



ICAO

Doc 10062

Manual on the Investigation of Cabin Safety Aspects in Accidents and Incidents

First edition, 2017



Approved by and published under the authority of the Secretary General

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AMENDMENTS

Amendments are announced in the supplements to the *Products and Services Catalogue*; the Catalogue and its supplements are available on the ICAO website at www.icao.int. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

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FOREWORD

Findings from past accident investigations have led to significant improvements in the fields of cabin safety and aircraft manufacturing such as 16G seats, lavatory smoke detectors and fire extinguishers, floor proximity emergency escape path markings, new requirements for cabin and insulation materials and inclusion of human performance training for cabin crew members. These improvements have increased the survivability of occupants involved in later accidents and helped reduce fatalities among passengers and crew. Cabin safety aspects, including survival factors, should be addressed as part of the investigation process. However, these aspects are often overlooked. States and industry may be missing out, therefore, on opportunities for further safety enhancements.

ICAO developed the *Manual on the Investigation of Cabin Safety Aspects in Accidents and Incidents* (Doc 10062) to encourage the uniform application of the Standards and Recommended Practices contained in Annex 13 — *Aircraft Accident and Incident Investigation*, particularly in relation to survival aspects. This manual provides information and guidance to States on the procedures, practices and techniques that may be used when investigating the cabin safety aspects of an occurrence.

This manual contains guidance for States to investigate specific types of occurrences, such as evacuations, and provides recommended qualifications and competencies for cabin investigators, thereby allowing the appropriate personnel to carry out the necessary functions during an investigation. This manual also provides guidance for States and operators when investigating incidents, such as mandatory reported events or events that do not require notification to the State of the Operator but may be a source of lessons learned. The content of this manual is consistent with guidance material contained in the *Manual of Aircraft Accident and Incident Investigation* (Doc 9756).

This manual was developed with input from experts from accident investigation authorities, civil aviation authorities, operators, aircraft manufacturers, training organizations and international organizations, and was thereafter submitted for an extensive peer review to take into account comments from the expert community. ICAO gratefully acknowledges the contributions of the International Society of Air Safety Investigators (ISASI), the ICAO Cabin Safety Group, and individual experts who provided support, advice and input for this manual.

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GLOSSARY

DEFINITIONS

Able-bodied passengers. Passengers who are clearly physically able and are willing to help cabin crew maintain good order and discipline on board the aircraft.

Accident. An occurrence associated with the operation of an aircraft which, in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time as it comes to rest at the end of the flight and the primary propulsion system is shut down, in which:

- a) a person is fatally or seriously injured as a result of:
 - being in the aircraft, or
 - direct contact with any part of the aircraft, including parts which have become detached from the aircraft, or
 - direct exposure to jet blast,except when the injuries are from natural causes, self-inflicted or inflicted by other persons, or when the injuries are to stowaways hiding outside the areas normally available to the passengers and crew; or
- b) the aircraft sustains damage or structural failure which:
 - adversely affects the structural strength, performance or flight characteristics of the aircraft, and
 - would normally require major repair or replacement of the affected component,except for engine failure or damage, when the damage is limited to a single engine (including its cowlings or accessories), to propellers, wing tips, antennas, probes, vanes, tires, brakes, wheels, fairings, panels, landing gear doors, windcreens, the aircraft skin (such as small dents or puncture holes), or for minor damages to main rotor blades, tail rotor blades, landing gear, and those resulting from hail or bird strike (including holes in the radome); or
- c) the aircraft is missing or is completely inaccessible.

Note 1.— For statistical uniformity only, an injury resulting in death within thirty days of the date of the accident is classified, by ICAO, as a fatal injury.

Note 2.— An aircraft is considered to be missing when the official search has been terminated and the wreckage has not been located.

Note 3.— The type of unmanned aircraft system to be investigated is addressed in ICAO Annex 13, paragraph 5.1.

Note 4.— Guidance for the determination of aircraft damage can be found in ICAO Annex 13, Attachment E.

Accident investigation authority. The authority designated by a State as responsible for aircraft accident and incident investigations within the context of Annex 13 — *Aircraft Accident and Incident Investigation*.

Accident investigator. A person engaged in the investigation of aircraft accidents, incidents and other aviation safety hazards.

Aircraft. Any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface.

Baggage. Personal property of passengers or crew carried on an aircraft by agreement with the operator.

Cabin crew member. A crew member who performs, in the interest of safety of passengers, duties assigned by the operator or the pilot-in-command of the aircraft, but who shall not act as a flight crew member.

Causes. Actions, omissions, events, conditions, or a combination thereof, which led to the accident or incident. The identification of causes does not imply the assignment of fault or the determination of administrative, civil or criminal liability.

Child. A passenger who has reached their second birthday but not their twelfth birthday.

Child restraint system. Any device, other than a seat belt, that is designed specifically to protect and restrain an infant or child during all phases of flight. It typically has an internal harness and belt combination. The device needs to interface with the aircraft seat. This includes devices that are secured using the aircraft seat belt as well as systems that secure the device to the aircraft seat. The device needs to meet minimum performance standards, as specified by the State of the Operator.

Classroom training. In-person, instructor-led training which may include group exercises and interactive instructional sessions.

Competency. A combination of skills, knowledge and attitudes required to perform a task to the prescribed standard.

Competency element. An action that constitutes a task that has a triggering event and a terminating event that clearly defines its limits, and an observable outcome.

Competency unit. A discrete function consisting of a number of competency elements.

Computer-based training. Training involving instructional aids, such as computers and tablets. Computer-based training may encompass the use of CD-ROMs as well as web-based training (commonly referred to as eLearning).

Contributing factors. Actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the accident or incident occurring, or mitigated the severity of the consequences of the accident or incident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability.

Crashworthiness. The incorporation in basic design of considerations pertinent to the protection of aircraft occupants in a survivable crash environment. It represents the ability of a structure, and its interiors, to maintain integrity during impact in order to enhance survivability and enable the evacuation of an aircraft.

Crew member. A person assigned by an operator to duty on an aircraft during a flight duty period.

Dangerous goods. Articles or substances which are capable of posing a risk to health, safety, property or the environment and which are shown in the list of dangerous goods in the Technical Instructions or which are classified according to those Instructions.

Direct access. A direct route or passage from a seat to an exit from which a passenger can proceed without entering an aisle or passing around an obstruction.

Disruptive passenger. A passenger who fails to respect the rules of conduct at an airport or on board an aircraft or to follow the instructions of the airport staff or crew members and thereby disturbs the good order and discipline at an airport or on board the aircraft.

Ditching. The forced landing of an aircraft on water.

Emergency exit. Door, window exit, or any other type of exit (e.g. hatch in the flight deck, tail cone exit) used as an egress point to allow maximum opportunity for cabin evacuation within an appropriate time period.

Emergency exit row seating. Each seat in a row of seats located at an emergency exit, having direct access to the exit.

Emergency locator transmitter (ELT). A generic term describing equipment which broadcast distinctive signals on designated frequencies and, depending on application, may be automatically activated by impact or be manually activated. An ELT may be any of the following:

Automatic-fixed ELT (ELT(AF)). An automatically activated ELT which is permanently attached to an aircraft.

Automatic-portable ELT (ELT(AP)). An automatically activated ELT which is rigidly attached to an aircraft but readily removable from the aircraft.

Automatic-deployable ELT (ELT(AD)). An ELT which is rigidly attached to an aircraft and which is automatically deployed and activated by impact, and, in some cases, also by hydrostatic sensors. Manual deployment is also provided.

Survival ELT (ELT(S)). An ELT which is removable from an aircraft, stowed so as to facilitate its ready use in an emergency, and manually activated by survivors

Expert/Specialist. A person invited to participate in an investigation, on the basis of his or her specialized knowledge, skills or experience.

Fatigue. A physiological state of reduced mental or physical performance capability resulting from sleep loss, extended wakefulness, circadian phase, and/or workload (mental and/or physical activity) that can impair a person's alertness and ability to perform safety-related operational duties.

Flight crew member. A licensed crew member charged with duties essential to the operation of an aircraft during a flight duty period.

Flight recorder. Any type of recorder installed in the aircraft for the purpose of complementing accident/incident investigation.

Automatic deployable flight recorder (ADFR). A combination flight recorder installed on the aircraft which is capable of automatically deploying from the aircraft.

Note.— See Annex 6, Parts I, II and III, for specifications relating to flight recorders.

Hands-on exercise. Exercise on the use of equipment/aircraft systems that is conducted without a specific context. Equipment that is removed from operation, or other representative training equipment considered acceptable by State, can be used for the purposes of this training.

Hard landing. A landing in which the vertical deceleration encountered required a hard landing check.

Hypoxia. A deficiency of oxygen in inspired gases, arterial blood or tissue, short of anoxia (almost complete absence of oxygen).

