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Safety Management Manual (SMM)

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AMENDMENTS

The issue of amendments is announced regularly in the *ICAO Journal* and in the monthly *Supplement to the Catalogue of ICAO Publications and Audio-visual Training Aids*, which holders of this publication should consult. The space below is provided to keep a record of such amendments.

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No.	Date	Entered by

CORRIGENDA		
No.	Date	Entered by

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ACARS	Aircraft Communications Addressing and Reporting System
ACI	Airports Council International
ADREP	Accident/Incident Data Reporting (ICAO)
AEP	Aerodrome Emergency Plan
AIRS	Aircrew Incident Reporting System
ALARP	As Low As Reasonably Practicable
AME	Aircraft Maintenance Engineer *Note.— For the purposes of this manual, AME will be used to represent Aircraft Maintenance Engineer/Mechanic/Technician*
AMJ	Advisory Material Joint
AMO	Approved Maintenance Organization
ASECNA	Agency for Air Navigation Safety in Africa and Madagascar
ASR	Air Safety Report
ASRS	Aviation Safety Reporting System (U.S.)
ATA	Air Transport Association of America
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
ATS	Air Traffic Service(s)
ATSB	Australian Transport Safety Bureau
BASIS	British Airways Safety Information System
CAA	Civil Aviation Authority
CANSO	Civil Air Navigation Services Organisation
CAP	Civil Air Publication (U.K.)
CAST	Commercial Aviation Safety Team
CD	Compact Disc
CEO	Chief Executive Officer
CHIRP	Confidential Human Factors Incident Reporting Programme (U.K.)
Cir	Circular
CMC	Crisis Management Centre
CNS	Communications, Navigation and Surveillance
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder
DASS	Directorate of Aerodromes Standards and Safety
DGAC	Direction Générale de l'Aviation Civile (France)
DME	Distance Measuring Equipment
Doc	Document
EASA	European Aviation Safety Agency
EBAA	European Business Aviation Association
ECCAIRS	European Co-ordination Centre for Aviation Incident Reporting Systems
EGPWS	Enhanced Ground Proximity Warning System
ERP	Emergency Response Plan
EU	European Union
EUROCONTROL	European Organisation for the Safety of Air Navigation
FAA	Federal Aviation Administration (U.S.)
FCO	Flight Crew Order

FDA	Flight Data Analysis
FDM	Flight Data Monitoring
FDR	Flight Data Recorder
FIR	Flight Information Region
FMEA	Failure Modes and Effects Analysis
FMS	Flight Management System
FOD	Foreign Object Damage
FOQA	Flight Operations Quality Assurance
FPD	FDA Programme Database
FSF	Flight Safety Foundation
FSO	Flight Safety Officer
ft	Feet
GAIN	Global Aviation Information Network
GASP	Global Aviation Safety Plan (ICAO)
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
HAZid	Hazard Identification
IATA	International Air Transport Association
IBAC	International Business Aviation Council, Ltd.
ICAO	International Civil Aviation Organization
IFALPA	International Federation of Air Line Pilots' Associations
IFATCA	International Federation of Air Traffic Controllers' Associations
ILS	Instrument Landing System
INDICATE	Identifying Needed Defences in the Civil Aviation Transport Environment
ISASI	International Society of Air Safety Investigators
ISIM	Integrated Safety Investigation Methodology
ISO	International Organization for Standardization
JAA	Joint Aviation Authorities
JAR	Joint Aviation Requirement(s) (JAA)
kg	Kilogram(s)
LOSA	Line Operations Safety Audit
m	Metre(s)
MEDA	Maintenance Error Decision Aid (The Boeing Company)
MNPS	Minimum Navigation Performance Specifications
MRM	Maintenance Resource Management
MSAW	Minimum Safe Altitude Warning
NASA	National Aeronautics and Space Administration (U.S.)
NBAA	National Business Aviation Association, Inc.
NM	Nautical Mile(s)
NOSS	Normal Operations Safety Survey
NTSB	National Transportation Safety Board (U.S.)
OFSH	Operator's Flight Safety Handbook
OIRAS	Operational Incident Reporting and Analysis Systems
OJT	On-the-job Training
OSH	Occupational Safety and Health
PANS	Procedures for Air Navigation Services
PANS-ATM	Procedures for Air Navigation Services — Air Traffic Management
PANS-OPS	Procedures for Air Navigation Services — Aircraft Operations
PC	Personal Computer
QAR	Quick Access Recorder
QAS	Quality Assurance System
RA	Resolution Advisory

RNP	Required Navigation Performance
R/T	Radiotelephony
RVSM	Reduced Vertical Separation Minimum
SARPs	Standards and Recommended Practices (ICAO)
SDCPS	Safety Data Collection and Processing Systems
SDR	Safety Data Request
SDR	Service Difficulty Reporting
SHEL	Software/Hardware/Environment/Liveware
SID	Standard Instrument Departure
SIL	Safety Issues List
SIN	Standing Instruction Number
SM	Safety Manager
SMM	Safety Management Manual
SMS	Safety Management System(s)
SOPs	Standard Operating Procedures
STAR	Standard Instrument Arrival
STCA	Short-term Conflict Alert
TCAS	Traffic Alert and Collision Avoidance System
TEM	Threat and Error Management
TOR	Tolerability of Risk
TP	Transport Publication (Canada)
TRM	Team Resource Management
U.K.	United Kingdom
U.S.	United States
USOAP	Universal Safety Oversight Audit Programme (ICAO)

Chapter 1

OVERVIEW

1.1 GENERAL

Aviation is remarkable for the giant technological leaps it has made over the last century. This progress would not have been possible without parallel achievements in the control and reduction of aviation's safety hazards. Given the many ways that aviation can result in injury or harm, those involved with aviation have been preoccupied with preventing accidents since the earliest days of flying. Through the disciplined application of best safety management practices, the frequency and severity of aviation occurrences have declined significantly.

1.2 CONCEPT OF SAFETY

1.2.1 In order to understand safety management, it is necessary to consider what is meant by "safety". Depending on one's perspective, the concept of aviation safety may have different connotations, such as:

a) zero accidents (or serious incidents), a view widely held by the travelling public;

b) the freedom from danger or risks, i.e. those factors which cause or are likely to cause harm;

c) the attitude towards unsafe acts and conditions by employees (reflecting a "safe" corporate culture);

d) the degree to which the inherent risks in aviation are *"acceptable";*

e) the process of hazard identification and risk management; and

f) the control of accidental loss (of persons and property, and damage to the environment).

1.2.2 While the elimination of accidents (and serious incidents) would be desirable, a one hundred per cent safety rate is an unachievable goal. Failures and errors will occur, in spite of the best efforts to avoid them. No human activity or human-made system can be guaranteed to be absolutely safe, i.e. free from risk. Safety is a relative notion whereby inherent risks are acceptable in a "safe" system.

1.2.3 Safety is increasingly viewed as the management of risk. Thus, for the purposes of this manual, safety is considered to have the following meaning:

> **Safety** is the state in which the risk of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and risk management.

1.3 NEED FOR SAFETY MANAGEMENT

1.3.1 Although major air disasters are rare events, less catastrophic accidents and a whole range of incidents occur more frequently. These lesser safety events may be harbingers of underlying safety problems. Ignoring these underlying safety hazards could pave the way for an increase in the number of more serious accidents.

1.3.2 Accidents (and incidents) cost money. Although purchasing "insurance" can spread the costs of an accident over time, accidents make bad business sense. While insurance may cover specified risks, there are many uninsured costs. In addition, there are less tangible (but no less important) costs such as the loss of confidence of the travelling public. An understanding of the total costs of an accident is fundamental to understanding the economics of safety.

1.3.3 The air transportation industry's future viability may well be predicated on its ability to sustain the public's perceived safety while travelling. The management of safety is therefore a prerequisite for a sustainable aviation business.

1.4 ICAO REQUIREMENTS

1.4.1 Safety has always been the overriding consideration in all aviation activities. This is reflected in the aims and objectives of ICAO as stated in Article 44 of the *Convention on International Civil Aviation* (Doc 7300), commonly known as the Chicago Convention, which charges ICAO with ensuring the safe and orderly growth of international civil aviation throughout the world.

1.4.2 In establishing States' requirements for the management of safety, ICAO differentiates between safety programmes and safety management systems (SMS) as follows:

- A ***safety programme*** is an integrated set of regulations and activities aimed at improving safety.

- A ***safety management system (SMS)*** is an organized approach to managing safety, including the necessary organizational structures, accountabilities, policies and procedures.

