TECHNISCHE UNIVERSITÄT DRESDEN

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Understanding the safety-relevance of visual cue perception at a Surface Manager HMI

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Overview

1. Motivation for empirical Risk Analysis of sociotechnical systems in ATM
2. Introduction to a new concept for Risk Analysis
3. Empirical Concept Evaluation
4. Results
5. Conclusions for further research

Definition of Risk:

"Risk is defined as the probability that an accident occurs during a stated period of time"

Blom (2003)

Motivation for the proof of concept study

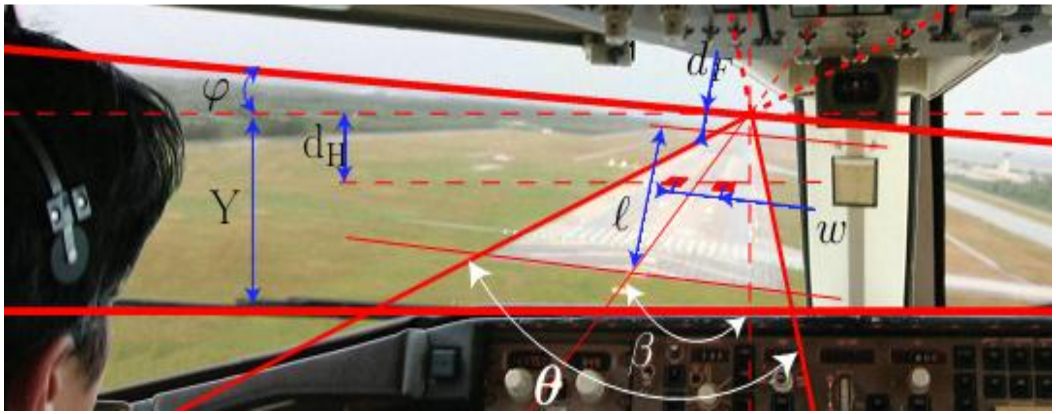
- The predictive Risk Analysis on sociotechnical systems provide valuable estimations on the resulting ATM safety-performance
- Traditional Risk Analysis rely on expert statements (subjective estimation)
- New concepts for model-based risk analysis have been evaluated (objective estimation). No direct evidence from current operations for validation.
- A pure empirical approach for Risk Analysis by means of Human-In-The-Loop Simulations often lacks statistic power when proving the system-safety against rare safety-critical events.
- An approach is needed that indicates risk predictively by objective measures
- A Human-In-The-Loop approach is proposed for an empiric approach for Risk Analysis

Using visual cue perception as a risk indicator

- Why using actions of the operator for visual cue perception as risk indicators?
  - Operators involve visual information essentially for decision-making in safety-critical situations (e.g. virtual tower, flare initiation)
  - We assume the safe decision-making as being strongly sensitive to the design of the visual provision of the traffic situation.
  - There is a trend of computerization and automation in tower and flight deck operations, involving increasingly the visual stimulation for information perception in ATM (e.g. datalink and A-SMGCS).
- Visual Cue Perception indicates the contribution of the system design to risk.

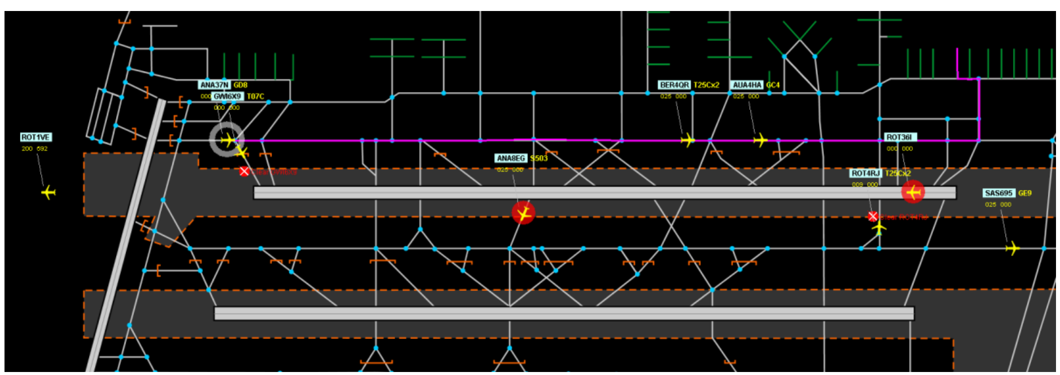
The provision of visual cues to the operator

