



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

9th SESAR Innovation Days



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Outline

- The GRADE project
- Human Factors Approach in GRADE
- Human Centred Design Approach to Validation Activities: HMIs & Procedures
- Validation Results & Conclusions

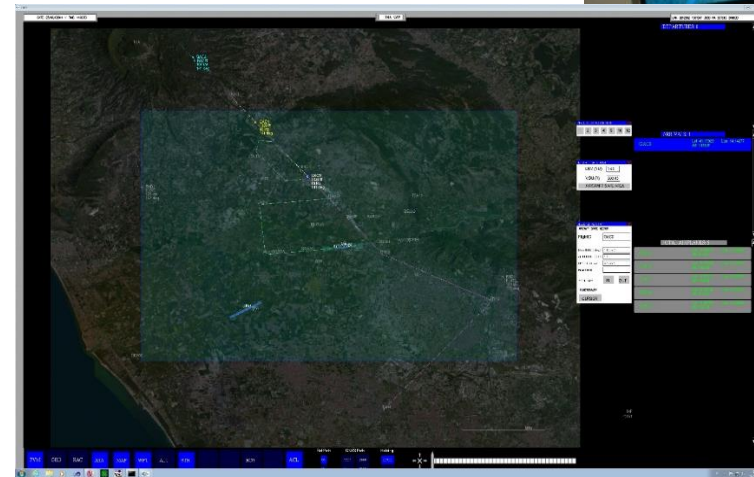
The GRADE Project

- 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: *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

