Carriage by Air of Special Categories of Passengers

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Final Report

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Issue 1.1. including clarifications of quotes in paragraphs 4.2.8.2 and 4.5.1.9.

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1 Abbreviations

A/C	Aircraft Cabin (US)
AAIB	Air Accident Investigation Branch, UK
ABP	Able Bodied Passenger
AC	Advisory Circular
ACAA	Air Carriers Access Act
ACM	Acceptable means of compliance
AD	Airworthiness directive
ADA	Air deregulation act
AIS	Abbreviated Injury Score
ARFF	Aircraft Rescue and Fire Fighting
ASRS	Aviation Safety Response System
BLIND	Blind or visually impaired passenger
CAA	Civil Aviation Authority
CFR	Code of Federal Regulations
CRS	Child Restraint System
CS	Certification Specification
DDA	Disability Discrimination Act
DEAF	Passenger who is deaf or a passenger who is deaf without speech
DEAF/BLIND	Blind and deaf passenger, who can move about only with the help of an accompanying person
DEPA	Code for a deportee who is escorted by authorised personnel during flight
DEPU	Code for a deportee who is not escorted by authorised personnel during flight
DPNA	Disabled Passenger with intellectual or developmental disability needing assistance. This covers passengers with disabilities such as learning difficulties, dementia, Alzheimer's' or Down's syndrome who travel alone and will need ground assistance
ECAC	European Civil Aviation Conference
EDF	European Disability Forum
EMAS	Engineered Materials Arresting System
ETF	European Transport Workers Federation
ETSC	European Transport Safety Council
ETSO	European Technical Standard Order
EU	European Union
F/A	Cabin Crew Member (EU Terminology) →Flight Attendant (US Terminology)
FFP	Frequent Flyers Programme
GTAA	Greater Toronto Airport Authority
HNC	Hydrogen Cyanide
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
IFE	Inflight Entertainment System
Irs	Implementing Rules
ISS	Injury Severity Score
JAA	Joint Aviation Authorities
LBA	Luftfahrtbundesamt (CAA Germany)
LSHPD	Long-standing Health Problem or Disability
MAAS	(meet and assist) All other passengers in need of special help
NPA	Notice of Proposed Amendment
NTSB	National Transportation Safety Board, USA
PA	Passenger Address

Table 1: Abbreviations

PBE	Protective Breathing Equipment
PPBE	Passenger Protective Breathing Equipment
PRM	Passenger with Reduced Mobility
RIA	Regulatory Impact Assessment
Samu	Service d'Aide Médicale d'Urgence
SCP	Special Categories of Passengers
SEP	Safety and Emergency Procedures
SPR_{Lim}	Limit of rate of number SCP to number of able-bodied passengers before entering the nonlinear risk region
STCR	Passenger who can only be transported on a stretcher. Such passenger may or may not have social protection or specific insurance
TSO	Technical Standard Order
UK	United Kingdom
WCHC	Passenger who is completely immobile who can move about only with the help of a wheelchair or any other means and who requires assistance at all times from arrival at the airport to seating in the aircraft or, if necessary, in a special seat fitted to his/her specific needs, the process being inverted at arrival
WCHP	Passenger with a disability of the lower limbs who has sufficient personal autonomy to take care of him/herself, but who requires assistance to embark or disembark and who can move about in an aircraft cabin only with the help of an on-board wheelchair
WCHR	Passenger who can walk up and down stairs and move about in an aircraft cabin, but who requires a wheelchair or other means for movements between the aircraft and the terminal, in the terminal and between arrival and departure points on the city side of the terminal
WCHS	Passenger who cannot walk up or down stairs, but who can move about in an aircraft cabin and requires a wheelchair to move between the aircraft and the terminal, in the terminal and between arrival and departure points on the city side of the terminal

Table 1: Abbreviations

2 Executive Summary

Over the years the number of air passengers has significantly increased and a continuous growth of the aviation sector is still anticipated. Simultaneously, travel patterns and the air passenger's profile have also significantly changed due to worldwide social developments and recent developments in passenger aviation. Encouraged by a decrease of ticket fares as well as by regulations on passengers' rights people who have not yet used this means of transport are encouraged to travel by air. As a result increasingly different groups of people participate in air travel.

These also include the special categories of passengers (SCPs) which comprise any person requiring special assistance, conditions and/or equipment. Among others the SCPs include:

- Disabled persons (e.g. with paralysed lower limbs) and persons with reduced mobility (e.g. aided walking, deaf, mute, blind)[1]
- Extremely overweight passengers[2]
- Expectant mothers
- Infants and children up to the age of 12[3]
- Mental deficient passengers
- Sick passengers and passengers on stretchers[4]
- Inadmissible passengers, deportees or persons in custody[5]

Taking into account the changes mentioned above, concerns have recently been expressed on whether the current aviation requirements (certification and operation) were adequate to avoid or mitigate any safety risk that would be associated to the carriage of special categories of passengers. Because there was no updated evidence in this area the aim of this study is to assess safety risks, if any, associated to the said persons.

Considering that 90% of aircraft accidents can be categorised as survivable (see 4.5.1.7), further special assistance and conditions may need to be provided to these passengers in case of emergency situations. In the USA for example, a study revealed that during a 16 month observation, evacuation takes place every 11 days. The most frequent event leading to an evacuation was an engine fire, accounting for 32 percent of the 46 evacuations included in the study cases. More than 65 percent were reported to be unplanned evacuations with little or no preparation time.

[1] See OPS 1.260, ECAC Doc 30
[2] See TGL No. 44
[3] See OPS 1.320
[4] See Appendix 1 to OPS 1.1045 A.8.2.2
[5] See OPS 1.265

Various regulations and guidelines as well as common practice have been analysed to obtain a comprehensive overview to the current regulative and operational situation applicable to passengers and crew safety, also including possible special needs for SCPs.

A multitude of studies, accident reports as well as various accident data bases have been analysed to identify potential safety risks regarding transport of SCPs. Furthermore evacuation tests with selected special categories of passenger have been conducted to extent experience in the field of SCP evacuation and to validate findings of other studies.

Based on the gathered data and information a scenario based risk assessment covering all phases of flight has been conducted concerning safety issues. Several passenger groups have been defined within the group of SCPs. Each group has been assessed to determine the risk to the included SCPs themselves and the risk they may induce to other passengers.

Results

The risk assessment identified a significant number of high risk scenarios for special categories of passengers within the phases crash and evacuation. Furthermore it revealed special categories of passengers that bear an exceptional high risk to themselves or induce an exceptional high risk to other passengers. A risk ranking of the categories has been generated. Passengers on stretchers, children, infants, extremely overweight passengers and non ambulatory passengers bear the highest risk to themselves. The highest risk to others is induced by non ambulatory passengers, extremely overweight passengers, passengers on stretchers and passengers with very low mobility. A comprehensive list is given in the report.

The risk to SCPs themselves mainly increases due to insufficient restraint during a crash and the inability to evacuate themselves in an appropriate manner and time. SCPs inducing a high risk to others frequently need assistance and delay the evacuation by temporarily blocking the aisles and the exits. As a result the risk for the assistants and other occupants affected by these SCPs increases due to longer smoke exposure during evacuation (hazard of asphyxia). Also the crew members are affected since they are responsible for the management of any emergency.

The degree of the SCPs' mobility is one of the vital factors affecting both the risk to themselves and to others. The average ambulatory SCP appears to possess adequate mobility for evacuation and therefore has rather a small impact in risk increase.

Up to a certain ratio of SCPs to the number of able bodied passengers the risk increases linearly with the number of SCPs aboard an aircraft. As soon as there are too few able-bodied passengers (see 6.1) available, evacuation of those SCPs facing problems to evacuate themselves is clearly hampered or impossible. This results in a step-function increase of the SCP's risk. The according ratio at this point is defined as SPR_{Lim}.

This is illustrated in the following diagram:

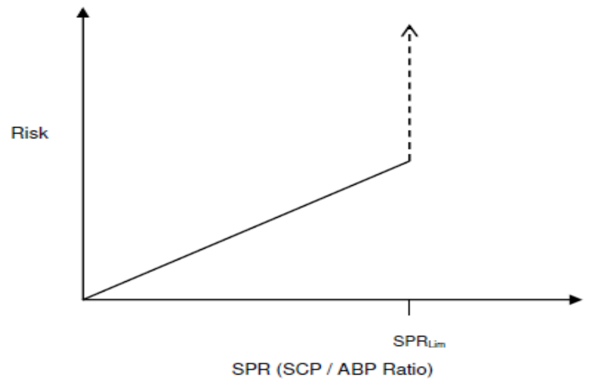

Figure 1: Step function increase of SCPs' risk

Based on data search and the risk assessment various causal relations have been analysed to identify measures to reduce the increased risk. Limitation of the number of SCPs with high risk on board an aircraft to an appropriate SCP to ABP ratio as well as the performance, training and the number of cabin crew were identified as potential measures to reduce the risk. The seating position of SCPs with high risk and accompanying persons for evacuation also affect the risk. Furthermore cabin configuration as well as tools and aids for the evacuation impact the risk. Also appropriate seats, berths, safety belts and harnesses are of crucial importance.

Conclusion

The study revealed that nearly all considered SCPs increase the risk of air travel to a greater or lesser extent.

The study demonstrated that various measures could reduce the increased risk, although not eliminate it. The major challenges will be to identify suitable measures for safe SCP restraint and to ensure a fast evacuation of the cabin with SCPs or to increase the survival time in the cabin.

If general exclusion to air travel of special categories of passengers should be avoided, the increased risk must be tolerated as part of the overall risk in air travel. Recommendations for risk acceptance criteria could not be given due to a lack of data. Definition of these criteria must be based on substantial statistical data. The issue of risk acceptance is finally also subject to a political decision respecting the social acceptability.

3 Methodology

The structure of the study is depicted in the following diagram. It shows how the individual phases interact and are subdivided in the overall structure.

Structure of the Study

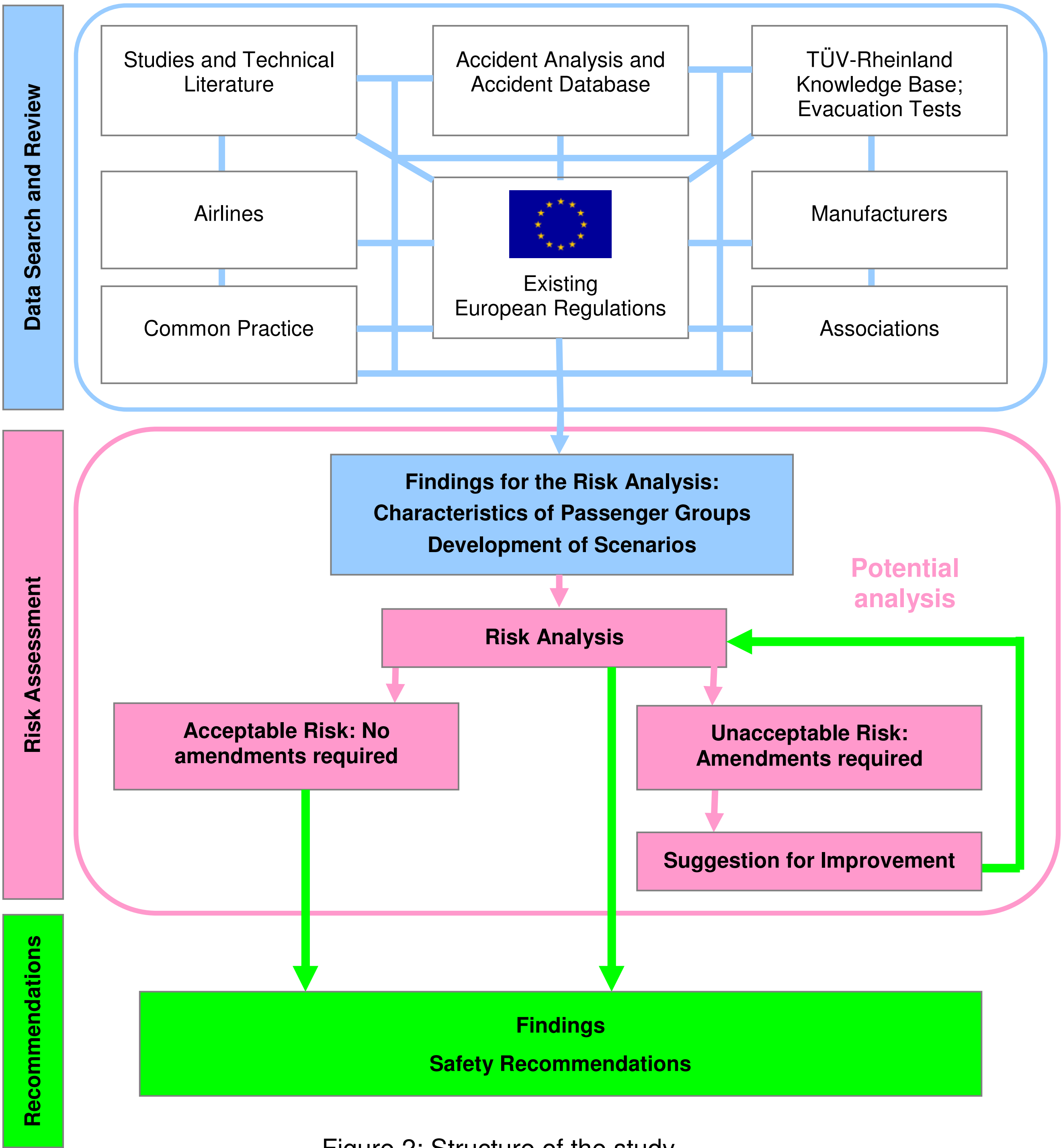

Figure 2: Structure of the study

Phase I, Part 1 "Literature and Data Search and Review" of the study gives an overview of relevant certification and operation requirements including their main standards for Europe as well as the applicable regulations regarding the transport of SCPs in aircraft.

Relevant studies, reports and articles were reviewed and several accident data bases were analysed to evaluate the existing aviation regulations and potential risks. In general it has to be noted that the database to analyse the particularities associated to the carriage of special categories of passengers was very fragmentary. Nevertheless a lot of information could derivate from different studies and sources.

Working with the various accident data bases was often very time consuming. Filtering of the data bases frequently produced accidents and incidents involving disabled persons, but no corresponding accident reports were available. Therefore detailed background information was sometimes unobtainable. Furthermore, the accident reports usually focus on the identification of the technical reasons and the recorded pathological information are hard or impossible to access.

Nevertheless, three well-documented accidents with SCPs on board were found in the evaluation of accident data bases and were analysed within this study.

A multitude of experts from operators, aviation industry, German Federal Police as well as various European stakeholders such as associations for persons with disabilities, cabin crew associations and airline associations were consulted to cover all areas relevant for this study. A huge number of information could be compiled both regarding the operational particularities and the needs and problems of SCPs in air transport.

The potential handicaps and attributes of the individual passenger groups are defined in a summary. These, if considered safety-relevant, are included and evaluated in the risk analysis.

Phase 1, Part 2 “Risk assessment” assesses the risks associated to the carriage of SCPs. Therefore a multitude of scenarios has been developed and analysed to achieve a comprehensive assessment of risks.

Identified approaches were analysed on their potential for improvement. If an approach turns out to be practical it has been taken over as a recommendation into the "recommendation phase".

Final Phase “recommendations” includes recommendations based on analysis of Phase 1 data and findings. Proposals for mitigating measures as considered necessary to ensure safety of passengers was provided, if relevant. Prior to the proposals, their benefits and drawbacks were carefully considered.

4 Data Search and Review

The chapter "Data Search and Review" describes existing aviation rules and guidelines for aeroplane certification and operations, applicable to passengers' safety. Furthermore safety relevant parts of studies are presented and, if applicable, commented. Potential safety deficits applicable to the carriage of special categories of passengers and those applicable to their interaction with other passengers are identified prior to the risk assessment.

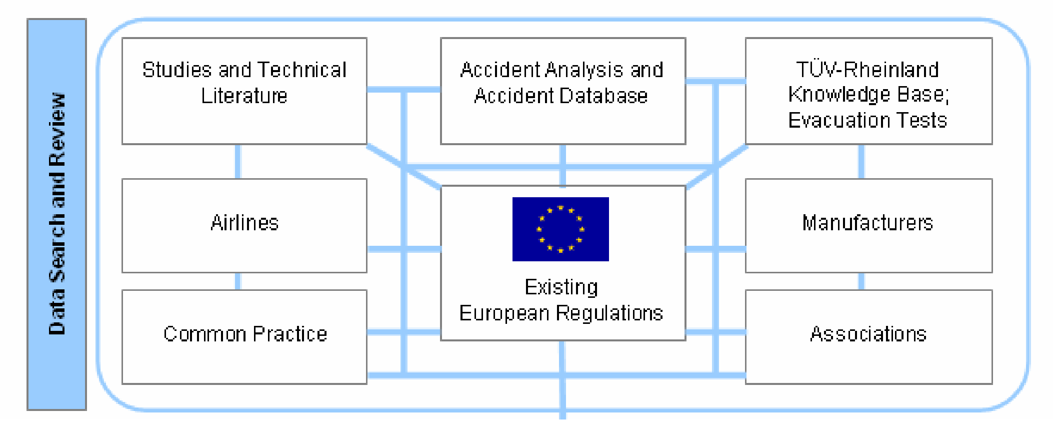

Figure 3 Data search and Review Network

4.1 Regulations

This section is intended to outline the present framework for the transport of SCPs.

4.1.1 International Classification of SCP

ECAC has defined codes for specific passenger groups which reflect the kind and, if applicable, the degree of disability aimed at a standardised specification of SCPs in air travel. These codes were mostly taken over by the airlines.

In the following, the codes including a brief description taken from ECAC document no. 30[1] are listed: Variants of these descriptions can also be found on the Internet sites of the airlines and of various guides[2],[3],[4].

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1 ECAC.CEAC DOC No. 30 (PART I), 5.2.2.1, amended 13 May 2009

2 ROYAUME DE BELGIQUE, CIRCULAIRE, TRANSPORT OF PRM'S COMMERCIAL AIR TRANSPORT, effective 12/2006

3 http://www.handicapnet.com/faq/faq.shtml, effective 20.02.2009

4 Access to Air Travel for Disabled Persons and Persons with Reduced Mobility – Code of Practice, Department for Transport, UK 2008

4.1.1.1 STCR

Passenger who can only be transported on a stretcher. Such passenger may or may not have social protection or specific insurance.

4.1.1.2 WCHR

Passenger who can walk up and down stairs and move about in an aircraft cabin, but who requires a wheelchair or other means for movements between the aircraft and the terminal, in the terminal and between arrival and departure points on the city side of the terminal.

4.1.1.3 WCHS

Passenger who cannot walk up or down stairs, but who can move about in an aircraft cabin and requires a wheelchair to move between the aircraft and the terminal, in the terminal and between arrival and departure points on the city side of the terminal.

4.1.1.4 WCHP

Passenger with a disability of the lower limbs who has sufficient personal autonomy to take care of him/herself, but who requires assistance to embark or disembark and who can move about in an aircraft cabin only with the help of an on-board wheelchair[6].

4.1.1.5 WCHC

Passenger who is completely immobile who can move about only with the help of a wheelchair or any other means and who requires assistance at all times from arrival at the airport to seating in the aircraft or, if necessary, in a special seat fitted to his/her specific needs, the process being inverted at arrival.

4.1.1.6 BLIND

Blind or visually impaired passenger.

4.1.1.7 DEAF

Passenger who is deaf or a passenger who is deaf without speech.

4.1.1.8 DEAF/BLIND

Blind and deaf passenger, who can move about only with the help of an accompanying person.

4.1.1.9 MAAS (meet and assist)

All other passengers in need of special help.

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[6] Not common within the airlines

4.1.1.10 DEPA

Code for a deportee who is escorted by authorised personnel during flight

4.1.1.11 DEPU

Code for a deportee who is not escorted by authorised personnel during flight

4.1.1.12 DPNA

Disabled Passenger with intellectual or developmental disability needing assistance. This covers passengers with disabilities such as learning difficulties, dementia, Alzheimer's' or Down's syndrome who travel alone and will need ground assistance

4.2 Existing Aviation Rules and Guidance Material

Essential safety-relevant regulations are to be identified to outline the applicable standards for passengers. This serves to work out potential gaps, overlaps or inconsistencies regarding the transport of passengers and special categories of passengers (SCPs), thus enabling an evaluation of safety hazards.

All requirements are analysed which give information regarding the restraint, attendance, emergency procedure and evacuation of passengers. Also requirements regarding crew training as well as the rights of access to air travel Regulation (EC) 1107/2006 are reviewed.

The following section compiles the relevant requirements. They were selected according to the following criteria which are likely to qualify a requirement as safety relevant:

- Transport of SCPs[*]
  - access to air travel
  - required assistance
  - special equipment (special carry on luggage)[**]
  - accompanying persons
  - restraint of SCPs
  - cabin environment
  - consistency of the regulations

- Potential difficulties for Special Categories of Passengers[***]
  - restraint of SCPs
  - board announcements
  - evacuations and impairments of evacuation
  - use of and access to emergency equipment
  - Safety Cards

- Relevant for the risk analysis[****]

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[*] E.g. *OPS 1.260(a) "An operator shall establish procedures for the carriage of Persons with Reduced Mobility"*

[**] "Special carry on equipment as personal portable oxygen bottles will not be assessed in the risk assessment since it is not relevant to this study, but to dangerous goods legislation. According to the EU-OPS only certified bottles are permitted aboard an aircraft. If these regulations are followed, no additional risk arises."

[***] E.g. *CS 25.1423: "A public address system required by operational rules must […] be intelligible at all passenger seats, lavatories, and cabin crew member seats and work stations."* - A deaf passenger is not able to use this assistance.

[****] E.g. *OPS 1.280: "An operator shall establish procedures to ensure that passengers are seated where, in the event that an emergency evacuation is required, they may best assist and not hinder evacuation from the aeroplane".* - It is e.g. not considered in the risk analysis that a PRM is seated in an exit row.

- access to air travel
- restraint of SCPs
- cabin environment

4.2.1 Regulation (EC) No 216/2008

This regulation contains general provisions for European aviation, adopted 20 February 2008. The requirements were selected according to the above mentioned criteria. Cited sections are written in italics, while summarized ones are not.

EC No. 216/2008 Annex IV, 2.a.2.

The crew must be familiar with, and passengers informed of, the location and use of relevant emergency equipment. Sufficient related information regarding emergency procedures and use of cabin safety equipment must be made available to crew and passengers using specified information.

EC No. 216/2008 Annex IV, 3.a.6.

In an emergency, the pilot in command must ensure that all passengers are instructed in such emergency action as may be appropriate to the circumstances;. (see also OPS 1.285)

EC No. 216/2008 Annex IV, 7.b.1.

Cabin crew members must […] be trained and checked on a regular basis to attain and maintain an adequate level of competency in order to perform their assigned safety duties

EC No 216/2008 Annex IV, 8.c.

The operator must establish procedures, as appropriate, so as to minimise the consequences to safe flight operations of disruptive passenger behaviour.

4.2.2 EU-OPS

EU-OPS provide operating regulations for Europe. Relevant parts were selected according to the above mentioned criteria. Cited sections are written in italics, while summarized ones are not.

OPS 1.085

(f)(4) The commander shall have authority to disembark any person, or any part of the cargo, which, in his/her opinion, may represent a potential hazard to the safety of the aeroplane or its occupants

OPS 1.085

(a) A crew member shall be responsible for the proper execution of his/her duties that are related to the safety of the aeroplane and its occupants […] and that are specified in the […] Operations Manual.

OPS 1.260

(a) An operator shall establish procedures for the carriage of Persons with Reduced Mobility (PRMs).

(b) An operator shall ensure that PRMs are not allocated, nor occupy, seats where their presence could:

(1) Impede the crew in their duties;

(2) Obstruct access to emergency equipment; or

(3) Impede the emergency evacuation of the aeroplane.

(c) The commander must be notified when PRMs are to be carried on board.

OPS 1.265

An operator shall establish procedures for the transportation of inadmissible passengers, deportees or persons in custody to ensure the safety of the aeroplane and its occupants. The commander must be notified when the above-mentioned persons are to be carried on board.

OPS 1.280

An operator shall establish procedures to ensure that passengers are seated where, in the event that an emergency evacuation is required, they may best assist and not hinder evacuation from the aeroplane.

OPS 1.285

(1) Passengers are given a verbal briefing about safety matters. Parts or all of the briefing may be provided by an audiovisual presentation.

(2) Passengers are provided with a safety briefing card on which picture type instructions indicate the operation of emergency equipment and exits likely to be used by passengers.

OPS 1.320

(1) Before take-off and landing, and during taxiing, and whenever deemed necessary in the interest of safety, the commander shall ensure that each passenger on board occupies a seat or berth with his/her safety belt, or harness here provided, properly secured.

(2) An operator shall make provision for, and the commander shall ensure that multiple occupancy of aeroplane seats may only be allowed on specified seats and does not occur other than by one adult and one infant who is properly secured by a supplementary loop belt or other restraint device

OPS 1.730

(a) An operator shall not operate an aeroplane unless it is equipped with:

(3) a child restraint device, acceptable to the Authority, for each infant;

(5) a safety belt with shoulder harness for each cabin crew seat and observer's seats

OPS 1.755

An operator shall not operate an aeroplane with more than 30 seats unless it is equipped with an emergency medical kit if any point on the route is more than 60 minutes flying time (at normal cruising speed) from an aerodrome at which qualified medical assistance could be expected to be available.

OPS 1.770,

(2)(II)The spare outlets and/or portable oxygen units are to be distributed evenly throughout the cabin to ensure immediate availability of to each required cabin crew member regardless of his/her location

(2)(IV) […] shall be provided with automatically deployable oxygen equipment immediately available to each occupant, wherever seated.

OPS 1.780

(Analogous): An operator must provide portable PBE to protect the eyes, nose and mouth of all required cabin crew members and provide breathing gas for a period of not less than 15 minutes.

OPS 1.988

An operator shall ensure that all cabin crew members comply with the requirements of this Subpart and any other safety requirements applicable to cabin crew.
For the purpose of this Regulation, 'cabin crew member' means any crew member, other than a flight crew member, who performs, in the interests of safety of passengers, duties assigned to him/her by the operator or the commander in the cabin of an aeroplane.

OPS 1.990

(a) an operator shall ensure that the minimum number of cabin crew is the greater of:

(b), 1) The minimum number of cabin crew is the greater of one cabin crew member for every 50, or fraction of 50, passenger seats installed on the same deck of the aeroplane)

(b), 2) The number of cabin crew who actively participated in the aeroplane cabin during the relevant emergency evacuation demonstration, or who were assumed to have taken part in the relevant analysis, except that, if the maximum approved passenger seating configuration is less than the number evacuated during the demonstration by at least 50 seats, the number of cabin crew may be reduced by 1 for every whole multiple of 50 seats by which the maximum approved passenger seating configuration falls below the certificated maximum capacity.

OPS 1.1000

Where required by OPS 1.990 to carry more than one cabin crew member, an operator shall not appoint a person to the post of senior cabin crew member unless that person […] has completed an appropriate course covering the following as a minimum:

[…] categories of passengers with particular attention to disabled, infants and stretcher cases)

Appendix 1 to OPS 1.1005

(e), 6) precautions to be taken when live animals are carried in the cabin

Appendix 1 to OPS 1.1005

(f) During training, emphasis shall be placed on the importance of effective communication between cabin crew and flight crew including technique, common language and terminology.

Appendix 1 to OPS 1.1010

(b), 1) An operator shall ensure that: 1. Each cabin crew member is given realistic and practical training in the use of all fire-fighting equipment including protective clothing representative of that carried in the aeroplane.

OPS 1.1015

(a) An operator shall ensure that each cabin crew member undergoes recurrent training, covering the actions assigned to each crew member in normal and emergency procedures and drills relevant to the type(s) and/or variant(s) of aeroplane on which they operate in accordance with Appendix 1 to OPS 1.1015.

(b) An operator shall ensure that the recurrent training programme approved by the Authority includes theoretical and practical instruction, together with individual practice, as prescribed in Appendix 1 to OPS 1.1015.

(c) The period of validity of recurrent training and the associated checking required by OPS 1.1025 shall be 12 calendar months.

Appendix 1 to OPS 1.1015

(b) An operator shall ensure that every 12 calendar months the programme of practical training includes the following:

1. emergency procedures including pilot incapacitation;

2. evacuation procedures including crowd control techniques;

3. touch-drills by each cabin crew member for opening normal and emergency exits for passenger evacuation;

4. the location and handling of emergency equipment, including oxygen systems, and the donning by each cabin crew member of lifejackets, portable oxygen and protective breathing equipment (PBE);

5. medical aspects and first-aid, first-aid kits, emergency medical kits, their contents and emergency medical equipment;

6. stowage of articles in the cabin;

7. security procedures;

8. incident and accident review;

9. awareness of the effects of surface contamination and the need to inform the flight crew of any observed surface contamination, and

10. crew resource management.

OPS 1.1025

At the discretion of the Authority, the organisation providing the training course shall ensure that each cabin crew member undergoes a check in order to verify his/her proficiency in carrying out normal and emergency safety duties.

Appendix 1 to OPS 1.1045, A 8.2.2:

Aeroplane, passengers and cargo handling procedures related to safety. A description of the handling procedures to be used when allocating seats and embarking and disembarking passengers and when loading and unloading the aeroplane. Further procedures, aimed at achieving safety whilst the aeroplane is on the ramp, must also be given.

Handling procedures must include:

(a) children/infants, sick passengers and persons with reduced mobility;

(b) transportation of inadmissible passengers, deportees or persons in custody;

(c) permissible size and weight of hand baggage;

(d) loading and securing of items in the aeroplane;

(e) special loads and classification of load compartments;

(f) positioning of ground equipment;

[…]

4.2.3 JAA Temporary Guidance Leaflet TGL No. 44

EU-OPS does not include any guidance material of the kind formerly contained in JAR-OPS 1 Section 2. The "Joint Aviation Authorities" has decided that appropriately up-dated guidance material for JAR-OPS 1 Amendment 14 should be published. The preferred format chosen by the JAA-LO is that of a TGL (this TGL 44) which comprises the material from JAR-OPS 1 Section 2 Amendment 13, updated with the guidance material from several NPAs. TGLs may be implemented as national rules if not covered by, and not conflicting with, EU rules. Cited sections are written in italics, while summarized ones are not.

[ACJ] OPS 1.260

1 A person with reduced mobility (PRM) is understood to mean a person whose mobility is reduced due to physical incapacity (sensory or locomotory), an intellectual deficiency, age, illness or any other cause of disability when using transport and when the situation needs special attention and the adaptation to a person's need of the service made available to all passengers.

2 In normal circumstances PRMs should not be seated adjacent to an emergency exit.

3 In circumstances in which the number of PRMs forms a significant proportion of the total number of passengers carried on board:

- *a. The number of PRMs should not exceed the number of able-bodied persons capable of assisting with an emergency evacuation; and*
- *b. The guidance given in paragraph 2 above should be followed to the maximum extent possible.*

[AMC] OPS 1.270

b. That a mix of the passengers and live animals should not be permitted except for pets (weighting not more than 8 kg) and guide dogs;

[ACJ] OPS 1.280

1 An operator should establish procedures to ensure that:

- *a. Those passengers who are allocated seats which permit direct access to emergency exits appear to be reasonably fit, strong and able to assist the* *rapid evacuation of the aeroplane in an emergency after an appropriate briefing by the crew:*

b. In all cases, passengers who, because of their condition, might hinder other passengers during an evacuation or who might impede the crew in carrying out their duties should not be allocated seats which permit direct access to emergency exits. If the operator is unable to establish procedures which can be implemented at the time of passenger 'check-in', he should establish an alternative procedure acceptable to the Authority that the correct seat allocation will, in due course, be made.

[ACJ] OPS 1.280

1 The following categories of passengers are among those who should not be allocated to, or directed to seats which permit direct access to emergency exits:

a. Passengers suffering from obvious physical, or mental, handicap to the extent that they would have difficulty in moving quickly if asked to do so;

b. Passengers who are either substantially blind or substantially deaf to the extent that they might not readily assimilate printed or verbal instructions given;

c. Passengers who because of age or sickness are so frail that they have difficulty in moving quickly;

d. Passengers who are so obese that they would have difficulty in moving quickly or reaching and passing through the adjacent emergency exit;

e. Children (whether accompanied or not) and infants;

f. Deportees or prisoners in custody; and,

g. Passengers with animals.

Note: "Direct access" means a seat from which a passenger can proceed directly to the exit without entering an aisle or passing around an obstruction.

4.2.4 Certification Specifications (Amendment 6)

CS25 provides design specifications for Europe, effective 6 July 2009. Relevant parts were selected according to the above mentioned criteria. Cited sections are written in italics, while summarized ones are not.

CS 25.562

(a) The seat and restraint system in the aeroplane must be designed as prescribed in this paragraph to protect each occupant during an emergency landing condition when:

(2) The occupant is exposed to loads resulting from the conditions prescribed in this paragraph.

(c) The following performance measures must not be exceeded during the dynamic tests:

(2) The maximum compressive load measured between the pelvis and the lumbar column of the anthropomorphic dummy must not exceed 680 kg. (1500lb)

(3) The upper torso restraint straps (where installed) must remain on the occupant's shoulder during the impact.

(4) The lap safety belt must remain on the occupant's pelvis during the impact.

(5) Each occupant must be protected from serious head injury. […] Where head contact with seats or other structure can occur, the head impact must not exceed a Head Injury Criterion (HIC) of 1000 units.

(8) Seats must not yield under the tests specified in this paragraph to the extent they would impede rapid evacuation

CS 25.785

(b) Each seat, berth, safety belt, harness, and adjacent part of the aeroplane at each station designated as occupiable during take-off and landing must be designed so that a person making proper use of these facilities will not suffer serious injury in an emergency landing as a result of the inertia forces specified in CS 25.561 and CS 25.562.

(e) Each berth must be designed so that the forward part has a padded end board, canvas diaphragm, or equivalent means that can withstand the static load reaction of the occupant when subjected to the forward inertia force specified in CS 25.561. Berths must be free from corners and protuberances likely to cause injury to a person occupying the berth during emergency conditions.

(f) Each seat or berth, and its supporting structure, and each safety belt or harness and its anchorage must be designed for an occupant weight of 77 kg (170 pounds), considering the maximum load factors, inertia forces, and reactions among the occupant, seat, safety belt, and harness for each relevant flight and ground load condition (including the emergency landing conditions prescribed in CS 25.561).

(j) If the seat backs do not provide a firm handhold, there must be a handgrip or rail along each aisle to enable persons to steady themselves while using the aisles in moderately rough air.

(k) Each projecting object that would injure persons seated or moving about the aeroplane in normal flight must be padded.

CS 25.789

Means must be provided to prevent each item of mass (that is part of the aeroplane type design) in a passenger or crew compartment or galley from becoming a hazard by shifting under the appropriate maximum load factors corresponding to the specified flight and ground load conditions, and to the emergency landing conditions of CS 25.561(b).

CS 25.791

(b) Signs that notify when seat belts should be fastened and that are installed to comply with the Operating Rules must be installed so as to be operable from either pilot's seat and, when illuminated, must be legible under all probable conditions of cabin illumination to each person seated in the cabin.

CS 25.801

Each practicable design measure must be taken to minimise the probability that in an emergency landing on water, the behaviour of the aeroplane would cause immediate injury to the occupants or would make it impossible for them to escape

CS 25.803

(a) Each crew and passenger area must have emergency means to allow rapid evacuation in crash landings[7]

(c) For aeroplanes having a seating capacity of more than 44 passengers, it must be shown that the aircraft can be evacuated from the aeroplane to the ground under simulated emergency conditions within 90 seconds using the test criteria outlined in Appendix J[8] *unless the Agency find that a combination of analysis and testing will provide data equivalent to that which would be obtained by actual demonstration.*

CS 25.807

Dimensions of Emergency exits; see Appendix 9.5

CS 25.810

(a) Each non-over-wing landplane emergency exit more than 1.8 m (6 feet) from the ground with the aeroplane on the ground and the landing gear extended and each non-over-wing Type A exit must have an approved means to assist the occupants in descending to the ground.

(b) Assist means from the cabin to the wing are required for each Type A exit located above the wing and having a step-down unless the exit without an assist means can be shown to have a rate of passenger egress at least equal to that of the same type of non-over-wing exit. If an assist means is required, it must be automatically deployed and automatically erected, concurrent with the opening of the exit and self-supporting within 10 seconds.

(c) An escape route must be established from each over-wing emergency exit, and (except for flap surfaces suitable as slides) covered with a slip resistant surface. Except where a means for channelling the flow of evacuees is provided –

[7] See also CS 25.807
[8] See Appendix 9.6

(1) The escape route must be at least 1·07 m (42 inches) wide at Type A passenger emergency exits and must be at least 61 cm (two feet) wide at all other passenger emergency exits, and

(2) The escape route surface must have a reflectance of at least 80%, and must be defined by markings with a surface-to-marking contrast ratio of at least 5:1. (See AMC 25.810 (c) (2).)

(d) If the place on the aeroplane structure at which the escape route required in sub-paragraph (c) of this paragraph terminates, is more than 1·8 m (6 feet) from the ground with the aeroplane on the ground and the landing gear extended, means to reach the ground must be provided to assist evacuees who have used the escape route. If the escape route is over a flap, the height of the terminal edge must be measured with the flap in the take-off or landing position, whichever is higher from the ground. The assisting means must be usable and self-supporting with one or more landing gear legs collapsed and under a 46 km/hr (25-knot) wind directed from the most critical angle. The assisting means provided for each escape route leading from a Type A emergency exit must be capable of carrying simultaneously two parallel lines of evacuees. For other than Type A exits, the assist means must be capable of carrying simultaneously as many parallel lines of evacuees as there are required escape routes.

(e) If an integral stair is installed in a passenger entry door that is qualified as a passenger emergency exit, the stair must be designed so that, under the following conditions, the effectiveness of passenger emergency egress will not be impaired:

(1) The door, integral stair, and operating mechanism have been subjected to the inertia forces specified in CS 25.561(b)(3), acting separately relative to the surrounding structure.

(2) The aeroplane is in the normal ground attitude and in each of the attitudes corresponding to collapse of one or more legs of the landing gear.

CS 25.811

(a) Each passenger emergency exit, its means of access, and its means of opening must be conspicuously marked.

(b) The identity and location of each passenger emergency exit must be recognisable from a distance equal to the width of the cabin.

(c) Means must be provided to assist the occupants in locating the exits in conditions of dense smoke.

(d) The location of each passenger emergency exit must be indicated by a sign visible to occupants approaching along the main passenger aisle (or aisles).

CS 25.812

(a) An emergency lighting system, independent of the main lighting system, must be installed. However, the sources of general cabin illumination may be common to both the emergency and the main lighting systems if the power supply to the emergency lighting system is independent of CS-25 BOOK 1 1-D-26 the power supply to the main lighting system.

CS 25.813

Each required emergency exit must be accessible to the passengers and located where it will afford an effective means of evacuation. Emergency exit distribution must be as uniform as practical, taking passenger distribution into account; however, the size and location of exits on both sides of the cabin need not be symmetrical. If only one floor level exit per side is prescribed, and the aeroplane does not have a tail cone or ventral emergency exit, the floor level exit must be in the rearward part of the passenger compartment, unless another location affords a more effective means of passenger evacuation. Where more than one floor level exit per side is prescribed, at least one floor level exit per side must be located near each end of the cabin, except that this provision does not apply to combination cargo/passenger configuration. In addition –

(a) There must be a passageway leading from each main aisle to each Type I, Type II, or Type A emergency exit and between individual passenger areas. If two or more main aisles are provided, there must be a cross aisle leading directly to each passageway between the exit and the nearest main aisle. Each passageway leading to a Type A exit must be unobstructed and at least 91 cm (36 inches) wide. Other passageways and cross aisles must be unobstructed and at least 51 cm (20 inches) wide. Unless there are two or more main aisles, each Type A exit must be located so that there is passenger flow along the main aisle to that exit from both the forward and aft directions.

(b) Adequate space to allow crew-member(s) to assist in the evacuation of passengers must be provided as follows:

(1) The assist space must not reduce the unobstructed width of the passageway below that required for the exit.

(2) For each Type A exit, assist space must be provided at each side of the exit regardless of whether the exit is covered by CS 25.810(a).

(3) For any other type exit that is covered by CS 25.810(a), space must at least be provided at one side of the passageway.

(c)There must be access from each aisle to each Type III or Type IV exit, and –

(1) For aeroplanes that have a passenger seating configuration, excluding pilot's seats, of 20 or more, the projected opening of the exit provided may not be obstructed and there must be no interference in opening the exit by seats, berths, or other protrusions (including seatbacks in any position) for a

distance from that exit not less than the width of the narrowest passenger seat installed on the aeroplane.

(2) For aeroplanes that have a passenger seating configuration, excluding pilot's seats, of 19 or less, there may be minor obstructions in this region, if there are compensating factors to maintain the effectiveness of the exit.

(d) If it is necessary to pass through a passageway between passenger compartments to reach any required emergency exit from any seat in the passenger cabin, the passageway must be unobstructed. However, curtains may be used if they allow free entry through the passageway.

(e) No door may be installed in any partition between passenger compartments.

(f) If it is necessary to pass through a doorway separating the passenger cabin from other areas to reach any required emergency exit from any passenger seat, the door must have a means to latch it in open position. The latching means must be able to withstand the loads imposed upon it when the door is subjected to the ultimate inertia forces, relative to the surrounding structure, listed in CS 25.561 (b).

CS 25.815

Width of aisle – minimum 38cm (15") for less than 64cm upright from aisle.

CS 25.817

On aeroplanes having only one passenger aisle, no more than three seats abreast may be placed on each side of the aisle in any one row.

CS 25.820

All lavatory doors must be designed to preclude anyone from becoming trapped inside the lavatory. If a locking mechanism is installed, it must be capable of being unlocked from the outside without the aid of special tools.

CS 25.1411

(a) Accessibility. Required safety equipment to be used by the crew in an emergency must be readily accessible.

CS 25.1415

(b), (1) […] the buoyancy and seating capacity beyond the rated capacity of the rafts must accommodate all occupants of the aeroplane in the event of a loss of one raft of the largest rated capacity.

(e) For aeroplanes, not certificated for ditching under CS 25.801 and not having approved life preservers, there must be an approved flotation means for each occupant. This means must be within easy reach of each seated occupant and must be readily removable from the aeroplane.

CS 25.1423

A public address system required by operational rules must –

(c) Be intelligible at all passenger seats, lavatories, and cabin crew member seats and work stations.

CS 25.1447

There must be an oxygen-dispensing unit connected to oxygen supply terminals immediately available to each occupant, wherever seated.

(c,1) The total number of dispensing units and outlets must exceed the number of seats by at least 10%. The extra units must be as uniformly distributed throughout the cabin as practicable.

CS 25.1557

(b) Emergency exit placards. Each emergency exit placard must meet the requirements of CS 25.811.

4.2.5 Acceptable Means of Compliance

This section provides further information to the European design specifications, effective 6 July 2009. Relevant parts were selected according to the above mentioned criteria. Cited sections are written in italics, while summarized ones are not.

AMC 25.785

(c)1 Sharp edges or excrescences on the seats or parts of the passenger accommodation which might prove a source of danger not only to the occupants of the seats but particularly to the occupant seated to the rear should be avoided. All surfaces of passenger accommodation and those areas of the seat back lying within the arc of travel of the head of an occupant seated to the rear and restrained by a safety belt should be smooth and of large radius.

3 If the top of the seat back occurs within the arc of travel of the head, it should be padded to at least 25 mm (1 in) radius with at least 12•5 mm (0•5 in) of firm padding.

4 […] No member should occur where it might be struck by the throat.

(g) Where there is a risk that a safety belt or harness might, when not in use, foul the controls or impede the crew, suitable stowage should be provided, unless it can be shown that the risk can be avoided by the application of suitable crew drills.

AMC 25.807

Relevant part of the FAA Advisory Circular 25-17 Transport Airplane Cabin Interiors Crashworthiness Handbook, dated 15/7/91 and AC 25.812-2 Floor Proximity Emergency Escape Path Marking Systems Incorporating Photoluminescent Elements, dated 24/7/97 are accepted by the Agency as providing acceptable means *of compliance with CS 25.812. - "relevant parts" means "the part of the AC 25-17 that addresses the applicable FAR/CS-25 paragraph".*

AMC 25.807 and 25.813

The term 'unobstructed' should be interpreted as referring to the space between the adjacent wall(s) and/or seat(s), the seatback(s) being in the most adverse position, in vertical projection from floor level to at least the prescribed minimum height of the exit.

AMC 25.812

Relevant parts of FAA Advisory Circular 25-17 Transport Airplane Cabin Interiors Crashworthiness Handbook, dated 15/7/91 and AC 25.812-2 Floor Proximity Emergency Escape Path Marking Systems Incorporating Photoluminescent Elements, dated 24/7/97 are accepted by the Agency as providing acceptable means of compliance with CS 25.812. - "relevant parts" means "the part of the AC 25-17 that addresses the applicable FAR/CS-25 paragraph".

AMC 25.815

Relevant part of the FAA Advisory Circular 25-17 Transport Airplane Cabin Interiors Crashworthiness Handbook, dated 15/7/91, are accepted by the Agency as providing acceptable means of compliance with CS 25.815. - "relevant parts" means "the part of the AC 25-17 that addresses the applicable FAR/CS-25 paragraph".

4.2.6 Technical Standard Orders

This section covers technical directives for compliance with the European certification specifications. Relevant parts were selected according to the above mentioned criteria. This section contains short summaries of the corresponding ETSO.

TSO/ETSO C22g

This technical standard order ((E)TSO) prescribes the minimum performance standard that safety belts must meet in order to be identified with the applicable (E)TSO marking. New models of safety belts that are to be so identified and that are manufactured on or after the date of this (E)TSO must meet the standards set forth in Society of Automotive Engineers, Inc. (SAE) Aerospace Standard (AS) Document No. AS 8043, "Torso Restraint Systems," dated March 1986, with the exceptions and revisions covered in subparagraphs (a) (4) and (a) (5) of this (E)TSO.

TSO/ETSO C39b

(E)TSO) prescribes the minimum performance standards that aircraft seats and berths of the following types must meet in order to be identified with the applicable (E)TSO marking:

Type I - Transport (9g forward load)

Type II - Normal and Utility

Type III - Acrobatic

Type IV – Rotorcraft

TSO/ETSO C64a

This ETSO gives the requirements which new models of oxygen mask, continuous flow, passenger, that is manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking. See AS8025A

TSO/ETSO C69c

This technical standard order ((E)TSO) prescribes the minimum performance standards (MPS) that emergency evacuation slides, ramps, ramp/slides, and slide/rafts must meet to be identified with the applicable (E)TSO marking:

Type I- Inflatable Slide

Type II- Inflatable Slide/Raft

Type III- Inflatable Exit Ramp

Type IV- Inflatable Exit Ramp/Slide

TSO C70a

This Technical Standard Order (TSO) prescribes the minimum performance standards that life rafts combinations must meet to be identified with the applicable (E)TSO marking. This (E)TSO has been prepared in accordance with the procedural rules set forth in Subpart O of the Federal Aviation Regulations Part 21.

TSO/ETSO C72c

This technical standard order ((E)TSO) prescribes the minimum performance standards that individual flotation devices must meet in order to be identified with the applicable (E)TSO marking.

TSO/ETSO–C78

(TSO C78 status: historical – C116 actual)

This Standard contains minimum performance standards for the manufacture of demand type oxygen masks for use with non-pressure demand (straight demand and diluter-demand) and pressure-demand oxygen systems.

TSO/ETSO C99

(TSO C78 status: historical – C116 actual)

This ETSO gives the requirements which protective breathing equipment that is manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking. See AS 8031

TSO/ETSO C100b

This Technical Standard Order ((E)TSO) tells persons seeking a (E)TSO authorization or letter of design approval what minimum performance standards (MPS) their child restraint systems must first meet in order to obtain approval and be identified with the applicable (E)TSO marking.

TSO/ETSO C114

This technical standard order ((E)TSO) prescribes the minimum performance standards that torso restraint systems must meet to be identified with the applicable (E)TSO marking. When an application for a TSO authorization is made on or after the date of this (E)TSO, the torso restraint system must meet the standards set forth in Society of Automotive Engineers, Inc. (SAE), Aerospace Standard (AS) 8043, “Aircraft Torso Restraint System,”

TSO/ETSO C127

This Technical Standard Order (TSO) prescribes the minimum performance standards (MPS) that rotorcraft, transport airplane, and normal and utility airplane seating systems of the following designated types must meet in order to be identified with the applicable TSO marking

4.2.7 The Passenger Rights in the EU

In the following, the rights of access to air travel which may have a direct or indirect effect on safety are presented. These were selected according to the same principle as in the previous chapter. The Passenger rights are included as complementary information.

4.2.7.1 Regulation (EC) No. 1107/2006

In the following, the rights of access to air travel which may have a direct or indirect effect on safety are presented. These were selected according to the same principle as in the previous chapter. The relation of these legislations with the scope of the study is not direct, but they are included as complementary information.

In the EU, the rights of disabled persons and persons with reduced mobility when travelling by air are governed by Regulation (EC) No. 1107/2006 of the European Parliament and the Council, effective 26. July 2008. Disabled persons or persons with reduced mobility are defined in Article 2 (a) as follows:

“’Disabled person’ or ‘person with reduced mobility’ means any person whose mobility when using transport is reduced due to any physical disability (sensory or locomotor, permanent or temporary), intellectual disability or impairment, or any other cause of disability, or age, and whose situation needs appropriate attention and the adaptation to his or her particular needs of the service made available to all passengers.”

Furthermore, the following applies:

“Disabled persons and persons with reduced mobility should therefore be accepted for carriage and not refused transport […] except for reasons which are justified on the grounds of safety requirements established by the authority that issued the air operator's certificate to the air carrier and prescribed by law or if the size of the aircraft or its doors makes the embarkation or carriage […] physically impossible[*].”

Pursuant to Regulation (EC) 1107/2006 air carriers and their agents as well as the managing bodies of airports are committed:

- Ensure the provision of the assistance specified in Annex I in such a way that the person is able to take the flight. This shall also cover a return flight, if the outward flight and the return flight have been contracted with the same air carrier. ((Art 7, (1))

- Accommodation of a recognised assistance dog in accordance with applicable national rules covering the carriage of assistance dogs on board aircraft, where such rules exist. (Art. 7, (2))

[*] The flight commander makes the final decision. (EU-OPS 1.085 (f) (4)): “The commander shall […] have authority to disembark any person, or any part of the cargo, which, in his/her opinion, may represent a potential hazard to the safety of the aeroplane or its occupants”

- Set quality standards for the assistance specified in Annex I in cooperation with organisations representing disabled passengers and passengers with reduced mobility for airports whose annual traffic is more than 150 000 commercial passenger movements. (Art 9, (1))

- Ensure that all their personnel, including those employed by any sub-contractor, providing direct assistance have appropriate knowledge (Art. 11)

- Loss or damage of wheelchairs or other mobility equipment or assistive devices shall be compensated, in accordance with rules of international, Community and national law. (Art. 12)

- In the event of refusal, the air carrier, its agent or the tour operator shall make reasonable efforts to propose an acceptable alternative. When an air carrier or its agent or a tour operator exercises derogation under paragraphs 1 or 2, it shall immediately inform the disabled person and, on request, shall communicate these reasons in writing within five working days of the request. (Art 4)

The disabled person should not be put at a financial disadvantage compared to other passengers for the above assistance. The costs for the provision of the respective infrastructure are shared among all passengers. (paragraph 8)

In organising the required assistance, the airports and the air carriers should take account of Document 30[**] - Part I - Section 5 of the European Civil Aviation Conference (ECAC) and the related annexes, especially the ”Code of Good Conduct in Ground Handling for Persons with Reduced Mobility“.

The disabled person is committed:

- To accept on request of an air carrier or its agent or a tour operator to be accompanied by another person who is capable of providing the assistance required by that person. (Art 4, (2))

- Transmit the need for assistance at least 48 hours before the published departure time for the flight (Art. 6, (2))

- If no time is stipulated, present himself not later than two hours before the published departure time at a point within the airport boundary designated in accordance with Article 5 or not later than one hour before the published departure time for check-in (Art. 7)

[**] ECAC DOC No. 30 10th Edition/December 2006 (Amended on 13 May 2009).
TÜV Rheinland was fully aware of an updated ECAC DOC No. 30 to be published by ECAC during conduction of this study. Unfortunately it was not available to the public at the time of the finalisation of this study.

4.2.7.2 Comparison of Passenger Rights in the EU and in the US

In the United States, the rights of disabled passengers are defined in the "Air Carrier Access Act, 14 CFR Part 382, Non-discrimination on the Basis of Disability in Air Travel", effective 18. March 2009.

In Europe, these are set forth in Regulation (EC) 1107/2006 (supported by guidance published in ECAC Doc 30, 10th Edition, amended 13 May 2009).

The following is a comparison of the safety-relevant sections of the US and EU requirements intending to assess interrelation between the passenger' right legislation and the aviation safety rules s. However, Since this study is concentrated on the European area, only the aviation safety requirements of EU-OPS are listed, but not the corresponding US FARs.

Scope of application

USA, § 73 FR 27614	[…] The Department of Transportation is amending its Air Carrier Access Act (ACAA) rules to apply to foreign carriers.
EU-OPS 1.001:	[…] any civil aeroplane for the purpose of commercial air transportation by any operator whose principal place of business and, if any, registered office is in a Member State
(EC)1107/2006, Art. 1:	The provisions of this Regulation shall apply to disabled persons and persons with reduced mobility, using or intending to use commercial passenger air services on departure from, on transit through, or on arrival at an airport, when the airport is situated in the territory of a Member State to which the Treaty applies.

Number of PRMs

USA, § 382.31(c):	A carrier shall not limit the number of such persons on a given flight.
(EC) 1107/2006, Art. 3:	An air carrier or its agent or a tour operator shall not refuse, on the grounds of disability or of reduced mobility to accept a reservation for a flight and to embark a disabled person who has a valid ticket and reservation.

Refusal of carriage

USA, (§ 382.31 (e):	[The transport may be denied when] transporting the person would or might be inimical to the safety of the flight.

EU-OPS 1.085:	The commander shall have authority to disembark any person, or any part of the cargo, which, in his/her opinion, may represent a potential hazard to the safety of the aeroplane or its occupants.
(EC) 1107/2006, Art. 4:	Disabled persons and persons with reduced mobility should therefore be accepted for carriage and not refused transport […] except for reasons which are justified on the grounds of safety requirements established by the authority that issued the air operator's certificate to the air carrier and prescribed by law or if the size of the aircraft or its doors makes the embarkation or carriage […] physically impossible

Accompanying persons

USA, § 382.35:	A carrier may require travel with an attendant if: - A stretcher or incubator is used for attending the medical needs - A person is unable to comprehend or respond appropriately to safety instructions - A person is unable to assist in his or her own evacuation - The person cannot establish some means of communication with carrier personnel
(EC) 1107/2006, Art. 4:	To accept on request of an air carrier or its agent or a tour operator to be accompanied by another person who is capable of providing the assistance required by that person.
EU- OPS:	No advice on accompanying persons
ECAC DOC 30 – 5.4.4.1:	Air carriers should be encouraged to offer discounts for the carriage of an accompanying person for disabled persons and PRMs in particular when the air carrier considers the presence of such a person necessary for safety reasons.
ECAC DOC 30 – 5.10.2	Where a disabled person or PRM is assisted by an accompanying person, the air carrier should make all reasonable efforts to give such person a seat next to the disabled person or PRM

Carrying of PRMs

USA, § 382.40:	[in the cabin]: Hand-carrying of passengers is permitted only for emergency evacuations.
(EC) 1107/2006, Annex I:	Assistance of the managing bodies of airports to board the aircraft, with the provision of lifts, wheelchairs or other assistance needed

Assistance by the crew

USA, § 382.39 (c):	Carriers are not required to provide assistance in actual eating or within the restroom or assistance at the passenger's seat with elimination functions or provision of medical services
(EC) 1107/2006, Annex II:	Assistance in moving to toilet facilities if required.
EU-OPS 1.285:	Provision of a Safety-Briefing
EU-OPS 1.988:	*(cabin crew members shall)* perform, in the interests of safety of passengers, duties assigned to him/her
ECAC DOC 30 – 5.10.2:	Assistance in moving to toilet facilities if required Communication of essential information concerning a flight in accessible formats.

Carriage of assistance dogs

USA, § 382.55:	Carriers shall permit a service animal in any seat in which the SCP sits, unless the animal obstructs an aisle or other area that must remain unobstructed in order to facilitate an emergency evacuation.
(EC) 1107/2006, Annex II:	Carriage of recognised assistance dogs in the cabin, subject to national regulations
EU-OPS:	(see also OPS 1.270 "Stowage of baggage and cargo" and Appendix to OPS 1.270)
ECAC DOC 30 – 5.10.2:	The assistance of air carriers should include carriage of recognised assistance dogs in the cabin, subject to national regulations

On-board wheelchair

USA, § 382.21:	On-board wheelchairs shall include footrests, armrests which are movable or removable, adequate occupant restraint systems, a backrest height that permits assistance to passengers in transferring, structurally

	sound handles for manoeuvring the occupied chair, and wheel locks or another adequate means to prevent chair movement during transfer or turbulence.
ECAC Doc 30 - 5.10.4:	In case an on-board wheelchair is available this should be easily accessible for any passenger in need of it during the flight.
ECAC Doc 30 - 5.10.5:	Aircraft of 60 or more seats which are equipped with a lavatory for PRMs should have at least one on-board wheelchair available on any flight. Aircraft of 100 or more seats should have at least one on-board wheelchair. Aircraft of 100 or more seats should have a priority space in the cabin, designated for storage of at least one vertically folding personal wheelchair not exceeding ISO dimensions.

Stowage

USA, § 382.41:	If in accordance with 14 CFR 121.589 and 14 CFR 121.285(c) or 14 CFR 135.87, as applicable, Carriers shall permit PRMs to bring on board: - personal ventilators/respirators including non-spillable batteries - canes and other assistive devices in close proximity to their seats, - a folding, collapsible, or break-down wheelchair, when a closet or other approved stowage area is provided in the cabin for passengers' carry-on items. This comprises battery-powered chairs without removing the battery.
ECAC Doc 30 - 5.10.5:	Aircraft of 100 or more seats should have a priority space in the cabin, designated for storage of at least one vertically folding personal wheelchair not exceeding ISO dimensions.
(EC) 1107/2006, App. 2:	In addition to medical equipment, transport of up to two pieces of mobility equipment per disabled person or person with reduced mobility, including electric wheelchairs (subject to advance warning of 48 hours and to possible limitations of space on board the aircraft, and subject to the application of relevant legislation concerning dangerous goods.

EU-OPS 1.1160: Equipment containing wet cell batteries must be kept and, when necessary secured, in an upright position to prevent spillage of the electrolyte

(see also OPS, SUBPART R, TRANSPORT OF DANGEROUS GOODS BY AIR)

Moveable armrests

USA, § 382.45: Movable aisle armrests shall be provided in aircraft with 30 or more seats on at least one-half of passenger aisle seats

ECAC Doc 30 - 5.10.5: In aircraft with 30 or more seats at least 50% of all aisle seats should have moveable armrests

Access to the board toilets

USA, § 382.21: For aircraft with more than one aisle: The lavatory shall permit a qualified individual with a disability to enter, manoeuvre within as necessary to use all lavatory facilities, and leave, by means of the aircraft's on-board wheelchair.

