TECHNISCHE UNIVERSITÄT DRESDEN

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Accelerated Risk Analysis in ATM: An Experimental Validation Using Time Pressure as a Stressor

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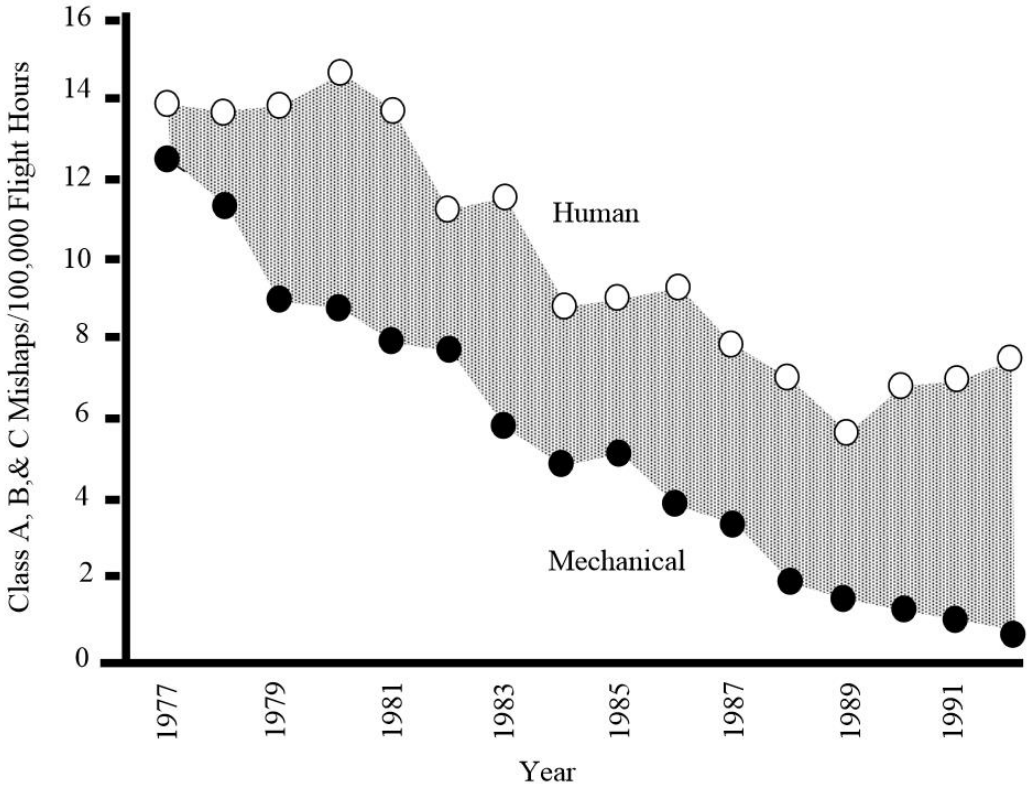
Human and technical contribution to aviation accidents

- The human operator is today a major contributor to risk



(Shappell & Wiegmann 1997)

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The challenge of introducing novel sociotechnical systems to aviation

- The predictive estimation of risk by means of experts statements
- Safety Cases are not known when starting to operate
- E.g. Remote Tower (see picture from LFV)

Methods of risk analysis in aviation

- Expert assessment
  - Fast identification of hazards and determination of risk
  - Subjektiv estimation
  - Often refering to status quo
  - No evidence of validity