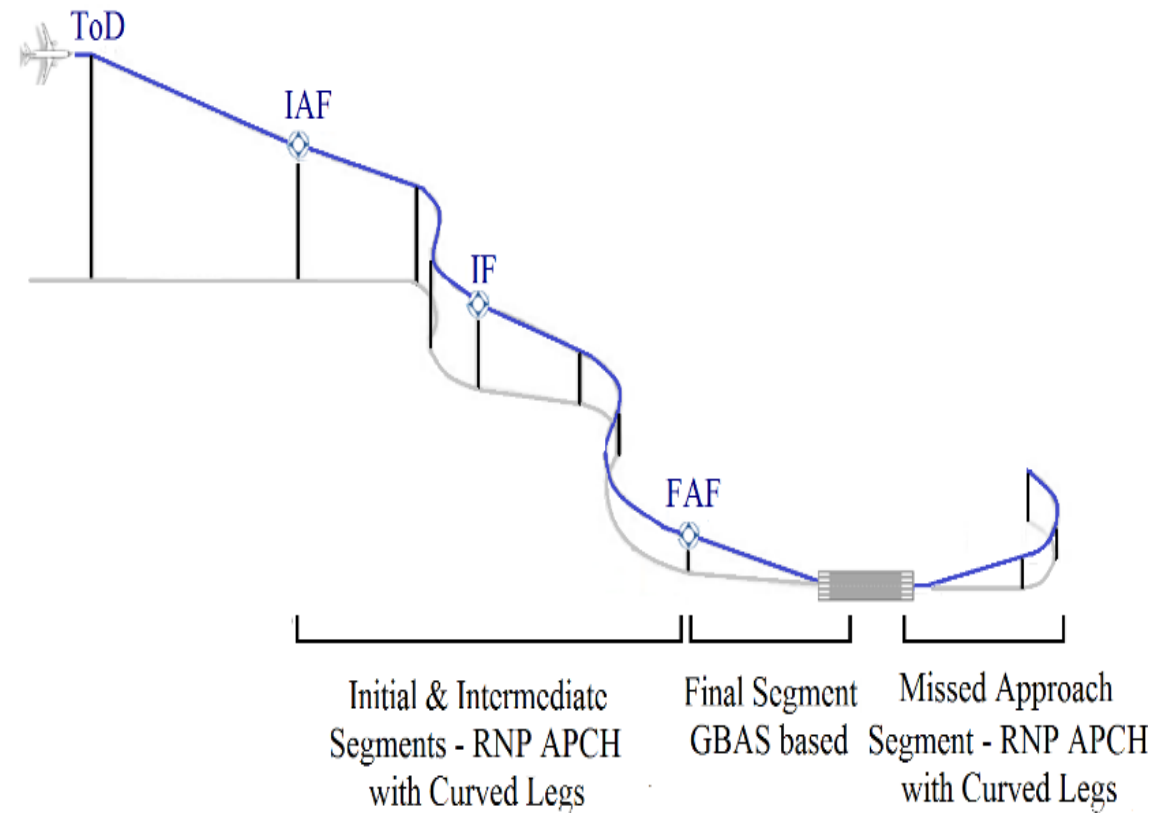


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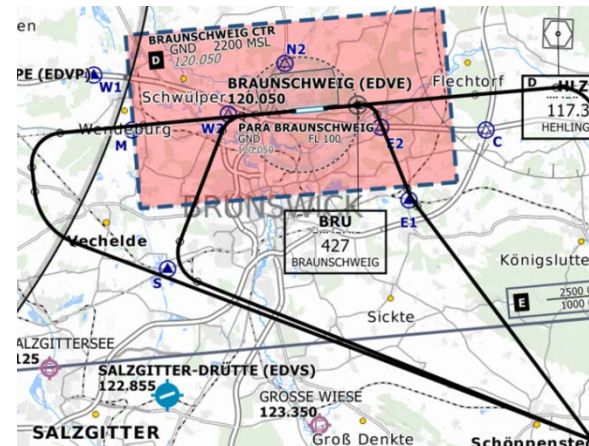
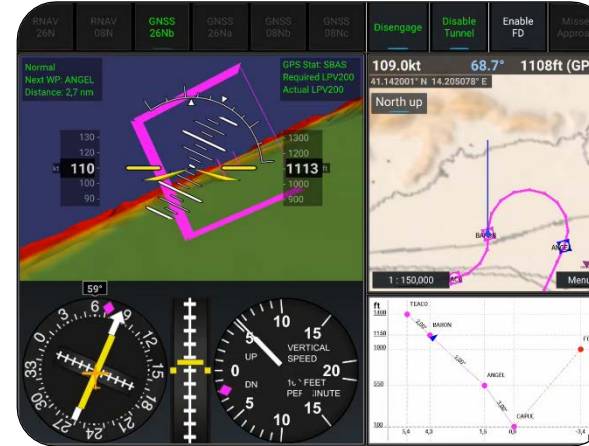
The GRADE Project: *SBAS and GBAS for GNSS-based Approach Procedures for GA*

- 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*

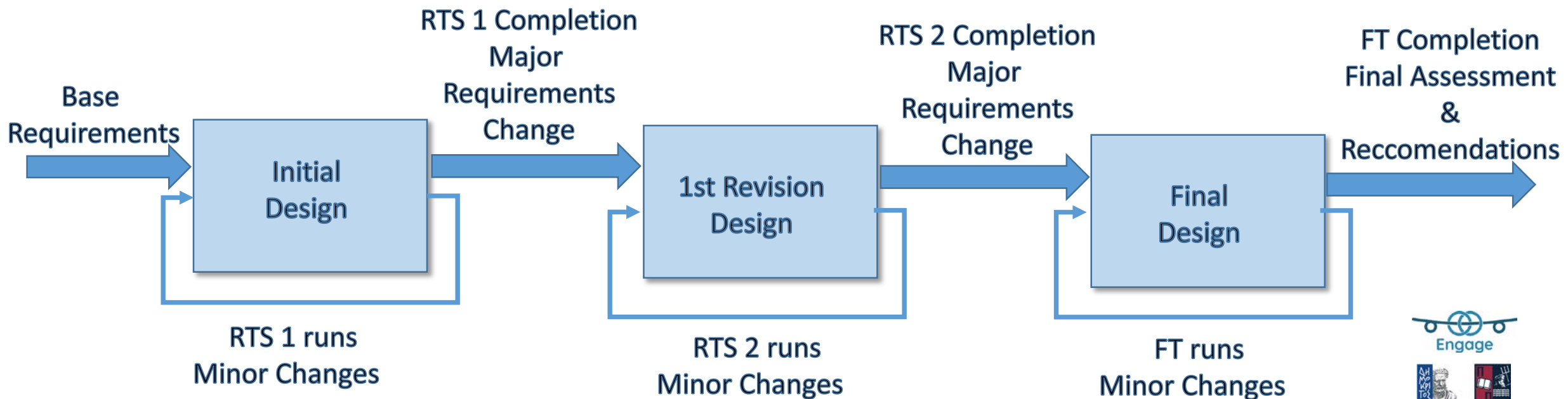
- Combined human-system performance assessment (situation awareness, human error, workload) with usability assessment (comprehensibility, readability, visibility, perceptibility)
- Human Factors data have been collected by subjective tools:
 - 2 post flight questionnaires (1 for ATCOs and 1 for pilot)
 - 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*