In-charge cabin crew member. Cabin crew leader who has overall responsibility for the conduct and coordination of cabin procedures applicable during normal operations and during abnormal and emergency situations for flights operated with more than one cabin crew member.

In-flight. The period from the moment all external aircraft doors are closed following boarding through the moment when one external door is opened to allow passengers to leave the aircraft or until, if a forced landing, competent authorities take over responsibility for the aircraft and individuals and property on the aircraft. For the purpose of the Tokyo Convention an aircraft is considered to be in flight from the moment when power is applied for the purpose of take-off until the moment when the landing run ends.

Incident. An occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of operation.

Note.— The types of incidents which are of main interest to the International Civil Aviation Organization for accident prevention studies are listed in ICAO Annex 13, Attachment C.

Infant. A passenger who has not reached their second birthday.

Investigation. A process conducted for the purpose of accident prevention which includes the gathering and analysis of information, the drawing of conclusions, including the determination of causes and/or contributing factors and, when appropriate, the making of safety recommendations.

Investigator-in-charge. A person charged, on the basis of his or her qualifications, with the responsibility for the organization, conduct and control of an investigation.

Note.— Nothing in the above definition is intended to preclude the functions of an investigator-in-charge being assigned to a commission or other body.

Master minimum equipment list (MMEL). A list established for a particular aircraft type by the organization responsible for the type design with the approval of the State of Design containing items, one or more of which is permitted to be unserviceable at the commencement of a flight. The MMEL may be associated with special operating conditions, limitations or procedures.

Minimum equipment list (MEL). A list which provides for the operation of aircraft, subject to specified conditions, with particular equipment inoperative, prepared by an operator in conformity with, or more restrictive than, the master minimum equipment list (MMEL) established for the aircraft type.

Mock-up. A training device that is a partial, functional replica of an actual aircraft, without motion.

Occurrence. Any accident or incident associated with the operation of an aircraft.

Operations manual. A manual containing procedures, instructions and guidance for use by operational personnel in the execution of their duties.

Operator. The person, organization or enterprise engaged in or offering to engage in an aircraft operation.

Passenger. A person who is not an operating crew member.

Performance criteria. Simple, evaluative statements on the required outcome of the competency element and a description of the criteria used to judge whether the required level of performance has been achieved.

Person with disabilities. Any person whose mobility is reduced due to a physical incapacity (sensory or locomotor), an intellectual deficiency, age, illness or any other cause of disability when using transport and whose situation needs special attention and the adaptation to the person's needs of the services made available to all passengers.

Pilot-in-command. The pilot designated by the operator, or in the case of general aviation, the owner, as being in command and charged with the safe conduct of a flight.

Portable electronic device (PED). Any lightweight, electrically-powered equipment. These devices are typically consumer electronic devices capable of communication, data processing and/or utility. Examples range from hand held, lightweight electronic devices such as tablets, e-readers, and smart phones to small devices such as MP3 players and electronic toys.

Protective breathing equipment (PBE). Breathing equipment providing full, sealed protection against smoke, fumes, etc., covering the head, the collar and upper shoulder area. Fifteen-minutes minimum oxygen supply per PBE is recommended.

Restraint. A device designed to safely restrain an occupant in his/her seat to prevent injuries resulting from inertia forces or other in-flight forces such as turbulence. A restraint may be a seat belt, safety harness or approved child restraint system.

Safety recommendation. A proposal of an accident investigation authority based on information derived from an investigation, made with the intention of preventing accidents or incidents and which in no case has the purpose of creating a presumption of blame or liability for an accident or incident. In addition to safety recommendations arising from accident and incident investigations, safety recommendations may result from diverse sources, including safety studies.

Serious incident. An incident involving circumstances indicating that there was a high probability of an accident and associated with the operation of an aircraft which, in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time as it comes to rest at the end of the flight and the primary propulsion system is shut down.

Note 1.— The difference between an accident and a serious incident lies only in the result.

Note 2.— Examples of serious incidents can be found in ICAO Annex 13, Attachment C.

Serious injury. An injury which is sustained by a person in an accident and which:

- a) requires hospitalization for more than 48 hours, commencing within seven days from the date the injury was received; or
- b) results in a fracture of any bone (except simple fractures of fingers, toes or nose); or
- c) involves lacerations which cause severe haemorrhage, nerve, muscle or tendon damage; or
- d) involves injury to any internal organ; or
- e) involves second or third degree burns, or any burns affecting more than 5 per cent of the body surface; or
- f) involves verified exposure to infectious substances or injurious radiation.

Simulated exercise. Exercise representing a full context scenario (e.g. aircraft evacuation) where cabin crew apply the operator's procedures and associated crew responsibilities for dealing with the specific situation. This is typically conducted in a representative training device capable of reproducing the appropriate environment/equipment characteristics (e.g. cabin, flight deck, accessible cargo compartment, crew rest area, etc.), or on an actual aircraft.

Special categories of passengers. Persons who need special conditions, assistance, or equipment when travelling by air. These may include but are not limited to:

- a) infants;
- b) unaccompanied children;
- c) persons with disabilities;
- d) persons with mobility impairments;
- e) persons on stretchers; and
- f) inadmissible passengers, deportees or persons in custody.

State of Design. The State having jurisdiction over the organization responsible for the type design.

State of Manufacture. The State having jurisdiction over the organization responsible for the final assembly of the aircraft, engine or propeller.

State of Occurrence. The State in the territory of which an accident or incident occurs.

State of the Operator. The State in which the operator's principal place of business is located or, if there is no such place of business, the operator's permanent residence.

State of Registry. The State on whose register the aircraft is entered.

Note.— In the case of the registration of aircraft of an international operating agency on other than a national basis, the States constituting the agency are jointly and severally bound to assume the obligations which, under the Chicago Convention, attach to a State of Registry. See, in this regard, the Council Resolution of 14 December 1967 on Nationality and Registration of Aircraft Operated by International Operating Agencies which can be found in Policy and Guidance Material on the Economic Regulation of International Air Transport (Doc 9587).

Survivable crash environment. An environment that prevails when the cabin occupants are subjected to crash forces within human tolerance levels, and the structural integrity of the passenger space remains intact such that the occupants can rapidly evacuate an aircraft.

Survivor. A victim who is not fatally injured as a result of the aircraft accident.

Unstaffed exit. Emergency exit for which no cabin crew member has been positioned for the flight.

Victim. An occupant of the aircraft, or any person outside the aircraft, who is unintentionally directly involved in the aircraft accident. Victims may include the crew, revenue passengers, non-revenue passengers and third parties.

ABBREVIATIONS

AAIB	Air Accidents Investigation Branch
AAIASB	Hellenic Air Accident Investigation and Aviation Safety Board
ABPs	Able-bodied passengers
ADH	Automatically disposable hatch
AED	Automated external defibrillator
AFDR	Automatic deployable flight recorder
CI	Cabin investigator
CVR	Cockpit voice recorder
CRM	Crew resource management
EASA	European Aviation Safety Agency
ELT	Emergency locator transmitter
FAA	Federal Aviation Administration
FAK	First-aid kit
I/C	In-charge cabin crew member
ICAO	International Civil Aviation Organization
IFE	In-flight entertainment system
ISASI	International Society of Air Safety Investigators
MEL	Minimum equipment list
MPET	Metallized polyethylene terephthalate
MSN	Aircraft manufacturer's serial number
NTSB	National Transportation Safety Board
PBE	Portable breathing equipment
PED	Portable electronic device
PIC	Pilot-in-command
PA	Public address
RAIO	Regional accident and incident investigation organization
RFF	Rescue and firefighting
SARPs	Standards and Recommended Practices
TSB	Transportation Safety Board of Canada
TSO	Technical standard order

PUBLICATIONS

(Referred to in this document)

ICAO PUBLICATIONS

Annex 13 — Aircraft Accident and Incident Investigation

Annex 18 — The Safe Transport of Dangerous Goods by Air

Manual of Aircraft Accident and Incident Investigation (Doc 9756)

Technical Instructions for the Safe Transport of Dangerous Goods by Air (Doc 9284)

Manual on Accident and Incident Investigation Policies and Procedures (Doc 9962)

Manual on Assistance to Aircraft Accident Victims and their Families (Doc 9973)

ICAO Policy on Assistance to Aircraft Accident Victims and their Families (Doc 9998)

Cabin Crew Safety Training Manual (Doc 10002)

Procedures for Air Navigation Services — Training (PANS-TRG, Doc 9868)

Training Guidelines for Aircraft Accident Investigators (Cir 298)

Hazards at Aircraft Accident Sites (Cir 315)

Guidelines on Education, Training and Reporting Practices related to Fume Events (Cir 344)

Human Factors Digest No. 7 — Investigation of Human Factors in Accidents and Incidents (Cir 240)

MISCELLANEOUS

EASA Safety Information Bulletin (EASA SIB No: 2009-33)

ISASI Cabin Safety Investigation Guidelines (www.icao.int/cabinsafety)

Chapter 1

INTRODUCTION

1.1 ACCIDENT INVESTIGATION

1.1.1 Not all aircraft accidents are survivable. However, a review of ICAO accident data from 2009-2013 involving commercial scheduled air transport indicated that the majority of accidents (87.7 per cent) resulted in no fatalities. The fact that most occupants survive accidents can be linked to improvements made in occupant protection. These improvements result from survival factor investigations, which address cabin safety aspects during accident investigations. The following aspects of an accident investigation are referred to as “survival factors”:

- a) injuries sustained by occupants of the aircraft or by other affected persons;
- b) aircraft exterior and interior configuration and damage;
- c) operator's policies and procedures relevant to cabin safety;
- d) aircraft search and rescue responses;
- e) crashworthiness issues;
- f) equipment location, operation and functionality;
- g) emergency response and escape paths;
- h) occupant and witness interviewing;
- i) human performance (crew and passengers);
- j) operator's cabin crew normal, abnormal and emergency procedures training programme;
- k) cabin crew training records; and
- l) other records, as applicable, that could have affected occupant survivability (e.g. cabin crew scheduling records).

