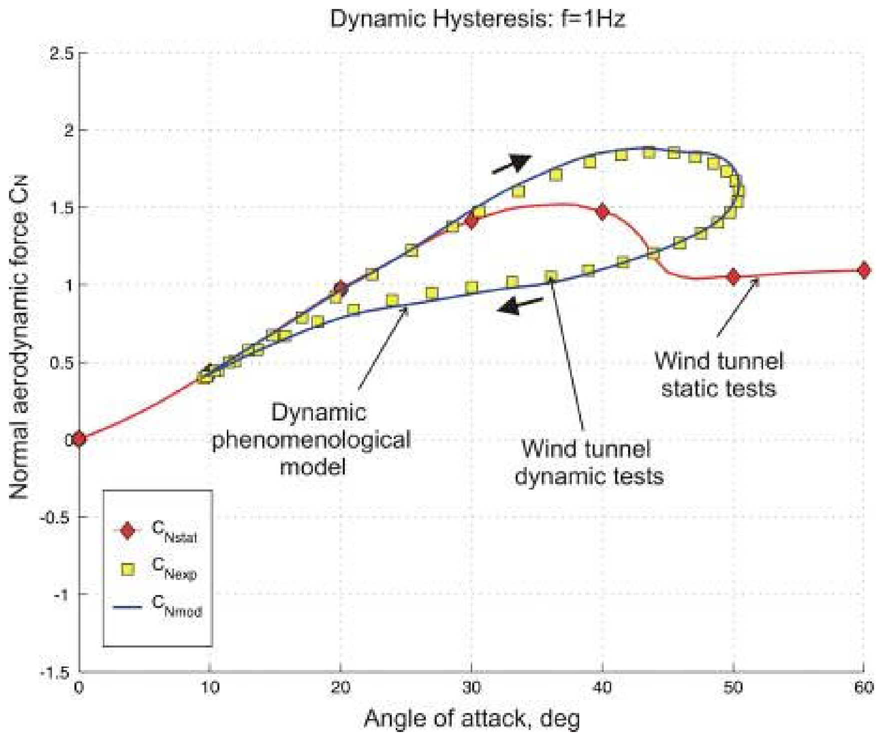
- Unsteady non-linear aerodynamics
- Load deformations



Aerodynamic modeling

Phenomological modeling

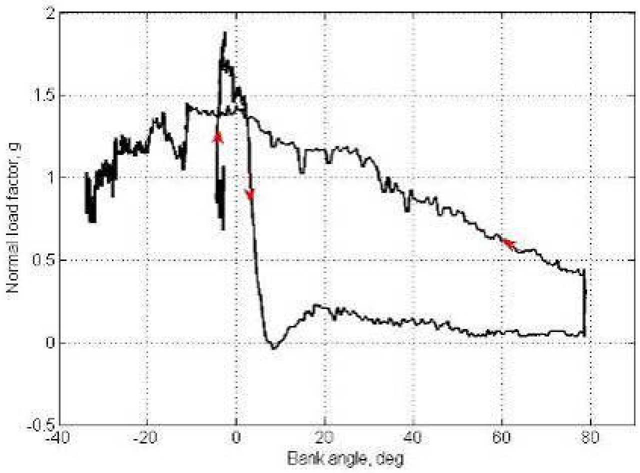
- Captures dynamic hysteresis
- Consistent with flight dynamics equations



Flight tests

- Instrumented TU-154
- High AoA, spin & stall, maximum loading
- To validate extended aerodynamic models
- To determine recovery procedures