1.4.3 ICAO's Standards and Recommended Practices (SARPs) (see the following Annexes to the Convention on International Civil Aviation: Annex 6 — *Operation of Aircraft,* Part I — *International Commercial Air Transport — Aeroplanes*, and Part III — *International Operations — Helicopters*; Annex 11 — *Air Traffic Services*; and Annex 14 — *Aerodromes*) require that States establish a ***safety programme*** to achieve an acceptable level of safety in aviation operations. The acceptable level of safety shall be established by the State(s) concerned. While the concept of safety programmes and SMS is restricted to Annexes 6, 11 and 14 at present, it is possible that the concept will be expanded to include additional operational Annexes in the future.

1.4.4 A safety programme will be broad in scope, including many safety activities aimed at fulfilling the programme's objectives. A State's safety programme embraces those regulations and directives for the conduct of safe operations from the perspective of aircraft operators and those providing air traffic services (ATS), aerodromes and aircraft maintenance. The safety programme may include provisions for such diverse activities as incident reporting, safety investigations, safety audits and safety promotion. To implement such safety activities in an integrated manner requires a coherent SMS.

1.4.5 Therefore, in accordance with the provisions of Annexes 6, 11 and 14, States shall require that individual operators, maintenance organizations, ATS providers and certified aerodrome operators implement SMS accepted by the State. As a minimum, such SMS shall:

a) identify safety hazards;

b) ensure that remedial actions necessary to mitigate the risks/hazards are implemented; and

c) provide for continuous monitoring and regular assessment of the safety level achieved.

1.4.6 An organization's SMS accepted by the State shall also clearly define lines of safety accountability, including a direct accountability for safety on the part of senior management.

1.4.7 ICAO provides specialized guidance material, including this manual on safety management, for the fulfilment of the SARPs. This manual includes a conceptual framework for managing safety and establishing an SMS as well as some of the systemic processes and activities used to meet the objectives of a State's safety programme.

Acceptable level of safety

1.4.8 In any system, it is necessary to set and measure performance outcomes in order to determine whether the system is operating in accordance with expectations, and to identify where action may be required to enhance performance levels to meet these expectations.

1.4.9 The introduction of the concept of *acceptable level of safety* responds to the need to complement the prevailing approach to the management of safety based upon regulatory compliance, with a performance-based approach. Acceptable level of safety expresses the safety goals (or expectations) of an oversight authority, an operator or a service provider. From the perspective of the relationship between oversight authorities and operators/service providers, it provides an objective in terms of the safety performance operators/service providers should achieve while conducting their core business functions, as a minimum acceptable to the oversight authority. It is a reference against which the oversight authority can measure safety performance. In determining an acceptable level of safety, it is necessary to consider such factors as the level of risk that applies, the cost/benefits of improvements to the system, and public expectations on the safety of the aviation industry.

1.4.10 In practice, the concept of acceptable level of safety is expressed by two measures/metrics (safety performance indicators and safety performance targets) and implemented through various safety requirements. The following explains the use of these terms in this manual:

- ***Safety performance indicators*** are a measure of the safety performance of an aviation organization or a sector of the industry. Safety indicators should be easy to measure and be linked to the major components of a State's safety programme, or an operator's/service provider's SMS. Safety indicators will therefore differ between segments of the aviation industry, such as aircraft operators, aerodrome operators or ATS providers.

- ***Safety performance targets*** (sometimes referred to as goals or objectives) are determined by considering what safety performance levels are desirable and realistic for individual operators/service providers. Safety targets should be measurable, acceptable to stakeholders, and consistent with the State's safety programme.

- ***Safety requirements*** are needed to achieve the safety performance indicators and safety performance targets. They include the operational procedures, technology, systems and programmes to which measures of reliability, availability, performance and/or accuracy can be specified. An example of a safety requirement is *deployment of a radar system in the State's three busiest airports within the next 12 months, with a 98 per cent availability of critical equipment.*

1.4.11 A range of different safety performance indicators and targets will provide a better insight of the acceptable level of safety of an aviation organization or a sector of the industry than the use of a single indicator or target.

1.4.12 The relationship between acceptable level of safety, safety performance indicators, safety performance targets and safety requirements is as follows: *acceptable level of safety* is the overarching concept; *safety performance indicators* are the measures/metrics used to determine if the acceptable level of safety has been achieved; *safety performance targets* are the quantified objectives pertinent to the acceptable level of safety; and *safety requirements* are the tools or means required to achieve the safety targets. This manual focuses primarily on safety requirements, i.e. the means to achieve acceptable levels of safety.

1.4.13 Safety indicators and safety targets may be different (for example, the safety indicator is *0.5 fatal accidents per 100 000 hours for airline operators*, and the safety target is *a 40 per cent reduction in fatal accident rate for airline operations*), or they may be the same (for example, the safety indicator is *0.5 fatal accidents per 100 000 hours for airline operators*, and the safety target is *not more than 0.5 fatal accidents per 100 000 hours for airline operators*).

1.4.14 There will seldom be a national acceptable level of safety. More often, within each State there will be different acceptable levels of safety that will be agreed upon by the regulatory oversight authority and individual operators/service providers. Each agreed acceptable level of safety should be commensurate with the complexity of the individual operator's/service provider's operational context.

1.4.15 Establishing acceptable level(s) of safety for the safety programme does not replace legal, regulatory, or other established requirements, nor does it relieve States from their obligations regarding the *Convention on International Civil Aviation* (Doc 7300) and its related provisions. Likewise, establishing acceptable level(s) of safety for the SMS does not relieve operators/service providers from their obligations under relevant national regulations, and those arising from the *Convention on International Civil Aviation* (Doc 7300).

Examples of implementation

1.4.16 ***State safety programme***. An oversight authority establishes an *acceptable level of safety* to be achieved by its safety programme that will be expressed by:

a) 0.5 fatal accidents per 100 000 hours for airline operators *(safety indicator)* with a 40 per cent reduction in five years *(safety target);*

b) 50 aircraft incidents per 100 000 hours flown *(safety indicator)* with a 25 per cent reduction in three years *(safety target);*

c) 200 major aircraft defect incidents per 100 000 hours flown *(safety indicator)* with a 25 per cent reduction over the last three-year average *(safety target);*

d) 1.0 bird strike per 1 000 aircraft movements *(safety indicator)* with a 50 per cent reduction in five years *(safety target);*

e) no more than one runway incursion per 40 000 aircraft movements *(safety indicator)* with a 40 per cent reduction in a 12-month period *(safety target);* and

f) 40 airspace incidents per 100 000 hours flown *(safety indicator)* with a 30 per cent reduction over the five-year moving average *(safety target)*.

1.4.17 The *safety requirements* to achieve these safety targets and safety indicators include:

a) the oversight authority accident prevention programme;

b) a mandatory occurrence reporting system;

c) a voluntary occurrence reporting system;

d) a bird strike programme; and

e) the deployment of radar systems in the State's three busiest airports within the next 12 months.

1.4.18 ***Airline operator SMS****.* An oversight authority and an airline operator agree on an *acceptable level of safety* to be achieved by the operator SMS, one measure of which — but not the only one — is 0.5 fatal accidents per 100 000 departures *(safety indicator);* a 40 per cent reduction in five years *(safety target)* and — among others — the development of GPS approaches for airfields without ILS approaches *(safety requirement)*.

1.4.19 ***Service provider and aerodrome operator SMS****.* An oversight authority, an ATS provider and an aerodrome operator agree on an *acceptable level of safety* to be achieved by the provider and operator SMS, one element of which — but not the only one — is no more than one runway incursion per 40 000 aircraft movements *(safety indicator);* a 40 per cent reduction in a 12-month period *(safety target)* and — among others — the establishment of low visibility taxi procedures *(safety requirement)*.

1.4.20 Chapter 5 contains further information on safety performance indicators and safety performance targets.

1.5 STAKEHOLDERS IN SAFETY

1.5.1 Given the total costs of aviation accidents, many diverse groups have a stake in improving the management of safety. The principal stakeholders in safety are listed below:

a) aviation professionals (e.g. flight crew, cabin crew, air traffic controllers (ATCOs) and aircraft maintenance engineers (AMEs)[1]);

b) aircraft owners and operators;

c) manufacturers (especially airframe and engine manufacturers);

d) aviation regulatory authorities (e.g. CAA, EASA and ASECNA);

e) industry trade associations (e.g. IATA, ATA and ACI);

f) regional ATS providers (e.g. EUROCONTROL);

g) professional associations and unions (e.g. IFALPA and IFATCA);

1. Annex 1 — *Personnel Licensing* also offers the possibility of referring to these persons as aircraft maintenance technicians or aircraft maintenance mechanics. This manual will refer to them as aircraft maintenance engineers (AMEs).

h) international aviation organizations (e.g. ICAO);

i) investigative agencies (e.g. United States NTSB); and

j) the flying public.