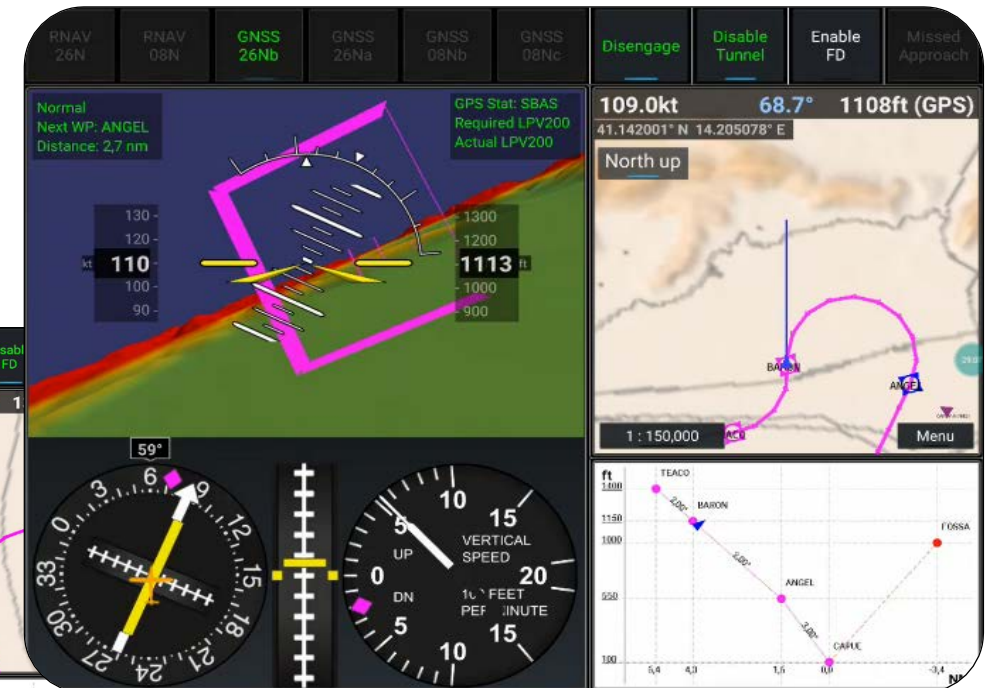
- Iterative process applied to both HMI and Procedures