ECAC Doc 30 – 5.10.5: Aircraft with more than one aisle should be equipped with at least one spacious lavatory for PRMs catering for all kinds of disabilities.

Safety briefing

USA, § 382.45: […] Carrier personnel shall not require to demonstrate that a SCP has listened to, read, or understood the information presented, except to the extent that carrier personnel impose such a requirement on all passengers with respect to the general safety briefing (§ 382.45)

USA, § 121.571 a required crewmember assigned to the flight shall conduct an individual briefing of each person who may need the assistance of another person to move expeditiously to an exit in the event of an emergency. In the briefing the required crewmember shall—

(i) Brief the person and his attendant, if any, on the routes to each appropriate exit and on the most appropriate time to begin moving to an exit in the event of an emergency; and

(ii) Inquire of the person and his attendant, if any, as to the most appropriate manner of assisting the person so as to prevent pain and further injury.

Visibility:

ECAC Doc 30 - 5.10.5: Particular attention should be paid to colour and tone contrast and also to having an even level of lighting.

4.2.8 National Aviation Requierements

In the following chapter requirements and guidelines of several national aviation authorities (NAA) regarding transport of SCPs are listed. All EU member states refer to European requirements (e.g. EU-OPS) or related guidance material (e.g. ECAC-Doc. 30 or JAA TGL No. 44). In addition some states have adopted specific national requirements or guidance material (e.g. Germany, United Kingdom, Belgium) which are also applicable as long as they are not contradictory to EU Regulations.

Analysis of the national requirements and further investigations revealed that a comprehensive list of national requirements regarding SCPs was unrewarding with respect to assess safety risks. Indeed some national regulations are an appropriate approach to manage potential problems associated to the carriage of special categories of passengers (e.g. procedures for the use of medically indicated seat pans, limitation of numbers). However, some specific national restrictions, specifically for SCP limitation and number of accompanying persons seem not to be based on scientific evidence. Neither further explanations nor studies were found to validate the specific restrictions of some European member states. Taking into account the above mentioned factors, and the limited time to conduct the study, it was concluded that using a sample overview of European wide national regulations was representative enough, as presented below.

4.2.8.1 CAA Germany

Transport of SCPs / General note

Germany has no specific national aviation requirements or guidelines regarding transport of Special Categories of Passengers. Transport of SCPs is regulated as followed:

1. Transportation of PRMs, for example, is guided by EU Regulation (EC) 1107/2006 and ECAC-Doc. 30 Section 5, by EU-OPS 1.280 and EU-OPS 1.260 and the so-called Section 2 Material under JAR-OPS 1, which also remains applicable after the introduction of EU-OPS, provided it is not contradictory to EU-OPS 1.

2. The procedures for transporting ill persons and persons on stretchers are individually stipulated by aviation companies in their manuals which must be approved by the authorities.

3. The procedures for transporting passengers without residence permits, deportees and passengers in custody (transport of prisoners) must be stipulated by the companies, in acc. with EU-OPS 1.265.

4. The procedures for transportation of infants are set out in the LBA circular 14/2008 below and are based on EU-OPS 1 and § 6 of 1. DV LuftBO *(Regulation on Aircraft Operation)*. A procedure for transporting severely disabled children requiring special seating aids is also available. This procedure is explained in the LBA Circular 06/2005.There are no national regulations on the transportation of children aged between two and 12, or unaccompanied minors (UM).

LBA Circular 14/2008
Qualification Procedures for Child restraint systems in Aircraft

<u>Published by:</u> Luftfahrtbundesamt (LBA), July 2008

The German Aviation Authority LBA developed a certification procedure for the use of automotive child restraint systems in aircraft in cooperation with various airlines, child restraint system manufacturers and TÜV Rheinland.

This procedure identifies suitable automotive child restraint systems for infants and children and ensures that child restraint systems fit on the aircraft passenger seat and can be safely fastened by means of the two-point belt; thus ruling out any operational imponderability during boarding and ensuring safe transportation of infants and children. Furthermore, it can be ruled out that a CRS which is not safely attached presents a hazard to other passengers.

LBA Circular 06/2005
Procedures for the use of medically indicated seat pans / sitting aids for the carriage of (very) severely disabled infants and children on board of aircraft

<u>Published by:</u> Luftfahrtbundesamt (LBA), August 2005

In specific cases, severely disabled children can only air travel in custom-built seats/sitting aids. To ensure that this special sitting aid fits into the aircraft passenger seat and can be safely attached with the two-point belt, the airline or the sales agency commissions an LBA authorised expert organisation with the drawing-up of a relevant expert opinion.

For this purpose, it is essential that the parents or guardians of the child (applicants) contact the respective airline in due time to request the terms of transport.

If all further air travel requirements are met and the expert opinion is complied with e.g. medical certificate on transportability, the entities involved in the air travel of the child and any accompanying person(s), i.e.

- airline OPS
- ground handling (including attendance services)

- flight operation
- traffic management centre and
- the crews of the relevant flight

are informed accordingly.

Every disabled infant / child is accompanied by an adult in charge of the infant / child who will be seated in an adjacent passenger seat. The accompanying person must be capable of attending to and evacuating the infant / child without assistance in flight and in case of emergency. The accompanying person must be informed that the sitting aid shall be left on the aircraft in case of an emergency evacuation.

The accompanying person(s) is/are responsible for the installation of the sitting aid on the passenger seat and for strapping the child into the sitting aid.

The flight attendants check both measures prior to take-off and landing in accordance with the installation instructions given in the expert opinion.

4.2.8.2 CAA United Kingdom

Code of Practice
Access to Air Travel for Disabled Persons and Persons with Reduced Mobility

Published by: Department for Transport, UK, July 2008

This document is aimed at all who are involved in providing services related to air travel. It covers the entire route - from booking to the arrival at the destination. It is not intended as a guide for passengers with reduced mobility under EU Regulation No. 1107/2006. Separate information is available for these persons.

It is estimated that around 20% of the UK's adult population has some form of disability. Estimates are similar for Europe as a whole.[9].

The document is subdivided into sections. Each section contains a statement. The statements which may have relevance to safety-related issues are:

1.17: Companies should review their policies, procedures and practices to ensure that they meet the needs of disabled persons and persons with reduced mobility, including not only the physical access and ease of use of facilities but also operational manuals, emergency procedures, evacuation arrangements, safety information and other documents.

2.17: Training for security staff should take account of guidance contained in Annex F to ECAC Doc 30 and guidance issued in support of the UK's National

[9] Comment TÜV Rheinland: According to EDF, 10% of all people in the EU are disabled

Aviation Security Programme by the Department for Transport's Transport Security and Contingencies Directorate (TRANSEC).

3.3: The language of important documents should be simple and clear, with appropriate illustrations. It would be good practice to have Braille versions available on request, particularly for documents which have a wide circulation and whose content does not change frequently.

3.13: Airlines should only require a personal assistant when it is evident that a disabled person is not self-reliant and that this could pose a safety risk. In practice, this means anyone who is incapable of unfastening their seat belt, leaving their seat and reaching an emergency exit unaided, retrieving and fitting a lifejacket, donning an oxygen mask without assistance, or is not capable of communicating with cabin crew and understanding their advice and instructions in an emergency situation.

3.18: EC Regulation 1107/2008 specifies that an air carrier shall permit the carriage of two items of mobility equipment free of charge. It is generally accepted that this means mobility equipment needed by the passenger for the purpose of the journey by air, for example a wheelchair and walking frame.

5.43: Under normal circumstances, all disabled and reduced mobility passengers who need assistance should board first on departure and be the last to disembark on arrival.

5.52: To avoid conflicts, all wheelchairs should be stored in the hold. However, other small mobility aids such as crutches, sticks, cushions or wheelchair accessories should be carried in the passenger cabin, provided they can be securely stowed.

6.6: The design of new aircraft should also consider facilitating lifting aids such as hoists.

6.7: Staff should be trained in the use of on-board wheelchairs in the cabin environment and should know where they are stowed.

6.9: On multi-deck aircraft, consideration should be given to the number of on-board wheelchairs needed to serve all decks and classes.

6.20 + 6.21: Lighting, except reading and other lights under the control of the passenger, should be directed and controlled to prevent glare or shadows. Lighting in the passenger cabin should not create sharp contrasts in intensity. Controlling the lighting in this way will benefit partially sighted people who would otherwise have difficulties with starkly contrasting lighting.

6.22: Signage should contrast with its surroundings and, where appropriate, be embossed and include pictograms.

7.2: Training should cover the circumstances under which an airline may legitimately refuse to embark a passenger. Ideally, refusal should be given when booking or at check-in, but it is recognised that there may be rare occasions when a decision to refuse carriage has to be taken by the cabin crew or flight crew.

7.11: The need for subtitles will be minimised if a video programme is produced without need for audio commentary, i.e. a video relying solely on pictures.

7.12: All emergency and other announcements relating to schedule changes, connections and on board services should be repeated visually and verbally to disabled people who request such a service.

7.19: For the safety of crew and passengers, cabin crew must not pick up disabled passengers. Passengers who need to be lifted must travel with a personal assistant(s) capable of performing this service.

7.23: In order to carry guide dogs, airlines must, acc. to UK animal movement regulations, first seek approval to carry dogs under the PET Travel Scheme for each individual route.

FLIGHT OPERATIONS DIVISION COMMUNICATION (FODCOM 49/2008)

Published by: CAA Safety Regulation Group, Flight Operations - Division Communication, UK, December 2008.

The purpose of this FODCOM is to provide further guidance on the circumstances in which an air carrier may refuse to embark a PRM.

The guidelines advise that, in normal circumstances, PRMs should not be seated adjacent to an emergency exit and, where PRMs form a significant proportion of the total number of passengers carried on board, the number of PRMs should not exceed the number of able-bodied persons (ABPs) capable of assisting with an emergency evacuation.

The maximum number of PRMs permitted by EU-OPS on any particular flight will depend on a number of variables. These variables include the type and configuration of the aircraft, the extent of the reduced mobility or disability of the PRMs seeking embarkation and the number of ABPs.

It is the responsibility of an operator to comply both with EU-OPS and with Regulation (EC) No. 1107/2006. If operators are considering refusal of reservation or boarding, they can only do so if they would otherwise exceed the legal maximum established by EU-OPS for that flight; it is the operator's responsibility to establish that maximum.

TÜV Rheinland Comment:

(1) *EU-OPS does not contain any recommendations for actions which would permit limiting of PRMs. Such recommendations were published by the JAA as a "Temporary Guidance Leaflet" TGL 44*

(2) *The hitherto only variable with respect to "type and configuration of the aircraft" is found in Regulation (EC) 1107/2006 – refusal of transport when the size of the aircraft or its doors makes boarding physically impossible.*

(3) *The FODCOM statement regarding the maximum number of PRMs permitted by EU-OPS is not clear. FODCOM highlights that refusal of booking may only be considered when the number of PRMs for a given flight would exceed the legal maximum established by EU-OPS. Since EU-OPS per se does not limit the number of PRMs on board, the FODCOM justification is misleading. TGL No. 44 does limit the number of PRMs on board. Airlines may use TGL No. 44 (based on Jar Ops 1 Section 2) as guidance material if not contradicting EU-OPS. For refusal of PRMs, TGL 44 can only be applied by an operator registered in a member state where TGL 44 has been adopted as a national rule by that member state with the view to complement EU-OPS.*

4.2.8.3 CAA Belgium

Circulaire CIR/OPS-04

Published by: Direction générale Transport aérien, Centre communication Nord, Belgium, December 2006

A circular entered into force in Belgium in December 2006, regulating the transportation of PRMs in commercial air traffic.

The number of PRMs on board is regulated under Item 3 of the circular. Differentiation is made between PRMs with and without accompanying persons.

1. Applicable to unaccompanied PRMs:

MEDA, MAAS, DEAF:	No limits
WCHR, Mentally handicapped:	No limits, but one qualified accompanying person on board per 12 WCHR or 12 mentally handicapped persons.
WCHS, STCR and all others:	The total number of these PRMs on board may not exceed half the number of available "floor level exits".

2. Applicable to accompanied PRMs:

MEDA, MAAS, DEAF:	No limits

WCHR, Mentally handicapped:	No limits, but one qualified accompanying person on board per 12 WCHR or 12 mentally handicapped persons.
WCHS, STCR and all others:	The total number of these PRMs on board may not exceed 10% of the max. permissible passenger capacity acc. to JAR-OPS Subpart O, 1.990 (b),(2))[10]. An exception for individual flights may be granted by the authorities upon request.

The number of persons accompanying PRMs (refer case 2) is specified as follows:

WCHS:	One accompanying person per PRM.
WCHP, WCHC, STCR:	Two accompanying persons per PRM unless the size of the PRM allows evacuation by one person
BLND, BLND-DEAF:	One accompanying person per two PRMs.
WCHR, Mentally handicapped:	One accompanying person per 12 PRMs.

The accompanying persons must be at least 15 years of age and be physically and mentally up to the task. They must be seated next to the PRM and not in an exit row. They are not allowed to have additional responsibilities, such as caring for an infant.

If the aircraft is chartered exclusively for the transportation of PRMs, their number is not limited. In this case, however, two accompanying persons are required per PRM who cannot move independently (e.g. WCHC, STCR) unless one person is able to prove his ability to evacuate such PRMs alone.

One accompanying person is required for PRMs with limited mobility.

One accompanying person is required per two BLND.

One accompanying person is required per 12 WCHR or 12 Mentally Disabled.

PRMs must embark and disembark separately and be seated where they do not hinder evacuation. At the same time, their own evacuation should be well catered for. Seats at emergency exits may not be occupied by PRMs or by accompanying persons.

Guide dogs are transported on board, but they must wear a muzzle.

[10] the max. permissible number of passengers depending on the cabin crew present or with respect to the relevant evacuation certificate (e.g. CS25, Appendix J)

The airlines should be guided by ECAC Doc 30 with regard to PRM arrangements.

4.2.8.4 CAA Netherlands

There are no specific national aviation requirements or guidelines for transportation of Special Categories of Passengers.

Transportation of PRMs is guided by EU Regulation (EC) 1107/2006 and ECAC-Doc. 30, by EU-OPS 1.280 and EU-OPS 1.260 and the so-called Section two Material under JAR-OPS 1, which also remains applicable after the introduction of EU-OPS, provided it is not contradictory to EU-OPS.

4.2.8.5 CAA Denmark

CAA Denmark stated that there are no specific national aviation requirements or guidelines regarding transport of Special Categories of Passengers.

4.2.8.6 CAA France and CAA Spain

Until the expiration of the Final Phase, unfortunately information was provided by neither CAA France nor CAA Spain.

4.3 Relevant Common Practice

The following information is taken from a research of the respective Internet and booking portals of different airlines as well as from interviews with various representatives of the different associations, authorities and companies. The focus of conducted interviews and meetings was safety, albeit questions regarding legislation and common practice were included. The subsequent summary was elaborated by TÜV Rheinland. The present chapter summarizes the findings from the above mentioned media and parties participated and does not necessarily reflect TÜV Rheinland's point of view.

4.3.1 Airlines

Infants / Children:

The European airlines handle the carriage of infants and children differently.

The large-sized European airlines allow the lap-held transport of infants in accordance with EU OPS 1.320 and 1.730 (double occupancy + loop belt) or in a seat of their own seated in a child restraint system accepted by the authority. The parents mainly provide the child restraint system.

One airline provides its own TSO approved child restraint systems for infants. A number of German airlines have taken part in a qualification procedure for child restraint systems. The qualification procedure identifies suitable child restraint systems for infants and children and ensures safe attachment to the aircraft passenger seat.

Some low-cost carriers do not provide the possibility to book an extra seat for the infant voluntarily and to attach a suitable child restraint system.

The major European airlines allow children aged five years and older to fly without an accompanying person. In practice, children aged up to 12 years are attended by ground and cabin staff of the airline during their travel. Some low-cost carriers allow unattended travelling of children only from the age of 16 years.

Expectant mothers:

Expectant mothers are in most cases allowed to fly up to gestation week 36. Afterwards, they are not admitted or they need a medical certificate.

Passengers with disabilities / persons with reduced mobility

The European airlines handle the number of PRMs per flight differently. Some airlines limit the number to a maximum of four or five PRMs per flight. The limitation of PRMs on board is mostly justified with safety provisions.

There are, however, airlines allowing up to eleven deaf persons, 22 WCHR/ WCHS and 15 to 22 DEAF/ BLIND person per flight, depending on the aircraft type.

There are also European charter flights to specific health resorts and places of pilgrimage. It is not unusual on these flights that PRMs occupy all seats of the aircraft or at least a major part of the seats.

Accompanying persons

The European airlines do not handle the number of required accompanying persons uniformly. Some airlines require accompanying persons, making reference to the service restrictions of the cabin crew, e.g. cabin crew is not obliged to feed someone. The following gives a number of examples for very different practices:

- One accompanying person for each WCHS, two accompanying persons for each WCHC
- Two accompanying persons for each stretcher
- One accompanying person for the medical attendance of a stretcher occupant
- One accompanying person for two blind persons

4.3.2 Associations for Persons with Disabilities

Access to air travel:

The associations for persons with disabilities stated that arbitrary denial of boarding for disabled persons or persons with reduced mobility to be the biggest concern. For safety reasons, limiting the numbers of SCP would be accepted, depending on the kind of disability. But the benefit in safety must be argued comprehensively. General denial of certain categories of persons with disabilities must be prevented. Balance between access to air travel for PRMs and safety in air travel for PRMs must be a particularly important task.

Transmission of Information

There might be a problem in the chain of information regarding procedures of 1107/2006 and IATA-Classification of SCP. It is not always ensured that a registered disabled person receives the assistance which he or she requires. Furthermore transmission of data might be interrupted between travel agency and airline/airport.

Assistance

Above all in the new EU member states, the Regulation (EC) 1107/2006 standards are not always known sufficiently. The biggest challenges for the future are the lack of infrastructure suitable for the disabled, but also training deficits in handling people with disabilities.

Ground staff and cabin staff have training deficits in handling PRMs, particularly when outsourced (ground staff). This can, for example, lead to painful and discriminating carrying.

The associations state that awareness training of cabin crew on disability issues is very important to prevent prejudices and assumptions on the PRMs degree of independence – e.g. coercion to accept assistance which is, from the PRMs' point of view, regarded inappropriate. Communication between PRM and Cabin crew about their special needs is regarded important. In an emergency, carrying is certainly accepted.

4.3.3 Aircraft Manufacturers

Aircraft manufacturers are very interested in the theme "Transport of handicapped persons or PRMs". Contemporary issues in human factors and aviation safety are taken into account in aircraft development. Aircraft certification has not yet included aspects of SCPs. Aircraft developers see two key factors to improve the survival probability after an aircraft crash – fire protection and evacuation. The following provisions are actual state of affairs:

Fire protection

- FAA issued a certification rule with the intention that the aircraft cabin can withstand a defined fire for 5 minutes. Reason: Firefighters at airports must reach planes within three minutes. 75 to 90 percent of accidents happen at or in close proximity of the airport.
- EASA adopts this rule late this year (June 2009)
- Limitations of burnthrough-protections:
  - fuselage must be intact
  - Objective is to keep fire outside the cabin to retard flashover.
- Interior materials are designed to limit exothermic reaction in fire and to limit release of combustible gases

Evacuation

- Evacuation certification is conducted by the manufacturers using the cabin layout with the highest possible passenger load.
- The manufacturer provides training manuals for evacuation
- Adopting the manuals by the airline is accepted for compliance
- The 90 seconds requirement serves as benchmark, not as a simulation for real evacuations
- The 90 seconds originate from the 60s. This time was regarded as achievable and sufficient for an evacuation

- The egress rate through any door may be determined by dividing the number of passengers that require such a door through 80 seconds. For door opening and slide inflating 10 sec are estimated.

- TSO states that a slide on a type A exit must deal with 70 passengers per lane per minute.

- A flow rate of 1,6 to 1,7 passengers per second is standard. Exceptional good is two passengers per second

- The test is conducted under well defined conditions (CS25 Appendix J)

- The participants must be of normal health to prevent serious injuries

- A PRM on board can not be represented by several passengers of normal health regarding evacuations

- There is no data on the behaviour and impact of PRMs on evacuations

- Due to their size, type III exits are least suitable for PRMs*

- Crew training and human factors are significant factors in evacuations

- Cabin crews PBE is intended to be used for fire fighting and not suited for evacuation purposes, because they impair vision and verbal communication.

- Drop down masks are intended to provide additional oxygen in case of depressurization of the cabin. Note that they do not fit tight, so they offer no protection against smoke-inhalation

4.3.4 Cabin Crew Associations

The cabin crew associations assume that Regulation (EC) 1107/2006 will lead to an increase in the number of PRMs. The associations criticise that the additional work load was not matched by an increase in the prescribed number of cabin crew members. This might be at the expense of safety.

The statements below are taken from discussions with cabin crew associations:

<u>Number and composition of cabin crew:</u>

- In the late 90s, most airlines reduced the cabin crew to the minimum allowed

- Regulation (EC) 1107/2006 has a high impact on cabin crew, because they are charged with its implementation

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* *TÜV Rheinland comment: FAA and TÜV Rheinland evacuation tests revealed that depending on the exit configuration and type of disability the opposite is the case.*

- Cabin crew's workload is considerable high. They are fully engaged with their obligations towards average passengers when aircraft are operated with minimum crew

- Individual briefings take too much time to be conducted by minimum cabin crew when many PRMs are on board

- The minimum crew should be increased when there are PRMs on board, due to workload increase

- OPS1.990 does not contain information on crew composition in relation to the number of PRMs on board

- Engagement of additional cabin crew when cabin layout changes (e.g. increase of seating-capacity not exceeding a whole multiple of 50 seats) is not mandatory, but only recommended in OPS 1.990 (c) and IEM OPS 1.990 Point 2

Training of cabin crew:

- Recurrent training of most airlines' cabin crew included PRMs before Regulation (EC) 1107/2006 was issued. Since Regulation (EC) 1107/2006 entered into force, training on PRMs is highlighted but has not changed.

- Cabin crew is trained on carrying techniques in case of passengers fainting or having heart attacks but, in an emergency, the handling of PRMs is up to the crew.

Evacuation – Duties and common practice of cabin crew:

- Cabin crew appoint someone to accompany unaccompanied minors

- In most cases, cabin crew will try to select passengers as able bodied assistants (ABA) to help the PRM

- Finally, the cabin crew would make a deliberate decision whom to assist in an evacuation

- Personal safety has highest priority

- Because of high workload with evacuation, cabin crew cannot be held responsible for egress of individual PRMs

- Depending on their disability, PRMs will considerably slow down the whole evacuation procedure

- There are no provisions in the flight manuals on how to handle an evacuation on pilgrim flights

- Cabin crew and flight crew are aware that it is impossible to evacuate so many PRMs
- Evacuation time increase due to transporting of PRMs cannot be estimated
- Cabin crew are told to double check if the PRMs have left the plane after evacuation
- The human voice has a range of four to five seat rows – megaphones up to maybe seven rows. This is a potential problem for the hearing impaired.
- Evacuation commands for unaccompanied minors and adults are identical

Briefing:

- Individual briefing of accompanying persons is not common practice, except when the PRM is severely disabled. When it is done, it is done on intuition.
- Because of the high workload while boarding, individual briefings are often not feasible at that time.
- Individual briefings take too much time to be conducted by minimum cabin crew when many SCPs are on board.
- The briefing should be provided by cabin crew because safety briefing via IFE in general does not tell the passengers who is responsible for evacuation on a given flight. Personal visual contact is important
- The importance of the safety briefing is not highlighted by airlines because many passengers suffer from fear-of-flying – the fear should not be intensified.

Turbulences:

- Turbulences are not always foreseeable. Advance warning time, if any, ranges from one to five minutes
- In turbulences, there is no way of securing occupied cabin wheelchairs

4.3.5 Aviation/ Airline Associations

Internationally operating airlines find themselves confronted with a safety relevant incompatibility between the European EC1107/2006 standard and the American Air Carrier Access Act 14CFR382. Every carrier offering flights to the USA must comply with these regulations which, contrary to EC1107/2006, do not cater for limiting PRMs. The US authorities are only able to grant an exception if limitations in the airlines' country of origin comply with applicable law. At present, limitations can only be imposed by European airlines based on handling recommendations such as TGL44, which are not legally binding.

Cost efficiency plays a role in the compliance with legal and additional own requirements. This is why airlines are interested in appropriate and clear provisions for transportation of SCPs.

4.3.6 German Federal Police

TÜV Rheinland consulted representatives of the German federal police and interviewed them regarding relevant safety problems and common procedures when transporting persons in custody and deportees.

The EU Common Guidelines (e.g Council Directive 2004/573/EC) are the basis for the procedures applied in Germany. According to the German Federal Police no safety problems arises if these guidelines are implemented consistently.

Over the years, a multitude of experience has been incorporated into the current procedures. Experience has confirmed that no safety problems arise if these procedures are consistently implemented. There were no safety relevant incidents in the past years in Germany and no evidence of such incidents in Europe was found by our research. The registered German cases contain security problems and no safety problems.

One can conclude that if other EU members implement the EU Common Guidelines consistently, which one can expect, no safety problems will arise (see also findings to *"Passengers in custody / deportees"* Chapter 6.10) Thus contact to additional member states has not been considered necessary.[*]

The following information's were gathered:

- A new, transparent information policy is pursued regarding the transport of deportees and inadmissible passengers

[*] Due to time constraints, TÜV Rheinland could not, as initially planned, consult the European Commission on the implementation status of the Council Directive 2004/573/EC but the risk assessment had also shown that the safety risks were very limited as regards this particular category of passengers

- De-escalating and confidence-building pre-flight measures are applied. The communication with the respective person in custody or deportee is a key factor

- Deportations are exclusively conducted by adequately trained staff

- If the removal in regular air travel is assessed as too risky, it will be discontinued (“No removal at all costs”)

- The cabin crews and the flight crews are informed, irrespective of whether the person is flying with or without an accompanying person

- Unaccompanied deportees are to be considered as regular passengers

- The person is possibly inspected by the aircraft captain

- The person and the officers will board the aircraft before the other passengers

- Deportees often try to draw the other passengers’ attention by loud shouting to stop their deportation. In most cases the situation calms down as soon as the aeroplane’s doors are locked

- Inflight- incidents and troubles occur very rarely. If necessary, the person is restraint by the officer. For this purpose, the well-trained officers can apply various gripping and holding techniques

- Assaults of other passengers are not known up to now

- The responsibility is put on the captain as soon as the doors are locked. The officers have an advisory function, but they do not have any authority anymore. They have to follow the instructions of the crew

- Each person assessed as having to be accompanied is accompanied by at least two unarmed officers

- The specifications of EU-OPS are adhered to

- The accompanying persons do not sit by the emergency exits and window seats

- They are seated as isolated as possible (mostly in the aft section of the aircraft cabin). However, there are no fixed seating arrangements

- On charter flights, the persons in custody and officers are distributed evenly – aggressors are not seated together

- The persons partly wear handcuffs or shackles

- The persons are neither tied to the seat nor to the officer

- In critical flight phases and at the instruction of the crew, the person in custody is not tied or the bonds are loosened

- All resources and procedures have been tested and approved

- Good training is the key to a safe transport / removal

4.4 Accident Reports

The AASK Accident data base of the "FIRE SAFETY ENGINEERING GROUP", University of Greenwich, the ADB accident database, the FAA's homepage and the internet have been considered. Regarding the databases, search-filters containing keywords* and combinations of these words were used. If an accident was found, an internet research by flight number and accident date was conducted. When detailed accident reports were found, they were analysed.

Internet research for accidents included key words like "PRM + evacuation" or "disabilities + evacuation" and comparable.

Three well-documented accidents with SCPs on board were found in the evaluation of accident data bases.

These are not the only accidents or evacuations where SCPs were involved. In the appendix to the FAA Study for evacuation of disabled persons, brief descriptions can be found on 28 relevant accidents. Unfortunately, the seat maps and the passenger profile of most accident reports are not recorded systematically or not recorded at all. The analyses usually focus on the identification of the technical reasons. Furthermore, the recorded pathological information is normally not accessible to the public.

The accidents are not comparable either in themselves or with other accidents. They do, however, serve to highlight some problems experienced with the evacuation of PRMs. It should be noted in this respect that significantly more cabin crew than prescribed by EU-OPS had been on board in all accidents.

While the accident reports of Toronto and Fort Worth are excerpts of original English documents, the accident report of Mulhouse-Habsheim is an abstract of the original French document of BEA (Bureau d'Enquêtes et d'Analyses). Original designations were adopted instead of translated (e.g. flight attendant or of cabin crew).

* e.g. "PRM", "assistance", "disability", "assistance received", "delayed", "special", "reduced", "mobility", "problem", "hindered", "elderly", "Infant", "blind", "mute", "deaf", "canes", "crutches", "handicapped", "custody"

4.4.1 Mulhouse-Habsheim, Air France A320

Place:	Mulhouse-Habsheim
Date:	26. June 1988
Aircraft type:	Airbus A320-100
Course of the accident:	Crash in a forest due to pilot's failure. Wreckage burnt out.
Occupants:	130 passengers (1 WCHC), 4 cabin crew, 2 flight crew
Injuries:	
Fatal:	3 passengers (2 children, one of them paraplegic).
Serious:	34 passengers, 2 crew members

<u>Course of flight:</u>

Air France A320-100 (registration F-GFKC, serial number 009) with flight number 296 was on a charter flight from Paris Charles de Gaulle to Bale-Mulhouse with 130 passengers on board. It was intended to perform a slow flyover in take-off configuration at 100 feet altitude within a flight show of the Mulhouse Aeroclub, followed by a fast flyover in cruising configuration. Most passengers had no carry-on luggage on board due to the special flight profile. Many of them had never flown before.

After a short intermediate landing, flight 296 took off for its first scenic flight just before 12.41. At 12.42 it had climbed an altitude of 2000 ft QNH.

At 1000 ft altitude over ground, the auto-thrust was switched off and the thrust was manually controlled. When the cruising altitude fell below 1000 ft over ground, two alarm signals sounded regarding the altitude and the retracted landing gear.

Descent towards the airport started at 12.44 which was already within sight. The landing gear was extended and the thrust reduced. At 12.45.14, a radar level of 100 ft. over ground was fallen below at a rate of decline of 600 ft/min, sinking to 50 ft within the next eight seconds. A 30 to 35 ft altitude over ground was maintained during the remaining flight. The thrust lever was in “IDLE” position while the speed was reduced. Between 12.45.34 and 12.45.35, the pilot moved the lever out of the IDLE position to increase the thrust. Five seconds later, the aircraft touched the first trees just behind the end of the runway. At this point of time, the rotational speed N1 was 83 percent, and the angle of attack was 14°.

The first tree contact was in the aft fuselage segment, followed by the steering gear, the engines and the extended main landing gear. The aircraft was slowly sinking into the forest. The right aerofoil was torn off and spilling jet fuel was immediately igniting. When the wreckage came to a stop, the flames were bursting through holes at both sides of the fuselage. All passengers, with the exception of two children and a woman, were rescued over the left-hand side of the aircraft in the immediately starting evacuation. Thereupon the fire destroyed the aircraft completely.

Cabin crew:

Chief - Purser:

Cabin crew member seat front left door

Cabin crew 2:

Seat 12 D at overwing exit level

Cabin crew 3:

Cabin crew member seat left, in the aft galley

Cabin crew 4:

Cabin crew member seat right at aft galley level

Fire:

When the right aerofoil got caught in the trees and tore off, the jet fuel was pouring forward due to inertia and ignited. A strong fire developed on the right until the wreckage came to a stop.

Passengers reported that at that time, the flames were entering the cabin through broken windows on the left at rows eight and nine as well as at rows 10 and 15 on the right.

The fire was further nourished by spilling jet fuel, leaving only the aft and the left aerofoil of the wreckage. This was also thanks to the fire-fighting service since without their intervention possibly nothing would have been left.

Evacuation:

The commander reported that he had given the signal for evacuation several times, but obviously the system had not worked. Therefore, the cabin crew started evacuation.

When the wreckage had come to a standstill, the cabin crew members seated at the forward and aft exits saw the flames on the right so they opened the left exits.

The left forward exit could only be opened partly since it was blocked by branches and boughs. Thereupon, its emergency escape slide partly inflated in the cabin. The purser and two cabin crew members from another airline who were on board by chance could push the door completely open in a joint effort. In this process, the purser and one cabin crew member fell out of the aircraft but remained fit operational since they landed on the slide.

A fit of panic developed in the front fuselage section. The cabin crew member who had stayed by the exit tried to evacuate the jostling passengers via the escape slide which, however, was congested by branches. Thereupon the slide got congested. Passengers who jumped into the open, past the escape slide, were quickly piling up on the ground. The cabin crew member discontinued the evacuation so that the passengers on the ground could get themselves to safety. They were assisted by the crew members who had already fallen out of the aircraft.

After a while the cabin crew member by the left exit left her post, suffering from smoke poisoning, and evacuated herself.

The cabin crew member in the mid position of the cabin at seat 12 D was first pushed into the aisle by a seriously burnt passenger on seat 12 F. Then she helped a passenger whose clothes were aflame to travel to the left forward exit. There, she took over the post of the cabin crew member who had left the aircraft due to her smoke poisoning. After the last passenger had passed her position, she shouted for survivors without receiving an answer. She was unable to conduct a visual check due to the smoke and the flames. She left the aircraft upon the instruction of the captain who had just rescued his injured co-pilot.

Then, the captain wanted to proceed to the cockpit to don his smoke hood to search the cabin for survivors. Before he could reach the smoke hood, however, he suffered a smoke poisoning and evacuated himself.

In contrast to the forward exit, the aft left exit could be opened without difficulty. The escape slide inflated as provided but was punctured by branches after some passengers had passed it. Thereupon, a crew member helped the passengers at the lower end of the slide.

Thanks to the authoritarian behaviour of the cabin crew member and the absence of smoke there was no panic during the evacuation over the aft exit. An older, very immobile person was evacuated thanks to the spontaneous help of a passenger.

Due to the developing smoke and flames, it was impossible for the cabin crew member to search the cabin for survivors after the last passenger had passed. Therefore, she shouted into the cabin without receiving an answer before she left the aircraft.

At the beginning, a passenger tried to open the left overwing exit but could not reach it. It would have been dangerous to open this exit since there was a raging fire.

Three passengers could not be evacuated.

- The paraplegic boy who obviously remained seated in his seat 4 F. He had occupied seat 4 D (aisle seat) when boarding the aircraft in Bale-Mulhouse. He was transferred to a non-aisle seat (seat 4 F) at the request of his family.

- A young girl on seat 8 C who did not know how to open the buckle and who was additionally cramped by the backrest of her seat.

- a woman who was seated on seat 10 B. Her husband reported that she had moved up to the aft exit before she returned to pick up the girl. She died of a smoke poisoning by her seat.

During the entire evacuation the cabin crew members could not see each other or communicate.

It could not be identified how long the evacuation took in total.

Injuries:

Due to the contact with trees and the ground, most passengers suffered from dizziness as well as from injuries of the face and the head since they had hit against the backrest of the seat in front.

Damage to the cabin:

In the aft section of the cabin, objects fell upon the cabin crew members.

Before the wreckage came to a stop the complete lighting failed except for the exit signs.

Cracks occurred at the bottom of the fuselage between rows 10 and 15. Passengers saw smoke and flames rising from the floor. A fire penetrated the fuselage on the left at rows 8 and 9 through the destroyed windows a few seconds after the wreckage had come to a standstill.

Furthermore, short circuits with sparking were observed at the forward crew sections.

Response by the fire-fighting service:

The alarm for the aircraft fire-fighting service of Mulhouse which consisted of six men with two vehicles was sounded immediately after the disaster. Ten minutes later, however, a group of eight vehicles from the neighbouring fire brigades were the first to arrive at the scene. The fire could only be reached by small vehicles since the access route was blocked by trees.

Summary:

- The cabin crew started the evacuation since the respective evacuation alarm of the pilot failed.
- The cabin crew did not think of donning the smoke hoods for any moment in order not to lose any time to open the doors and start evacuation.
- The failure of the PA, of the light and finally of the escape slides made evacuation difficult.
- An older gait-impaired person could be rescued thanks to the spontaneous help of a passenger. Evacuation could benefit from the fact that there was no immediate hazard in the respective fuselage section.
- The firm commands of the cabin crew member at the aft exit helped speed up evacuation and prevent a panic.
- The passengers read the safety cards attentively since many of them had never flown before. Most of the passengers had no carry-on luggage on board.
- The passengers used the nearest exit. Only one aircraft passenger chose a less favourable route in order to join his family. (Remark: This may be due to

the fact that only two exits were used and the fire between rows 8 and 9 possibly divided the fuselage into two halves.)

- Nobody evacuated the paraplegic boy on seat 4 D. His relatives had obviously left him behind.
- Some passengers were overstrained with releasing the lift-lever buckle which led to the death of the little girl on seat 8 C.
- One female passenger lost her life when she returned into the cabin to rescue the girl and who was overwhelmed by the fire gases herself.

4.4.2 Toronto, Air France A340-313

Place:	Toronto, Ontario
Date:	2. August 2005
Aircraft type:	Airbus A340-313
Course of the accident:	Runway overrun due to piloting error. Wreckage consumed by fire.
Occupants:	297 passengers (3 wheelchairs, 1 blind, 8 children, 3 infants), 10 cabin crew, 2 flight-crew
Injuries:	
serious:	10 passengers, 2 crew

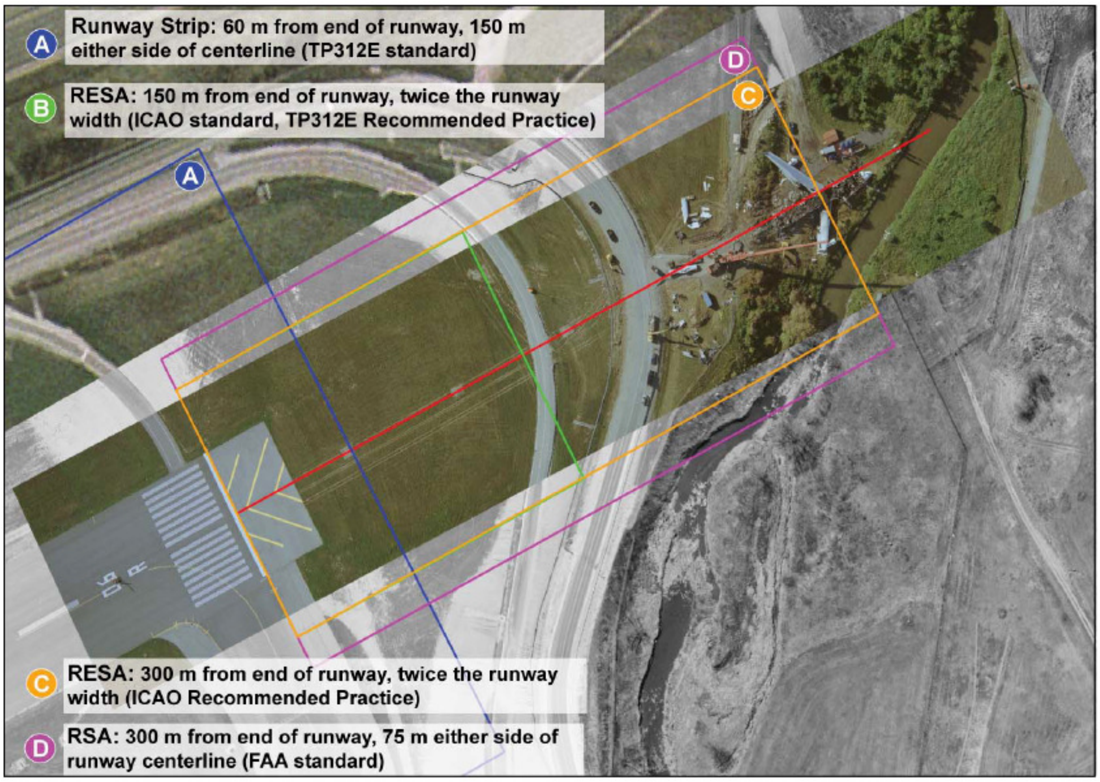


Figure 4: Resting position of AF 358

<u>Course of flight:</u>

The Air France Airbus A340-313 aircraft (registration F-GLZQ, serial number 0289) departed Paris, France, at 1153 Coordinated Universal Time (UTC) as Air France Flight 358 on a scheduled flight to Toronto, Ontario, with 297 passengers and 12 crew members on board. Before departure, the flight crew members obtained their arrival weather forecast, which included the possibility of thunderstorms. While approaching Toronto, the flight crew members were advised of weather-related delays. On final approach, they were advised that the crew of an aircraft landing ahead of them had reported poor braking action.

At about 200 feet above the runway threshold, while on the instrument landing system approach to Runway 24L with autopilot and autothrust disconnected, the aircraft deviated above the glideslope and the groundspeed began to increase. The aircraft crossed the runway threshold about 40 feet above the glideslope.

The aircraft touched down about 3800 feet down the runway, reverse thrust was selected about 12.8 seconds after landing, and full reverse was selected 16.4 seconds after touchdown. The aircraft was not able to stop on the 9000-foot runway and departed the far end at a groundspeed of about 80 knots. The aircraft stopped in a ravine at 2002 UTC (1602 eastern daylight time) It was substantially damaged during the overrun, and was subsequently destroyed by the post-crash fire. All passengers and crew members were able to evacuate the aircraft before the fire reached the escape routes. A total of two crew members and ten passengers were seriously injured during the crash and the ensuing evacuation.

Cabin crew:

There were ten cabin crew on board; nine cabin crew plus one additional crew member, a crew member not yet qualified. The minimum crew for this flight was six. In accordance with French regulatory requirements, all of the occurrence cabin crew were certified and qualified for their assigned duties. Apart from the minimum crew, supplemental crew does not need to be qualified on the type of aircraft being operated.

Cabin Crew Position	Cabin Crew Experience at Air France
L1 (Chief Purser – Minimum Crew)	20 years
L2 (Forward Purser – Minimum Crew)	18 years
L3 (Minimum Crew)	8 years
L4 (Aft Purser – Minimum Crew)	13 years
R1 (Supplemental Crew)	5 years
R2 (Supplemental Crew)	10 years
R3 (Minimum Crew)	10 years
R4 (Minimum Crew)	5 years
Cabin Crew Seat 9 (Additional Crew)	5 weeks
Cabin Crew Seat 10 (Supplemental Crew)	4 years

Table 2: Cabin crew and positions

Aircraft cabin:

The AF A340-313 passenger cabin was configured to accommodate 291 passenger seats. Passenger seats were placed six abreast in business class (forward cabin) and eight abreast in economy (mid/aft cabin). There were 30 seats in business class (rows one to six), 140 in the first section of economy (rows 14 to 31), and 121 in the second section of economy (rows 32 to 48).

Passenger profile:

The Passengers consisted of 68 adult males, 118 adult females, 8 children;and 3 infants. Adult passengers included: three wheelchair passengers and one blind passenger. Three non-revenue passengers were seated in crew seats: one in the third occupant seat of the flight deck, and two in the flight crew rest area.

	Crew	Passengers	Others	Total
Fatal	–	–	–	–
Serious	2	10	–	12
Minor/None	10	287	–	297
Total	12	297	–	309

Table 3: Injuries

Seats and belts:

The passenger and cabin crew seats were certified to JAR 25.561 (described as 9 g horizontally) and JAR 25.562 (described as 16 g horizontally). Passenger seats were equipped with a lap belt. The cabin crew seats and the seats in the flight crew rest area were equipped with three-point restraint harnesses. In accordance with JAR-OPS 1.730 (Subpart K), supplemental loop belts were provided for infants.

While the pilot’s seat failed upon impact, the passenger’s seats and restraints remained intact. This is due the fact that the pilot seats were certified to a lower standard (CS25.561 to CS 25.562)

Figure 5: Flight-crew seats

Response of ARFF:

As the flight landed, three or four bright orange flashes were observed from the control tower through the heavy rain. The tower supervisor was immediately advised and the crash alarm was triggered. The 1 Alpha system alerts the emergency response agencies on and off the airport that an on-airport crash has occurred, and it initiates the complete mobilization of all available fire and rescue services. When the tower controller activated the crash alarm at 2002:45 UTC, notification went to both fire halls on the airport, the GTAA operations centre, and surrounding fire halls in the City of Mississauga, Ontario. A group of ARFF fire fighters were in the alarm room of the south fire hall watching the storm and witnessed the aircraft landing.

They responded before the crash alarm activation by the control tower and the first response vehicle arrived at the scene within *one minute* of the crash alarm sounding.

The ARFF initial response team consisted of 15 members. The minimum staffing level is 11 members per shift. There were additional crews on hand at the time because fire fighters were beginning to arrive for a scheduled shift change. Others were called in, arrived for their regular shift, or came in on their own initiative after hearing of the accident through the media.

Evacuation:

When the aircraft came to a full stop, the chief purser, in the front of the aircraft, released his seat belt and retrieved the PA handset from the floor. He was not aware of the smoke/fire from where he was standing, nor did he know that many passengers were already in the aisles making their way to the emergency exits. He made a direct PA, stating “Everything is OK, remain seated, the crew will look after you”. The L2 purser then arrived and told the chief purser that there was a fire by door L3, and that an evacuation was required. The chief purser turned and faced the cabin, and saw the fire outside the aircraft through the windows on the left side of the aircraft and the passengers in the aisles. When the captain was advised of the fire and the need to evacuate, as per the flight crews emergency procedures, he pushed the EVAC ON pushbutton to activate the evacuation alert system. The system did not respond. The cabin crew commanded the evacuation at four of the aircrafts eight emergency exits.

The flight deck and first six rows of passenger seats were checked for survivors before the fire fighters were ordered to evacuate from the aircraft due to increasing danger because explosions were occurring. No one was observed to be on board. Except for the one passenger with a broken leg, no passengers were observed that required assistance by any ARFF fire fighters.

Approximately two-thirds of the passengers evacuated via exit R4. The remainder evacuated via exits L1, R1, and R2, and a few evacuated at exits L2 and R3. It is estimated that the aircraft was evacuated in a little more than two minutes.

Forty-two per cent of passengers who responded to the passenger safety questionnaire saw flames on the outside of the aircraft while it was still moving and 10 per cent saw smoke in the cabin before the aircraft came to a stop.

Black smoke first entered the cabin from the left side of the aircraft, just below the windows in the area of passenger seat rows 29 and 31. When the aircraft came to a stop, smoke continued to enter the cabin, making it difficult to see during the evacuation. The L3 cabin crew member, whose station was just aft of row 31, donned a smoke hood for personal protection, however, she subsequently removed it because the passengers could not hear/understand what she was saying to them. During emergency procedures training, cabin crews are taught to use a megaphone when wearing a smoke hood so as to make themselves heard/understood. In this occurrence, the L3 cabin attendant did not have ready access to either megaphone on the aircraft.

There was no fire in the cabin during the evacuation.

The evacuation was successful due to the training and actions of the whole cabin crew. With few exceptions, the performance of the cabin crew was exemplary and professional, and was a significant factor in the successful evacuation of the accident. There was effective communication between the flight crew and the cabin crew. Because the cabin crew were advised of the possibility of a missed approach, they were in a state of heightened awareness during the landing phase and were, therefore, prepared to respond immediately in the event of an emergency.

The aft purser effectively assessed the risks to passenger safety, given the presence of fire, and did not hesitate to take the decision to immediately initiate an emergency evacuation.

Other cabin crew also exhibited effective risk assessment and decision making as evidenced by the actions of the R1 and the R2 cabin crews.

They had initially correctly determined that their emergency exits were unusable given the creek flowing just outside the aircraft; however, as the amount of smoke in the cabin worsened, they quickly reassessed the overall risk to passenger safety and concluded that the risk presented by the creek was not as great as the immediate threat presented by the smoke in the cabin. Both crew members took actions to commence evacuation at their respective exits. When the R3 cabin crew saw that passengers were not following his emergency instructions to not use that exit, he quickly assumed a much more assertive manner, resulting in passengers responding quickly and appropriately to his commands. In spite of the fact that the L2 door opened while the aircraft was still moving and the fact that its associated slide did not deploy, the evacuation was successful, primarily due to the training and actions of the whole cabin crew.

Overall, there was effective communication among the cabin crew during the emergency situation. The PA made by the aft purser stating that there was a fire and that she was commencing an evacuation at R4 facilitated a coordinated emergency response by the cabin crew. In addition, the PA provided direction to those passengers who understood French.

Eventually, the lack of emergency power rendered the PA system inoperable, introducing the risk that the onset of the evacuations would be delayed, jeopardizing passenger safety. This risk was particularly significant because the aircraft was on fire. Given that the PA system and the evacuation alert system were supplied by the same emergency power source, the evacuation alert system also did not activate.

The availability of three supplemental cabin crew members on AFR358 undoubtedly contributed to the success of the evacuation, as evidenced by the roles they played during the evacuation. Two were in command of passenger evacuations at emergency exits and the third played a pivotal role in opening an emergency exit and subsequently assisted passengers at the foot of the R4 slide.

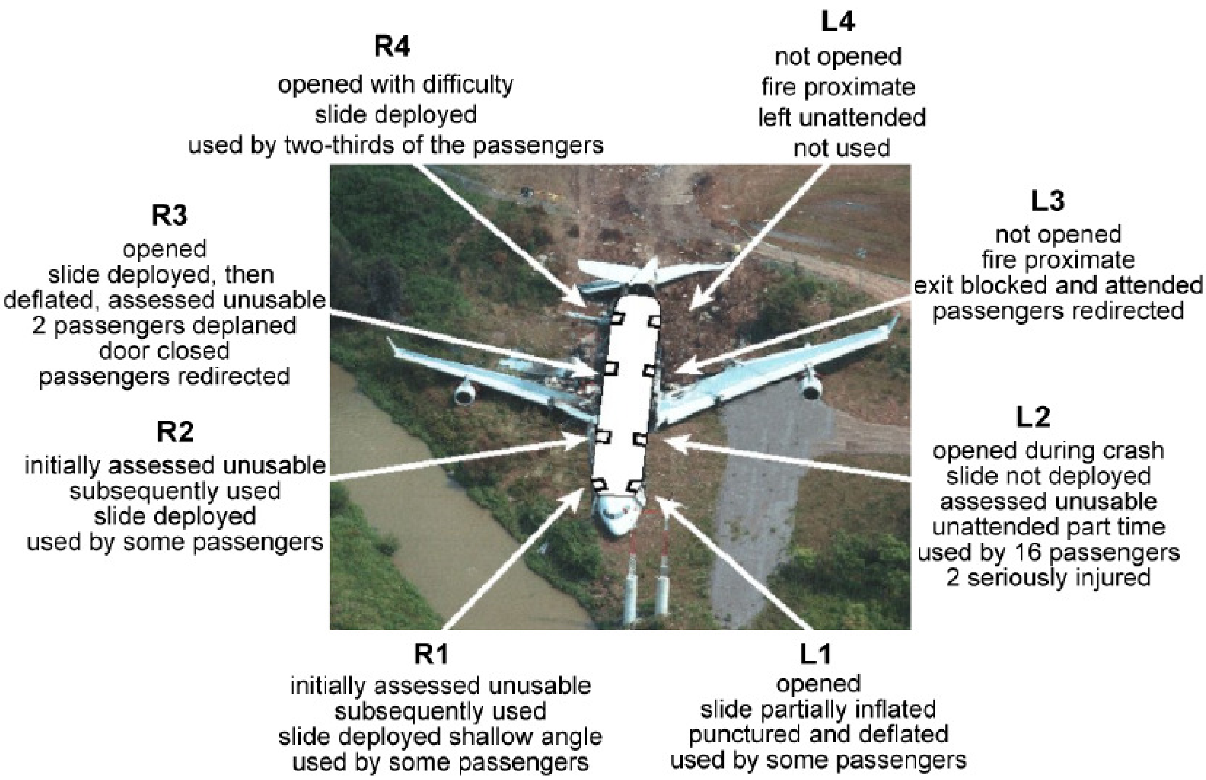


Figure 6: Exit-usage

There are no clear visual cues to indicate that some dual-lane slides actually have two lanes. As a result, these slides were used mostly as single-lane slides. This likely slowed the evacuation, but this fact was not seen as a contributing factor to the injuries suffered by the passengers.

Carry-on baggage and other items spilled into the cabin, potentially injuring passengers and creating debris in the aisles leading to the emergency exits, thereby impeding emergency egress. In one case, a cabin attendant noted that a passenger blocked egress while retrieving and arranging items in his carry-on baggage. The passenger did not respond to the attendant's commands to leave his baggage and go to the emergency exit, nor did he respond to the angry comments from passengers standing behind him. Consequently, the attendant had to redirect passengers through the middle bank of seats to the other side of the aircraft to access the only available emergency exit in the aft cabin.

Fire:

Initially, the fire in the wing roots did not directly involve the fuselage. The intensity of the fire grew while the evacuation was in progress, and shortly after the completion of the evacuation after 2 minutes, the fuselage was engulfed in flames. The cabin furnishing, carry-on luggage, and cargo hold contents sustained the fire. The dilution of the firefighting foam agent by the heavy downpour reduced its efficiency in dousing the fire.

Figure 7: Burning wreckage

Performance of cabin crew:

The evacuation was successful due to the training and actions of the whole cabin crew. With few exceptions, the performance of the cabin crew was exemplary and professional, and was a significant factor in the successful evacuation of the passengers. There was effective communication between the flight crew and the cabin crew.

The cabin crew ordered an evacuation within seconds of the aircraft stopping because fire was observed out the left side of the aircraft, and smoke was entering the cabin.

After exiting his seat with difficulty, the first officer got a flashlight and went to the rear of the aircraft with the chief purser and one of the cabin attendants, checking to see if there was anyone left in the cabin or any of the lavatories. They returned to the front of the aircraft via the opposite aisle, confirming that the cabin was completely evacuated before they left the aircraft via the L1 door, from which they had to jump because the slide was only partially deployed.

The first officer was the last person to exit the aircraft

Performance of ARFF:

The response of ARFF was exceptionally fast - the first response vehicle arrived at the scene within one minute of the crash alarm sounding. The response equipment exceeded the number of fire-fighting vehicles and the total quantity of water that is required under Section 303.09 of the CARs for Category 9 ARFF. GTAA ARFF trucks delivered an initial quantity of 39 500 litres of water to the fire, 63 percent more than the capacity required by applicable regulations. However, the dilution of the fire fighting foam agent by the heavy downpour reduced its efficiency in dousing the fire and subsequently the aircraft was destroyed by the post-crash fire.

Performance of emergency equipment:

The aircraft was equipped with 13 smoke hoods for cabin crew, eleven of which were located at the cabin crew stations, and two megaphones (one at the L1 cabin crew station, the other at the L4 station), as per the applicable regulations. ten cabin crew members were on board. Air France emergency training procedures include use of megaphones with smoke hoods because smoke hoods impair communication. However, only two megaphones were on board. Subsequently, one cabin attendant without a megaphone removed her smoke hood in dense black smoke because the passengers could not hear/understand what she was saying to them.

Half of the exits were used. Approximately two-thirds of the passengers evacuated via exit R4 (Type A). The remainder evacuated via exits L1 (Type A), R1 (Type A), and R2 (Type A), and a few passengers evacuated at exits L2 (Type A) and R3 (Type 1). It is estimated that the aircraft was evacuated in a little more than two minutes.

Dual-Lane Slides were used as Single Lane. This slowed down the evacuation. The slides of Exits L2 and R3 had either not deployed or had deflated due to debris.

Summary:

- The passengers consisted of 68 adult males, 118 adult females, eight children;and three infants. Adult passengers included: three wheelchair passengers and one blind passenger.

- It is estimated that the aircraft was evacuated in a little more than two minutes.

- ten cabin crew members were on board.

- The performance of the cabin crew was exemplary and professional, and was a significant factor in the successful evacuation.

- The availability of three supplemental cabin crew members on AFR358 undoubtedly contributed to the success of the evacuation

- The aircraft was equipped with 13 smoke hoods for cabin crew, eleven of which were located at the cabin crew stations

- Dual-lane slides were used as single lane. This slowed down the evacuation. The slides of exits L2 and R3 had either not deployed or had deflated due to debris.

- Spilled baggage potentially impeded the passengers' egress though this cannot be assessed because fire consumed most of the aircraft.

- 49% of 31% of respondents of the accident questionnaire answered that they took their carry-on baggage with them. This slowed down the evacuation.

- ARFFs response exceeded CARs requirements. However the plane was consumed by fire.

- The pilot seats were certified to a lower standard than the passenger seats and thus failed upon impact. (CS25.561 to CS 25.562)

4.4.3 Fort Worth International, American Airlines DC-10-30

Place:	Dallas/ Fort Worth International
Date:	14. April, 1993
Aircraft type:	McDonnel Douglas DC-10-30
Course of the accident:	Runway excursion due to pilot's failure. Subsequent evacuation. The aircraft was written off due to the structural damage.
Occupants:	189 passengers (many of them in retirement age with associated mobility-impairments), 10 cabin crew, 3 flight crew
Injuries:	
serious:	2 passengers
minor:	35 passengers, 2 cabin crew, 1 flight crew

Course of flight:

American Airlines DC 10- 30 with flight number 102 was on a scheduled flight from Honolulu International to Dallas, Fort Worth, with 189 passengers on board.

With a 1753 Hawaii-Aleutian standard time departure, (23:53 CDT) on 13 April, 1993, the flight from HNL to touchdown at DFW took about seven hours and seven minutes.

There was bad weather during the landing - including thunderstorm, heavy rain shower, fog; surface wind 300 degrees at 22 knots gusting to 33 knots.

The flight crew completed the landing checklist and activated the windshield wipers at 06:57:54. At 06:59:29 the aircraft touched down at 144 kts. At 06:59:41 the aircraft left the runway to the right at 95 kts and rolled over the grass. At 06:59:46 it crossed a high-speed-taxiway at approx. 87 kts, before it came to a standstill at approx. 06:59:50 on soft soil.

In the following professional evacuation two passengers suffered severe injuries including broken bones and/or back injuries and 38 evacuees suffered minor injuries (35 pertaining to passengers, two to the cabin crew and 1 to the flight crew). The evacuation was difficult due to the failure of emergency lights, fire hazard, the large number of older passengers as well as the final position of the wreckage.

Performance of the cabin crew:

The cabin crewmembers performed in a professional manner in assisting 189 passengers, a high percentage of which were of retirement age, off the airplane. The evacuation was complicated and difficult:

- The cabin was darkened after the airplane came to rest.

- Furthermore, because the nose gear and left main landing gear were fractured, the airplane came to rest in an approximately 10-degree left wing down and slight nose-down pitch attitude.

- A flight attendant made a self-described difficult decision to exit his station at 3-R, and walk out onto the right wing to try to see why there was a holdup of passengers on the wing at the top of the 3-R slide. When he looked down and saw the steepness of the slide and some of the elderly who seemed to nearly fall down the vertical slide, he made the decision to direct the remaining passengers back into the cabin, although he knew that there were flames out the aft left cabin windows, and to move them forward to another exit.