1.5.2 Major aviation safety occurrences invariably involve additional groups which may not always share a common objective in advancing aviation safety, for example:

a) next of kin, victims, or persons injured in an accident;

b) insurance companies;

c) travel industry;

d) safety training and educational institutions (e.g. FSF);

e) other government departments and agencies;

f) elected government officials;

g) investors;

h) coroners and police;

i) media;

j) general public;

k) lawyers and consultants; and

l) diverse special interest groups.

1.6 APPROACHES TO SAFETY MANAGEMENT

1.6.1 With global aviation activity forecast to continue to rise, there is concern that traditional methods for reducing risks to an acceptable level may not be sufficient. New methods for understanding and managing safety are therefore evolving.

1.6.2 Safety management may therefore be considered from two different perspectives — traditional and modern.

Traditional perspective

1.6.3 Historically, aviation safety focused on compliance with increasingly complex regulatory requirements. This approach worked well up until the late 1970s when the accident rate levelled off. Accidents continued to occur in spite of all the rules and regulations.

1.6.4 This approach to safety **reacted** to undesirable events by prescribing measures to prevent recurrence. Rather than defining best practices or desired standards, such an approach aimed at ensuring minimum standards were met.

1.6.5 With an overall fatal accident rate in the vicinity of 10^{-6} (i.e. one fatal accident per one million flights), further safety improvements were becoming increasingly difficult to achieve using this approach.

Modern perspective

1.6.6 In order to keep safety risks at an acceptable level with the increasing levels of activity, modern safety management practices are shifting from a purely reactive to a more **proactive** mode. In addition to a solid framework of legislation and regulatory requirements based on ICAO SARPs, and the enforcement of those requirements, a number of other factors, some of which are listed below, are considered to be effective in managing safety. It must be emphasized that this approach complements, or is in addition to, the obligations of States and other organizations to comply with ICAO SARPs and/or national regulations.

a) application of scientifically-based risk management methods;

b) senior management's commitment to the management of safety;

c) a corporate safety culture that fosters safe practices, encourages safety communications and actively manages safety with the same attention to results as financial management;

d) effective implementation of standard operating procedures (SOPs), including the use of checklists and briefings;

e) a non-punitive environment (or just culture) to foster effective incident and hazard reporting;

f) systems to collect, analyse and share safety-related data arising from normal operations;

g) competent investigation of accidents and serious incidents identifying systemic safety deficiencies (rather than just targets for blame);

h) integration of safety training (including Human Factors) for operational personnel;

i) sharing safety lessons learned and best practices through the active exchange of safety information (among companies and States); and

j) systematic safety oversight and performance monitoring aimed at assessing safety performance and reducing or eliminating emerging problem areas.

1.6.7 No single element will meet today's expectations for risk management. Rather, an integrated application of most of these elements will increase the aviation system's resistance to unsafe acts and conditions. However, even with effective safety management processes, there are no guarantees that all accidents can be prevented.

1.7 USING THIS MANUAL

Purpose

1.7.1 The purpose of this manual is to assist States in fulfilling the requirements of Annexes 6, 11 and 14 with respect to the implementation of SMS by operators and service providers.

Target audience

1.7.2 The methods and procedures described in this manual have been compiled from experience gained in the successful development and management of aviation safety activities by aviation operators, ATS providers, aerodromes and maintenance organizations. In addition, the manual embodies best practices from sources such as governments, manufacturers and other reputable aviation organizations.

1.7.3 Application of the guidance material herein is not limited to operational personnel. Rather, it should be relevant to the full spectrum of stakeholders in safety, including senior management.

1.7.4 In particular, this manual is aimed at those personnel who are responsible for designing, implementing and managing effective safety activities, namely:

a) government officials with responsibilities for regulating the aviation system;

b) management of operational organizations, such as operators, ATS providers, aerodromes and maintenance organizations; and

c) safety practitioners, such as safety managers and advisers.

1.7.5 Users should find sufficient information herein for the justification, initiation and operation of a viable SMS.

1.7.6 The manual is not prescriptive. However, based on an understanding of the philosophy, principles and practices discussed herein, organizations should be able to develop an approach to safety management suited to their local conditions.

Manual contents

1.7.7 This manual targets a wide audience ranging from State aviation regulators to operators and service providers. It also aims to address all levels of personnel in these organizations from senior management to front-line workers. Chapters 1 to 3 contain an introduction to safety management. Chapters 4 to 11 cover the management of safety. Safety management systems are dealt with in Chapters 12 to 15. Chapters 16 to 19 address applied safety management.

1.7.8 The manual is not designed to be read from the beginning to the end. Rather, users are encouraged to focus on their areas of interest, depending on their level of knowledge and experience in the area of aviation safety management.

1.7.9 Throughout this manual, the use of the male gender should be understood to include male and female persons.

Acknowledgements

1.7.10 In developing this manual, ICAO has drawn heavily on the work, writing and best practices of many organizations and individuals. While the source of all such material cannot be identified, ICAO would like to acknowledge, in particular, inputs from the following States: Australia, Canada, New Zealand, the United Kingdom and the United States; manufacturers: Airbus Industrie and The Boeing Company; consultants: Integra; service providers: European Organisation for the Safety of Air Navigation (EUROCONTROL) and the Airports Council International (ACI); private author: Richard W. Wood; and others: Global Aviation Information Network (GAIN) and Flight Safety Foundation (FSF).

Relationship to other ICAO documents

1.7.11 This manual provides guidance for fulfilling the requirements of the SARPs of Annexes 6, 11, and 14 with respect to the implementation of safety programmes and SMS. Some of these requirements are expanded upon in the *Procedures for Air Navigation Services — Aircraft Operations* (PANS-OPS, Doc 8168), *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM, Doc 4444), and the *Manual on Certification of Aerodromes* (Doc 9774).

1.7.12 The manual should also assist States in the fulfilment of the SARPs of Annex 13 — *Aircraft Accident and Incident Investigation* with respect to the investigation of accidents and incidents, including recommendations to States for the promotion of safety by the analysis of accident and incident data and by the prompt exchange of safety information.

1.7.13 This manual should also serve as a companion document for other ICAO documents, including:

a) *Airworthiness Manual* (Doc 9760), which provides guidance for the conduct of a continuing airworthiness programme;

b) *Human Factors Digest No. 16 — Cross-Cultural Factors in Aviation Safety* (Cir 302), which presents the safety case for cross-cultural factors in aviation;

c) *Human Factors Guidelines for Aircraft Maintenance Manual* (Doc 9824), which provides information on the control of human error and the development of countermeasures to error in aviation maintenance;

d) *Human Factors Guidelines for Air Traffic Management (ATM) Systems* (Doc 9758), which assists States in the consideration of Human Factors issues when purchasing and implementing CNS/ATM-related technology;

e) *Human Factors Guidelines for Safety Audits Manual* (Doc 9806), which provides guidelines for preparing for, or conducting, a safety oversight audit that includes consideration of human performance and limitations;

f) *Human Factors Training Manual* (Doc 9683), which describes in greater detail much of the underlying approach to the human performance aspects of safety management in this manual;

g) *Line Operations Safety Audit (LOSA)* (Doc 9803), which presents information on the control and management of human error and the development of countermeasures to error in operational environments;

h) *Manual of Aircraft Accident and Incident Investigation* (Doc 9756), which provides information and guidance to States on the procedures, practices and techniques that can be used in aircraft accident investigations;

i) *Manual on Certification of Aerod*romes (Doc 9774), which describes the salient features of an SMS to be included in the aerodromes manual for certified aerodromes;

j) *Preparation of an Operations Manual* (Doc 9376), which provides detailed guidance to operators in such areas as training and the supervision of operations, and includes direction on the need to maintain an accident prevention programme;

k) *Safety Oversight Audit Manual* (Doc 9735), which provides guidance and information on standard auditing procedures for the conduct of ICAO Safety Oversight audits; and

l) *Training Manual* (Doc 7192), Part E-1 — *Cabin Attendants' Safety Training*, which provides guidance for the training of cabin crew required by Annex 6.[2]

2. A change of terminology from "cabin attendant" to "cabin crew" became applicable in 1999 (see Annex 6 — *Operation of Aircraft*). The term "flight attendant" is sometimes used in the industry.

Chapter 2

RESPONSIBILITY FOR MANAGING SAFETY

2.1 PARTIES RESPONSIBLE FOR MANAGING SAFETY

2.1.1 The responsibility for safety and effective safety management is shared among a wide spectrum of organizations and institutions, including international organizations, State regulatory authorities for civil aviation, owners and operators, service providers for air navigation services and aerodromes, major aircraft and power plant manufacturers, maintenance organizations, industry and professional associations, and aviation education and training institutions. In addition, third parties that provide aviation support services (including contracted services) also share in the responsibility for managing safety. Generally, these responsibilities fall into the following areas:

a) defining policies and standards affecting safety;

b) allocating resources to sustain risk management activities;

c) identifying and evaluating safety hazards;

d) taking action to eliminate hazards or reduce the associated level of risk to what has been decided as being an acceptable level of risk;

e) incorporating technical advances in the design and maintenance of equipment;

f) conducting safety oversight and safety programme evaluation;

g) investigating accidents and serious incidents;

h) adopting the most appropriate best industry practices;

i) promoting aviation safety (including the exchange of safety-related information); and

j) updating regulations governing civil aviation safety.