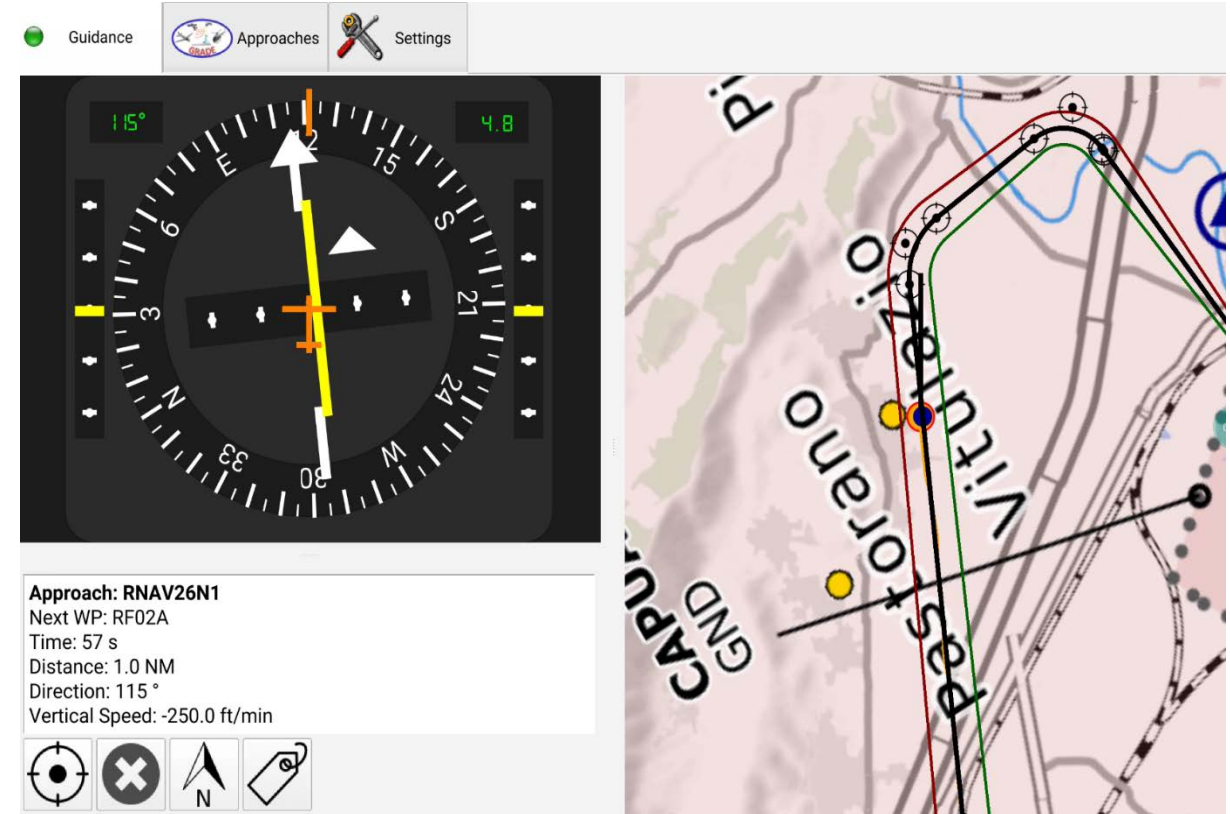
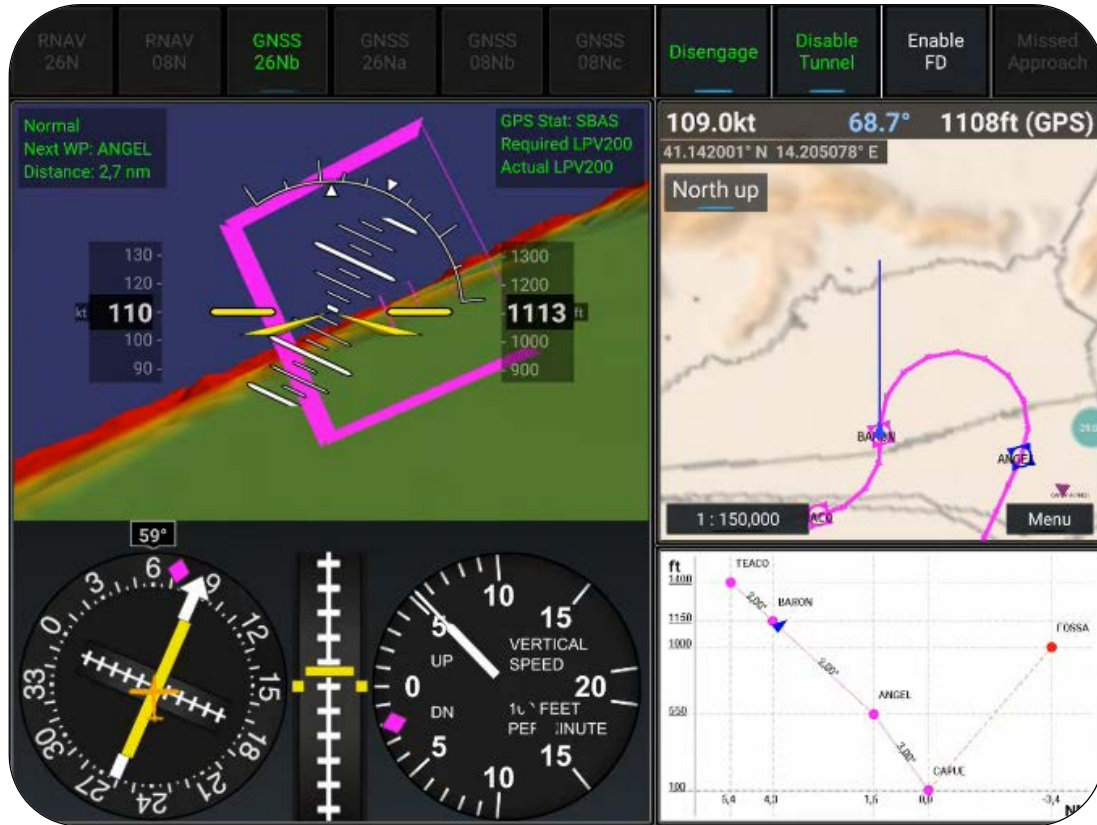
The GRADE Project: *Outcomes of HCD Approach to Validation Activities*