Fire:

All fuel tanks were found intact. In the No. 1 engine pylon area, fuel and hydraulic lines, electrical cables, wire bundles, and fire extinguisher lines were severed at a point near the wing-to-pylon interface.

The left lower wing skin, between the front and rear spars and outboard of the rear pylon to the No. three flap track fairing, was heavily sooted. The lower surface of the inboard aileron and portions of the flaps and wing panels between the No. 1 and No. two flap track fairings were burned through.

Evacuation:

The flight attendants attempted to evacuate the passengers from exits on both sides of the cabin. The left roll and nose-down pitch attitude of the airplane caused the angle of the right rear slides to steepen to what appeared to some witnesses as a near vertical angle.

At one point during the evacuation from 3-R, passengers bunched up on the right wing because of the steepness of the slide from the wing to the ground. A flight attendant saw a holdup at the top of the slide and came out on the wing. Noting the steepness of the slide, the high number of older passengers attempting to evacuate, and the passenger pileup at the bottom of the slide, the flight attendant told the passengers on the wing that they would have to return to the cabin and use another exit. At the same time, some passengers said that a flight attendant inside the cabin, behind the group of people trying to exit onto the right wing, told them that they would have to move quickly from the airplane because of a fire out the left side cabin windows.

There were a large number of elderly passengers lined up at 3-R and 4-R, and some of them were unwilling to jump onto the slides until they were urged to do so or were pushed onto the slides. Some female passengers wanted to take personal items with them, especially handbags. Flight attendants warned against taking these items and physically removed them from several passengers as they jammed forward attempting to enter the slides.

Whilst evacuation, The floor path and side wall exit sign lights illuminated, but the power and charge level of the airplanes system battery packs was not sufficient to illuminate the overhead and door emergency lighting system.

Injuries:

Two passengers received minor injuries that could be attributed to ceiling panels as the airplane slowed to a stop in the soft soil.

However, most of the minor injuries and all of the serious injuries were reported to have occurred during the emergency evacuation, especially as passengers attempted to slide down steep-angled slides from the right side of the cabin, landing in sticky mud that made it difficult or impossible for some of them to move away from the bottom of the slides.

The flight attendant stationed at 3-R said that the problem was exacerbated by the high number of elderly persons attempting to evacuate at that exit.

Due to the resting attitude of the airplane, slides at 3-R and 4-R were described by some witnesses as not touching the ground.

Damage to the cabin:

The right side of the runway, a few ceiling panels and some articles stored in overhead bins were reported to have fallen, striking two passengers and causing minor injuries. In rows 11 to 16, two ceiling 42 panels by the right aisle and two by the left aisle were separated from the ceiling. There was no evidence of fire or smoke.

Response of the fire rescue service:

The DFW fire and rescue department's crash alarm sounded about 0701, within about 1 minute from the time the airplane came to rest. About 1 minute later, the first trucks were arriving at the airplane. They extinguished a fire at the left wing in about 50 seconds, while the passengers were still exiting the airplane.

Summary:

- The cabin crewmembers performed in a professional manner in assisting 189 passengers.
- The airplane came to rest in an approximately 10-degree left wing down and slight nose-down pitch attitude.
- The cabin was darkened.
- A high percentage of passengers were of retirement age.
- There were a large number of elderly passengers lined up at 3-R and 4-R, and some of them were unwilling to jump onto the slides until they were urged to do so or were pushed onto the slides.
- Most of the minor injuries and all of the serious injuries occurred during the emergency evacuation, especially as passengers attempted to slide down steep-angled slides from the right side of the cabin, landing in sticky mud that

made it difficult or impossible for some of them to move away from the bottom of the slides.

- The problem was exacerbated by the high number of elderly persons attempting to evacuate at that exit.
- Some female passengers wanted to take personal items with them, especially purses.

4.5 Relevant results of reviewed studies

4.5.1 Short summary of relevant results

A short summary of relevant results of the studies is given in the following subchapters. A more detailed summary of the corresponding studies can be found in appendix 9.3. When the year of the study was unknown, no information on the year or no information at all is given.

4.5.1.1 Aircraft Evacuation Testing: Research and Technology Issues

Published by: Office of Technology Assessment, USA, September 1993

Relevant Results:

⇒ Extending the survival time through a protection against heat and smoke will increase survivability more than a faster evacuation.

4.5.1.2 Regulatory Study on Emergency Evacuations -Final Synthesis and Recommendations

Ordered by: Ministere der L'equipement des transports et du logement direction generale de l'aviation Civile, France, 1999

Contractor: Service de la formation aeronautique et du contrôle, France

Relevant Results:

⇒ Competences of the cabin crew are essential for the rate of survivors (crew's physical attributes as well as its training)

⇒ Multitude of aircraft types and cabin layouts leads to confusion among the cabin crews. In an emergency, problems occurred in the handling of the equipment. Cabin crew's pre-flight preparation have to be improved

⇒ Cabin crew training has to be improved and has to be more realistic

4.5.1.3 CAA Paper 2006/01 - A Database to Record Human Experience of Evacuation in Aviation Accidents

Ordered by: Civil Aviation Authority, Aviation House, Gatwick Airport South, West Sussex, UK, 2002

Contractor: E. R. Galea, K. M. Finney, A. J. P. Dixon, A. Siddiqui and D. P. Cooney; Fire Safety Engineering Group, University of Greenwich, UK

Relevant Results:

⇒ Passengers seated at most five seat rows to a viable exit are statistically more likely to survive than to perish. Seated 6 or more rows from a viable exit the chances of perishing far outweigh that of surviving

⇒ If fires are involved, this travel distance decreases to approx. three seat rows

⇒ The statistically highest survival chance is given for a seating position over the wing

⇒ The second-highest chance is in the front fuselage, i.e. each as close as possible to an exit

⇒ Occupying a window or an aisle seat has no statistical influence on survival rate.

⇒ The travel distances to an exit should be as short as possible in an evacuation

⇒ Statistically speaking, evacuation improves with the number of operational crew

4.5.1.4 ATSB, Evacuation Commands for Optimal Passenger Management

Ordered by: Australian Transport Safety Bureau, 15 Mort Street, Canberra City, Australian Capital Territory, Australia, 2006

Contractor: Cranfield University in cooperation with Virgin Blue Airlines, UK

Relevant Results:

⇒ The interaction between the passengers and the crew has proven to be of crucial importance

⇒ Passenger briefing is essential for survival since the majority of crashes is survivable

⇒ Passengers who insist on taking their luggage with them delay evacuation

⇒ Ambiguous commands should be replaced by self-explanatory commands e.g. "heads down, feet back" instead of "brace"

⇒ The crew should give brief and specific tactile[11] commands

⇒ It must be avoided that the life jacket is inflated too early inside the cabin

⇒ Rare incidents such as evacuations have to be trained frequently

4.5.1.5 NTSB - Emergency Evacuation of Commercial Airplanes

Published by: National Transportation Safety Board, Notation 7266 490 L'Enfant Plaza, S.W., Adopted June 27, 2000 Washington, D.C. 20594, USA, 2000

Relevant Results:

⇒ In the USA, an evacuation takes place every 11 days (or at every 336,328 take-offs) - 32 percent of them due to an assumed engine fire.

⇒ More than 65 percent of evacuations were unplanned with little or no preparation time.

⇒ There is no statistical correlation between the age of a passenger and the suffered injuries. The older passengers interviewed, however, stated that their age was an obstacle to them during evacuation.

⇒ In those cases where the cabin interior has burst evacuation was strongly impaired.

⇒ In statistical terms, females are more prone to injuries than males. (This statement coincides with the result of a CAMI study, see Chapter 2.2.4)

Following recommendations are presented in the study:

⇒ Conduct research and explore creative and effective methods that use state-of- the-art technology to convey safety information to passengers. The presented information should include a demonstration of all emergency evacuation procedures, such as how to open the emergency exits and exit the aircraft, including how to use the slides. (A-00-86)

⇒ Review the requirements for safety briefing cards.

[11] Tactile commands make use of human sense of touch.

4.5.1.6 Computer Simulation of VLTA Evacuation Performance: VERRES Project Report

Published by: E.R.Galea, S.Blake and P.Lawrence, Fire Safety Engineering Group, University of Greenwich, London SE10 9LS, UK, 2007

Relevant Results:

⇒ Simulation shows that the staircase, which is connecting the decks, is a bottleneck

⇒ Distance to emergency exits should be kept as short as possible

⇒ If passengers are directed to free exits on another deck, the distance almost doubles

Following recommendations are presented in the study:

⇒ All available exits should be used uniformly

⇒ All exits should have the same passenger flow rate/time

⇒ In evacuation passengers should use the respective emergency exits of their deck, if possible, and should not use the staircases to other decks

⇒ Distance to emergency exits should be kept as short as possible

4.5.1.7 ETSC Increasing the Survival Rate in Aircraft Accidents - Impact Protection, Fire Survivability and Evacuation

Published by: European Transport Safety Council, Rue du Cornet 34, B-1040 Brussels, Belgium, 1996

Relevant Results:

⇒ 90% of all accidents are technically survivable. Of 1500 casualties worldwide each year, 600 die in technically survivable accidents, approximately half of them due to smoke inhalation or fire.

⇒ 75 percent of all accidents take place in close proximity to the airport

⇒ In the cabin, the passengers are not protected against smoke

⇒ Fires produce high concentrations of highly toxic HCN which reduces the survival time

⇒ Flash-over hazard is overestimated since the gases mostly evaporate due to damage of the fuselage structure before reaching ignitable concentrations

⇒ Acoustic signals to attract passengers to operational exits and increasing orientation in smoke-filled cabins had no effects on the evacuation rate

⇒ It is impossible to fight cabin fires from outside

⇒ Within the cabin, the fire-fighting means are limited

⇒ Spreading of fire through the cabin must be prevented

⇒ Cabin water spray systems extend the survival rate

⇒ Protective masks which would ensure passengers a longer survival, (PPBE, Passenger Protective Breathing Equipment) have already been specified in accordance with EUROCAE but have not yet been incorporated in the operation / certification requirements

⇒ The delay caused by putting on PPBE in an evacuation is acceptable compared to the consequences of a smoke inhalation

⇒ Number of crash fires in US navy aircraft reduced from 85 to 35 percent after the introduction of "JP5"

4.5.1.8 CAA Paper 2002/04 Benefit Analysis for Cabin Water Spray Systems and Enhanced Fuselage Burnthrough Protection

Ordered by: Civil Aviation Authority, Aviation House, Gatwick Airport South, West Sussex, UK, 2002

Contractor: R.G.W. Cherry & Associates Limited, e Priory, High Street, Ware, Herts, G12 9AL. UK

Relevant Results:

⇒ Introduction of singular (*modular*) cabin water spray systems would rescue at least 27 (*34*) lives per year

⇒ This figure would increase to 34 (46) in combination with a burnthrough protection cabin

⇒ Service water of the cabin can be used. In most cases there will be enough water for fire fighting at the time of landing despite in-flight consumption

4.5.1.9 CAA Paper 2009/01 – Cabin Crew Fire Training

Ordered by: Civil Aviation Authority, Aviation House, Gatwick Airport South, West Sussex, UK, 2009

Contractor: R.G.W. Cherry & Associates Limited, e Priory, High Street, Ware, Herts, G12 9AL. UK

Relevant Results:

Protective breathing equipment (PBE) and its storage place:

⇒ 58 percent of all problems with PBEs were related to their removal from the rigid package

⇒ Forces up to 14 kg are necessary to open the storage pouches

⇒ Donning the PBE regularly poses problems in the training even though the neck seals of the training units were often so loose that the donning was not comparable to an unused PBE

⇒ Wearing PBEs impairs hearing and speaking

⇒ The PBE Oxygen supply is so noisy that the crew members had to hold their breath to understand the others

⇒ It is not mandatory that the crew is informed of new storage places of PBEs in case of a change of layout. This slows down fire fighting in case of an emergency

Clothing:

⇒ Air carriers should adhere to the requirement of rapid fire-fighting regarding their dress code focusing on the compatibility of neckscarves and PBE

4.5.1.10 Protective Brace / Safety Positions for Passengers and Cabin and Cockpit Crew in Emergency Landing Conditions or Aborted Take-Off

Ordered by: Federal Ministry of Transport, Building and Urban Affairs, Department LS 15, Robert-Schumann-Platz 1, 53175 Bonn, Germany, 2007

Contractor: TÜV Kraftfahrt GmbH, Technology Center Traffic Safety, Team Aviation, Am Grauen Stein, 51105 Cologne, Germany

Relevant Results:

⇒ During aircraft accidents incorrect seating position and/or wrong fastening of the seatbelt entails skull, facial, abdominal and leg injuries or fractures

⇒ Failure to adopt brace/safety positions entails critical head accelerations which are well above the biomechanical tolerance

⇒ Failure to adopt brace/safety positions entails high loads on the vertebral spine

⇒ Brace/safety positions are not effective for children smaller than 1.25 m (approx. six to seven years of age)

⇒ Infants and children have to be fastened in their own seat in a suitable child restraint system

4.5.1.11 Study on Child Restraint Systems

Ordered by: European Aviation Safety Agency, Rulemaking Directorate, Postfach 10 12 53, D-50452 Cologne, Germany, 2008

Contractor: TÜV Rheinland Kraftfahrt GmbH, Team Aviation, Am Grauen Stein, D-51105 Cologne, Germany

Relevant Results:

⇒ Double occupancy with loop belt attachment can result in serious internal injuries

⇒ The restraint of children up to seven years with adult lap belts can result in serious internal injuries

Following recommendations are presented in the study:

⇒ Individual seat for every aircraft passenger

⇒ Transport of infants and children aged up to seven years should not be allowed without an suitable child restraint system

4.5.2 SCP Evacuation

A summary of relevant results regarding SCP evacuation is given in the following subchapters. It is more detailed because the results are crucial to outline the causal relation due to SCP evacuation.

4.5.2.1 Caring for Precious Cargo, Part I: Emergency Aircraft Evacuations with Infants onto Inflatable Escape Slides

Requested by:	Office of Aviation Medicine, Federal Aviation Administration, 800 Independence Ave, Washington, D.C., 20591DOT/FAA/AM-01/18, USA November 2001
Tenderer:	Civil Aerospace Medical Institute, Federal Aviation Administration, Oklahoma City, OK 73125, USA

Contents of the Study:

This Study analysed the evacuation of infants via a Type-I exit onto inflatable emergency evacuation slides. The purpose of this study was to validate the most favourable egress methods for infant carriers and the influence of infant carriers on the evacuation of the other aircraft passengers.

Emergency Exits as defined in CS 25.807

Type A:	107cm x 183cm
Type I:	61cm x 122cm
Type II:	51cm x 112cm
Type III:	51cm x 91cm
Type IV:	48cm x 66cm

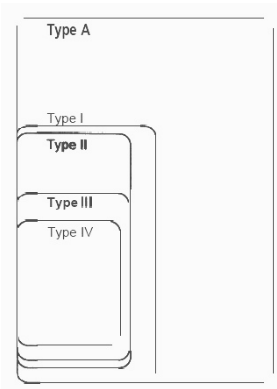


Figure 8: Exit Dimensions

For this purpose, six groups of 32 adult evacuees participated in six evacuation trials. Eight evacuees in each group (25 per cent) carried one of eight dummies representative of infants ranging from two to 24 months old. In the first and last trials, no instructions were given as to how the dummies should be carried. The intervening trials included instructions to carry the dummies horizontally or vertically and to jump onto the slide or to sit on the slide to board. This method allowed the passengers to choose the carrying position which they found most convenient pursuant to their experience.

The cabin layout consisted of a six abreast configuration with one three-seat row on each side. The aisle width was 19". The passageway to the exit was 20“ wide with a 5” aft seat encroachment. The seat pitch was 31”, and the lighting was dimmed down to the required minimum lighting level of 10.76 lux. (corresponds to 1 foot-candle)[5]

In the last test, the simulator was flooded with theatrical smoke.

The results were analysed in view of the correlations between the speed of egress and the carrying orientation and boarding manoeuvres.

Results of the Study:

A multivariate analysis of variance (MANOVA) showed that the sliding manoeuvre had significant effects on the speed of egress. The fastest method of egress is the “jump and slide” manoeuvre jumping onto the evacuation slide with the bottom landing first, and the upper torso being upright.

The smoke in the last trial extended the evacuation by approx. 1/3.[6] (This finding was made in the follow-up study “Caring for precious Cargo Part II” repeating some of the results). In contrast to this the carrying manoeuvre and the interaction between the carrier and infant was insignificant.

Taking account of the injury hazard, it is advisable to protect the head and neck of a vertically held infant with the hand and to fold his/her extremities with one’s free arm as best as possible. In a horizontal carrying manoeuvre, the infant’s head should be protected.

The authors recommend including the findings of their study into the safety briefings.

The details on the cabin layout and on the effects of smoke were included in the study “Caring for precious Cargo Part II“.

The speed of egress amounts to 1.5 to 2.5 seconds per infant carrier. This corresponds to 24 to 40 evacuated infant carriers per minute. An average of 1.4 to 1.7 seconds was required (mean value derived from the 4 conducted evacuations).

For passengers without an infant, the average time was:

- 1.5 seconds for passengers directly behind infant carriers
- 1.2 seconds for all other passengers. This equals 40 to 50 passengers per minute.

Analysis for Risk Assessment:

One Type-I exit is required per 45 passengers in accordance with CS25.807. This means that 45 passengers have to egress through this exit within 77 seconds (10 seconds for opening of the exit, an estimated three seconds for the sliding time of the final passenger up to the ground) (see Appendix J), which corresponds to a rate of egress of 1.7 seconds per passenger or 35 passengers per minute.

Due to essentially different outline conditions, the figures are not necessarily comparable to those of other evacuations. Nevertheless the trend is clear - infants slow down evacuation. However, it is still possible to evacuate the aircraft within the timeframe given in the aircraft specifications.

4.5.2.2 Caring for Precious Cargo, Part II: Behavioral Techniques for Emergency Aircraft Evacuations with Infants Through the Type III Overwing Exit

Ordered by: Office of Aviation Medicine, Federal Aviation Administration, 800 Indepence Ave, Washington, D.C., 20591, DOT/FAA/AM-05/2, USA, November 2005

Contractor: Cynthia L. Corbett, Civil Aerospace Medical Institute, Federal Aviation Administration, Oklahoma City, OK 73125, USA

Contents of the Study:

This Study analysed the evacuation of infants through a Type-III overwing Exit, which is the nearest emergency exit for 2/3 of the passengers. The findings are intended to support the set-up of safety briefings and training.

For this purpose, six groups of 32 adult evacuees participated in six evacuation trials. Eight evacuees in each group carried infant dummies representative of infants ranging from two to 24 months old. On the first and last trials, no instructions were given as to how the dummies should be carried. Intervening trials included instructions to carry the dummies horizontally or vertically. This method allowed the identification of the carrying manoeuvre the evacuees considered to be the most convenient one.

In the last test, the simulator was flooded with theatrical smoke.

The cabin layout consisted of a six abreast configuration with one three-seat row on each side. The aisle width was 19". The passageway to the exit was 20“ wide with a 5” aft seat encroachment. The seat pitch was 31”, and the lighting was dimmed down to the required minimum lighting level of 10.76 lux. (corresponds to 1 foot-candle)

The results were analysed in view of the correlations between the speed of egress and the carrying manoeuvre.

Results of the Study:

A multivariate analysis of variance (MANOVA) showed that it is significantly faster to carry the dummy through the emergency exit than to pass it on to a passenger waiting outside. *However*, if the infant is passed on nevertheless, the handing over has to be agreed with another passenger.

The evacuees found the vertical carrying manoeuvre of the dummies safer for the infant and more convenient for the carrier. The head of the infant should be protected against collision with the doorframe during egress.

The comparison of the egress times of the evacuees showed that there was no significant impairment of an individual by the infant carriers. However, the total egress time increased - especially, if the dummies were passed on at the exit.

The conclusion of this study as well as of the previous study "Caring for precious Cargo, Part I", is the fact that the chances to survive after a crash significantly increase if the passengers are familiar with the evacuation manoeuvres since the total egress time is less if the manoeuvres are known. Therefore, the aircraft passengers should plan an egress manoeuvre in advance. This applies especially if an infant is carried and an assisting person is to pass on the infant through the exit if this kind of evacuation is considered to be more comfortable.

The rates of egress amounted to 1.3 and 1.8 seconds each, and passing on the infant took up to 3.3 seconds, whereas the egress of evacuees without an infant took between 1.1 and 1.2 seconds.

This equals the times of a TYPE-I exit from the previous study.

Analysis for Risk Assessment:

One TYPE-III exit is required per 35 passengers in accordance with the building specification. If we estimate 77 seconds for an evacuation, the egress rate through this exit would be 2.2 seconds per evacuee.

Pursuant to the study, this rate is well achievable provided that the infant is not passed on at the exit.

4.5.2.3 Access-to-Egress II: Subject Management and Injuries in a Study of Emergency Evacuation Through the Type-III Exit

Ordered by: Office of Aerospace Medicine, Federal Aviation Administration, 800 Independence Ave. Washington, DC 20591DOT/FAA/AM-03/15, USA, October 2003

Contractor: Cynthia L. Corbett , Garnet A. McLean, James E. Whinnery, Civil Aerospace Medical Institute, Federal Aviation Administration, Oklahoma City, OK 73125, USA

Contents of the Study:

The Study analysed the injury patterns in experimental evacuation tests through TYPE-III emergency exits. Four evacuation trials with 2544 evacuees each were carried out. Each trial was conducted by two professional flight attendants who used typical evacuation commands and procedures. These procedures were not specified in further detail. The evacuees could choose between low motivation trials and high motivation trials. In the high motivation trials, which accounted for half of all trials, individuals were allowed the opportunity to gain double pay by being among the fasted 25 percent of evacuees. 49 percent of the groups were females and 51 percent were males ranging in age between 18 and 65 years. The following figure provides a scatter plot of subjects by weight and height:

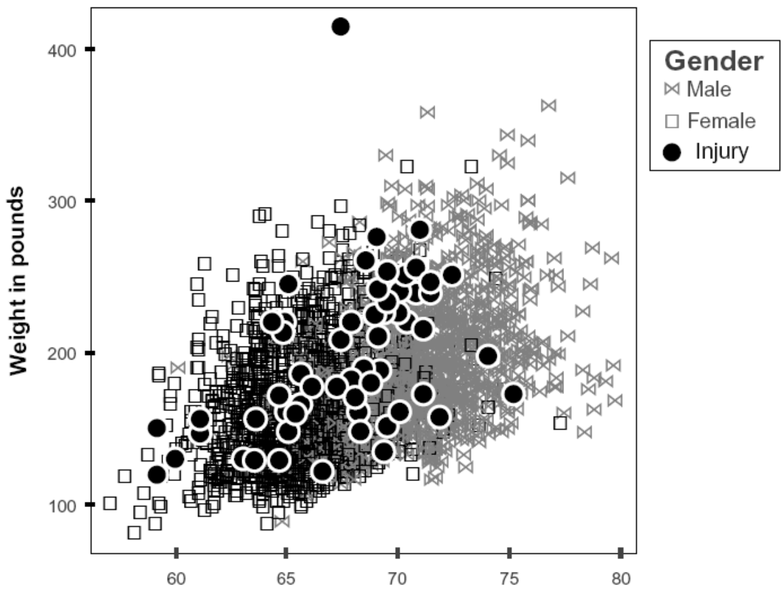


Figure 9: Weight (pounds) over height (inch)

:

A graph of the age distribution is not available.

The conditions of blindness, deafness, Type 1 diabetes, serious cardiopulmonary disorders, hepatitis or tuberculosis as well as prosthetic limbs disqualified individuals from participation.

Different group sizes were employed (30, 50 and 70 participants) to create the subject density variable as well as the exit hatch disposal location which consisted of having the hatch placed either inside or outside the Type III exit. The trials were carried out with different configurations of the passageway:

- aisle width 6“, outboard seat removed
- aisle width 2 x 10“, 14“ encroachment
- aisle width 13”, 10“ encroachment
- aisle width 20“, 5“ encroachment

Results of the Study:

The total rate of injuries was 0.0057 per exit-crossing. The injuries were in all cases uniformly distributed between the genders (27 male, 31 female). However, 69 percent of all injuries were caused in high motivation trials. Of 11 serious injuries[12], six knee/ankle injuries were incurred.

A correlation between the ankle/knee injuries and the motivation level was identified, trying to predict the type of injuries. 69 percent of all injuries were sustained in the high motivation trials; the proportion of injured females to males regarding ankle/knee injuries was 9:1. In contrast to that, this type of injuries was uniformly distributed between females and males in the low motivation trials.

An analysis of variance, which should be considered with some reservation due to the unfavourable ratio of injuries and events, shows that there is no correlation between injuries and passageway configuration. However, a significantly large number of injuries (22) incurred with a passageway to the emergency exit with 10" widths and 14" seat encroachment. (See passageway configuration on page 8 of this study)

A major factor of injuries was the command “step through – foot first“, which led to serious knee and ankle injuries. These injuries were even furthered by weak knees as well as overweight of the evacuees.

[12] Broken bones, serious muscle injuries or the like, strongly bleeding wounds or other injuries requiring treatment

4.5.2.4 Access-To-Egress III: Repeated Measurement of Factors That Control the Emergency Evacuation of Passengers through the Transport Airplane Type-III Overwing Exit

Ordered by: Office of Aerospace Medicine Federal Aviation Administration 800 Independence Ave. Washington, DC 20591, USA, January 2004

Contractor: Garnet A. McLean, Cynthia L. Corbett, FAA Civil Aerospace Medical Institute P.O. Box 25082 Oklahoma City, OK 731258, USA

Contents of the Study:

This Study analysed the effects on the egress time through Type III overwing exits. Four trials with 48 groups were conducted, each consisting of 30, 50 or 70 inexperienced subjects. Half of the subjects were assigned to high motivation trials. Double pay was offered to subjects who were among the fastest 25 percent of their group to evacuate the airplane simulator.

The trials analysed the effects of the passageway configuration, the hatch disposal location and the subject group density. Furthermore, they validated the evacuees' physical attributes and the different motivation levels.

The cabin layout consisted of a six abreast configuration with one three-seat row on each side. The aisle width was not specified. The passageways to the emergency exit had a width of 10", 13" and 20" and a seat encroachment of 14", 10" and 5". Additionally, a two-way passageway configuration with 6" each was tested. In this trial, one seat row was located directly in front of the exit.

Results of the Study:

Several multivariate and monovariate analyses of variance (MANOVA/ANOVA) showed that the physical attributes of the evacuees had the largest influence. The waist size was most significant, with an effect being three times stronger than that of the evacuees' gender. The effect of the waist size was followed by the age of the evacuees and then the interaction of these two factors. The average egress times per person increased with approx. 0.037 seconds per inch of waist size to a maximum value of 1.88[13] seconds/evacuee. The body height of the evacuees had no significant effects.

The best times were achieved at aisle widths of 10" to 13". The second-best times were achieved with two 6" passageways. The aisle widths, however, had little effect compared to the physical attributes.

Women of an advanced age with broad hips had the worst effect given only one passageway to the exit. Combining the significant negative effects, the average time

[13] *The value suggested in the building specifications is 2.2 seconds per passenger for TYPE-III exits*

per evacuee is 2.3 seconds. The aisle width for this worst case is 10”. This would be the only layout in which the time recommended in CS25 was not met using the evacuee profile of the study.

The study points out once again that the briefing of passengers for an accident must not be underestimated.

4.5.2.5 FAA Evacuation Tests: Emergency Escape of Handicapped Air Travellers

Ordered by: Office of Aviation Medicine, Federal Aviation Administration, 800 Independence Ave, Washington, D.C., 20591DOT/FAA-AM-77-11, USA July 1977

Contractor: Civil Aerospace Medical Institute, Federal Aviation Administration, Oklahoma City, OK 73125, USA

Contents of the study:

This study analyses the effect of PRMs (passengers with reduced mobility) on evacuations from passenger aircraft. The study includes analyses of the movement of individual PRMs and also the results of evacuation tests with a combination of normal passengers and PRMs. The factors affecting the evacuation times were determined by means of suitable procedures. A cabin simulator of the Civil Aerospace Medical Institute was used in the study.

The cabin simulator has a single class layout with six-abreast seating, 32” seat pitch and 15” aisle width. The row clearance was 12”.

The aft left exit of the cabin simulator was 42” wide and 72” high (present Type A) and could be reached via a 33” wide cross aisle. A floor level exit, 24” wide and 48” high (present Type I), was arranged opposite, plus two overwing exits (20” x 36”, present Type III) in the front third of the fuselage.

The layout was realised in a 77ft long fuselage section of a C-124 “Globemaster 2”[14], mounted on a hydraulic platform. This platform could be lifted by up to 16 ft and pitched and rolled by up to 20°.

[14] Due to the size of the C-124 fuselage, a cabin ceiling was in principle not simulated. The overhead bins were suspended on carriers.

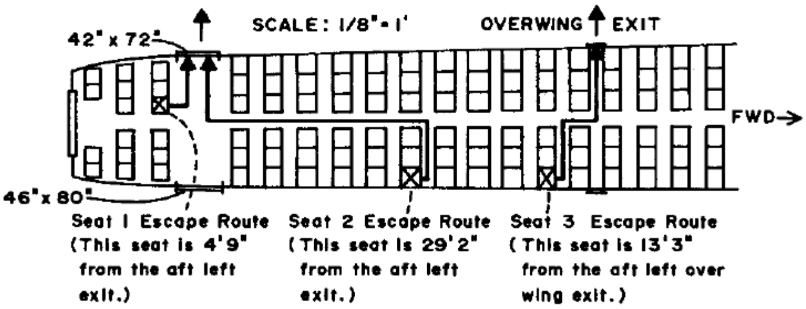


Figure 10: CAMI Cabin simulator layout

It was initially tested how passengers with various disabilities might move around the aircraft unaided. This was followed by evacuation tests with full occupancy of the cabin. Some of the PRMs were simulated by dummies and simulating test persons. The following data affecting evacuation times were established:

- Disability of individual PRMs
- Width and length of the aisle
- Access to the exits
- Exit types
- Angle of pitch and roll of the cabin
- Choice of seats by the PRMs and distances to the exit
- Number of PRMs in the cabin
- Accompanying of the PRM
- Transport of individually seated and grouped PRMs

In the first test, the PRM had to move from a designated seat alone, to reach the Type A exit as quickly as possible and touch it. The seats assigned to him are shown in the above illustration (seat 1, 2 and 3). This was carried out to determine the independence, the speed of the PRM and the effect of the path lengths on the evacuation time and the average speed.

In the second test, accompanying persons were assigned to move PRMs through an exit into the emergency slide and the times were compared to those in the first test. In the course of this, findings were made regarding the best methods for assistance.

In the following test series, the effect of PRM groups (only non-ambulatory (STRC) dummies!) on the evacuation was examined. The number of dummies on board ranged between approx. 5% (distributed individually in the cabin) and 20% in the last test series (two tests using eight grouped PRMs with 42 ABPs). The dummies were carried by accompanying persons assigned by the crew beforehand. After the start signal, the exit was blocked for 10 seconds to simulate its opening and the unfolding of the emergency slide. Obstructions caused by the dummy and assistant pair to the flow of people and the causes were determined.

In an exception, a human paraplegic (19 years old, 56 kg) was used in one of the test series. Apart from this person, no other PRM was on board in any of the six tests in the series. Only the seating of the paraplegic was varied. The paraplegic had an accompanying person next to him, to carry him out. In every test, this pair blocked the aisle when leaving their seats. This obstructed any persons coming up from behind.

In one of the tests, the paraplegic evacuated himself, without an accompanying person.

He pushed himself to the emergency exit feet first, but although physically fit and used to such manoeuvres, he was unable to keep up with the other passengers. The evacuation time of the passengers behind the paraplegic increased by four seconds. It would have been shorter, had the passengers simply stamped him down.

In the last test series to measure the effect of PRM groups, two tests were carried out to determine the effect of PRMs in groups. In the first exercise, two PRMs were left behind because no qualified ABPs assisted. In the second exercise, all the PRMs were evacuated – firstly, because they were seated closer to the exit, and secondly because the crew delayed qualified ABPs, instructing them to evacuate the PRMs.

The following test series established the effects of distances to exits. The cabin was occupied by PRMs and normal passengers.

In one of the tests, two PRMs were seated in the exit row and, in another test, two PRMs were seated at the rear of the cabin. In another test, a third PRM was seated in the middle of the cabin, in addition to the two PRMs in the rear.

In these tests, the passenger flow was obstructed as soon as the PRM and assistant pairs attempted to move into the aisle. This could only be avoided if the PRM pairs entered the aisle last. This was the only way of maintaining an even passenger flow overall through the exit. The delay caused by the PRM pairs during their evacuation was not allowed to obstruct the other passengers. Although the other passengers are ahead in this case, they also accumulate at the exits. The PRM pairs were therefore generally able to catch up with the passenger queue.

Finally, the effect of the exit configuration was tested. In these tests, 17 tests were carried out through the Type A and 17 through the Type III overwing exit. Two test runs were made in each test series in order to reduce a training effect during the remaining 15 tests[15].

Among the 50 participants in each case, the PRM group was exchanged after every fifth test. The first of these 5 tests was carried out without PRMs, the following tests

[15] This had become necessary since there were insufficient participants to fill the cabin with inexperienced passengers for each test. Thus the same group had to be used to carry out these tests.

with 2, 4, 6 and 8 PRMs. The seating positions of the PRMs are shown in seat maps. It was shown that non-ambulatory passengers found overwing exits easiest to negotiate. The floor-level-exits suit PRMs with lower limb disabilities best. For PRMs with upper limb disabilities, types of exit have no significant effect on the evacuation.

All the results of the test series are presented in the form of tables, graphs and drawings and evaluated. An overview of aircraft accidents involving PRMs and a list of participating PRMs and their disabilities are provided in the appendix. Also provided are proposals by the PRMs with regard to improvement of aircraft evacuation.

Results of the study:

Whilst the PRMs apparently did their best to follow their instructions, the other participants do not appear to have been very motivated.

Individual Handicap Evaluation

It was observed that paraplegics used the backrests and armrests as support, enabling them to move towards the door in an upright position. Near the exit at the latest, they used the last backrest to lower themselves to the floor (or simply dropped down) and crawled up to the door. Had they intended to use an emergency slide there, they would have had to perform a 180° turn, not to slide down head first.

PRMs paralysed on one side only moved and turned better in the direction of the functioning half of the body.

Blind persons oriented themselves by the width of the gaps between seat rows in order to find the cross aisle leading to the exit.

Mental deficient persons were distracted by objects in the cabin and/or forgot their task after a short time.

Obese (extremely overweight) persons sometimes felt trapped between the armrests and could lift themselves out of the seat only with great difficulty. In three instances, the safety belt clasp disappeared in the stomach flab. Once in the aisle, they moved with adequate speed. They needed 43% of their total evacuation time just to reach the aisle.

In general the considered PRMs sitting in the window seat need 32% to 49% more time to get to the aisle than sitting in an aisle seat. Furthermore PRMs sitting in the window seat took 50% more time to reach the exit than did those sitting in the aisle seat. Paralytic persons demonstrated the greatest delay

Effect of the seats:

Totally incapacitated passengers should not be seated in bottlenecks in the cabin (e.g. in front of the exits). They should also not be seated in the same row (PRM – aisle – PRM) since the assistants then obstruct one another.

PRMs should not obstruct the developing flow of passengers and should join the queue at the end. In this way, they do not obstruct the evacuation and are also not injured by the passenger flow.

Effect of the cabin pitch:

In a cabin with a 5° pitch and a 5° roll, the evacuation times of most people improved compared to a cabin with 0° pitch.

Effect of accompanying persons:

Assistants with a PRM must be physically capable of maintaining a speed of over 0.3 m/sec.

PRMs with cerebral palsy have variable mobility. Their limbs were generally stiff and their gait unsure. The stress of evacuation impaired their motor function even more. Pulling these PRMs gently accelerated their movement by 30%. At 0.3 m/s, more than half moved too slowly for a successful evacuation, however.

The average passenger cannot be expected to apply the best technique for evacuating a PRM – although the PRM could advise him. The cabin crew should also be in a position to instruct the assistants.

In the case of a PRM paralysed on one side of the body, an accompanying person can only assist by carrying the paralysed person. The reason generally is limited cabin space.

Depending on their own weight and the strength of an assistant, non-ambulatory passengers need one to three assistants for evacuation. The speed of such pairs down the aisle is acceptable. Delays are caused by lifting out of the seat row and by turning the PRM in front of the slide. In view of this manoeuvre, it is recommended that such PRMs be evacuated last.

Since, during the tests involving the emergency slide, dummies simulated the fully immobile persons for safety reasons, the result may deviate from an actual situation. Dummies were carried with less care and they behave differently to live bodies. The measured times are nevertheless regarded as representative.

PRMs were not assisted whilst on the wing, since the commands given by the crew were not followed. This support is regarded as important.

Effect of the passenger flow:

It was observed that PRMs sometimes remained in their seats until they were prompted by other passengers to move. It appears that passengers shoving along the aisle prevented these PRMs from joining the queue ("*In some tests, handicapped passengers remained in the seats until passengers in the main aisle encouraged them to move. Assistance for these handicapped passengers was not mandatory but* *was most effective in making minimum support available and in discouraging the shoving tendencies of other passengers"*).

Individual PRMs, who must evacuate independently along the cabin floor, are run over in an emergency or they slow down the evacuation.

Exit configuration:

Positioning of the PRMs to face the floor level exit slides required some time.

Passengers with disabilities of the lower limbs found floor level exits easier and quicker to negotiate since there were no barriers here.

Totally paralysed passengers can negotiate overwing exits easier and faster than floor level exits. They don't need to pass through the exit "feet-first". Subsequently leaving the wing poses a risk of injury.

For evacuation via the slide, the person should be carried with feet forward.

Effect of walking aids:

Crutches and other walking aids did not improve the speed and were hazardous with regard to movement in the cabin and when using the slides.

The seat backs and armrests were useful, since they offered the PRMs support. (seat backs and armrests).

General:

PRMs can in principle be evacuated.

The evacuation speed in the aisle must be over 0.3 m/s (1ft/second).

At the *start* of the evacuation, a PRM must not obstruct the formation of passenger flow in the aisle, since the time lost here cannot be made up again.

The critical factor is therefore the PRM's movement from the seat into the aisle.

If the PRM and assistant(s) group enters the aisle last, they can normally catch up with the evacuating passengers.

The evacuation times were not always in proportion to the difficulties experienced in some tests. This was due to the adaptability of the participants, tiring or bored assistants or due to the splint and cast mock-ups on PRM simulators being more flexible than the real thing, for reasons of safety.

<u>TÜV Rheinland comment:</u>

The dimensions of the Type A exit given in the text of the study are incorrect. (32” instead of 42”)

In the test, the paralysed persons pointed out that contusions and bruises they may suffer do not heal well. This may have affected the speed of evacuation, since the assistants handled the paralysed persons with care.

The recorded evacuation times within the FAA study regarding the type and the number of PRMs in correlation to delaying effects during evacuation are not statistically significant. The associated tests (fully occupied cabin, 2, 4, 6 and 8 PRMs on board) were carried out only once. Also other recorded evacuation times partly have a considerable range of spread, possibly due to the limited number of repetitions. Thus they can not be considered statistically resilient.

A proportional relationship of total delay of evacuation on the one hand and the type of PRM, the distance and the type of exit on the other hand is only valid when the PRM enters the aisle last. As soon as PRMs hinder other passengers, the estimation of total delay is not trivial anymore.

Due to the volume of information’s not all findings could be summarized. The time tables could therefore also not be inserted into this study.

Although the evaluated data could not be generalized and have to be treated with care, this study gives a comprehensive and detailed overview to significant relationships in PRM evacuation. The tests covered by TÜV Rheinland in its evacuation tests described in 4.5.2.6 validated the corresponding crucial findings.

4.5.2.6 TÜV Rheinland Evacuation Tests

Evacuation tests were carried out to validate some of the identified problems which might arise with the evacuation of SCPs according to the above mentioned studies and to extend their results and own experience. The scope of the study on carriage by air of SCPs did not include the performance of evacuation tests. These tests could therefore only be carried out to a very limited extent. Due to the test conditions, the number of test persons and the number of tests performed, the results of these tests are not statistically representative. However, results of other evacuation test could be validated and further basic insights could be gained.

<u>Description of tests</u>

In the “Canadair CRJ 200” and “Avro RJ85” mock-ups, the evacuation of a non-ambulatory adult and an approx. six-year-old child was simulated in several tests. A child dummy weighing about 12 kg was used to simulate the child. The non-ambulatory adult was simulated using a dummy (WCHC dummy) weighing 60 kg. In addition, two participants weighting 70 kg and 120 kg volunteered to simulate complete immobility of the lower limbs (WCHC simulator). Various males aged 30 to 40 years were tasked, individually or in pairs, with evacuating the dummies and simulators. These evacuations were carried out with and without theatrical smoke in the cabin.

In the Canadair CRJ 200 mock-up, evacuations were simulated using the following exits:

- Type III overwing Exit (OW)
- Type I (oversized) with lowered staircase
- Type I (oversized) without staircase

In the Avro RJ85 mock-up, the following exit was used:

- Type I (oversized) with emergency slide

<u>Cabin layouts:</u>

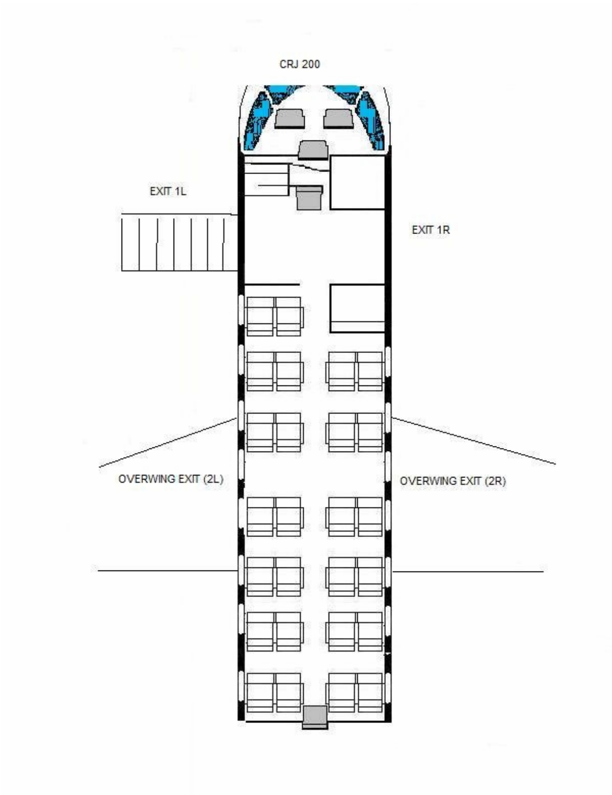


Figure 11: Canadair CRJ200 Mockup

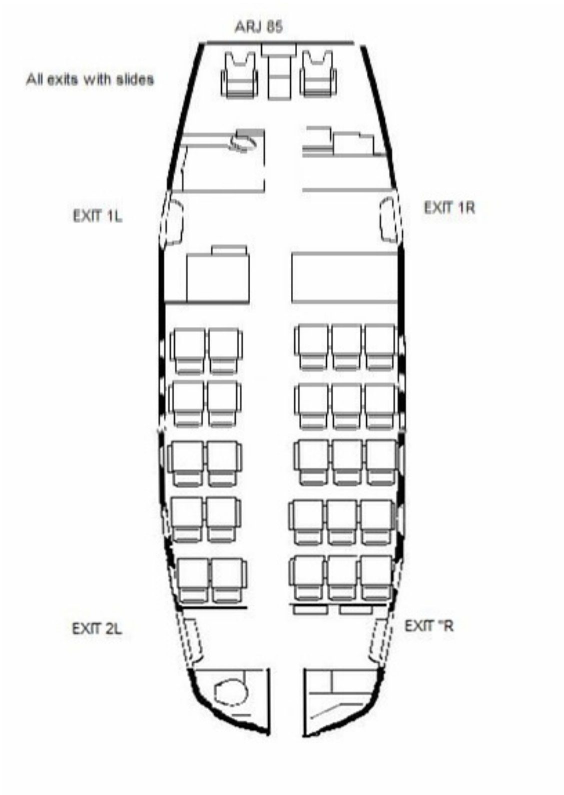


Figure 12: Avro RJ85 Mockup

The following configurations were used in the evacuations:

Data of Carrying Test Person: Male, 27 years, 75 kg						
	Single or assisted evacuation		Exit			
	Single	Assisted	CRJ 200 Exit 2L (Type III overwing)	CRJ 200 Exit 1L (Type I with stairs)	CRJ 200 Exit 1R (Type I without support)	RJ 85 Exit 1L (Type I with Slide)
Child Dummy 12 kg	X	---	X	X	X	X
WCHC Dummy 60 kg	X	---	X	---	---	---

Data of Carrying Test Person: Male, 30 years, 61 kg						
	Single or assisted evacuation		Exit			
	Single	Assisted	CRJ 200 Exit 2L (Type III overwing)	CRJ 200 Exit 1L (Type I with stairs)	CRJ 200 Exit 1R (Type I without support)	RJ 85 Exit 1L (Type I with Slide)
Child Dummy 12 kg	X	---	X	X	X	X
WCHC Dummy 60 kg	X	---	X	---	---	X
WCHC Simulator 70 kg	X	---	X	---	---	---

Data of Carrying Test Person: Male, 33 years, 70 kg						
	Single or assisted evacuation		Exit			
	Single	Assisted	CRJ 200 Exit 2L (Type III overwing)	CRJ 200 Exit 1L (Type I with stairs)	CRJ 200 Exit 1R (Type I without support)	RJ 85 Exit 1L (Type I with Slide)
Child Dummy 12 kg	X	---	X	X	X	X
WCHC Dummy 60 kg	X	---	X	---	---	X
WCHC Dummy 60 kg	---	X	X	X	X	---
WCHC Simulator 120 kg	---	X	---	---	---	X

Data of Carrying Test Person: Male, 40 years, 83 kg						
	Single or assisted evacuation		Exit			
	Single	Assisted	CRJ 200 Exit 2L (Type III overwing)	CRJ 200 Exit 1L (Type I with stairs)	CRJ 200 Exit 1R (Type I without support)	RJ 85 Exit 1L (Type I with Slide)
Child Dummy 12 kg	X	---	X	X	X	---
WCHC Dummy 60 kg	X	---	X	---	---	---
WCHC Dummy 60 kg	---	X	---	X	---	---
WCHC Simulator 70 kg	---	---	X	---	---	---

Findings:

The following basic findings were made:

Evacuation of children

- The test persons were able to unbuckle, pick up and carry the 12 kg child dummy without significant time delay. This was possible using any of the exits of the Canadair CRJ and Avro RJ85.
- After the carrying person has picked up the child, the carrying person and the child are considered one unit

Evacuation of WCHC dummies and WCHC simulators

- Evacuation of the WCHC dummies and the simulators was executed successfully in the abovementioned configurations and under the described conditions.
- Significantly longer evacuation times were required for evacuation of the WCHC dummies and the simulators.
- It was also demonstrated in the evacuation tests that the seat position of a healthy passenger in a row of seats had little effect on his evacuation. Even if the healthy passenger is seated at the window and has to climb over a WCHC dummy seated next to him, his evacuation is delayed very little, if at all. It must be taken into account, however, that the test persons had good physical condition.
- In some instances, positioning of the WCHC on the passenger seat by the assisting person (carrying preparation) caused significant obstruction in the aisle. The effects of this obstruction depend on the width of the aisle. With the narrow aisles (20”) of the CRJ, the test persons approaching from behind were unable to move past this obstruction, in contrast with the wide aisles (28”) of the Avro. Obstruction of the wide aisles cannot be excluded, however, since the simulation only had a small number of test persons and not an evacuating stream of passengers as in reality. The effect of the flow of passengers on the assistant’s ability to position the WCHC could also not be simulated.
- Armrests that cannot fold away complicate the assistant’s task of pulling the WCHC over to the aisle seat and picking him up.
- After the carrying person has picked up the WCHC, the carrying person and the WCHC are regarded as a unit.
- As soon as the carrying person has entered the aisle with the WCHC, the delays caused by this unit are minor.

- Another obstruction is experienced at the exits.

Influence of Exits

The following findings were made with regard to the four different exits:

Type I with emergency slide

The WCHCs were in most cases pulled along the aisle walking backwards. In front of the Type I exit, the carrying person and WCHC had to make a 180° turn for the WCHC to be positioned facing the slide "feet first". This was very difficult in the cramped exit area. In the case of single evacuation, the WCHC had to be pushed up to the slide. This was very difficult with WCHCs wearing rubber soles. Sometimes, the WCHC simulator used his arms to push himself towards the slide in the final approach.

When evacuating with two persons, the WCHC was carried up to the slide. The person carrying the feet then used the slide for evacuation. In one test, a WCHC used his arms to lift himself onto the slide. One WCHC simulated complete immobility. This WCHC had to be shoved into the slide by a person behind him.

Type I with lowered staircase

The exit with staircase caused the least delays. Turning in front of the stairs was not necessary. The WCHC dummy could be pulled by an assisting person climbing down the stairs backwards, or could be carried either forward or backward through the exit by two ABPs.

Type I without staircase

Evacuation without stairs was extremely complicated. As with the exits with slides, the PRM was first to be positioned in front of the exit. A person then had to move past the PRM and through the exit. Afterwards the WCHC dummy was positioned by the assistants outside and inside the aircraft and could finally be carried away by the assistant outside the aircraft.

Overwing Exit

Evacuation of the WCHC via the overwing exit showed that it was more convenient and faster for the test person to pull the WCHC dummies and the simulators through the overwing exit, rather than correctly positioning them on the slide of the Type I exit. The test persons found the seats in front of the overwing exit useful. In negotiating the exit, the WCHC was briefly placed on the seat, the carrying person then stepped through the exit backwards and finally pulled the WCHC outside across the seat and onto the wing.

Conclusion**:**

As soon as a non-ambulatory SCP (WCHC) takes part in an evacuation with the assistance of other persons, the evacuation time of the assistants and passengers caught behind this group of WCHC and assistant increases. The delays are caused by two factors:

- Blocked aisles (caused by the assistant picking up the SCP)

  and

- Blocked exit.

It has been proven that one assistant is capable of evacuating one non-ambulatory passenger up to 70 kg while two assistants are capable of evacuating one non ambulatory passenger up to 120 kg. However it must be kept in mind that the assistants were all in good physical shape. This is certainly not to be expected from all airline passengers – their physical capabilities may be inferior to these of the test-participants.

5 Risk Assessment

The risk assessment systematically investigates scenarios based on the results of data search and review, focussing on the identification of hazards, evaluation and reduction of risks.

5.1 Scope of Risk Assessment

Risk Assessment is a generally accepted method and might be applied to technical systems as well as processes and non-technical systems. Several international and national standards exist; e.g. MIL-STD 882 or ESA-PSS 01 403 in accordance to which the risk assessment was carried out.

The scope was restricted to the special categories of passengers listed in Chapter 4.1.1 to avoid excessive high complexity.

Due to the method some restrictions exist in risk assessment. The results are exclusively valid for the identified special category of passengers and scenarios, although completeness was envisaged and broadly achieved. The risk class gives no absolute values for the risk. The results are relative and based on data and information gathered during investigation phase and on expert opinion.

General Note:
In a risk assessment all possible scenarios have to be considered. It is not necessary that every scenario already has been proven by incidents, as the main function of a risk assessment is avoidance of dangerous conditions.

5.2 Procedure

Absolute safety is an ideal state of a system, where there are no threats to humans or to hardware and software parts of the system. Any real system, however, comprises a number of hazards that arise from the system design, operation or environment. That means that any system always has risks. These risks might be acceptable or not. Whether a risk is acceptable depends on criteria that are common for a society. For example, the risk of driving a car is broadly accepted. If a system admits an unacceptable risk, it is called in colloquial speech that "it has a risk", whereas a system with acceptable risks is thought of a "system without risk".

Risk analysis is carried out according to the following steps.

1. Establishing a matrix of hazards and special categories of passengers.

   For establishing the matrix, a checklist of hazards taken from ESA-PSS 01-403 is used. For each special category of passengers, where the combination with a certain hazard might give rise to a chain of events possibly leading to an accident in a specific phase, it is marked with the corresponding phase of flight. If it turns out for specific hazards that no passenger category is concerned in any flight phase or that all passengers including the able-bodied passengers are concerned with the same risk this hazard is not taken into consideration.

This study focuses on safety problems. In some parts, it is inevitable to take account of security problems which become a safety problem.

The following phases have been identified:

- boarding

  The phase boarding includes entering the aircraft, seating and preparing the passengers for take-off. During this phase the safety briefing takes place.

- aborted take-off

  This phase addresses the event of aborted take off on the runway.

- take-off / climbing

  This phase includes taxing to the runway and take-off. The phase ends when cruising altitude is reached.

- in-flight

  This phase addresses travelling without special incidents in normal flight operation. Overlap with phases take-off / climbing, rapid decompression, turbulences and landing / descent are possible in the risk assessment as these phases are addressing only events being specific for the particular phase only.

- rapid decompression

  This phase addresses the events of rapid decompression and decompression in general.

- turbulences

  This phase addresses the event of severe turbulences

- landing / descent

  This phase includes descending, landing and taxing until the aircraft has reached its parking position.

- crash

  This phase addresses the event of crash

- evacuation

  This phase addresses the event of evacuation. It starts after a crash or when the cabin crew or passengers have initiated an evacuation. The phase ends when the passengers have left the hazardous region of the aircraft. It is assumed that smoke is present.

- ditching

  The phase ditching addresses the additional hazards arising from landing and evacuation on water. Everything that applies for evacuation also applies for ditching and is not mentioned here again in risk assessment.

- disembarkment

  The phase disembarking includes leaving the seats and the aircraft

For each mark, later on a scenario is developed. Such a scenario is a chain of events starting from the hazard and the initiating event and leading through a chain of undesirable events to an accident.

2. Setting up a table with scenarios

In the next step, scenarios are described in a table for every combination. Here, all possible scenarios are listed including improbable ones. It is important that the list of scenarios is as complete as possible.

A scenario consists of the hazard, the initiating event, following undesirable events and ending with an accident with consequences for the passengers or crew. Material damages of e.g. the aircraft are not in scope of the study.

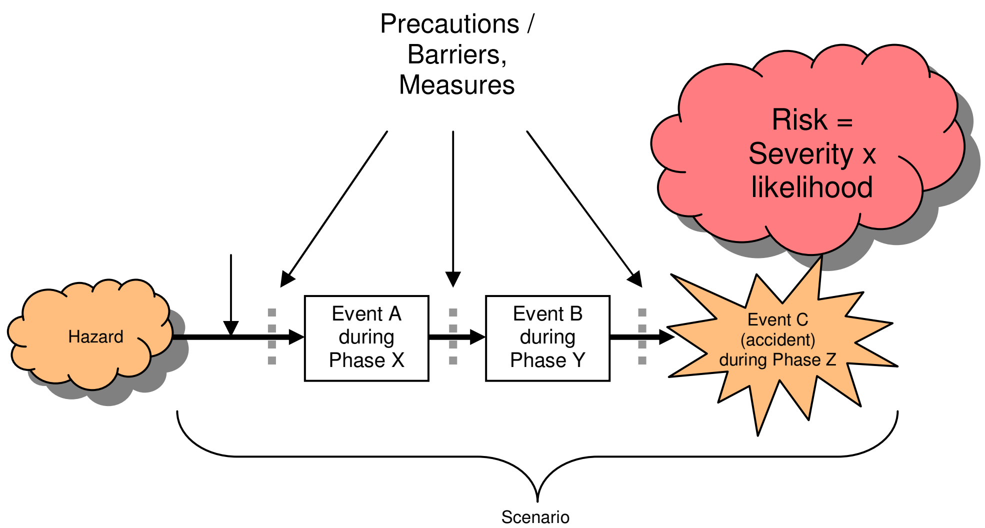


Figure 17: Principle scheme of a scenario

3. Description of scenarios

Sorted by phases of flight, the hazardous conditions, the initiator event, the undesirable event and consequences (including the accident) are listed. The scenarios are described according to the structure in figure 17. For each scenario it is stated if it is comparable to other means of transport, for example if the situation could be the same in a train or a bus with similar consequences.

4. List precautions and barriers

In addition, existing precautions and barriers are described. Note that, existing precautions and barriers reduce the risk in most scenarios to such an extent that the risk is acceptable, i.e. in common understanding it is perceived as a “no risk” situation or scenario.

5. Providing mitigation measures for avoiding the consequences

Additional mitigation measures are provided that might reduce the risk of the scenario.

6. The severity and probability for the accident are assigned leading to a risk

Depending on the possible consequences, a certain severity class is assigned to the scenario. Also, the likelihood of occurrence of the accident is estimated. The risk is then derived as a combination of both. This classification allows distinguishing between scenarios with a high and unacceptable risk and scenarios with a low and acceptable risk. Most of the scenarios usually fall into the latter category. For details, see chapter 5.3

7. Recommendations

Recommendations are given how to improve the situation in order to further reduce the risk.

Figure 18 illustrates the approach.

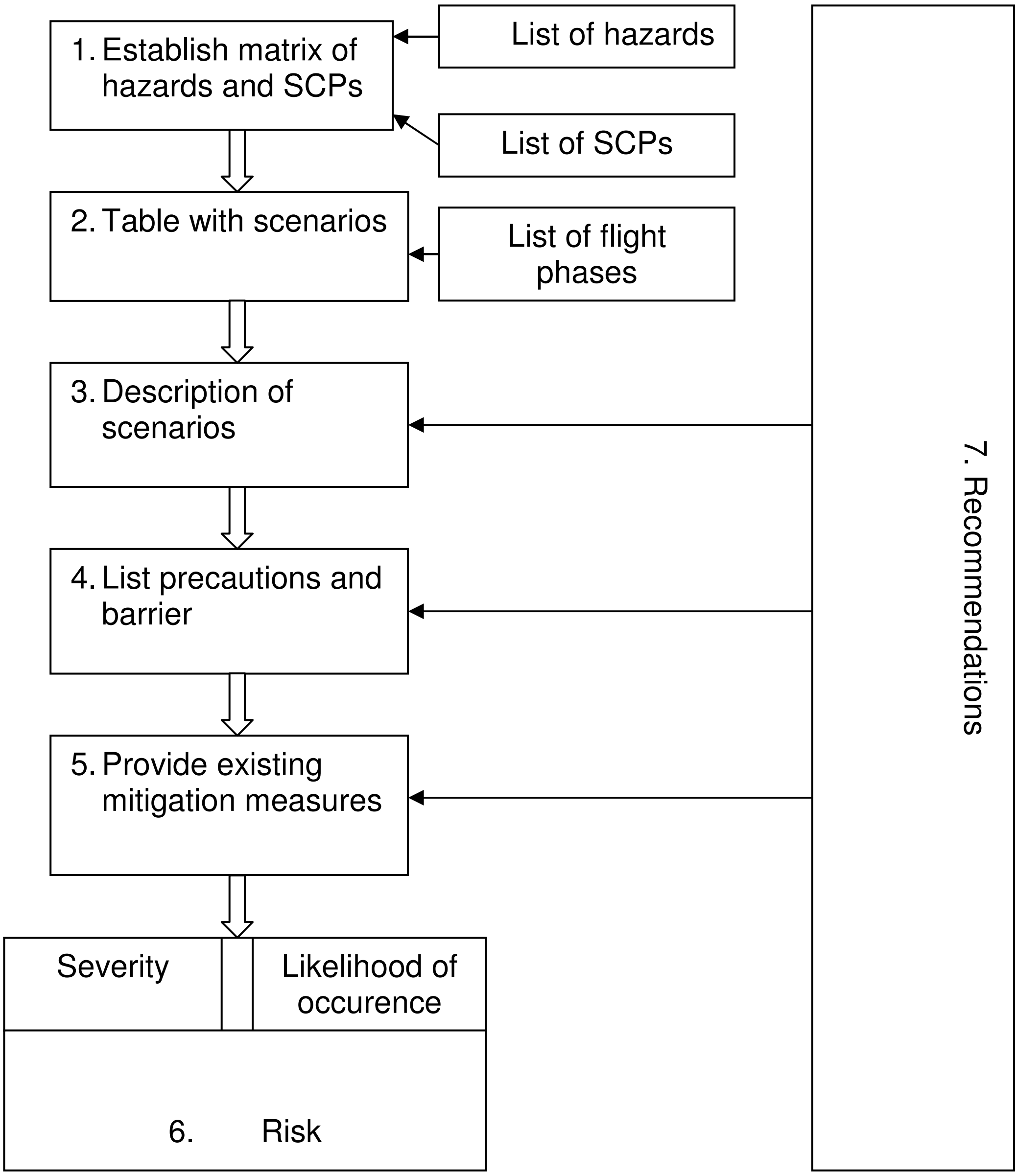


Figure 18: Approach of risk assessment

Note that, the analysis process gives rise to scenarios that admit a risk for the special category of passengers to themselves as well as to scenarios caused by SCPs that cause a risk to other passengers.