SUPRA Research simulators

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Hexapod-based FFS

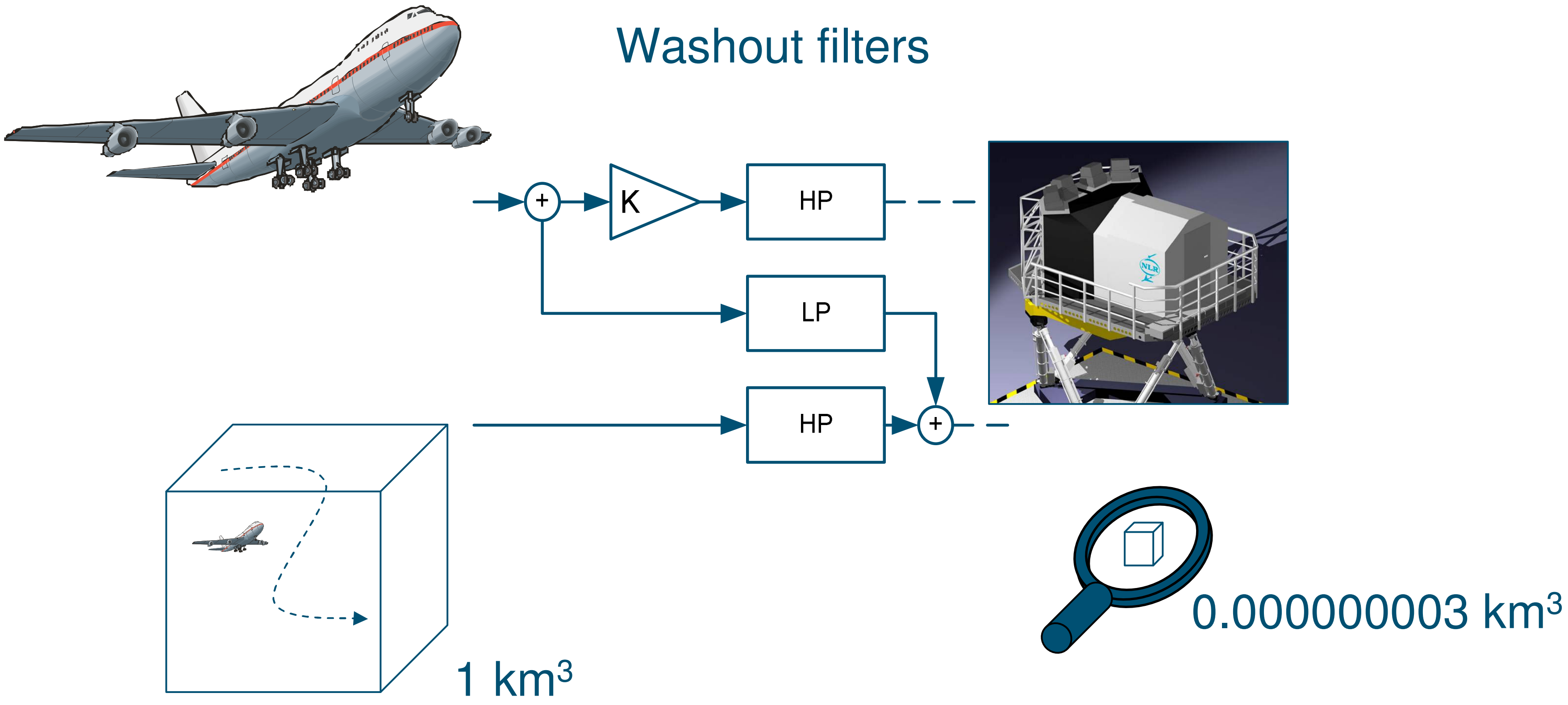
- GRACE (NLR)
- PSPK-102 (TsAGI)

New-generation motion platforms

- DESDEMONA (TNO)
- Kuka (Max Planck)

Motion cueing

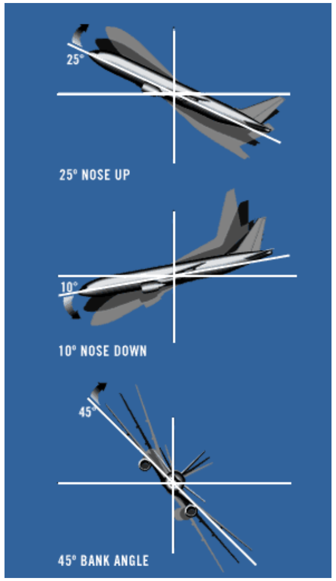
- Mathematical filters that confine the motion space of the simulator, while still providing the *relevant* motion cues



Motion cueing

Classical washout filters

- Linear transfer functions
- Optimized for normal flight envelope



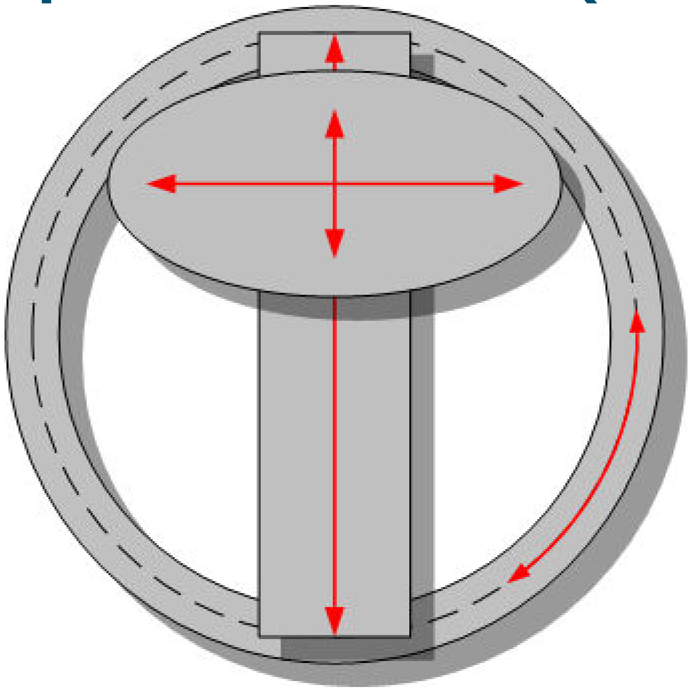
Advanced motion filters (TNO, NLR, TsAGI):

