Aeronautical Studies / Safety Assessments in the context of SMS

– Theory and Practice –


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Safety Risk Management is one of the four pillars of SMS

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Need of Safety Assessment

- The need of a Safety Assessment could arise from
  - Implementation of SMS
  - Identification of hazards
  - Audits, Inspections
  - Change of infrastructure (e.g. airport expansion)
  - Change of operation (e.g. implementation of A380)
  - Change of regulations (e.g. Annex 14)
  - Compliance checks
  - Certification of aerodromes

Safety Assessment is a commonly used method and widely accepted, e.g.

- Nuclear industry
- Aircraft Manufacturer (e.g. FAR 25/CS-25)
- ANSP (e.g. ESARRs für ATM)
- AACG (A380 Airport Compatibility Group)
- References in aerodrome related ICAO Docs
  - Annex 14
  - Doc 9774 (Manual on Certification of Aerodromes)
  - Doc 9859 (Safety Management Manual)
# How to conduct a Safety Assessment

<table>
<thead>
<tr>
<th>Severity</th>
<th>Probability</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>minor</td>
<td>acceptable</td>
<td>acceptable</td>
</tr>
<tr>
<td>major</td>
<td>acceptable</td>
<td>unacceptable</td>
</tr>
<tr>
<td>hazardous</td>
<td>undesirable</td>
<td>undesirable</td>
</tr>
<tr>
<td>catastrophic</td>
<td>undesirable</td>
<td>unacceptable</td>
</tr>
</tbody>
</table>

- **„Just“ identify**
  - hazards
- **calculate**
  - probability
  - severity
- **compare to**
  - Target Level of Safety (TLS)

**TLS:**
Target Level of Safety
The „little“ problems of Safety Assessments

In general
- Risk quantification (how much risk is inherent)
- TLS (how much safety/risk is adequate)
- Method (how to do it)

For possible solutions one can
- conduct trials (sometimes you better don’t)
- use experts opinion (not always appropriate method)
- refer to historical data (e.g. accident data base)
- conduct simulations (mostly expensive)

Some Examples and Case Studies
- Runway End Safety Area (RESA) – risk quantification
- Taxiway Separation – TLS derivation and mitigation measures
- Airplanes and Ships – risk networks
- Runway Holding Positions – development of new models
- Pilots confusion/blinding – qualitative assessments

TLS:
Target Level of Safety
Risk Quantification:
How much safety is inherent to a RESA?

- Depending on the specific airports infrastructure and operations, e.g.
  - Operations (LDG, DEP)
  - Approach (PA, NPA)
  - Traffic Mix (jet, prop)
  - Weather conditions (dry, wet)

- Models from different Risk Assessments
  - Large accident/incident data base
  - Flight Simulator Trails

- Example for a risk quantification taking into account one airport’s individual situation

  **OVERRUN RISK**
  - Take Off 4.67E-07
  - LDG (PA) 4.62E-07
  - LDG (NPA) 3.06E-06

  **UNDERSHOOT RISK**
  - ILS 1.04E-09
  - LOC (PAPI on) 5.37E-06
  - VOR (PAPI on) 4.43E-05
  - VOR (PAPI off) 1.69E-03

RESA: Runway End Safety Area
PA: Precision Approach
NPA: Non Precision Approach
LDG: Landing
ILS: Instrument Landing System
LOC: Localizer Approach
PAPI: Precision Approach Path Indicator
Risk Quantification: How much safety is inherent to a RESA?

Models for RWY | Parameter | Source
--- | --- | ---
Lateral excursion (DEP, PA, NPA) | Strip width | accident database
Overrun (DEP, PA, NPA) | RESA length | accident database
Undershoot (PA, NPA) | RESA length | flight simulator trials
RWY land-off (PA, NPA) | Strip length, RESA width | accident database, flight simulator trials

RESA: Runway End Safety Area
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## Taxiway Separation Study:
### TLS Derivation – Risk Quantification – Mitigation Measures