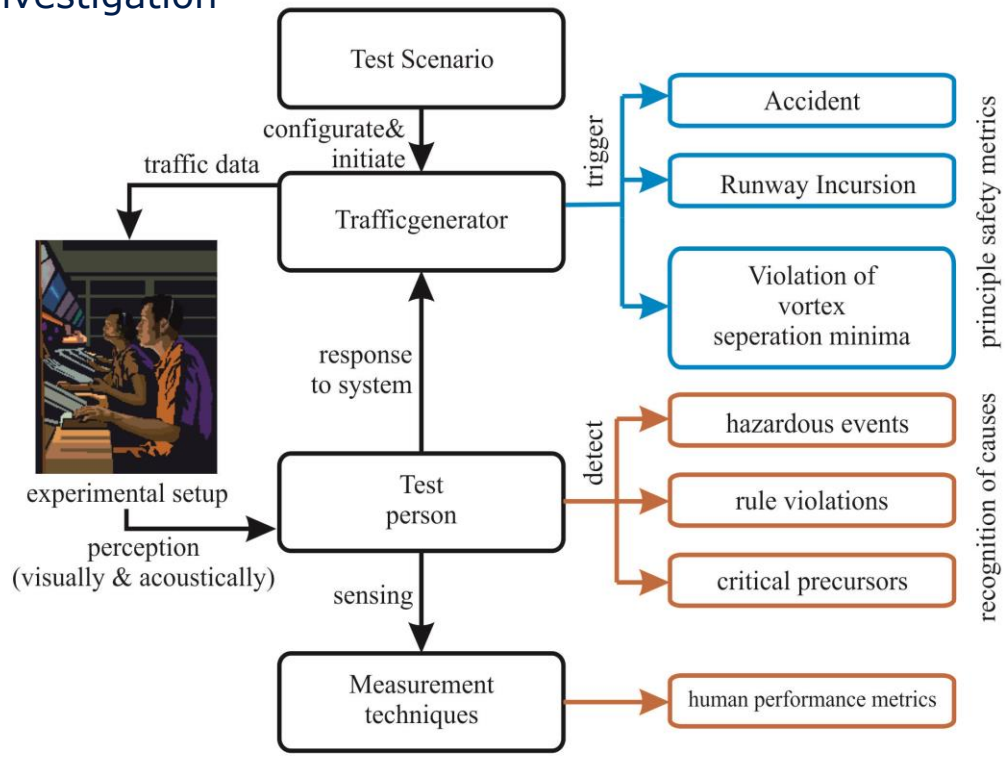
Human in the loop as a mean to analyze risk

- Control of initial and boundary conditions
- Proving human safety performance by observation data
- Integration of novel systems without risk
- Simulating situations that involve multiple operators (human to human)

Source CAE Electronics

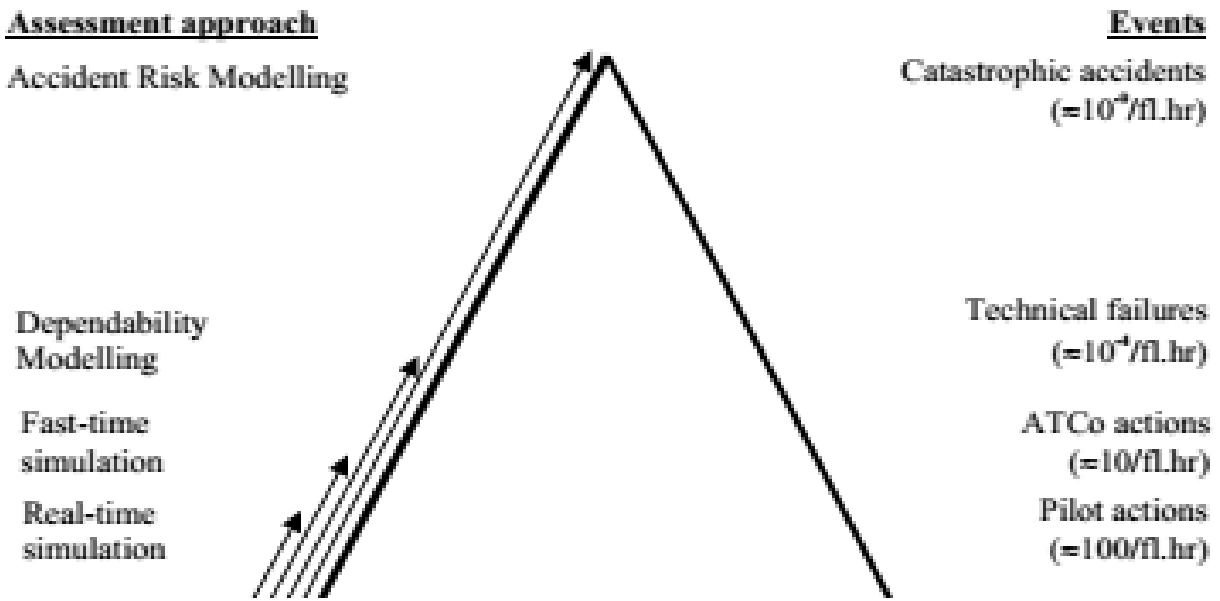
Human-In-The-Loop as a mean to analyze risk