Examples of evidencies from HCD approach

- Vertical profile
- Dimension of navigation instruments
- Positioning of alarms



The GRADE Project: *The Pilot HMIs*



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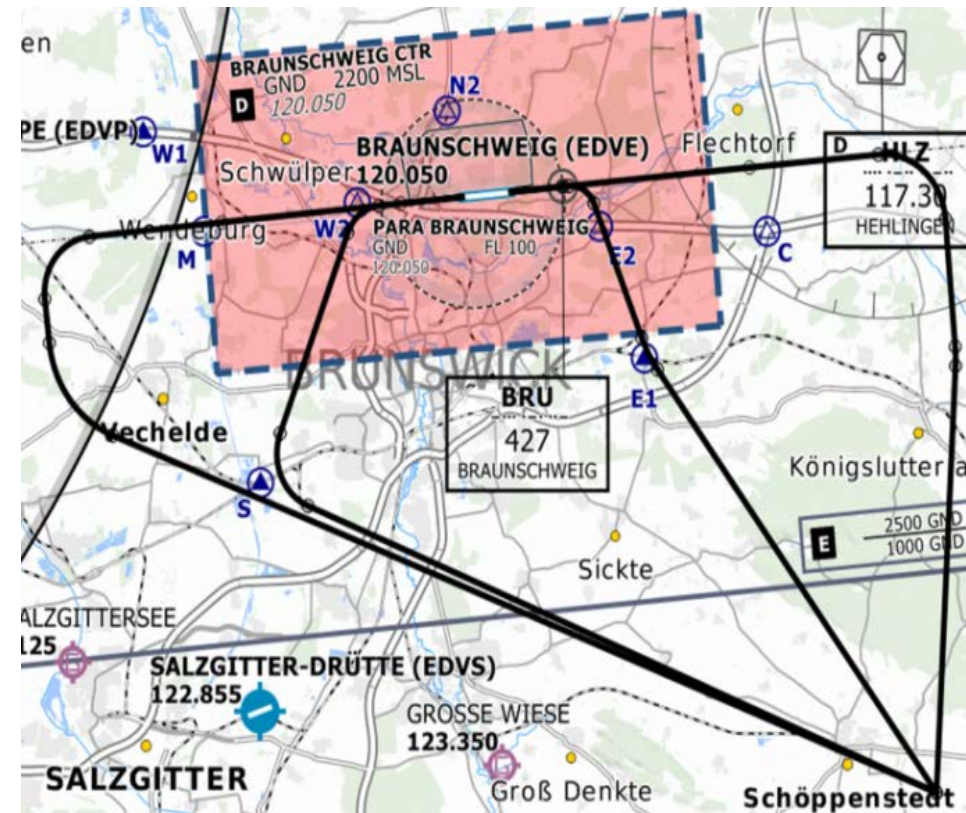
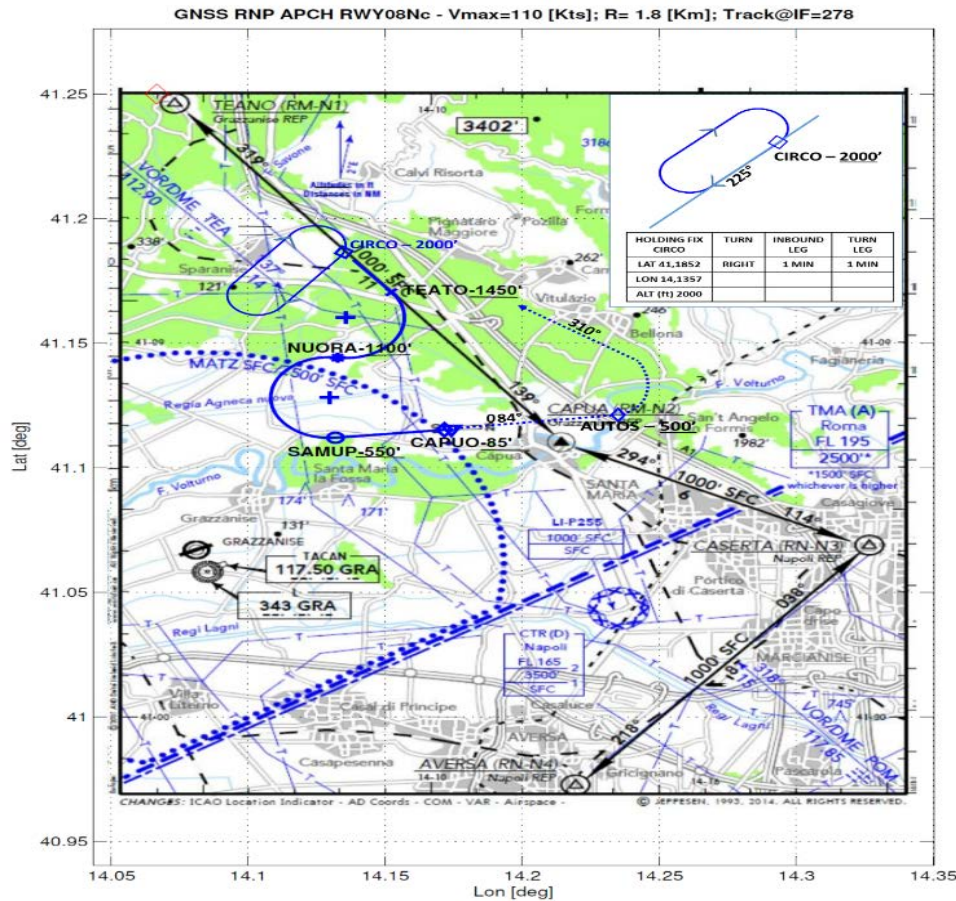
The GRADE Project: *Outcomes of HCD Approach to Validation Activities*