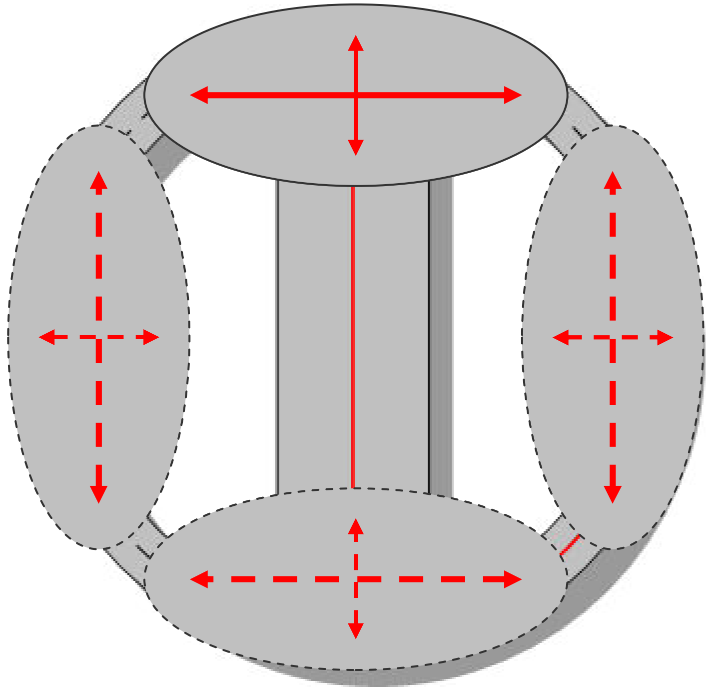
- Extreme attitudes
- High angular rates
- G-cueing

