VALIDATION OF AN EMPIRIC METHOD FOR SAFETY ASSESSMENT OF MULTI REMOTE TOWER

Thirteenth USA/Europe Air Traffic Management Research and Development Seminar (ATM2019)

Speaker: Lothar Meyer

Team: Lothar Meyer, Maximilian Peukert, Billy Josefsson, Jonas Lundberg

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LFV Multi Remote Tower Simulator in Malmö
What is the challenge for the tower controller?

- Operating two completely independent airports
- Need to run two (mental) models to ensure an adequate situation awareness (Moehlenbrink, Papenfuss & Jakobi, 2011)
- Distinctive features needed to avoid confusion (Meyer & Fricke 2016)
Safety Workshops

- Identifying hazards induced by Multi Remote Tower
- 4 operational participants
  - 3 tower controllers, 1 pilot
- 3 days
- 27 hazards identified
<table>
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The MERASSA Concept
The MERASSA Concept

Multi Remote Tower (target system)

A

B

C

system definition and design

safety workshop

feedback

hazard database

adapt to an equivalent scenario

stress (hazardous) scenarios with expected severe outcomes

Experimental risk analysis

Single Remote Tower (reference system)

Multi Remote Tower (target system)
The MERASSA Concept

Multi Remote Tower (target system)

System definition and design

Safety workshop

Feedback

Hazard database

Adapt to an equivalent scenario

Stress (hazardous) scenarios with expected severe outcomes

Experimental risk analysis

Single Remote Tower (reference system)

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Comparison

Safety indicators (safety profile)
The MERASSA Concept
The MERASSA Concept

Multi Remote Tower (target system)

A
B
C

system definition and design

safety workshop

feedback

hazard database

risk mitigation measures

develop

risk mitigation workshop

no

ELoS maintained?
safety benchmark

adapt to an equivalent scenario

stress (hazardous) scenarios with expected severe outcomes

Experimental risk analysis

Single Remote Tower (reference system)

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safety indicators (safety profile)

risk mitigation measures

risk mitigation workshop

safey benchmark

final safety requirements

yes  
no

ELoS maintained ?

adapt to an equivalent scenario

stress (hazardous) scenarios with expected severe outcomes

safety workshop

safety workshop
The MERASSA Concept

Multi Remote Tower (target system)

A  B  C

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Safey workshop

Adapt to an equivalent scenario

Stress (hazardous) scenarios with expected severe outcomes

Experimental risk analysis

Single Remote Tower (reference system)  Multi Remote Tower (target system)

safety indicators (safety profile)  safety indicators (safety profile)

Comparison

Safety benchmark

yes  no

possible causes

risk mitigation measures

develop

final safety requirements

risk mitigation workshop

ELoS maintained?
The MERASSA Concept
Testing Procedures - Working Principles

Conflict Induction Test
- Detect Hazard
- Detect Effects
- Consequences
- Causes
- Effect on Operation

Query Test
- Indicate Causes
- Consequences
- Causes
- Effect on Operation

Secondary Task Test
- Detect Hazard
- Consequences
- Causes
Human Performance and Safety Performance Metric

✓ Every task dividable into

Quality & Time

✓ Heinrich Bubb 2005

Performance = \frac{\text{Quality}}{\text{Time}}

✓ Speed vs Accuracy Tradeoff

A1 - Sequential Sampling Models (Wickelgren, 1977)
A2 – Empiric studies (Schouten & Bekker, 1967)
Human Performance and Safety Performance Metric

RI rate [%]

TE

A

B

C

\( t_i = 30s \)

\( t_i = 20s \)

SESAR Innovation Days 2014 (Meyer, Gaunitz & Fricke 2014)
Test Procedures

- **Conflict Induction Test**
  - Car on Runway
  - Moose on Runway
  - VFR flying into CTR without permission

- **Equipment handling (Secondary Task)**
  - Finding the helicopter on the backside
  - Push emergency button
  - Push frequency button

- **Situational Awareness SPAM Queries**
  - Wind
  - Braking Action
  - Position of A/C
  - QNH
  - Vehicle on Runway