1.1.2 Cabin safety aspects should be addressed as part of the investigation process. The goal of a cabin safety investigation is to analyse all aspects of an accident or incident, in relation to the actions of cabin crew members and passengers, as well as the cabin environment and relevant systems and equipment on board, in order to identify safety deficiencies and lessons learned. The investigation may result in the development of recommendations related to operator procedures, fatigue (e.g. scheduling practices), training, safety and emergency equipment, aircraft systems, etc. Guidance on accident investigation may be found in Chapter 5.

1.2 INCIDENT INVESTIGATION

1.2.1 As per ICAO definitions, accidents and incidents are differentiated by their outcomes. For example, an evacuation in which occupants sustain serious injuries is classified as an accident. An evacuation without injuries or aircraft damage is classified as an incident. However, the lack of a negative outcome (e.g. serious injury) does not mean that lessons cannot be learned from the occurrence. Incidents may provide evidence of hazards or deficiencies within the aviation system. A well conducted incident investigation should identify all immediate and underlying systemic causes of an occurrence and subsequently recommend appropriate safety actions aimed at avoiding the hazards or eliminating the deficiencies.

1.2.2 With the goal of improving safety, the State and the operator should consider conducting in-depth investigations of mandatory reported events. Likewise, events not requiring notification to the State of the Operator may be a source of lessons learned and should be considered for investigation by the operator in its safety management system, taking into account available resources. Guidance on incident investigation is presented in Chapter 6.

1.3 PURPOSE

1.3.1 The purpose of this manual is to encourage the uniform application of the Standards and Recommended Practices (SARPs) contained in Annex 13 – *Accident and Incident Investigation*, and to provide information and guidance to States on the procedures, practices and techniques that may be used in aircraft accident investigations, specific to cabin safety. It is also intended to complement guidance presented in the *Manual of Aircraft Accident and Incident Investigation* (Doc 9756).

1.3.2 Furthermore, this manual provides guidance to help operators investigate incidents, which do not meet the ICAO definition of an accident, hence do not require an accident investigation by the State of Occurrence, but which may provide evidence of hazards or deficiencies within the aviation system.

1.4 SCOPE

This manual focuses specifically on cabin safety aspects that should be addressed as part of the investigation process. Other aspects required during an investigation are outside the scope of this manual. However, they should be included as part of the final report, which is produced at the completion of an investigation. Since accident investigations vary in complexity, a document of this kind cannot cover all eventualities. However, the most common techniques and processes are included herein. Although this manual is of use to both experienced and inexperienced investigators, it is not a substitute for investigation training. Guidance on cabin investigator training is presented in Chapter 4.

Chapter 2

OVERVIEW OF ICAO SARPs AND GUIDANCE MATERIAL

2.1 ICAO STANDARDS AND RECOMMENDED PRACTICES

2.1.1 Annex 13 — *Aircraft Accident and Incident Investigation* contains the Standards and Recommended Practices for aircraft accident and incident investigation. Annex 13, 3.1 defines the sole objective of the investigation of an aircraft accident or incident to be the prevention of future accidents and incidents. It also states that it is not the purpose of an investigation to apportion blame or liability.

2.1.2 The Annex addresses the following aspects:

- a) definitions, including those that differentiate accidents from incidents;
- b) applicability of the specifications in the Annex;
- c) general aspects related to an investigation, such as the objective of the investigation, the protection of evidence, custody and removal of aircraft, and the responsibility of the State of Occurrence;
- d) notification of accidents or serious incidents, including the responsibility of the State of Occurrence, the State of Registry, the State of the Operator, the State of Design, and the State of Manufacture;
- e) investigation, including responsibilities, organization and conduct of, and participation therein;
- f) final report, including the responsibility of a State receiving or issuing safety recommendations;
- g) reporting of accidents to ICAO; and
- h) accident prevention measures, such as incident reporting systems and exchange of safety information.

2.2 ICAO GUIDANCE MATERIAL

2.2.1 Aircraft accident and incident investigation

2.2.1.1 The *Manual of Aircraft Accident and Incident Investigation* (Doc 9756) was developed to encourage the uniform application of the SARPs contained in Annex 13 and to provide information and guidance to States on the procedures, practices and techniques that may be used in accident and incident investigations. It is issued in four parts and supersedes the *Manual of Aircraft Accident Investigation* (Doc 6920).

- a) Part I — *Organization and Planning*, includes considerations for the establishment of an aircraft accident investigation authority in terms of its structure, legislation, funding and personnel. The planning of an investigation and the notification process for accidents and incidents are also

addressed, as are the initial actions to be taken at an accident site, with particular emphasis on the safety of personnel. A directory of the accident investigation authorities in all States and their contact details is included.

- b) Part II — *Procedures and Checklists* provides information on common techniques and procedures, as well as checklists to assist States in aircraft accident and incident investigations. The manual also provides guidelines on major investigations that may be used, particularly in the conduct of larger accident investigations.
- c) Part III — *Investigation* provides guidance for the investigation of all technical areas that could be involved in an accident or incident. Guidance is also provided for the multiple phases of an investigation. The content includes wreckage investigation, structures and systems investigation, flight recorders, aircraft performance, survival factors, etc.
- d) Part IV — *Reporting* provides guidance in developing the final reports as a result of the investigation of accidents and incidents, including comprehensive guidelines on the drafting and processing of safety recommendations. It outlines the format, content and the procedures for consultation, release, distribution and dissemination of the final report.

2.2.2 Accident investigator training

2.2.2.1 The *Training Guidelines for Aircraft Accident Investigators* (Cir 298) outlines the training requirements for aircraft accident investigators, including background experience, initial and on-the-job training and basic and advanced investigation courses. It also provides guidelines for accident investigation courses.

2.2.2.2 Working at aircraft accident sites has the potential to expose investigators and search and rescue personnel to a wide range of health and safety hazards. These hazards, generated by the damage to structures, systems, components and aircraft contents, will be variable in nature and will be influenced by the factors associated with the accident scenario (e.g. location, weather conditions, environment, security, etc.). The *Hazards at Aircraft Accident Sites* (Cir 315) was produced to assist individuals in applying effective occupational safety management practices to both their own activities and to the activities of the teams that they work with or for which they are responsible. The circular discusses the nature and variety of occupational hazards and the management of risks associated with exposure to these hazards during the investigation of aircraft accidents.

2.2.3 Organizational aspects of an investigation

2.2.3.1 The *Manual on Regional Accident and Incident Investigation Organization* (Doc 9946) provides information and guidance on the establishment and management of a regional accident and incident investigation organization (RAIO) to assist States in fulfilling their obligations pertaining to accident and incident investigation. A regional investigation system may provide economies of scale by allowing for the sharing of required resources. The manual outlines the duties and responsibilities of States, individually and/or collectively, with respect to the establishment and management of a regional accident and incident investigation system.

2.2.3.2 The *Manual on Accident and Incident Investigation Policies and Procedures* (Doc 9962) is an implementation tool to assist States in developing a policies and procedures manual for accident and incident investigation. The manual provides a template for States to modify, as necessary, their accident investigation documentation in accordance with Annex 13 provisions and to standardize and harmonize accident investigation processes among States. The manual was developed in such a manner that States may adapt it by “filling in the blanks” with State-specific material, such as legislation and regulations.

2.2.4 Assistance to aircraft accident victims and their families

2.2.4.1 The *Manual on Assistance to Aircraft Accident Victims and their Families* (Doc 9973) provides guidance on the types of family assistance to aircraft accident victims and their families. The document updates and expands relevant guidance by incorporating recent lessons learned and developments in the area of family assistance. It discusses the types of assistance that may be provided, as well as the providers and recipients of such assistance. Examples of several States' legislation or regulations for the provision of family assistance are also provided.