Motion cueing

New motion cueing strategies

- **Hexapod emulation (4x2x2m)**
- **Spherical washout (∞ x2x2m)**

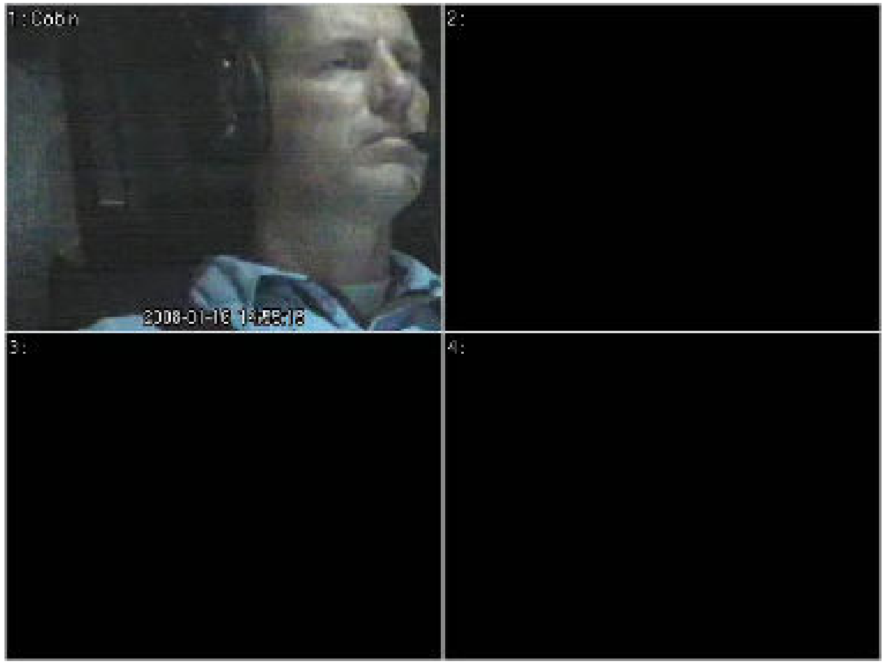


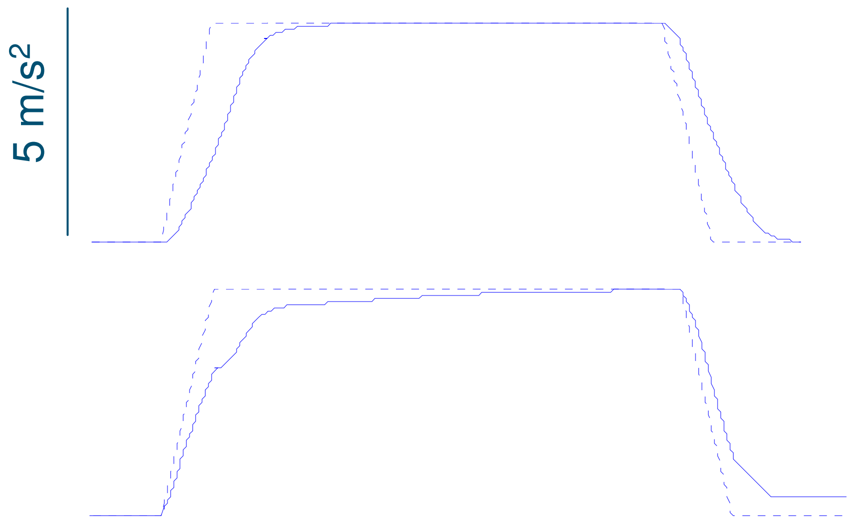


Motion cueing

New motion cueing strategies

- **G-cueing**
  - Currently being developed for F-16 (and SUPRA)
  - Smart use of extra DoF's (e.g. extra Heave onset)