- **Primary Dependent Metric**
  - Reaction Time divided into
    - Time To Detect (TTD)
    - Time To Solve (TTS)
  - Human Error (HE)
<table>
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<th>Rank</th>
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<th>Safety Performance Indicator</th>
<th>Test Procedure(s)</th>
<th>Safety Metric</th>
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<tr>
<td>1.</td>
<td>Confusion of the Emergency Indicator Button in case of an accident</td>
<td>Accident</td>
<td>Awareness for the position of the correct inputs on the instrument panel and its associated airport</td>
<td>Equipment handling: Emergency Button Test</td>
<td>TTS HE</td>
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<td>2.</td>
<td>Confusion of the Braking Action Values</td>
<td>Accident</td>
<td>Situational Awareness for the current braking action values</td>
<td>SPAM: Braking Action Value</td>
<td>TTS HE</td>
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<td>3.</td>
<td>Confusion of visual conditions. Use of wrong runway holding positions not corresponding to the current conditions.</td>
<td>Serious Incident</td>
<td>Situational Awareness for current QNH, Wind values and position of relevant objects</td>
<td>SPAM: QNH, Wind values, and position</td>
<td>TTS HE</td>
</tr>
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<td>4.</td>
<td>The limited FOV hides parts of the airport vicinity. No immediate visual contact to hidden objects possible.</td>
<td>Minor Incident</td>
<td>Situational Awareness for the current position of objects in the CTR and on the maneuvering area</td>
<td>Conflict Induction: Moose and Car on the runway. Helicopter in the vicinity</td>
<td>TTD HE</td>
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<td>5.</td>
<td>Confusion of frequencies (button or microphone). Landing clearance is given falsely.</td>
<td>Major Incident</td>
<td>Awareness for the current position of the correct inputs on the instrument panel</td>
<td>Equipment handling: Frequency Test</td>
<td>TTS HE</td>
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<td>6.</td>
<td>Confusion of obstacles such as buildings or mountains in the environment of the Airport</td>
<td>Accident</td>
<td>Awareness for airport-related topological structure</td>
<td>No test available</td>
<td></td>
</tr>
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<td>7.</td>
<td>Missing the transmission that ground vehicles vacated runway due to transmissions at both airports at a time</td>
<td>Minor Incident</td>
<td>Situational Awareness for the current runway occupancy</td>
<td>SPAM: Position of snow sweeper</td>
<td>TTS HE</td>
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<td>8.</td>
<td>Missing unknown movements on one airport while spending attention to the other airport</td>
<td>Minor incident</td>
<td>Situational Awareness for all safety-relevant events on both airports</td>
<td>Conflict Induction: Moose and Car on the runway.</td>
<td>TTD HE</td>
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<td>Confusion of QNH value during landing situation</td>
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<td>Situational Awareness for QNH</td>
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Safety Relevance of Hazards

Using Reaction Time and Error Rate

1. Compare Human Error Rates
2. Samples are pairing and compared (Single vs Multi)

\[ \Delta RT = RT_{\text{Multi}} - RT_{\text{Single}} \]

**HE Safety Criteria**

1. Error Rates equal
2. Error rates lower in Multi Mode

**RT Safety Criteria**

1. Reaction Times equal
2. Working speed slower in Multi Mode
Safety Relevance of Hazards

![Diagram showing the relationship between Working Speed and Error Rate with various types of TO: Multi TO 1, Multi TO 2, and Single TO.]

- Multi TO 1
- Multi TO 2
- Single TO
Sample Characteristics

First Iteration Trials (Dec 2017)

- Prestudy poster-presented at SID 2018
- 6 Test Persons
- Airports Örnsköldsvik and Sundsvall
- 24 Trials
- Scenario lasts ca. 90 min
- 11 tests were applied per trial
- 238 tests successfully (90.1% success rate)

Second Iteration Trials (Sep 2018)

- 8 Test Persons
- Airports Örnsköldsvik and Sundsvall
- 32 Trials
- Scenario lasts ca. 90 min
- 17 tests were applied per trial
- 492 tests successfully (90.4% success rate)
First Iteration Results

Just one error measured in a SPAM test:
Wrong QNH value in Multi Mode

Test Persons applied risk compensation?

(Meyer, SESAR Innovation Days 2018)
Second Iteration Results

Visual Conflict Testing

Equipment Handling (sec. task)

SPAM Query

Multi slower

Multi faster

-100
-80
-60
-40
-20
0
20
40
60
80
100

Carousion
Moose
CTR Intruder
Helicopter Intruder Frequency
Set
Emergency Button

Wind
Location of AIC
QNH
Breaking Action
Vehicle on RWY
Workload

✓ ISA scale 1 – 5
✓ No significant differences found
1. I think that the artificiality of the simulation had an impacted on my behavior.

2. In general, I could predict the events more than in reality.

3. I prepared for the events because I could predict the occurrence.

4. I’m of the opinion that the tests are treating single and multi-remote tower unfair.

5. I’m of the opinion that my attention was significantly impacted by the need to control two airports.

1 – don’t agree at all………………5 – Totally agree
Self Evaluation

✓ Post Questionnaire
✓ Confidence in the own performance
Post Interview Statements

✓ Self-managing of attentional resources is regarded as stressful in multi operations

✓ Visual attention is limited
   – only one critical monitoring task at a time

✓ Most problems are related to problems of
   – Adapting to a environment providing more information
   – Develop work methods that help to sequence time-critical tasks
Conclusions on MERASSA

✓ No safety-relevance could be concluded from the safety metrics
✓ Primary problem for the analysis is the lack of errors committed by the test persons
✓ Risk compensation is an indication of feeling uncertain
✓ Feedback to safety assessment process by combining
  - Safety metrics
  - Post interview data
  - Investigation of outliers
Thank you!

Lothar Meyer (lothar.meyer@lfv.se)
Maximilian Peukert (maximilian.peukert@lfv.se)
Billy Josefsson (billy.josefsson@lfv.se)
Jonas Lundberg (jonas.lundberg@liu.se)