- Measuring safety metrics and safety indicators offers optimal conditions for safety related investigation



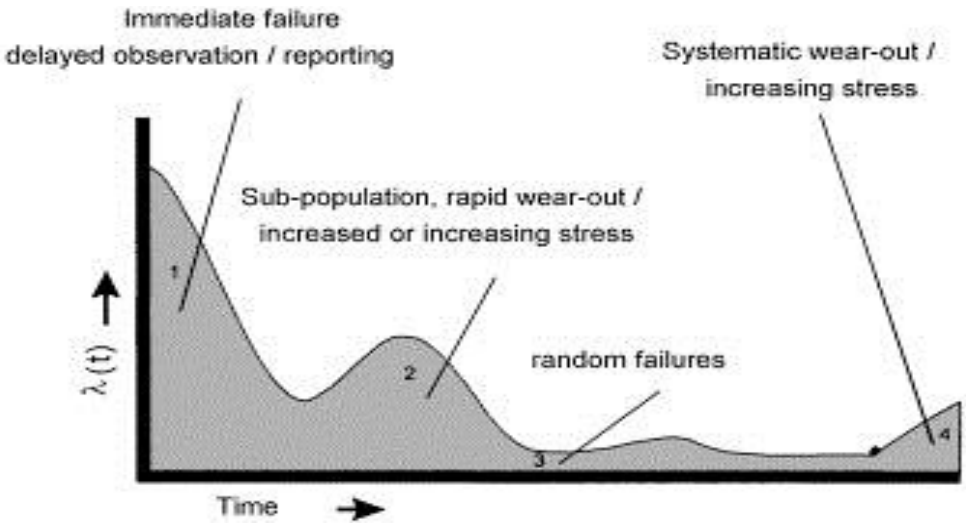
Safety Iceberg Problem

- General problem of proving a safety critical systems on the compliance with given safety objectives in aviation (Blom 2001)



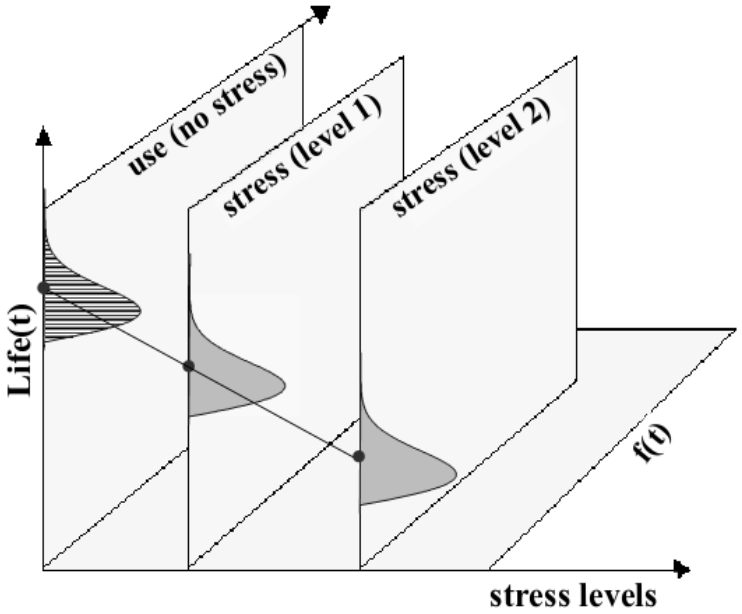
Accelerated Risk Analysis

- Approach of the concept: **Controlled stimulation of human error**
  - Human error: The decision making with an unacceptable low quality
  - Amplifying human uncertainty (quality degradation)
  - Effect: Acceleration of a statistic convergence in probability (J. Bernoulli).
- This concept is motivated by the methods of *Accelerated Life Testing*