2.2.4.2 The *ICAO Policy on Assistance to Aircraft Accident Victims and their Families* (Doc 9998) sets out ICAO policies regarding the provision of assistance to aircraft accident victims and their families. States are encouraged to incorporate these policies when planning, developing and implementing their legislation, regulations, policies and procedures related to family assistance.

2.3 ADDITIONAL GUIDANCE MATERIAL

The *Cabin Safety Investigation Guidelines* of the International Society of Air Safety Investigators (ISASI) were developed to provide investigators and other operational personnel with the tools to investigate the survival aspects of incidents and accidents. Guidance is provided for documenting damage to the cabin interior and its equipment and conducting cabin crew and passenger interviews. The guidelines are adaptable to any type of occurrence (e.g. turbulence). A copy of the ISASI guidelines may be obtained from the ICAO website in the Cabin Safety Library at: www.icao.int/cabinsafety.

Chapter 3

ACCIDENT INVESTIGATION AND CABIN SAFETY IMPROVEMENTS

3.1 HISTORICAL REVIEW

This chapter presents a historical review of accidents that had significant cabin safety components and that represent a turning point in the field of cabin safety. Accident reports for each of the occurrences referenced in this chapter may be obtained from the ICAO website in the Cabin Safety Library at: www.icao.int/cabinsafety.

3.2 IN-FLIGHT FIRE

3.2.1 In June 1983, a DC-9-32 on a scheduled passenger flight from Dallas to Montreal via Toronto, with 41 passengers and five crew members on board, experienced a fire which was discovered by cabin crew members in the aft lavatory during cruise flight. The crew made an emergency descent and landed at the Greater Cincinnati International Airport. When the aircraft came to a stop, the cabin crew and passengers began to evacuate. Approximately 60 to 90 seconds after the exits were opened, a flash fire enveloped the aircraft interior. Twenty-three passengers were fatally injured; the aircraft was destroyed by fire.

3.2.2 The National Transportation Safety Board (NTSB) determined that the probable causes of the accident were a fire of undetermined origin, an underestimate of fire severity and misleading fire progress information provided to the captain. The report stated that it is likely that some of the fatally injured passengers had made their way aft in the cabin trying to locate the overwing exits. However, the visibility had deteriorated so badly that they were not able to locate them. Survivors also noted difficulties locating exits in the thick smoke.

3.2.3 Recommendations in the accident report included, but were not limited to:

- a) requirements for smoke detectors in lavatories;
- b) requirements for the installation of automatic fire extinguishers adjacent to and in lavatory waste receptacles;
- c) the need for operator review of firefighting training and procedures to focus on: taking "aggressive actions" to determine the source and severity of suspected cabin fires, communication between flight and cabin crew and the need for hands-on training;
- d) passenger instruction in how to open emergency exits to become standard practice within the airline industry; and
- e) the need to install (or improve) in-cabin fire safety enhancements, including but not limited to:
 - 1) fire-blocking seat materials to limit both the spread of fire and the generation of toxic chemicals through ignition;

- 2) emergency track lighting at or near the floor, strong enough to cut through heavy fuel-fire smoke;
- 3) raised markings on overhead bins indicating the location of exit rows to aid passengers in locating these rows in case of passenger visual impairment (either pre-existing or caused by emergency conditions); and
- 4) hand-held fire extinguishers using advanced technology extinguishing agents such as Halon.

3.3 FIRE AND EVACUATION AFTER REJECTED TAKE-OFF

3.3.1 In August 1985, a B737-200 on a charter flight from Manchester to Corfu, with 131 passengers and six crew members on board, rejected its take-off following an uncontained engine failure which punctured the wing fuel tank access panel. A fire broke out in the left engine of the aircraft and the flight crew made a public address (PA) instructing occupants to evacuate via the right side. Fire spread to the cabin shortly after the aft right exit was opened. Fifty-three passengers and two crew members were fatally injured; the aircraft was damaged beyond repair.

3.3.2 The Air Accidents Investigation Branch (AAIB) cited the major cause of the fatalities as being rapid incapacitation due to the inhalation of the dense toxic/irritant smoke atmosphere within the cabin, aggravated by evacuation delays caused by a door malfunction and restricted access to exits. The report also cited issues related to the presentation of instructions in the safety briefing card, difficulties in operating overwing exits and congestion in the aisles and at exits.

3.3.3 Recommendations in the accident report included, but were not limited to:

- a) consideration of the requirement for fitting an evacuation alarm permitting the flight crew to instruct the cabin crew to initiate an evacuation;
- b) the need to stow emergency equipment used during an evacuation at cabin crew stations;
- c) the review of cabin configuration approval, with reference to restrictions to overwing exit access;
- d) the review of requirements related to “unobstructed access” to exits, taking into account high density seating configurations; and
- e) the review of evacuation certification requirements to include aspects such as unusable exits, dense smoke, passenger aisle flow, the identification of exits and opening egress rate.

3.4 ENGINE FAILURE AND EMERGENCY LANDING

3.4.1 In January 1989, a B737-400 on a scheduled passenger flight from London to Belfast, with 118 passengers and eight crew members on board, experienced a fan blade fracture in the No. 1 engine. Believing that the No. 2 engine suffered the damage, the flight crew shut it down and diverted to East Midlands Airport. The No. 1 engine subsequently suffered a major thrust loss and the aircraft impacted a field near the embankment of a motorway. Forty-seven passengers were fatally injured and 74 occupants, including seven crew members and one infant, sustained serious injuries. The aircraft was destroyed.

3.4.2 According to the AAIB, one of the factors contributing to the incorrect response from the flight crew (i.e. shutting down the wrong engine), was that they were not informed of the flames, which emanated from the No. 1 engine and were observed by many on board, including three cabin crew members in the aft cabin. The investigation noted that

noises, vibrations, odours, smoke and signs of fire were observed by passengers and cabin crew members; these were not relayed to the flight deck. During the diversion, the captain made a PA explaining to passengers that trouble with the right engine had produced smoke and it was shut down. The accident report noted that many passengers who saw the fire in the left engine were puzzled by the captain's reference to the right engine, but never brought the discrepancy to the attention of the cabin crew.

3.4.3 Following impact, the majority of passengers were trapped due to injury, seat failure or debris from overhead. Both flight crew members as well as two cabin crew were also trapped by seat failure or debris.

3.4.4 Among the recommendations, the report stated that training exercises for pilots and cabin crew should be introduced to improve coordination between flight and cabin crew in response to an emergency. Other recommendations included:

- a) research into seat design with emphasis on effective upper torso restraint and aft-facing passenger seats;
- b) modifications to certification requirements for cabin floors of new aircraft types;
- c) the use of child seats as restraint systems for infants and children;
- d) modifications to certification requirements for cabin stowage bins and other cabin items of mass; and
- e) the introduction of training exercises for pilots and cabin crew to improve coordination in response to an emergency.

3.5 LOSS OF CONTROL AFTER TAKE-OFF

3.5.1 In March 1989, a Fokker F-28 Mk1000 on a scheduled passenger flight from Thunder Bay to Winnipeg via Dryden, with 65 passengers and four crew members on board, crashed off the end of the runway after take-off from the Dryden Municipal Airport. The aircraft failed to gain altitude after its attempted take-off and continued on a flat flight path, barely clearing a bluff approximately 700 metres from the end of the runway and crashing into a densely wooded area. Twenty-one passengers and three crew members, including the captain, the first officer, and one of the two cabin crew members, were fatally injured as a result of the crash and the accompanying fire. There was extensive physical and fire damage to the aircraft.

3.5.2 Contamination on the wings resulted in a loss of control of the aircraft. The final report issued by the Commission of Inquiry into the accident noted that one of the cabin crew members and several passengers noticed ice build-up on the wings but failed to transmit this information to the flight crew. Poor crew resource management and deficiencies in cabin crew training were also cited as contributing factors. Findings included, but were not limited to:

- a) aircraft interior furnishings burned and gave off heavy, sooty smoke and toxic gases; and burning, molten-plastic-like material fell on passengers;
- b) the clothing and slip-on shoes worn by the cabin crew member did not afford her adequate protection after the crash, since the weather was cold;
- c) passenger seats were deformed and many were detached from the aircraft floor and bunched in the front of the cabin after impact;
- d) overhead bins fell on several passengers; and

- e) many survivors of the crash were hindered in their escape by debris in the aircraft, some of which was carry-on baggage from the overhead bins and from under the aircraft seats.