The approach of the risk assessment can be illustrated with the example of the “kinetic energy” hazard. Every item of mass in an aircraft has high kinetic energy during a flight. However, an initiating event is necessary to generate a hazardous situation. A crash transforms the existing kinetic energy into a strong deceleration which in turn exerts strong forces on the passengers. This in itself does not yet lead to life threatening injuries of persons. Such injuries only occur in case of a failure of the restraint system or seat or if the design is not appropriate.

The following methods should be applied successively in order to reduce the risks. The preferable strategy is in principle the elimination of the hazard. Where this is not possible, the initiating event should be avoided or the likelihood of its occurrence be reduced. If this is not feasible either, the likelihood of subsequent events is to be minimised. This can be minimised both by using technical systems (e.g. by suitable restraint systems) and by applying procedures and methods (e.g. by suitable safety briefing making reference to the brace position) or by specific circumstances (e.g. a crash does not lead to large decelerations, so that the present restraint system is sufficient). Potential Measures shall be applied in exactly this order.

The risk analysis carried out here requires a subdivision into phases and passenger categories. The respective hazard can develop into an “undesirable event” for a specific passenger for each combination of phase and hazard.

The subdivision into phases and categories is essential to enable a targeted analysis. The phases and categories are also essential for the risk assessment to enable definition or validation of the likelihood of occurrence of the respective scenario. It has to be taken into account that the overall risk of a scenario is affected by the distribution within the different categories of passengers and by the frequency of occurrence of the different flight phases.

The relation of the flight phases is shown in figure 19.

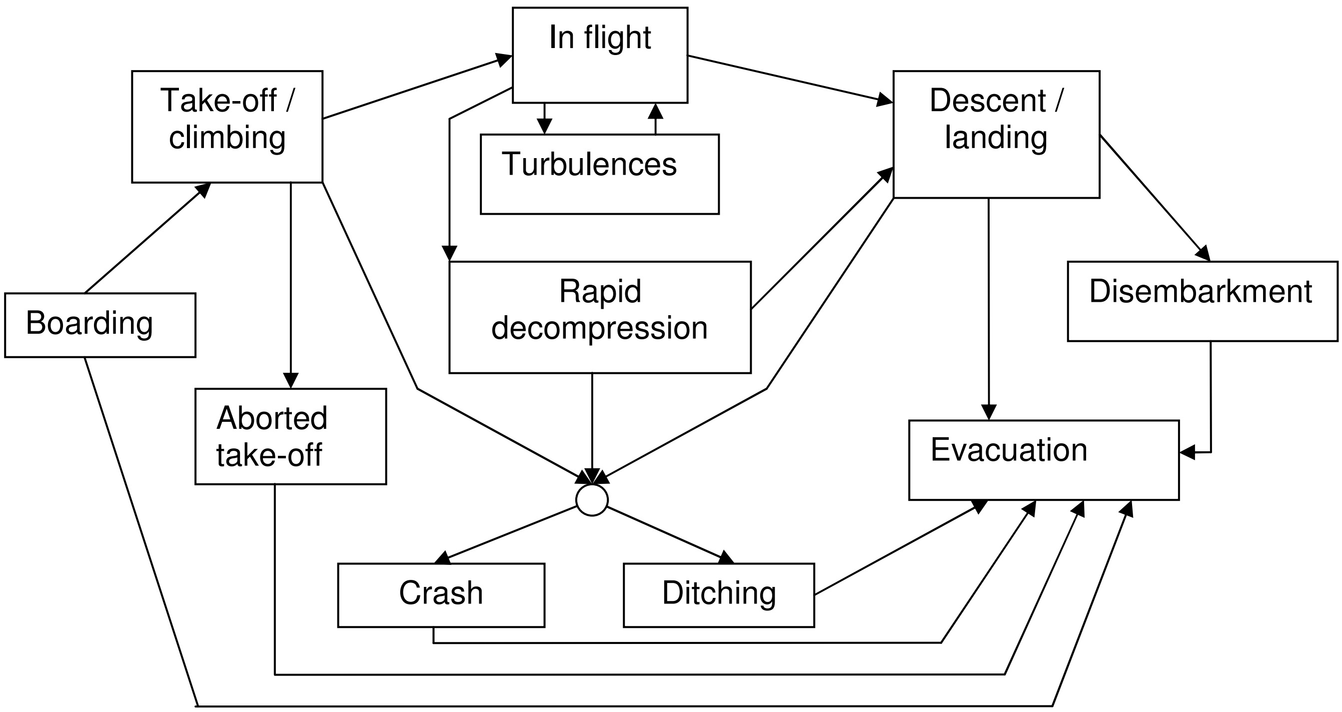


Figure 13: (Flight) phases

The analysis refers both to standard situations and to emergencies. The order of the phases corresponds to the pre-defined or expected course during the flight although it is not necessarily bound to a chronological order (see Figure 13). It is assumed for this risk assessment that smoke is always present during evacuation, as an evacuation without smoke does not imply an immediate safety risk.

All risks from boarding the aircraft up to disembarking are analysed. It may however be necessary under specific circumstances to include also certification, check-in and immigration within the risk minimisation and for the illustration of the development of a specific scenario.

Such a diversified examination of phases is necessary since there is an interaction between these phases. Measures during boarding might avoid critical situations during flight. For example it is checked during check-in if a passenger has the ability to operate the overwing exit and thus can be seated next to it.

A table is set up on the basis of this list for each passenger category, in which the scenarios are depicted. The development from a hazard up to the consequence is broken down to the individual phases as far as possible.

The risks are assessed by defining the severity and likelihood of occurrence.

The severity is subdivided into five classes. The following classes are used:

Code	Designation	Definition
0	SEVERE	Death of several occupants; life-threatening or permanently disabling injury or occupational illness of several occupants
1	CATASTROPHIC	Death of one occupants; life-threatening or permanently disabling injury or occupational illness of one occupant
2	CRITICAL	Temporarily disabling, but not life-threatening injury or occupational illness Loss of, or major damage to, the aircraft.
3	MARGINAL	Minor non-disabling injury or occupational illness. Minor damage to the aircraft. Minor damage to private property.
4	NEGLIGIBLE	will not result in any of the above

Table 4: Definition of hazard severity

The likelihood of occurrence is assessed in six groups. The estimation will be done on the basis of comprehensive experience from other risk analyses for means of transport. This likelihood indicates whether or not an accident will develop from the present hazard.

The following classes including the related likelihood are defined:

Code	Designation	Definition
A	Always	Likely to occur always when the hazard is present.
B	Frequently	Likely to occur frequently, when the hazard is present.
C	Probable	Will occur several times, when the hazard is present.
D	Occasional	Likely to occur several times, when the hazard is present.
E	Improbable	Unlikely to occur but possible, when the hazard is present.
F	Incredible	Extremely unlikely to occur. It can be assumed that the hazard may not occur, when the hazard is present.

Table 5: Definition of likelihood of occurrence

Note that, the classes given above assume the hazard to be present.

The risk is defined according to the risk matrix given in the following. Risk classes H to R are used, H representing the highest and R the lowest risk.

		Likelihood of Occurrence					
		A	**B**	**C**	**D**	**E**	**F**
Severity	**0**	H	I	K	L	M	N
	1	I	K	L	M	N	O
	2	K	L	M	N	O	P
	3	L	M	N	O	P	Q
	4	M	N	O	P	Q	R

Table 6: Risk classes

The risk classes are ordered from H (high) to R (remote). This is illustrated by figure 19.

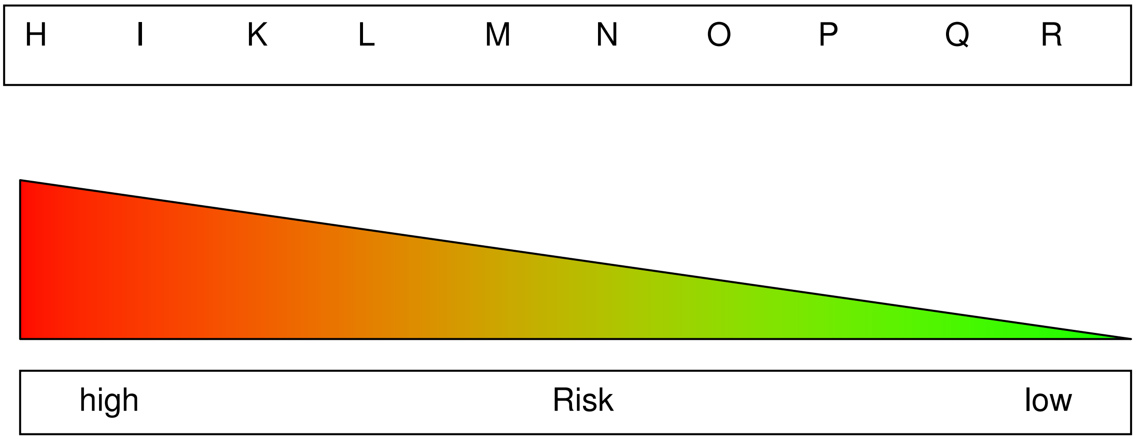


Figure 20: Risk classes

Each scenario, even those with small severities and small occurrence likelihood have a risk which can be acceptable or not acceptable. This can be judged by qualitative methods, i.e. comparing the risk with a similar situation, which is broadly accepted.

5.3 Description of the Tables used for Risk Assessment

The risk assessment is compiled in working tables. These have been extracted to a readable format in Appendix 9.7 “Scenarios of Risk Assessment” One scenario is depicted per page describing its development. The hazard from which the scenario arises is given for each. The development of the hazard is distributed over the defined phases, if possible. The events triggering the development of the incident and the “precautions / barriers” are defined for each flight phase. The “precautions / barriers” cover already implemented measures to limit the development of the scenario. The "mitigation measures" column depicts possible counter-measures yet to be implemented which mitigate the effects of the scenario. If the counter-measures are applied it should be done in the order given in Chapter 5.2.

The "severity" and "likelihood of occurrence" columns are filled in for each scenario individually using the information from according tables in Chapter.5.2 The Risk is determined by the risk matrix to be found in the same Chapter.

This enables a scenario ranking according to the respective risk.

The significant scenarios identified for each category are listed in Chapter 5.5.

5.4 Special Categories of Passengers

In the following, the SCP classes are subdivided further for the risk analysis. Where possible, ECAC classification (ECAC.CEAC DOC No. 30) has been used. In other cases a new classification was necessary due to missing definition, too comprehensive definition or mistakable definition. In this case the ECAC classification being comparable is stated if possible.

In general the ECAC classification is mostly not applicable for safety related aspects in cabin due to being worked out for accessibility to air transport and passengers rights. The idea behind is being able to plan needs for the PRM at the airport in advance. Depending on the classification it is known where and when the PRM needs assistance. For example a WCHR needs assistance from entering the airport to the jet bridge or stairs. In addition a WCHS needs assistance on stairs to the plane and in the airport. A WCHC needs assistance from entering the airport to being seated in the cabin and vice versa. For evacuation the mobility has a high impact and is not modelled sufficiently for our analysis in the ECAC classification.

Another major drawback is that a lot of passengers will not find themselves in the classification.

A passenger with a broken leg might serve as example for a mistakable definition. He would probably not rate himself as WCHR, WCHS or WCHC prior to the flight; even if the impairment is comparable.

At first, the categories are defined in accordance to the needs of the risk assessment and for complete coverage of the fundamental SCPs, followed by a description of their characteristics and a brief outline of the highlighted findings for the risk analysis. The general provisions (e.g. observing the law and complying with applicable regulations) are assumed to be fulfilled. In accordance with OPS 1.280, only able-bodied passengers are allowed to sit at the emergency exits. Therefore, the risks involved by SCP seated by emergency exits are not analysed in further detail.

5.4.1 Infants

ECAC Classification:

None

Definition:

Infants are passengers who have not yet reached the age of two years.

Characteristics:

Infants are physically not yet fully developed. Infants are neither able to board and take their seat without assistance, nor to follow the pre-flight briefing nor to follow the in-flight safety instructions of the crew neither to disembark without assistance. As a rule, infants are accompanied by an adult during transport. They are seated lap-held in double-occupancy or in a seat of their own and are restrained with an accepted restraint system. Infants are unable to help themselves in case of a loss of pressure or an evacuation.

Findings from investigation phase:

- Infants require a restraint system, which is suitable for children and their own survival space – for the time being, they are regularly transported lap-held and are restrained with a loop belt. Thus, not only the infant is endangered, but also the dynamic behaviour of the aircraft passenger seat and the occupant is affected. These effects are not yet taken into account for aircraft passenger seat approval

- They are unable to support the evacuation actively and they cannot evacuate themselves without assistance

- Infants are carried during evacuating an aircraft. Carrying persons are thus impaired in their mobility

- Infants are dependant on the attendance by an accompanying person during the entire air travel

5.4.2 Children up to seven years

ECAC Classification:

None

Definition:

Children up to seven years are passengers, who have reached the age of two years but not yet the age of seven years.

Characteristics:

Children up to seven years are not physically fully developed. Investigations have shown that the adult lap belt is not suitable to the pelvis of younger children (up to seven years). The adult belt's geometry does not fit to the smaller pelvis of children, facilitates load inducing into the abdominal region.

They require assistance in standard situations (boarding), but in particular in exceptional situations like evacuation or rapid decompression. It may e.g. not be ensured that children are able to reach the oxygen masks dropped down.

Most airlines admit children from five years to fly on their own without an accompanying person. The cabin crew looks after them. This may require additional cabin crew (e.g. for minimum crew operations).

Children are very likely to be overburdened in exceptional situations in comparison to adults.

Findings from investigation phase:

- Children aged up to seven years or of a length of less than 125 cm require a restraint system which is suitable for children

- Children require assistance in standard and emergency situations

5.4.3 Children up to 12 years

ECAC Classification:

None

Definition:

Children up to twelve years are passengers who have reached the age of seven years but not yet the age of 12 years.

Characteristics:

The pelvis of children who have reached the age of seven is being able to bear the forces of a lap belt. So no special restraint systems are necessary.

Children up to twelve years have a certain degree of independence. They might not require assistance in standard situations (boarding) anymore, but still in exceptional situations.

Children are very likely to be overburdened in exceptional situations in comparison to adult.

Findings from investigation phase:

- Children up to twelve years are normally seated in a seat of their own and are restrained with an adult lap belt

- Children require assistance in emergency situations

5.4.4 Expectant Mothers

ECAC Classification:

None

Definition:

This category covers pregnant women.

Characteristics:

Expectant mothers have a worse general condition due to their higher physical strain and the changed hormonal balance. On the one hand, this can be evident in psychological, and on the other hand in physical effects. Many airlines admit expectant mothers up to gestation week 36. Afterwards, transport is denied or a medical certificate is required.

Problems can occur because of their restricted mobility due to their waist, in particular when leaving the seat and the aircraft.

Findings from investigation phase:

- The lap belt attachment can lead to injuries of the foetus in accidents
- Expectant mothers have an increased risk of slipping and/or tripping over obstacles as well as an increased injury risk for the knees and ankles in evacuations

5.4.5 Passengers on stretchers

ECAC Classification:

STCR

Definition:

Passengers who can only be transported on a stretcher.

Characteristics:

These passengers have to be transported in a lying position. They may require medical attendance which must be provided by a qualified accompanying person

Findings from investigation phase:

- They are unable to support the evacuation actively and they cannot evacuate themselves without assistance

- They are endangering other passengers. Stretchers are not approved like aircraft passenger seats in accordance with CS25.562 (16g dynamic), but in accordance with CS25.561 (9g static) as “berths“. The assumed “payload“ is 77 kg without a load factor

- The safe biomechanical restraint for the patient is not tested

5.4.6 Small Adults

ECAC Classification:

None

Definition:

This category includes adult persons (older than 12 years) who are smaller than 125cm.

Characteristics:

Partially, this category has characteristics comparable to children due to their particularly small physique. Such passengers may have problems, due to their short legs, in assuming an ergonomic sitting position.

Depending on the waist size, the lap belt may not be pulled tight.

Findings from investigation phase:

- Doorstep heights in overwing exits may constitute a major obstacle

5.4.7 Tall Passengers

ECAC Classification:

None

Definition:

This category covers persons who are taller than 95%tile of adult aircraft passengers.

Characteristics:

Tall persons have a specific head curve.

Findings from investigation phase:

- Due to their body length, the impact against the backrest of the seat in front lies outside the provided area

5.4.8 Extremely Overweight Passengers

ECAC Classification:

None

Definition:

This category considers persons being extremely obese.

Characteristics:

The regular lap belt may be too short for an extremely overweight passenger.

These persons have an increased risk of slipping and/or tripping over obstacles when leaving the seat. Furthermore, their risk for knee and ankle injuries when passing the emergency exits is increased. A Type-III exit might be too small for extremely overweight passengers in case of an evacuation

Findings from investigation phase:

- Small seat pitch and low distance between the arm rests width may hinder the evacuation of obese passengers
- An extension belt must be available on board
- Their weight may overstress the seat-structure
- TYPE-III exits may be too small.
- The injury risk in evacuations is higher
- Extremely overweight passengers delay evacuation in general
- Extremely overweight passengers delay their own evacuation

5.4.9 Physical Disabled Passengers (upper limbs)

ECAC Classification:

None

Definition:

Passengers in this category have an impairment of both arms and/or hands. This includes missing arms or hands and cast on both arms/hands.

Characteristics:

The degree of independence decreases depending on the level of disability. The passengers may not be able to operate their buckle or to put on the oxygen masks on their own and require assistance in these situations. They may not be able to put on a life vest without assistance.

Findings from investigation phase:

- They may be unable to put on their oxygen masks without assistance
- They may be unable to operate their buckle without assistance
- They may be unable to put on their life vest without assistance
- They cannot support evacuation actively and require assistance themselves, depending on the level of disability.

5.4.10 Physical Disabled Passengers (low mobility)

ECAC Classification:

Comparable to WCHR, WCHS

Definition:

Impaired walking – slower than average.

Characteristics:

These passengers admit decreased mobility but are still mobile. They are able to climb stairs but are slower and less agile than regular passengers. This category includes e.g. older people and passengers with early-stage multiple sclerosis.

Findings from investigation phase:

- They require assistance in an evacuation, since they have problems to get over obstacles and have an increased risk of slipping and/or tripping

- They delay evacuation of themselves, of the persons behind them and of their assistants

5.4.11 Physical Disabled Passengers (aided walking)

ECAC Classification:

Comparable to WCHS, WCHC, WCHP

Definition:

These passengers need crutches or other walking aids in order to move.

Characteristics:

These passengers are not able or only able in a strongly impaired manner to move without walking aids or other mobility equipment. They must have their walking aid available to move during the flight (e.g. go to the toilet). This category includes e.g. passengers with broken legs or a stiff hip.

Findings from investigation phase:

- Their walking aids must be safely stowed at all times
- They are unable to support the evacuation actively
- They require assistance in an evacuation since they are restricted in getting over obstacles and have an increased risk of slipping and/or tripping
- They slow down evacuation of themselves, of the persons behind them and of their assistants

5.4.12 Physical Disabled Passengers (paralysed lower limbs)

ECAC Classification:

Comparable to WCHC, WCHP

Definition:

Passengers whose lower limbs are paralysed, who can move about only with the help of a wheelchair or any other means and who require assistance at all times from arrival at the airport to seating in the aircraft or, if necessary, in a special seat fitted to their specific needs, the process being inverted at arrival.

Characteristics:

This category includes passengers with absent or paralysed lower limbs. These passengers require their wheelchair on all routes and an onboard wheelchair. They can hardly move such a wheelchair without assistance. Such passengers may require seats with foldable armrests in order to take their seat.

Findings from investigation phase:

- They are unable to support the evacuation actively and they cannot evacuate themselves without assistance
- They have to be carried by assisting passengers in all probability
- They delay evacuation of themselves, of the persons behind them and of their assistants

5.4.13 Deaf Passengers

ECAC Classification:

DEAF

Definition:

These passengers have a hearing impairment or are deaf.

Characteristics:

They require a second way of perception (e.g. seeing) for information given acoustically. During an evacuation they are unable to respond to the instructions given by the crew in an adequate form. Note that passengers not understanding the language are more comparable to passengers with hearing impairment as they are still able to react on commands interpreting the tone of the command. Where it is necessary in risk assessment, this will be distinguished.

Some scenarios in the risk assessment for deaf passengers are valid for passengers not understanding any of the languages spoken on board also. These scenarios in chapter 9.7 are identified in by a remark.

Findings from investigation phase:

- Are unable to follow the safety briefing acoustically
- Are unable to perceive acoustic stimuli
- Are unable to follow the verbal instructions given by the crew

5.4.14 Mute Passengers

ECAC Classification:

None

Definition:

These passengers are mute or speech impaired.

Characteristics:

These passengers are unable to express their wishes and needs. This, however, can in most cases be compensated with gestures and by writing down information. Emergency situations pose a problem when mute persons need to ask for help quickly. In principle, however, they are able to draw attention to themselves.

Findings from investigation phase:

- In emergency situations, mute persons may have deficits to draw attention to themselves or to other persons

5.4.15 Blind Passengers

ECAC Classification:

BLIND

Definition:

A blind passenger has an impaired visibility.

Characteristics:

Passengers of this category have a significant impairment of their visibility or are blind.

Blind persons may require a mobility cane, assistance dog or an accompanying person. Their aids must be placed on board. Blind persons require a second way of perception. It is easier for blind persons to orient themselves on staircases with handrails than on ramps.

Findings from investigation phase:

- They are unable to read the safety cards
- They are unable to follow the safety briefing visually
- They are unable to see viable means of egress/emergency exits

5.4.16 Mental Deficient Passengers

ECAC Classification:

None

Definition:

Mental deficient passengers are not at adult level in their intellectual development.

Characteristics:

Regarding their intellectual development, mental deficient persons are comparable to children – their physical development, however, equals that of an adult. Depending on the degree of impairment, they are dependent on the attendance by an accompanying person.

They are unable to grasp the information given in the safety briefing or to make use of such information. These passengers may easily be overstrained in exceptional situations.

Findings from investigation phase:

- They require assistance in emergency situations

5.4.17 Deportees and Passengers in Custody

ECAC Classification:

None

Definition:

Passengers who are transported on behalf of authority

Characteristics:

The EU has established regulations and recommendations regarding the handling of deportees. If these are implemented consequently and by adequately trained staff, safety-relevant escalations on board are very unlikely. As the police representatives stated in an interview, there were no incidents during the past years.

Findings from investigation phase:

- It must be ensured that the passenger is not handcuffed in case of emergency
- Passenger might provoke an emergency landing

5.4.18 Inadmissible Passengers

ECAC Classification:

None

Definition:

A passenger, who is refused admission to a state by authorities of that state, or who is refused onward carriage by a state authority at a point of transfer, e.g. due to lack of a visa, expired passport etc.

Characteristics:

These passengers could pose a risk since they may be under a high degree of stress.

Findings from investigation phase:

No safety-relevant incidents could be identified

5.4.19 Passengers with any pre-existing conditions which may lead to unforeseeable potential hazards

Definition:

This category accounts for people who cause situational stoppages/problems which are unforeseeable.

Characteristics:

Psychosis

Passengers with psychosis are people who suffer from disorders the symptoms of which occur in episodes. The study also classified epilepsy in this category.

Cardio-vascular diseases

Passengers, who suffer from a known cardiovascular disease or from pre-existing disorders affecting the cardiovascular system. This category also includes problems of the respiratory organs.

Diabetes

Passengers with diabetes, who suffer from a disorder as a result of which the blood sugar level cannot be controlled or can hardly be controlled without medication.

Addiction

Passengers, who suffer from an addiction with a psychic or physical dependence syndrome or behavioural addiction and who suffer from withdrawal phenomena if the addictive drug is not available.

Drunken / on drugs

Drunken passengers whose behaviour or coordination is impaired by alcohol or other intoxicants.

Findings from investigation phase:

As it is impossible to give a forecast, it is only possible to control the consequences. The arising situations are not safety relevant within the scope of this study. So these categories have not been regarded as SCPs.

It has to be noted that some of these categories can represent a high safety risk to other passengers. As these risks are unforeseeable and mostly arising from security problems they are not scope of this study.

5.4.20 General note on special categories of passengers

The list provides a comprehensive compilation of fundamental disabilities. Further categories can be analysed if all scenarios of disabilities to be considered are combined. Older persons, for instance, can be combined from the following categories:

- physically disabled passengers (low mobility)
- deaf passengers
- blind passengers

As second example drunken passengers may be combined from these categories:

- physically disabled passengers (low mobility)
- mental deficient passengers

It must be taken into account that in some cases it is not possible to apply mitigating measures since there are constraints due to other categories.

The analysed impairments can be permanent or temporary and visible or invisible. Persons with alcohol or drug problems are not included in the PRMs in the stricter sense. The legal situation regarding the definition of PRMs is not clear in this respect. In accordance with European railroad directive EC/164/2008, persons are considered to be PRMs if their addiction was caused by medical treatment*. Then, they have to be taken into account since they may pose a safety risk.

* 2008/164/EC technical specification of interoperability relating to ‘persons with reduced mobility in the trans-European conventional and high-speed rail system

5.5 Results of Risk Assessment

5.5.1 Risk Charts

For comprehensibility the risk arising from the scenarios compiled during the assessment has been visualized in three charts. The risk is shown as colours; green representing the lowest or no risk in the chart and red the highest risk within the chart. The colours are only comparable between the chart “Risk to Others per Flight Phase” and “Risk to SCPs Themselves per Flight Phase”. They do not represent absolute risks but the relative risk compared to other categories or to other flight phases.

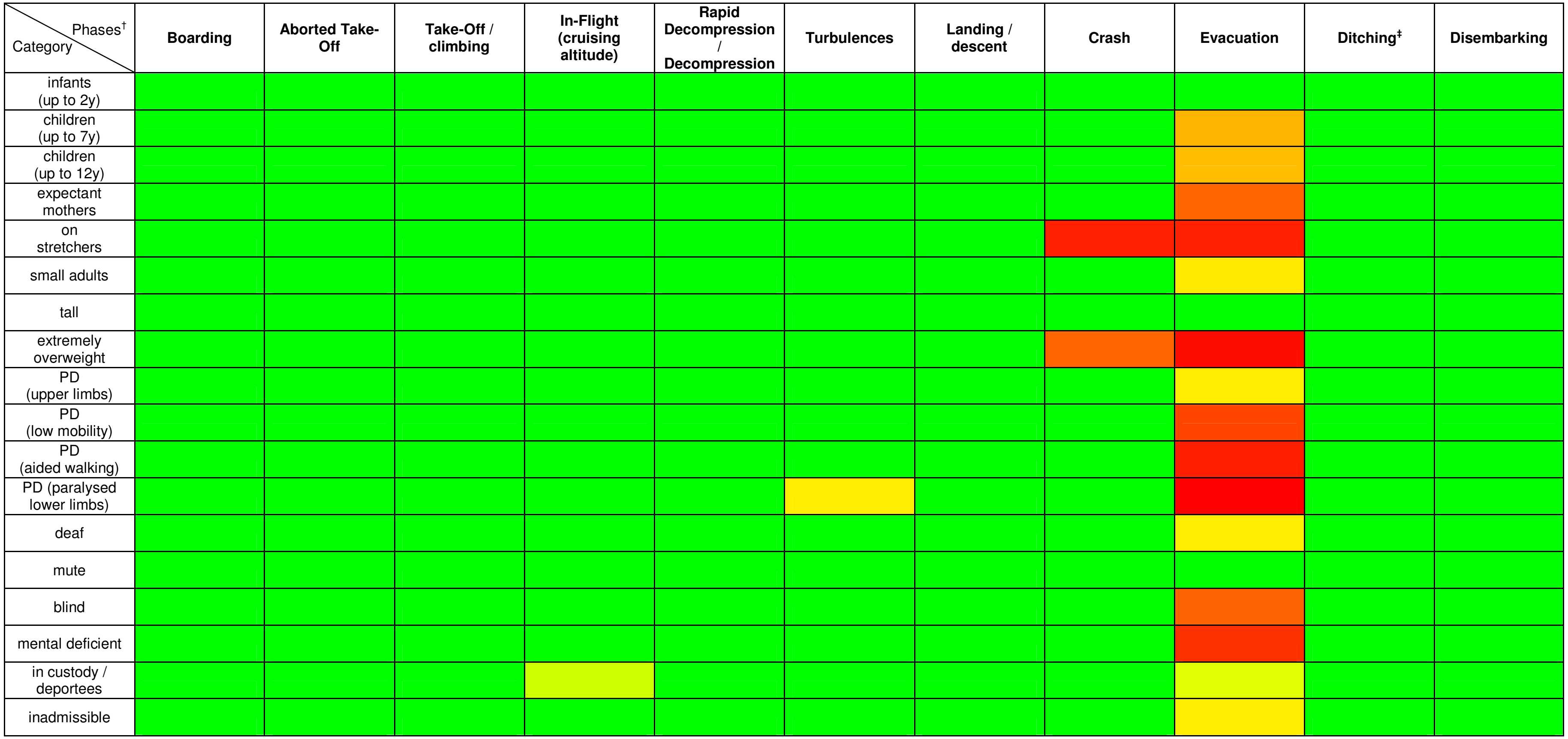
Chart 1: Risk* to SCPs Themselves per Flight Phase

* colour code: from green to red: green: no risk / lowest risk in chart – red: highest risk in chart

† For relation and order of the phases of flight see Figure 14

‡ The risk occuring in phase Ditching only represents the additional risk to a evacuation.

Chart 2: Risk* to Others per Flight Phase



* colour code: From green to red: green: no risk / lowest risk in chart – red: highest risk in chart
† For relation and order of the phases of flight see Figure 14
‡ The risk occuring in phase Ditching only represents the additional risk to a evacuation.

Chart 3: Risk[*] Classification of Special Categories of Passengers

Category	PD (paralysed lower limbs)	extremely overweight	on stretchers	PD (aided walking)	mental deficient	PD (low mobility)	blind	expectant mothers	children (up to 7y)
Risk to Others									

Category (continued)	children (up to 12y)	small adults	PD (upper limbs)	deaf	inadmissible	in custody / deportees	infants (up to 2y)	tall	mute
Risk to Others									

Summarised risk to others per special category of passengers sorted by risk in descending order

Category	on stretchers	children (up to 7y)	infants (up to 2y)	extremely overweight	PD (paralysed lower limbs)	children (up to 12y)	PD (aided walking)	mental deficient	PD (low mobility)
Risk to Themselves									

Category (continued)	expectant mothers	blind	small adults	PD (upper limbs)	tall	deaf	inadmissible	in custody / deportees	mute
Risk to Themselves									

Summarised risk to the SCPs themselves per special category of passengers sorted by risk in descending order

[*] colour code: From green to red: green: no risk / lowest risk in chart – red: highest risk in chart

5.5.2 Description of the Charts

The charts “Risk to Others per Flight Phase” and “Risk to SCPs themselves per Flight Phase” are visualising the risks of each SCP per flight phase. For each scenario the risk is allocated to the phase in which the accident happens. These charts facilitate the overview of the phases with the highest risk per passenger category. Only in these two charts the colours are comparable.

The risk to the passenger himself is distributed over all phases with highest risk occurring in the phases crash and evacuation. The risk in phase crash mostly arises from insufficient restraint or insufficient ability of seats or other parts to withstand loads. The risk in phase evacuation mainly arises from SCPs being unable to evacuate themselves in an appropriate time. This leads to higher exposure times in smoke.

For extremely overweight passengers, passengers on stretchers, blind and mental deficient passengers also a higher risk during ditching is notable. The assessed risk during ditching is only the additional risk to a normal evacuation, as ditching can be seen as normal evacuation on water. So the risk during evacuation applies here too. The phase ditching only facilitates the scenarios in which an additional risk occurs – e.g. due to misuse or misfit of life jackets.

As examples for risks in the other phases, the risk for physically disabled passengers (upper limbs) during decompression is considered. This risk arises due to not being able to put the oxygen masks to their nose and mouth. Another example is the risk for physically disabled passengers (paralysed lower limbs) in wheelchairs during turbulences. Serious injuries might occur when the passenger is in the cabin wheelchair while sudden turbulences occur. All scenarios for all combinations the according scenarios can be found in Appendix 9.7 “Scenarios of Risk Assessment”.

Risk to others mainly occurs during the phase evacuation due to delay of evacuation which leads to longer exposure times in toxic smoke or fire. During crash extremely overweight passengers and passengers on stretchers have also an impact on the safety of other persons in the cabin due to high loads and forces. Here also a detailed list of scenarios can be found in Appendix 9.7 “Scenarios of Risk Assessment”.

The chart “Special Categories of Passengers” displays the risk for each special category of passengers themselves and the risk they bear to other persons in the cabin. Here it is visualised which categories have to be considered regarding recommendations for mitigating the risk and for which categories the risk is tolerable.

The risk shown in this chart is a sum of the risks over all flight phases. The both upper rows show the combined risk to others coming from the chart “Risk to Others per Flight Phase” and the two lower rows show the risk to others coming from “Risk to SCPs themselves per Flight Phase”.

Passengers on stretchers are having the highest risk to themselves, followed by children up to seven years, infants, extremely overweight passengers, physically disabled passengers (paralyzed lower limbs), children up to twelve years, physically disabled passengers (aided walking) and mental deficient passengers. Physically disabled passengers (low mobility), expectant mothers and blind passengers are having a lower risk for themselves. For all other SCPs the risk is in an acceptable low range and further measures are not necessary.

The highest risk to others arises by transport of physically disabled passengers (paralyzed lower limbs), extremely overweight passengers, passengers on stretchers and physically disabled passengers (aided walking), followed by mental deficient passengers and physically disabled passengers (low mobility). By transport of blind passengers and expectant mothers a lower risk arises. For all other SCPs the risk to others is in an acceptable low range and no further measures are necessary.

6 Findings

As a result of the survey of accidents and studies as well as of risk assessment, the following fundamental findings were compiled:

6.1 Risk accumulation and saturations

Risk analysis has shown that among the SCPs, the risk is increased especially by non ambulatory passengers or passengers with very low mobility.

It is worthwhile to assume that the risk to SCPs themselves, and also to others, increases linearly with the number of SCPs transported. This is not only motivated by a first order approximation of the influence of the number of SCPs but also by the lack of interaction between the SCPs. The slope is proportional to the own risk of the SCP in the specific group of passengers. The linear increase in this case is explained by the fact that, according to the analysis, there is no clear interaction between individual SCPs. Interaction between SCPs in the same or in different groups would produce additional scenarios for risk assessment. These scenarios would thus progressively increase the risk proportionally with the number of SCPs.

Two main scenarios, potentially arising from transportation of multiple SCPs, could be identified.

One scenario would be an exponentially increase of evacuation time when transporting several SCPs, since the SCPs interact in various ways. The “Emergency Escape of Disabled Air Travellers” study shows, however, that – with suitable seat selection – it may be assumed that an increase in the number of PRMs results in a linear or degressive increase of the total evacuation time. This was examined for the “Totally incapacitated”, “Lower Limb and Partial Immobility” and “Upper Limb and Sensorial Handicaps” passenger groups considered there and is applicable to overwing exits as well as floor-level exits. This renders interaction of the disabled unlikely in the evacuation tests.

The second scenario would be that no passengers are available as assistants to other SCPs, since they are not able to provide help or even would need assistance themselves . In some situations, precautionary measures are then not applicable and the overall risk in that situation is higher than calculated, because the risk assessment always assumes that ABP passengers are seated next to the SCPs as precautionary measure.

This situation can be mitigated by appropriate seating and by distributing the SCPs across the aircraft, ensuring that all SCPs are surrounded by a maximum number of able-bodied passengers.

Up to a certain ratio of SCPs to the number of able bodied passengers the risk increases linearly with the number of SCPs aboard an aircraft. As soon as there are too few able-bodied passengers available, evacuation of those SCPs facing problems to evacuate themselves is clearly hampered or impossible. This results in a step-function increase of the SCP's risk. The according ratio at this point is defined as SPR_{Lim}.

This is illustrated in the diagram below:

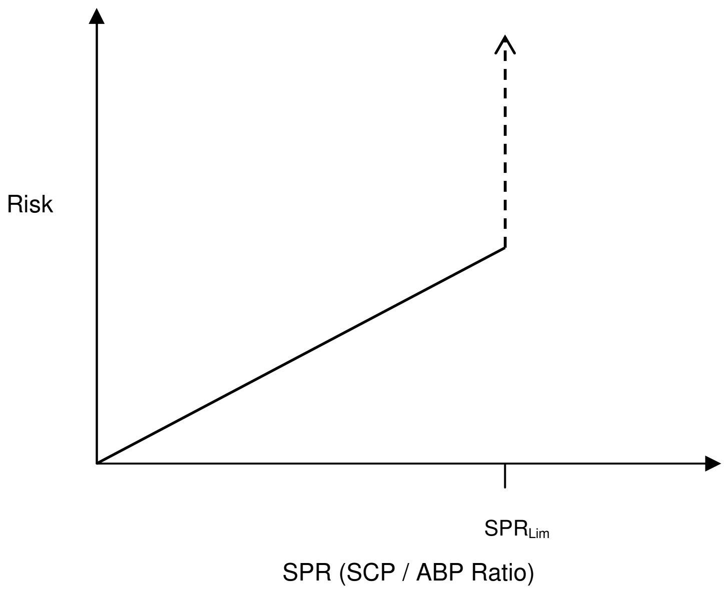


Figure 14: Step function increase of SCPs' risk

The risk to others is proportional to the number of SCPs on board. The lack of assistance does not increase their risk, i.e. there is no step-function increase at SPR_{Lim} that is the ratio of SCPs to able-bodied passengers. Due to the lack of statistic and experimental data on the effects of these special passenger groups, the percentage of SCPs on board rendering the risk intolerable cannot be determined. The statistical threshold the number of PRMs should not exceed thus remains unknown. To this end, further representative studies and supplementary investigations would be required, including variables such as type and severity of the disability, seat location of SCPs, number of aisles and distance of the SCP from the exit, as well as the number of persons behind the PRMs.

A study[24] calculates the probability of availability of the exits. The accident analyses evaluated in the study showed that the availability of aft-exits was the lowest. The results are not significant, however, due to the limited data. Until more significant tests are available, it should be assumed that each exit has the same statistical availability.

In the table below, first attempts are made to determine the saturation point SPR_{Lim} for a passenger category. All cases still require separate investigations, however.

[24] A Database to Record Human Experience of Evacuation in Aviation Accidents, CAA UK, 2006, chapter 5.6.4

Passenger category	Justification for SPR_{Lim}
Infants	It should not be assumed that infants can travel unaccompanied. In general, one accompanying person is required per infant. The upper limit during an evacuation is given by the max. number of infants an average person is able to carry.
Children up to seven years	Children up to seven years require guidance during an evacuation. The number of children per guide depends mainly on the stage of development of the accompanied children. Further investigations are required to find an upper limit to the number of children up to seven years.
Children up to 12 years	Children up to 12 years require passengers whom they can follow in case of an evacuation. It is regarded as adequate here that the children can see, hear and follow this person. Poor visibility must be assumed due to smoke, and also a short calling distance due to high noise levels. This should be considered when specifying SPR_{Lim}. Further tests are necessary for accurate figures.
Expectant Mothers	Risk analysis shows that pregnant passengers do not require accompanying persons. It may thus be assumed that the risk increases linearly only and no SPR_{Lim} exists. However, expectant mothers could only partially assist other SCPs during evacuation.
Small Adults	Risk analysis shows that passengers with a small physique do not require accompanying persons. It may thus be assumed that the risk increases linearly only and no SPR_{Lim} exists.

Tall Passengers	Risk analysis shows that passengers above average size do not require accompanying persons. It may thus be assumed that the risk increases linearly only and no SPR_{Lim} exists.
Extremely Overweight Passengers	Risk analysis shows that extremely overweight passengers do not require accompanying persons. It may thus be assumed that the risk increases linearly only and no SPR_{Lim} exists.
Physically Disabled Passengers (Upper Limbs)	Passengers with upper limb disabilities may require assistance to open the seat belt buckle in case of an evacuation. This assistance could be given by the passenger in the adjacent seat (ABP). The number of PRMs may therefore not exceed the number of able-bodied persons.
Physically Disabled Passengers (low mobility)	Depending on the degree of their disability, these passengers may require ABPs during evacuation - to stabilise them and optimise walking speed. Further investigations are required to determine upper limits to how many SCPs of this group are acceptable per passenger.
Physically Disabled Passengers (aided walking)	Depending on the degree of their disability, these passengers may require ABPs during evacuation to stabilise them and optimise walking speed. Further investigations are required to determine upper limits to how many SCPs of this group are acceptable per passenger.
Physically Disabled Passengers (paralysed lower limbs)	Depending on the weight of the PRM, at least one assistant ABP is required. For evacuation of the passenger via floor-level exits in the case he was pulled rearwards, turning is required in the exit area, to position the PRM "feet first", facing the slide. Assistance by other persons makes turning easier and quicker.

Passengers on stretchers	To evacuate a passenger on a stretcher, assisting ABPs must be able to carry the passenger maybe on the stretcher, if necessary. It may be assumed that at least two accompanying persons are required to do this.
Deaf Passengers	Deaf passengers can orientate themselves by the hearing passengers during an evacuation. It is regarded as satisfactory in this case if the deaf passenger is able to see and follow the hearing passengers. Poor visibility caused by smoke must be assumed. It is not generally required that every deaf person must have a hearing person in view, since deaf passengers can also orientate themselves by other deaf passengers who can see a hearing passenger. This should be considered when specifying SPR_{Lim}. Further tests are necessary for accurate figures.
Blind Passengers	Blind passengers are potentially able to orientate themselves well around the cabin. However, this does, depend on each person. The period for which the person has been blind has a major effect, for instance. It must be assumed that the average blind person depends on able-bodied guides during an evacuation. SPR_{Lim} depends on the number of guided blind passengers per accompanying person. Further investigations are required to determine the exact number.
Mute Passengers	Risk assessment shows that mute passengers do not require accompanying persons. It may thus be assumed that the risk increases linearly only and no SPR_{Lim} exists.

Mental Deficient Passengers	Mental deficient passengers require accompanying persons to assist them in reacting appropriately during an evacuation. SPR_{Lim} is determined by the number of mental deficient passengers who can be suitably assisted by another person. Further investigation is required to determine the exact number.
Passengers in custody / deportees	An SPR_{Lim} exists only with handcuffed passengers. An accompanying person is required in such instances, who removes the restraints in an emergency. This is required by EC regulations. In all other instances it may be assumed that the risk increases linearly only and no SPR_{Lim} exists.
Inadmissible Passengers	Risk assessment shows that inadmissible passengers do not require accompanying persons for safety reasons. It is also not possible to request such. It may thus be assumed that the risk increases linearly only and no SPR_{Lim} exists.

The SPR_{Lim} ratio – the limiting number of SCPs divided by the number of able-bodied passengers – is influenced by several factors. On the one hand, this ratio depends on the mobility or the independence of the specific passenger in a SCP group. On the other hand, the ratio is also affected by the physical fitness and ability to guide people of the ABP, , the load factor of the aircraft and the cabin layout. SPR_{Lim} can thus not be determined absolutely and the value might vary widely.

When SPR_{Lim} is reached, the overall evacuation time and also the overall risk are very high and might be socially intolerable. Individual evacuation time increases correspondingly. Acceptance criteria for evacuation in the presence of SCPs are therefore recommended. Based on these criteria, it can be calculated how many SCPs can be tolerated on a flight, given a specific group. This requires statistically significant data on evacuation time increase in the presence of a number of PRMs. This data is not existent. Further investigations and tests are recommended.

Recommendation: Risk accumulation and saturations

→ Further research to specify a number of accompanying persons per SCP (see chapter 6.1, Risk accumulation and saturations) is recommended. Characteristic attributes for possible assistants with a guidance function e.g. for blind passengers evacuation and for assistants with carrying function e.g. have to be evaluated.

→ Further research to specify a criterion for an acceptable increase of risk is recommended. The definition of a specific ratio of able-bodied passenger to SCP per category should be considered.

6.2 Cabin crew

As a result of the survey of accidents and studies as well as of risk assessment, the following findings regarding cabin crew were compiled:

Training

Studies prove that the skills of the cabin crew have a significant effect on the speed of evacuation. Factors such as passenger and crew interaction, passenger briefing as well as concise and specific tactile commands have proven to be of crucial importance towards increasing the survival chances of passengers.

Common Practice analysis revealed that training of the cabin crew is not to any common standards. According to EU-OPS, for instance, no obligatory evacuation exercise with e.g. unconsciousness adults, WCHC or dummies are required. Carrying techniques (e.g. rescue grasp according to Rautek), as it is to be used with ill persons (e.g., unconscious ones), is trained generally in the first aid instruction. During a basic training course the practical part is required for each participant. However, depending on the quality of recurrent training only a few participants are obliged to demonstrate these carrying techniques to a group again. In an emergency the handling of e.g. non-ambulatory SCPs is left to the crew.

Accident analyses and crew interrogations have revealed that practical experience with emergency equipment is also often lacking. Depending on the airline and the different types of emergency devices this leads to complications during emergencies (e.g. the use of smoke hoods or fire extinguishers). In-flight fire fighting is sometimes not adequately simulated during training, too. Furthermore instruction of passengers regarding the use of the over wing exits is not conducted consequently and is not explicit required by regulations.

The beneficial effects of crew skills as described above clearly illustrates that cabin crew training is of particular importance. Frequent training is required for rare incidents such as onboard fire and evacuations.

Number of Cabin Crew

Cabin crew's work load during an evacuation is generally high, especially in the case of flights with the legally prescribed minimum number of crew. EU OPS 1.311 prescribes a minimum ratio of at least 1 cabin crew member per 50 passengers, or the minimum ratio verified by the evacuation certification (CS 25 Appendix J). Analysis of the three accident reports revealed a ratio of 1 cabin crew member per 20-30 passengers.

The Toronto Accident Report stated that the availability of supplemental cabin crew members undoubtedly contributed to the success of the evacuations, as evidenced by the roles they played during the evacuation.

The CAA Paper 2006/01 "*A Database to Record Human Experience of Evacuation in Aviation Accidents*" confirms a statistical relationship between the number of operational cabin crew members and evacuation efficiency. For the six accidents considered the authors noted that when there are a small number of crew available to control the evacuation, passengers tend to fail to make use of their optimal exits and tend to travel significantly further than is necessary in order to evacuate. Therefore, this study defined the evacuation efficiency as the theoretical shortest distance to the nearest viable exit divided by the actual distance travelled by a passenger. The greater the efficiency of cabin crew, the less excess distance is travelled. However, the approach to measure the evacuation efficiency as a function of distance travelled is partly inappropriate. Preliminary analysis of data for e.g. multi aisle aircrafts (wide body aircraft) suggests that due to more instances of passenger redirection and exit bypass by cabin crew, passenger's travel further than the theoretical minimum distance. Here rather the decrease of total evacuation time due to cabin crew performance is the efficiency improving factor than distance travelled by the passenger. Nevertheless it could be determined that evacuation efficiency increases with the number of cabin crew.

If this relationship can be generalised, then the loss of even a single cabin crewmember as e.g. a result of the accident may have serious implications for passenger safety. This will be particularly relevant in evacuation situations where any extra time spent in egress will compromise the survival chances of the passengers, such as situations involving fire.

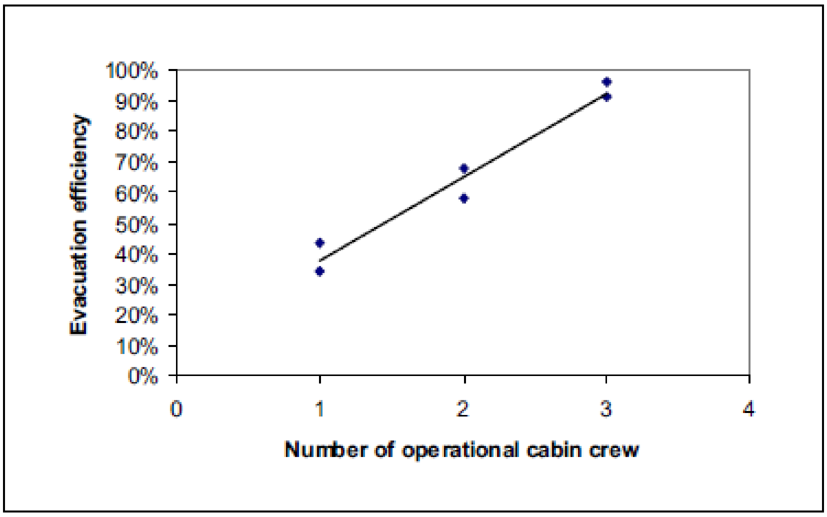


Figure 15
Relationship between Evacuation Efficiency and the number of operational cabin crew for the six narrow body accidents
(source: CAA Paper 2006/1)

The results of this study show that evacuation of certain special categories of passengers (SCPs) leads to a delays of the evacuation. In contrast the evacuation efficiency increases with the number of cabin crew. Therefore it would be possible that additional cabin crew has a compensating effect.

Responsibility of Cabin Crew

According to the findings of the analysed studies and the risk assessment, the cabin crew should be responsible primarily for the evacuation of the entire aircraft and only then for the evacuation of individuals. It is not recommended to task the cabin crew primarily with the evacuation of SCPs or to obligate them to assist. The legal status of the cabin crew (liability) in the event of evacuations is not clear. The decision to assist should remain a situation-dependent, subjective decision by the cabin crew.

The physical ability to carry or to support a SCP, if necessary, is also important in this respect. The selection criteria for cabin crew staff do not include suitability for physical evacuation of passengers.

Recommendation: Cabin crew

→ Further research relating to the cabin crews influence on evacuation velocity and their possibility to control evacuation queues with respect to SCP evacuation.

→ Review rules relating to the cabin crew ratio, considering the evacuation delaying effects of certain SCPs and possible compensating effects due to number of cabin crew.

→ Development of more detailed European standards for cabin crew training.

→ Mandate cabin crew to instruct passenger how to use self-help exits (e.g. over wing exits)

→ Improve safety of cabin crew stations

→ The legal status (liability) of the cabin crew in the event of evacuations is not clear. In view of the increasing readiness to sue, questions of liability should be addressed.

6.3 Accompanying persons for evacuation

Risk analysis shows that, as soon as an assistance needing SCP is on board, the risk increases for all passengers. Although an assistant reduces a SCP risk, the assistant’s risk increases.

From a risk point of view it is questionable whether accompanying persons who, under Regulation (EC) 1107/2006, fly along for reasons of convenience (toileting, catering, general assistance etc.) should be obligated to evacuate SCPs.

Some airlines and national aviation authorities require disabled passengers to have accompanying persons for evacuation. Obligating an accompanying person for the evacuation of an SCP is only beneficial to the SCP if the accompanying person:

- is physically and mentally capable of evacuating the SCP

and

- is able to assess a situation and react in the appropriate manner.

In the absence of any one of these characteristics, the SCP’s risk is not reduced by the presence of such accompanying person. However, the risk of the accompanying person himself may increase to an intolerable level.

A prerequisite for risk-effectively obliging an accompanying person to perform evacuation would thus be the proof of his skills. It is expected that this will be impossible in practice, or very difficult to check. The obligation to have an accompanying person for evacuation is thus not recommended.

Nevertheless the survey of accident reports and studies as well as risk analyses shows that accompanying persons reduce the risk to certain SCPs (see 6.1). According to a FAA study, an accompanying person is thus highly effective in providing minimum support and discouraging the shoving tendencies of other passengers to allow the SCP to enter the evacuation queue. It is also shown that an accompanying person is able to motivate and prompt other persons to provide support. This is also confirmed by accident reports, where voluntary assistants evacuate disabled persons.

For the above mentioned reasons an accompanying person makes sense. But the obligation to evacuate is not recommended. The fact that everyone is obliged to assist and to help to the best of his abilities in an emergency should be taken into account. However, self preservation has priority in such situations and none can be obligated to assist if he needs to put himself under unacceptable risk. The decision to assist should remain a situation-dependent, subjective decision of the assistant.

Recommendation: Accompanying persons for evacuation

→ The legal status of accompanying persons during evacuation have to be clarified.

→ It is not recommended to mandate accompanying persons for evacuation reasons. Especially when fly along for reasons of convenience (toileting, catering, general assistance etc.) as under (EC) 1107/2006. Review corresponding European and national rules

→ Further research to specify a number of accompanying persons per SCP (see chapter 6.1, Risk accumulation and saturations) is recommended. Characteristic attributes for possible assistants with a guidance function e.g. for blind passengers evacuation and for assistants with carrying function e.g. have to be evaluated.

→ Develop European standard definition of able bodied assistants for the evacuation of SCPs.
Able bodied assistants key characteristics should include:

1. physically and mentally able to evacuate the SCP.
2. able to assess the situation and react in the appropriate manner

In addition, the following steps are recommended:

- Define an appropriate age for able bodied assistants. They must be able to manage the SCPs evacuation and be aware of the responsibility.
- Provide appropriate means to inform the able bodied assistant about the risks and options during an evacuation and consider the SCP's needs

6.4 Evacuation Certification

The cabin layouts of the different aircraft categories – narrow body, wide body and multi deck – must all comply with the certification requirements under CS25, Appendix J. This specifies that it must be possible to evacuate all cabins within 90 seconds, using half the mandatory emergency exits. For this evacuation certification, the passengers must be a representative average of the population. Travel patterns and the use of aircraft for transportation have changed, due to social developments and far ranging developments in air traffic (extended passenger rights, increased need and awareness of safety, low cost airlines, VLTAs). Increasingly different groups of people participate in air travel. Analyses of the studies and evacuation tests have shown that SCPs significantly affect the evacuation times of aircraft.

Allthough the full scale evacuation demonstrations (CS25 Appendix J) are just used as a benchmark for certification they show correlations between cabin configurations (minimum seat pitch, Exit configuration etc.) and evacuation time. It can be assumed that, as long as different passenger groups are not considered in CS 25 Appendix J specifications for the evacuation demonstration test, developments to improve SCP-evacuation are not encourage (e.g. innovative decent devices or cabin configurations)

<u>Recommendation Evacuation Certification:</u>

→ Include a representative number of SCPs during evacuation tests to improve developments in SCP evacuation

→ Determination of acceptance criteria including the effects of SCPs on evacuation times

6.5 Aisles

The findings of several studies showing that aisle configuration has only minimal effects on emergency egress. (see 4.5.2.4). In contrast, differences in the physical characteristics and lack of knowledge of individual participants produce large differences in emergency evacuation performance. Although these studies were performed with varying groups of passengers (waist size, gender and age), the evaluated groups can be categorised under as able bodied Persons (ABPs).

The evacuation tests with WCHCs show that narrow aisles significantly affect the evacuation speed. Positioning the WCHC to enable carrying is one of the determined delaying factors. An assistant blocks a narrow aisle during this time. The FAA evacuation test also reveals that a narrow seat pitch and a narrow main aisle restricted assistance.

Obstruction of the evacuation stream cannot be excluded even with wide aisles. But in this case it is more likely that passengers can negotiate the obstruction created by non-ambulatory SCP and an assistant. This would require further investigation. In this context the findings of Cranfield University involving competition between passengers in high motivation evacuation tests has to be considered[25]. The study stated that increasing the width of the aperture through a bulkhead from 20 to 30 inches, the speed of passengers able to pass through the aperture was significantly increased.. However, making the gap even wider did not significantly increase the

[25] Source: “Contemporary Issues in Human Factors and Aviation Safety”; Don Harris and Helen C. Muir, 2005

flow rate and led to problems as research and accidents have shown. It was stated that a cabin crew member has been pushed out through the exit by the rush of passengers at the start of the evacuation because the cabin crew member had no bulkhead for protection.

Recommendation aisle:

→ Further research to optimise aisle widths regarding evacuation of SCPs.

6.6 Exits

According to Regulation (EC) 1107/2006, disabled persons or PRMs may be refused if the size of the aircraft or its doors makes the embarkation or carriage of a disabled person or PRMs physically impossible. Regulation (EC) 1107/2006 is ambiguous in this regard, since it only considers embarkation. Embarkation is generally through the larger aircraft doors (e.g. Type A or Type 1). Possible evacuation by overwing exits or other smaller exits is not considered here.

However, analyses of the studies and evacuation tests have shown that the exits play a key role during the evacuation of SCPs. The evacuation time increases when e.g. a non-ambulatory SCP participates in the evacuation (alone or with the aid of others). Delays are caused by the following factors:

→ Blocked aisles

→ Blocked exits

Studies show that the relatively slow speed of the evacuation stream in the aisle enables the disabled person and his assistant as well as persons behind them to catch up with the evacuation queue in the aisle. In these cases no or only a little delay originate from blocking the aisle. Consequently blocking the exit is the main delaying factor in these cases.

Handicap Category	Number of Simulated Handicapped Passengers	Increase in Total Evacuation Time (s)	
		Floor Level Exit	Overwing Exit[26]
Totally incapacitated passengers	2	17.4	3.4
	4	36.1	5.7
	6	45.5	5.5
	8	49.8	9
Lower limb and partial immobility	2	2.5	8.8
	4	8.9	17.7
	6	11.6	13.6
	8	8.5	17.3
Upper limb and sensory handicaps	2	4.3	14.3
	4	4.9	13.2
	6	3.9	36.7
	8	9	42.5

Table 7: Increase in Total Evacuation Time.
(source: FAA-AM-77-1)

The above table show that the extent of delays depends on the type of exit and the type of disability.