### Current situation at the region of interest

<table>
<thead>
<tr>
<th>Code Letter</th>
<th>TWY Centre Line to TWY Centre Line [m]</th>
<th>TWY Centre Line to Object [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>66.5</td>
<td>40.5</td>
</tr>
<tr>
<td>E</td>
<td>80</td>
<td>47.5</td>
</tr>
<tr>
<td>Current situation at the region of interest</td>
<td>76.13</td>
<td>40.26</td>
</tr>
</tbody>
</table>

**Pier A**

**Pier B**

**TWY S**

**TWY R4**

**TWY Centre Line**

**Object**

**ICAO Annex 14**

**TLS**: Target Level of Safety

**TWY**: Taxiway
Taxiway Separation Study: TLS Derivation

- Problems
  - Multiple hazards
    - from a FHA-Workshop with all Stakeholders
  - No TLS available
    - for ground operations in a local operational area

- Review of existing similar TLS (NTSB, ICAO, ECAC)
  - choice of most conservative TLS: ICAO A-SMGCS
    - $1 \times 10^{-8}$ collision per movement on ground
  - conducting a time based fraction (for local operational area)
  - considering number of relevant movements
  - resulting in $8.6 \times 10^{-6}$ collisions per year
Taxiway Separation Study: Risk Quantification
Taxiway Separation Study: Risk Quantification

Total Risk: $5.3 \times 10^{-5}$
TLS: $8.6 \times 10^{-6}$
Taxiway Separation Study: Quantification of Mitigation Measures

- limitation of aircraft size for one stand
- operational restriction or limit push back deviation
- displacement of holding positions K & M

Total Risk:
- TLS: $5.3 \times 10^{-5}$
- $8.6 \times 10^{-6}$
- $2.1 \times 10^{-6}$
- $1.1 \times 10^{-6}$
Assessment on temporary mobile objects: Risk Networks

- Approaching aircraft’s flight path is penetrated by large ships
  - Method?
  - Conduct trials?
  - Available data bases?
  - Risk calculation?

- Solution
  - Using experts’ opinions
  - and Bayesian networks
Bayesian Networks

- Frequencies: derived from statistics

- A/C on course to conflict area
  - 500 events per year

- Vessel (>21m) on course to conflict area
  - 2000 events per year

- A/C and vessel on conflict course
  - 7 events per year
Frequency and Probability in Bayesian Networks

Air Traffic Controllers: „this happened 5 times within the last 10 years“
with 500 approaches p.a. this yields 1 in 1000 approaches

Probabilities: derived from experience of domain experts

Controller notice possible conflict late
0.00369805005 events per year

0,00021484330005 events per year

99999:10000
Assessment on Runway Holding Positions: Model development

The problem
- aircraft penetrate obstacle limitation surfaces
- displacement of holding positions has negative impact on capacity
- ICAO collision risk model not valid below OCH

OCH: Obstacle Clearance Height
Assessment on Runway Holding Positions: Model development

Solution

- Development of
  - collision risk model for visual segment (PA and NPA)
  - based on ICAO Balked Landing Study (Circular 301)
- Application of model to calculate risks
Pilots confusion/blinding: Qualitative Safety Assessment

The problem

- Pilots might get blinded by lights from
  - Cars
  - Trains
- Pilots might misinterpret runway with
  - Road
Safety Assessment: Pilots confusion/blinding

Solution

- Visualization within a Flight Simulator
- Hazard Identification
- Definition of critical visual situations
  - night, offset approaches, crosswind, lights on road, NPA, ...
- Assessment of visual cues pilots receive

No TLS, no quantification of risk

- judgment purely based on opinion of experts and CAA

CAA:
Civil Aviation Authority

NPA:
Non Precision Approach
Conclusions

- Safety Risk Management is a crucial part of SMS
  - but maybe the most difficult

- There is always the same theoretical approach to Risk Assessment
  - But different methods in real life
    - from simple qualitative expert's opinion
    - to complex quantitative network assessment

- Safety Assessments have to be
  - Systematically
  - Serious and robust
  - well communicated (with CAA)

- Safety Assessments are sometimes very complex and expensive
  - But give the opportunity to cope with special situations
    (e.g. non-compliance)

- So rather see it as a chance than as a burden
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Thank you for your attention!