2.1.2 The systematic procedures and practices for the management of safety are generally referred to collectively as a safety management system (SMS).

ICAO

2.1.3 From a regulatory perspective, ICAO's role is to provide procedures and guidance for the safe conduct of international aircraft operations and to foster the planning and development of air transport. This is largely achieved by developing Standards and Recommended Practices (SARPs), which are contained in the Annexes to the Chicago Convention and reflect the best operational experience of States. The Procedures for Air Navigation Services (PANS) contain practices beyond the scope of the SARPs, where a measure of international uniformity is desirable for safety and efficiency. The Air Navigation Plans detail requirements for facilities and services specific to ICAO regions. In essence, these documents define the international framework for promoting safety and efficiency in aviation.

2.1.4 In addition to this regulatory framework, ICAO contributes to safety management by promoting best safety practices. More specifically, ICAO:

a) provides guidance material for States and operators covering most aspects of aviation safety (including flight operations, airworthiness, air traffic services, aerodromes and airport security). Generally this guidance material is in the form of manuals or circulars;

b) developed this manual which outlines the principles of safety management and provides guidance for the conduct of effective safety management programmes;

c) defines international procedures for accident and incident investigation and reporting;[1]

d) promotes aviation safety by:

   1) disseminating accident and incident information through the Accident/Incident Reporting (ADREP) system and by other means;

   2) disseminating aviation safety information in publications and, more recently, in electronic formats; and

   3) participating in conferences, seminars, etc. addressing specific aspects of aviation safety (i.e. accident investigation, accident prevention and Human Factors); and

e) conducts audits under the Universal Safety Oversight Audit Programme (USOAP).

States

2.1.5 States bear significant responsibility for establishing an environment conducive to safe and efficient flight operations. Irrespective of any risk management methods they may employ, such as those described in this manual, States, as the signatories to the Chicago Convention, have an obligation to implement ICAO SARPs. To this end, each State must:

a) provide the legislative and regulatory provisions needed to govern the State's aviation system. Some of the areas requiring a legal framework for effective safety management are listed below:

   1) Aviation legislation establishes a State's objectives for aviation — both commercial and private. Typically, this legislation includes the State's vision for aviation safety and delineates the broad responsibilities, accountabilities and authorities for fulfilling those objectives.

   2) Manufacturing and trade laws govern the production and sale of safe aeronautic equipment and services.

   3) Labour laws (including Occupational Safety and Health (OSH) laws) set the rules for the work environment in which aviation employees are expected to perform their duties safely.

1. These are contained in Annex 13 — *Aircraft Accident and Incident Investigation, the Manual of Aircraft Accident and Incident Investigation* (Doc 9756) and the *Accident/Incident Reporting Manual (ADREP Manual)* (Doc 9156).

4) Security laws contribute to safety in the workplace, for example, they govern who may enter into operational areas and under what terms. Also, they may protect sources of safety information.

5) Environmental laws affecting the siting of airports and navigation aids impact on flight operations (such as noise abatement procedures);

b) establish an appropriate State body, usually referred to as the Civil Aviation Administration (CAA), with the necessary powers to ensure compliance with the regulations. This responsibility includes:

1) establishing the necessary statutory authority and delegations to regulate the aviation industry;

2) ensuring it is adequately staffed with competent technical officials; and

3) maintaining an effective system of safety oversight to assess how well regulatory requirements are being met; and

c) establish appropriate safety oversight mechanisms to ensure that operators and service providers maintain an acceptable level of safety in their operations.

2.1.6 Safe and efficient aviation requires significant infrastructure and aeronautic services, including airports, navigation aids, air traffic management, meteorological services, and flight information services. Some States own and operate their own air navigation services and major airports; others own and operate their own national airline. However, many States have corporatized these operations and they operate under the oversight of the State. Regardless of the approach taken, States must ensure that the infrastructure and services in support of aviation are maintained to meet international obligations and the needs of the State.

2.1.7 Where the regulatory function and the provision of particular services are both under the direct control of one State body (such as the CAA), a clear distinction must be maintained between these two functions, i.e. service provider and regulator.

2.1.8 Finally, States have a responsibility to be “good citizens” in the international aviation community. They can best do this by ensuring conformity with the Chicago Convention and ICAO SARPs. When a State cannot adapt its national legislation and regulations to the SARPs, it is required to file a “difference”. ICAO publishes these differences so that other States may be aware of departures from internationally agreed Standards. The ICAO USOAP is used to determine States’ compliance with safety-critical SARPs.

Civil Aviation Administrations (CAAs)

2.1.9 Having developed appropriate legislation governing aviation, a State must establish a CAA to set the rules, regulations and procedures by which the State implements its safety programme. Chapter 3 (State Safety Programme) of this manual outlines the principal functions and activities of the CAA for delivering an effective safety programme. Basically, the CAA provides the necessary oversight for compliance with the State’s laws and regulations for air safety and for the fulfilment of the State’s safety goals.

Manufacturers

2.1.10 Each new generation of equipment incorporates improvements based on the latest *“state of the art”* and operational experience. Manufacturers produce equipment that complies with the airworthiness and other standards of domestic and foreign governments, and meets the economic and performance requirements of purchasers.

2.1.11 Manufacturers also produce manuals and other documentation to support their products. In some States, this may be the only guidance material available for the operation of a specific aircraft type or piece of equipment. Thus the standard of documentation provided by the manufacturer is important. Additionally, through their responsibilities for providing product support, training, etc., manufacturers can provide the safety record of a particular piece of equipment, or the in-service record of a component.

2.1.12 In addition, the major aircraft manufacturers have active safety departments whose roles include monitoring in-service experience, providing feedback to the manufacturing process and disseminating safety information to customer airlines.

Aircraft operators

2.1.13 Major airlines usually employ many of the safety management activities outlined in this manual. Such activities are often carried out by a safety office which monitors overall operating experience and provides independent advice to company management on the action needed to eliminate or avoid identified hazards, or reduce the associated risk to an acceptable level.

2.1.14 The safety management concepts outlined in this manual are in addition to existing requirements to comply with ICAO SARPs and/or national regulations.

Service providers

2.1.15 Safe and efficient flight operations depend on the effective delivery of a variety of services separate from the aircraft operators, for example:

a) air traffic management;

b) aerodrome operations, including airport emergency services;

c) airport security; and

d) navigation and communication aids.

2.1.16 Traditionally, such services have been provided by the State — usually through its civil or military aviation authorities. However, civil aviation authorities in some States have discovered the potential conflicts of interest in the dual roles of the State as both a regulator and a service provider. Moreover, some States believe that there are operational efficiencies and economies to be gained from the corporatization (or privatization) of many of these services, particularly ATS and aerodrome operations. As a result, a growing number of States have delegated responsibility for the provision of many of these services.

2.1.17 Regardless of the ownership or management structure of any aviation service, responsible managers are expected to develop and implement SMS within their areas of expertise. The guidance material provided in this manual applies equally to flight operations and the provision of aviation services, regardless of whether they are governed by the State or corporate management.

Third party contractors

2.1.18 The provision of services supporting flight operations often involves private contractors in such areas as refuelling; catering and other aircraft ground services; aircraft maintenance and overhaul; runway and taxiway construction and repair; crew training; and flight planning, flight dispatch and flight following.

2.1.19 Whether a large corporate contractor or small entrepreneur, the contracting authority (e.g. an airline, aerodrome operator or air navigation service provider) holds overall responsibility for managing the safety risks taken by the contractor. The contract must specify safety standards to be met. The contracting authority then has the responsibility for ensuring that the contractor complies with the safety standards prescribed in the contract.

2.1.20 An SMS must ensure that the level of safety of an organization is not eroded by the inputs and supplies provided by external organizations.

Business and professional associations

2.1.21 Business and professional associations also play a vital role in safety management.

2.1.22 International, national and regional stakeholder associations are usually formed to advance commercial interests; however, stakeholders increasingly recognize the strong links between aviation safety and profitability. Stakeholders realize that an accident by one airline can compromise their own business. Thus, for example, airline associations maintain an active watch on industry developments in technology, procedures and practices. Their members collaborate in the identification of safety hazards and in the actions required for reducing or eliminating those deficiencies. Through such associations, many airlines are now sharing safety-related data with a view to enhancing safety management.