The analysed evacuation tests revealed that four types of exits must be treated separately:

Exits with slides

Depending on the carrying technique, the carrying assistant of an non-ambulatory SCP must make a 180° turn in front of the slide in order to position the SCP on the slide „feet first“. With passengers shoving from behind and depending on the space around the exit area (bulkheads etc.), this manoeuvre is difficult especially in narrow exit areas. The non-ambulatory SCP must thereafter either be pushed forward up to the slide, or be carried to the slide with the aid of a second person. Only then can the

[26] Note: The presented overwing evacuation times reflect only the times to egress onto the wing. The time to reach the ground was not measured within the FAA study.

assistant carrying the feet of the SCP use the slide for evacuation. Using the arms, the non-ambulatory SCP can then lift himself into the slide or, in the case of total immobility, he must be pushed into the slide by the person behind him. Evacuation tests have shown that the evacuation of disabled persons at exits with slides causes major delays. But if an SCP is ambulant, the delay at exits with slides is minor.

Overwing exits

The disadvantage of overwing exits is that they are often smaller than forward, aft or other exits. Depending on the aircraft type, they may also have a fairly high sill height. The evacuation of high corpulent passengers leads to complications and delays. The risk for the high corpulent passenger as well as the risk for other passengers increases if these passengers block an exit during evacuation.

Analysis of Table 7 indicated that evacuation of non-ambulatory SCPs seems to be easier through an overwing exit than through a floor level exit. Studies and evacuation tests have also revealed that carrying test persons found the evacuation of non-ambulatory SCPs via overwing exits easier than via exits with slides. The decisive factor usually mentioned here was that it was not necessary to position the carried SCP “feet first” facing the slide. He was “piggybacked” or pulled through the overwing exit. This was also confirmed by the TÜV Rheinland tests. In addition, the carrying assistant found the seats in front of the overwing exit useful during these evacuation tests. In negotiating the exit, the WCHC Dummy or simulant was briefly placed on the seat, the carrying assistant stepping through the exit and then pulling the WCHC onto the wing. The sill height, for instance, was irrelevant in this case.

It has to be noted that this seat configuration is not always present. Furthermore the above mentioned overwing evacuation times reflect only the egress times onto the wing. If the overwing exit, however, is equipped with a slide to reach the ground, the same problems as described in chapter ”exits with slides” exist. A non ambulatory SCP must also be positioned “feet first” facing the slide. Therefore additional time is needed.

Nevertheless, within the overwing egress time values of Table 7, the increase of total evacuation time for passengers with upper limb or sensory disability is striking. They may have difficulties to use an overwing exit. This disadvantage has to be further investigated considering that once on the wing they have only a minimal increase in evacuation time when using the slides to the ground.

Overwing exits without a wing-to-ground descent device, increases the risk of injury to every SCP with reduced mobility as they need assistance to get off the wing.

Exits with Staircase

During evacuation tests, evacuation via exits with staircase caused the least delays, since no positioning was necessary facing the staircase. By descending the staircase backwards, a single carrying assistant was able to pull and evacuate a non ambulatory SCP alone, or the SCP was carried (forward or rearward) through the exit by two ABPs. However, an evacuation stream could not be simulated in the tests. Pushing and shoving by other passengers and steep or very narrow stairs are a potential injury risk.

Exits without descent devices

In accordance with CS 25.810, aircraft to ground descent devices (e.g. overwing slides, staircases) are only required for exit heights above 1,8 m and for each non overwing Typ A exit. Studies show that the evacuation of certain SCPs (e.g. non-ambulatory passengers) via exits without aircraft to ground descent devices constitutes an additional potential hazard to the SCP and to other passengers. The evacuation tests reveal that it is extremely difficult to evacuate for example a non-ambulatory SCP from this height without supporting means. Furthermore, the required procedure of positioning at the exit and disembarking blocked the exit.

Recommendation for exits:

→ Review of Regulation (EC) 1107/2006 Article 4, 1(b)
The physical possibility to evacuate is of crucial importance for the safety of the concerned passengers. Therefore, the evacuation of disabled persons or PRMs must be physically possible through every existing emergency exit and this should be clarified accordingly in the legislation, in lieu of only the embarkation through common aircraft doors..

→ Research to optimise the exit areas and exits to speed up the evacuation of SCPs and other passengers

→ Review of CS 25 with respect to exit sizes based on the above mentioned research

→ Develop suitable carrying techniques for SCP evacuation. Carrying “feet first” can save turning at the exit

→ Provide guidance for possible assistants

6.7 Seating of SCPs

Accident analyses revealed that the seat position, as a function of the distance from the exit, has a statistically significant influence on the chances of survival. Passengers who are seated up to five rows from the exit have higher statistical chances of survival, for example. There is, however, no statistically significant correlation between the position inside a row of seats (window, centre or aisle seat) and a passenger’s chances of survival.

In evacuation tests it was also shown that the position of a SCP in a row of seats had only little effect on the evacuation of other occupants. Even if a test person is seated at the window and has to climb over a WCHC dummy, his evacuation is delayed very little, if at all. It must, however, be borne in mind that no evacuation stream could be simulated in these tests and that the able bodied assistants were trained people, aged 27 to 40 years. Depending on a persons' physical condition and training, delays may therefore occur. A study to analyse the ergonomics of seat row configuration with regard to evacuation, revealed that a narrow seat pitch increases the risk of stumbling and injuries for overweight passengers. It may be inferred that these passengers will experience great difficulty in climbing over non-ambulatory SCPs, thus delaying their evacuation. This is also applicable to passengers with low mobility, e.g. the elderly.

Analysis of evacuation test has shown that persons in window seats participate in evacuations later because they are blocked in their seat rows once a queue has formed.

Therefore the density of the queue is of importance. It can be anticipated that at the beginning of the evacuation the density of the queue is less and increases from the exits along the aisles e.g. due to still closed exits or not prepared slides. The queues velocity is inversely proportional to its density. While the queue is build and started to move or speedup again the queues behaviour is affect to dynamic processes based on human factors and aircraft configuration (seat pitch, aisle width, bulkheads, exits, etc.). Thus, the density of the queue during evacuation varied with time at several places. It may be deduced from this that the following factors significantly affects the possibility to enter the aisle:

- → The velocity of queue density increase during evacuation
- → The time the queue is entered
- → The seating position where the queue is entered (distance to exit)
- → The physical ability of the passenger to integrate into the queue

<u>Models for positioning of SCPs</u>

To reduce the risk, the following models for positioning SCPs within the cabin were developed and analysed, based on studies and evacuation tests:

1.) Positioning of SCPs within a seat row.

2.) Positioning of the SCPs as far from the exits as possible

3.) Positioning of the SCPs near the exits

4.) Positioning of more than one SCP (multi-SCP seating / group seating)

The following findings were made:

<u>1.) Positioning of the SCPs in a seat row</u>

An analysis of movement from a window seat to the exit revealed, that non ambulatory SCPs expended up to 50 percent of the total time in moving from the window seat to the aisle. It would thus be advantageous for an e.g. non-ambulatory SCP to be seated in an aisle seat, rather than at a window seat.

However, an e.g. non ambulatory SCP in an aisle seat may obstruct other persons sitting beside. The following findings must also be considered. By taking longer to reach the aisle, it is possible that a queue forms in the aisle. During this first phase, the evacuation flow is faster, especially in the aisles. The evacuation flow is disrupted when an SCP blocks the aisle. It may happen during this first phase that, irrespective of the duration of the blockage, the evacuation flow between this plug and the exit dissolves, since no further passengers can move up to the exit. This implies loss of potential evacuation time due to an exit flow rate decrease down to zero. Studies confirm that time lost during the first evacuation phases cannot be made up again. If an e.g. non-ambulatory SCP joins the evacuation only later, a queue may form and the non-ambulatory SCP can be pulled into the aisle by an assistant. According to studies, time lost with this manoeuvre can be made up again, due to the relatively slow movement of the queue towards the exit. As described under Chapter 6.6 "*Exit*" only the exits now form a bottleneck. Still to be considered, however, is that a potential assistant will in reality find it more difficult to resist the shoving tendencies of a fully formed evacuation flow in order to pull an SCP into the aisle. Further investigations are necessary.

2.) Positioning of the SCPs as far as possible from the exits

Positioning an SCP with high delaying attributes as far as possible from the exits facilitates later participation of this SCP in the evacuation process, thus reducing the risk to other passengers.

Evaluation of the various cabin configurations (e.g. Figure 16, Figure 17, Figure 18) showed that positioning SCPs with high delaying attributes in seats between two exits supports them in joining the end of the evacuation queue. A prerequisite is, however, that all exits are usable.

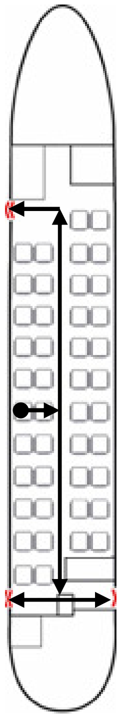


Figure 16:
ATR42 AT4

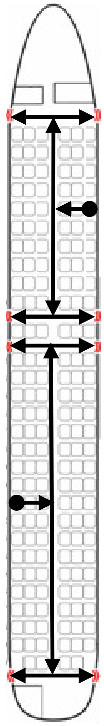


Figure 17:
Airbus A320

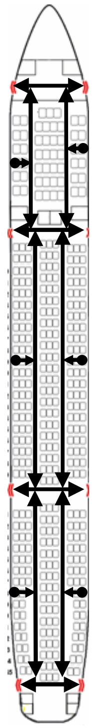


Figure 18:
Airbus A330-200

Different cabin configurations enable a positioning of SCPs with high delaying attributes in the rows at the back of the Cabin, facilitate the SCPs to join the evacuation queue preferably at the end.

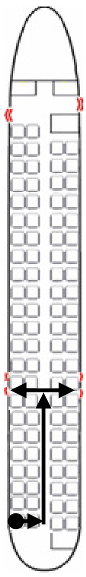


Figure 19:
Canadair CRJ-900

Figure 20:
Bombardier
Dash 8Q-300

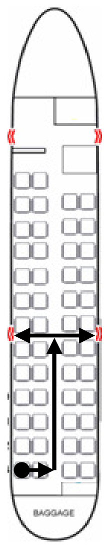


Figure 21:
Canadair CRJ-200

The layout analysis in e.g. Figure 19, Figure 20 and Figure 21 shows that SCPs sitting in the last rows of the cabin always join a possible evacuation queue at its end. Regardless of which exits are operational.

Thus, there are theoretically optimised seating positions to reduce the delaying effects of SCPs. But, as mentioned above, a prerequisite of these models is that all exits are usable. It has to bear in mind that this is not the case in the most evacuation situations and not even in the evacuation certification.

The following aspect should also be considered in regard to seating position. The risk assessment revealed that, under Regulation (EC) 1107/2006, no accompanying persons might be obliged to assist in evacuation (see Chapter 6.3 "*Accompanying Person for evacuation*"*)*. According to the findings in the accident reports, ABPs are assumed volunteers. If the SCPs are positioned as far as possible from the exit, it cannot always be guaranteed that they will be assisted by other passengers. In a FAA Study two test dummies were not evacuated, for instance. The study stated that this could be attributed to the following factors:

→ The size, age and general health of the nearest volunteer assistants were not conducive to the task.

→ The volunteer assistants were unable to reach the dummies

→ The area was cleared of unimpaired passengers before all dummies were accounted for

→ Most passengers in other parts of the cabin were unaware of the SCPs situation

3.) Positioning of the SCPs near the exits

The model for positioning SCPs close to cabin crew exits is based on the following assumptions:

→ The relevant exit must be a crew exit

→ The crew at the relevant exit must be as uninjured as possible and capable to lead a evacuation.

→ The number of SCPs positioned close to the exit must be in range of the crew (approximately 1-2 rows) and the number must be manageable.

→ The crew must have a good visual overview of the approaching evacuation flow

→ The SCPs follows the instructions of the crew despite imminent danger and remains in his seat. But shifts to the aisle seat already, if possible.

→ The crew identifies one or more ABPs at the end of the queue and prompt them to evacuate the SCPs. The crew can also lend support in this.

In this case, positioning near exits with cabin crew is advantageous.

The advantage of this procedure is that the SCP is within range of the crew and the crew would have options for supervision and possibly assistance the SCPs evacuation. The FAA study also shows that a cabin crew member in the immediate vicinity of the test dummies asked the assistants to help. Furthermore, the distance to the exit was much shorter, thus requiring less effort by the assistant. Even if the exits cannot be used, the crew can give instructions for the SCP to be carried to another exit.

By training, the crew should be prepared for such evacuations and therefore in a better position than the average passenger to assess dangerous situations. Studies prove that a well-trained crew is certainly able to also control passenger flows in panic situations. Further studies show that, under these circumstances, instructions in the form of clear commands are advantageous.

Practical implementation is, however, questionable here. The greatest disadvantages of this model are the numerous imponderabilities. In practice, it will be difficult to ensure that an SCP positioned close to an exit will be one of the last to be evacuated. In addition, the crew's responsibility is very high. The crew determines the SCP's time of evacuation, not the SCP himself. The legal situation of the crew and the constantly increasing readiness of passengers to sue must also be considered here.

4.) Multi-SCP seating / Group seating

Positioning in groups leads to obstruction among the assisting persons themselves. If, for instance, two rows (LH and RH) are occupied only with non-ambulatory SCPs, the SCPs can only be positioned and pulled into the aisle one after the other. In the course of this, the next assistants have to wait in the seat aisles to allow the first group, i.e. assistant and SCP, to move along the aisle in the direction of the exit. Depending on the width of the aisle and the seat pitch, only one person is able to stand in the aisle directly opposite the SCP to support him. The SCP on the other side must wait until this group has made the aisle available again.

Therefore group seating of SCPs should be avoided. SCPs should be positioned such that they are distributed over the cabin and the SCP and its accompanying persons are located preferably at the end of a row of passengers to be evacuated in order to avoid obstruction of other passengers.

Conclusion to Seating of SCPs

The survey of studies, accident databases and evacuation tests as well as analysis of risk assessment indicates that the average ambulatory SCP appears to possess adequate mobility for evacuation. Except in an exit row or a primary overwing exit route, where he might impede the early stage of an evacuation, he could be seated anywhere (see FAA-Study 4.5.2.5).

The above mentioned relationships show that later evacuation participation of SCPs increases the risk for the SCP, but decreases the risk of other passengers due to a faster evacuation. The analysis of the evacuation models and the FAA study confirm that better evacuation times were achieved in general when the SCPs with high delaying attributes and their assistants were seated far from an exit. This means that the more immobile an SCP is, the further away he should be seated from the aisle (e.g. window seat) and the further from the exit (see Chapter 6.7 *"Positioning of the SCPs as far as possible from the exits").* The following Figure 22 shows two comparative evacuation tests with two dummies simulated non-ambulatory passengers seated near the exit (Test1) and two seated away from the exit (Test 2). The evacuation started with a 10 second delay to simulate the preparation of exits and slides. Then the passengers evacuate the aircraft. The difference in numbers evacuated at the end of 20 seconds is notable. After 20 seconds only eight passengers (including the Dummies) could leave the aircraft in test 1 while 17 passengers could leave the plane in test 2.

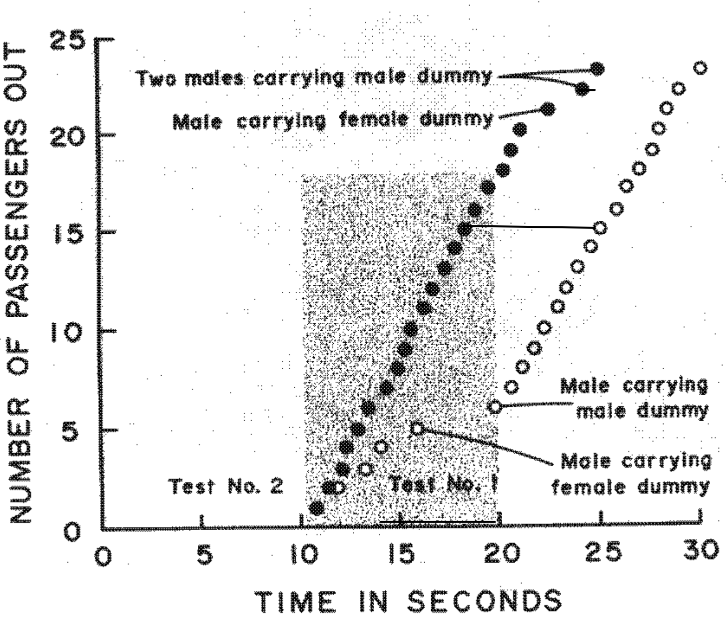


Figure 22:
Comparative evacuation tests. (Test1) two incapacitated passengers seated near the exit and two seated away from the exit (Test 2)
(source: FAA-AM-77-1)

The following figure shows two comparative evacuation tests with eight dummies seated near the exit and eight seated away from the exit. The evacuation started with a 10 second delay to simulate the preparation of exits and slides. Then the 50 passengers started to evacuate the aircraft. In the test in which the dummies were located far from the exit, 33 passengers evacuated within the first 45s. In the test in which the dummies were located near the exit, only nine passengers had evacuated the cabin at that time.

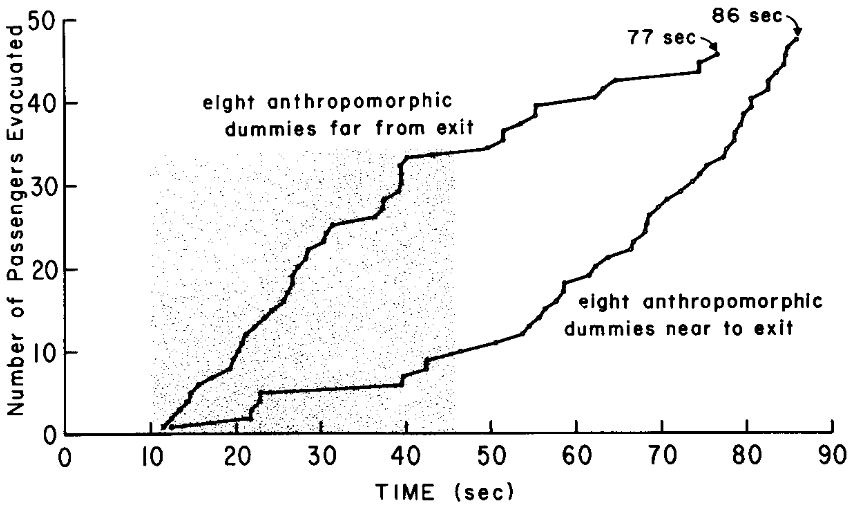


Figure 23:
Comparative evacuation tests. (Test1) eight incapacitated passengers seated near the exit and eight seated away from the exit (Test 2)
(source: FAA-AM-77-1,)

Although the above cited data were gathered only within two tests they show that there is a significant relationship between seating position of non ambulatory SCPs and number of passengers evacuated. But a final decision where to place SCPs has to be based on resilient statistical data. Therefore further investigations are recommended.

Recommendation for seating of SCPs

→ Until no resilient statistical data is available, the more immobile an SCP is, the further away he should be seated from the aisle and the further from the exit

→ Group seating of SCPs should be avoided. SCPs should be positioned such that the SCP and its accompanying persons are located at the end of a row of passengers to be evacuated, in order to avoid obstructing other passengers.

→ Further investigations are recommended.

6.8 Seats, berths, safety belts and harnesses

In the aviation field, seating and harness systems are important safety elements on which specific demands are made. According to CS 25.785 each seat, berth, safety belt, harness and adjacent part of the aircraft at each station designated as occupiable during take-off and landing must be designed such that a person making proper use of these facilities will not suffer serious injury in an emergency landing as a result of the inertia forces specified in CS 25.561 and CS 25.562.

Analysis of the regulations and studies reveals that these specifications are not consistently adhered to all passenger groups. According to the risk assessment, the following passenger groups have a highly increased potential risk in the event of a crash:

→ Infants

→ Children up to seven years

→ Extremely overweight passengers

→ Passengers on stretchers

Infants

Under EU OPS 1.320 (b) (2), occupants are permitted to have infants (children up to two years of age) on their laps during the flight (lap held). The infant is secured to the adult's safety belt by a loop belt.

Various European and American studies stated that Loop Belt restraint is not safe. The Loop Belt induces high forces into the abdominal region and the infants may suffer severe to fatal injuries, under forces described in the Emergency Landing Conditions CS 25.562. Inducing restraint forces into the abdominal region is against all world wide accepted restraint principles.

Studies propose that infants should be transported on an own seat and with a suitable child restraint seat. The own seat guarantees an own survival space for the infant. The child restraint seat offers the infant protection from forces experienced during a crash.

According to present knowledge there are no statistical data to fatal incidents caused by a loop belt. But, within a risk assessment it is necessary to consider all possible scenarios. It is not necessary that every scenario already has been proven by incidents, as the main function of a risk assessment is avoidance of dangerous conditions.

Recommendation for infants:

→ Infants should be transported in their own seat and in suitable child restraint seats.

Children up to seven years

Children aged between two and seven are seated on their own seat restraint by the adult lap belt. Children up to seven years are not physically fully developed. Investigations have shown that the adult lap belt is not suitable to the pelvis of younger children (up to seven years). The adult belt's geometry does not fit to the smaller pelvis of children, facilitates load inducing into the abdominal region. Therefore children up to seven may suffer severe to fatal injuries under forces described in the Emergency Landing Conditions CS 25.562. Studies propose that children up to seven years of age should be transported in a suitable child restraint seat. The child restraint seat offers the children protection from forces experienced during a crash.

Recommendation for children up to seven years:

→ Children up to seven years should be transported in suitable child safety seats

Extremely overweight passengers

Studies reveal that people are becoming taller and heavier. In view of nutritional habits in industrial nations and the commensurate increase in numbers of the extremely overweight passengers, it must be taken into account that, depending on the weight of extremely overweight passengers, the seating structure is approaching its permissible limits.

According to CS 25.785,"… *each seat or berth, and its supporting structure, and each safety belt or harness and its anchorage must be designed for an occupant weight of 77 kg (170 pounds), considering the maximum load factors, inertia forces and reactions among the occupant, seat, safety belt and harness for each relevant flight and ground load condition (including the emergency landing conditions prescribed in CS 25.561)."*

The supporting structure of e.g. a three-seat row is thus proven to carry a maximum weight of 3 x 77 kg = 231 kg. Analysis of common practice revealed that highly corpulent passengers usually occupy two seats. If the third seat is occupied by a passenger weighting 77 kg, the corpulent passenger must not weigh more than 154 kg.

A seat is not designed and not proven for occupying two seats with one highly obese passenger. Doing so results in crucial different load paths and different points where loads are induced into the seat structure than expected. Although simulations have far developed, the alternated dynamic behaviour of structures under these loads can only be verified by real life tests.

Furthermore analysis of common practice revealed occasions where common belt extensions were not long enough. In these cases, according to the requirements transportation must be denied.

Recommendation for extremely overweight passengers:

→ Extremely overweight passengers should be seated where a failure of their restraint system has minimal effects on other passengers (e.g. in front of a lavatory or bulkhead)

Passengers on stretchers

According to CS 25.785 also berth must be designed so that a person making proper use of these facilities will not suffer serious injury in an emergency landing as a result of the inertia forces specified in CS 25.561 (9g) and CS 25.562 (16g). CS 25.562 applies to each seat and berth occupied while take-off and landing. Further more each seat or berth must be approved.

Although occupied whilst take-off and landing, stretchers are not required to meet the CS 25.562 requirements. Within an exemption they are tested statically in FWD direction with 9g only. Passenger seats are, however, dynamically tested with 16g. Lower certification standards are thus made on stretchers than on passenger seats. Under emergency landing conditions as prescribed in CS 25.562, it is thus not guaranteed that a stretcher will withstand these stresses. A stretcher may break loose due to this lower load capacity. This poses a risk to patients lying on the stretcher and to other passengers.

CS 25.562 was drafted to assess the behaviour of the human body and its interaction with the structural features of the seating/safety belt system during an accident. Apart from the above mentioned 16g for dynamic testing of structures, CS 25.562 stipulates limits for the biomechanical stress on the human body. The existing dummy protection criteria can, however, only be applied to persons seated in an upright position, not lying persons. Thus, the biomechanical effects on stretcher passengers due to crash loads according to CS 25.562 cannot be proven.

Furthermore there are no procedures to evacuate a person on a stretcher. The ability to evacuate a stretcher via slide was not proven according to the present knowledge. The evacuation of a patient on a stretcher via a slide seems very risky. Slides are not designed for stretchers and vice versa stretchers are not designated to slide. Sharp edges on the stretcher may damage the slide. There is also a high risk for stretcher patients during ditching. There are neither procedures/provisions to keep the stretcher floatable if no life raft is existent or in reach nor where life rafts designed to accommodate a stretcher.

Recommendation for stretchers:

→ Certification of stretchers according to CS 25.562 (at least structurally)

→ Development of dummy protection criteria for passengers transported in lying position

→ Development of evacuation procedures for stretcher passengers

→ Stretchers passengers should be seated where a failure of their berth system has minimal effects on other passengers (e.g. in front of a lavatory or bulkhead)

→ Further investigations are recommended

6.9 Tools, aids and equipment for evacuation

Canes, crutches and comparable walking aids do not improve the evacuation times of SCPs. They in fact constitute an additional hazard in the cabin and when using the slides during an evacuation. Onboard wheelchairs require too much preparation time before they are ready to be used. Apart from this, they are usually not in the vicinity of non ambulatory SCPs. An unobstructed aisle can also not be assumed after a crash. Even if so, the vacant wheelchair constitutes a new obstacle, at the entrance at the latest. It must either be thrown out of the aircraft here or parked somewhere in the exit area. It could delay evacuation here, too.

It has been ascertained that people with disabilities use seat backs and armrests for support. Evacuation tests have shown that it must be possible to fold away armrests, since they obstruct movement from the window seat to the aisle.

Carrying non ambulatory SCPs has up to now been proven to be the quickest and most reliable method of evacuation. Stretcher patients should also be evacuated without the stretcher, if possible. Vital medical devices (respiration apparatus, infusions etc.) mounted on the stretcher should be removable and mobile. As mentioned in chapter 6.8 the ability to evacuate a stretcher via slide was not proven according to the present knowledge. Sharp edges on the stretcher may damage the slide. Furthermore the behaviour of a stretcher on a slide and during leaving the slide is not known. Further investigations are necessary.

Studies, accident analysis as well as accident reports and risk assessment indicated that the hazard of asphyxia due to smoke exposure is the time limiting factor. Statistically the hazard of asphyxia is rather a problem than the death by drowning after ditching. There are no provisions to protect passengers from toxic fumes during an evacuation with fire aboard an aircraft. The issue of PPBE for passengers is contrary discussed due to the possible oxygen enrichment in cabin air and the correlating fire hazard increase. But, it has to bear in mind that there are already pulse controlled breathing masks which reduce the oxygen leakage to a minimum. Analysis of common practice revealed that proper usage of present available PBE (e.g. smoke hoods) is often very complicated and the hazard of misuse is high.

Nevertheless, according to studies extending the survival time will increase survivability more than a faster evacuation. Furthermore longer survival time may compensate delaying factors due to SCP transportation. PPBE seems to be an appropriate measure to enhance the survival chances for all passengers but especially for e.g. non ambulatory passengers on stretchers. They cannot evacuate due to the mentioned problems of stretchers evacuation. A PPBE gives the opportunity to extend the survival frame and may enable an evacuation by professional rescue services.

Due to the significance of mortality rates further research and developments in the field of PPBEs for passengers as an additional safety item e.g. to life vests are recommended.

Recommendation for tools, aids and equipment for evacuation

→ Existing equipment should be assessed and suitable carrying methods for SCP evacuation should be developed (e.g. carrying devices, carrying belts, etc.)

→ Further investigations regarding evacuation of stretchers.

→ Development of procedures for stretcher evacuation also considering ditching

→ Vital medical equipment of stretcher patients should be portable to allow the patient to be evacuated without the stretcher

→ Further research in PPBE is recommended. PPBE gives the opportunity to extend the survival frame and may enable an evacuation by professional rescue services.

6.10 Passengers in custody / deportees

According to the German Federal Police no safety problems arise if the EU Common Guidelines (e.g. 2004/573/EC) are consistently implemented. There were no safety relevant incidents in the past years in Germany. Also analysis of scenarios revealed that there is only a low risk by transportation of these SCP group. There are rather security problems than safety problems. Therefore the experiences of other member states are not necessarily needed, because it could be derived, if all other EU members implement the EU Common Guidelines consistently, no safety problem will arise.

Recommendation Passengers in custody / deportees:

→ The EU common guidelines have to be implemented consistently in all EU member states

→ An European wide exchange of experiences by implementing the Common Guidelines has to be conducted by the authorities concerned

→ Due to Europe- wide transportation of these SCP groups, standardised procedures have to ensure safe transportation

6.11 Accident reports / Accident data bases

Far reaching findings could be made on the basis of accident reports and accident data bases. The extension of the data bases and more detailed recording of accident data are nevertheless recommended.

The seat maps and passenger profiles are not recorded systematically or not recorded at all in most accident reports. The analyses usually focus on the identification of the technical reasons. Accident reports often lack important data to allow analysis of the forces acting on passengers during a crash and consideration of human factors (e.g. during an evacuation). It is, for instance, very difficult, partly impossible, to trace where each passenger was seated, what injuries he suffered and how he disembarked from the crashed aircraft. The recorded pathological data are normally hard to access and are not always clearly attributable. Eye witness reports are often unstructured.

Working with the various accident data bases is often very time consuming and due to incompatible filters does not always produce the desired results. Detailed background information is sometimes unobtainable, due to missing links to accident reports. Filtering of the data bases frequently produced accidents and incidents involving disabled persons, but no corresponding accident reports were available.

Recommandation: Accident reports / Accident data bases:

→ Review/ extension of the existing standards for recording of accident data (e.g. calculation of crash loads, structural conditions of seats and cabin crew stations, conditions of the survival space for occupants between the seat rows, conditions of the evacuation paths, Human factors during evacuation)

→ Prove compatibility of accident questionnaires and accident data bases in order to obtain the broadest possible spectrum of statistically significant data.

→ Further integration of occupants data e.g. age, gender where was each occupant seated, what were the pre-existing illnesses (e.g. type and degree of disability), which injuries did he suffer in the accident, via which exit did he leave the crashed aircraft, etc.

→ Further investigations in the development of a comprehensive accident data base are recommended

→ Eye witness reports should be structured to be integrated into the accident data bases

7 Conclusion

The risk assessment identified a significant number of high risk scenarios for special categories of passengers within the phase's crash and evacuation. Furthermore it revealed special categories of passengers that bear an exceptional high risk to themselves or induce an exceptional high risk to other passengers. A risk ranking of the categories has been generated. Passengers on stretchers, children, infant's, extremely overweight passengers and non ambulatory passengers bear the highest risk to themselves. The highest risk to others is induced by non ambulatory passengers, extremely overweight passengers, passengers on stretchers and passengers with very low mobility.

The risk to SCPs themselves mainly increases due to insufficient restraint during a crash and the inability of SCPs to evacuate themselves in an appropriate manner and time. SCPs inducing a high risk to others frequently need assistance and delay the evacuation by temporarily blocking the aisles and the exits. As a result the risk for the assistants and other occupants affected by these SCPs increases due to longer smoke exposure during evacuation (hazard of asphyxia). Also the crew members are affected since they are responsible for the management of any emergency.

The degree of the SCPs' mobility is one of the vital factors affecting both, the risk to themselves and to others. The average ambulatory SCP appears to possess adequate mobility for evacuation and therefore has rather a small impact in risk increase.

Up to a certain ratio of SCPs to the number of able bodied passengers the risk increases linearly with the number of SCPs aboard an aircraft. As soon as there are too few able-bodied passengers (see 6.3) available, evacuation of those SCPs is clearly hampered or impossible. This results in a step-function increase of the SCP's risk. The according ratio at this point is defined as SPR_{Lim}.

This is illustrated in the following diagram:

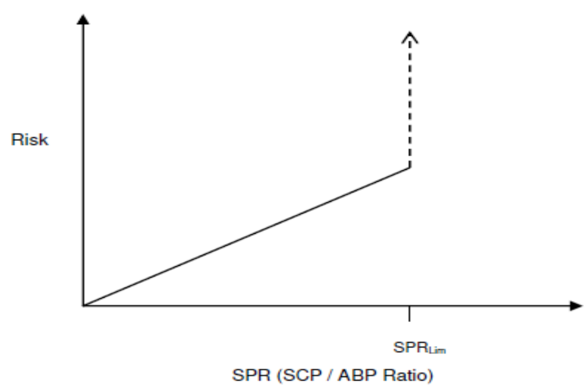


Figure 24: Step function increase of SCPs' risk

Based on data search and the risk assessment various causal relations have been analysed to identify measures to reduce the increased risk. Limitation of the number of SCPs with high risk on board an aircraft (appropriate SCP to ABP ratio) as well as the performance, training and even the number of cabin crew were identified as potential measures to reduce the risk. The seating position of SCPs with high risk and accompanying persons for evacuation also affect the risk. Furthermore aisle width as well as tools and aids for the evacuation impact the risk. Also appropriate seats, berths, safety belts and harnesses are of crucial importance.

Final Conclusion

The study revealed that nearly all considered SCPs increase the risk of air travel to a greater or lesser extent.

The study demonstrated that various measures could reduce the increased risk, although not eliminate it. The major challenges will be to identify suitable measures for safe SCP restraint and to ensure a fast evacuation of the cabin with SCPs or to increase the survival time in the cabin.

If general exclusions to air travel of special categories of passengers should be avoided, this increased risk must be tolerated as part of the overall risk in air travel. Recommendations for risk acceptance criteria could not be given due to a lack of data. Definition of these criteria must be based on substantial statistical data. The issue of risk acceptance is finally also subject to a political decision respecting the social acceptability

8 Outlook

The following chapter consider future steps which have to be undertaken to continue the research in air traffic passenger safety.

8.1 Statistical Data regarding SCP evacuation

The study revealed that there is a lack of resilient statistical data regarding evacuation of SCPs, especially persons with walking disabilities. Individual evacuation time increases with the kind and degree of impaired mobility and the number of the determined SCPs with high risk are on board an aircraft. Acceptance criteria for e.g. evacuation time increase in the presence of SCPs with high risk are therefore recommended. Based on these criteria, it can be calculated how many SCPs with high risk can be tolerated on a flight, given a specific group. This requires statistically significant data on evacuation time increase in the presence of a number of SCPs with high risks. These data are not existent. Further investigations and tests are recommended to quantify risk increase and specify any limitation on a scientific base. Thus enabling an economically cost and benefit analysis.

8.2 Procedures regarding SCP evacuation

The study revealed that neither Regulation (EC) 1107/2006 nor EU-OPS contain standards for handling SCPs in emergencies. Furthermore there are no distinct procedures to evacuate non- ambulatory SCPs, especially passengers on stretchers.

According to studies analysed extending the survival time will increase survivability more than a faster evacuation. Protective masks (PPBE) which would ensure passengers a longer survival have already been specified in accordance with EUROCAE but have not yet been incorporated in the operation / certification requirements. Longer survival time may compensate delaying factors due to SCP transportation.

Further investigations and developments in the field procedures and equipment (e.g. stretcher, PPBEs, etc.) are recommended. The effects have to be proven by cost and benefit analysis.

8.3 Side facing seats

This type of seating was a special case within the study. Risks arising of this seat configuration apply to all passengers, not only to SCPs. Therefore they were not considered within this study. Furthermore side facing seats are hardly found in regular service, but are rather found in general aviation.

Nevertheless, the findings are relevant in view of new aircraft types and future cabin designs. Analysis of regulations revealed that side facing seats are permitted by special approval. An equivalent level of safety (ELOS) to forward and rearward facing seats must be proven for this purpose. Further investigations offer that no appropriate measures are existing to determine and quantify the mainly biomechanical stresses of body-to-body contact, lateral head contact and lateral neck flexion. No European guideline exists on this topic. ETSO C127a refers to various Advisory Circulars (ACs) of the FAA for further information. At present, the automotive industry's protection criteria for lateral crashes are referred to. But they are not comparable and applicable to the crash- impulse- characteristic and the crash behaviour of an aircraft in any case. The head, chest and neck protection criteria HIC, TTI and Nij, recommended in the ACs, are medically validated and suited for automotive frontal crashes only. The effects of lateral loads on the human body are completely different to forward or rearward loads. Especially for lateral head impact and lateral neck flexion. The proposed automotive side impact dummies seem also not validated to determine these lateral loads. Further investigations are recommended.

9 Appendix

9.1 Table of Recommendations

This chapter contains a synthesis of recommendations. A distinction is drawn between recommendations related to further investigation and recommendations related to design, certification and operational aspects. These must not be regarded separately, since some of the recommendations related to design, certification and operational aspects require preliminary research. These recommendations are grouped in the same row as the corresponding research.

	Research	Design/Certification	Operation
Cabin crew	Investigate the effects of cabin crew to passenger ratio and its potential to compensate evacuation delay by SCPs.	Review the rules relating to the cabin crew ratio. Consider the results of foregoing research.	Review EU OPS relating to the cabin crew ratio. Consider the results of foregoing research.
	---	---	The legal status (liability) of the cabin crew in the event of evacuations is not clear. In view of the increasing readiness to sue, questions of liability should be addressed.
	European standards for cabin crew training regarding SCP evacuation should be developed.	---	A detailed European standard for cabin crew training should be introduced considering SCP evacuation.
	The combined effects of crowed control by the cabin crew and the influence on SCP evacuation should be investigated (see 6.7).	---	Include the results of foregoing research into training and operational manuals.
	The safety of cabin crew stations should be improved.	Adopt improvements of cabin crew stations in relating rules.	---
	---	---	Briefing of passengers on self-help exits by the cabin crew should be mandatory.

	Research	Design/Certification	Operation
Accompanying persons (Part I)	A European definition of able bodied assistants should be developed to ensure that the able bodied assistant is: ⇒ physically and mentally able to evacuate the SCP. ⇒ able to assess the situation and react in an appropriate manner In addition, the following steps are recommended: 1. Define an appropriate age for able bodied assistants. They must be able to manage the SCPs evacuation and be aware of the responsibility. 2. Determine characteristic attributes for possible assistants with a guidance function (e.g. for blind passengers) and for assistants with carrying function (e.g. for non-ambulatory passengers).	---	A European standard definition of able bodied assistants for the evacuation of SCPs should be introduced with respect to the specific SCP group. Able bodied assistant's key characteristics should include: 1. physical and mental ability to evacuate the SCP. 2. ability to assess emergency situations in aviation and react in an appropriate manner.
	Further research to specify a number of accompanying persons per SCP (see 6.1) is recommended.	---	A number of accompanying persons per SCP (see 6.1) should be specified.
	---	---	The legal status of accompanying persons during evacuation has to be clarified.

	Research	Design/Certification	Operation
Accompanying persons (Part II)	Develop suitable carrying techniques for SCP evacuation (e.g. carrying "feet first" can save turning at the exit).	---	Include SCP evacuation procedures in EU OPS. Provide appropriate means to inform accompanying persons on carrying techniques for SCPs.
	Appropriate means to inform the able bodied assistant about the risks and options during an evacuation as well as the SCP's needs should be developed.	---	Appropriate means to inform the able bodied assistant about the risks and options during an evacuation as well as the SCP's needs should be provided.
	Evacuation procedures for stretcher passengers should be developed.	---	Evacuation procedures for stretcher passengers should be introduced.
Evacuation Certification	Specify a criterion for an acceptable increase of risk (Risk Acceptance Criterion). The definition of a specific ratio of able-bodied passenger to SCP per category should be considered.	Consider the effects of SCP evacuation in evacuation tests.	---
	---	Include a representative number of SCPs during evacuation tests to encourage developments in SCP evacuation.	---
Aisles	Research to optimise aisle widths regarding evacuation of SCPs should be conducted.	Depending on the results of foregoing research review Certification Specifications relating to aisle configuration.	---

	Research	Design/Certification	Operation
Exits	The effects of exit configuration to speed up the evacuation of SCPs and other passengers should be investigated.	Depending on the results of foregoing research review Certification Specifications relating to exit configuration.	---
	---	---	Regulation (EC) 1107/2006 Article 4, 1(b) should be reviewed. The physical possibility to evacuate is of crucial importance for the safety of the concerned passengers. Therefore, the evacuation of disabled persons or PRMs must be physically possible through every existing emergency exit. This should be clarified accordingly in the legislation, in lieu of only the embarkation through common aircraft doors.

	Research	Design/Certification	Operation
Seating of SCP	Further investigation relating to the seating position of SCPs should be conducted (see 6.7). The potential of seating the SCPs far away from the exits or in the radius of the cabin crew should be assessed. Cabin crew capabilities for crowd control should be analysed and considered.	---	Stretchers and extremely overweight passengers should be seated where a failure of their restraint system has minimal effects on other passengers (e.g. in front of a lavatory or bulkhead). The seating of SCPs should be dependent on their mobility. The more immobile a SCP is, the further away he should be seated from the aisle and the exit. Group seating of SCPs should be avoided. SCPs and their companions should be positioned such that they find themselves at the end of a row of passengers to be evacuated in order to avoid hindering other passengers.
Seats, berths and harnesses	Dummy protection criteria for passengers not sitting in an upright position should be developed (i.a. passengers on stretchers).	Stretchers should be certified according to CS25.562 (at least structurally to prevent failure under dynamic loads).	---
	Improve stretcher design for evacuation.	Depending on the results of foregoing research review relating rules to stretchers design and certification.	---
	---	---	Infants and children up to seven years should be transported in their own seat in a suitable child restraint system.

	Research	Design/Certification	Operation
Tools aids and equipment for evacuation	PPBE for passengers is contrary discussed due to the possible oxygen enrichment in cabin air and the correlating fire hazard increase. Further research is recommended.	---	---
	Breathing equipment should be developed to protect passengers from inhaling smoke while minimising oxygen enrichment in cabin air. They should be easy to use and provided for all passengers during emergencies.	PPBE for all passengers should be introduced to compensate for the slower SCP-evacuation.	PPBE for all passengers should be introduced to compensate for the slower SCP-evacuation.
	Existing equipment should be assessed and suitable carrying methods for SCP evacuation should be developed (e.g. carrying devices, carrying belts, etc.).	---	Include the results of foregoing research into training and operational manuals.
	Further investigations regarding evacuation of stretchers should be conducted. For example the effects of stretchers on emergency slides and life rafts should be investigated.	Depending on the results of foregoing research relating to stretcher evacuation review the relating rules.	---
	Develop procedures for stretcher evacuation - also considering ditching.	---	Include the results of foregoing research into training and operational manuals.
	---	Passenger safety cards in braille should be developed.	Mandate safety cards in international braille.

	Research	Design/Certification	Operation
Passengers in custody	---	---	The EU common guidelines have to be implemented consistently in all member states.
	---	---	A European wide exchange of experiences by implementing the Common Guidelines has to be conducted by the authorities concerned.
	---	---	Due to Europe- wide transport of these SCP groups, standardised procedures have to ensure safe transportation.
Accident reports	The existing standards for recording of accident data should be improved to enable detailed investigation of evacuation procedures. Research on how accident investigation questionnaires can be harmonized with the accident databases in order to obtain the broadest possible spectrum of statistically significant data should be conducted.	---	---
	The survey of eye witness reports should be structured and standardized.		---

	Research	Design/Certification	Operation
Data	Statistical relevant data on SCP-evacuation should be gathered through evacuation tests (e.g. delay of evacuation per category of disability). Specify a criterion for an acceptable increase of risk (e.g. relating to the evacuation delaying effects of SCPs).	---	Risk Acceptance criteria can be used to limit the number of SCPs on board an aircraft.

9.2 Top Scenarios of the risk analysis

This chapter gives an overview of particularly dangerous scenarios for the respective passenger group.

The risk assessment contains numerous scenarios, some of them particularly dangerous, but most of them of rather low risk. Generally the low risk scenarios bear no life-threatening risk. Thus it is reasonable to focus on high risk scenarios with regard of the efficiency of mitigation measures. This chapter summarizes the most dangerous scenarios of the risk assessment.

Note: The scenario-no. refers to the number of the scenario given in Appendix 9.7 “Scenarios of Risk Assessment” while the reference, if applicable, refers to the corresponding study. The described problems are the ones that bear the highest danger concerning the respective passenger group – the highest three risk evaluations have been chosen.

Infants

Top Scenarios:

The following Scenarios have proven particularly dangerous.

Scenario No.:	*3:*
See also:	-
Reference:	*Study on Child Restraint Systems, Chap. 4.5.15*
Problem:	*the loop belt is no suitable child restraint system in case of a crash.*

Scenario No.:	*1, 2, 4:*
See also:	-
Reference:	*Increasing the Survival Rate in Aircraft Accidents, Chap. 4.5.11*
Problem:	*the infant suffers severe to lethal injuries from smoke inhalation.*

Children up to seven years

Top Scenarios:

The following Scenarios have proven particularly dangerous:

Scenario No.:	*69:*
See also:	*67, 72:*
Reference:	*Study on Child Restraint Systems, Chap. 4.5.15*
Problem:	*the loop belt is no suitable child restraint system in case of a crash.*

Scenario No.:	*44:*
See also:	*50, 71:*
Reference:	*Evacuation Commands for Optimal Passenger Management, Chap. 4.5.; Protective Brace/Safety Positions in Emergency Landing Conditions, Chap. 4.5.14*
Problem:	*The child fails to comprehend the safety briefing. It suffers severe injuries in case of a crash because it fails e.g. to adopt the safety-position.*

Scenario No.:	*36, 37, 38:*
See also:	*-*
Reference:	*Increasing the Survival Rate in Aircraft Accidents, Chap. 4.5.11*
Problem:	*the child suffers severe to lethal injuries from smoke inhalation.*

Scenario No.:	*46:*
See also:	*39, 52, 55, 56, 57, 60, 63, 64, 75:*
Reference:	*Evacuation Commands for Optimal Passenger Management, Chap. 4.5.; A Database to Record Human Experience of Evacuation in Aviation Accidents, Chap. 4.5.7; Increasing the Survival Rate in Aircraft Accidents, Chap. 4.5.11*
Problem:	*The child fails to handle its own evacuation, thus extending the child's exposition to smoke.*

Children from seven years to 12 years

Top Scenarios:

The following Scenarios have proven particularly dangerous:

Scenario No.: *80:*

See also: -

Reference: *Evacuation Commands for Optimal Passenger Management, Chap. 4.5.; Protective Brace/Safety Positions in Emergency Landing Conditions, Chap. 4.5.14*

Problem: *The child fails to comprehend the safety briefing. It suffers severe injuries in case of a crash because it fails to adopt the safety-position.*

Scenario No.: *76, 77:*

See also: *78:*

Reference: *Increasing the Survival Rate in Aircraft Accidents, Chap. 4.5.11*

Problem: *the child suffers severe to lethal injuries from smoke inhalation*

Scenario No.: *86, 92:*

See also: *97, 100, 103, 107:*

Reference: *Evacuation Commands for Optimal Passenger Management, Chap. 4.5.; A Database to Record Human Experience of Evacuation in Aviation Accidents, Chap. 4.5.7; Increasing the Survival Rate in Aircraft Accidents, Chap. 4.5.11*

Problem: *The child fails to handle its own evacuation, thus extending the child's exposition to smoke.*

Expectant Mothers

Top Scenarios:

The following Scenarios have proven particularly dangerous:

Scenario No.:	*125, 126:*
See also:	*-*
Reference:	*Anthropometric Study to Update Minimum Aircraft Seating Standards, Chap., Subject Management and Injuries in a Study of Emergency Evacuation Through the Type-III Exit, Chap 7.1.3; Increasing the Survival Rate in Aircraft Accidents, Chap. 4.5.11*
Problem:	*The expectant mother hinders the evacuation due to limited mobility, thus extending her and maybe other passenger's exposition to smoke.*

Small Adults (smaller than 125 cm)

Top Scenarios:

The following Scenarios have proven particularly dangerous:

Scenario No.:	*141:*
See also:	*-*
Reference:	*Study on Child Restraint Systems, Chap. 4.5.15*
Problem:	*The adult lap belt does not fit snuggly around the pelvis and thus causes severe injuries in case of a crash*

Extremely Overweight Passengers

Top Scenarios:

The following Scenarios have proven particularly dangerous:

Scenario No.:	*149:*
See also:	*-*
Reference:	*Accident Air France A340-313, Toronto, Chap 4.4.2*

Problem: *The extremely overweight passengers and the seat structure break lose in a crash. Its kinetic energy endangers passengers in front.*

Scenario No.: *154, 155, 157, 158:*

See also: -

Reference: *Anthropometric Study to Update Minimum Aircraft Seating Standards, Chap., Subject Management and Injuries in a Study of Emergency Evacuation Through the Type-III Exit, Chap 7.1.3; Increasing the Survival Rate in Aircraft Accidents, Chap. 4.5.11*

Problem: *The extremely overweight passengers slip and/or trip over obstacles or get injured when exiting the seat row or using a TYPE-III overwing exit, thus extending their and maybe other passenger's exposition to smoke.*

Mental Deficient Passengers

Top Scenarios:

The following Scenarios have proven particularly dangerous.

Scenario No: *240, 244, 247:*

See also: -

Reference: *Protective Brace/Safety Positions in Emergency Landing Conditions, Chap. 4.5.14*

Problem: *In case of crash mentally deficient passengers fail to adopt the brace position when advised by cabin crew.*

Scenario No.: *233 -238, 241-243, 245, 246:*

See also: -

Reference: *Increasing the Survival Rate in Aircraft Accidents, Chap. 4.5.11;*

Problem: *The mentally deficient passengers fail to handle their own evacuation. This hinders evacuation, thus extending their and maybe other passenger's exposition to smoke.*

Scenario No.: *239:*

See also: -

Reference: -

Problem: *In case of ditching passengers with mental deficiencies fail to use their life jacket properly.*

Blind Passengers

Top Scenarios:

The following Scenarios have proven particularly dangerous.

Scenario No.: 220, 221, 223:

See also No.: 224:

Reference: *Evacuation Commands for Optimal Passenger Management, Chap. 4.5; Increasing the Survival Rate in Aircraft Accidents, Chap. 4.5.11*

Problem: *During evacuation blind passengers hinder the evacuation as they are not used to the environment and have no tactile aid available, thus extending their and maybe other passenger's exposition to smoke.*

Scenario No.: 222:

See also No.: --

Reference: *Evacuation Commands for Optimal Passenger Management, Chap. 4.5*

Problem: *As blind passengers can only use the audible information from the safety briefing they have a gap of knowledge and fail to apply their life jacket.*

Passengers on Stretchers

Top Scenarios:

The following Scenarios have proven particularly dangerous.

Scenario No.: 207, 210:

See also No.: -

Reference: *Air France A340-313, Toronto, Chap 4.4.2*

Problem: *High acceleration during crash may lead to stretcher breaking lose. Its kinetic energy endangers the occupant and the passengers in front of it.*

Scenario No.: 203, 208:

See also No.: -

Reference: *Increasing the Survival Rate in Aircraft Accidents, Chap. 4.5.11*

Problem: *In case of evacuation the passengers on stretcher have no ability to evacuate themselves and consequently die from smoke inhalation.*

Scenario No.: *205, 206:*

See also No.: *-*

Reference: *-*

Problem: *In case of ditching the passengers on stretcher have no ability to evacuate themselves and it is nearly not possible to evacuate them by others.*

Scenario No.: *204, 209:*

See also No.: *-*

Reference: *Increasing the Survival Rate in Aircraft Accidents, Chap. 4.5.11*

Problem: *Carrying passengers on stretchers through cabin hinders the evacuation, thus extending their and other passengers' exposition to smoke.*

Physical Disabled Passengers (low mobility)

Top Scenarios:

The following Scenarios have proven particularly dangerous.

Scenario No.: *171-176:*

See also No.: *-*

Reference: *Accident of American Airlines DC-10-30, Fort Worth International, Chap 4.4.3; Increasing the Survival Rate in Aircraft Accidents, Chap. 4.5.11*

Problem: *During evacuation physical disabled passengers (low mobility) hinder the evacuation, thus extending their and maybe other passengers' exposition to smoke.*

Physical Disabled Passengers (aided walking)

Top Scenarios:

The following Scenarios have proven particularly dangerous.

Scenario No.: *181-184:*

See also No.: *185*

Reference: *Accident of American Airlines DC-10-30, Fort Worth International, Chap 4.4.3; Increasing the Survival Rate in Aircraft Accidents, Chap. 4.5.11*

Problem: *During evacuation physical disabled passengers (aided walking) hinder the evacuation, thus extending their and maybe other passengers' exposition to smoke.*

Physical Disabled Passengers (paralysed lower limbs)

Top Scenarios:

The following Scenarios have proven particularly dangerous.

Scenario No.: *188,191:*

See also No.: *-*

Reference: *Increasing the Survival Rate in Aircraft Accidents, Chap. 4.5.11*

Problem: *In case of evacuation physical disabled passengers (paralysed lower limbs) have no ability to evacuate themselves and consequently die from smoke inhalation.*

Scenario No.: *189:*

See also No.: *-*

Reference: *Increasing the Survival Rate in Aircraft Accidents, Chap. 4.5.11*

Problem: *The standalone evacuation of physical disabled passengers (paralysed lower limbs) hinder evacuation, thus extending their and maybe other passengers' exposition to smoke*

Scenario No.: *190, 192:*

See also No.: *-*

Reference: *Increasing the Survival Rate in Aircraft Accidents, Chap. 4.5.11*

Problem: *If physical disabled passengers (paralysed lower limbs) are placed in a seat row without foldable armrest, accompanying passengers have problems to extract them from their seat row,* *thus extending their and maybe other passengers' exposition to smoke*

9.3 Relevant Studies:

9.3.1 Aircraft Evacuation Testing: Research and Technology Issues

Published by: Office of Technology Assessment, USA, September 1993

Contents of the report:

The report is subdivided into four sections.

- Background and overview of the applicable provisions in the USA
- Evacuation demonstrations for certification
- Research and technologies for evacuation systems
- Findings and conclusions

Results of the Study:

Full-scale evacuation demonstrations can only serve as a benchmark to assess whether or not the emergency equipment and emergency procedures work in principle. They serve as a comparison of the layouts and are intended to ensure that a specific design is no regression compared to another design. Full-scale evacuation demonstrations are not significant with regard to real-life situations because the subject profile does not represent the present aircraft passenger profile and no smoke is simulated[7] amongst other reasons.

FAA is criticised in view of full-scale tests since aircraft certifications through these tests neither give incentives to introduce new technologies such as fire suppression systems nor are they useful for the optimisation of systems. It is furthermore criticised that data on injuries incurred in evacuation trials (approx. six percent of all evacuees are injured), are gathered in piecemeal fashion.

In the authors' opinion, full-scale evacuation tests can also be replaced by computer simulations. These offer the possibility to restrict evacuation tests to a very small scope which would only have to prove the correctness of the simulation.

It is stated that extending the survival time through a protection against heat and smoke will increase survivability more than a faster evacuation.

TÜV Rheinland Remark:

It has so far not been possible to replace full-scale tests by simulations due to the fact that the computer simulations strongly depend on the input parameters. Such parameters are estimated or defined by the developers.

FAA introduced burnthrough protection to block cabin fires. The aircraft fuselage must resist a defined fire for four (insulation of the aircraft passenger cabin) to 5 minutes (insulation of the cargo compartment) (Appendix F, Parts III and VI). It is planned to mend CS25 by the end of this year accordingly. For the time being, CS25 only includes the rule on the cargo compartment insulation equivalent to CFR.

9.3.2 Regulatory Study on Emergency Evacuations -Final Synthesis and Recommendations

Ordered by: Ministere der L'equipement des transports et du logement direction generale de l'aviation Civile, France, 1999

Contractor: Service de la formation aeronautique et du contrôle, France

Contents of the study:

This study compiled the findings of several studies and publications focussing on evacuation. At first, the relevant incidents of American, Japanese, Canadian, British and French airlines were analysed, followed by human and technical factors. Crew training centres were inspected for this purpose and practices in merchant navy and with fire brigades were analysed.

Furthermore, the effects of cabins of especially small-capacity and very large-capacity aircraft accommodating less than 50 and more than 500 passengers were analysed.

A conclusion was drawn on the basis of these findings including recommendations.

Results of the Study:

The skills of the cabin crew are essential for the rate of survivors. These are affected by the crew's physical attributes as well as its training. The authors hold the opinion that the training is carried out too seldom due to the high costs involved. The following deficits were found:

- At some airlines, the multitude of aircraft types and cabin layouts leads to confusion among the crews. In an emergency, problems occurred in the handling of the equipment. So it happened, for instance, that the escape slide was thrown off instead of spreading out due to an operation error or exit doors could not be opened.

- The cabin crews have deficits regarding the communication with the cockpit crews. Therefore, situations are not assessed correctly.

- The crews have further deficits regarding crowd management. They find it hard to switch from a friendly service tone to firm commands which have an accelerating effect in evacuations.

- The training of the cabin crew is out of touch with reality. It simulates no jammed exit doors, the intercom works in a training at all times, there are no screams and background noise nor are there any real-life effects by smoke and fire simulations.

- The final recommendations are subdivided into groups.

- The authorities are recommended to reduce the prescribed training intervals to three months. The training time should be reduced to one hour each.

- The airlines are recommended to produce training videos which show the crew members the procedures and particularities regarding the aircraft type to be flown prior to take-off. The crew members should have a room where the exit doors and major emergency equipment of the aircraft types to be flown can be tried out. The safety training should be adequately taken into consideration in the training schedule.

- The crew members should be checked for their physical fitness in principle with regard to evacuation in their employment test.

9.3.3 CAA Paper 2006/01 - A Database to Record Human Experience of Evacuation in Aviation Accidents

Ordered by: Civil Aviation Authority, Aviation House, Gatwick Airport South, West Sussex, UK, 2002

Contractor: E. R. Galea, K. M. Finney, A. J. P. Dixon, A. Siddiqui and D. P. Cooney; Fire Safety Engineering Group, University of Greenwich, UK

Contents of the Study:

The Aircraft Accident Statistics and Knowledge (AASK) database is a repository of survivor accounts from aviation accidents. Its main purpose is to store observational and anecdotal data from interviews of the passengers involved in aircraft accidents. The database is intended to represent a complete autopsy database that would allow researchers to look for common trends in accidents, among other things. In addition, it contains seat plans, the survivors' exit-routes and their suffered injuries. This information would help the researchers analyse factors that might have an impact on survival. Furthermore, AASK allows assessment on how people behave during evacuations.

To facilitate research, the data is categorised. There are e.g. four subcategories of accidents: Emergency evacuation, unplanned emergency, precautionary evacuation and post-incident deplaning.

The Fire Safety Engineering Group, University of Greenwich, was commissioned with the maintenance and functional development of the AASK database which compiles analyses from the AASK database, among other things. These analyses have to be evaluated taking account of the limitations of the database. These include the non-reproducibility of some accident data. It has to be taken into consideration for the replies of the survivors that those who would incriminate themselves with any statements have not completed their questionnaire.

Version AASK V4.0 contains 105 accidents which occurred between 1977 and 1999. 49 of them include detailed passenger and crew accounts. The reply rate for the 48 aircraft for which the number on board is known varies from 3 percent to 95 percent. The average reply rate for these 48 is 45 percent, and in 22 accidents there are replies from at least 50 percent of the survivors.

The following figure gives an overview of the age and gender distribution of the on-board passengers.

