GRADE Practice for Designing Pilot’s HMI and Experimental Procedures for General Aviation Enhanced Terminal Operations Based on GNSS

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Outline

• The GRADE project

• Human Factors Approach in GRADE

• Human Centred Design Approach to Validation Activities: HMI & Procedures

• Validation Results & Conclusions
The GRADE Project

• It is a Very Large Demonstration Project

• It aims to exploit SBAS and GBAS for GNSS-based and Category II/III procedures on GA Aircraft and Rotorcraft

• It encompasses the design of pilot HMIs for General Aviation equipment and of operational procedures applicable to such aircraft

• It is a European Cooperation involving 7 partners
The GRADE Project: \textit{Very Large Demonstration for GA}

- Demonstrations through real-time simulations and live flight trials

- 2 RTS campaigns
  - each one-week long,
  - 75 different approaches,
  - 17 hours of simulated flight

- 2 FT campaigns
  - 2 GA vehicles: CESSNA 172N, TECNAM P92
  - 2 airports: Braunschweig (EDVE), Capua (LIAU)
  - about 50 approaches,
  - about 20 flight hours
The GRADE Project: **SBAS and GBAS for GNSS-based Approach Procedures for GA**

- SESAR Solutions extension to GA
- Curved Continuous Descent precision approach procedures
- Integration of the project outcomes with the ATM Performance Framework and E-OCVM
- Relevant KPAs: Safety, Capacity, Cost-Efficiency, Equity, Human Performance
The GRADE Project: *Pilot HMI and Procedures Design*

- Two different pilot’s HMIs have been designed, developed and tested
- For each test airport, different precision approach procedures have been defined
- Human Factors (HF) perspective: tested technologies and procedures could impact current working methods of pilots and controllers, affecting the human component of the overall system performances
The GRADE Project: Human Factors Objectives

• Human Factors validation objectives:
  • acceptability of tested operations by ATCOs and Pilots in normal and abnormal operating conditions
  • cognitive workload
  • situational awareness and shared situational awareness for ATCOs and Pilot
  • capability of HMI to provide pilot with clear and complete information to execute landing procedures with a sufficient level of confidence and precision
The GRADE Project: Human Factor Evaluation Approach

• Combined human-system performance assessment (situation awareness, human error, workload) with usability assessment (comprehensibility, readability, visibility, perceptibility)

• Human Factors data have been collected by subjective tools:
  • 2 post flight questionnaires (1 for ATCOs and 1 for pilot)
  • 2 post session questionnaires (1 for ATCOs and 1 for pilot)
  • 2 semi-structured collective debriefings (1 post flight and 1 post session)
  • 1 collective session for procedures co-design to refine procedures, phraseology and scenario details
  • SART and NASA TLX (in some of Exercises)
The GRADE Project: *Involvement of Professionals*

- 2 Experimental Pilots in the first RTS campaign
- 1 (of the two) Experimental Pilot in the second RTS campaign
- 4 Experimental Pilots (1 in Capua, 3 in Braunschweig) in the FT campaigns
- 4 Professional TMA ATCOs and 1 Supervisor involved in all the RTS and FT campaigns
The GRADE Project: **Human Centred Design Approach to Design Validation Activities**

- Iterative process applied to both HMI and Procedures
The GRADE Project: Outcomes of HCD Approach to Validation Activities

Examples of evidences from HCD approach

- Vertical profile
- Dimension of navigation instruments
- Positioning of alarms
The GRADE Project: The Pilot HMs
The GRADE Project: *Outcomes of HCD Approach to Validation Activities*

Examples of needs from procedures design process

- Precise dimensioning and positioning of CCD procedures with respect to RNAV;
- Need and positioning of stacked holding patterns
The GRADE Project: *The Final Procedures*
The GRADE Project: Preliminary Conclusions

- All the HP Validation Objectives have been validated and tested
- Solutions have proven to be feasible and beneficial for GA with respect to conventional RNAV procedures
The GRADE Project: *Preliminary Conclusions*

- Relevant KPIs assessment results:
  - **Safety**: GNSS procedures allow improving the navigation accuracy (TSE widely lower than 0.3 NM), reducing the risk of incident and CFIT.
  - **Capacity**: measured in terms of average time between two consecutive approaches, resulted in very limited reduction, in the order of few seconds, confirmed in flight tests.
  - **Cost Efficiency**: the KPI used to assess the airport throughput is also an indirect measurement of the number of aircraft managed by the ATCO in the considered period.
  - **Equity**: the GA aircraft capability to take advantage from the solutions developed during SESAR 1 positively affects the KPA, because the same opportunities are available for all the airspace users.
The GRADE Project: Final Considerations

The project results showed that:

• Designed HMIs and procedures allowed demonstrating that GNSS-based procedures with CDA and curved legs are feasible and beneficial for GA

• Design process could highly benefit from the HCD iterative process, strongly exploiting RTS and FT campaigns for the final assessments

• A similar approach was used in the project for rotorcraft PinS and SNI approach maneuvers, not presented in this paper

• The HCD allowed gaining a high level of significance of RTS and FT activities and results, paving the floor to a wider range of use cases and potential users that could benefit of tested solutions
The GRADE Project

Many Thanks