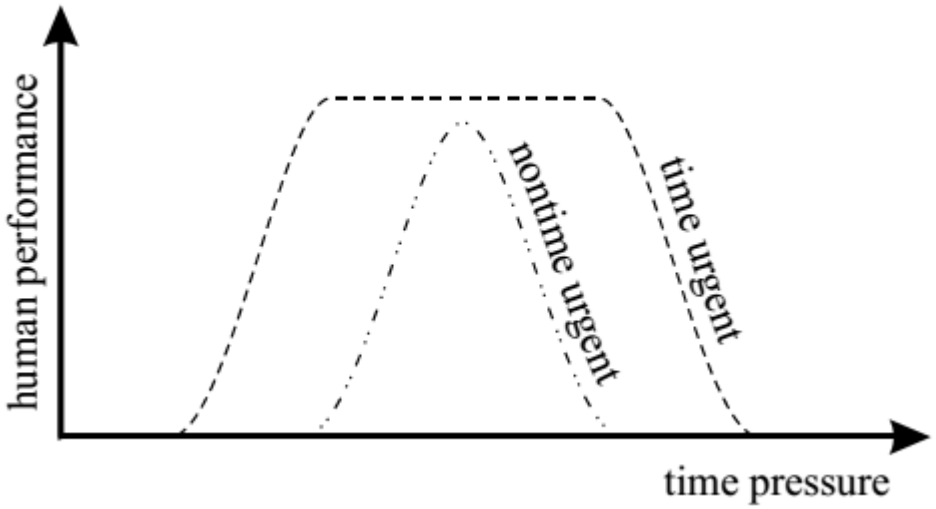
Accelerated Risk Analysis

- Life Testing: Conclusion from failure rates under conditions of accelerated stress on failure rates under design conditions by means of a stress-life-relation
- Calibrated stress induction

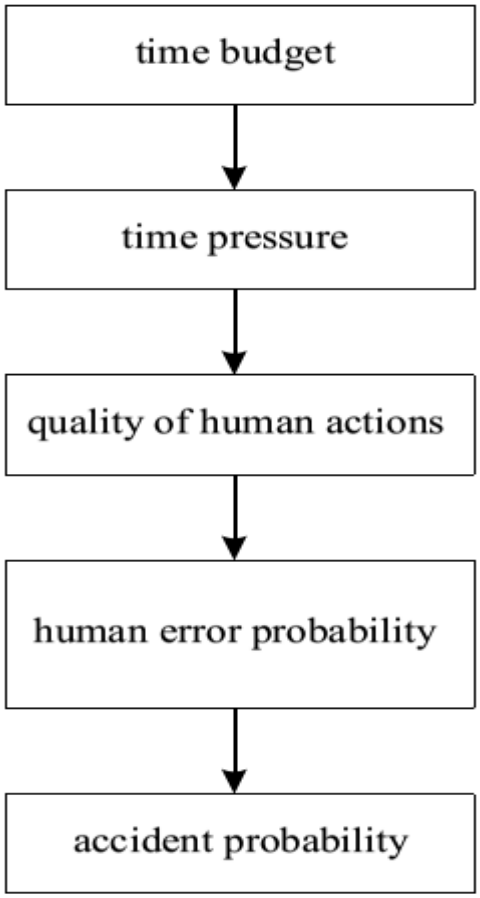


Stimulation of human error

- Intensifying uncertainty of human decision making by inducing a controlled time pressure
- Time pressure is defined„*…as the difference between the amount of available time and the amount of time required to resolve a decision task"* (Rastegary, 1993)
- Human performance of decision making as a function of time pressure (Freedman & Edwards, 1988), basing on the *Yerkes–Dodson* law (1908)