Flightdeck



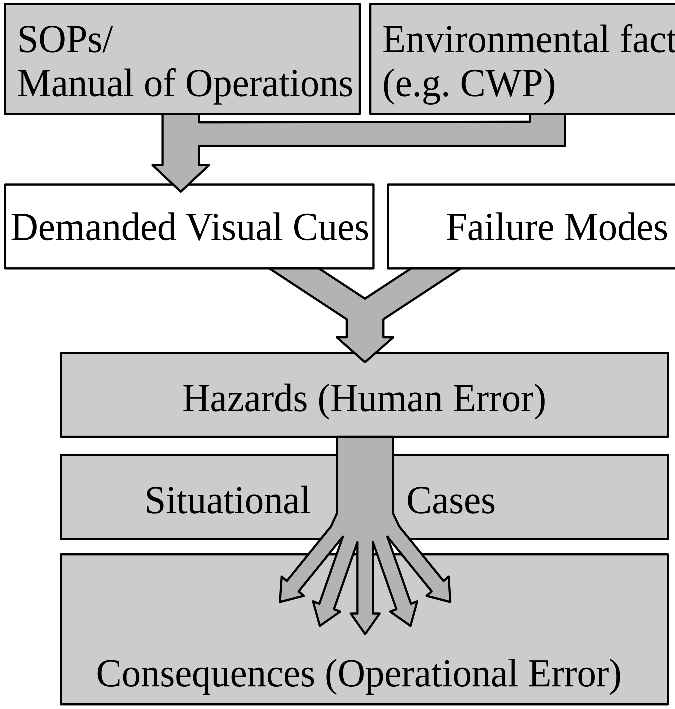
Source Entzinger (2008)

Aerodrome control



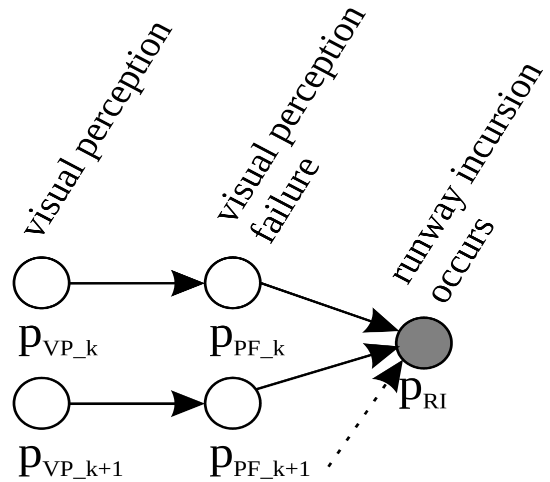
The proof of concept study

- The objective is
  - To develop a concept for a methodology that identifies the safety-relevance of visual cues
  - To identify the relative importance of visual cues within a set of visual cues
  - To determine the relative contribution to risk by a specific visual cue



