EU funded project **ICEPS**: 

**Injury Criteria for Enhanced Passive Safety in aircraft**

*Atlantic City, October, 2001*

**Speaker:** Dipl.-Ing. Martin Sperber  
TÜV Rheinland / Aviation Technology  
Cologne, Germany

*(Partner of the project: TÜV Rheinland, Hapag Lloyd, University Innsbruck)*
Contents of the presentation

- Objectives of the project
- Accident analysis
- Evaluation of injury criterias
- Correlation of injuries and evaluation criterias
- Results
- Outlook
Objectives of the project

- Investigation of two aircraft accidents:
  - Engineering aspects
  - Medical aspects

- Evaluation of existing injury criterias in the field of automotive and aviation industry

- Correlation of injuries and evaluation criterias

- Development of new injury criteria for enhanced passive safety in aircraft
The following two accidents were investigated:

**Accident 1:**  Airbus A320, Warsaw Airport, 14. Sep. 1993

(64 passengers: 1 passenger and one pilot died at scene).

**Accident 2:**  Boeing 737-400, near Kegworth, 08.Jan. 1989

(119 passengers: 39 died at scene, 80 were rescued, 4 persons died in the following days).
Accident analysis

Warsaw accident
Accident analysis

Kegworth accident
Accident analysis

Kegworth accident
Accident analysis

Warsaw accident
14. September 1993
Airbus 320

Seat distribution

PCP 64 / 4 / 2
- black: death
- red: injured
- green: not injured
Accident analysis

Kegworth accident
08. January 1989
Boeing 737 - 400

Seat distribution

Area of structural failure

PCP 119 / 5 / 2

- death
- injured
- not injured
- mother and baby
- mother death / baby injured

Unternehmensgruppe TÜV Rheinland/Berlin-Brandenburg
Accident analysis

With the help of the detailed personal informations from Prof. Wallace and the Medical Service of Lufthansa an allocation of the injuries to the body region and the seating position could be made.

On this basis a detail description of the injuries for each passenger per seat was made.
Evaluation of injury criterias

Survival area in aircraft cabins

forward

Survival area  Passenger

Unternehmensgruppe TÜV Rheinland/Berlin-Brandenburg
Evaluation of injury criterias

All existing criterias in aircraft and automotive technology were investigated in view of their applicability in an aircraft cabin.

These criterias are coming from the “Regulations of the Economic Commission for Europe“ (ECE – Regulation) for vehicles, Federal Motor Vehicle Safety Standards (FMVSS) and JAR 25.

These criterias deal with interiors, occupant protection in interior impact and occupant crash protection.
Evaluation of injury criteria

Aeronautic Sector Forward / Downward Direction
- **Head**
  - Head Injury Criterion (HIC)
- **Pelvis**
  - Lumbar Spine Load
  - Submarining
- **Femur**
  - Femur Load

Automotive Sector Forward Direction
- **Head**
  - Head Injury Criterion (HIC)
  - Head acceleration (xms)
  - Time range (xg)
- **Neck**
  - Neck Injury Criterion (NIC)
- **Chest**
  - Thoracic Compression Criterion (ThCC)
  - Viscous Criterion (VC)
  - Chest acceleration (xms)
  - Time range (xg)
- **Femur**
  - Femur Force Criterion (FFC)
- **Tibia**
  - Tibia Index (TI)
  - Tibia Compression Force Criterion (TCFC)
Warsaw accident

Number of examined occupants: 27

Number of injuries per body region: 38 (100%)

- Pelvis: 0%
- Legs: 3%
- Lumber Spine: 42%
- Abdomen: 16%
- Thoracic Spine: 18%
- Thorax: 5%
- Cervical Spine: 0%
- Head, Face: 16%

Unternehmensgruppe TÜV Rheinland/Berlin-Brandenburg
Correlation of injuries and evaluation criterias

Kegworth accident

Number of examined occupants: 75

Number of injuries per body region: 306 (100%)

- Legs 19%
- Pelvis 12%
- Lumber Spine 6%
- Abdomen 7%
- Thoracic Spine 1%
- Thorax 13%
- Head, Face 20%
- Cervical Spine 3%
- Arms 19%

Unternehmensgruppe TÜV Rheinland/Berlin-Brandenburg
Results

The existing injury criterias are insufficient to describe and evaluate the effects of accidents on passengers.

That means new/additional criterias are necessary with focus on:

- the aircraft passengers‘ state of consciousness
- the possibility of freeing themselves
- the passengers‘ ability to walk.
Results

The level of passive passenger safety can only be enhanced by a comprehensive consideration and examination of the aircraft interior, i.e. by:

- The evaluation of the survival area (tests with interior parts, with aircraft passenger seats)
- Determination of the energy absorption capacity of covered rigid structures in the survival area
- Application of dummies of the Hybrid III series in dynamic tests
- Application of extended dummy protection criteria
## Results

<table>
<thead>
<tr>
<th>Criteria required due to accident analysis and main idea</th>
<th>Known biomechanic tolerance limits</th>
<th>dummy protection criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>head</td>
<td>head</td>
<td>head</td>
</tr>
<tr>
<td>cervical spine</td>
<td>cervical spine</td>
<td>cervical spine</td>
</tr>
<tr>
<td>upper arms</td>
<td>upper arms</td>
<td></td>
</tr>
<tr>
<td>forearms</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>hands</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>thorax</td>
<td>thorax</td>
<td>thorax</td>
</tr>
<tr>
<td>lumbar spine</td>
<td>lumbar spine</td>
<td>lumbar spine</td>
</tr>
<tr>
<td>abdomen</td>
<td>abdomen</td>
<td>abdomen</td>
</tr>
<tr>
<td>femurs</td>
<td>femurs</td>
<td>femurs</td>
</tr>
<tr>
<td>lower legs</td>
<td>lower legs</td>
<td>lower legs</td>
</tr>
<tr>
<td>feet</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Outlook

For the continuous enhancement of passive safety in aircraft cabins the following activities are necessary:

- Development of new accident questionnaire forms
- Additional training of aircraft crash investigators
- Development of new evaluation strategies
- Exchange of information with the crashworthiness divisions of aircraft manufacturers
- Exchange of information between the doctors treating the accident victims and the technicians analysing the accident