3.5.3 Recommendations included, but were not limited to:

- a) the prohibition of refuelling an aircraft with an engine operating when passengers are on board, boarding, or deplaning;
- b) the development and implementation of a mandatory and comprehensive education programme for all air crew engaged in commercial operations, including an integrated programme for flight crew members and cabin crew members, on the adverse effects of wing contamination on aircraft performance, with provision for knowledge verification;
- c) the adoption of standards for aircraft interiors that would prevent the rapid spread of fire and emission of toxic fumes;
- d) the requirement for each operator to provide the competent authority with an operator cabin crew manual for review and approval, either as part of the flight operations manual or as a separate manual;
- e) the development and implementation of regulations, setting the training and competency requirements for cabin crew members;
- f) that the competent authority monitor and periodically audit the cabin crew training programme of all operators to ensure that such training meets the standards set;
- g) that the competent authority ensure that the intention of the "clean-wing" concept be incorporated into and given effect in the appropriate operational manuals of operators in the State;
- h) the requirement to retrofit shoulder harnesses and other safety-enhancing features for cabin crew seats on older aircraft types such as the F-28 aircraft;
- i) that the competent authority address the lack of maximum flight times and maximum flight duty times prescribed for cabin crew members;
- j) the development and implementation of regulations requiring operators to provide approved crew resource management (CRM) training and standard operating procedures for all operators' flight crews and cabin crews. This training should be designed to coordinate the flight activities and information exchange of the entire air crew team (flight and cabin crew);
- k) that the captain of an aircraft operating in adverse winter weather conditions be formally required to advise the in-charge cabin crew member, prior to departure from the gate, whether ground de-icing of the aircraft is to take place and, in order to eliminate potential apprehension on the part of passengers, that they be advised accordingly on the PA system of the aircraft; and
- l) the development and implementation of a regulation requiring that, at any time prior to commencement of the take-off roll, in the absence of prior advice by the captain that ground de-icing of the aircraft in adverse winter weather conditions is to be conducted, the in-charge cabin crew member be required to report to the captain his or her own concerns, or any concerns conveyed to him or her by any cabin crew member or any passenger on board the aircraft, relating to wing contamination.

3.6 ENGINE FAILURE AND EMERGENCY LANDING

3.6.1 In July 1989, a DC-10-10 on a scheduled passenger flight from Denver to Philadelphia, with 285 passengers and 11 crew members on board, experienced a catastrophic failure of the No. 2 tail-mounted engine during cruise flight. The separation, fragmentation and forceful discharge of stage 1 fan rotor assembly parts from the No. 2 engine led to the loss of the three hydraulic systems that powered the aircraft's flight controls. The flight crew experienced severe difficulties controlling the aircraft, which subsequently crashed during an attempted landing at Sioux Gateway Airport, Iowa. One hundred and ten passengers and one cabin crew member were fatally injured. The aircraft was destroyed by impact and post-impact fire.

3.6.2 There were four lap-held infants on board. During the preparations for the emergency landing, parents were instructed to place their infants on the floor and to hold them there when the parent assumed the protective brace position. Two out of the four infants were projected through the cabin during the impact sequence. One infant was found by a passenger, the other fatally injured. A third infant became airborne but was caught by his mother. The NTSB's analysis of this accident included an evaluation of cabin survivability issues, including child (infant) seat restraints.

3.6.3 Some of the safety issues raised in the NTSB report related to cabin safety, including infant restraint systems, and airport rescue and firefighting facilities. The report urged that infants and small children be required to be restrained in child safety seats appropriate to their height and weight.

3.7 RUNWAY COLLISION

3.7.1 In February 1991, a B737-300 with 83 passengers and six crew members on board collided with a SA-227-AC (Metroliner) at Los Angeles International Airport. Upon landing, the B737 struck the Metroliner, continued down the runway with the SA-227 crushed beneath it, exited the runway, and caught fire. All 12 occupants on board the Metroliner, as well as 20 passengers and two crew members on board the Boeing were fatally injured. Both aircraft were destroyed by impact forces of the collision and a post-impact fire.

3.7.2 Four of the B737's six exits were used. The NTSB report noted congestion at the overwing exits, only one of which was usable. The majority of fatalities aboard the B737 were due to asphyxiation in the post-impact fire. Fifteen passengers seated aft of the overwing area who made their way to the rear of the cabin reported using emergency floor path lighting.

3.7.3 The NTSB accident report cited as a finding that the exit row briefing provided by the operator of the B737 increased the preparedness of passengers for the evacuation. It also noted that the delay in opening the right overwing exit, the partially blocked exit opening, and the reaction to stress, all caused delays in the egress of some passengers. Many of the fatally injured B737 passengers were found near the overwing exit. They did not proceed to another available exit in the rear of the aircraft and were overcome when the cabin fire intensified. The report noted that the lack of use of available aft exits may have been the result of smoke and limited visibility in the cabin.

3.7.4 Safety issues raised in the report included air transport accident survivability, evacuation standards and procedures, interior furnishing flammability standards and survival devices.

3.8 IN-FLIGHT FIRE AND IMPACT WITH TERRAIN

3.8.1 In May 1996, a DC-9-32 on a scheduled passenger flight from Miami to Atlanta, with 105 passengers and five crew members on board, experienced a loss of control caused by an uncontrolled fire which started in the aircraft's forward cargo compartment. The aircraft crashed while attempting to return to Miami. There were no survivors; the aircraft was destroyed.

3.8.2 The NTSB determined that the fire was initiated by the actuation of one or more chemical oxygen generators, which were being improperly carried as cargo on board the aircraft. The report stated that a smoke/fire warning device would have promptly alerted the flight crew to the fire and allowed them more time to land the aircraft. Had the aircraft been equipped with a fire suppression system, it might have suppressed the spread of the fire (although the intensity of the fire might have been so great that a suppression system would not have been sufficient to fully extinguish the fire). A fire suppression system would certainly have delayed the spread of the fire, however, and, in conjunction with an early warning, would likely have provided time to land the aircraft safely.

3.8.3 Recommendations in the accident report included, but were not limited to:

- a) expediting final rulemaking by the competent authority to require smoke detection and fire suppression systems for all Class D cargo compartments;
- b) research to develop technologies and methods for enhancing passenger respiratory protection from toxic atmospheres resulting from in-flight and post-crash fires involving transport-category aircraft; and
- c) evaluating the usefulness and effectiveness of the Douglas DC-9 procedures involving the partial opening of cabin doors and similar procedures adopted by some operators of other transport-category aircraft for evacuating cabin smoke or fumes and, based on that evaluation, determining whether these or other procedures should be included in all manufacturers' aircraft flight manuals and operators' operating manuals.

3.9 IN-FLIGHT FIRE AND IMPACT WITH WATER

3.9.1 In September 1998, an MD-11 on a scheduled passenger flight from New York to Geneva, with 215 passengers and 14 crew members on board, experienced an in-flight fire. The aircraft crashed while attempting to divert to Halifax. There were no survivors; the aircraft was destroyed.

3.9.2 The accident report, issued by the Transportation Safety Board of Canada (TSB), stated that flammable material propagated a fire that started above the ceiling on the right side of the flight deck near its rear wall. The fire spread and intensified rapidly, thereby degrading aircraft systems and the flight deck environment, ultimately leading to the loss of control of the aircraft. The TSB concluded that aircraft certification standards for material flammability were inadequate, in that they allowed the use of materials that could be ignited and sustain or propagate fire.

3.9.3 The accident report stated that the metallized polyethylene terephthalate (MPET)-type cover material was most likely the first material to ignite and constituted the largest portion of the combustible materials that contributed to the propagation and intensity of the fire. The TSB recommended that competent authorities take action, on an urgent basis, to reduce or eliminate the risk associated with the use of MPET-type cover material on the thermal acoustic insulation blankets in aircraft.

3.9.4 The accident report also stated that, once ignited, other types of thermal acoustic insulation cover materials exhibit flame propagation characteristics similar to MPET-covered insulation blankets and do not meet the proposed revised flammability test criteria. Metallized polyvinyl fluoride-type cover material was installed in the accident aircraft and was involved in the in-flight fire. The TSB recommended that competent authorities test all thermal acoustic insulation materials against more rigorous test criteria, and that flammability standards for material used in the manufacture of any aeronautical product be revised, based on realistic ignition scenarios, to prevent the use of any material in the construction of aircraft that sustains or propagates fire.

3.10 RUNWAY OVERRUN AND FIRE

3.10.1 In August 2005, an A340-300 on a scheduled passenger flight from Paris to Toronto, with 297 passengers¹ and 12 crew members on board, overran the runway after landing at Toronto International Airport. The aircraft was not able to stop on the runway and departed the far end. It stopped in a ravine and caught fire. All passengers and crew members were able to evacuate the aircraft before the fire reached the escape routes. A total of 10 passengers and two crew members were seriously injured during the crash and the ensuing evacuation; the aircraft was destroyed by fire.

3.10.2 The TSB accident report included the following findings:

- a) the emergency power for both the PA and evacuation alert systems are located in the avionics bay. A less vulnerable system and/or location would reduce the risk of these systems failing during a survivable crash;
- b) brace commands were not given by the cabin crew during this unexpected emergency condition. Although it could not be determined if some passengers were injured as a result, research indicates that the risk of injury is reduced if passengers brace properly;
- c) 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; and
- d) although all passengers managed to evacuate, the evacuation was impeded because nearly 50 per cent of passengers retrieved carry-on baggage. It is estimated that the aircraft was evacuated in a little more than two minutes.