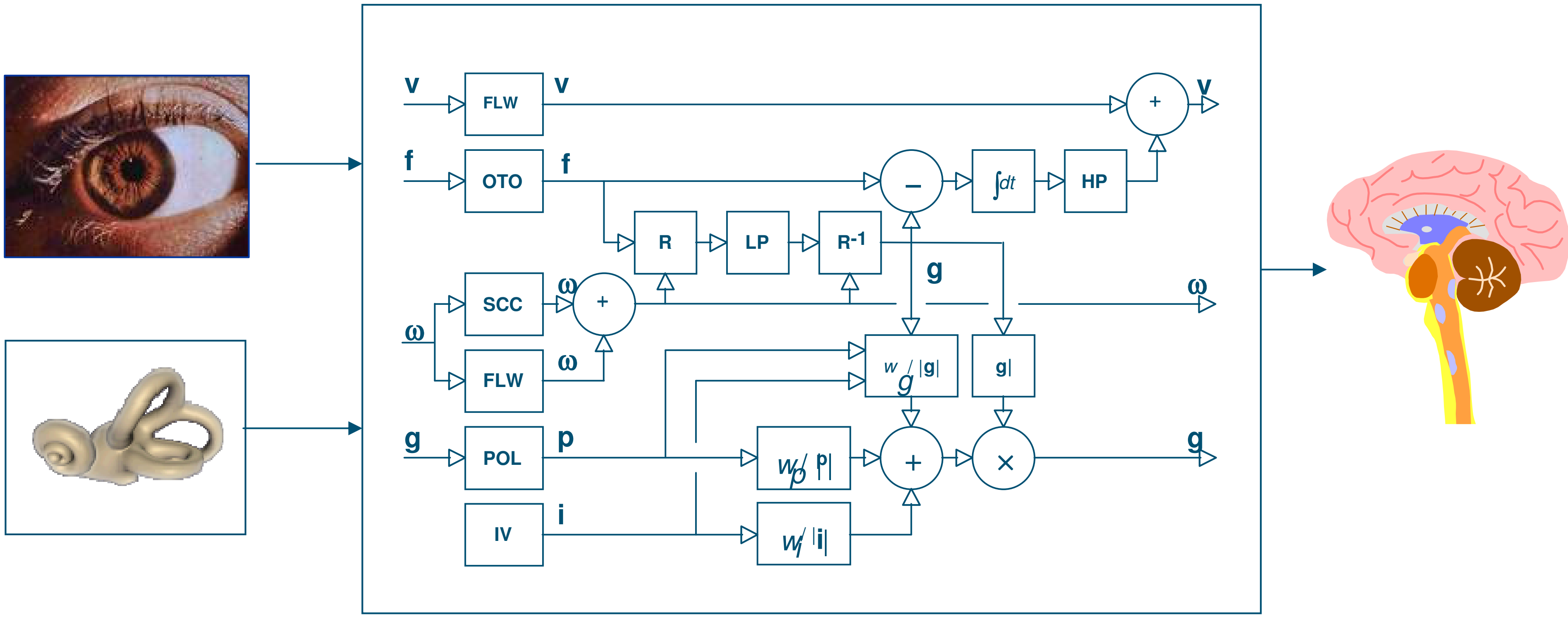




Motion perception modeling

TNO model

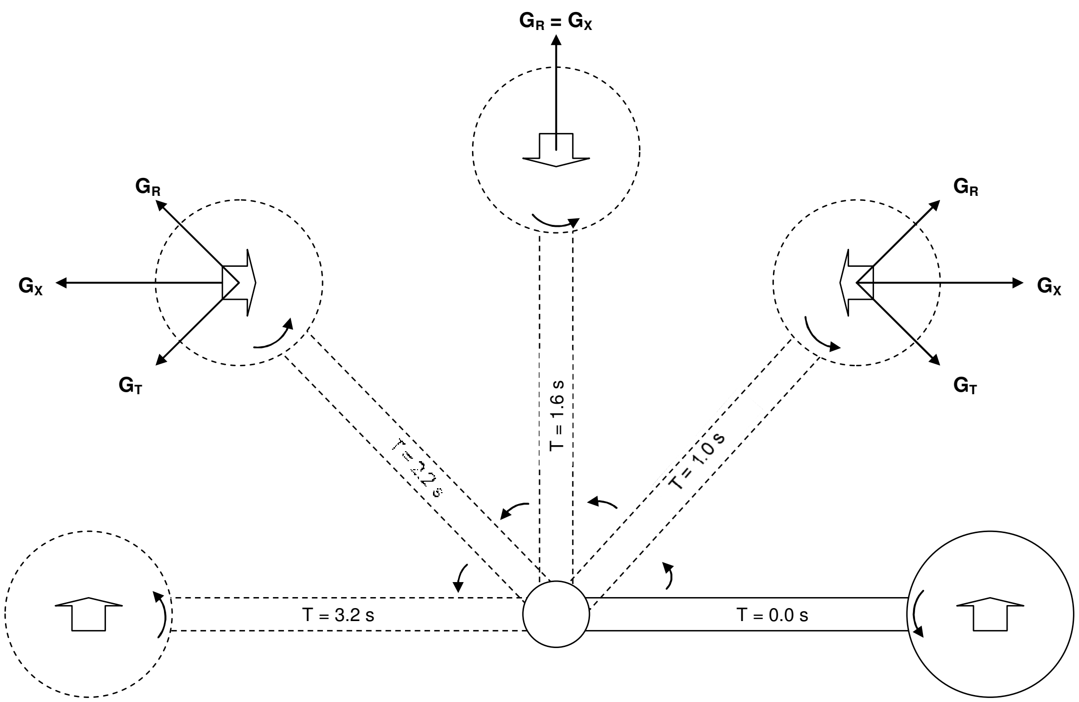
- Transfer functions of visual-vestibular interactions
- Validated at 1g in hexapod FFS (takeoff, decrab)



Motion perception modeling

Research issues

- Motion perception under G-load
- Detection thresholds and tolerances
  - False cues (e.g. Coriolis stimulation)



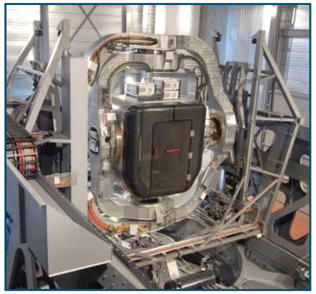
Experimental validation

- Experimental test pilots
- Airline pilots
- Quasi transfer-of-training

Aircraft model

Motion cueing

Upset scenario →



End result

Efficacy of different simulator configurations for upset recovery

- Hexapod
- DESDEMONA

Recommendations

- Upset recovery procedures
- Aerodynamic model extensions
- Motion cueing requirements

SUPRA Expert Group

Expert	Organisation
Cpt. Dave Carbaugh	Boeing
Cpt. Etienne Tarnowski	Airbus
Cpt. Vladimir Birykov	Russian Interstate Aviation Committee
Cpt. Wilhelm Brugger	Austrian Cockpit Association
Cpt. Heinz Fruewirth	European Cockpit Association
Cpt. Dieter Reisinger	IATA Accident Classification Task Force
Cpt. Raymond Teunissen	KLM
Cpt. Fili van Biervliet	Sabena Flight Academy
Dr. Sunjoo Advani	IDT
Ir. Victor Fuchs	AUA Flying School

Conclusion

The SUPRA project:

- Integrative approach to stretch the envelope of ground-based simulators for upset recovery
- Unique expertise and facilities

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