Model of time pressure induction for error stimulation

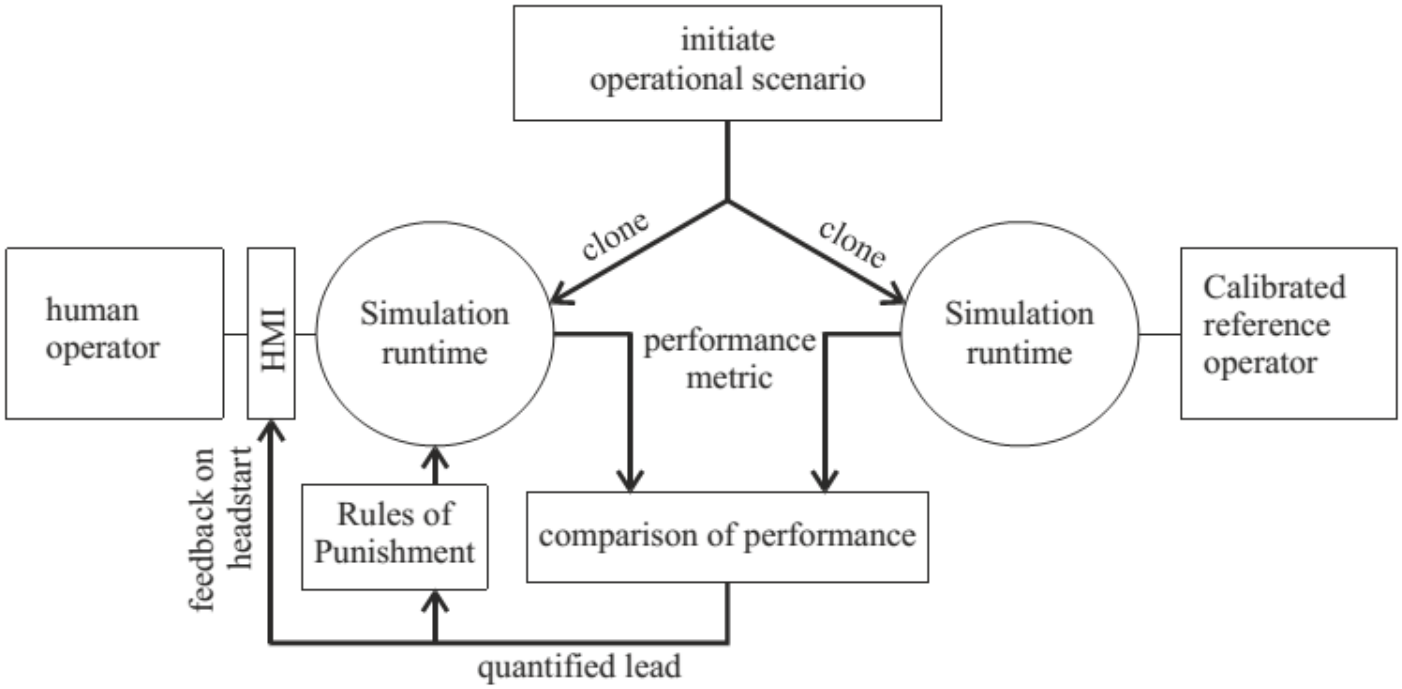


Empiric study

- Proving internal validity
  - Reproducing time pressure effects and stress responses
  - Proving the stimulation of safety metrics
- Surface Movement Manager at Frankfurt a. Main Airport

Competitive Performance

- Two operators competing under equal operational conditions
- Using a calibrated reference operator as a competitor
- Task of the human operator: Maintaining the head start over the competitor



Test persons and scenarios

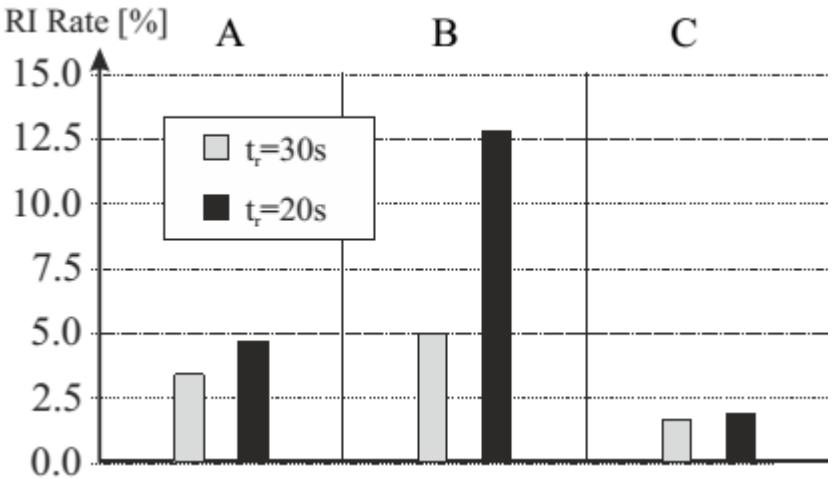
- Three test persons were selected and trained 10 hours according to the procedures (ICAO manual doc. 4444 PANS-ATM)
  - E.g. Taxi clearances, Lineup clearances, Take-off clearances
- Accomplishment of a final qualification test
- The traffic volume consisted of 160 movements inbound and outbound in 240 minutes (120 min. in real time)