Introduction to the concept - Assumptions

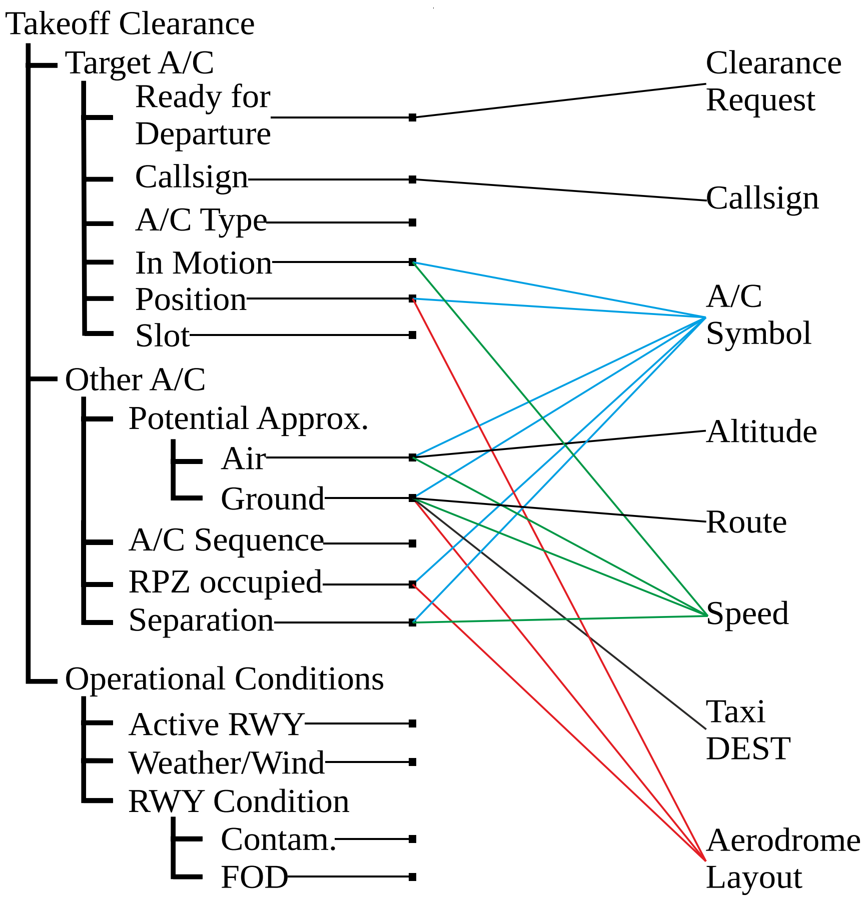
- A system provides a set of cues visually to an operator
- The accident event as well as the related precursors (e.g. loss-of-separation or runway incursion) are defined as safety-relevant events
- The visual cue *k* might cause a safety-relevant event in the case of failed perception
- The unification of all failed perception events determines the resulting probability of the safety-relevant events



The Human-In-The-Loop Simulation approach

- An A-SMGCS-SMAN HMI serves as a test setup at Frankfurt airport
- Novices are selected as test persons (4 trained students, each one tested 10 hours), acting as tower controllers
- Measuring methods
  - Regular (periodic) questionnaires for the importance of visual cue when granting take-off clearances ➔ demand of visual cues
  - Detecting runway incursions ➔ runway incursion rate
  - In the case of a detected runway incursion: Instant (closed ended) questionnaire for the identification of the related visual cue that was not percepted adequately ➔ Identification of the safety-relevance
  - Eye tracking measures ➔ demand of visual cues