3.10.3 The report stated that the evacuation was successful due to the training and actions of the whole cabin crew. In general, the performance of the cabin crew was deemed exemplary and professional, and was a significant factor in the successful evacuation of the aircraft. The report cited effective communication between the flight crew and the cabin crew members. It noted that the cabin crew were advised of the possibility of a missed approach. Therefore, they were in a state of heightened awareness during the landing phase and were prepared to respond immediately in the event of an emergency.

3.11 FLIGHT CREW INCAPACITATION

3.11.1 In August 2005, a B737-300 on a scheduled passenger flight from Larnaca to Athens, with 115 passengers and six crew members on board, failed to pressurize due to the aft outflow valve being partially open. As the aircraft climbed, the cabin altitude warning horn sounded. The warning was misidentified by the flight crew as a take-off configuration warning. They attempted to troubleshoot with assistance from the operator's personnel on the ground. The oxygen masks in the passenger cabin automatically deployed. The aircraft continued to climb and both flight crew members succumbed to hypoxia. The aircraft continued on auto-pilot and entered the holding pattern near Athens International Airport. It remained in the holding pattern, under control of the auto-pilot, until it suffered from fuel exhaustion and crashed. There were no survivors; the aircraft was destroyed.

3.11.2 The Hellenic Air Accident Investigation and Aviation Safety Board (AAIASB) report stated that direct causes of the accident included the non-identification of warnings and reasons for the activation of such warnings, such as the deployment of passenger oxygen masks in the cabin. Latent causes included inadequate application of crew

1. Passengers included eight children and three infants; adult passengers included three wheelchair-using passengers and one blind passenger.

resource management principles. The AAIASB further concluded that one of the factors that could have contributed to the accident was the lack of cabin crew procedures (at an international level) to address events involving loss of pressurization and continuation of the climb despite passenger oxygen mask deployment.

3.11.3 In the accident report, the AAIASB recommended to amend cabin crew procedures, so that, when the oxygen masks deploy in the cabin due to loss of cabin pressure or insufficient cabin pressure and if the aircraft does not suspend climb, or level off or start a descent, the in-charge cabin crew member (or the cabin crew member situated closest to the flight deck) be required to immediately notify the flight crew of the oxygen mask deployment and to confirm that the flight crew have donned their oxygen masks.

3.11.4 As a follow up to the accident, the European Aviation Safety Agency (EASA) issued a Safety Information Bulletin (EASA SIB No: 2009-33), recommending that operations manuals should be reviewed and amended, where necessary, to address the following: "If the oxygen masks deploy in the cabin or there is any other sign of loss of or insufficient cabin pressure, in addition to the standard procedure (e.g. ensure their oxygen supply, secure themselves, etc.) the cabin crew should, as soon as practicable, inform, by the appropriate means, the flight crew of the situation and confirm that flight crew members wear their oxygen masks."

3.11.5 A copy of the EASA SIB may be obtained from the ICAO website in the Cabin Safety Library at: www.icao.int/cabinsafety.

3.12 DITCHING

3.12.1 In January 2009, an A320-200 on a scheduled passenger flight from New York to Charlotte, with 150 passengers (including a lap-held infant) and five crew members, ditched on the Hudson River about 8.5 miles from LaGuardia Airport, New York City, after an almost complete loss of thrust in both engines following an encounter with a flock of birds. The event occurred about two minutes after take-off. All occupants evacuated the aircraft by the forward and overwing exits. Four passengers and one cabin crew member were seriously injured, and the aircraft was substantially damaged.

3.12.2 The report noted that the post-crash environment, which included a 41°F (5°C) water temperature and a 2°F (approximately -16°C) wind chill factor and a lack of sufficient slide-rafts (resulting from water entering the aft fuselage), posed an immediate threat to the occupants' lives. Although the route did not require the aircraft to carry equipment mandatory for flights over water, the accident aircraft was equipped for an extended overwater flight, which included life jackets and slide-rafts.

3.12.3 The NTSB report discussed survival-related issues, including passenger brace positions; slide-raft stowage; passenger immersion protection; life line usage; life jacket stowage, retrieval, and donning; pre-flight safety briefings; and passenger education.

3.12.4 The information provided by passengers during the investigation indicated that the following occurred during the flight and evacuation:

- a) seventeen per cent of passengers reported watching most of the pre-flight safety demonstration and an additional 13 per cent reported watching some of the demonstration;
- b) eight per cent reported reading the safety information card before or during the flight;
- c) fifty-three per cent retrieved seat cushions during the evacuation; and

- d) three per cent reported retrieving life jackets from under their seats after impact. An additional three per cent reported retrieving a life jacket from under a different seat after impact. Passengers experienced difficulties retrieving and donning life jackets.

3.12.5 Of the four passengers who sustained serious injuries, three received their injuries during impact. The two passengers who sustained very similar shoulder fractures both described assuming similar brace positions. The NTSB concluded that the recommended brace positions did not take into account seats that did not have a breakover feature and that, in this accident, the recommended brace position might have contributed to the shoulder fractures of two passengers. The NTSB recommended that research be conducted to determine the most beneficial passenger brace position in aircraft with non-breakover seats installed. The report suggested that new guidance material on passenger brace positions may need to be issued based on research results.

3.12.6 The report cited the following factors, which contributed to the survivability of the accident:

- a) the fortuitous use of an aircraft that was equipped for an extended overwater flight, including the availability of the forward slide-rafts, even though it was not required to be so equipped; and
- b) the performance of the cabin crew members while expediting the evacuation of the aircraft.

3.13 TAIL STRIKE DURING LANDING

3.13.1 In July 2013, a B777-200ER on a scheduled passenger flight from Incheon to San Francisco, with 291 passengers and 16 crew members on board, struck the seawall short of runway 28L at San Francisco International Airport. Three passengers were fatally injured; 40 passengers, eight of the 12 cabin crew members, and one of the four flight crew members received serious injuries. The aircraft was destroyed by impact forces and fire.

3.13.2 The dynamics of the impact sequence in this accident were such that occupants were thrown forward and experienced a significant lateral force to the left, which resulted in serious passenger injuries. Two of the three fatally injured passengers were ejected from the aircraft during the impact sequence. The investigation concluded that these two passengers were not wearing their seat belts at the time of the accident. None of the passenger seat units were ejected from the aircraft. The report stated that, had the two ejected passengers been restrained, they likely would have survived the accident.

3.13.3 After the aircraft came to a stop, the in-charge cabin crew member came forward to the flight deck and asked if the cabin crew should evacuate the aircraft; the flight crew told her to wait. Once the pilot monitoring understood that emergency vehicles were responding, he issued the evacuation order. By this time, the cabin crew member at L2A had already commanded the evacuation after observing fire outside door 2R. Upon hearing his command, the in-charge cabin crew member began commanding passengers to evacuate. A review of video footage indicated the evacuation was initiated about 1 minute and 33 seconds after the aircraft came to a stop. The NTSB concluded that the cabin crew acted appropriately when they initiated an emergency evacuation upon determining there was a fire outside door 2R. Further, the delay of about 90 seconds in initiating an evacuation was likely due partly to the pilot monitoring's command not to begin an immediate evacuation, as well as disorientation and confusion. Due to injuries and unusable exits, the evacuation was accomplished by five of the 12 cabin crew members, using three out of the eight exits.

3.13.4 Two slide-rafts released and inflated inside the cabin. This was a result of the catastrophic nature of the crash, which produced loads far exceeding design certification limits. Given the critical nature of these evacuation devices and their proximity to essential crew members, the report noted that the data obtained during the accident investigation could prove useful for future slide-raft design.

3.13.5 The aircraft's structure and seats absorbed a tremendous amount of energy, which, despite multiple spinal fractures, resulted in a complete absence of passenger paralyses. Despite the catastrophic nature of the crash, the NTSB report noted that aircraft provided protection to the extent that 99 per cent of the occupants survived and 98 per cent of the passengers were able to self-evacuate.

3.14 CABIN SAFETY IMPROVEMENTS

3.14.1 The findings from past accident investigations (including those cited in this chapter) have led to significant improvements in the fields of cabin safety and aircraft manufacturing. These include, but are not limited to, the following aspects:

- a) 16G seats;
- b) fire retardant materials;
- c) floor proximity emergency escape path marking;
- d) lavatory smoke detectors and fire extinguishers;
- e) the low heat/smoke release tests;
- f) radiant heat resistant evacuation slide;
- g) exit design;
- h) distances between emergency exits;
- i) cargo compartment fire detection/suppression; and
- j) thermal/acoustic insulation.

3.14.2 Detailed information on each of these improvements is presented in 3.15 to 3.24.

3.15 16G SEATS

In 1988, 16G dynamic standards for all passenger and cabin crew seats became applicable. These standards improved protection against serious head injury (where head contact with seats or other structures occurred). The 16G seats also protect crew members from serious chest injury when upper-torso restraints are used, and prevent occupants from being trapped in their seats due to excessive seat deformation.