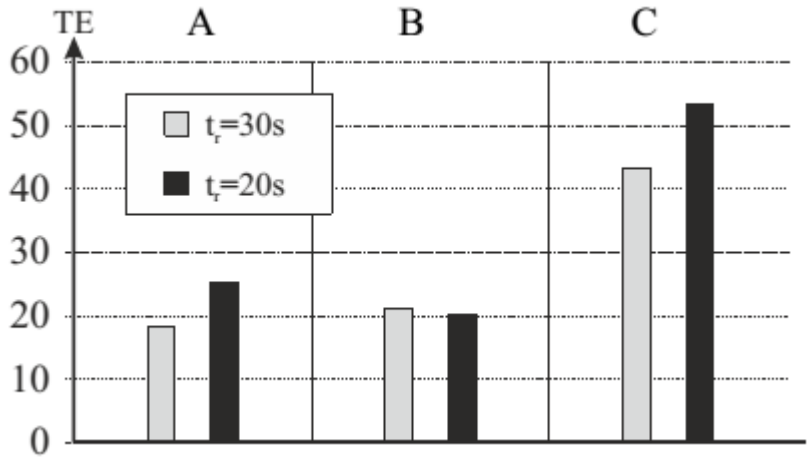
The software based controller agent

- The reference operator is a software-based controller agent, capable to control traffic safely.
- The agents speed work is adjustable by a reaction (latency) time t_r per clearance
- Two target load are parameterized, defining two graduations of time pressure load
  - Load 1: $t_r = 30$ sec.
  - Load 2: $t_r = 20$ sec.
- The visual feedback is implemented as a clock, indicating the head start
- The acoustic feedback is implemented as a hard alarm noise
- The penaltly increased the aircraft-queue by two.

Results

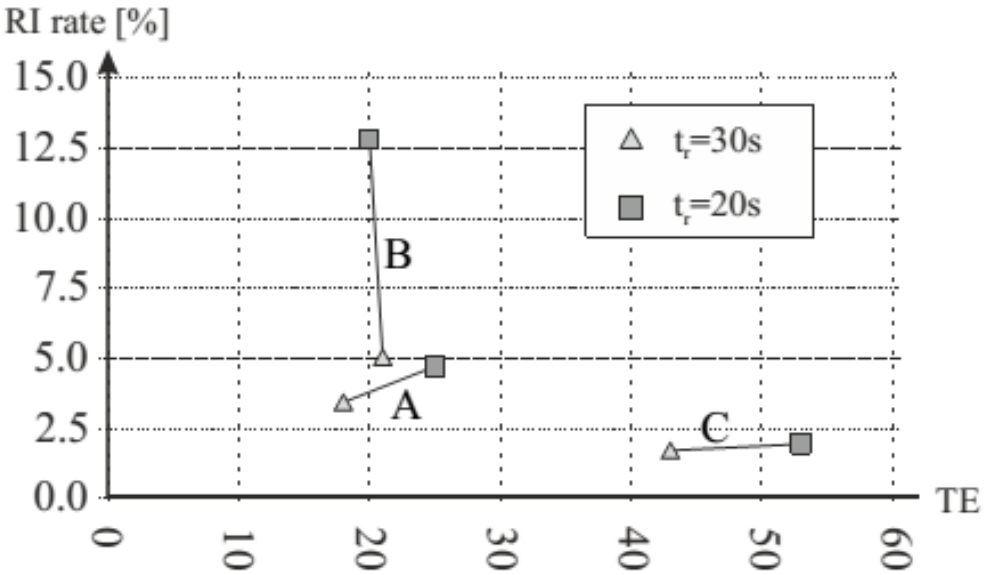
- Runway Incursion event is selected as a principle safety metric
- RI-Rate: Frequency of Runway Incursion divided by the frequency of take-off clearances
- TE: Frequency of time errors occurred





Conclusion

- The speed-accuracy-trade-off is identified for all test persons, confirming *Fitts* Law (1954)



Conclusion

- An increasing rate of runway incursion was measured for all test persons when decreasing the reaction time t_r, indicating a decrease in the quality of decision
- Compensation effects were identified:
  - Increasing robustness against the induction procedure (test person C)
  - Changing strategies during the experiment, promoting the occurrence of Runway Incursion (test person B) and indicating a loss of control
- Test persons A and C maintained a stable trade-off between time errors and RI-Rate.

Thank you!

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