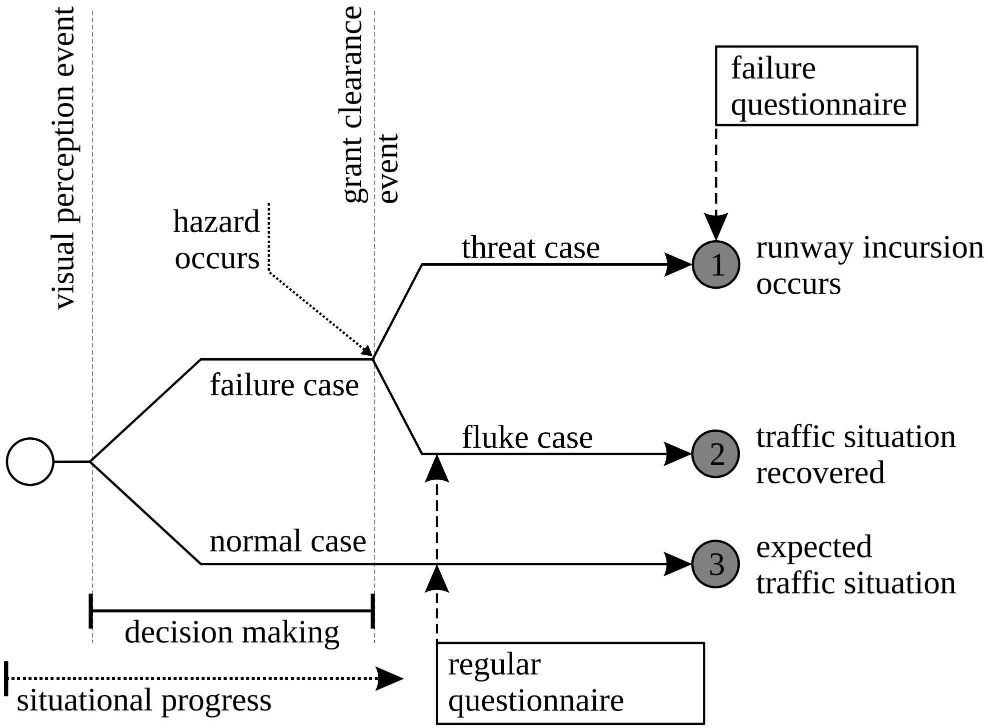
Modeling the visual demand in aerodrome control: The take-off clearance



Models bases upon

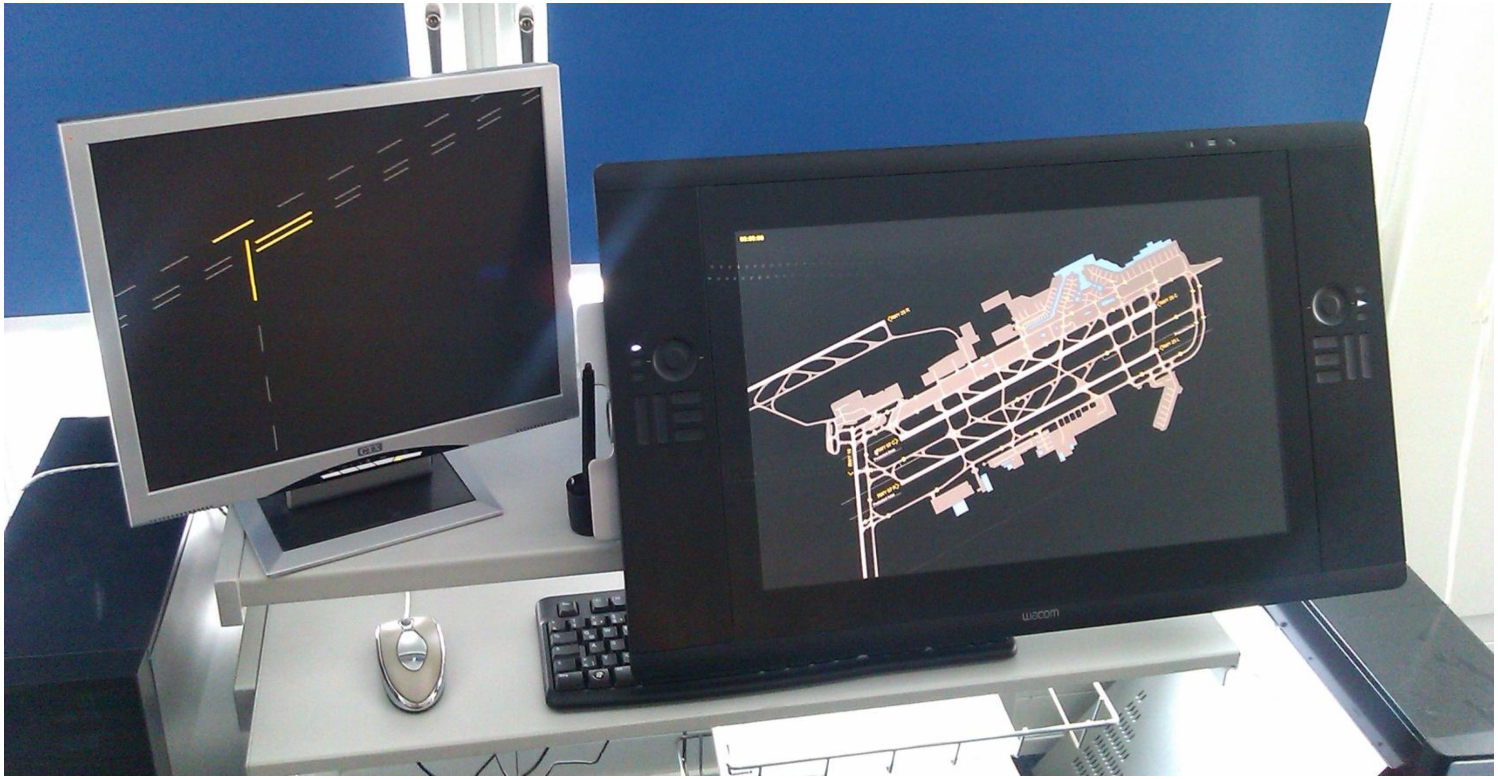
- Manual of operations (DFS)
- ICAO PANS-ATM Doc 4444
- Task Analysis in the scope of Virtual Tower research
  - Expert Judgment
  - Field evaluation