2.1.23 In a similar manner, professional associations representing the interests of various professional groups (e.g. pilots, ATCOs, AMEs, and cabin crew) are active in the pursuit of safety management. Through study, analysis and advocacy, such groups provide subject matter expertise for identifying and ameliorating safety hazards.

2.1.24 Increasingly, airlines are joining partnerships or alliances with other airlines to extend their effective route structure through code-sharing agreements. This can result in a flight segment being operated by an airline other than that expected by the passenger. These arrangements can have safety implications. No airline wants to be associated with an unsafe partner. To protect their own interests, the alliance partners conduct mutual safety audits — thereby enhancing airline safety.

2.1.25 The general aviation community has a system of national and international associations that have been formed to enhance safety and further their interests in the aviation community. The business aviation sector is also active in SMS and in pursuing safety issues for its members.

2.2 MANAGEMENT'S SPECIAL RESPONSIBILITY FOR SAFETY[2]

2.2.1 The management teams of operators and service providers bear a special responsibility for safety management. In a major study of airlines around the world, it was found that the safest airlines had a clear safety mission, starting at the top of the organization and guiding actions right down to the operational level. Lautman and Gallimore found that in the safest airlines:

2. The *Human Factors Training Manual* (Doc 9683), Part 1, Chapter 2, further addresses the importance of management in the establishment of a positive safety culture.

"Flight operations and training managers recognize their responsibility to flight safety and are dedicated to creating and enforcing safety-oriented policies. … There is a method of getting information to the flight crews expeditiously and a policy that encourages confidential feedback from pilots to management. … The management attitude … is a dynamic force that sets the stage for the standardization and discipline in the cockpit brought about by a training programme oriented to safety issues."

2.2.2 The safest organizations are often the most efficient. Although trade-offs between safety management and costs may occur, management needs to recognize the hidden costs of accidents and that safety is good for business. By taking a systematic approach to corporate decision-making and risk management, accidental losses are reduced.

2.2.3 Management has the authority and the responsibility to manage safety risks in the company. This is achieved by establishing a systematic method for identifying hazards, assessing risks, assigning priorities to these risks and then by reducing or eliminating those hazards which pose the greatest potential loss. Management alone has the ability to introduce changes in the organization's structure, staffing, equipment, policies and procedures.

2.2.4 Above all, management sets the organizational climate for safety. Without its wholehearted commitment to safety, safety management will be largely ineffective. By positively reinforcing safety actions, management sends the message to all staff that it really cares about safety and that they should too.

2.2.5 Management needs to establish safety as a core value of the organization. It can accomplish this by setting objectives and safety goals, then holding managers and employees accountable for achieving those goals. Staff look to management for:

a) ***clear direction*** in the form of credible policies, objectives, goals, standards, etc.;

b) ***adequate resources***, including sufficient time, to fulfil assigned tasks safely and efficiently; and

c) ***expertise*** in terms of access to experience through safety literature, training, seminars, etc.

2.2.6 This onus on management applies regardless of the size or type of organization providing the aviation service. The role of management in managing safety is a recurring theme throughout this manual.

2.3 RESPONSIBILITIES AND ACCOUNTABILITIES

2.3.1 Responsibility and accountability are closely related concepts. While individual staff members are responsible for their actions, they are also accountable to their supervisor or manager for the safe performance of their functions and may be called on to justify their actions. Although individuals must be accountable for their own actions, managers and supervisors are accountable for the overall performance of the group that reports to them. Accountability is a two-way street. Managers are also accountable for ensuring that their subordinates have the resources, training, experience, etc. needed for the safe completion of their assigned duties.

2.3.2 A formal statement of responsibilities and accountabilities is advisable, even in small organizations. This statement clarifies the formal and informal reporting lines on the organizational chart and specifies accountabilities for particular activities with no overlap or omission. The contents of the statement will vary depending on organizational size, complexity and relationships.

2.4 GLOBAL COOPERATION

2.4.1 Although the organizational elements described above have specific roles and responsibilities for safety management, the international nature of aviation demands that their individual efforts be integrated into a coherent, global aviation safety system, requiring cooperation and collaboration at all levels.

2.4.2 Global collaboration occurs in international fora such as:

a) corporate associations (e.g. IATA, ACI, ATA and CANSO);

b) national and international aviation associations (e.g. NBAA, EBAA and IBAC);

c) international federations of national associations (e.g. IFALPA and IFATCA);

d) international safety bodies (e.g. FSF and ISASI);

e) industry/government groups (e.g. CAST and GAIN); and

f) major manufacturers' safety forums.

2.4.3 Such organizations are able to provide "subject matter experts" for meetings and studies. For example, manufacturers may invite input through "user" groups, and the users themselves may consult the manufacturers to better understand particular operating practices. As a result, there is a healthy cross-pollination of safety-related information and knowledge. Such collaborative efforts not only are safety-oriented but also make good business sense for the following reasons:

a) The air transport industry is strongly interdependent. The consequences of a major air disaster can affect many of the stakeholders. Mutual concern over damage to the industry's reputation, goodwill and public confidence tends to promote collective action over the parochial pursuit of special interests.

b) There is strength in collective action.

c) Globalization of markets has transcended State borders and authority.

2.4.4 Examples of the ways in which global collaboration improves the efficiency and effectiveness of safety management efforts include:

a) harmonization, coherence and interoperability through universal design standards, SOPs and terminology;

b) global sharing of safety-related information;

c) early identification and resolution of global systemic hazards; and

d) back-up and mutual reinforcement through overlapping effort and sharing of specialist resources.

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Chapter 3

STATE SAFETY PROGRAMME

3.1 GENERAL

3.1.1 As discussed in Chapter 2, States bear significant responsibility for establishing an environment conducive to safe and efficient aviation activities. The State, as the signatory to the Chicago Convention, is responsible for implementation of ICAO SARPs affecting flight operations, airspace and navigation services, and aerodromes for which it has responsibility. Generally, these responsibilities include both regulatory functions (licensing, certification, etc.) and safety oversight functions to ensure compliance with regulatory requirements.

3.1.2 Each State must make provisions for the safety of the aviation system within its jurisdiction. However, each State is but one component of the larger global aviation system. In that sense, States also have a responsibility for meeting the requirements of the larger international system.

3.1.3 The systems approach to the State's aviation safety programme advocated in this manual encompasses all organizational levels, disciplines and system life-cycle phases. Factors related to meteorology, aeronautical charts, aircraft operations, airworthiness, aeronautical information, the transport of dangerous goods, etc. could all have an impact on the safety of the total system. To fulfil its diverse safety responsibilities effectively, a State requires a *"safety programme"* to integrate its multidisciplinary safety activities into a coherent whole.

3.1.4 A State's safety management responsibilities may extend beyond regulatory and oversight functions. In many States, the State is both the safety regulator and a service provider. Notwithstanding the trend in many States towards privatization and corporatization, many States still deliver services for air traffic management and airports. Where a State is both the regulatory authority and a provider of operational services, a clear distinction must be made between the two functions.

3.1.5 ICAO requires that operators and service providers implement a safety management system (SMS) to achieve acceptable levels of safety within their operations. Generally, a State does not require an SMS for its regulatory and oversight functions. However, those States conducting flight operations, operating aerodromes or providing operational services (such as ATS, aeronautical information services and meteorological services) will require an SMS that is quite distinct from the safety programme implemented for the regulatory function of the CAA. The relationship between the regulatory authority and the regulated body should be the same whether the regulated body is an external entity or part of the State organization.

3.2 REGULATORY RESPONSIBILITIES

3.2.1 Through their actions as the regulatory authority, States set the tone for safe and efficient aviation operations conducted within their jurisdiction, for example:

a) ***SARPs****.* The State, as the signatory to the Chicago Convention, is responsible for implementation of ICAO SARPs.

b) ***Civil Aviation Administration (CAA)***. States must establish an appropriate body, often referred to as the Civil Aviation Administration (CAA), with the necessary powers to ensure compliance with the aviation regulations.

c) ***Safety oversight***. States must establish appropriate safety oversight mechanisms to ensure that operators and service providers maintain an acceptable level of safety in their operations.

3.2.2 In the discharge of the State's regulatory responsibilities, the regulatory authority may adopt either an active role, involving close supervision of the functioning of all aviation-related activities, or a passive role, whereby greater responsibility is delegated to the operators and service providers.

3.2.3 Many States are moving away from a very active role in the supervision of aviation activities. The reasons for this include the large number of inspectors required to perform this function, confusion over safety responsibilities, and the need for a large enforcement organization — factors which contradict the safety culture that modern safety management practices promote.

3.2.4 In a more passive role, the State leaves the interpretation and implementation of the regulations to the operator or service provider, relying upon their technical competence and encouraging compliance through the threat of enforcement action.