3.16 FIRE RETARDANT MATERIALS

Improved standards in resistance to flammability for passenger and cabin crew seat cushions were established in 1984. Cushion material now provides 40 to 60 seconds of additional time for aircraft evacuation compared to the previously used cushions. Improved test standards for large surface area panels (e.g. ceilings, walls, galleys, overhead bins, and

partitions) have been implemented since 1985 to delay the onset of a cabin flashover (flash fire) event. The improved standards give passengers and crew members more time to evacuate the aircraft after an accident. This improvement in cabin material flammability was demonstrated to delay flashover in the cabin.

3.17 FLOOR PROXIMITY EMERGENCY ESCAPE PATH MARKING

In 1986, floor proximity emergency escape path marking became a requirement to aid passengers by marking evacuation paths and identifying exits utilizing illumination sources close to the floor. This system is aimed at improving the evacuation rate under significant smoke conditions in the cabin.

3.18 LAVATORY SMOKE DETECTORS AND FIRE EXTINGUISHERS

Since 1986, all aircraft lavatories are required to be equipped with smoke detectors and, since 1987, automatic fire extinguishers in the waste paper bin in all aircraft lavatories.

3.19 LOW HEAT/SMOKE RELEASE TESTS

The requirement for aircraft cabin materials (e.g. ceiling, sidewall, stowage bins, partitions) to meet low heat/smoke release tests help reduce heat and smoke in the aircraft.

3.20 RADIANT HEAT RESISTANT EVACUATION SLIDE

In 1983, changes made to Technical Standard Order (TSO) for emergency evacuation slides to incorporate a radiant heat test for slide material improved the ability of a slide to resist heat from a large fuel fire nearby.

3.21 EXIT DESIGN

The minimum width specified for the passageway from the aisle to the exit for aircraft with 60 or more passengers was modified to improve access to Type III exits. Egress rates through the exits were found to be faster than previous narrower passageways. Use of an Automatically Disposable Hatch (ADH), instead of the conventional Type III exit for new aircraft types, removes manual intervention to ensure that the hatch's final location after opening does not impede the evacuation path inside or outside the aircraft.

3.22 DISTANCES BETWEEN EMERGENCY EXITS

Since 1989, for aircraft with more than one passenger emergency exit on each side of the fuselage, no passenger emergency exit must be more than 60 feet from any adjacent passenger emergency exit on the same side of the same deck of the fuselage. This is meant to ensure adequate exits for passengers' use in an emergency. Exits are required to be distributed as uniformly as practicable, since this is considered to provide a reasonable seat-to-exit and exit-to-exit distance.

3.23 CARGO COMPARTMENT FIRE DETECTION/SUPPRESSION

In 1998, the Federal Aviation Administration (FAA) required that all large passenger aircraft have fire detection and suppression systems installed in all cargo compartments by March 2001. All existing Class D cargo compartments required an upgrade to Class C or Class E and all existing cargo smoke or fire detection systems required an update to meet the more stringent requirements (detection to occur within one minute). This rule affected aircraft in service and all newly manufactured aircraft.

3.24 THERMAL/ACOUSTIC INSULATION

New regulations on thermal/acoustic insulation were adopted following the accident described in 3.9. These regulations provide specific flammability standards for thermal/acoustic insulation materials typically installed on the fuselage of transport-category aircraft. These standards included the adoption of flammability test methods and criteria that specifically address flame propagation and entry of an external fire into the aircraft (burn through) under realistic fire scenarios. All aircraft manufactured after September 2005 had to install thermal/acoustic insulation materials complying with this rule. The new regulation also affected refurbishment and/or replacement of thermal/acoustic insulation materials in aircraft manufactured prior to September 2005.

Chapter 4

CABIN INVESTIGATOR

4.1 CABIN INVESTIGATOR QUALIFICATIONS AND RESPONSIBILITIES

4.1.1 The cabin investigator (CI) is a person responsible for examining and documenting the factors that affect the survival of occupants involved in accidents, incidents and occurrences involving safety violations. In addition to survival factors, the CI is responsible for determining factors that affect the safety of flight and contribute to an occurrence and its outcomes (e.g. change in an operator policy or procedure that is not supported by training). In the context of an accident or incident investigation, these factors are collectively referred to as "contributing factors".

4.1.2 The CI may be employed by a State, an operator, or an independent accident investigation authority. The content of this chapter can be adapted to any of these roles and/or capacities.

4.1.3 Recommended qualifications of the CI should include, but are not limited to, the following:

- a) ability to investigate, document and analyze issues pertaining to contributing factors in aircraft accidents and incidents;
- b) current knowledge of, and experience in, evaluating:
 - 1) aircraft cabin interior configuration and certification;
 - 2) emergency equipment requirements, design and certification;
 - 3) cabin crew safety and emergency procedures and related training;
 - 4) cabin safety; and
 - 5) occupant protection;
- c) knowledge of:
 - 1) survivability principles;
 - 2) seats and restraint systems performance;
 - 3) crashworthiness principles (e.g. structural integrity, impact energy absorption);
 - 4) emergency response;
 - 5) assisting evacuation means;
 - 6) interior materials and flammability;
 - 7) biomechanics and human tolerances;

- 8) factors that affect performance (e.g. behavioural, medical, operational, equipment design, or environmental);
 - 9) current research on crashworthiness (e.g. research studies);
 - 10) national regulations and international standards applicable to cabin safety subject areas; and
 - 11) legislation from States regarding aviation disaster family assistance;
- d) ability to:
- 1) collate, organize, write, edit and review detailed and comprehensive technical reports;
 - 2) initiate special research projects, studies, and investigations concerning aviation safety;
 - 3) identify safety issues and develop them into safety recommendations to promote aviation safety;
 - 4) research and develop comprehensive, technical, and accurate position statements and responses to inquiries regarding contributing factors and aviation safety;
 - 5) effectively motivate, challenge and direct others, and adapt leadership style to a variety of situations;
 - 6) organize work, set priorities, determine resource requirements and determine short-term and long-term goals and strategies to achieve them;
 - 7) provide effective leadership and manage a team; and
 - 8) work effectively alone or as part of a team environment;
- e) proficiency in using word processing software;
- f) experience and ability to research, develop and conduct formal, technical briefings to a wide range of audiences including senior government officials; and
- g) general fitness to meet the physical demands associated with the possible rigours of field work.

4.1.4 The CI's responsibilities may include, but are not limited to, the following:

- a) act as cabin safety expert during aircraft accident or incident investigations with special emphasis on cabin interior and emergency equipment design, safety and emergency procedures, cabin safety, occupant protection and related issues;
- b) act as a resource for investigations into other survival factor issues that may be outside the area of primary expertise;
- c) conduct surveys, special studies and investigations and develop proposed safety recommendations and testimony;
- d) document, analyze and evaluate survival factors including, but not limited to, cabin safety and cabin crew training, occupant protection, airport operations and airport and community emergency management factors that may arise during an investigation;

- e) determine requirements for special tests, studies and technical assistance that may be necessary in one or more aspects of a given investigation. Direct and monitor these special activities and evaluate their findings in terms of relevancy to contributing factors and occupant survivability;
- f) develop a formal report including significant findings from the investigation in relation to cabin safety and survivability, together with the development of supporting documentation such as photographs, records, charts and diagrams;
- g) ensure the report is timely, complete, logically presented and technically correct and accurately reflects the findings;
- h) identify pertinent safety recommendations and contributing factors determinations;
- i) participate as a member on technical panels in investigations involving survival issues;
- j) prepare, or direct the preparation of, hearing exhibits and examine witnesses, if applicable; and
- k) liaise with the appropriate authorities, as applicable.

4.2 CI TRAINING

4.2.1 CI training programmes should focus on the development of competencies and skills listed in Appendix A and Appendix B, respectively, to this chapter. The competency framework consists of competency units, competency elements and performance criteria. This CI competency framework is based on the following competency units:

- a) prepare for the investigation;
- b) collect data;
- c) analyse data;
- d) present findings and recommendations; and
- e) continuously improve performance.

4.2.2 Prior to the issuance of a CI qualification, all candidates should successfully complete a formal competency assessment in the role. The final assessment of CI competence should be made against the competency framework contained in Appendix A to this chapter.

4.2.3 This chapter is written in the same format as the existing ICAO guidance material which addresses specific competency elements. It provides guidance on the following:

- a) the performance criteria;
- b) the recommended conditions under which the training should be conducted (e.g. classroom-based training versus hands-on exercises);
- c) the reference material that is relevant during the training;
- d) the recommended performance standard used to verify that the performance criteria are met;

- e) the recommended knowledge that the trainees should demonstrate; and
- f) the recommended skills needed to support the competencies (defined in Appendix B to this chapter).

