The SUPRA project
Overview

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OPTICS Conference, December 17-18, 2014, Brussels
Project information

- **Budget** € 4.9M (3.7M from FP-7 Transport & Aeronautics)
- **Duration** 3 years, Oct 2009 – Aug 2012
- **EC objectives**
  - Reduce aircraft accident rate by 80%
  - Improve elimination of, and recovery from human error
- **Consortium**
  - (NL) TNO, NLR
  - (RU) TsAGI, GFRI, Dinamika
  - (UK) DeMontfort University
  - (AT) AMST
  - (DE) MPI for Biological Cybernetics
  - (ES) Boeing R&TE
- **Expert Group**
  - Test and airline pilots, flight control and modeling experts
Rationale

- Loss of Control In-flight (LOC-I) leading cause of fatal accidents

LOC-I

- Normal flight
- Upset
- Loss of Control

No adequate prevention
No adequate recovery
The problem

- Upsets are extremely rare
- Current training focus on avoidance, not recovery
- Hence, flight crews may be inexperienced with upset situations:
  - Altered control behavior
  - G-loads
  - Startle factor
  - No, or delayed, response to indications

→ Training need
  - Academics
  - Exposure to flight environment
Exposure to flight environment

- Real aircraft
- Small aircraft
- Simulator
Flight simulator

• Main limitations for simulation of upset conditions

1. Aerodynamic model
   • Applies only to validated, normal flight envelope

2. Platform motion
   • Motion limits
   • No G-loads
SUPRA technical achievements

- Overcoming both limitations of flight simulators:
  - New extended aerodynamic model
  - New motion cueing strategies
SUPRA aerodynamic model

- Objective
  - Capture (post-)stall characteristics
SUPRA aerodynamic model (1/2)

- Approach
  - Phenomenological model
  - Extensive use of wind tunnel data
  - CFD data for dynamic hysteresis, autorotation, and aerodynamic asymmetry

$$C_{dyn} = \frac{\Delta C(\alpha)}{\alpha + 1}$$
SUPRA aerodynamic model (2/2)

- Capabilities at large angle-of-attack
  - Degraded lateral/directional stability
  - Uncommanded roll/yaw response
  - Degraded control response (pitch, roll, yaw)
  - Randomness
SUPRA motion cueing (1/4)

- 2 types of motion platforms
  - Hexapod-type (NLR, TsAGI)
  - Centrifuge-based (Desdemona)
SUPRA motion cueing (2/4)

- Hexapod-type simulators
  - Use standard washout filters, filtering out large aircraft motions, while only keeping “onset cues”

- SUPRA objective
  - Optimize filter parameters (gain, bandwidth)
  - Enhanced buffet motion
SUPRA motion cueing (3/4)

- Result hexapod-type simulators:
  - Improved **motion fidelity** from “low” to “medium”

Motion fidelity (“Sinacori plot”)

![Graph showing motion fidelity levels]

- Low
- Medium
- High
SUPRA motion cueing (4/4)

- DESDEMONA motion in SUPRA
  - Emulate “onset cueing” (no centrifuge, all other axes)
  - Reproduce G-loads (centrifuge)
  - Enhanced buffet motion
Final test pilot evaluation

- 10 experimental test pilots

- Man-in-the-loop evaluation of:
  - SUPRA aerodynamic model (18 different stall scenarios)
  - SUPRA motion solutions (Onset cueing, G-cueing, Buffeting)
Test pilot evaluation

• “Unique aerodynamic model, valuable for training”

• Simulator motion
  • No motion = “unacceptable”
  • Onset cueing = “just acceptable”
  • G-cueing = “identical to aircraft”
Valorization of SUPRA

- DESDEMONA training
- SUPRA-based stall handling
- Spatial Disorientation (pitch-up illusion at Go-Around)

- End-users
  - RNLAF military pilots
  - Civil flight operator(s)
Link of SUPRA to regulations

• Guidelines for Upset Prevention and Recovery Training (UPRT)
  • ICATEE (2009-2013)
  • ICAO (2013)
  • Rulemaking FAA / EASA
Link of SUPRA to regulations

- ICATEE (80+ experts)
- Training needs analysis

DESDEMONA
- Special devices
- Level D+ Enhanced model required
- SUPRA aerodynamic model

Possible with current means
• “...require part 121 air carriers to provide flight crewmembers with ground training and flight training or flight simulator training—

  • to recognize and avoid a stall of an aircraft or, if not avoided, to recover from the stall; and
  • to recognize and avoid an upset of an aircraft or, if not avoided, to execute such techniques as available data indicate are appropriate to recover from the upset in a given make, model, and series of aircraft”
U.S. Regulatory Context

- Part 121 Subparts N & O: Qualification, Service, and Use of Crewmembers and Aircraft Dispatchers
  - ... 
  - Requires pilots to complete ground training during qualification and recurrent training on **stall prevention and recovery** and upset prevention and recovery. This training adds 2 hours to qualification ground training and 30 mins to recurrent ground training.
  - ...
U.S. Regulatory Context

- 14 CFR Part 60 – Flight Simulation Training Device
  - Stall model characteristics
    - Degradation in static/dynamic lateral-directional stability
    - Degradation in control response (pitch, roll, yaw)
    - Uncommanded roll response
    - Apparent randomness or non-repeatability
    - Stall hysteresis
    - Stall buffet
    - Must be evaluated by an subject matter expert pilot

☑️ = provided by SUPRA
Link to SRIA enablers

• Enabler 9: New Crew and Team Concepts
  • Capability 2: Optimization of the Human Performance Envelope through better job design and management, to reduce current problems of fatigue, vigilance, poor decision making and loss of situation awareness or **loss of control**.

• Enabler 6: Standardisation and Certification
  • Capability 1: Common framework for Certification / Approvals which embrace **new technologies** and their integration within the systems to be certified and the use of new technologies and methods in the certification / approval processes.