3.2.5 Considerable merit exists in a State regulatory system which falls between the active and passive extremes and which should:

a) represent a well-balanced allocation of responsibility between the State and the operator or service provider for safety;

b) be capable of economic justification within the resources of the State;

c) enable the State to maintain continuing regulation and supervision of the activities of the operator or service provider without unduly inhibiting the effective direction and control of the organization; and

d) result in the cultivation and maintenance of harmonious relationships between the State and operators and service providers.

3.3 CIVIL AVIATION ADMINISTRATIONS (CAAs)

3.3.1 The CAA is the State body responsible for implementing the legislative and regulatory provisions for aviation safety. In effect, the CAA develops and delivers the State's safety programme. In doing so, effective CAAs are guided by:

a) a clear statement of their vision and mission (regarding safety);

b) a well-understood and accepted set of:

   1) operating principles, such as delivering safe and efficient service consistent with public expectations and at reasonable cost, and treating regulated organizations (clients) and employees with respect; and

   2) corporate values such as competence, openness, fairness, integrity, respect and responsiveness to client needs;

c) a statement of the Administration's safety objectives, for example, reduce the probability and consequences of unsafe aviation occurrences, and improve understanding throughout the aviation industry and general public of the State's actual safety performance; and

d) strategies for fulfilling their objectives, for example, reduction of safety risks to aviation through the identification of those operations that fall below accepted levels, encouraging their return to an acceptable level of safety or, if necessary, rescinding their certification.

3.3.2 Based on such broad direction, State Administrations typically have responsibilities for some or all of the following:

a) establishing and implementing the rules, regulations and procedures for safe and efficient aviation, for example:

  1) personnel licensing;

  2) procedures for obtaining and renewing:

    — operating certificates;

    — airworthiness certificates; and

    — airport certifications;

  3) operation of air traffic services; and

  4) (in many States) conduct of accident and incident investigations;

b) implementing a system for safety oversight of the entire civil aviation system by surveillance, inspections and safety audits, etc.;

c) carrying out enforcement actions as necessary;

d) monitoring technological developments and best industry practices with a view to improving the State's aviation system performance;

e) maintaining a system of aviation records, including licences and certificates, infractions, and reported accidents and incidents;

f) conducting analyses of safety trends, including accident/incident data, and service difficulty reports; and

g) promoting safety through the dissemination of specific safety materials, conducting safety seminars, etc.

3.3.3 Many States delegate responsibility for the investigation of accidents and serious incidents (pursuant to Annex 13) to their CAAs. However, this practice raises a potential conflict of interest whereby the investigators may be required to report on shortcomings in the State's safety oversight performance (perhaps even their own performance as regulators). Increasingly, States are creating specialist investigative agencies that are independent of the regulatory authorities.

3.4 STATE SAFETY PERFORMANCE

3.4.1 ICAO's Universal Safety Oversight Audit Programme has identified fundamental weaknesses in the safety programmes of many States, resulting in significant differences in safety standards around the globe. Notwithstanding the obligations of Contracting States to fulfil the requirements of ICAO SARPs, States should be concerned with the safety performance of their national aviation system. The following are some indicators that a State's safety programme may be deficient:

a) inadequate governing legislation and regulations (incomplete, out of date, etc.);

b) potential conflicts of interest (regulator versus service provider, educator versus enforcer, regulator investigating occurrences involving failures by the regulator, etc.);

c) inadequate civil aviation infrastructure and systems (navigation and communication aids, aerodromes, airspace management, etc.);

d) inadequate (incomplete, out-of-date, inconsistent) fulfilment of regulatory functions such as licensing, surveillance and enforcement (due to resource limitations, political situation, state of national emergency, etc.);

e) inadequate resources and organization for the magnitude and complexity of regulatory requirements (shortages in trained and competent personnel, administrative capacity, information technology, etc.);

f) instability and uncertainty within the CAA compromising quality and timeliness of regulatory performance (staff morale, political interference, resource limitations, etc.);

g) absence of formal safety programmes (voluntary incident reporting programme, regulatory safety audits, etc.); and

h) stagnation in safety thinking (rising occurrence rates, weak national safety culture, reluctance to embrace proven best practices, etc.).

3.4.2 On the other hand, having the following elements in a State's safety programme suggests that the programme is providing a sound basis for preserving the desired margins of safety:

a) the administrative machinery for coordinating and integrating all aspects of the State's safety programme into a coherent whole;

b) performance monitoring for all State safety functions (licensing, certification, enforcement, etc.);

c) provision of State hazard identification programmes (mandatory occurrence reporting, voluntary (non-punitive) incident reporting, service difficulty reporting, etc.);

d) competent accident and incident investigation capabilities (independent from regulatory authority);

e) risk-based resource allocations for all regulatory functions (proactively targeting regulatory attention on known areas of high risk);

f) active and passive safety promotion programmes to assist operators and to make safety information broadly accessible (including safety databases, trend analysis, monitoring of best industry practices, etc.);

g) national safety monitoring programmes (trend monitoring and analysis, safety inspections, incident investigations and safety surveillance); and

h) regular regulatory safety audits to ensure compliance by all operators and service providers.

Chapter 4

UNDERSTANDING SAFETY

4.1 GENERAL

4.1.1 As discussed in Chapter 1, safety is a condition in which the risk of harm or damage is limited to an acceptable level. The safety hazards creating risk may become evident after an obvious breach of safety, such as an accident or incident, or they may be proactively identified through formal safety management programmes before an actual safety event occurs. Having identified a safety hazard, the associated risks must be assessed. With a clear understanding of the nature of the risks, a determination can be made as to the "acceptability" of the risks. Those found to be unacceptable must be acted upon.

4.1.2 Safety management is centred on such a systematic approach to hazard identification and risk management — in the interests of minimizing the loss of human life, property damage, and financial, environmental and societal losses.

4.2 CONCEPT OF RISK

4.2.1 Since safety is defined in terms of risk, any consideration of safety must therefore involve the concept of risk.

4.2.2 There is no such thing as absolute safety. Before any assessment can be made as to whether or not a system is safe, it is first necessary to determine what the acceptable level of risk is for the system.

4.2.3 Risks are often expressed as probabilities; however, the concept of risk involves more than probabilities. To illustrate this with a hypothetical example, let us assume that the probability of the supporting cable of a 100-passenger cable car failing and allowing the cable car to fall was assessed as being the same as the probability of a 12-passenger elevator failing and allowing the elevator to fall. While the probabilities of the events occurring may be the same, the potential consequences of the cable car accident are much more severe. Risk is therefore two-dimensional. Evaluation of the acceptability of a given risk associated with a particular hazard must always take into account both the **likelihood** of occurrence of the hazard and the **severity** of its potential consequences.

4.2.4 The perceptions of risk can be derived from the following three broad categories:

a) risks that are so high that they are unacceptable;

b) risks that are so low that they are acceptable; and

c) risks in between the two categories in a) and b), where consideration needs to be given to the various trade-offs between risks and benefits.

4.2.5 If the risk does not meet the predetermined acceptability criteria, an attempt must always be made to reduce it to a level that is acceptable, using appropriate mitigation procedures. If the risk cannot be reduced to or below the acceptable level, it may be regarded as tolerable if:

a) the risk is less than the predetermined unacceptable limit;

b) the risk has been reduced to a level that is as low as reasonably practicable; and

c) the benefits of the proposed system or changes are sufficient to justify accepting the risk.

Note.— All three of the above criteria should be satisfied before a risk is classed as tolerable.

4.2.6 Even where the risk is classed as acceptable (tolerable), if any measures that could result in the further reduction of the risk are identified, and these measures require little effort or resources to implement, then they should be implemented.

4.2.7 The acronym ***ALARP*** is used to describe a risk that has been reduced to a level that is ***as low as reasonably practicable***. In determining what is *"reasonably practicable"* in this context, consideration should be given to both the technical feasibility of further reducing the risk, and the cost; this could include a cost-benefit study.

4.2.8 Showing that the risk in a system is ALARP means that any further risk reduction is either impracticable or grossly outweighed by the costs. It should, however, be borne in mind that when an individual or society "accepts" a risk, this does not mean that the risk is eliminated. Some level of risk remains; however, the individual or society has accepted that the residual risk is sufficiently low that it is outweighed by the benefits.

4.2.9 These concepts are illustrated diagrammatically in the Tolerability of Risk (TOR) triangle in Figure 4-1. (In this figure, the degree of risk is represented by the width of the triangle.)