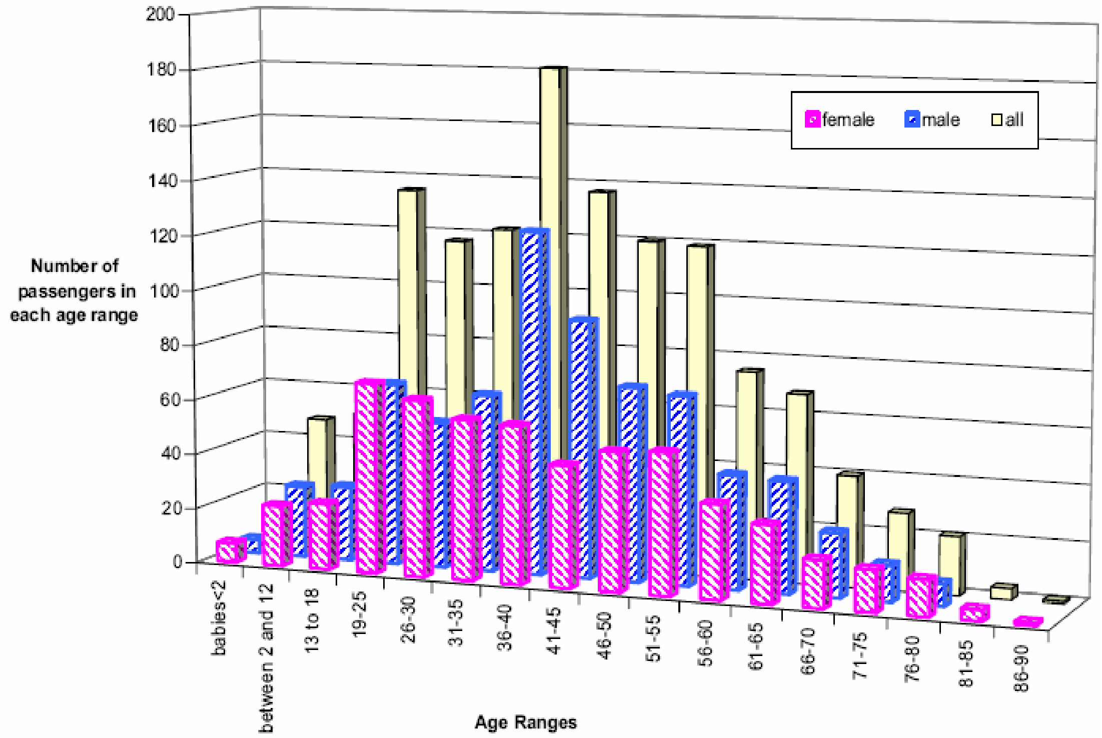


Figure 25: Age distribution

In some evacuations, the passengers were unable to start evacuation since they could not leave their seat. One reason for that were congested aisles, another reason was the fact that the buckle could not be released due to the following reasons:

- Unfamiliar with buckle release mechanism: e.g. "It took him five to six seconds to determine how to undo his seat belt."
- Environmental related complications excluding immersion in water: e.g. "could not release seat belt due to smoke reduced visibility problems. Erroneously tugged on the buckle instead of undoing it."
- Buckle location: e.g. "thought seat belt buckle was at side as in a car not in centre."

Older people appear to be more frequently affected from such problems. Furthermore, twice as many females than males experience problems. (20 percent versus 10 percent). (The age distribution suggests that older passengers appear to be more likely to experience difficulties with seat belts than younger passengers.)

Regarding the selection of exits, 70 percent of the passengers, to whom the route to the exit was comprehensible chose the nearest exit. 19 percent of the remaining passengers used a farther exit while following the instructions of the crew.

The survivors travelled an average of seven seat rows to the nearest exit.

Accident reference Appendix B	Pax Loading	Fwd (%)	Mid (%)	Aft (%)
(7)	39.0%	44.7 [I]	50.0 [III]	5.3 [I]
(43)	93.6%	19.2 [I]	61.5 [III]	19.2 [I]
(59)	96.6%	39.5 [I]	37.2 [III]	23.3 [I]
(80)	79.5%	23.6 [I]	58.3 [III]	18.1 [I]
(87)	78.1%	17.3 [I]	48.3 [III]	34.5 [I]
(90)	31.7%	27.8 [I]	16.7 [III]	55.6 [I]
(95)	85.2%	38.9 [I]	27.7 [III]	33.3 [I]
(96)	102.0%	6.3 [I]	11.3 [III]	82.5 [I]
Mean	**75.8%**	**27.2**	**38.8**	**34.0**

Table 8:
Exit usage in terms of percentage of passengers using each generalised exit position. Information in square brackets identifies exit type.

Accident reference Appendix B	Pax Loading	Fwd (%)	Mid (%)	Aft (%)
(43)	93.6%	19.2 [I]	61.5 [III]	19.2 [I]
(59)	96.6%	39.5 [I]	37.2 [III]	23.3 [I]
(80)	79.5%	23.6 [I]	58.3 [III]	18.1 [I]
(87)	78.1%	17.3 [I]	48.3 [III]	34.5 [I]
Mean	**87.0%**	**24.9** [I]	**51.3** [III]	**23.8** [I]

Table 9:
Exit usage in terms of percentage of passengers using each generalised exit position during higher loaded, authorised evacuations with minimal exit redirection.

The highest likelihood of finding viable exits is in the middle and front section of the fuselage:

	Availability (%) of exit in exit pair		
Exit Position	**No Exits**	**One Exit**	**Both Exits**
FWD	8.3%	41.7%	50.0%
MID	8.3%	33.3%	58.3%
AFT	25.0%	33.3%	41.6%

Table 10:
Proportion of exit availability in terms of generalised exit positions for three-exit pair aircraft, discounting orchestrated artificial conditions

In case of a fire, the travel distance to the nearest emergency exit is vital. Four accidents involving fires were analysed:

Survivors		Aircraft	Fatalities	
Number of survivors	**Theoretical mean travel distance**	**Maximum actual travel distance for a seated passenger**	**Theoretical mean travel distance**	**Number of fatalities**
40	3.03	B737 300 / 6.0	3.50	20
15	2.20	DC-9-20 / 11.0	3.17	6
17	2.06	DC-9-32 / 8.0	4.14	22
76*	3.14	B737 236 / 15.0	6.75	52*
*in-lap infants discounted				

Table 11:
Comparison of theoretical average distance to the nearest viable exit for survivors and fatalities (for which data is avilable within AASK) from four aircraft accidents

Passengers seated at most five seat rows to a viable exit are statistically more likely to survie than to perish. Seated 6 or more rows from a viable exit the chances of perishing far outweigh that of surviving

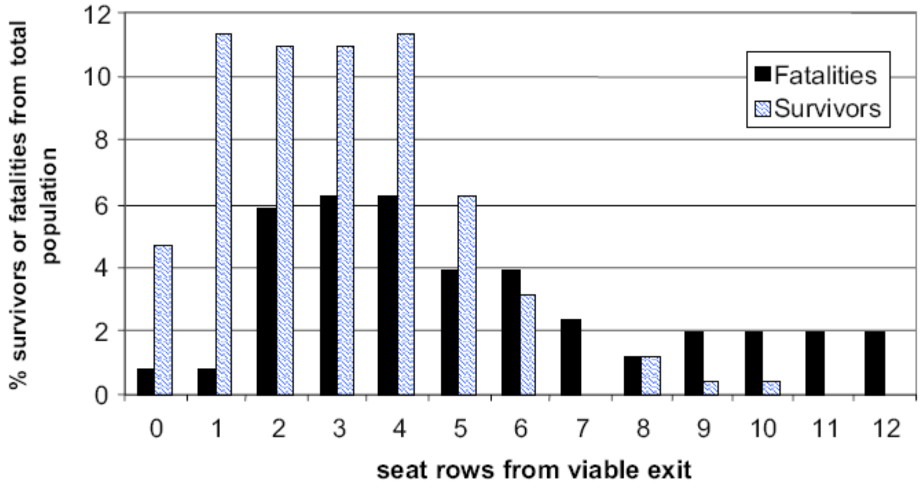


Figure 26:
Distribution of rows to nearest viable exits for survivors and fatalities

It does not make a major difference for survival whether a non-aisle seat or an aisle seat is occupied.

The efficiency of the evacuation was defined as the relationship between the travel distance taken by the passenger to the mean shortest possible distance to a serviceable exit. The correlation between the number of operational cabin crew and the efficiency of the evacuation is outlined here. 17 accidents were analysed, four of them with a wide-body cabin. The loading factor was at least 50 percent:

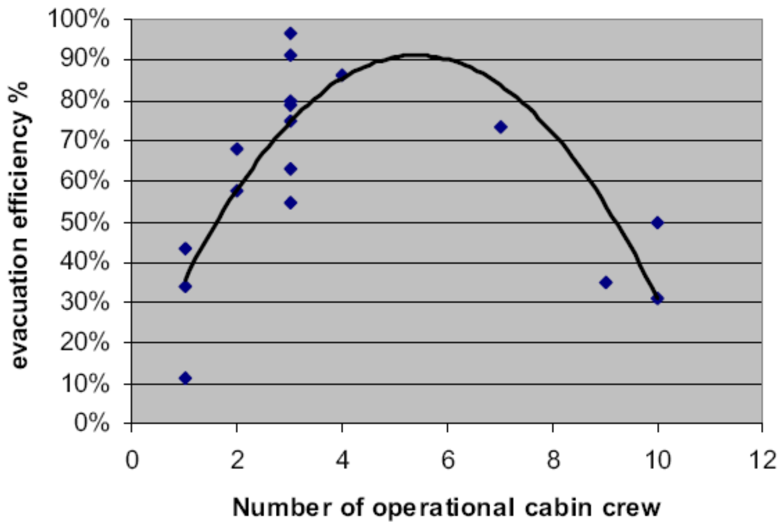


Figure 27:
Tentative relationship between Evacuation Efficiency and the number of operational cabin crew for 17 accidents

In single-aisle cabins, efficiency steadily increases with the number of operational cabin crew. In double-aisle fuselages, it decreases from a specific number. This is due to the passageways to the emergency exits. In double-aisles, it is easier to route passengers past emergency exits used to capacity. This increases the travel distance taken by a passenger. The quotient between the shortest travel distance and the covered travel distance is thus decreasing.

These statements are to be understood as a trend since there are a multitude of factors affecting evacuation. The definition of efficiency via the covered travel distances can only depict a partial aspect for validation.

Summary:

Experience with the problems of older passengers using buckles correctly in an emergency suggests a design of aircraft buckles similar to those used in cars - as a lateral plug-in buckle.

Passengers who have to travel at most seven seat rows to the exit statistically have higher survival chances. If fires are involved, this travel distance decreases to approx. three seat rows. The highest likelihood to find a serviceable exit is in the front up to the central fuselage section.

Given these aspects, the statistically highest survival chance is given for a seating position over the wing, and the second-highest chance is in the front fuselage, i.e. each as close as possible to an exit.

The travel distances to an exit should be as short as possible in an evacuation. In statistical terms, 89 percent of the passengers choose the shortest possible travel distance.

There is a correlation between the *absolute* number of on-board crew and the travel distance taken by the passenger. Statistically speaking, evacuation improves with the number of operational crew

9.3.4 ATSB, Evacuation Commands for Optimal Passenger Management

Ordered by: Australian Transport Safety Bureau, 15 Mort Street, Canberra City, Australian Capital Territory, Australia, 2006

Contractor: Cranfield University in cooperation with Virgin Blue Airlines, UK

Contents of the study:

This study analysed the question as to what effects communication between the crew and the passengers has on an evacuation. The study is subdivided into two phases. The first phase discussed the common practice for crowd management in an emergency within a "best-practice forum“ of the Asia-Pacific Cabin Safety Working Group, followed by a survey of different airlines on this issue.

The second phase developed an experiment based on the results of the first phase which was carried out with a total of 159 volunteers at Cranfield University in Great Britain. At first, the participants were asked to note commands which they considered to be helpful during an evacuation, providing an insight into passenger expectations. The participants then took part in a session of four evacuation trials using two evacuation simulators. In the smaller simulator (B737), the crew alternately assumed an active and a passive role each. In the “Large Cabin Evacuation Simulator”, the visibility between the crew and the passengers varied. Furthermore, dual-lane flow commands were used in some trials which means that two passengers used one exit in parallel instead of alternately. The results were evaluated via video footage and on the basis of questionnaires completed by the participants.

Results of the Study:

- The interaction between the passengers and the crew has proven to be of crucial importance. An active pre-flight briefing should be conducted, requiring the passengers to point out e.g. the nearest exit. This improved the attention in the briefing as well as passenger confidence in evacuating the cabin. According to a passenger survey of 1992, it should be pointed out that briefing is essential for survival since the majority of crashes is survivable.

- Ambiguous commands should be replaced by self-explanatory commands e.g. "heads down, feet back" instead of "brace". The crew should give brief and specific tactile[27] commands. Friendly notes by the crew had the same effect as being absent. In addition, each crew member should use the same vocabulary.

- A brief, but unambiguous command is necessary for the use of life jackets. It must be avoided that the life jacket is inflated too early inside the cabin.

[27] Tactile commands make use of human sense of touch.

- It must be made clear to the passengers even before leaving the aircraft that the hand luggage must be left behind. Passengers who insist on taking their luggage with them delay evacuation. In addition, they may get into a conflict with the cabin crew at the emergency exits.

- The bulkheads at the exit should be laid out in such a form that the gestures made by the crew can be seen by the passengers, giving them a second way of perception.

- The crew should be allowed a certain creativity. Only the basic commands should be mandatory.

- Rare incidents such as evacuations have to be trained frequently.

9.3.5 NTSB - Emergency Evacuation of Commercial Airplanes

Published by: National Transportation Safety Board, Notation 7266 490 L'Enfant Plaza, S.W., Adopted June 27, 2000 Washington, D.C. 20594, USA, 2000

Contents of the study:

This study analysed 46 evacuations which took place between 1997 and 1999. It considered 18 aircraft types. Safety-relevant issues were analysed in the following areas based on the data collected from passengers, flight attendants, flight crews, airlines and the rescue teams:

a) Certification issues in view of evacuations

b) Effectiveness of the evacuation equipment

c) The management of rescue teams on the ground

d) Communication issues related to evacuations

20 safety recommendations were issued as a result of the study.

Results of the Study:

- During a 16 month observation, evacuation takes place every 11 days. The most frequent event leading to an evacuation was an engine fire, accounting for 32 percent of the 46 evacuations included in the study cases. More than 65 percent were reported to be unplanned evacuations with little or no preparation time.

- There is no statistical correlation between the age of a passenger and the suffered injuries. The older passengers interviewed, however, stated that their age was an obstacle to them during evacuation.

- In those cases where the cabin interior has burst evacuation was strongly impaired.

- In statistical terms, females are more prone to injuries than males. (This statement coincides with the result of a CAMI study, see Chapter 2.2.)

The following recommendations were given:

- Require all newly certificated commercial airplanes to meet the evacuation demonstration requirements prescribed in Title 14 Code of Federal Regulations Part 25, regardless of the number of passenger seats on the airplane. (A-00-72)

- Require all commercial operators to meet the partial evacuation demonstration requirements prescribed in Title 14 Code of Federal Regulations Part 121, regardless of the number of passenger seats on the airplane. (A-00-73)

- Conduct additional research that examines the effects of different exit row widths, including 13 inches and 20 inches, on exit hatch removal and egress at Type III exits. The research should use an experimental design that reliably reflects actual evacuations through Type III exits on commercial airplanes. (A-00-74)

- Issue, within two years, a final rule on exit row width at Type III exits based on the research described in Safety Recommendation A-00-74. (A-00-75)

- Require Type III overwing exits on newly manufactured aircraft to be easy and intuitive to open and have automatic hatch stowage out of the egress path. (A-00-76

- Require air carriers to provide all passengers seated in exit rows in which a qualified crewmember is not seated a preflight personal briefing on what to do in the event the exit may be needed. (A-00-77)

- Require the aft flight attendants on Fokker 28[28] and Fokker 100 airplanes to be seated adjacent to the overwing exits, their assigned primary exits. (A-00-78)

- Review the six-foot height requirement for exit assist means to determine if six feet continues to be the appropriate height below which an assist means is not needed. The review should include, at a minimum, an examination of injuries sustained during evacuations. (A-00-79)[**]

- Require flight operations manuals and safety manuals to include on abnormal and emergency procedures checklists a checklist item that directs flight crews to initiate or consider emergency evacuation in all emergencies that could reasonably require an airplane evacuation (for example, cabin fire or engine fire). (A-00-80)

- Review air carriers' procedures to ensure that for those situations in which crews anticipate an eventual evacuation, adequate guidance is given both to pilots and flight attendants on providing passengers with precautionary safety briefings. (A-00-81)

- Review air carrier training programs to ensure that evacuation procedures call, at a minimum, for evacuation through all available floor level exits that are not blocked by a hazard. (A-00-82)

[28] These planes are no longer common
[**] The 6-foot height requirement still exists (CS25 Amdt 6, CS 25.810 (a))

- Review air carrier procedures and training programs to ensure that the commands used for slide evacuations are consistent with the commands used for slide evacuations during certification. (A-00-83)
- Establish a task force to address the issue of providing periodic hands-on familiarization training, or the equivalent, for aircraft rescue and firefighting personnel at all Title 14 Code of Federal Regulations Part 139 certified airports on each airplane type that serves the airport on a scheduled basis. (A-00-84)
- Require air carriers to conduct periodic joint evacuation tests involving flight crews and flight attendants. (A-00-85)
- Conduct research and explore creative and effective methods that use state-of- the-art technology to convey safety information to passengers. The presented information should include a demonstration of all emergency evacuation procedures, such as how to open the emergency exits and exit the aircraft, including how to use the slides. (A-00-86)
- Require minimum comprehension testing for safety briefing cards. (A-00-87)
- Develop advisory material to address ways to minimize the problems associated with carry-on luggage during evacuations. (A-00-88)
- Require all newly manufactured transport-category airplanes operating under Title 14 Code of Federal Regulations Part 121 to be equipped with independently powered evacuation alarm systems operable from each crewmember station, and establish procedures and provide training to flight crews and flight attendants regarding the use of such systems. (A-00-90)
- Document the extent of false indications for cargo smoke detectors on all airplanes and improve the reliability of the detectors. (A-00-91)

9.3.6 Computer Simulation of VLTA Evacuation Performance: VERRES Project Report

Published by: E.R.Galea, S.Blake and P.Lawrence, Fire Safety Engineering Group, University of Greenwich, London SE10 9LS, UK, 2007

Contents of the Study:

This Study tests the potential of unconventional evacuations of a virtual VLTA (very large transport aircraft). This virtual aircraft is equipped with two full-length passenger decks which are connected by a two-lane staircase. The upper deck seats 236 passengers in the first and business class and has four Type-A exits, while the lower deck seats 344 passengers in the first and economy class and has five Type-A exits. The staircase is positioned towards the front of the aircraft.

The trial is carried out using the simulation software “airEXODUS”.

EXODUS is a software suite simulating the evacuation of big crowds in various environments. “airEXODUS” is the respective programme for aircraft evacuations which is also used by some manufacturers for the simulation of certification tests.

The programme is based on data which are gathered during real-life evacuations and the respective simulations. The data are processed in 5 submodels which interact and integrate behaviour models. The submodels are called: ”Passenger“, “Movement“, “Behaviour“, “Toxicity“ and “Hazard“. Furthermore, there is a Geometry representation storing the cabin data (also using the .DFX file format). The Geometry representation subdivides the cabin into nodes spaced at 0.5 m intervals which are interlinked. Each node represents a region of space typically occupied by a single passenger.

Each programme step simulates the movement of a passenger from the current position to a neighbouring position. The five programme submodels keep interacting until the best-suited neighbouring position has been found iteratively, taking account of the data stored in the submodels. An obstacle can be simulated in the Passenger submodel, for instance, and a spreading fire or toxic fume gas can be simulated in the Hazard submodel. Human reaction to hazards is simulated in the Toxicity submodel. The behaviour of the crew regarding their passenger management can be stored in the Behaviour submodel. So it is possible to define for instance the radius of action and visibility of each crew member as well as the interaction of the crew who may e.g. be equipped with headsets. Thus, the crew can route the passengers dynamically to new exits in the programme if exits are congested or become unusable. The Behaviour submodel furthermore stores behaviour patterns such as the willingness to obey to the commands of the crew.

The study compared four scenarios. Each scenario has been run 1000 times to capture stochastic variations. The mix of passengers was generated in accordance with FAR 121.291 Appendix D.

Scenario 1 simulates a precautionary evacuation. All emergency exits are usable and the cabin is intact. It is the best possible outline condition for an evacuation.

Scenario 2 simulates a standard 90 seconds evacuation in accordance with FAR 121.291.

In scenario 3a, only the emergency exits in the main deck work. The passengers of the upper deck have to go downstairs via the internal staircase. Four variants are analysed:

- b and c) The crew attempts to optimise the evacuation.
- d) The staircase is widened.
- e) The staircase is moved.

In scenario 4, part of the passengers are sent from the main deck to free exits in the upper deck since the upper deck is cleared faster than the lower deck.

All scenarios only measure the time up to the crossing of the exit, so the sliding times would have to be added subsequently.

Results of the Study:

- In scenarios 1 and 2, the egress times are approx. 55 and 66 seconds.
- In scenario 3(…) they are between 150 and 160 seconds.
- Scenario 4 takes approx. 110 seconds.

It should be tried to use all available exits uniformly, that means that they all have the same passenger flow rate/time.

The simulation shows that the staircase is a bottleneck. The inflow over two aisles is higher than the staircase flow rate. The emergency exits have a higher passenger flow rate as well so that the passengers are forced to queue in front of the staircase which disperses at the foot of the staircase.

If the passengers are directed to free exits on another deck, the distance almost doubles. In contrast to this, the total time savings of 10 seconds is considered to be negligible since in an emergency case, it must be assumed that passengers are injured and obstacles are in the cell and therefore the distance should be kept as short as possible.

Limitations:

The programme calculates on the basis of data which are collected from real trials/incidents. The more data are available, the more reliable are the results of the computer simulation. Therefore, unconventional designs can only be tested in combination with the respective tests which prove the validity of the simulation. It is pointed out that staircases which might be built in according to the aircraft construction specifications are not specified in detail. In such cases, ship building specifications should be taken over.

9.3.7 JAA: Anthropometric Study to Update Minimum Aircraft Seating Standards

Ordered by: Joint Aviation Authorities, European Aviation Safety Agency D-50452 Koeln, Germany, 2001

Contractor: ICE Ergonomics, Holywell Building, Holywell Way, Loughborough, Leics LE11 3UZ, UK

Contents of the Study:

This Study analysed the seating arrangement in passenger aircraft cabins focusing on safety aspects and deliberately not taking account of comfort issues.

The study was carried out against the background trend towards ever more increasing body dimensions among the inhabitants of the EU. On the other hand, there is the trend towards a higher passenger density in aircraft cabins and longer flight times. This constitutes a conflict which also affects the speed of egress. The study developed standards based on CAD models to ensure a rapid evacuation in a changed passenger profile. For this purpose, population data, aircraft passenger surveys and scientific findings on air travel thrombosis were evaluated to find seat geometries which are adequate both for 5 percentile and 99 percentile passengers.

Results of the Study:

It is recommended to lay out the seating with a view to the increasing age of the population to avoid an unfavourable weight shift when taking and leaving the seat which may lead to a loss of balance. For this purpose, the lengths A, B, C as well as the foot space should be defined in a regulation for the design of new seats.

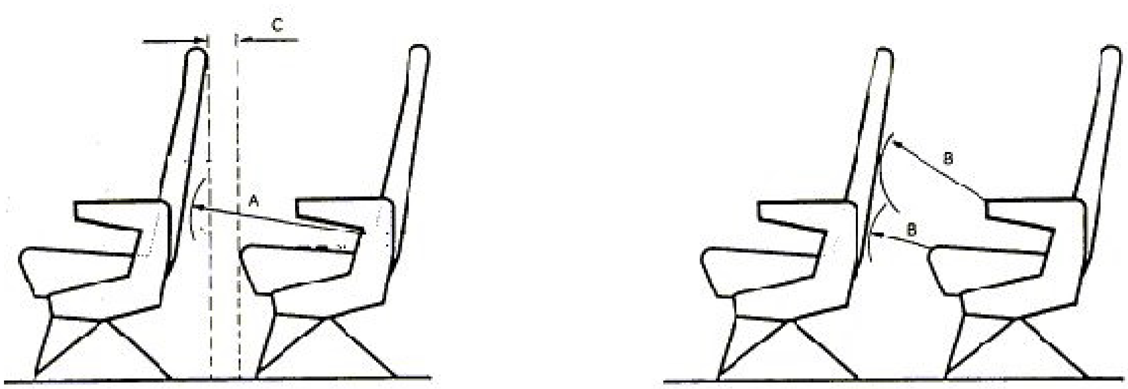


Figure 28: Seating Dimensions

Furthermore, it is recommended to investigate the effects of long travel times on passenger mobility, thus, also analysing the seat spacing.

To prevent cardiovascular problems caused by compression of the femurs, each aircraft passenger should be able to place his or her legs on the ground. For smaller passengers, foldable foot-rests could be built in on long-distance flights.

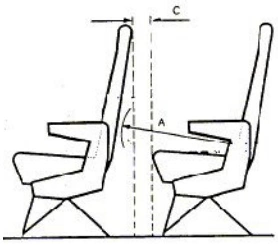
Taller passengers need higher armrests to ensure a relaxed seating position. Alternatively, they would have to provide of more knee space clearance so that they can slip down in their seat to reach low armrests. It is recommended to lay out the armrest level for a 50 percentile and to provide more knee space clearance.

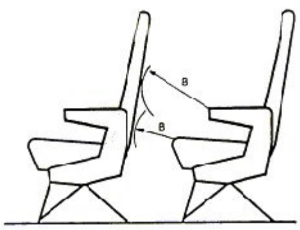
The aircraft passengers stated in a survey that approx. 10 percent of the Economy Class passengers found it rather difficult to leave their seat. The biggest problems were the seat pitch and the distance between the armrests. Due to the growing dimensions of people, the seat width between the armrests should be 23“ and at shoulder level 24“ (99 percentile male, USA).

75 percent of the passengers developed symptoms of deafness, pain and stiffness on long flights, especially in the knees, the buttocks, the hips and the neck. This could be problematic in an evacuation.

Due to the small seat pitch in combination with the seat geometry the passengers had to go to the aisle with bent knees when leaving the seat row. Thus, the centre of gravity is rearwards, especially in tall and overweight people. Therefore these passengers have to hold on to the head rests of the seat row in front. The resulting bent-forward position may lead to stumbling over the seat attachment to the seat support structure. In the case of small, heavily built passengers, the hips collide with the armrests or the seat padding.

For the certification of a cabin layout it is recommended to use an SAE-H-point dummy modified to represent a 99 percentile passenger.





Minimum values of JAA (see AN64*)	Recommendations of the study
Length A: 26“ Length B:7“ Length C:3“	Length A: minimum 28“, ideal 29.4” (26”vertical) Length B: 8.2” (cushion level) , 9” (armrest level) length C: 12” to stand upright** foot space: minimum 13.8“, ideal 14.2” seat depth: ideal 14.9“ for evacuation and comfort seat surface width: minimum 19.6“, ideal 23“
sufficient for: 5 …95 percentile	sufficient for: 1…99 percentile
	Seats are too high for small people foldable footrest recommended.
	locking for fold-up tables which is not released by passing-by is recommended

Table 12: Recommendations for seat dimensions

* The purpose of Airworthiness Notice 64 is to regulate the minimum seat space dimensions for all UK registered aircraft over 5700kg MTWA which carry 20 passengers or more.

** It is noted in the study that this value cannot be implemented. Therefore, a bent posture when exiting the seat is unavoidable.

9.3.8 ETSC Increasing the Survival Rate in Aircraft Accidents - Impact Protection, Fire Survivability and Evacuation

Published by: European Transport Safety Council, Rue du Cornet 34, B-1040 Brussels, Belgium, 1996

Contents of the Study:

This Study analysed the increase of the survival rate in aircraft accidents.

90 percent of all accidents are technically survivable. Of 1,500 fatalities worldwide per year, 600 persons die in survivable accidents, 270 of which in fire or due to the effects of smoke.

The operating safety of aircraft cannot be increased to a major extent any more. The cabin, however, still provides a large potential to increase the survivability of accidents.

Results of the Study:

It is impossible to fight cabin fires from outside. Within the cabin, the fire-fighting means are limited. Therefore, the spreading of fire through the cabin must be prevented.

A cabin water spray system could be installed in the cabin which extends the survival rate. It would be supplied with water available on board. If such a cabin water spray system is used, it must be ruled out that it is triggered accidentally. It should be possible for the fire service to feed such a cabin water spray system with water from outside. This is useful, the study states, since 75 percent of all accidents take place in close proximity to the airport.

In the cabin, the passengers are not protected against smoke. Fires produce high concentrations of highly toxic HCN which reduces the survival time. Protective masks which would ensure passengers a longer survival, (PPBE, Passenger Protective Breathing Equipment) have already been specified in accordance with EUROCAE but have not yet been incorporated in the operation / certification requirements. The delay caused by putting on such masks in an evacuation is acceptable compared to the consequences of a smoke inhalation. The delay is frequently rejected on the grounds of the so-called flash-over, with fire gases concentrating at the cabin ceiling and igniting at any time. This hazard, however, is overestimated since the gases mostly evaporate due to damage of the fuselage structure before reaching ignitable concentrations.

The use of acoustic signals to attract passengers to operational exits was tested, aimed at increasing orientation in smoke-filled cabins. This however had no effects on the evacuation rate.

To prevent crash fire, the fuel type “JP5“ can be used to replace “Jet-A1“. According to the experience of the US Air Force, the number of crash fires in navy aircraft reduced from 85 to 35 percent after the introduction of "JP5".[*]

9.3.9 JP 5 Jetfuel

Published by: Agency for Toxic Substances and Disease Registry, 4770 Buford Hwy NE, Atlanta, USA, 2009

Contents of the paper:

Jet fuels are refined from distillation of crude oil which have to comply with specific standards. Light jet fuels such as A1 are straight distillations of crude oil in the presence of a catalyst. JP[29]-5 and JP-8 furthermore include chemical additives shifting the flashpoint and having an anticorrosive effect.

Jet-A1 is a commercial jet fuel. It is used as a fuel in all civil turbojet engines. Its specification equals JP-8 (JP8 additionally includes anticorrosive and lubricating additives).

JP-5 was developed by the US Navy in 1950 to reduce the volatility of jet fuel and to increase the flashpoint to 60°C / 333K. During the Vietnam war the probability of post-crash-fires for aircraft fuelled with JP-5 was only 35 percent whereas the probability for JP-4 was 83 percent.

Comparison of jet fuel specifications:

	JP-8 (Jet A1)	JP-5	JP-4
Flashpoint	38°C	60°C	0°C

Table 13: Flashpoint of jet fuels

[*] Cited from „JP 5 Jetfuel“ – the reduction of crash fires is compared to JP-4 which has a lower flashpoint (-18°C) than Jet A1 (min. 43°C)

***29 Jet Propellant

9.3.10 CAA Paper 2002/04 Benefit Analysis for Cabin Water Spray Systems and Enhanced Fuselage Burnthrough Protection

Ordered by: Civil Aviation Authority, Aviation House, Gatwick Airport South, West Sussex, UK, 2002

Contractor: R.G.W. Cherry & Associates Limited, e Priory, High Street, Ware, Herts, G12 9AL. UK

Contents of the Study:

This Study analysed the potential provided by cabin water spray systems in conjunction with burnthrough protection (five minutes of protection from large external pool fires before the penetration of fire into the passenger cabin) regarding the survivability of aircraft accidents, investigating 136 suitable accidents which took place in the USA between 1967 and 1996. Two methodologies were used for assessment. The more significant methodology determined the benefit in terms of safety per year.

Two systems are distinguished. Singular systems only use one exclusive water source. Modular systems use three water sources (one each in the aft, mid and forward sections). The individual modules operate autonomously. The following outline conditions are defined for the two systems:

- The system operates for three minutes.
- It is triggered automatically.
- It prevents flashover and burning of cabin components.
- It reduces the temperature

The assessment of the systems took account of the condition of the cabin and the passengers immediately upon the crash as well as the time needed by the rescue teams to arrive at the scene in each accident.

Results of the Study:

The introduction of singular (*modular*) cabin water spray systems would rescue at least 27 (*34*) lives per year. This figure would increase to 34 (46) in combination with a burnthrough protection cabin. If the service water of the cabin is used, it can be assumed that in most cases there will be enough water for firefighting at the time of landing despite in-flight consumption.

9.3.11 CAA Paper 2009/01 – Cabin Crew Fire Training

Ordered by: Civil Aviation Authority, Aviation House, Gatwick Airport South, West Sussex, UK, 2009

Contractor: R.G.W. Cherry & Associates Limited, e Priory, High Street, Ware, Herts, G12 9AL. UK

Contents of the Study:

This study was aimed at identifying the contents to be covered by cabin crew fire training to evaluate potential training improvements and to give recommendations. These also include amendments in the European aviation regulations. This study is based on the evaluation of the current crew training in accordance with JAR-OPS 1 Subpart O – cabin crew – (JAR OPS 1.1010; JAR OPS 1.1015; JAR-OPS 1.1005).

Eight operators were inspected in Great Britain and two operators in Europe to review their training programmes. The fleets of the operators included turbo-props as well as narrow-bodied and wide-bodied jet operations. The operations covered low-cost and charter as well as short and long-distance flights.

The gained insights were compared with a best practice recommendation to FAA in the United States.

Results:

Fire extinguishers and their locations:

The training does not use halon extinguishers as are found onboard. Instead, water or dry powder fire extinguishers were used. Only one of the inspected facilities pointed out the difference between halon and other extinguishing agents. In many cases the fire extinguishers used in the training furthermore differed completely from those used onboard.

The membranes in the fire extinguishers were a big problem. The force required to open them is higher than it is often shown in the training. Moreover, it is rather difficult to operate the fire extinguisher with fire gloves.

In accordance with JAR-OPS, the removal of the fire extinguishers from their attachment must be practised only in the first training. Therefore, it is admissible, if the crew never had to remove a fire extinguisher from its attachment for years. Furthermore, it is not mandatory that the crew is informed of new storage places of fire extinguishers in case of a change of layout. This delays fire fighting in case of an emergency.

The decision when a gas-fired simulator is extinguished must be linked to realistic guidelines. At present, this point of time is often defined at random by the trainer who switches off the gas supply. In most cases, this point of time was too early so that the crew was trained a wrong awareness of the demands of fire-fighting.

Protective breathing equipment (PBE) and its storage place:

Donning and fire-fighting is trained with PBE in the training sessions. However, the removal of the PBE from their transport containers is not trained - as a consequence, 58 percent of all problems with PBEs were related to their removal from the rigid package. The PBE is vacuum-packed in a container or a storage pouch. The storage pouch is taken out when the container has been opened. The storage pouch is opened and the PBE is shaken out. Afterwards, the PBE is ready to use. Forces up to 14 kg are necessary to open the storage pouches.

Donning the PBE regularly poses problems in the training even though the neck seals of the training units were often so loose that the donning was not comparable to an unused PBE.

The PBE makes communication via the interphone system difficult – nevertheless, communication is partly not trained. (see also Air France Crash in Toronto – there, a crew member took off his smoke hood because he was not understood by the passengers)

Furthermore, it is not mandatory that the crew is informed of new storage places of PBEs in case of a change of layout. This slows down fire fighting in case of an emergency.

Communication:

Communication between the flight crew and cabin crew members should be trained. The cabin crew members should be aware that the pilots have a high workload when communicating via ATC and between them, especially in unscheduled landings. Therefore, only essential information should be communicated to the flight crew. Cooperation will increase the efficiency of inflight fire-fighting.

Wearing PBEs makes hearing and speaking difficult. Communication can become difficult or even impossible when all cabin crew members wear PBEs. The PBE Oxygen supply is so noisy that the crew members had to hold their breath to understand the others (statement on page 74).

Flight manuals and training contents:

It was identified that the training and flight manuals of third-party instructors did not correspond in some cases, since the operators failed to put their flight manuals at disposal. On the other hand, the operators did not know in some cases what was taught in the training by the third-party organisation. In some cases, he or she was not even able to say whether the third-party training organisation fulfils JAR-OPS.

Single cabin crew operations:

If only one crew member is on board, he or she needs assistance by physically suitable passengers in the communication with the flight crew as well as in fire-fighting. Since these passengers have to be briefed first, delays in fire-fighting are likely to occur.

Clothing:

The air carriers should adhere to the requirement of rapid fire-fighting regarding their dress code focusing on the compatibility of necklaces and PBE.

Problems with in-flight fire fighting:

The following figure depicts the distribution of problems which the cabin crew members encountered in fire-fighting measures at work.

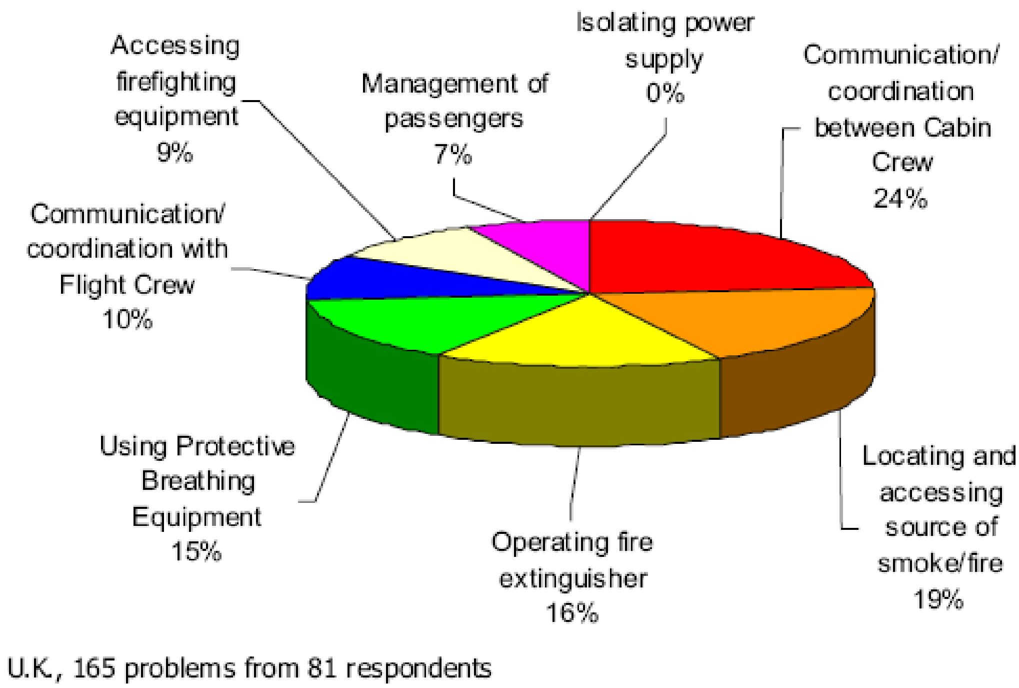


Figure 29: Problems during firefighting

9.3.12 A Study to the Specific Contributors to U.S. Airline Passenger Air Rage

Written by: Douglas W. Beeks, Embry-Riddle Aeronautical University, Extended Campus, Luke Resident Center, USA, 2000

Contents of the graduate Study:

This study identified the contributors to misconduct on board of US aircraft.

First of all, it gives a number of examples of extreme situations on board where passengers had to be overwhelmed by the crew.

Thereupon the available literature and surveys were evaluated to identify the contributors of passenger conduct giving a multitude of correlations. Some safety-relevant correlations are outlined in the following.

Results of the Study:

As ALPA stated, alcohol accounted for 25 percent of the incidents, the seat distribution for 16 percent, hostile and threatening behaviour for 12 percent, ten percent were related to tobaccos, nine percent were due to hand luggage and eight percent due to stubbornness (perception) of the passenger.

There is no connection between the different air carriers and the number of incidents.

The three main contributors to misconduct are cramped seating, the fear of missing the connecting flight (or having it actually missed) as well as conflicts related to the storage of carry-on luggage.

According to the ASRS database of NASA, the following contributors could be identified in 1998 (double entries were obviously possible)

- 43 percent - alcohol
- 44.2 percent - ban on using electronic devices such as laptop, mobile phone etc.
- 9.2 percent - illegal smoking in the toilet
- eight percent - drugs
- 5 percent - carry-on luggage

9.3.13 Protective Brace/Safety Positions for Passengers and Cabin and Cockpit Crew in Emergency Landing Conditions or Aborted Take-Off

Ordered by: Federal Ministry of Transport, Building and Urban Affairs, Department LS 15, Robert-Schumann-Platz 1, 53175 Bonn, Germany, 2007

Contractor: TÜV Kraftfahrt GmbH, Technology Center Traffic Safety, Team Aviation, Am Grauen Stein, 51105 Cologne, Germany

Contents of the Study:

This Study was intended to define crash-optimised protective positions for passengers and cabin and cockpit crew in unscheduled landing conditions or aborted take-off. For this purpose, several aircraft accidents were analysed in view of their injury patterns incurred by an incorrect seating position and/or wrong fastening of the seatbelt. Furthermore, dynamic 16g tests with aircraft passenger seats were evaluated.

Results of the Study:

The following injury patterns were identified in forward-facing seats:

- Injury pattern: Scull fracture/facial injuries
  Possible mistake: Upright sitting position
  Cause of injury: Hard impact against the seat structure in front

- Injury pattern: Scull fracture fracture of both forearms
  Possible mistake: Upright sitting position in the front row
  Cause of injury: Hard impact of the head and arms against the partition

- Injury pattern: Abdominal injuries
  Possible mistake: Belt not tightened firmly → belt too slack
  Cause of injury: Submarining of the occupant's pelvis under the lap belt (submarining effect)

- Injury pattern: Lower leg fracture
  Possible mistake: Flexed leg position
  Cause of injury: Feet/lower legs swing forward. Hard impact of the lower legs against the rigid structure of the seat in front

The general positions as well as the Kegworth safety positions are tested at 16g. For this purpose 50 percentile Hybrid-II dummies are used. The following safety positions for forward facing seats are recommended upon the evaluation of these tests:

- Slide well back in the passenger seat as far backward as possible towards the backrest with your buttock.
- The fastened belts must not be twisted.
- Tighten the seat belt across your pelvis firmly.
- Bend the upper torso well forward and place your head, if possible, against the backrest of the seat in front.
- Place hands flat to the left and right beside the head against the seat in front. Stretch out arms in the front row and grasp your lower legs with your hands.
- Stretch out legs and, if possible, place them flat against the rigid structure of the seat in front.
- Put any luggage under the seat in front and push it up to the front. Put your feet against the piece of luggage.
- Keep up this position until the aircraft has come to a complete stop.

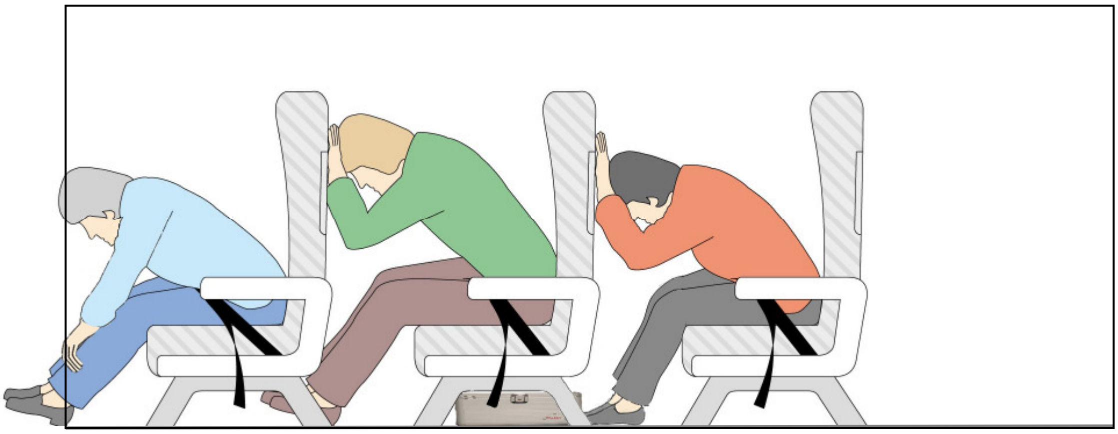


Figure 30: Recommendet brace positions

The above-outlined brace/safety positions are not effective for children smaller than 1.25 m (approx. six to seven years of age). According to the findings of the R&D project "Requirements for Child Restraint Systems in Aircraft" (L-5/95-50140/95) and ”Examination for the Enhancement of the Cabin Safety of Infants“ (L-2/97-50157/97) small occupants (children and infants) have to be fastened in their own seat in a suitable child restraint system.

Two dynamic tests were furthermore carried out without adopting a safety position. The first test used a 95 percentile Hybrid-II dummy in an upright sitting position with a seat row mounted in front of the dummy, whereas the second test was carried out with a 50 percentile Hybrid-II dummy on a front row. Critical head accelerations are incurred in both tests, which are well above the critical biomechanical tolerance in the first test. In the latter test, a high load on the vertebral spine was incurred in flexion.

9.3.14 Study on Child Restraint Systems

Ordered by: European Aviation Safety Agency, Rulemaking Directorate, Postfach 10 12 53, D-50452 Cologne, Germany, 2008

Contractor: TÜV Rheinland Kraftfahrt GmbH, Team Aviation, Am Grauen Stein, D-51105 Cologne, Germany

Contents of the Study:

The issue to be addressed by this study was the protection from injuries caused by turbulence, aborted take-off, hard landings and/or in emergency landing conditions, of children, particularly those two or less years old (infants), on board aircraft used for commercial transport of passengers. This Study evaluated studies, provisions and findings, including from the automotive industry, and analysed technical solutions. Three options were proved operational and were subjected to a regulatory impact assessment (RIA):

Option 1: Do nothing

Option 2: Add-on systems

- Variant 1: The airline provides the CRDs
- Variant 2: The passenger provides a CRD

Option 3: Built-in systems

Results of the Study:

The current method of transporting infants, double occupancy with loop belt attachment is not suitable. The loop belt rests by almost 100 percent within the infant's abdominal region. The induction of forces into the abdominal region of the infant results in extremely serious internal injuries. For the same reasons a restraint of children with an adult lap belt is not suitable. Furthermore, it may be impossible to tighten the adult belt firmly due to the child's small pelvis. An adult lap belt should only be used for the restraint of children aged at least seven years or taller than 125 cm.

Infants and children should be transported in suitable child restraint systems.

Pursuant to the evaluation of the impacts on the individual options (RIA), two options have proven practicable – Add-on systems and Built-in systems.

These two options fulfil the performance standards for safe restraint of children in aircraft defined in the study:

- All passengers, including infants, are entitled to a seat of their own.

- Children aged up to seven years shall be transported on their seat in a CRD which is appropriate for their age group.
- The functionality of the CRD must be ensured by a practicable procedure.

The costs analysis shows that the potential costs or benefits in relation to the total cost structure of an airline are relatively small. (approx. 0,1 to 0,2 per cent of the total operational costs)

The study recommends amending both the certification and the operating specifications to provide for an individual seat for every aircraft passenger. It should not be allowed to transport children aged up to seven years without an approved child restraint system. Furthermore ETSO C127a should include a minimum standard for child restraint systems oriented at ECE R44, FMVSS213, CMVSS213 and TSO C100. Child restraint systems integrated in the aircraft passenger seat should be approved in accordance with ETSO C127a.

All other child restraint systems should be approved in accordance with ECE-R44, FMVSS 213, ETSO-C100b or an equivalent standard. In addition, the possibility of a safe attachment of the child restraint system to the aircraft passenger seat should be proven e.g. by a fit-check procedure.

9.3.15 ICEPS

Ordered by: European Commission DGVII, Transport; AI-97-AM.0235-ICEPS; 1999

Contractor: TÜV Kraftfahrt GmbH, Technology Center Traffic Safety, Team Aviation, Am Grauen Stein, D-51105 Cologne, Germany

Results of the Study:

Since the current aircraft certification requirements only analyse partial aspects of passive safety it is not ensured that passengers are still capable of acting after a crash and that they are moreover capable of evacuating themselves.

At present, CS 25.562 only defines HIC, lumbar spine and femur tolerance values. Tolerance values, however, should be defined for all body regions relevant for an unassisted evacuation: Neck/cervical spine, chest, pelvis/vertebral column, upper extremities and lower extremities. For some of these body regions, however, no biomechanical limits are available (when the study was published in 1999).

A comparison of the protection criteria clearly indicates the limitations of Hybrid-II dummies.

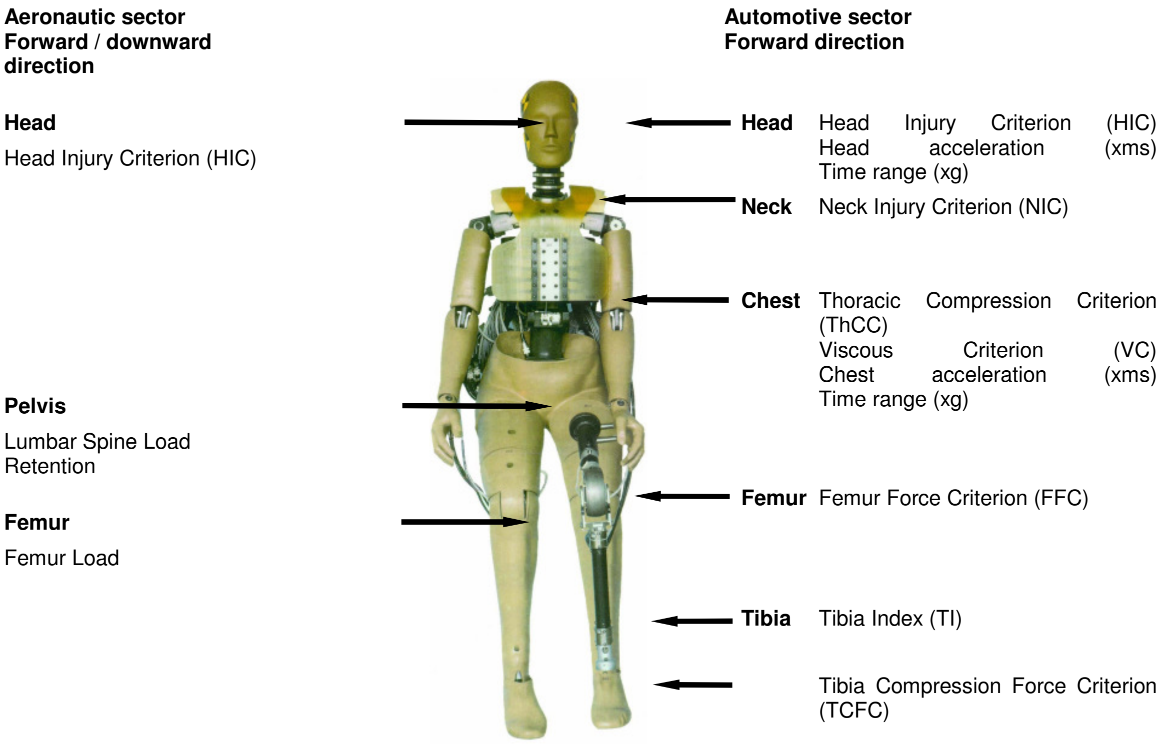


Figure 31: Dummy protection criteria

It is suggested to analyse the passenger survival space with regard to sharp edges. Covered structures must provide a minimum energy absorption capacity.

9.3.16 Effects of Lap Belt and Three-Point Restraints on Pregnant Baboons Subjected to Deceleration

Written by: Albert I. King, Rolf H Eppinger, Warren M. Crosby and L. Clarke Stout, 1971

Contents of the Study:

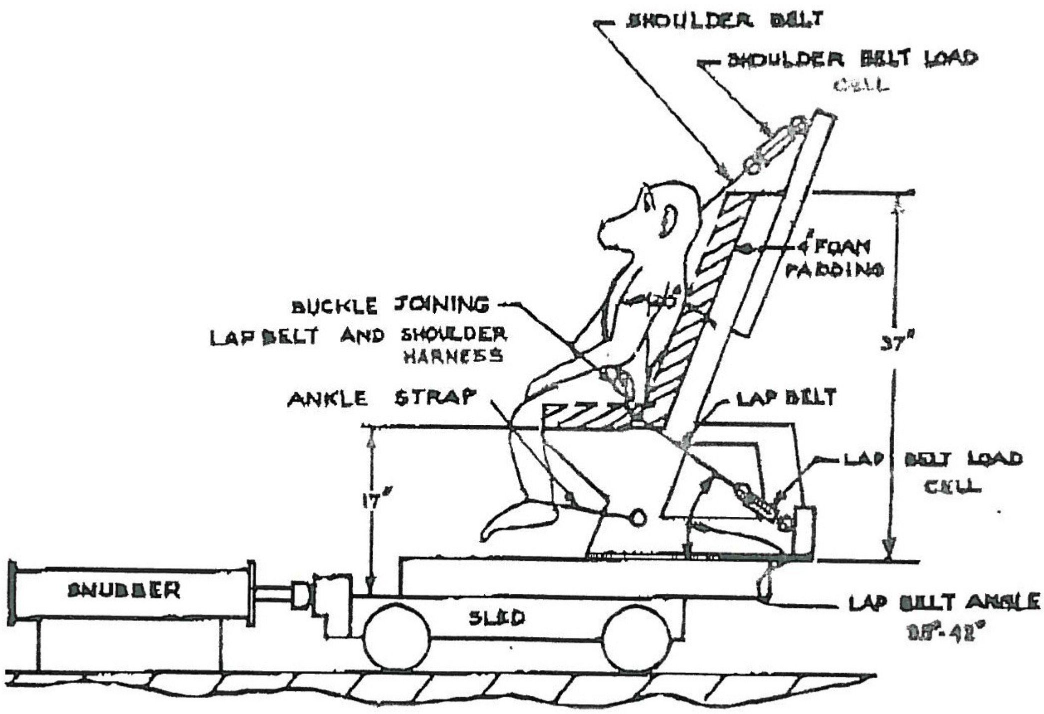
A series of 24 pregnant baboons was impacted under the following conditions. The only major variable was the difference in maternal restraint.

- The animals were pregnant for 119 to 168 days. The average time until delivery is180 days.
- Prior and after the impact-tests, external examinations have been conducted. Thus injuries and fatalities would be reduced solely to the impact
- The animals have been anesthetized using nitrous oxide and positioned on the test sled. A loop belt or three-point belt was attached to them.
- The harness consisted of standard-nylon-webbing which has been cut into stripes of 1“thickness to account for the small size of the baboons.
- The anchorage points of the restraint systems were attached to the test seat.
- The pelvis-belt was placed below the fundus of the uterus and just above the tights.
- lap belt preload was 2lbs.
- The shoulder-harness was fitted snuggly.
- The buckle was of standard make and not scaled down. It was placed below and slightly left of ilium.
- The back of the chair has foam padding and was extended above the animals head to prevent rebound whiplash.
- The backrest was at a 20 degree angel from the seat pan.
- The animals were fixed in their position by straps that did not interfere with the body kinematics.

- The peak longitudinal deceleration was 25 to 28,5g. The variations coincide with the animals weight. The impulse was calibrated with a constant weight.

The following values have been recorded:

- Longitudinal sled deceleration
- Sled velocity
- Belt-force
- X-Rays at the point of impact. (Only one X-Ray was useable)
- High-Speed captures with a frame rate of 500 to 1000 frames/second.



chair

Figure 32: The sled with the attached baboon

Results of the Study:

Examination of the recorded data showed that peak deceleration and duration were comparable for both the lap-belt and three-point-belt impact tests.

Only cases where the mother-animals have not sustained serious injuries were further investigated. Additionally, a relation between the injuries of the fetus and the impact test was to be verifiable.

Fetus-fatality-rate for those baboons with lap belt restraint was five out of ten. The post impact survival time ranged between four days and one hour. One fatality had an almost complete separation of the placenta. There was no clear explanation for the cause of death (cardiac failure) for the other fatalities. One fatality has been excluded because the mother became paraplegic as a result of the impact.

Fetus-fatality-rate for those baboons with three-point-restraint was one out of twelve. Two further fatalities could not be attributed to the impact.

Flexion of the maternal upper torso was assumed to be the reason for the high fatality rate of lap belt restraint. As a result, either the fetus crane may be crushed or the uterus of the maternal animal may be distorted so much as to detach the placenta.

9.3.17 Study on Identification and Prioritisation of Health Issues on Board Aircraft

Ordered by: European Aviation Safety Agency, D-50452 Cologne, Germany, August 2008,

Contractor: BRE Garstin, WD25, 9XX, UK

Contents of the Study:

This study identified health hazards in air travel. It conducted a comprehensive validation of available papers dealing with this issue. The following medical incidents were analysed:

- Cardiology
- Cerebrovascular event
- Deep vein thrombosis (DVT)
- Pregnancy/premature birth on board an aircraft
- Fainting

The study was intended to answer the following questions:

- What is the size of the problem regarding medical events during flight?
- What are the possible causes of medical events other than underlying medical conditions?
- What health issues should be given priority if action is considered?
- What are the significant gaps in knowledge which affect the possibility to draw conclusions, and
- Which should therefore be the subject of further studies?

Results of the Study:

Cardiology:

Qiang et al. found out that there is a correlation between the BMI and cardiovascular disorders. The risk increased by approx. 22 percent with a BMI between 30 and 34.9 [kg/m²]. (The subjects were aged between 62 and 72 years at the time of the study.)

Possick and Barry stated in 2004 that cardiovascular disorders account for 10 to 20 percent of all medical incidents on board. They found hints to influencing factors of air travel in arrhythmia and ischaemia. An increased risk in air travel, however, was not verified.

According to an analysis by Donaldson and Pearn, between 1 and 2.5 passengers per million passengers died of heart failure on long-distance flights in 1993, most of them due to coronary occlusion. In a more recent study (Cocks and Liew, 2007), the death rate amounts to one death per 3 – 5 million passengers.

Cerebrovascular events:

According to Sirven et al., 31 percent of the medical events of a major airline involved neurological symptoms. Approx. 1 percent accounted for cerebrovascular infarcts.

Deep vein thrombosis (DVT):

There is no sufficient evidence available yet that air travel increases the risk of thrombosis. However, there are some hints suggesting that the risk increases in extended air travel. Fatal thrombosis is rare and has not yet been investigated systematically.

Pregnancy:

The latest studies by Freeman et al. (2004) as well as by Chibber et al. (2006) identify no increased risks for in-flight pregnancies up to gestation week 36. Chibber states a potential risk of premature birth in women who frequently fly long distances, but it cannot be ruled out that also alcohol and cigarette consumption by the test persons can be the reason for premature birth. In addition, many of the concerned passengers were obviously pregnant women who wanted to give birth to their child in foreign countries (e.g. USA), presumably for economic reasons.

Every 34,250 to 74,605 flights experience an incident involving the onset of labour or birth.