4.2.4 General provisions for competency-based training and assessment, as well as a detailed description of the ICAO course development methodology, may be found in *Procedures for Air Navigation Services — Training* (PANS-TRG, Doc 9868). Additional guidance on accident investigator training may be found in the *Training Guidelines for Aircraft Accident Investigators* (Cir. 298).

4.2.5 Sections 4.3 to 4.7 provide detailed guidance for the development of competency-based training for CI.

4.3 COMPETENCY UNIT 1 — PREPARE FOR THE INVESTIGATION

4.3.1 Preparing for departure

Competency element 1.1: Conduct departure preparations

Performance criteria:

- 1.1.1 Gather launch information.
- 1.1.2 Verify that the necessary documents are available and valid.
- 1.1.3 Verify that the required clothing is available and suitable for the physical environment.
- 1.1.4 Verify that all required inoculations and vaccinations are valid.
- 1.1.5 Verify that the investigation field kit is available, accessible and functional.
- 1.1.6 Verify that the necessary funds for the mission are available.
- 1.1.7 Follow a quick reference checklist, if applicable.

4.3.1.1 *Conditions:*

- a) classroom and/or computer-based training (including, for example, a role-playing exercise on conducting departure preparations); and
- b) hands-on exercise on verifying documentation.

4.3.1.2 *Reference:* policies and procedures.

4.3.1.3 *Performance standard:*

- a) describe how to gather launch information (e.g. number of occupants involved in the accident, aircraft status, etc.);
- b) identify and list the necessary documents for travel and explain the method to validate necessary documents (e.g. passport, required travel documents, manual, etc.);

- c) identify and list the clothing that is most suitable for the physical environment (e.g. hot or cold weather);
- d) explain how to determine which inoculations and vaccinations are necessary;
- e) identify how and where to obtain the required inoculations and vaccinations for the investigation site;
- f) identify the location of the investigation field kit and explain the process to ensure its availability, accessibility and functionality;
- g) explain the travel expense policy as applicable to the mission; and
- h) explain where to obtain and demonstrate use of a quick reference checklist, if applicable.

4.3.1.4 Knowledge:

- a) the required launch information;
- b) the documentation requirements for travel;
- c) the clothing for the physical environment;
- d) the required inoculations and vaccinations and their validity;
- e) the investigation field kit (see Appendix C to this chapter);
- f) funds for the mission; and
- g) the quick reference checklist, if applicable (see Appendix D to this chapter).

4.3.1.5 Skills:

- a) communication;
- b) delegation;
- c) flexibility;
- d) planning and coordination;
- e) problem solving and decision making;
- f) situational awareness;
- g) teamwork and leadership; and
- h) workload and time management.

4.3.2 Gathering documentation

Competency element 1.2: Gather documentation

Performance criteria:

- 1.2.1 Establish a method of data collection.
- 1.2.2 Collect relevant operator records.
- 1.2.3 Collect relevant operator documentation.
- 1.2.4 Collect documentation relevant to the occurrence.
- 1.2.5 Collect other relevant documentation.

4.3.2.1 *Conditions:*

- a) classroom and/or computer-based training (including, for example, a role-playing exercise on gathering documentation); and
- b) hands-on exercise on verifying documentation.

4.3.2.2 *Reference:* policies and procedures.

4.3.2.3 *Performance standard:*

- a) describe how to establish the method(s) of data collection (e.g. a formal request);
- b) explain and identify which relevant operator records are needed for collection (e.g. cabin crew training records, minimum equipment list, cabin defect log, crew reports, etc.);
- c) explain and identify which relevant operator documentation is needed for collection (e.g. operations manual, training programme content, aircraft specifications, etc.);
- d) explain and identify which documentation is relevant to the occurrence (e.g. crew list, passenger manifest, cargo manifest, etc.); and
- e) explain and identify how to collect other relevant documentation (e.g. State regulations and oversight of cabin records).

4.3.2.4 *Knowledge:*

- a) method of data collection;
- b) types of operator records;
- c) types of operator documentation; and
- d) what information other relevant documentation entails.

4.3.2.5 *Skills:*

- a) communication;
- b) delegation;
- c) flexibility;
- d) planning and coordination;
- e) problem solving and decision making;
- f) situational awareness;
- g) teamwork and leadership; and
- h) workload and time management.

4.4 COMPETENCY UNIT 2 — COLLECT DATA**4.4.1 Self-protection***Competency element 2.1: Protect self while on site*

Performance criteria:

- 2.1.1 Use appropriate protective equipment, as required.
- 2.1.2 Follow the exposure control plan, as required.
- 2.1.3 Identify hazards and manage associated risks
- 2.1.4 Communicate any concerns regarding the investigation site to the investigator-in-charge.
- 2.1.5 Clean and decontaminate equipment and materials, as appropriate.
- 2.1.6 Apply procedures for the containment and disposal of regulated waste.
- 2.1.7 Apply procedures for exposure incident, as required.
- 2.1.8 Apply procedures for critical incident stress response, if needed.

4.4.1.1 *Conditions:*

- a) classroom and/or computer-based training; and
- b) hands-on exercise on donning, using and removing appropriate protective equipment.

4.4.1.2 *Reference:* policies and procedures.

4.4.1.3 Performance standard:

- a) identify and demonstrate how to use appropriate protective equipment;
- b) describe the exposure control plan;
- c) describe and demonstrate the applicable procedures to minimize and manage risks associated with hazards found on an accident site (e.g. blood-borne pathogens);
- d) demonstrate the ability to communicate any concerns regarding the investigation site to the investigator-in-charge;
- e) describe the procedures to clean and decontaminate equipment and materials;
- f) describe how to apply procedures for the containment and disposal of regulated waste;
- g) describe how to apply procedures for an exposure incident; and
- h) describe how to apply procedures for critical incident stress response.

4.4.1.4 Knowledge:

- a) protective equipment;
- b) exposure control plan;
- c) accident site hazard identification and risk management;
- d) communication protocols of the investigation site;
- e) process of cleaning and decontaminating equipment and materials;
- f) containment and disposal of regulated waste;
- g) procedures for exposure incident; and
- h) procedures for critical incident stress response.

4.4.1.5 Skills:

- a) communication;
- b) flexibility;
- c) planning and coordination;
- d) problem solving and decision making;
- e) situational awareness;
- f) teamwork and leadership; and
- g) workload and time management.

4.4.2 Documenting the cabin

Competency element 2.2: Document the cabin

Performance criteria:

- 2.2.1 Establish methods of evidence documentation.
- 2.2.2 Examine evidence of damage, malfunctions and failures.
- 2.2.3 Examine evidence of utilisation of systems and equipment in the cabin.
- 2.2.4 Inspect items and document with photographs, aircraft layout diagrams and notes.
- 2.2.5 Record findings/wreckage, as per established procedures.

4.4.2.1 *Conditions:*

- a) classroom and/or computer-based training; and
- b) simulated exercise on documenting the cabin in a mock-up in a simulated crash site.

4.4.2.2 *Reference:* policies and procedures.

4.4.2.3 *Performance standard:*

- a) describe how to establish the methods of evidence documentation (e.g. team allocation, camera and or tools utilised, specific area delegation);
- b) demonstrate the ability to examine evidence of damage, malfunctions and failures;
- c) demonstrate the ability to examine evidence of utilisation of systems and equipment in the cabin;
- d) demonstrate the ability to inspect items and document with photographs, aircraft layout diagrams and notes (e.g. interior damage to the cabin); and
- e) demonstrate and/or describe the procedures to recognize and record findings/wreckage.

4.4.2.4 *Knowledge:*

- a) methods of evidence documentation;
- b) damage, malfunctions and failures;
- c) utilisation of systems and equipment in the cabin; and
- d) inspection and documentation protocols.

4.4.2.5 Skills:

- a) communication;
- b) delegation;
- c) flexibility;
- d) planning and coordination;
- e) problem solving and decision making;
- f) situational awareness; and
- g) teamwork and leadership.

4.4.3 Conducting interviews

Competency element 2.3: Conduct the interview

Performance criteria:

- 2.3.1 Gather and review the information related to events prior to, during, and following the occurrence.
- 2.3.2 Set a clear objective for the interview.
- 2.3.3 Determine a series of basic questions.
- 2.3.4 Coordinate the roles of other investigators in the interview, if applicable.
- 2.3.5 Verify that all required documentation and equipment are available.
- 2.3.6 Apply interview protocol.
- 2.3.7 Obtain permission from the hospital, if applicable.
- 2.3.8 State clear objectives and clarify roles for the investigation being undertaken.
- 2.3.9 Establish and maintain an atmosphere of open communication and mutual respect.
- 2.3.10 Recognize and be flexible and supportive to the interviewee's needs.
- 2.3.11 Demonstrate effective facilitation.
- 2.3.12 Document information in an accurate, complete and detailed manner.
- 2.3.13 Manage time.
- 2.3.14 Prepare and facilitate the distribution of passenger questionnaires to gather information remotely.