4.2.10 Additional guidance regarding risk management is contained in Chapter 6.

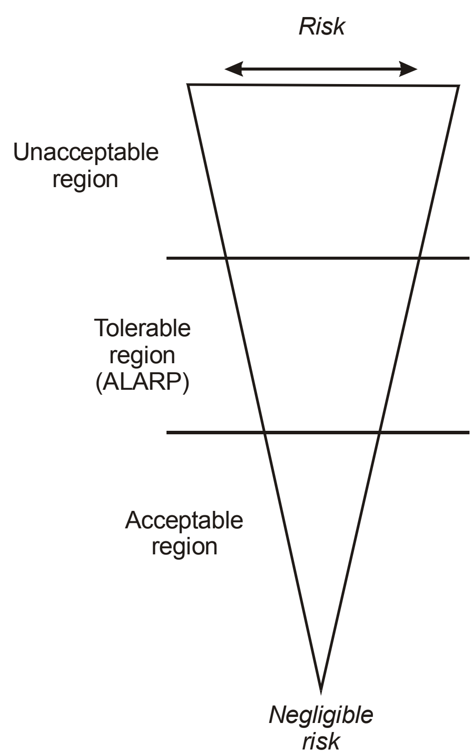

Figure 4-1. Tolerability of Risk (TOR) triangle

4.3 ACCIDENTS VERSUS INCIDENTS

4.3.1 Annex 13 provides definitions of accidents and incidents that may be summarized as follows:

a) An **accident** is an occurrence during the operation of an aircraft which entails:

   1) a fatality or serious injury;

   2) substantial damage to the aircraft involving structural failure or requiring major repair; or

   3) the aircraft is missing or is completely inaccessible.

b) An **incident** is an occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of operation. A serious incident is an incident involving circumstances indicating that an accident nearly occurred.

4.3.2 The ICAO definitions use the word "occurrence" to indicate an accident or incident. From the perspective of safety management, there is a danger in concentrating on the difference between accidents and incidents using definitions that may be arbitrary and limiting. Many incidents occur every day which may or may not be reported to the investigation authority but which come close to being accidents — often exposing significant risks. Since there is no injury, or little or no damage, such incidents might not be investigated. This is unfortunate because the investigation of an incident may yield better results for hazard identification than the investigation of an accident. The difference between an accident and an incident may simply be an element of chance. Indeed, an incident may be thought of as an undesired event that under slightly different circumstances could have resulted in harm to people or damage to property and thus would have been classified as an accident.

4.4 ACCIDENT CAUSATION

4.4.1 The strongest evidence of a serious breach of a system's safety is an accident. Since safety management aims to reduce the probability and consequences of accidents, an understanding of accident and incident causation is essential to understanding safety management. Because accidents and incidents are closely related, no attempt is made to differentiate accident causation from incident causation.

Traditional view of causation

4.4.2 Following a major accident, the questions listed below may be asked:

a) *How* and *why* did competent personnel make the errors necessary to precipitate the accident?

b) Could something like this happen again?

4.4.3 Traditionally, investigators have examined a chain of events or circumstances that ultimately led to someone doing something inappropriate, thereby triggering the accident. This inappropriate behaviour may have been an error in judgement (such as a deviation from SOPs), an error due to inattention, or a deliberate violation of the rules.

4.4.4 Following the traditional approach, the investigative focus was more often than not on finding someone to blame (and punish) for the accident. At best, safety management efforts were concentrated on finding ways to reduce the risk of such unsafe acts being committed in the first place. However, the errors or violations that trigger accidents seem to occur randomly. With no particular pattern to pursue, such safety management efforts to reduce or eliminate random events may be ineffective.

4.4.5 Analysis of accident data all too often reveals that the situation prior to the accident was *"ripe for an accident"*. Safety-minded persons may even have been saying that it was just a matter of time before these circumstances led to an accident. When the accident occurs, often healthy, qualified, experienced, motivated and well-equipped personnel were found to have committed errors that triggered the accident. They (and their colleagues) may have committed these errors or unsafe practices many times before without adverse consequences. In addition, some of the unsafe conditions in which they were operating may have been present for years, again without causing an accident. In other words, an element of chance is present.

4.4.6 Sometimes these unsafe conditions were the consequence of decisions made by management; it recognized the risks, but other priorities required a trade-off. Indeed, front-line personnel often work in a context that is defined by organizational and management factors beyond their control. The front-line employees are merely part of a larger system.

4.4.7 To be successful, safety management systems (SMS) require an alternative understanding of accident causation — one that depends on examining the total context (i.e. the *system*) in which people work.

Modern view of causation

4.4.8 According to modern thinking, accidents require the coming together of a number of enabling factors — each one necessary but in itself not sufficient to breach system defences. Major equipment failures or operational personnel errors are seldom the sole cause of breaches in safety defences. Often these breakdowns are the consequence of human failures in *decision-making*. The breakdowns may involve *active failures* at the operational level, or *latent conditions* conducive to facilitating a breach of the system's inherent safety defences. Most accidents include both active and latent conditions.

4.4.9 Figure 4-2 portrays an accident causation model that assists in understanding the interplay of organizational and management factors (i.e. system factors) in accident causation. Various "defences" are built into the aviation system to protect against inappropriate performance or poor decisions at all levels of the system (i.e. the front-line workplace, the supervisory levels and senior management). This model shows that while organizational factors, including management decisions, can create latent conditions that could lead to an accident, they also contribute to the system's defences.

4.4.10 Errors and violations having an immediate adverse effect can be viewed as ***unsafe acts***; these are generally associated with front-line personnel (pilots, ATCOs, AMEs, etc.). These unsafe acts may penetrate the various defences put in place to protect the aviation system by company management, the regulatory authorities, etc., resulting in an accident. These unsafe acts may be the result of normal errors, or they may result from deliberate violations of prescribed procedures and practices. The model recognizes that there are many error- or violation-producing conditions in the work environment that may affect individual or team behaviour.

4.4.11 These unsafe acts are committed in an operational context which includes ***latent unsafe conditions***. A latent condition is the result of an action or decision made well before an accident. Its consequences may remain dormant for a long time. Individually, these latent conditions are usually not harmful since they are not perceived as being failures in the first place.

4.4.12 Latent unsafe conditions may only become evident once the system's defences have been breached. They may have been present in the system well before an accident and are generally created by decision-makers, regulators and other people far removed in time and space from the accident. Front-line

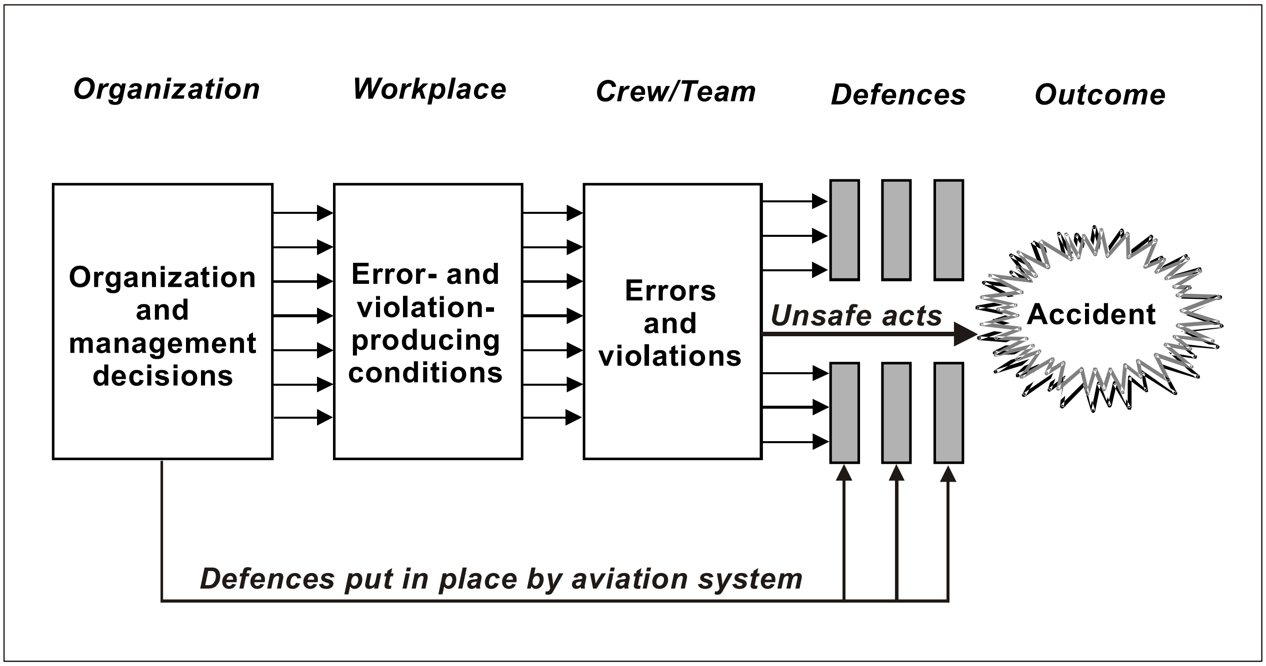

Figure 4-2. Accident causation model
(Adapted from Prof. James Reason)

operational personnel can inherit defects in the system, such as those created by poor equipment or task design; conflicting goals (e.g. service that is on time versus safety); defective organizations (e.g. poor internal communications); or bad management decisions (e.g. deferral of a maintenance item). Effective safety management efforts aim to identify and mitigate these latent unsafe conditions on a system-wide basis, rather than by localized efforts to minimize unsafe acts by individuals. Such unsafe acts may only be symptoms of safety problems, not causes.