Fainting:

Sirven et al. associate fainting and dizziness/vertigo with the following reasons:

- Cabin pressurisation and humidity
- Hypoxemia
- Dehydration
- Sleep deprivation
- Hyperventilation as a consequence of stress (approx. 20 percent of passengers are affected by fear of flying)
- Heightened effects of alcohol and medications due to the cabin environment

The data on the frequency range between once in every 19,571 flights to once in every 102,137 flights. The most likely triggers for fainting are hyperventilation due to fear of flying and venous pooling associated with prolonged sitting leading to cerebral arterial insufficiency when standing up.

9.4 List of Hazards

ESA PSS 01-403:

AA1-pressure difference
AA2-high pressure
AA3-low pressure
AA4-vacuum
AB1-temperature difference
AB2-high temperature
AB3-low temperature
AC1-heat radiation
AC2-heat convection
AD-fluid jet
BA1-high voltage
BA2-medium voltage
BA3-low voltage
BB-static electricity
BC1-high electric current
BC2-low electric current
CA1-X, RF, Laser etc. radiation
CA2-nuclear radiation
CB-light (radiation)
CC1-induced magnetic field
CC2-external magnetic filed
CD-ionisation
DA1-acidity
DA2-alkalinity
DA3-corrosivity
DA4-flammability
DA5-explosivity
DA6-hypergolicity
DA7-pyrophoricity
DB1-high toxicity
DB2-low toxicity
DC-carcinogenicity
DD-asphyxiant
EA1-potential energy
EA2-kinetic energy
EA3-rotation energy
EB1-sharpness
EB2-cutting edge
EB3-roughness
EB4-slipperiness
EC1-tension (stress)
EC2-compression (stress)
EC3-friction (stress)
ED1-linear force
ED2-torque
ED3-vibration
ED4-acceleration
EE1-brittleness
EE2-tearing susceptibility
FA1-lack of previous experience
FA2-lack of specific training
FB1-human decision error susceptibility
FB2-human judgement error susceptibility
FB3-human bad information selection susceptibility
FC1-emotions (fear, joy,etc.) susceptibility
FC2-human stress susceptibility
FC3-lack of adaptability of human being
FC4-human susceptibility to claustrophoby
FD1-poor motivation
FD2-distraction susceptibility
GA1-human fatigue
GA2-illness
GA3-human sensorial weakness
GB1-limited human physical strength
GB2-limited human flexibility
GB3-limited human sensitiveness
GB4-limited human reaction capability
GB5-limited human autonomy (consumables)
GB6-limited human susceptibility to biorythm changes
GC1-human vomit
GC2-human fecals
GC3-human sweat
GD1-bad ergonomics
GD2-bad anthropometric characteristics
GD3-uncomfortable position (Human discomfort)
GD4-noise, darkness, light (human discomfort)
HA1-zero g
HA2-multi g
HB1-vacuum (environmental hazard)
HB2-low environmental pressure
HC1-high environmental temperature
HC2-low environmental temperature
HD1-solar rays and flares
HD2-nuclear environmental radiation
HD3-X rays (environmental hazard)
HE-light (environmental hazard)
HF-contaminants in environment
HG-meteorite and space debris
HH1-weather change
HH2-dust, sand (climate)
HH3-wind forces
HH4-moisture, wetness
HH5-dryness (climate)
HH6-fog (climate)
HI-earthquake
IA1-fungus
IA2-bacteria
IA3-virus
IA4-yeast
KA-impr.inform. processing
KB-impr.inform. propagation

9.5 CS 25.807 Emergency exits

(See AMC to 25.807 and 25.813 and AMC 25.807)

(a) Type. For the purpose of this CS–25, the types of exits are defined as follows:

(1) Type I. This type is a floor level exit with a rectangular opening of not less than 61 cm (24 inches) wide by 1·22 m (48 inches) high, with corner radii not greater than onethird the width of the exit.

(2) Type II. This type is a rectangular opening of not less than 51 cm (20 inches) wide by 1.12 m (44 inches) high, with corner radii not greater than onethird the width of the exit.Type II exits must be floor level exits unless located over the wing, in which case they may not have a stepup inside the aeroplane of more than 25 cm (10 inches) nor a stepdown outside the aeroplane of more than 43 cm (17inches).

(3) Type III. This type is a rectangular opening of not less than 51 cm (20 inches) wide by 91 cm (36 inches) high, with corner radii not greater than onethird the width of the exit, and with a stepup inside the aeroplane of not more than 51 cm (20 inches). If the exit is located over the wing, the stepdown outside the aeroplane may not exceed 69 cm (27 inches).

(4) Type IV. This type is a rectangular opening of not less than 48 cm (19 inches) wide by 66 cm (26 inches) high, with corner radii not greater than onethird the width of the exit, located over the wing, with a stepup inside the aeroplane of not more than 74 cm (29 inches) and a stepdown outside the aeroplane of not more than 91 cm (36 inches).

(5) Ventral. This type is an exit from the passenger compartment through the pressure shell and the bottom fuselage skin. The dimensions and physical configuration of this type of exit must allow at least the same rate of egress as a Type I exit with the aeroplane in the normal ground attitude, with landing gear extended.

(6) Tail cone. This type is an aft exit from the passenger compartment through the pressure shell and through an openable cone of the fuselage aft of the pressure shell. The means of opening the tail cone must be simple and obvious and must employ a single operation.

(7) Type A. This type is a floor level exit with a rectangular opening of not less than 1.07 m (42 inches) wide by 1·83 m (72 inches) high with corner radii not greater than onesixth of the width of the exit.

(b) Step down distance. Step down distance, as used in this paragraph, means the actual distance between the bottom of the required opening and a usable foot hold, extending out from the fuselage that is large enough to be effective without searching by sight or feel.

(c) Oversized exits. Openings larger than those specified in this paragraph, whether or not of rectangular shape, may be used if the specified rectangular opening can be inscribed within the opening and the base of the inscribed rectangular opening meets the specified stepup and stepdown heights.

(d) Passenger emergency exits. (See AMC 25.807 (d). Except as provided in subparagraphs (d)(3) to (7) of this paragraph, the minimum number and type of passenger emergency exits is as follows:

(1) For passenger seating configurations of 1 to 299 seats –

Passenger seating configuration (crew member seats not included)	Emergency exits for each side of the fuselage			
	Type I	Type II	Type III	Type IV
1 to 9				1
10 to 19			1	
20 to 39		1	1	
40 to 79	1		1	
80 to 109	1		2	
110 to 139	2		1	
140 to 179	2		2	

Additional exits are required for passenger seating configurations greater than 179 seats in accordance with the following table:

Additional emergency exits (each side of fuselage)	Increase in passenger seating configuration allowed
Type A	110
Type I	45
Type II	40
Type III	35

(2) For passenger seating configurations greater than 299 seats, each emergency exit in the side of the fuselage must

be either a Type A or a Type I. A passenger seating configuration of 110 seats is allowed for each pair of Type A exits and a passenger seating configuration of 45 seats is allowed for each pair of Type I exits.

(3) If a passenger ventral or tail cone exit is installed and that exit provides at least the same rate of egress as a Type III exit with the aeroplane in the most adverse exit opening condition that would result from the collapse of one or more legs of the landing gear, an increase in the passenger seating configuration beyond the limits specified in subparagraph (d)(1) or (2) of this paragraph may be allowed as follows:

(i) For a ventral exit, 12 additional passenger seats.

(ii) For a tail cone exit incorporating a floor level opening of not less than 51 cm (20 inches) wide by 1·52 m (60 inches) high, with corner radii not greater than onethird the width of the exit, in the pressure shell and incorporating an approved assist means in accordance with CS 25.810(a), 25 additional passenger seats.

(iii) For a tail cone exit incorporating an opening in the pressure shell which is at least equivalent to a Type III emergency exit with respect to dimensions, stepup and stepdown distance, and with the top of the opening not less than 1.42 m (56 inches) from the passenger compartment floor, 15 additional passenger seats.

(4) For aeroplanes on which the vertical location of the wing does not allow the installation of overwing exits, an exit of at least the dimensions of a Type III exit must be installed instead of each Type IV exit required by subparagraph (1) of this paragraph.

(5) An alternate emergency exit configuration may be approved in lieu of that specified in subparagraph (d)(1) or (2) of this paragraph provided the overall evacuation capability is shown to be equal to or greater than that of the specified emergency exit configuration.

(6) The following must also meet the applicable emergency exit requirements of CS 25.809 to 25.813:

i. Each emergency exit in the passenger compartment in excess of the minimum number of required emergency exits.
ii. Any other floor level door or exit that is accessible from the passenger compartment and is as large or larger than a Type II exit, but less than 1·17 m (46 inches) wide.
iii. Any other passenger ventral or tail cone exit.

(7) For an aeroplane that is required to have more than one passenger emergency exit for each side of the fuselage, no passenger emergency exit must be more than 18·3 m (60 feet) from any adjacent passenger emergency

exit on the same side of the same deck of the fuselage, as measured parallel to the aeroplane's longitudinal axis between the nearest exit edges.

(e) *Ditching emergency exits for passengers.* Ditching emergency exits must be provided in accordance with the following requirements whether or not certification with ditching provisions is requested:

(1) For aeroplanes that have a passenger seating configuration of nine seats or less, excluding pilots seats, one exit above the waterline in each side of the aeroplane, meeting at least the dimensions of a Type IV exit.

(2) For aeroplanes that have a passenger seating configuration of 10 seats or more, excluding pilots seats, one exit above the waterline in a side of the aeroplane, meeting at least the dimensions of a Type III exit for each unit (or part of a unit) of 35 passenger seats, but no less than two such exits in the passenger cabin, with one on each side of the aeroplane. The passenger seat/exit ratio may be increased through the use of larger exits, or other means, provided it is shown that the evacuation capability during ditching has been improved accordingly.

(3) If it is impractical to locate side exits above the waterline, the side exits must be replaced by an equal number of readily accessible overhead hatches of not less than the dimensions of a Type III exit, except that for aeroplanes with a passenger configuration of 35 seats or less, excluding pilots seats, the two required Type III side exits need be replaced by only one overhead hatch

(f) Flight crew emergency exits. For aeroplanes in which the proximity of passenger emergency exits to the flight crew area does not offer a convenient and readily accessible means of evacuation of the flight crew, and for all aeroplanes having a passenger seating capacity greater than 20, flight crew exits must be located in the flight crew area. Such exits must be of sufficient size and so located as to permit rapid evacuation by the crew. One exit must be provided on each side of the aeroplane; or, alternatively, a top hatch must be provided. Each exit must encompass an unobstructed rectangular opening of at least 48 by 51 cm (19 by 20 inches) unless satisfactory exit utility can be demonstrated by a typical crewmember.

(g) [Reserved]

(h) Other exits. The following exits must also meet the applicable emergency exit requirements of CS 25.809 through 25.812, and must be readily accessible:

(1) Each emergency exit in the passenger compartment in excess of the minimum number of required emergency exits.

(2) Any other floorlevel door or exit that is accessible from the passenger compartment and is as large or larger than a Type II exit, but less than 1.17m (46 inches) wide.

(3) Any other ventral or tail cone passenger exit.

(i) [Reserved]

(j) [Reserved]

(k) Each passenger entry door in the side of the fuselage must qualify as a Type A, Type I, or Type II passenger emergency exit.

[Amdt. No.:25/4]

[Amdt. No.:25/5]

[Amdt. No.:25/6]

9.6 CS 25 Appendix J Emergency Demonstration

The following test criteria and procedures must be used for showing compliance with CS 25.803:

(a) The emergency evacuation must be conducted either during the dark of the night or during daylight with the dark of night simulated. If the demonstration is conducted indoors during daylight hours, it must be conducted with each window covered and each door closed to minimise the daylight effect. Illumination on the floor or ground may be used, but it must be kept low and shielded against shining into the aeroplane's windows or doors.

(b) The aeroplane must be in a normal attitude with landing gear extended.

(c) Unless the aeroplane is equipped with an off-wing descent means, stands or ramps may be used for descent from the wing to the ground. Safety equipment such as mats or inverted life rafts may be placed on the floor or ground to protect participants. No other equipment that is not part of the aeroplane's emergency evacuation equipment may be used to aid the participants in reaching the ground.

(d) Except as provided in paragraph (a) of this Appendix, only the aeroplane's emergency lighting system may provide illumination.

(e) All emergency equipment required for the planned operation of the aeroplane must be installed.

(f) Each external door and exit, and each internal door or curtain, must be in the take-off configuration.

(g) Each crew member must be seated in the normally assigned seat for take-off and must remain in the seat until receiving the signal for commencement of the demonstration. Each crewmember must be a person having knowledgeof the operation of exits and emergency equipment and, if compliance with the applicable Operating Rules is also being demonstrated, each cabin crewmember must be a member of a regularly scheduled line crew.

(h) A representative passenger load of persons in normal health must be used as follows:

(1) At least 40% of the passenger load must be females.

(2) At least 35% of the passenger load must be over 50 years of age.

(3) At least 15% of the passenger load must be female and over 50 years of age.

(4) Three life-size dolls, not included as part of the total passenger load, must be carried by passengers to simulate live infants 2 years old or younger.

(5) Crew members, mechanics, and training personnel who maintain or operate the aeroplane in the normal course of their duties, may not be used as passengers.

(i) No passenger may be assigned a specific seat except as the Agency may require. Except as required by sub-paragraph (g) of this Appendix, no employee of the applicant may be seated next to an emergency exit.

(j) Seat belts and shoulder harnesses (as required) must be fastened.

(k) Before the start of the demonstration, approximately one-half of the total average amount of carry-on baggage, blankets, pillows, and other similar articles must be distributed at several locations in aisles and emergency exit access ways to create minor obstructions.

(l) No prior indication may be given to any crewmember or passenger of the particular exits to be used in the demonstration.

(m) There must not be any practising, rehearsing or description of the demonstration for the participants nor may any participant have taken part in this type of demonstration within the preceding six months.

(n) The pre take-off passenger briefing required by the applicable Operating Rules may be given. The passengers may also be advised to follow directions of crewmembers but not be instructed on the procedures to be followed in the demonstration.

(o) If safety equipment as allowed by subparagraph (c) of this Appendix is provided, either all passenger and cockpit windows must be blacked out or all of the emergency exits must have safety equipment in order to prevent disclosure of the available emergency exits.

(p) Not more than 50% of the emergency exits in the sides of the fuselage of an aeroplane that meets all of the requirements applicable to the required emergency exits for that aeroplane may be used for the demonstration. Exits that are not to be used in the demonstration must have the exit handle deactivated or must be indicated by red lights, red tape, or other acceptable means placed outside the exits to indicate fire or other reason why they are unusable. The exits to be used must be representative of all of the emergency exits on the aeroplane and must be designated prior to the demonstration and subject to approval by the Agency. At least one floor level exit must be used.

(q) Except as provided in sub-paragraph (c) of this paragraph, all evacuees must leave the aeroplane by a means provided as part of the aeroplane’s equipment.

(r) The applicant’s approved procedures must be fully utilised, except the flight-crew must take no active role in assisting others inside the cabin during the demonstration.

(s) The evacuation time period is completed when the last occupant has evacuated the aeroplane and is on the ground. Provided that the acceptance rate of the stand or ramp is no greater than the acceptance rate of the means available on the aeroplane for descent from the wing during an actual crash situation, evacuees using stands or ramps allowed by sub-paragraph (c) of this Appendix are considered to be on the ground when they are on the stand or ramp.

[Amdt. No.:25/2]

9.7 Scenarios of Risk Assessment

Scenario No.: 1
Group of Passengers: infants (up to 2y)
Hazard: DB1-high toxicity

Development of scenario:

Phase Evacuation:

Event:
High toxicity of smoke during fire could seriously harms infants. During fire several extreme toxic substances (e.g. hydrocyanic acid) may set free.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Reduce smoke in cabin
Providing smoke hoods
Avoidance of substances yielding toxic products when burning.

Severity: 1 **Occurrence: B**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 2
Group of Passengers: infants (up to 2y)
Hazard: DD-asphyxiant

Development of scenario:

Phase Evacuation:

Event:
Smoke is asphyxiant. due to lack of oxygen breathing may not be possible anymore.

Precautions:
Common practice: children up to 5 years are accompanied by adults; over 5 years are accompanied by cabin crew.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Reduce smoke in cabin
Providing smoke hoods
Avoidance of substances yielding toxic products when burning.

Severity: 1 **Occurrence: B**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 3
Group of Passengers: infants (up to 2y)
Hazard: HA2-multi g

Development of scenario:

Phase Boarding:

Event:
Infants in double occupancy are restraint by loop belt.

Phase Crash:

Event:
If the infant is being seated on the lap and restrained by loop-belt, high acceleration might lead to serious injuries.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Use of CRS.

Severity: 1 **Occurrence: B**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 4
Group of Passengers: infants (up to 2y)
Hazard: DA3-corrosivity

Development of scenario:

Phase Evacuation:

Event:
Smoke contains gases being corrosive leading to seriously injuries of the respiratory system.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Reduce smoke in cabin
providing smoke hoods
avoidance of substances yielding toxic products when burning.

Severity: 2 **Occurrence: B**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 5
Group of Passengers: infants (up to 2y)
Hazard: AA1-pressure difference

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Due to pressure differences damages of ear-drum are possible.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Severity: 2 **Occurrence: D**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 6
Group of Passengers: infants (up to 2y)
Hazard: AB3-low temperature

Development of scenario:

Phase Boarding:

Event:
Low temperatures due to failures of air condition lead to hypothermia.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same situation applies when entering train or bus with air-condition

Mitigation Measures:
Improve reliability of a/c.

Severity: 2 **Occurrence: D**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 7
Group of Passengers: infants (up to 2y)
Hazard: AB3-low temperature

Development of scenario:

Phase Landing:

Event:
Low temperatures due to failures of air condition or leakage of cabin lead to hypothermia.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same situation applies when entering train or bus with air-condition

Mitigation Measures:
Improve reliability of a/c.

Severity: 2 **Occurrence: D**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 8
Group of Passengers: infants (up to 2y)
Hazard: HA2-multi g

Development of scenario:

Phase Boarding:

Event:
Infants in double occupancy restraint by loop belt.

Phase Turbulences:

Event:
During the flight acceleration caused by turbulences harm infants if they are fixed by loop-belt.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Use of CRS.

Severity: 2 **Occurrence: D**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 9
Group of Passengers: infants (up to 2y)
Hazard: GA2-illness

Development of scenario:

Phase In-Flight:

Event:
Infants may suffer from various diseases with spontaneous symptoms. Especially during long-haul flights these diseases may not be medicated adequately.

Precautions:
The parents of the infant know about the risk connected with flying. It is commonly known that prior to the flight the attending doctor should be consulted and accompanying persons have to be briefed by the parents.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same situation applies during travelling by train or bus

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 10
Group of Passengers: infants (up to 2y)
Hazard: HA2-multi g

Development of scenario:

Phase Boarding:

Event:
Infants in double occupancy restraint by loop belt.

Phase Aborted Take-Off:

Event:
Deceleration due to aborted take-offs will harm infants with loop belt.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Use of CRS.

Remark:
Decelerations during aborted take-off are low.

Severity: 2 **Occurrence: D**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 11
Group of Passengers: infants (up to 2y)
Hazard: AA1-pressure difference

Development of scenario:

Phase Take-Off / Climbing:

Event:
Due to pressure differences damages of ear-drum are possible.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Severity: 2 **Occurrence: E**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 12
Group of Passengers: infants (up to 2y)
Hazard: AA1-pressure difference

Development of scenario:

Phase Landing:

Event:
Due to pressure differences damages of ear-drum are possible.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Severity: 2 **Occurrence: E**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 13
Group of Passengers: infants (up to 2y)
Hazard: AB2-high temperature

Development of scenario:

Phase Boarding:

Event:
High temperatures due to failures of air condition when grounded lead to hyperthermia.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same situation applies when entering train or bus with air-condition

Mitigation Measures:
Improve reliability of a/c.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 14
Group of Passengers: infants (up to 2y)
Hazard: AB2-high temperature

Development of scenario:

Phase Landing:

Event:
High temperatures due to failures of air condition when grounded lead to hyperthermia.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same situation applies when entering train or bus with air-condition

Mitigation Measures:
Improve reliability of a/c.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 15
Group of Passengers: infants (up to 2y)
Hazard: DD-asphyxiant

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
In case of rapid decompression the atmosphere in the cabin is asphyxiant if the oxygen-masks are not applied in appropriate time.

Precautions:
Surrounding passengers are briefed to help Infant next to them.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 16
Group of Passengers: infants (up to 2y)
Hazard: FA2-lack of specific training

Development of scenario:

Phase Boarding:

Event:
Infants are not able to follow a safety-briefing at all.

Phase Evacuation:

Event:
Infants are not able to follow the crews' orders in case of evacuation and may be left back.

Precautions:
Its common practice of the airlines and in the responsibility of the parents not allowing infants to travel unaccompanied.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 17
Group of Passengers: infants (up to 2y)
Hazard: FB2-human judgement error susceptibility

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
If persons accompanying infants put the oxygen mask to the infant prior to themselves, the accompanying person is harmed due to undersupply with oxygen.

Precautions:
In the safety briefing clear procedures regarding order of first using own mask and then helping others.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Remark:
Risk is judged to be mitigated with the instruction.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 18
Group of Passengers: infants (up to 2y)
Hazard: FB2-human judgement error susceptibility

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
If persons accompanying the infant put the oxygen mask first to the infant and only then to themselves, the accompanying passenger could be harmed due to undersupply of oxygen.

Precautions:
In the safety briefing clear procedures regarding order of first using own mask and then helping others are given.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Remark:
Risk is judged to be mitigated with the instruction.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 19
Group of Passengers: infants (up to 2y)
Hazard: GB4-limited human reaction capability

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
In case of rapid decompression the accompanying person may not react in appropriate manner leading to anoxia.

Precautions:
Clear procedures regarding oxygen masks are defined in the safety briefing.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 20
Group of Passengers: infants (up to 2y)
Hazard: GB4-limited human reaction capability

Development of scenario:

Phase Evacuation:

Event:
Infants could not react to the advices of the crew in appropriate time. This seriously harms the infants.

Precautions:
Its common practice of the airlines and in the responsibility of the parents not allowing infants to travel unaccompanied.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same applies to evacuations in trains or coaches

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 21
Group of Passengers: infants (up to 2y)
Hazard: GC1-human vomit

Development of scenario:

Phase In-Flight:

Event:
If an infant seated in CRS is vomiting, asphyxia could be possible.

Precautions:
Its common practice of the airlines and in the responsibility of the parents not allowing infants to travel unaccompanied.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same applies to travel in trains, coaches or cars

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 22
Group of Passengers: infants (up to 2y)
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
The infant being not accompanied will be not able to reach the oxygen masks in the case of rapid decompression.

Precautions:
Its common practice of the airlines and in the responsibility of the parents not allowing infants to travel unaccompanied.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 23
Group of Passengers: infants (up to 2y)
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase Evacuation:

Event:
In case of evacuation the infants could not use overwing exits in the planned manner as their body size is not allowing this.

Precautions:
Its common practice of the airlines and in the responsibility of the parents not allowing infants to travel unaccompanied.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same applies to other means of transport as coaches and trains

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 24
Group of Passengers: infants (up to 2y)
Hazard: AB1-temperature difference

Development of scenario:

Phase Boarding:

Event:
High temperature differences between ambient and cabin temperature harm infants.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same situation applies when entering train or bus with air-condition

Mitigation Measures:
Boarding by jet bridges.

Remark:
To protect children against ambient temperature is in the responsibility of the accompanying persons.

Severity: 3 **Occurrence: E**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 25
Group of Passengers: infants (up to 2y)
Hazard: AB1-temperature difference

Development of scenario:

Phase Disembarking:

Event:
High temperature differences between cabin and ambient temperature harm infants.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same situation applies when entering train or bus with air-condition

Mitigation Measures:
Boarding by jet bridges.

Remark:
To protect children against ambient temperature is in the responsibility of the accompanying persons.

Severity: 3 **Occurrence: E**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 26
Group of Passengers: infants (up to 2y)
Hazard: GB5-limited human autonomy

Development of scenario:

Phase In-Flight:

Event:
If a passenger runs short in baby food, acute undersupply could be the result. This may end up in dangerous conditions for the infant. Especially on long haul flights this may have effect.

Precautions:
Accompanying person knows about flight time and needed food and has full responsibility.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same applies to other means of transport as coaches and trains

Mitigation Measures:
No additional mitigation measures necessary

Severity: 2 **Occurrence: F**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 27
Group of Passengers: infants (up to 2y)
Hazard: HH5-dryness (climate)

Development of scenario:

Phase In-Flight:

Event:
The extreme dryness of the cabin atmosphere supports dehydration of infants. As infants are not aware of this problem, dehydration might reach a critical point.

Precautions:
Parents or accompanying persons need to be aware of this and must offer enough water.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Severity: 2 **Occurrence: F**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 28
Group of Passengers: infants (up to 2y)
Hazard: FB3-human bad information selection susceptibility

Development of scenario:

Phase Evacuation:

Event:
The situation of evacuation may overwhelm the infant leading collapse of the infant could be possible.

Precautions:
Its common practice of the airlines and in the responsibility of the parents not allowing infants to travel unaccompanied.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same applies to other means of transport as coaches and trains

Mitigation Measures:
Rules regarding the minimum age of unaccompanied children should be implemented.

Severity: 3 **Occurrence: F**

Class	H	I	K	L	M	N	O	P	**Q**	R
Risk										

Scenario No.: 29
Group of Passengers: children (up to 7y)
Hazard: AA3-low pressure

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
In case of rapid decompression children are not be able to use the oxygen masks without getting help. This leads to anoxia.

Precautions:
Help of surrounding passengers.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one person accompanying the child.

Severity: 2 **Occurrence: E**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 30
Group of Passengers: children (up to 7y)
Hazard: AB1-temperature difference

Development of scenario:

Phase Boarding:

Event:
High temperature differences between ambient and cabin temperature may harm children.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same situation applies when entering a train or bus with air-condition

Mitigation Measures:
Temperature differences should be avoided by e.g. using a passenger boarding bridge instead of stairs.

Remark:
To protect children against ambient temperature is in the responsibility of the accompanying persons.

Severity: 4 **Occurrence: E**

Class	H	I	K	L	M	N	O	P	**Q**	R
Risk										

Scenario No.: 31
Group of Passengers: children (up to 7y)
Hazard: AB1-temperature difference

Development of scenario:

Phase Disembarking:

Event:
High temperature differences between cabin and ambient temperature may harm children.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same situation applies when entering a train or bus with air-condition

Mitigation Measures:
Temperature differences should be avoided by e.g. using a passenger boarding bridge instead of stairs.

Remark:
To protect children against ambient temperature is in the responsibility of the accompanying persons.

Severity: 4 **Occurrence: E**

Class	H	I	K	L	M	N	O	P	**Q**	R
Risk										

Scenario No.: 32
Group of Passengers: children (up to 7y)
Hazard: AB2-high temperature

Development of scenario:

Phase Boarding:

Event:
High temperatures due to failures of air condition when grounded lead to hyperthermia.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same situation applies when using train or bus with air-condition

Mitigation Measures:
Improvement of reliability and availability of air-condition.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 33
Group of Passengers: children (up to 7y)
Hazard: AB2-high temperature

Development of scenario:

Phase Disembarking:

Event:
High temperatures due to failures of air condition when grounded lead to hyperthermia.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same situation applies when using train or bus with air-condition

Mitigation Measures:
Improvement of reliability and availability of air-condition.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 34
Group of Passengers: children (up to 7y)
Hazard: AB3-low temperature

Development of scenario:

Phase Boarding:

Event:
Low temperatures due to failures of air condition can lead to hypothermia.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same situation applies when entering train or bus with air-condition

Mitigation Measures:
Improvement of reliability and availability of air-condition and aircraft-body.
Providing blankets for children.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 35
Group of Passengers: children (up to 7y)
Hazard: AB3-low temperature

Development of scenario:

Phase Disembarking:

Event:
Low temperatures due to failures of air condition lead to hypothermia.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same situation applies when entering train or bus with air-condition

Mitigation Measures:
Improvement of reliability and availability of air-condition and aircraft-body.
Providing blankets for children.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 36
Group of Passengers: children (up to 7y)
Hazard: DA3-corrosivity

Development of scenario:

Phase Evacuation:

Event:
Smoke may contain gases being corrosive leading to serious injuries of the respiratory system.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Using e.g. water spray systems
Providing smoke hoods for children.

Remark:
Children accompanied by adults/crew are not subject to heightened risk of asphyxiation compared to the average passenger.

Severity: 2 **Occurrence: B**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 37
Group of Passengers: children (up to 7y)
Hazard: DB1-high toxicity

Development of scenario:

Phase Evacuation:

Event:
High toxicity of smoke during fire seriously harms young children. During fire several high toxic substances (e.g. hydrocyanic acid) are set free.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Using e.g. water spray systems
Providing of smoke hoods for children
Avoidance of substances yielding toxic products when burning.

Remark:
Children accompanied by adults/crew are not subject to heightened risk of asphyxiation compared to the average passenger.

Severity: 1 **Occurrence: B**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 38
Group of Passengers: children (up to 7y)
Hazard: DD-asphyxiant

Development of scenario:

Phase Evacuation:

Event:
Smoke could be asphyxiant. Breathing may not be possible anymore.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Reduction of smoke

Remark:
Children accompanied by adults/crew are not subject to heightened risk of asphyxiation compared to the average passenger.

Severity: 1 **Occurrence: B**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 39
Group of Passengers: children (up to 7y)
Hazard: FB1-human decision error susceptibility

Development of scenario:

Phase Evacuation:

Event:
Misjudgement of the situation during evacuation (not understanding the evacuation process) leads to delays and harms other passengers.

Precautions:
Common practice: children up to 5 years are accompanied by adults, over 5 years are accompanied by cabin crew.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
Yes: The same applies for other means of transport (coaches, trains)

Mitigation Measures:
At least one accompanying person should be available.

Severity: 0 **Occurrence: E**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 40
Group of Passengers: children (up to 7y)
Hazard: DD-asphyxiant

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
In case of rapid decompression the atmosphere in the cabin is asphyxiant if the oxygen-masks are not applied in appropriate time.

Precautions:
Surrounding passengers are advised to help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Child has to be accompanied by at least one person being responsible for putting on the oxygen masks for the child.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 41
Group of Passengers: children (up to 7y)
Hazard: EB4-slipperiness

Development of scenario:

Phase In-Flight:

Event:

Fatigue during long-haul flight causes physical weakness.

Phase Evacuation:

Event:
In case of evacuation - especially if structural damage of the aircraft occurs - children may stumble in this situation or might slip away when leaving the aircraft.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: The same applies for other means of transport (coaches, trains)

Mitigation Measures:
At least one person should accompany the child

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 42
Group of Passengers: children (up to 7y)
Hazard: EB4-slipperiness

Development of scenario:

Phase Boarding:

Event:
During boarding children may stumble on the way to the seat leading to injuries.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: The same applies for other means of transport (coaches, trains)

Mitigation Measures:
At least one person should accompany the child during boarding and disembarkment.

Severity: 3 **Occurrence: E**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 43
Group of Passengers: children (up to 7y)
Hazard: EB4-slipperiness

Development of scenario:

Phase In-Flight:

Event:
Fatigue during long-haul flight causes physical weakness.

Phase Disembarking:

Event:
During disembarkment children could slip and/or trip over obstacles leading to injuries and breaking their bones.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: The same applies for other means of transport (coaches, trains)

Mitigation Measures:
At least one person should accompany the child during boarding and disembarkment.

Severity: 3 **Occurrence: E**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 44
Group of Passengers: children (up to 7y)
Hazard: FA2-lack of specific training

Development of scenario:

Phase Boarding:

Event:
The safety briefing is not suitable for children (lack of understanding the procedures or lack of understanding the language).

Phase Crash:

Event:
Children are not able to adopt the brace-position as they are not able to extract this information from the safety- cards.

Precautions:
Common practice: children up to 5 years are accompanied by adults, over 5 years are accompanied by cabin crew.
Surrounding passengers may help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Offering a special safety card for children. Special briefing for unaccompanied children and surrounding passengers.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 45
Group of Passengers: children (up to 7y)
Hazard: FA2-lack of specific training

Development of scenario:

Phase Boarding:

Event:
The safety briefing is not suitable for children.

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Children may not be able to use the oxygen masks on their own, as the safety-briefing is not suitable for children.

Precautions:
Surrounding passengers are advised to help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Offering a special safety briefing for children.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 46
Group of Passengers: children (up to 7y)
Hazard: FB1-human decision error susceptibility

Development of scenario:

Phase Evacuation:

Event:
During evacuation the child could wrongly use an adjacent exit and delaying its own evacuation.

Precautions:
Common practice: children up to 5 years are accompanied by adults; over 5 years are accompanied by airlines-staff.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 47
Group of Passengers: children (up to 7y)
Hazard: FB1-human decision error susceptibility

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
If persons accompanying infants put the oxygen mask to the infant prior to themselves, the accompanying person may faint and thus oxygen supply for both may be interrupted.

Precautions:
Information regarding order of self-protection and helping others is given during safety-briefing.

Precautions:
Surrounding passengers are advised to help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 48
Group of Passengers: children (up to 7y)
Hazard: FB2-human judgement error susceptibility

Development of scenario:

Phase Aborted Take-Off:

Event:
Judgement errors of the child regarding the situation seriously harms the child when opening the seatbelt prior to aborted take-off.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: The same applies for e.g. coaches or cars (emergency breaking)

Mitigation Measures:
At least one accompanying person should be available.

Severity: 2 **Occurrence: F**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 49
Group of Passengers: children (up to 7y)
Hazard: FB2-human judgement error susceptibility

Development of scenario:

Phase Turbulences:

Event:
Judgement errors of the child regarding the situation seriously harms the child if it opens the seatbelt during turbulences.

Precautions:
Surrounding passengers are advised to help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: The same applies for e.g. coaches or cars (emergency breaking, change manoeuvre)

Mitigation Measures:
At least one accompanying person should be available.

Severity: 2 **Occurrence: D**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 50
Group of Passengers: children (up to 7y)
Hazard: FB2-human judgement error susceptibility

Development of scenario:

Phase Landing:

Event:
Judgement errors of the child regarding the situation could lead to opening the seatbelt during emergency landing.

Phase Crash:

Event:
In case of crash the child is not restraint. This leads to serious injuries during crash.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: The same applies for e.g. coaches or cars

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 51
Group of Passengers: children (up to 7y)
Hazard: FB3-human bad information selection susceptibility

Development of scenario:

Phase Evacuation:

Event:
Due to a lot of impulses (e.g. smoke, heat) and impressions (e.g. fire, victims) children may not be able to concentrate on crews' advices leading to a delay in evacuation and thus harming passengers.

Precautions:
Common practice: children up to 5 years are accompanied by adults; over 5 years are accompanied by cabin crew.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 0 **Occurrence: E**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 52
Group of Passengers: children (up to 7y)
Hazard: FB3-human bad information selection susceptibility

Development of scenario:

Phase Evacuation:

Event:
Due to a lot of impulses (e.g. smoke, heat) and impressions (e.g. fire, victims) children could not concentrate on crews' advices leading to a significant delay in evacuation and harming the child.

Precautions:
Common practice: children up to 5 years are accompanied by adults; over 5 years are accompanied by cabin crew.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: D**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 53
Group of Passengers: children (up to 7y)
Hazard: FB3-human bad information selection susceptibility

Development of scenario:

Phase Boarding:

Event:
Due to bad information selection susceptibility and many new impressions children may not focus on safety-briefing.

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
In case of decompression the child is not trained what to do.

Precautions:
Help of surrounding passengers.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Special safety-briefing for children.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 54
Group of Passengers: children (up to 7y)
Hazard: FB3-human bad information selection susceptibility

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Due to a lot of impulses and impressions (e.g. pain, noise, wind) children may not be able to concentrate on crew's advices.

Precautions:
Help of surrounding passengers.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 55
Group of Passengers: children (up to 7y)
Hazard: FC3-lack of adaptability of human being

Development of scenario:

Phase Evacuation:

Event:
The situation of evacuation may overwhelm the child leading to delays of evacuation.

Precautions:
Common practice: children up to 5 years are accompanied by adults; over 5 years are accompanied by cabin crew.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
Yes: The same applies for other means of transport (coaches, trains)

Mitigation Measures:
At least one accompanying person should be available.

Severity: 0 **Occurrence: E**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 56
Group of Passengers: children (up to 7y)
Hazard: FD1-poor motivation

Development of scenario:

Phase Evacuation:

Event:
Due to missing risk perception children are not realizing the seriousness of evacuation. This leads to extensive delays even if the child would be physically able to evacuate itself and so harming other passengers.

Precautions:
Common practice: children up to 5 years are accompanied by adults; over 5 years are accompanied by cabin crew.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one person having sufficient authority should accompany the child.

Severity: 0 **Occurrence: E**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 57
Group of Passengers: children (up to 7y)
Hazard: FD1-poor motivation

Development of scenario:

Phase Evacuation:

Event:
Due to missing risk perception children may not realize the seriousness of evacuation. This harms the child due to delay of its own evacuation.

Precautions:
Common practice: children up to 5 years are accompanied by adults; over 5 years are accompanied by cabin crew.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: The same applies for other means of transport (coaches, trains)

Mitigation Measures:
At least one person having sufficient authority should accompany the child.

Severity: 1 **Occurrence: D**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 58
Group of Passengers: children (up to 7y)
Hazard: FD1-poor motivation

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Due to missing risk perception children may not realise the seriousness of a rapid decompression and not use the oxygen mask in appropriate time.

Precautions:
Common practice: children up to 5 years are accompanied by adults; over 5 years are accompanied by cabin crew.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one person should accompany the child with sufficient authority.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 59
Group of Passengers: children (up to 7y)
Hazard: FD2-distraction susceptibility

Development of scenario:

Phase Boarding:

Event:
Due to many new impressions and impulse the possibility for distraction is very high. This will lead to missing attention during the safety-briefing.

Precautions:
Common practice: children up to 5 years are accompanied by adults; over 5 years are accompanied by cabin crew.

Phase Evacuation:

Event:
In case of evacuation the child is not trained how to react. This leads to delays in evacuation harming passengers.

Precautions:
Common practice: children up to 5 years are accompanied by adults; over 5 years are accompanied by cabin crew.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
Special safety briefing for children.

Severity: 0 **Occurrence: E**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 60
Group of Passengers: children (up to 7y)
Hazard: FD2-distraction susceptibility

Development of scenario:

Phase Boarding:

Event:
Due to many new impressions and impulse the possibility for distraction is very high. This will lead to missing attention during the safety-briefing.

Precautions:
Common practice: children up to 5 years are accompanied by adults; over 5 years are accompanied by cabin crew.

Phase Evacuation:

Event:
In case of evacuation the child is not trained how to react. This leads to delays in evacuation harming the child.

Precautions:
Common practice: children up to 5 years are accompanied by adults; over 5 years are accompanied by cabin crew.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Special safety briefing for children.

Severity: 1 **Occurrence: D**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 61
Group of Passengers: children (up to 7y)
Hazard: FD2-distraction susceptibility

Development of scenario:

Phase Boarding:

Event:
Due to many new impressions and impulses distraction is very probable. This will lead to missing attention during the safety-briefing.

Precautions:
Common practice: children up to 5 years are accompanied by adults; over 5 years are accompanied by cabin crew.

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
In case of decompression the child is not trained how to react.

Precautions:
Common practice: children up to 5 years are accompanied by adults; over 5 years are accompanied by cabin crew.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Special safety briefing for children.
Alternatively: accompanying person for the child.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 62
Group of Passengers: children (up to 7y)
Hazard: GB1-limited human strength

Development of scenario:

Phase Evacuation:

Event:
Due to limited human strength children might not be able to perform the evacuation process in appropriate time harming other passengers.

Precautions:
Help of surrounding passengers
Common practice: children up to 5 years are accompanied by adults, over 5 years are accompanied by airlines-staff.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 0 **Occurrence: E**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 63
Group of Passengers: children (up to 7y)
Hazard: GB1-limited human strength

Development of scenario:

Phase Evacuation:

Event:
Due to limited human strength children might not be able to perform the evacuation process in appropriate time harming other passengers.

Precautions:
Common practice: children up to 5 years are accompanied by adults; over 5 years are accompanied by cabin crew.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 0 **Occurrence: E**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 64
Group of Passengers: children (up to 7y)
Hazard: GB2-limited human flexibility

Development of scenario:

Phase Evacuation:

Event:
Limited human flexibility leads to a problem during evacuation and emergency landing if orders of the crew are not put into action. This harms the child or lead to delay of evacuation harming the child.

Precautions:
Common practice: children up to 5 years are accompanied by adults; over 5 years are accompanied by cabin crew.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: D**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 65
Group of Passengers: children (up to 7y)
Hazard: GB2-limited human flexibility

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Due to limited human flexibility children could not adapt to the new situation. This may lead to asphyxia.

Precautions:
Common practice: children up to 5 years are accompanied by adults; over 5 years are accompanied by cabin crew.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 66
Group of Passengers: children (up to 7y)
Hazard: GB4-limited human reaction capability

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
At high altitudes limited human reaction capability during rapid decompression might lead to anoxia quickly.

Precautions:
Common practice: children up to 5 years are accompanied by adults; over 5 years are accompanied by cabin crew.
Passengers in surrounding are advised to help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 67
Group of Passengers: children (up to 7y)
Hazard: HA2-multi g

Development of scenario:

Phase Boarding:

Event:
Child is restrained by lap belt.

Phase Landing:

Event:
Due to body height the child might not being fully restrained by the lapbelt. Hard landing might lead to injuries.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Use of CRS.

Severity: 2 **Occurrence: D**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 68
Group of Passengers: children (up to 7y)
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Due to limited body height children could not reach the oxygen masks. This may lead to anoxia quickly in high altitudes.

Precautions:
Help of surrounding passengers.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 69
Group of Passengers: children (up to 7y)
Hazard: HA2-multi g

Development of scenario:

Phase Boarding:

Event:
Child is restrained by lap belt.

Phase Crash:

Event:
In case of a crash very high forces will occur. The lapbelt is no adequate restraint system.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No: Due to higher speed the resulting deceleration may be higher than in e.g. coaches

Mitigation Measures:
Use of CRS.

Severity: 1 **Occurrence: B**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 70
Group of Passengers: children (up to 7y)
Hazard: HA2-multi g

Development of scenario:

Phase Aborted Take-Off:

Event:
Deceleration due to aborted take-off will harm children.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Use of CRS.

Remark:
Decelerations during aborted take-off are low.

Severity: 3 **Occurrence: B**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 71
Group of Passengers: children (up to 7y)
Hazard: HA2-multi g

Development of scenario:

Phase Turbulences:

Event:
Children could not realize the importance of seatbelts and may open it or not using it during the seatbelt-signs are switched on.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: The same applies for other means of transport (coaches, trains)

Mitigation Measures:
At least one accompanying person should be available.

Severity: 2 **Occurrence: D**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 72
Group of Passengers: children (up to 7y)
Hazard: HA2-multi g

Development of scenario:

Phase Turbulences:

Event:
Severe turbulences with high forces during the flight may harm children as the restraint system with lapbelts might not be adequate.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Use of CRS.

Severity: 3 **Occurrence: B**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 73
Group of Passengers: children (up to 7y)
Hazard: HH5-dryness

Development of scenario:

Phase In-Flight:

Event:
The extreme dryness of the cabin atmosphere supports dehydration of children. As children are not aware of this problem, dehydration might reach a critical point.

Precautions:
Water is severed during the flight.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Special care must be given for ingest water.

Severity: 3 **Occurrence: E**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 74
Group of Passengers: children (up to 7y)
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase Boarding:

Event:
Due to stress during boarding the attention for the safety briefing could be limited.

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Rapid decompression leads to stress resulting in nervous breakdown or inappropriate behaviour. This could lead to undersupply of oxygen.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Persons knowing the child very well should accompany it.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 75
Group of Passengers: children (up to 7y)
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase Boarding:

Event:
Due to stress during boarding the attention for the safety briefing could be limited.

Phase Evacuation:

Event:
Emergency situations lead to stress resulting in nervous breakdown or inappropriate behaviour.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Persons knowing the child very well should accompany it.

Severity: 1 **Occurrence: D**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 76
Group of Passengers: children (up to 12y)
Hazard: DA3-corrosivity

Development of scenario:

Phase Evacuation:

Event:
Smoke may contain gases being corrosive leading to serious injuries of the respiratory system.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Using e.g. water-spray systems to reduce smoke emission and to wash out toxic substances.
Providing smoke hoods
Avoidance of substances yielding toxic products when burning.

Remark:
Children accompanied by adults/crew are not subject to heightened risk of chemical burn compared to the average passenger.

Severity: 2 **Occurrence: B**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 77
Group of Passengers: children (up to 12y)
Hazard: DB1-high toxicity

Development of scenario:

Phase Evacuation:

Event:
High toxicity of smoke during fire seriously harms children. During fire several highly toxic substances (e.g. hydrocyanic acid) are set free.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Using e.g. water-spray systems to reduce smoke emission and to wash out toxic substances.
Providing smoke hoods
Avoidance of substances yielding toxic products when burning.

Severity: 1 **Occurrence: B**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 78
Group of Passengers: children (up to 12y)
Hazard: DD-asphyxiant

Development of scenario:

Phase Evacuation:

Event:
Smoke is asphyxiant. Breathing is not possible anymore.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: D**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 79
Group of Passengers: children (up to 12y)
Hazard: DD-asphyxiant

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
In case of rapid decompression the atmosphere in the cabin is asphyxiant. If oxygen-masks are not applied in appropriate time the child might suffer from anoxia.

Precautions:
Surrounding passengers could help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Child has to be accompanied by at least one person being responsible for putting on the oxygen masks to the child.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 80
Group of Passengers: children (up to 12y)
Hazard: FA2-lack of specific training

Development of scenario:

Phase Boarding:

Event:
The safety briefing is not suitable for children.

Phase Crash:

Event:
Children are not able to adopt the brace-position as they are not able to extract this information from the safety-cards.

Precautions:
Common practice: accompanied by cabin crew or other adults.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Offering a special safety card for children and brief the content of the safety card.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 81
Group of Passengers: children (up to 12y)
Hazard: FA2-lack of specific training

Development of scenario:

Phase Boarding:

Event:
The safety briefing is not suitable for children.

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Children could not use the oxygen masks on their own, as the safety-briefing is not suitable for children.

Precautions:
Surrounding passengers are advised to help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Offering a special safety briefing for children.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 82
Group of Passengers: children (up to 12y)
Hazard: FB1-human decision error susceptibility

Development of scenario:

Phase Evacuation:

Event:
During evacuation the child could use an adjacent, but unsuitable exit and thus delaying evacuation harming passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 0 **Occurrence: E**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 83
Group of Passengers: children (up to 12y)
Hazard: FB1-human decision error susceptibility

Development of scenario:

Phase Evacuation:

Event:
During evacuation the child could use an adjacent, but unsuitable exit and thus delaying evacuation harming itself.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 84
Group of Passengers: children (up to 12y)
Hazard: FB1-human decision error susceptibility

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Helping the child first to put on the oxygen mask may harm the accompanying person due to anoxia.

Precautions:
Information regarding order of self-protection and helping others is given during safety-briefing.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Severity: 2 **Occurrence: F**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 85
Group of Passengers: children (up to 12y)
Hazard: FB1-human decision error susceptibility

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Helping the child first to put on the oxygen mask may harm the child due to anoxia.

Precautions:
Information regarding order of self-protection and helping others is given during safety-briefing.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 86
Group of Passengers: children (up to 12y)
Hazard: FB2-human judgement error susceptibility

Development of scenario:

Phase Evacuation:

Event:
Misjudgement of the situation during evacuation leads to delays and harming other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 0 **Occurrence: E**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 87
Group of Passengers: children (up to 12y)
Hazard: FB2-human judgement error susceptibility

Development of scenario:

Phase Evacuation:

Event:
Misjudgement of the situation during evacuation leads to delay harming the child itself.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 88
Group of Passengers: children (up to 12y)
Hazard: FB2-human judgement error susceptibility

Development of scenario:

Phase Aborted Take-Off:

Event:
Judgement errors of the child regarding the situation seriously harm the child when opening the seatbelt prior to aborted take-off.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: The same applies for e.g. coaches or cars (e.g. emergency breaking)

Mitigation Measures:
At least one accompanying person should be available.

Severity: 2 **Occurrence: F**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 89
Group of Passengers: children (up to 12y)
Hazard: FB2-human judgement error susceptibility

Development of scenario:

Phase Turbulences:

Event:
Judgement errors of the child regarding the situation seriously harm the child when it opens the seatbelt during turbulences.

Precautions:
Surrounding passengers are advised to help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: The same applies for e.g. coaches or cars (emergency breaking, change manoeuvre)

Mitigation Measures:
At least one accompanying person should be available.

Severity: 2 **Occurrence: E**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 90
Group of Passengers: children (up to 12y)
Hazard: FB2-human judgement error susceptibility

Development of scenario:

Phase Landing:

Event:
Judgement errors of the child regarding the situation could lead to opening the seatbelt during emergency landing.

Phase Crash:

Event:
In case of crash the child may not be restraint. This leads to serious injuries during crash.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: The same applies for e.g. coaches or cars

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 91
Group of Passengers: children (up to 12y)
Hazard: FB3-human bad information selection susceptibility

Development of scenario:

Phase Evacuation:

Event:
Due to a lot of impulses and impressions (e.g. smoke, heat, fire, victims) children are not able to concentrate on crews' advices leading to a significant delay in evacuation harming passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 0 **Occurrence: E**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 92
Group of Passengers: children (up to 12y)
Hazard: FB3-human bad information selection susceptibility

Development of scenario:

Phase Evacuation:

Event:
Due to a lot of impulses and impressions (e.g. smoke, heat, fire, victims) children could not concentrate on crews' advices leading to a significant delay in evacuation harming the child itself.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 93
Group of Passengers: children (up to 12y)
Hazard: FB3-human bad information selection susceptibility

Development of scenario:

Phase Boarding:

Event:
Due to bad information selection susceptibility and many new impressions children could not focus on safety-briefing.

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
In case of decompression the child is not trained what to do.

Precautions:
Help of surrounding passengers.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Special safety-briefing for children.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 94
Group of Passengers: children (up to 12y)
Hazard: FB3-human bad information selection susceptibility

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Due to a lot of impulses and impressions (e.g. pain, noise, wind) children could not concentrate on crews' advices.

Precautions:
Help of surrounding passengers.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person must be available.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 95
Group of Passengers: children (up to 12y)
Hazard: FC3-lack of adaptability of human being

Development of scenario:

Phase Evacuation:

Event:
The situation of evacuation could overwhelm the child leading to extensive delays of evacuation. A collapse of the child may also be possible.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: The same applies for other means of transport (coaches, trains)

Mitigation Measures:
At least one accompanying person should be available.

Severity: 3 **Occurrence: C**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 96
Group of Passengers: children (up to 12y)
Hazard: FD2-distraction susceptibility

Development of scenario:

Phase Boarding:

Event:
Due to many new impressions and impulses the possibility for distraction is very high. This could lead to missing attention during the safety-briefing.

Phase Evacuation:

Event:
In case of evacuation the child is not trained what to do. This could lead to delay and could harm passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
Special safety-briefing for children.

Severity: 0 **Occurrence: E**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 97
Group of Passengers: children (up to 12y)
Hazard: FD2-distraction susceptibility

Development of scenario:

Phase Boarding:

Event:
Due to many new impressions and impulses the possibility for distraction is very high. This could lead to missing attention during the safety-briefing.

Phase Evacuation:

Event:
In case of evacuation the child is not trained what to do. This could lead to delay and may harm the child itself.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Special safety-briefing for children.

Severity: 1 **Occurrence: D**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 98
Group of Passengers: children (up to 12y)
Hazard: FD2-distraction susceptibility

Development of scenario:

Phase Boarding:

Event:
Due to many new impressions and impulses the possibility for distraction is very high. This could lead to missing attention during the safety-briefing.

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
In case of decompression the child is not trained how to use the oxygen mask. This may lead to anoxia.

Precautions:
Help of surrounding passengers.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Special safety-briefing for children.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 99
Group of Passengers: children (up to 12y)
Hazard: GB1-limited human physical strength

Development of scenario:

Phase Evacuation:

Event:
Due to limited human strength children could not perform the evacuation process in appropriate time.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: The same applies for other means of transport (coaches, trains)

Mitigation Measures:
At least one accompanying person should be available all the flight being able to carry the child.

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 100
Group of Passengers: children (up to 12y)
Hazard: GB2-limited human flexibility

Development of scenario:

Phase Evacuation:

Event:
Limited human flexibility can lead to a problem during evacuation and emergency landing if orders of the crew are not put into action.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: D**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 101
Group of Passengers: children (up to 12y)
Hazard: GB2-limited human flexibility

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Due to limited human flexibility children could not adapt to the new situation resulting in anoxia.

Precautions:
Surrounding passengers are advised to help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 102
Group of Passengers: children (up to 12y)
Hazard: GB4-limited human reaction capability

Development of scenario:

Phase Evacuation:

Event:
Limited human reaction capability could lead during emergency landing and evacuation to dangerous situations and to significant delays harming passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available all the flight being able to carry the child.

Severity: 0 **Occurrence: E**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 103
Group of Passengers: children (up to 12y)
Hazard: GB4-limited human reaction capability

Development of scenario:

Phase Evacuation:

Event:
Limited human reaction capability might lead during emergency landing and evacuation to dangerous situations and to significant delays harming the child itself.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available being able to carry the child.

Severity: 1 **Occurrence: D**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 104
Group of Passengers: children (up to 12y)
Hazard: GB4-limited human reaction capability

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
At high altitudes limited human reaction capability during rapid decompression could lead to anoxia quickly.

Precautions:
Surrounding passengers are advised to help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person must be available.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 105
Group of Passengers: children (up to 12y)
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Due to the limited body height children might not be able to reach the oxygen masks. In high altitudes this can lead to anoxia quickly.

Precautions:
Help of surrounding passengers.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 106
Group of Passengers: children (up to 12y)
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Rapid decompression can lead to emotional pressure leading to nervous breakdown or inappropriate behaviour.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: The same applies for other means of transport (coaches, trains)

Mitigation Measures:
Persons knowing the child very well should accompany it.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 107
Group of Passengers: children (up to 12y)
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase Evacuation:

Event:
Emergency situations can lead to emotional pressure resulting in nervous breakdown or inappropriate behaviour.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: The same applies for other means of transport (coaches, trains)

Mitigation Measures:
Persons knowing the child very well should accompany it.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 108
Group of Passengers: expectant mothers
Hazard: AB1-temperature difference

Development of scenario:

Phase Boarding:

Event:
High temperature differences between ambient and cabin temperature could harm expectant mothers as their cardiovascular system is already stressed due to pregnancy.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same applies when entering an air-conditioned bus or train

Mitigation Measures:
Temperature differences should be avoided by e.g. using a passenger boarding bridge instead of stairs.

Remark:
It is within the responsibility of an expectant mother to decide whether to fly or not after consultation of her physician.

Severity: 3 **Occurrence: E**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 109
Group of Passengers: expectant mothers
Hazard: AB1-temperature difference

Development of scenario:

Phase Disembarking:

Event:
High temperature differences between cabin and ambient temperature could harm expectant mothers as their cardiovascular system is already stressed due to pregnancy.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same applies when entering an air-conditioned bus or train.

Mitigation Measures:
Temperature differences should be avoided by e.g. using a passenger boarding bridge instead of stairs.

Remark:
It is within the responsibility of an expectant mother to decide whether to fly or not after consultation of her physician.

Severity: 3 **Occurrence: E**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 110
Group of Passengers: expectant mothers
Hazard: EB4-slipperiness

Development of scenario:

Phase Evacuation:

Event:
Due to problems with overall physique and weakness the risk of slipping is increased for expectant mothers.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same applies for other means of transport (coaches, trains)

Mitigation Measures:
Avoid slippery surfaces where possible.

Remark:
This type of risk is also present in other everyday situations for expectant mothers. It is sufficient, to avoid slippery surfaces to such an extent as for all other passengers.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 111
Group of Passengers: expectant mothers
Hazard: EB4-slipperiness

Development of scenario:

Phase Boarding:

Event:
Due to problems with overall physique and weakness the risk of slipping is increased for expectant mothers.

Precautions:
Slip resistant floor.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No boarding over slippery apron.

Remark:
This type of risk is also present in other everyday situations for expectant mothers. It is sufficient, to avoid slippery surfaces to such an extent as for all other passengers.

Severity: 3 **Occurrence: E**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 112
Group of Passengers: expectant mothers
Hazard: EB4-slipperiness

Development of scenario:

Phase Disembarking:

Event:
Due to problems with overall physique and weakness the risk of slipping is increased for expectant mothers.

Precautions:
Slip resistant floor.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No boarding over slippery apron.

Remark:
This type of risk is also present in other everyday situations for expectant mothers. It is sufficient, to avoid slippery surfaces to such an extent as for all other passengers.

Severity: 3 **Occurrence: E**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 113
Group of Passengers: expectant mothers
Hazard: FC1-emotions (fear, joy, etc.) susceptibility

Development of scenario:

Phase Boarding:

Event:
As expectant mothers could have mood swings strong emotions during boarding can lead to deficits in information reception (e.g. during safety briefing).

Phase Evacuation:

Event:
Due to inattention during safety briefing the passenger might delay evacuation harming other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Remark:
It is within the responsibility of an expectant mother to decide whether to fly or not after consultation of her physician.

Severity: 0 **Occurrence: F**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.:	114
Group of Passengers:	expectant mothers
Hazard:	FC1-emotions (fear, joy, etc.) susceptibility

Development of scenario:

Phase Evacuation:

Event:
As expectant mothers could have mood swings strong emotions during evacuation this may lead to improper reaction to crew-orders and delayed evacuation harming passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Remark:
It is within the responsibility of an expectant mother to decide whether to fly or not after consultation of her physician.

Severity: 0 **Occurrence: F**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 115
Group of Passengers: expectant mothers
Hazard: FC1-emotions (fear, joy, etc.) susceptibility

Development of scenario:

Phase Crash:

Event:
As expectant mothers could have mood swings, strong emotions during or prior to a crash are possible. This may lead to delay adapting the brace position.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Remark:
It is within the responsibility of an expectant mother to decide whether to fly or not after consultation of her physician.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 116
Group of Passengers: expectant mothers
Hazard: FC1-emotions (fear, joy, etc.) susceptibility

Development of scenario:

Phase Boarding:

Event:
As expectant mothers could have mood swings strong emotions during boarding can lead to deficits in information reception (e.g. during safety briefing).

Phase Evacuation:

Event:
Due to inattention during safety briefing expectant mothers could delay evacuation harming themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Remark:
It is within the responsibility of an expectant mother to decide whether to fly or not after consultation of her physician.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 117
Group of Passengers: expectant mothers
Hazard: FC1-emotions (fear, joy, etc.) susceptibility

Development of scenario:

Phase Evacuation:

Event:
As expectant mothers could have mood swings strong emotions during evacuation may lead to improper reaction to crew-orders and delayed evacuation harming themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Remark:
It is within the responsibility of an expectant mother to decide whether to fly or not after consultation of her physician.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 118
Group of Passengers: expectant mothers
Hazard: FC1-emotions (fear, joy, etc.) susceptibility

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
As expectant mother could have mood swings strong emotions during decompression may lead to delayed reaction which may harm the foetus and the expectant mother due to anoxia.

Precautions:
Surrounding passengers are advised to help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Not placing expectant mothers alone.