Event tree of the decision-making „take-off clearance“



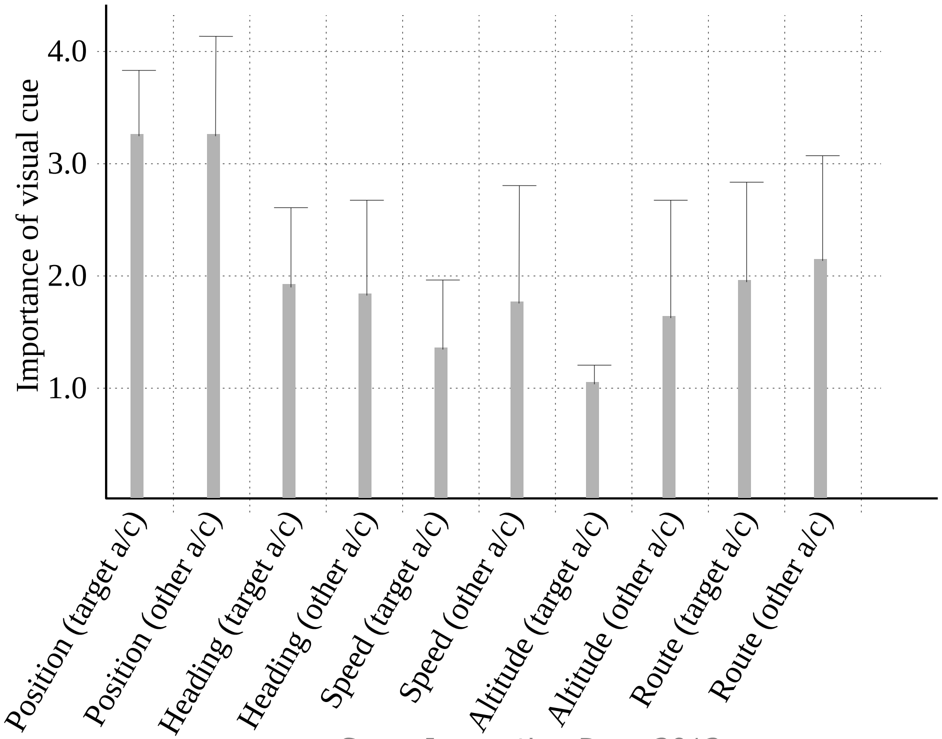
The test setup

- Surface Movement Manager



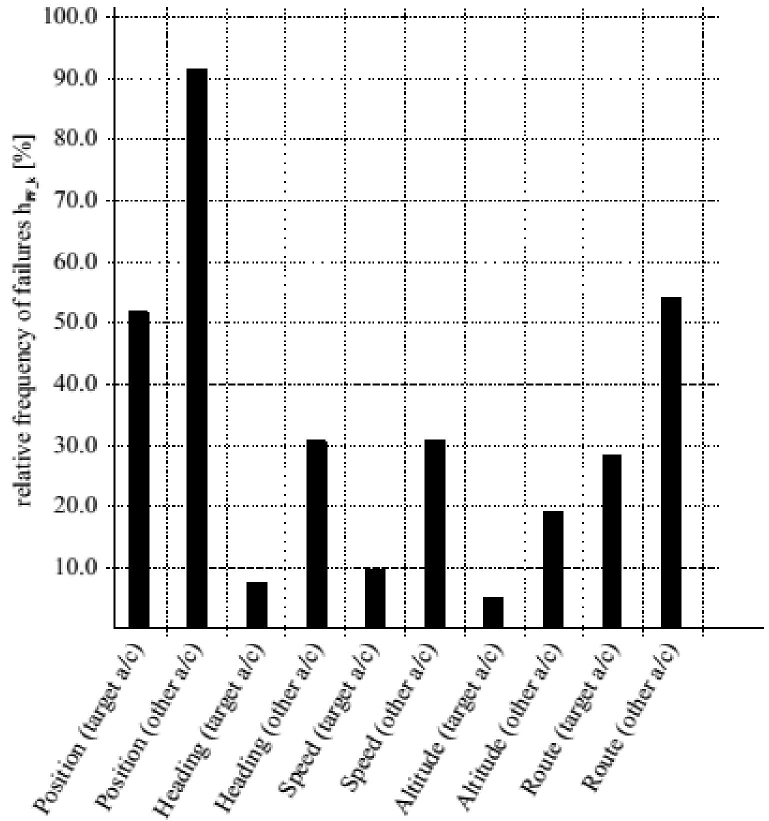
Results – Regular questionnaire h_{VP_k}

- Subjective rating of the importance of proposed visual cues on a scale from 1 (no agreement) to 4 (total agreement)



Results – Failure questionnaire $h_{PF_k|RI}$

- Subjective rating of the contribution to runway incursion (yes/no-options)



Contribution of a visual cue to risk

- VP_k Perception event of the visual cue *k.*
- PF_k Perception failure event of the visual cue *k*
- RI Runway Incursion event
- $p_{PF_k|RI}$ Conditional probability of failed perception k when RI has occured (event tree case 1) ➔ failure questionnaire $h_{PF_k|RI}$
- p_{VP_k} Probability to use the visual k for granting the take-off clearance

  ➔ regular questionnaire h_{VP_k}

$$P(RI|VP_k) = \frac{p_{PF_k|RI}}{p_{VP_k}} \cdot p_{RI}$$

Results

Visual cue	$P(RI\|VP_k)$
Route (other a/c)	3.0 %
Position (other a/c)	2.6 %
Heading (other a/c)	2.4 %
Speed (other a/c)	2.4 %
Speed (target a/c)	2.1 %
Route (target a/c)	2.0 %
Altitude (other a/c)	2.0 %
Position (target a/c)	1.4 %
Heading (target a/c)	0.6 %
Altitude (target a/c)	? (p_{VP_k} = 0)

Conclusion

- Questionnaires give valuable clues on the importance the demanded cues.
- The safety-relevance of visual cues was determined by the Failure Questionnaires. This offers a data-basis for further design evaluation early in the product life-cycle
- A contribution to risk by a specific visual cue could be quantified. It suffers of non-calibrated estimates which might impair the results accuracy.
- The results of the Proof-of-concept study has little external validity as the novice test persons have no reference to real operations.
- Further research will concentrate on more objective measures of the visual cue perception, e.g. eye tracking analysis.

Thank you.

Contact

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