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

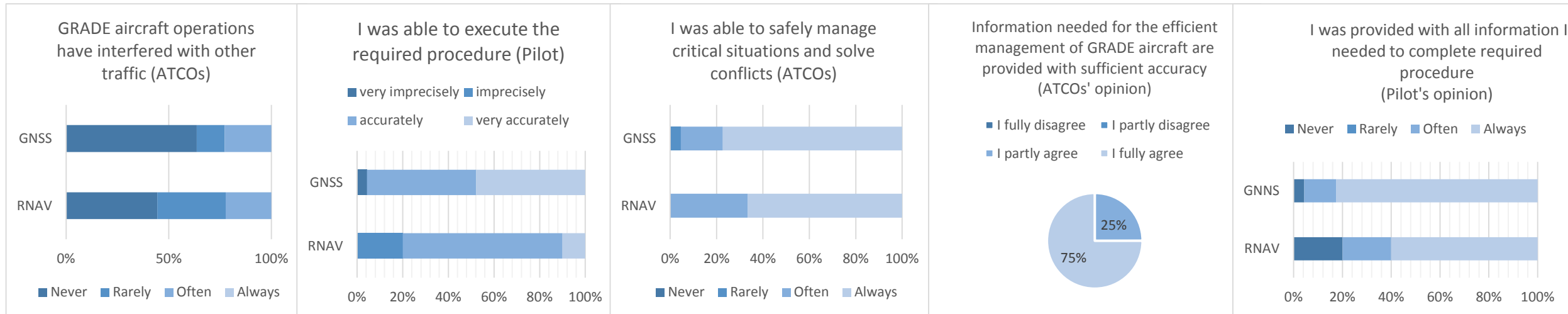


The GRADE Project: *The Final Procedures*



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



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