Remark:
It is within the responsibility of an expectant mother to decide whether to fly or not after consultation of her physician.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 119
Group of Passengers: expectant mothers
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase Boarding:

Event:
Stress due to the possible new situation of using an aircraft could lead to a high stress level that may result up to premature birth.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Remark:
It is within the responsibility of an expectant mother to decide whether to fly or not after consultation of her physician.

Severity: 2 **Occurrence: F**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 120
Group of Passengers: expectant mothers
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase Aborted Take-Off:

Event:
Stress due to aborted take-off could lead to a high stress level which may result up to premature birth.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Remark:
It is within the responsibility of an expectant mother to decide whether to fly or not after consultation of her physician.

Severity: 2 **Occurrence: E**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 121
Group of Passengers: expectant mothers
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Stress due to rapid decompression could lead to a high stress level which may result up to premature birth.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Remark:
It is within the responsibility of an expectant mother to decide whether to fly or not after consultation of her physician.

Severity: 2 **Occurrence: E**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 122
Group of Passengers: expectant mothers
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase Crash:

Event:
Stress due to crash could lead to a high stress level which may result up to premature birth.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Remark:
It is within the responsibility of an expectant mother to decide whether to fly or not after consultation of her physician.

Severity: 2 **Occurrence: D**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 123
Group of Passengers: expectant mothers
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase Evacuation:

Event:
Stress due to evacuation could lead to a high stress level which can result up to premature birth.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Remark:
It is within the responsibility of an expectant mother to decide whether to fly or not after consultation of her physician.

Severity: 2 **Occurrence: D**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 124
Group of Passengers: expectant mothers
Hazard: GA2-illness

Development of scenario:

Phase In-Flight:

Event:
Any problems due to the pregnancy could seriously harm the expectant mothers and the unborn.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Medical kit with appropriate content and medically trained persons should be available.

Severity: 2 **Occurrence: E**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 125
Group of Passengers: expectant mothers
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase Evacuation:

Event:
During evacuation expectant mothers could not evacuate as fast as the other passengers. This may lead to delays harming passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
Support expectant mothers by other passengers or cabin personnel.

Remark:
It is within the responsibility of an expectant mother to decide whether to fly or not after consultation of her physician.

Severity: 0 **Occurrence: C**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 126
Group of Passengers: expectant mothers
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase Evacuation:

Event:
During evacuation expectant mothers could not evacuate as fast as the other passengers. This may lead to delays harming the expectant mother herself.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Support expectant mothers by other passengers or cabin personnel.

Remark:
It is within the responsibility of an expectant mother to decide whether to fly or not after consultation of her physician.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 127
Group of Passengers: expectant mothers
Hazard: GD3-uncomfortable position (human discomfort)

Development of scenario:

Phase In-Flight:

Event:
During flight the expectant mother is seated in a position leading to a special risk for deep venous thrombosis.

Precautions:
Its common knowledge that compression stockings should be used.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Appropriate seat pitch and seat size.
Offering of a higher class if possible and advised.

Remark:
It is within the responsibility of an expectant mother to decide whether to fly or not after consultation of her physician.

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 128
Group of Passengers: expectant mothers
Hazard: GD3-uncomfortable position (human discomfort)

Development of scenario:

Phase In-Flight:

Event:
Due to an uncomfortable position during flights (esp. long-haul-flights) the stress level for the expectant mother could be very high. This may lead to complications up to premature birth.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Appropriate seat pitch and seat size.
Offering of a higher class if possible and advised.

Severity: 2 **Occurrence: F**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 129
Group of Passengers: expectant mothers
Hazard: HA2-multi g

Development of scenario:

Phase Crash:

Event:
High forces in crashes could be dangerous for expectant mothers. Due to lap restraint the foetus may die.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
Yes: Same applies for lap belt restraint in coaches

Mitigation Measures:
Three-point harness or rear facing seats.

Severity: 2 **Occurrence: C**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 130
Group of Passengers: expectant mothers
Hazard: HA2-multi g

Development of scenario:

Phase Turbulences:

Event:
Due to turbulences forces could lead to load on the foetus and the uterus. This may result in abort.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Remark:
It is within the responsibility of an expectant mother to decide whether to fly or not after consultation of her physician.

Severity: 2 **Occurrence: D**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.:	131
Group of Passengers:	expectant mothers
Hazard:	HA2-multi g

Development of scenario:

Phase Turbulences:

Event:
Severe turbulences could seriously harm the foetus.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Remark:
It is within the responsibility of an expectant mother to decide whether to fly or not after consultation of her physician.

Severity: 3 **Occurrence: C**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 132
Group of Passengers: expectant mothers
Hazard: HA2-multi g

Development of scenario:

Phase Crash:

Event:
Expectant mothers might not be able to adopt the brace position properly which may lead to serious injuries and abort in case of crash.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Consider specific position for expectant mothers.

Remark:

It is within the responsibility of an expectant mother to decide whether to fly or not after consultation of her physician.

Severity: 2 **Occurrence: E**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 133
Group of Passengers: small adults
Hazard: GB1-limited human physical strength

Development of scenario:

Phase Evacuation:

Event:
Small adults with limited human physical strength might cause delays during evacuation and harm other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Severity: 0 **Occurrence: F**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 134
Group of Passengers: small adults
Hazard: GB1-limited human physical strength

Development of scenario:

Phase Evacuation:

Event:
Small adults with limited human physical strength might cause delays during evacuation and harm themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 135
Group of Passengers: small adults
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase Evacuation:

Event:
Small adults with bad anthropometric characteristics might have problems using the overwing exits, which could cause delays during the evacuation and could harm other passengers.

Precautions:
Other passengers or the crew assist small adults at the exits.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Severity: 0 **Occurrence: E**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 136
Group of Passengers: small adults
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase Evacuation:

Event:
Small adults with bad anthropometric characteristics might have problems using the over wing-exits, which could cause delays during the evacuation and could harm themselves.

Precautions:
Other passengers or the crew assist small adults at the exits.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 137
Group of Passengers: small adults
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase Evacuation:

Event:
Small adults might have problems leaving their seat quickly on their own, which could cause delays during the evacuation and could harm other passengers.

Precautions:
Other passengers or the crew assist small adults.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Other passengers sitting next to the small adult should help.

Severity: 1 **Occurrence: D**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 138
Group of Passengers: small adults
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
In case when oxygen is needed small adults with bad anthropometric characteristics might not be able to reach the oxygen masks without help. Depending on the aircraft's altitude this could lead to anoxia quickly.

Precautions:
Passengers in surrounding are advised to help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Other passengers sitting next to the small adult should help.

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 139
Group of Passengers: small adults
Hazard: GD3-uncomfortable position (human discomfort)

Development of scenario:

Phase In-Flight:

Event:
For small passengers the seats might not offer a comfortable position, which could lead to numbness in legs and to an increased risk of deep venous thrombosis.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Special seats for small passengers like child restraint systems must be provided.
Leg rests must be provided.

Severity: 2 **Occurrence: D**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 140
Group of Passengers: small adults
Hazard: HA2-multi g

Development of scenario:

Phase Boarding:

Event:
Small adults are restrained by the lap belt.

Phase Aborted Take-Off:

Event:
Small passengers might not be restrained by the lap belt in a sufficient manner. In case of aborted take-off with high forces small adults could be harmed.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Special seats for small passengers like the CRS seats must be provided.

Severity: 3 **Occurrence: B**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 141
Group of Passengers: small adults
Hazard: HA2-multi g

Development of scenario:

Phase Boarding:

Event:
Small adults are restrained by the lap belt.

Phase Crash:

Event:
Small passengers might not be restraint by the lapbelt in a sufficient manner. In case of a crash with high forces small adults could be harmed.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Special seats for small passengers like the CRS seats must be provided.

Severity: 2 **Occurrence: B**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 142
Group of Passengers: small adults
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Rapid decompression and masks being not reachable for small adults could lead to stress. This shortens the time to anoxia.

Precautions:
Passengers in surrounding are advised to help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Severity: 3 **Occurrence: E**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 143
Group of Passengers: tall
Hazard: FC4-human susceptibility to claustrophoby

Development of scenario:

Phase In-Flight:

Event:
Tall passengers might suffer from claustrophoby more than other passengers, which could lead to critical situations during the flight.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Offer a larger seat pitch or place tall passengers in more appropriate seats like in the first row or exit row.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 144
Group of Passengers: tall
Hazard: GD3-uncomfortable position (human discomfort)

Development of scenario:

Phase In-Flight:

Event:
The seats for tall passengers might not offer a comfortable position, which could lead to critical situations during the flight.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Offer a larger seat pitch or place tall passengers in more appropriate seats like in the first row or exit row.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 145
Group of Passengers: tall
Hazard: HA2-multi g

Development of scenario:

Phase Crash:

Event:
During a crash head injuries of tall passengers might occur by hitting the ceiling or the backrest of the seat in front of them.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Tall passengers must be seated in areas with enough space for head trajectory.
Aircraft designers must take into account the increasing percentage of tall passengers.

Severity: 2 **Occurrence: C**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 146
Group of Passengers: tall
Hazard: HA2-multi g

Development of scenario:

Phase Turbulences:

Event:
During violent turbulences head injuries of tall passengers might occur by hitting the ceiling or the backrest of the seat in front of them.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Tall passengers must be seated in areas with enough space for head trajectory.
Aircraft designers must take into account the increasing percentage of tall passengers.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 147
Group of Passengers: tall
Hazard: HA2-multi g

Development of scenario:

Phase Crash:

Event:
In case of crash tall passengers might not be able to adopt the brace position, which could lead to hitting against structural parts that are not covered by the head-movement-path of CS 25.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Tall passengers must be seated in areas with enough space for head trajectory.
Aircraft designers must take into account the increasing percentage of tall passengers.

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 148
Group of Passengers: tall
Hazard: HA2-multi g

Development of scenario:

Phase Crash:

Event:
As the head of tall passengers is not stabilised by a neck-rest, whiplash injury are likely.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Offer seats with backrests of sufficient height to tall passengers.

Severity: 3 **Occurrence: E**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 149
Group of Passengers: extremely overweight
Hazard: EA2-kinetic energy

Development of scenario:

Phase Crash:

Event:
Extremely overweight passengers might overstress the seat and pose a threat to the passengers in front of them.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
Provide appropriate seats for extremely overweight passengers,
Extremely overweight passengers must be placed in such a way that they cannot pose a risk to other passengers.

Severity: 0 **Occurrence: C**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 150
Group of Passengers: extremely overweight
Hazard: ED4-acceleration

Development of scenario:

Phase Crash:

Event:
Extremely overweight passengers might not be properly restrained by the seatbelt, which could result in serious inner injuries.

Precautions:
Extension belts must be available on aircrafts.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 151
Group of Passengers: extremely overweight
Hazard: ED4-acceleration

Development of scenario:

Phase Aborted Take-Off:

Event:
Extremely overweight passengers might not be properly restrained by the seatbelt, which could result in injuries during aborted take off.

Precautions:
Extension belts must be available on aircrafts.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Severity: 2 **Occurrence: F**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 152
Group of Passengers: extremely overweight
Hazard: ED4-acceleration

Development of scenario:

Phase Turbulences:

Event:
Extremely overweight passengers might not be properly restrained by the seatbelt during turbulences, which could result in injuries.

Precautions:
Extension belts must be available on aircrafts.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Severity: 2 **Occurrence: F**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 153
Group of Passengers: extremely overweight
Hazard: FC4-human susceptibility to claustrophoby

Development of scenario:

Phase In-Flight:

Event:
Extremely overweight passengers might suffer from claustrophoby more than other passengers, which could lead to critical situations during the flight.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Providing appropriate seating pitch for extremely overweight passengers.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 154
Group of Passengers: extremely overweight
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase Evacuation:

Event:
During evacuation extremely overweight passengers might delay the evacuation process and harm passengers due to problems using the overwing exits.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
Provide bigger emergency exits.
Extremely overweight passengers must not be placed in seating areas with overwing exits.

Severity: 0 **Occurrence: B**

Class	H	**I**	K	L	M	N	O	P	Q	R
Risk										

Scenario No.: 155
Group of Passengers: extremely overweight
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase Evacuation:

Event:
During evacuation extremely overweight passengers might delay the evacuation process and harm themselves due to problems using the overwing exits.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Provide bigger emergency exits.

Severity: 1 **Occurrence: B**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 156
Group of Passengers: extremely overweight
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase Ditching:

Event:
During evacuation extremely overweight passengers might have problems using the life jacket.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Proving life jackets of appropriate size for extremely overweight passengers.

Severity: 1 **Occurrence: A**

Class	H	**I**	K	L	M	N	O	P	Q	R
Risk										

Scenario No.: 157
Group of Passengers: extremely overweight
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase Evacuation:

Event:
During evacuation extremely overweight passengers might have problems leaving their seat on their own, which could harm other passengers sitting next to them.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
Yes: The same applies to busses and trains

Mitigation Measures:
Providing appropriate seat pitch and seatbase width for extremely overweight passengers.

Severity: 0 **Occurrence: B**

Class	H	**I**	K	L	M	N	O	P	Q	R
Risk										

Scenario No.: 158
Group of Passengers: extremely overweight
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase Evacuation:

Event:
During evacuation extremely overweight passengers might have problems leaving the seat on their own and harm themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Providing appropriate seat pitch and seatbase width for extremely overweight passengers.

Severity: 1 **Occurrence: B**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 159
Group of Passengers: extremely overweight
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase Disembarking:

Event:
Extremely overweight passengers might need more time for disembarking than other passengers. This could stress themselves and could cause a nervous breakdown.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Late disembarking of extremely overweight passengers.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 160
Group of Passengers: extremely overweight
Hazard: GD3-uncomfortable position (human discomfort)

Development of scenario:

Phase In-Flight:

Event:
During flight extremely overweight passengers might sit in a position leading to a special risk for deep venous thrombosis.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Seating extremely overweight passengers more comfortable or in higher classes if possible.

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 161
Group of Passengers: extremely overweight
Hazard: GD3-uncomfortable position (human discomfort)

Development of scenario:

Phase In-Flight:

Event:
During flight the extremely overweight might sit in an uncomfortable position, which could lead to stress resulting up to a nervous breakdown.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Seating extremely overweight passengers more convenient to their needs or in higher classes if possible.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 162
Group of Passengers: extremely overweight
Hazard: HA2-multi g

Development of scenario:

Phase Crash:

Event:
Extremely overweight passengers might overstress the seat and pose a threat to themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Appropriate seats for extremely overweight passengers.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 163
Group of Passengers: extremely overweight
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase Evacuation:

Event:
Extremely overweight passengers realizing that they are causing delays during the evacuation might get stressed, which could lead to further delays in the evacuation phase and could harm other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
Appropriate training of crew to manage the situation.

Severity: 0 **Occurrence: E**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 164
Group of Passengers: extremely overweight
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase Evacuation:

Event:
Extremely overweight passengers realizing that they are causing delays during the evacuation might get stressed, which could lead to further delays in the evacuation phase and could harm themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Appropriate training of crew to manage the situation.

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 165
Group of Passengers: PD (upper limbs)
Hazard: AA3-low pressure

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
In case when oxygen is needed physical disabled passengers (upper limbs) might not be able to reach the oxygen masks without help. Depending on the aircraft's altitude this could lead to anoxia quickly.

Precautions:
Surrounding passengers help the physical disabled passengers (upper limbs).

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
The cabin crew should assist physical disabled passengers (upper limbs) in case of decompression.

Severity: 2 **Occurrence: E**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 166
Group of Passengers: PD (upper limbs)
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase Ditching:

Event:
If life jackets are needed the physical disabled passengers (upper limbs) might very likely not be able to use them correctly without help of other passengers / crew.

Precautions:
Surrounding passengers / crew might help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person must be available during the flight for passengers lacking both arms.

Severity: 1 **Occurrence: D**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 167
Group of Passengers: PD (upper limbs)
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase Evacuation:

Event:
Physical disabled passengers (upper limbs) might very likely not be able to open their seatbelt on their own, which could harm other passengers as they are hindered in evacuation.

Precautions:
Surrounding passengers should help.

Risk classification and mitigation:

Risk to themselves or to others: To others

Mitigation Measures:
No additional mitigation measures necessary

Severity: 0 **Occurrence: E**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 168
Group of Passengers: PD (upper limbs)
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase Evacuation:

Event:
Physical disabled passengers (upper limbs) might very likely not be able to open seatbelt on their own, which could harm themselves.

Precautions:
Surrounding passengers should help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: D**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 169
Group of Passengers: PD (upper limbs)
Hazard: HA2-multi g

Development of scenario:

Phase Crash:

Event:
Due to difficulties for physical disabled passengers (upper limbs) adopting the brace position during crash, serious injuries could occur to physical disabled passengers (upper limbs).

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Remark:
Only problematic, if person lacks both arms.

Severity: 2 **Occurrence: D**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 170
Group of Passengers: PD (upper limbs)
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
In case when oxygen is needed physical disabled passengers (upper limbs) might not be able to reach and use the oxygen masks without help. Depending on the aircraft's altitude this could lead to anoxia quickly.

Precautions:
Surrounding passengers help the physical disabled passengers (upper limbs)

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: D**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 171
Group of Passengers: PD (low mobility)
Hazard: DD-asphyxiant

Development of scenario:

Phase Evacuation:

Event:
Physical disabled passengers (low mobility) might cause delays during evacuation, which could lead to asphyxia for other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
Reduction of smoke.

Severity: 0 **Occurrence: C**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 172
Group of Passengers: PD (low mobility)
Hazard: EB4-slipperiness

Development of scenario:

Phase Evacuation:

Event:
During evacuation physical disabled passengers (low mobility) have higher risks of slipping and/or tripping (over obstacles) than other passengers, which could cause delays in the evacuation and harm other passengers.

Precautions:
Use of slip resistant materials on the aircraft's floor.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
Passenger should be accompanied by at least one person.

Severity: 0 **Occurrence: C**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 173
Group of Passengers: PD (low mobility)
Hazard: GB1-limited human strength

Development of scenario:

Phase Evacuation:

Event:
Physical disabled passengers (low mobility) with walking disabilities and limited human strength might delay the evacuation, which could harm other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
Passenger should be accompanied by at least one person.

Severity: 0 **Occurrence: C**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 174
Group of Passengers: PD (low mobility)
Hazard: DD-asphyxiant

Development of scenario:

Phase Evacuation:

Event:
Physical disabled passengers (low mobility) might cause delays during evacuation, which could lead to asphyxia for themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Reduction of smoke.
Protecting physical disabled passengers (low mobility) from inhaling smoke.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 175
Group of Passengers: PD (low mobility)
Hazard: EB4-slipperiness

Development of scenario:

Phase Evacuation:

Event:
During evacuation physical disabled passengers (low mobility) have higher risks of slipping and/or tripping (over obstacles) than other passengers, which could cause delays in the evacuation and harm themselves.

Precautions:
Use of slip resistant materials on the aircraft's floor.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Passenger should be accompanied by at least one person.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 176
Group of Passengers: PD (low mobility)
Hazard: GB1-limited human strength

Development of scenario:

Phase Evacuation:

Event:
Physical disabled passengers (low mobility) with walking disabilities and limited human strength might delay the evacuation, which could harm themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Passenger should be accompanied by at least one person.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 177
Group of Passengers: PD (low mobility)
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase Evacuation:

Event:
Physical disabled passengers (low mobility) might be stressed, which could limit the actionability, situation awareness and the ability to escape. This could lead to delays in the evacuation and could harm themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Passenger should be accompanied by at least one person.

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 178
Group of Passengers: PD (low mobility)
Hazard: EB4-slipperiness

Development of scenario:

Phase Boarding:

Event:
During boarding physical disabled passengers (low mobility) have higher risks of slipping and/or tripping (over obstacles) than other passengers.

Precautions:
Use of slip resistant materials on the aircraft's floor and on the gangway.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person should be available during boarding.
No boarding over slippery apron.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 179
Group of Passengers: PD (low mobility)
Hazard: EB4-slipperiness

Development of scenario:

Phase Disembarking:

Event:
During disembarkment physical disabled passengers (low mobility) have higher risks of slipping and/or tripping (over obstacles) than other passengers.

Precautions:
Use of slip resistant materials on the aircraft's floor and on the gangway.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person should be available during disembarkment.
No disembarkment over slippery apron.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 180
Group of Passengers: PD (low mobility)
Hazard: EB4-slipperiness

Development of scenario:

Phase In-Flight:

Event:
During in-flight physical disabled passengers (low mobility) have higher risks of slipping and/or tripping (over obstacles) than other passengers.

Precautions:
Use of slip resistant materials on the aircraft’s floor.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Passenger should be accompanied by at least one person.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 181
Group of Passengers: PD (aided walking)
Hazard: DD-asphyxiant

Development of scenario:

Phase Evacuation:

Event:
Physical disabled passengers (aided walking) might cause delays during evacuation, which could lead to asphyxia for other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
Reduction of smoke.
Physical disabled passengers (aided walking) shall be seated in such a way that other passengers will not be blocked during evacuation.
At least one accompanying person shall be available.
.

Severity: 0 **Occurrence: B**

Class	H	**I**	K	L	M	N	O	P	Q	R
Risk										

Scenario No.: 182
Group of Passengers: PD (aided walking)
Hazard: DD-asphyxiant

Development of scenario:

Phase Evacuation:

Event:
Physical disabled passengers (aided walking) might cause delays during evacuation, which could lead to asphyxia for themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Reduction of smoke.
Providing of smoke hoods to physical disabled passengers (aided walking).
At least one accompanying person shall be available.

Severity: 1 **Occurrence: B**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 183
Group of Passengers: PD (aided walking)
Hazard: EB4-slipperiness

Development of scenario:

Phase Evacuation:

Event:
During evacuation physical disabled passengers (aided walking) have higher risks of slipping and/or tripping (over obstacles) than other passengers, which could lead to delays in the evacuation and could harm other passengers.

Precautions:
Use of slip resistant materials on the aircraft’s floor.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
Passenger should be accompanied by at least one person.

Severity: 0 **Occurrence: C**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 184
Group of Passengers: PD (aided walking)
Hazard: EB4-slipperiness

Development of scenario:

Phase Evacuation:

Event:
During evacuation physical disabled passengers (aided walking) have higher risks of slipping and/or tripping (over obstacles) than other passengers, which could lead to delays in the evacuation and could harm themselves.

Precautions:
Use of slip resistant materials on the aircraft's floor.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Passenger should be accompanied by at least one person.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 185
Group of Passengers: PD (aided walking)
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase Evacuation:

Event:
Physical disabled passengers (aided walking) might be stressed, which could limit the actionability, situation awareness and the ability to escape. This could lead to delays in the evacuation and could harm themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Passenger should be accompanied by at least one person.

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 186
Group of Passengers: PD (aided walking)
Hazard: EB4-slipperiness

Development of scenario:

Phase Disembarking:

Event:
During disembarkment physical disabled passengers (aided walking) have higher risks of slipping and/or tripping (over obstacles) than other passengers, which could lead to delays in the evacuation and could harm themselves.

Precautions:
Use of slip resistant materials on the aircraft’s floor and on the gangway.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person shall be available during disembarkment.
No disembarkment over slippery apron.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 187
Group of Passengers: PD (aided walking)
Hazard: EB4-slipperiness

Development of scenario:

Phase In-Flight:

Event:
During in-flight physical disabled passengers (aided walking) have higher risks of slipping and/or tripping (over obstacles) than other passengers.

Precautions:
Use of slip resistant materials on the aircraft’s floor.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Passenger should be accompanied by at least one person.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 188
Group of Passengers: PD (paralysed lower limbs)
Hazard: DD-asphyxiant

Development of scenario:

Phase Evacuation:

Event:
Physical disabled passengers (paralysed lower limbs) might not be able to leave the aircraft on their own, which could lead to delays in the evacuation. This could harm other passengers due to smoke inhalation that could lead to asphyxia.

Precautions:
Other passengers in surrounding should help physical disabled passengers (paralysed lower limbs).

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
Place physical disabled passengers (paralysed lower limbs) in such a way that other passengers are not hindered during ther evacuation.
Preferable two accompanying persons should be available to assist physical disabled passengers (paralysed lower limbs).

Severity: 0 **Occurrence: B**

Class	H	**I**	K	L	M	N	O	P	Q	R
Risk										

Scenario No.: 189
Group of Passengers: PD (paralysed lower limbs)
Hazard: GB1-limited human physical strength

Development of scenario:

Phase Evacuation:

Event:
Physical disabled passengers (paralysed lower limbs) might very likely delay the evacuation.

Precautions:
Help of surrounding passengers. Airline guidelines consider accompanying persons.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
At least two accompanying persons should be available to assist the physical disabled passengers (paralysed lower limbs) in case of emergency.
Specified seating areas for passengers with wheelchairs must be provided where they do not hinder the evacuation.

Severity: 0 **Occurrence: B**

Class	H	**I**	K	L	M	N	O	P	Q	R
Risk										

Scenario No.: 190
Group of Passengers: PD (paralysed lower limbs)
Hazard: GB1-limited human physical strength

Development of scenario:

Phase Boarding:

Event:
Physical disabled passengers (paralysed lower limbs) are placed in a seat row without foldable armrest.

Phase Evacuation:

Event:
Physical disabled passengers (paralysed lower limbs) needing assistance in leaving their seat might delay the evacuation due to the fixed armrest. This could harm other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
Physical disabled passengers (paralysed lower limbs) must be seated in rows with foldable armrest.

Severity: 0 **Occurrence: B**

Class	H	**I**	K	L	M	N	O	P	Q	R
Risk										

Scenario No.: 191
Group of Passengers: PD (paralysed lower limbs)
Hazard: DD-asphyxiant

Development of scenario:

Phase Evacuation:

Event:
Physical disabled passengers (paralysed lower limbs) might not be able to leave the aircraft on their own, which could lead to asphyxia due to smoke inhalation.

Precautions:
Other passengers in surrounding might help physical disabled passengers (paralysed lower limbs).

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Reduction of smoke.
Protecting physical disabled passengers (paralysed lower limbs) from inhaling smoke.
At least two accompanying persons should be available to assist physical disabled passengers (paralysed lower limbs) in case of emergency.

Severity: 1 **Occurrence: B**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 192
Group of Passengers: PD (paralysed lower limbs)
Hazard: GB1-limited human physical strength

Development of scenario:

Phase Boarding:

Event:
Physical disabled passengers (paralysed lower limbs) are placed in a seat row without foldable armrest.

Phase Evacuation:

Event:
Physical disabled passengers (paralysed lower limbs) needing assistance in leaving their seat might delay the evacuation due to the fixed armrest. This could harm themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Physical disabled passengers (paralysed lower limbs) must be seated in rows with foldable armrest.

Severity: 1 **Occurrence: B**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 193
Group of Passengers: PD (paralysed lower limbs)
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase Boarding:

Event:
During boarding physical disabled passengers (paralysed lower limbs) might suffer from stress as they might delay the boarding process. This could lead to a lack of attention during the safety briefing.

Phase Evacuation:

Event:
Due to a lack of safety related information physical disabled passengers (paralysed lower limbs) might delay the evacuation process and could harm other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
Making boarding as comfortable as possible. Tactical orders of the cabin crew have to be obeyed.

Severity: 0 **Occurrence: D**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.:	194
Group of Passengers:	PD (paralysed lower limbs)
Hazard:	FB3-human bad information selection susceptibility

Development of scenario:

Phase Boarding:

Event:
During safety briefing physical disabled passengers (paralysed lower limbs) might arrange themselves in the cabin and might therefore be distracted from the safety briefing.

Precautions:
Preboarding of the disabled.

Phase Evacuation:

Event:
Due to a lack of safety related information physical disabled passengers (paralysed lower limbs) might delay the evacuation process and could harm other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
Obligatory procedures regarding preboarding,preferable two accompanying passengers.

Severity: 0 **Occurrence: E**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 195
Group of Passengers: PD (paralysed lower limbs)
Hazard: HA2-multi g

Development of scenario:

Phase Turbulences:

Event:
While physical disabled passengers (paralysed lower limbs) are getting transported by wheelchair to lavatory,, turbulences might occur. If the crew is not able to bring the physical disabled passengers (paralysed lower limbs) back to their seat and to stow the wheelchair before turbulences start (approx. 1-5 min after information by cockpit), this could harm other passengers.

Precautions:
Information of turbulences is tried to be given as early as possible.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
Passenger needs to be restrained of wheelchair and wheelchair needs to be fixable in cabin.

Severity: 0 **Occurrence: E**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 196
Group of Passengers: PD (paralysed lower limbs)
Hazard: HA2-multi g

Development of scenario:

Phase Turbulences:

Event:
While physical disabled passengers (paralysed lower limbs) are getting transported by wheelchair to lavatory, turbulences might occur. If the crew is not able to bring the physical disabled passengers (paralysed lower limbs) back to their seat and to stow the wheelchair before turbulences start (approx. 1-5 min after information by cockpit), physical disabled passengers (paralysed lower limbs) could be harmed, since no safe position is posed.

Precautions:
Information of turbulences is tried to be given as early as possible.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Passenger needs to be restrained of wheelchair and wheelchair needs to be fixable in cabin.

Severity: 1 **Occurrence: D**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 197
Group of Passengers: PD (paralysed lower limbs)
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase Evacuation:

Event:
During emergency landing PD (WCH needed) passengers might suffer from stress, when realizing that they are delaying the evacuation. This could lead to more delay as the passenger is not able to focus on the evacuation process, which could harm other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
A special safety briefing for the physical disabled passengers (paralysed lower limbs) helps to master emergency situations.

Severity: 0 **Occurrence: E**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 198
Group of Passengers: PD (paralysed lower limbs)
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase Boarding:

Event:
During boarding physical disabled passengers (paralysed lower limbs) might suffer from stress as they might delay the boarding process. This could lead to a lack of attention during the safety briefing.

Phase Evacuation:

Event:
Due to a lack of safety related information physical disabled passengers (paralysed lower limbs) might delay the evacuation process and could harm themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Obligatory procedures regarding preboarding, preferable two accompanying passengers.

Severity: 1 **Occurrence: D**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 199
Group of Passengers: PD (paralysed lower limbs)
Hazard: FB3-human bad information selection susceptibility

Development of scenario:

Phase Boarding:

Event:
During safety briefing physical disabled passengers (paralysed lower limbs) might arrange themselves in the cabin and might therefore be distracted from the safety briefing.

Precautions:
Preboarding of the disabled.

Phase Evacuation:

Event:
Due to a lack of safety related information physical disabled passengers (paralysed lower limbs) might delay the evacuation process and could harm themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Obligatory procedures regarding preboarding, preferable two accompanying passengers.

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 200
Group of Passengers: PD (paralysed lower limbs)
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase Evacuation:

Event:
Physical disabled passengers (paralysed lower limbs) might suffer from stress, when realizing that they are delaying the evacuation. This could lead to more delay as the passenger is not able to focus on the process, which could harm themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
A special safety briefing for the disabled person helps to master emergency situations.

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 201
Group of Passengers: PD (paralysed lower limbs)
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase Boarding:

Event:
Physical disabled passengers (paralysed lower limbs) might suffer from stress as they might delay the boarding process. This could lead to a lack of attention during the safety briefing.

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
In case that oxygen masks are dropped, physical disabled passengers (paralysed lower limbs) are not able to use the oxygen masks in a appropriate manner because of lacking information of the safety briefing. This could lead to anoxia.

Precautions:
Passengers in surrounding are advised to help the physical disabled passengers (paralysed lower limbs).

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Making boarding as comfortable as possible.

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 202
Group of Passengers: PD (paralysed lower limbs)
Hazard: FC2-human stress susceptibility

Development of scenario:

Phase Disembarking:

Event:
Physical disabled passengers (paralysed lower limbs) might suffer from stress as they might delay the disembarking process. This could lead to a nervous breakdown of physical disabled passengers (paralysed lower limbs).

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Obligatory procedures for disembarkment of physical disabled passengers (paralysed lower limbs).

Severity: 3 **Occurrence: E**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 203
Group of Passengers: on stretchers
Hazard: DD-asphyxiant

Development of scenario:

Phase Evacuation:

Event:
In case smoke is present passengers on stretchers have no ability to evacuate themselves, which will result in asphyxia.

Precautions:
Accompanying persons should be normally available.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Accompanying persons need special emergency training.

Severity: 1 **Occurrence: A**

Class	H	**I**	K	L	M	N	O	P	Q	R
Risk										

Scenario No.: 204
Group of Passengers: on stretchers
Hazard: DD-asphyxiant

Development of scenario:

Phase Evacuation:

Event:
In case passengers on stretchers being carried through the cabin, delays will occur harming other passengers.

Precautions:
Accompanying persons should be aware.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
Accompanying persons need special emergency training.

Severity: 0 **Occurrence: B**

Class	H	**I**	K	L	M	N	O	P	Q	R
Risk										

Scenario No.: 205
Group of Passengers: on stretchers
Hazard: DD-asphyxiant

Development of scenario:

Phase Ditching:

Event:
Passengers on stretchers could not be evacuated in case of ditching. This leads to drowning of the passenger on stretcher.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 206
Group of Passengers: on stretchers
Hazard: DD-asphyxiant

Development of scenario:

Phase Ditching:

Event:
Passengers on stretchers could not use life jackets in case of ditching. This leads to drowning of the passenger on stretcher.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: B**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 207
Group of Passengers: on stretchers
Hazard: EA2-kinetic energy

Development of scenario:

Phase Crash:

Event:
Certification of stretcher 9g instead of 16g. In case of accelerations in during crash, the stretcher might break loose and move into flight-direction and harm other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Severity: 0 **Occurrence: B**

Class	H	**I**	K	L	M	N	O	P	Q	R
Risk										

Scenario No.: 208
Group of Passengers: on stretchers
Hazard: GB1-limited human physical strength

Development of scenario:

Phase Evacuation:

Event:
Passengers on stretchers are not able to evacuate themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least two trained accompanying persons must be available being strong enough to carry (on stretchers) – passengers.

Severity: 1 **Occurrence: A**

Class	H	**I**	K	L	M	N	O	P	Q	R
Risk										

Scenario No.: 209
Group of Passengers: on stretchers
Hazard: DD-asphyxiant

Development of scenario:

Phase Evacuation:

Event:
In case of passengers on stretchers being carried through the cabin, delays in evacuation could harm the passengers on stretchers.

Precautions:
Accompanying persons must be aware.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: B**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 210
Group of Passengers: on stretchers
Hazard: EA2-kinetic energy

Development of scenario:

Phase Crash:

Event:
Certification of stretcher 9g instead of 16g. In case of accelerations during crash, the stretcher might break loose and move into flight-direction and harm passengers on stretchers.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: B**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 211
Group of Passengers: on stretchers
Hazard: GC1-human vomit

Development of scenario:

Phase In-Flight:

Event:
If passengers on stretchers vomiting and not be observed, passengers on stretchers could be harmed by suffocation.

Precautions:
Medical team is accompanying the passenger.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person has to be present at (on stretchers) – passenger.

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 212
Group of Passengers: on stretchers
Hazard: FC4-human susceptibility to claustrophoby

Development of scenario:

Phase In-Flight:

Event:
At all phases of flight passengers on stretcher suffering from claustrophoby might be stressed up to nervous breakdown.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Psychological support during flight.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 213
Group of Passengers: on stretchers
Hazard: GD4-noise, darkness, light (human discomfort)

Development of scenario:

Phase Aborted Take-Off:

Event:
During long-haul flights the acoustic monitoring of vital parameters can stress passengers on stretchers and surrounding passengers.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Risk comparable to other means of transport:
No

Mitigation Measures:
Only using visual monitoring. Only alarms are acoustically signalled.

Remark:
Situation is comparable with that on an intensive care station. No further risk reduction necessary.

Severity: 3 **Occurrence: F**

Class	H	I	K	L	M	N	O	P	**Q**	R
Risk										

Scenario No.: 214
Group of Passengers: deaf
Hazard: DD-asphyxiant

Development of scenario:

Phase Boarding:

Event:
As deaf passengers / passengers not understanding the language are not able to understand the safety briefing these passengers have a lack of safety related information.

Precautions:
The briefing is visualized and
safety cards are provided.

Phase Evacuation:

Event:
Due to a lack of safety related information, also the verbal support from surrounding passengers and crew cannot be understood by deaf passengers / passengers not understanding the language. This could lead to delays in the evacuation and hinder the others passengers.

Precautions:
Deaf passengers / passengers not understanding the language are adopting the behaviour of other passengers and are able to identify visual orders of the crew.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
Deaf passenger is informed individually by cabin crew.

Severity: 0 **Occurrence: E**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 215
Group of Passengers: deaf
Hazard: DD-asphyxiant

Development of scenario:

Phase Boarding:

Event:
As deaf passengers / passengers not understanding the language are not able to understand the safety briefing, these passengers have a lack of safety related information.

Precautions:
The briefing is visualized and
safety cards are provided.

Phase Evacuation:

Event:
Due to a lack of safety related information, also the verbal support from surrounding passengers and crew cannot be understood by the deaf passengers / passengers not understanding the language. This could lead to delays in the evacuation and could harm themselves.

Precautions:
Adopt the behaviour of other passengers and are able to identify visual orders of the crew.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Deaf passengers / passengers not understanding the language should be informed individually by cabin crew.

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 216
Group of Passengers: deaf
Hazard: FA2-lack of specific training

Development of scenario:

Phase Boarding:

Event:
As deaf passengers / passengers not understanding the language are not able to understand the safety briefing, these passengers have a lack of safety related information.

Precautions:
The briefing is visualized.
Safety cards are provided.

Phase Ditching:

Event:
Due to deficiencies from the safety briefing these passengers might not know how to use the life jackets.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 217
Group of Passengers: deaf
Hazard: FA2-lack of specific training

Development of scenario:

Phase Boarding:

Event:
As deaf passengers / passengers not understanding the language are not able to understand the safety briefing, these passengers have a lack of safety related information.

Precautions:
The briefing is visualized.
Safety cards are provided.

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Due to deficits from the safety briefing these passengers might not be able to use the oxygen masks. Verbal support from surrounding passengers is not understood.

Precautions:
Direct help from surrounding passengers.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Severity: 2 **Occurrence: F**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 218
Group of Passengers: deaf
Hazard: HA2-multi g

Development of scenario:

Phase In-Flight:

Event:
Deaf passengers might not get the information to fasten the seatbelt as the acoustic signal could not be heard and the announcement by PA is not understood.

Precautions:
Optical sign.

Phase Turbulences:

Event:
Serious injuries and fatalities might occur due to not being restrained.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Deaf passengers are informed individually by cabin crew.

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 219
Group of Passengers: deaf
Hazard: HA2-multi g

Development of scenario:

Phase Crash:

Event:
Prior to a crash the command for posing into brace position is not understood or could not be heard by deaf passengers.

Precautions:
Adopt from surrounding passengers.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 220
Group of Passengers: blind
Hazard: EB4-slipperiness

Development of scenario:

Phase Evacuation:

Event:
During evacuation blind passengers have an increased risk of tripping (over obstacles) especially if no tactile aid is available. This could harm other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
Blind passengers should be accompanied by at least one person.

Severity: 0 **Occurrence: C**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 221
Group of Passengers: blind
Hazard: EB4-slipperiness

Development of scenario:

Phase Evacuation:

Event:
During evacuation blind passengers have an increased risk of tripping (over obstacles) especially if no tactile aid is available. This could harm themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Blind passengers should be accompanied by at least one person.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 222
Group of Passengers: blind
Hazard: FA2-lack of specific training

Development of scenario:

Phase Boarding:

Event:
Blind passengers lack the visual information of the safety briefing.

Precautions:
The safety briefing contains always audible information.

Phase Ditching:

Event:
In case of ditching blind passengers do not know how to use the life jackets due to the lack of safety related information.

Precautions:
Passengers in surrounding might be able to help the disabled person.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Personal safety briefing.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 223
Group of Passengers: blind
Hazard: FC3-lack of adaptability of human being

Development of scenario:

Phase Evacuation:

Event:
In case of evacuation blind passengers have problems with orientation in the cabin. This might hinder other passengers.

Precautions:
Adopt the behaviour of other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
Personal safety briefing.
Safety cards in braille.
Clear and loud commands by the cabin crew.

Severity: 0 **Occurrence: D**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 224
Group of Passengers: blind
Hazard: FC3-lack of adaptability of human being

Development of scenario:

Phase Evacuation:

Event:
In case of evacuation blind passengers have problems with orientation in the cabin.

Precautions:
Adopt the behaviour of other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Personal safety briefing.
Safety cards in braille.
Clear and loud commands by the cabin crew.

Severity: 1 **Occurrence: D**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 225
Group of Passengers: blind
Hazard: HA2-multi g

Development of scenario:

Phase In-Flight:

Event:
As blind passengers cannot see the seatbelt warning signs, blind passengers might not fasten the seatbelt.

Precautions:
Acoustic signal exists.

Phase Turbulences:

Event:
Serious injuries and fatalities might occur due to not being restrained properly by the seatbelt.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Unambiguous acoustic signal for seat belt use. PA should be always used to inform passengers.

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 226
Group of Passengers: blind
Hazard: AA3-low pressure

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
In case of rapid decompression blind passengers need longer to find the oxygen mask which might lead to anoxia.

Precautions:
Passengers in surrounding may help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
The cabin crew should assist every blind passenger in case of decompression.

Severity: 2 **Occurrence: E**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 227
Group of Passengers: blind
Hazard: FC3-lack of adaptability of human being

Development of scenario:

Phase Boarding:

Event:
As the environment is not familiar to blind passengers, they might have problems with orientation. This could lead to minor injuries during boarding.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Guidance to seat during boarding.

Severity: 3 **Occurrence: D**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 228
Group of Passengers: blind
Hazard: EB4-slipperiness

Development of scenario:

Phase In-Flight:

Event:
When walking during the flight blind passengers have an increased risk of tripping (over obstacles) (e.g., by going to lavatory).

Precautions:
The crew is advised to guide the passenger to the toilet (EG1107/2006 Appendix II).

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
The passenger should be accompanied by at least one person.

Severity: 3 **Occurrence: E**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 229
Group of Passengers: blind
Hazard: EB4-slipperiness

Development of scenario:

Phase Boarding:

Event:
During boarding blind passengers have an increased risk of tripping (over obstacles).

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
The passenger should be accompanied by at least one person.

Severity: 3 **Occurrence: E**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 230
Group of Passengers: blind
Hazard: EB4-slipperiness

Development of scenario:

Phase Disembarking:

Event:
During disembarking blind passengers have an increased risk of tripping (over obstacles).

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
The passenger should be accompanied by at least one person.

Severity: 3 **Occurrence: E**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 231
Group of Passengers: blind
Hazard: FA2-lack of specific training

Development of scenario:

Phase Boarding:

Event:
Blind passengers lack the visual information of the safety briefing.

Precautions:
The safety briefing contains always audible information.

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
In case of decompression blind passengers do not know how to use the masks due to a lack of safety related information.

Precautions:
Direct help from surrounding passengers.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Personal safety briefing.

Severity: 2 **Occurrence: F**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 232
Group of Passengers: mental deficient
Hazard: FA2-lack of specific training

Development of scenario:

Phase Boarding:

Event:
During boarding the mental deficient passengers might not be able to understand the information from the safety-briefing.

Phase Evacuation:

Event:
In case of evacuation mental deficient passengers might be overstressed by the situation. This could lead to delays and could harm other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 0 **Occurrence: C**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 233
Group of Passengers: mental deficient
Hazard: FB1-human decision error susceptibility

Development of scenario:

Phase Evacuation:

Event:
In case of emergency landing mental deficient passengers might misinterpret the situation, which could delay the evacuation and could harm other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 0 **Occurrence: C**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 234
Group of Passengers: mental deficient
Hazard: FB3-human bad information selection susceptibility

Development of scenario:

Phase Evacuation:

Event:
Due to a lot of impulses and impressions (e.g. fire, victims, smoke, heat) mental deficient passengers might not be able to concentrate on crew's advices, which could lead to delays in the evacuation and could harm other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 0 **Occurrence: C**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 235
Group of Passengers: mental deficient
Hazard: FD1-poor motivation

Development of scenario:

Phase Evacuation:

Event:
Due to missing risk perception mental deficient passengers might delay the evacuation process harming other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 0 **Occurrence: C**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 236
Group of Passengers: mental deficient
Hazard: GB2-limited human flexibility

Development of scenario:

Phase Evacuation:

Event:
As the situation of evacuation is new and complex, mental deficient passengers might not be able to react properly and flexible to the situation and on commands of the crew. This could lead to delays and could harm other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 0 **Occurrence: C**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 237
Group of Passengers: mental deficient
Hazard: GB4-limited human reaction capability

Development of scenario:

Phase Evacuation:

Event:
In case evacuation limited human reaction capability can lead to delays in the evacuation harming passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
At least one accompanying person should be available.

Severity: 0 **Occurrence: C**

Class	H	I	**K**	L	M	N	O	P	Q	R
Risk										

Scenario No.: 238
Group of Passengers: mental deficient
Hazard: FA2-lack of specific training

Development of scenario:

Phase Boarding:

Event:
During boarding mental deficient passengers might not be able to understand the information from the safety-briefing.

Phase Evacuation:

Event:
In case of evacuation the mental deficient passengers might be overstressed by the situation. This could lead to delays and could harm themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 239
Group of Passengers: mental deficient
Hazard: FA2-lack of specific training

Development of scenario:

Phase Boarding:

Event:
During boarding mental deficient passengers might not be able to understand the information from the safety-briefing.

Phase Ditching:

Event:
In case of ditching mental deficient passengers might not be able to use the life-vest, which could lead to drowning.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 240
Group of Passengers: mental deficient
Hazard: FB1-human decision error susceptibility

Development of scenario:

Phase Crash:

Event:
In case of a crash mental deficient passengers might misinterpret the situation and might not adopt the brace position, which could harm themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 241
Group of Passengers: mental deficient
Hazard: FB1-human decision error susceptibility

Development of scenario:

Phase Evacuation:

Event:
In case of evacuation mental deficient passengers might misinterpret the situation, which could lead to delays in the evacuation and could harm themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 242
Group of Passengers: mental deficient
Hazard: FB3-human bad information selection susceptibility

Development of scenario:

Phase Evacuation:

Event:
Due to a lot of impulses and impressions (e.g. fire, victims, smoke, heat) mental deficient passengers might not be able to concentrate on crew's advices, which could lead to delays in the evacuation and could harm themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 243
Group of Passengers: mental deficient
Hazard: FD1-poor motivation

Development of scenario:

Phase Evacuation:

Event:
Due to missing risk perception mental deficient passengers might delay the evacuation process harming themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 244
Group of Passengers: mental deficient
Hazard: FD1-poor motivation

Development of scenario:

Phase Crash:

Event:
Due to missing risk perception mental deficient passengers might not initiate the necessary measures to avoid serious injuries.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 245
Group of Passengers: mental deficient
Hazard: GB2-limited human flexibility

Development of scenario:

Phase Evacuation:

Event:
As the situation of evacuation is new and complex, mental deficient passengers might not be able to react properly and flexible to the situation and on commands of the crew. This could lead to delays and could harm themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 246
Group of Passengers: mental deficient
Hazard: GB4-limited human reaction capability

Development of scenario:

Phase Evacuation:

Event:
In case evacuation mental deficient passengers might react slower than other passengers, which could lead to delays in the evacuation and could harm themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 247
Group of Passengers: mental deficient
Hazard: GB4-limited human reaction capability

Development of scenario:

Phase Crash:

Event:
Prior to crash mental deficient passengers might react slower than other passengers, which could lead to serious injuries to themselves due to not adopting brace position at impact.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person should be available.

Severity: 1 **Occurrence: C**

Class	H	I	K	**L**	M	N	O	P	Q	R
Risk										

Scenario No.: 248
Group of Passengers: mental deficient
Hazard: FD1-poor motivation

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Due to missing risk perception mental deficient passengers might not be able to initiate the necessary measures to avoid anoxia.

Precautions:
Surrounding passengers are advised to help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person should be available.

Severity: 2 **Occurrence: E**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 249
Group of Passengers: mental deficient
Hazard: GB2-limited human flexibility

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
As the situation of rapid decompression is new mental deficient passengers might not be able to react properly, which could lead to anoxia.

Precautions:
Surrounding passengers are advised to help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person should be available.

Severity: 2 **Occurrence: E**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 250
Group of Passengers: mental deficient
Hazard: GB4-limited human reaction capability

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Mental deficient passengers might react slower on decompression than other passengers, which in high altitudes could lead to anoxia.

Precautions:
Passengers in surrounding are advised to help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person should be available.

Severity: 2 **Occurrence: E**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.:	251
Group of Passengers:	mental deficient
Hazard:	AA3-low pressure

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
During rapid decompression mental deficient passengers might not be able to use the oxygen masks without help of other passengers. This could lead to anoxia.

Precautions:
Passengers in surrounding are advised to help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person should be available.

Severity: 2 **Occurrence: F**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 252
Group of Passengers: mental deficient
Hazard: FA2-lack of specific training

Development of scenario:

Phase Boarding:

Event:
During boarding mental deficient passengers might not be able to understand the information from the safety-briefing.

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
In case of rapid decompression mental deficient passengers might be overstressed due to a lack of safety related information. This could lead to anoxia.

Precautions:
Passengers in surrounding are advised to help.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person should be available.

Severity: 2 **Occurrence: F**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 253
Group of Passengers: mental deficient
Hazard: FB1-human decision error susceptibility

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
In case of rapid decompression mental deficient passengers might misinterpret the situation not initiating the necessary measures, which could lead to anoxia.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person should be available.

Severity: 2 **Occurrence: F**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 254
Group of Passengers: mental deficient
Hazard: FB3-human bad information selection susceptibility

Development of scenario:

Phase Boarding:

Event:
Due to many new impressions during the boarding phase mental deficient passengers might not focus on the safety-briefing instructions.

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
In case of decompression mental deficient passengers might lack safety related information, which could harm themselves.

Precautions:
Help of surrounding passengers.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
Special briefing for mental deficient passengers. Accompanying person to take care of the custody.

Severity: 2 **Occurrence: F**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 255
Group of Passengers: mental deficient
Hazard: FB3-human bad information selection susceptibility

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Due to a lot of impulses and impressions (e.g. pain, noise, wind) mental deficient passengers might not be able to concentrate on crew’s advices.

Precautions:
Help of surrounding passengers.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
At least one accompanying person should be available.

Severity: 2 **Occurrence: F**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 256
Group of Passengers: in custody / deportees
Hazard: AA3-low pressure

Development of scenario:

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
In case of rapid decompression passengers in custody / deportees are not able to use the mask by themselves (if in handcuffs). This could lead to anoxia.

Precautions:
Guards have to help. The guards are obliged to unfasten the handcuffs in case of rapid decompression.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Severity: 2 **Occurrence: E**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 257
Group of Passengers: in custody / deportees
Hazard: EB4-slipperiness

Development of scenario:

Phase Boarding:

Event:
During boarding passengers in custody / deportees being chained have an increased risk for slipping and tripping (over obstacles) as passengers in custody / deportees are not able to use their upper limbs for balancing.

Precautions:
Passengers in custody / deportees are always accompanied by guards.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Severity: 3 **Occurrence: E**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 258
Group of Passengers: in custody / deportees
Hazard: EB4-slipperiness

Development of scenario:

Phase Disembarking:

Event:
During disembarking passengers in custody / deportees being chained have an increased risk for slipping and tripping (over obstacles) as passengers in custody / deportees are not able to use their upper limbs for balancing.

Precautions:
Passengers in custody / deportees are always accompanied by guards.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Severity: 3 **Occurrence: E**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 259
Group of Passengers: in custody / deportees
Hazard: FC4-human susceptibility to claustrophoby

Development of scenario:

Phase In-Flight:

Event:
Passengers in custody / deportees being chained might suffer from high stress due to claustrophoby, which could lead to a nervous breakdown.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
If claustrophoby is recognized the guards should unchain passengers in custody / deportees.

Severity: 3 **Occurrence: F**

Class	H	I	K	L	M	N	O	P	**Q**	R
Risk										

Scenario No.: 260
Group of Passengers: in custody / deportees
Hazard: FD2-distraction susceptibility

Development of scenario:

Phase Boarding:

Event:
During boarding passengers in custody / deportees might not be able to concentrate on the safety briefing as they could be distracted by the boarding process.

Precautions:
Preboarding is common practice.

Phase Evacuation:

Event:
In case of evacuation passengers in custody / deportees lack safety related information, which could lead to delays in the evacuation and could harm other passengers.

Precautions:
Guards are informed and take care of passengers in custody / deportees.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
This scenario has to be taken into account when training the guards.
Crew should be able / allowed to open chains.

Severity: 0 **Occurrence: F**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 261
Group of Passengers: in custody / deportees
Hazard: FD2-distraction susceptibility

Development of scenario:

Phase Boarding:

Event:
During boarding passengers in custody / deportees might not be able to concentrate on the safety briefing as they could be distracted by the boarding process.

Precautions:
Preboarding is common practice.

Phase Evacuation:

Event:
In case of evacuation passengers in custody / deportees lack safety related information, which could lead to delays in the evacuation and could harm themselves.

Precautions:
Guards are informed and take care of passengers in custody / deportees.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
This scenario has to be taken into account when training the guards.
Crew should be able / allowed to open chains.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 262
Group of Passengers: in custody / deportees
Hazard: FD2-distraction susceptibility

Development of scenario:

Phase Boarding:

Event:
During boarding passengers in custody / deportees might not be able to concentrate on the safety briefing as they could be distracted by the boarding process.

Precautions:
Preboarding is common practice.

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
In case of rapid decompression passengers in custody / deportees lack safety related information, which could lead to asphyxia and could harm themselves.

Precautions:
Guards are informed and take care of passengers in custody / deportees.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
This scenario has to be taken into account when training the guards.

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 263
Group of Passengers: in custody / deportees
Hazard: GA1-human fatigue

Development of scenario:

Phase In-Flight:

Event:
If guards are suffering from fatigue passengers in custody / deportees might provoke an emergency landing by, e.g., kicking out a window. This could harm other passengers.

Precautions:
The guards are having stand-by teams to ensure necessary breaks.
Passengers in custody / deportees are not placed at the window.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Severity: 0 **Occurrence: F**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 264
Group of Passengers: in custody / deportees
Hazard: GA1-human fatigue

Development of scenario:

Phase In-Flight:

Event:
If guards are suffering from fatigue passengers in custody / deportees might provoke an emergency landing by, e.g., kicking out a window. This could harm themselves.

Precautions:
The guards are having stand-by teams to ensure necessary breaks.
Passengers in custody / deportees are not placed at the window.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 265
Group of Passengers: in custody / deportees
Hazard: GC1-human vomit

Development of scenario:

Phase In-Flight:

Event:
During flight vomit could lead to suffocation as passengers in custody / deportees might not be able to move due to their enchainment.

Precautions:
Guards accompanying passengers in custody / deportees.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 266
Group of Passengers: in custody / deportees
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase Evacuation:

Event:
As passengers in custody / deportees' upper limbs are chained, these passengers have no support of their hands during evacuation, which could delay the evacuation process and could harm other passengers.

Precautions:
EU-directives are regulating that the deportee must not be chained during landing and in case of emergency.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
No additional mitigation measures necessary

Severity: 0 **Occurrence: F**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 267
Group of Passengers: in custody / deportees
Hazard: GD2-bad anthropometric characteristics

Development of scenario:

Phase Evacuation:

Event:
As passengers in custody / deportees' upper limbs are chained, these passengers have no support of their hands during evacuation, which could delay the evacuation process and could harm themselves.

Precautions:
EU-directives are regulating that the deportee must not be chained during landing and in case of emergency.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: F**

Class	H	I	K	L	M	N	**O**	P	Q	R
Risk										

Scenario No.: 268
Group of Passengers: in custody / deportees
Hazard: HA2-multi g

Development of scenario:

Phase Crash:

Event:
As passengers in custody / deportees are chained posing into the brace position is not possible, which could lead to serious injuries.

Precautions:
EU-directives are regulating that the deportee must not be chained during landing and in case of emergency.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
No additional mitigation measures necessary

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 269
Group of Passengers: inadmissible
Hazard: FB1-human decision error susceptibility

Development of scenario:

Precautions:
Exclusion of hazard: Check presence of passport and visa for the destination and deny boarding to inadmissible passengers.

Phase Evacuation:

Event:
Due to the increased stress-level, inadmissible passengers might make wrong decisions in case of an evacuation that could delay the evacuation process and could harm other passengers.

Risk classification and mitigation:

Risk to themselves or to others: To others

Risk comparable to other means of transport:
No

Mitigation Measures:
The cabin crew must be trained for it. Carriers can establish good rules to identify inadmissible passengers (also based on information of the destination country), to prevent boarding.

Remark:
Reactions of inadmissible passengers might mostly be comparable with psychotic or stressed persons and can be handled in the same manner.

Severity: 0 **Occurrence: E**

Class	H	I	K	L	**M**	N	O	P	Q	R
Risk										

Scenario No.: 270
Group of Passengers: inadmissible
Hazard: FB1-human decision error susceptibility

Development of scenario:

Precautions:
Exclusion of hazard: Check presence of passport and visa for the destination and deny boarding to inadmissible passengers.

Phase Evacuation:

Event:
Due to the increased stress-level, inadmissible passengers might make wrong decisions in case of an evacuation, which could delay the evacuation process and could harm themselves.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
The cabin crew must be trained for it. Carriers can establish good rules to identify inadmissible passengers (also based on information of the destination country), to prevent boarding.

Remark:
Reactions of inadmissible passengers might mostly be comparable with psychotic or stressed persons and can be handled in the same manner.

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

Scenario No.: 271
Group of Passengers: inadmissible
Hazard: FB1-human decision error susceptibility

Development of scenario:

Precautions:
Exclusion of hazard: Check presence of passport and visa for the destination and deny boarding to inadmissible passengers.

Phase In-Flight:

Event:
Failure of pressurisation system or aircraft fuselage.

Phase (Rapid) Decompression:

Event:
Due to the increased stress-level, inadmissible passengers might make wrong decisions during a decompression phase. This could lead to anoxia.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
The cabin crew must be trained for it. Carriers can establish good rules to identify inadmissible passengers (also based on information of the destination country), to prevent boarding.

Remark:
Reactions of inadmissible passengers might mostly be comparable with psychotic or stressed persons and can be handled in the same manner.

Severity: 2 **Occurrence: F**

Class	H	I	K	L	M	N	O	**P**	Q	R
Risk										

Scenario No.: 272
Group of Passengers: inadmissible
Hazard: FB1-human decision error susceptibility

Development of scenario:

Precautions:
Exclusion of hazard: Check presence of passport and visa for the destination and deny boarding to inadmissible passengers.

Phase Crash:

Event:
Due to the increased stress-level, inadmissible passengers might make wrong decisions in case of a crash, e.g., not adopting the brace position.

Risk classification and mitigation:

Risk to themselves or to others: To themselves

Mitigation Measures:
The cabin crew must be trained for it. Carriers can establish good rules to identify inadmissible passengers (also based on information of the destination country), to prevent boarding.

Remark:
Reactions of inadmissible passengers might mostly be comparable with psychotic or stressed persons and can be handled in the same manner.

Severity: 1 **Occurrence: E**

Class	H	I	K	L	M	**N**	O	P	Q	R
Risk										

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