4.4.13 Even in the best-run organizations, most latent unsafe conditions start with the decision-makers. These decision-makers are subject to normal human biases and limitations, as well as to very real constraints of time, budget, politics, etc. Since some of the unsafe decisions cannot be prevented, steps must be taken to detect them and to reduce their adverse consequences.

4.4.14 Fallible decisions by line management may take the form of inadequate procedures, poor scheduling or neglect of recognizable hazards. They may lead to inadequate knowledge and skills or inappropriate operating procedures. How well line management and the organization as a whole perform their functions sets the scene for error- or violation-producing conditions. For example, how effective is management with respect to setting attainable work goals, organizing tasks and resources, managing day-to-day affairs, and communicating internally and externally? The fallible decisions made by company management and regulatory authorities are too often the consequence of inadequate resources. However, avoiding the costs of strengthening the safety of the system can facilitate accidents that are so expensive as to bankrupt the operator.

Incidents: precursors of accidents

4.4.15 Regardless of the accident causation model used, typically there would have been precursors evident before the accident. All too often, these precursors only become evident with hindsight. Latent unsafe conditions may have existed at the time of the occurrence. Identifying and validating these latent unsafe conditions require an objective, in-depth risk analysis. Although it is important to fully investigate accidents with high numbers of fatalities, it may not be the most fruitful means for identifying safety deficiencies. Care must be taken to ensure that the *"blood priority"* (often prevalent in the media after significant loss of life) does not detract from a rational risk analysis of latent unsafe conditions in aviation. While using accident investigations to identify hazards is important, it is a reactive and costly method to improve safety.

1:600 Rule

4.4.16 Research into industrial safety in 1969 indicated that for every 600 reported occurrences with no injury or damage, there were some:

- 30 incidents involving property damage;
- 10 accidents involving serious injuries; and
- 1 major or fatal injury.

4.4.17 The 1-10-30-600 ratio shown in Figure 4-3 is indicative of a wasted opportunity if investigative efforts are focused only on those rare occurrences where there is serious injury or significant damage. The

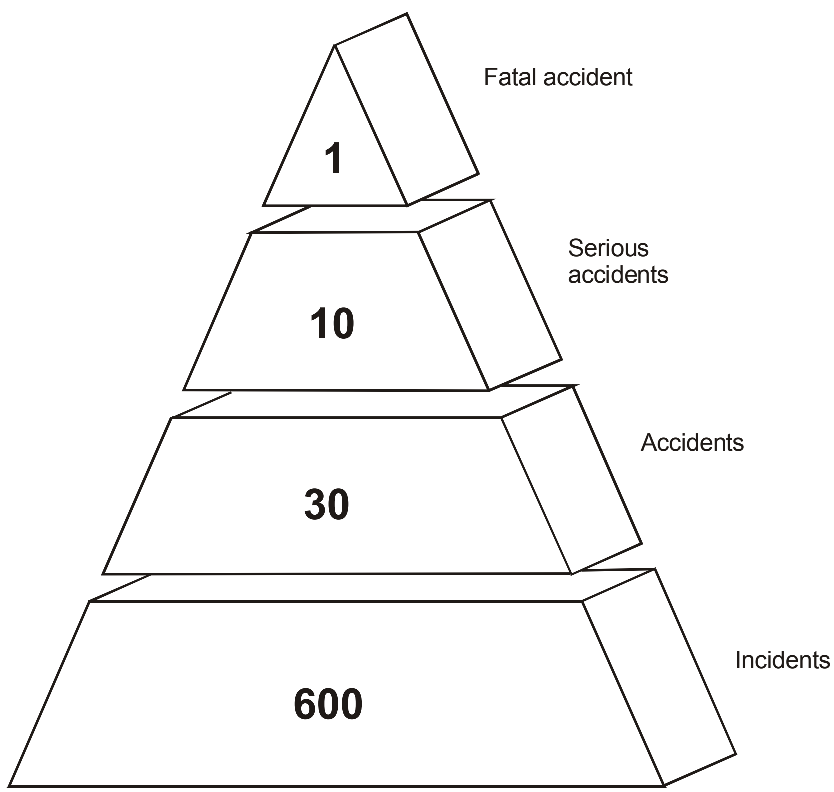

Figure 4-3. 1:600 Rule

factors contributing to such accidents may be present in hundreds of incidents and could be identified — before serious injury or damage ensues. Effective safety management requires that staff and management identify and analyse hazards before they result in accidents.

4.4.18 In aviation incidents, injury and damage are generally less significant than in accidents. Accordingly, there is less publicity associated with these occurrences. In principle, more information regarding such occurrences should be available (e.g. live witnesses and undamaged flight recorders). Without the threat of substantial damage suits, there also tends to be less of an adversarial atmosphere during the investigation. Thus, there should be a better opportunity to identify *why* the incidents occurred and, equally, *how* the defences in place prevented them from becoming accidents. In an ideal world, the underlying safety deficiencies could all be identified and preventive measures to ameliorate these unsafe conditions could be initiated before an accident occurs.

4.5 CONTEXT FOR ACCIDENTS AND INCIDENTS

4.5.1 Accidents and incidents occur within a defined set of circumstances and conditions. These include the aircraft and other equipment, the weather, the airport and flight services, as well as the regulatory, industry and corporate operating climate. They also include the permutations and combinations of human behaviour. At any given time, some of these factors may converge in such a way as to create conditions that are ripe for an accident. Understanding the context in which accidents occur is fundamental to safety management. Some of the principal factors shaping the context for accidents and incidents include equipment design, supporting infrastructure, human and cultural factors, corporate safety culture and cost factors. All of these factors are discussed in this section except for the cost factors which are covered in 4.8.

Equipment design

4.5.2 Equipment (and job) design is fundamental to safe aviation operations. Simplistically, the designer is concerned with such questions as:

a) Does the equipment do what it is supposed to do?

b) Does the equipment interface well with the operator? Is it “user-friendly”?

c) Does the equipment fit in the allocated space?

4.5.3 From the equipment operator’s perspective, the equipment must “work as advertised”. The ergonomic design must minimize the risk (and consequences) of errors. Are the switches accessible? Is the controlling action intuitive? Are the dials and displays adequate under all operating conditions? Is the equipment resistant to mistakes? (For example, “Are you sure you want to delete this file?”)

4.5.4 The designer also needs to consider the equipment maintainer’s perspective. There must be sufficient space available to permit access for required maintenance under typical working conditions and with normal human strength and reach limitations. The design must also incorporate adequate feedback to warn of an incorrect assembly.

4.5.5 With advances in automation, design considerations become even more apparent. Whether it is the pilot in the cockpit, ATCOs at their consoles, or an AME using automated diagnostic equipment, the scope for new types of human errors has expanded significantly. Although increased automation has reduced the potential for many types of accidents, safety managers now face new challenges induced by that automation, such as the lack of situational awareness and boredom.

Supporting infrastructure

4.5.6 From the perspective of an operator or a service provider, the availability of adequate supporting infrastructure is essential to the safe operation of aircraft. This includes the adequacy of the State's performance with respect to such matters as:

a) personnel licensing;

b) certification of aircraft, operators, service providers and aerodromes;

c) ensuring the provision of required services;

d) investigation of accidents and incidents; and

e) provision of operational safety oversight.

4.5.7 From a pilot's perspective, supporting infrastructure includes such matters as:

a) airworthy aircraft suitable for the type of operation;

b) adequate and reliable communications, navigation and surveillance (CNS) services;

c) adequate and reliable aerodrome, ground handling and flight planning services; and

d) effective support from the parent organization with respect to initial and recurrent training, scheduling, flight dispatch or flight following, etc.

4.5.8 An ATCO is concerned with such matters as:

a) availability of operable CNS equipment suitable for the operational task;

b) effective procedures for the safe and expeditious handling of aircraft; and

c) effective support from the parent organization with respect to initial and recurrent training, rostering and general working conditions.

Human Factors[1, 2]

4.5.9 In a high-technology industry such as aviation, the focus of problem solving is often on technology. However, the accident record repeatedly demonstrates that at least three out of four accidents involve performance errors made by apparently healthy and appropriately qualified individuals. In the rush to embrace new technologies, the people who must interface with and use this equipment are often overlooked.

4.5.10 The sources of some of the problems causing or contributing to these accidents may be traced to poor equipment or procedure design, or to inadequate training or operating instructions. Whatever the

1. Adapted from the *Human Factors Guidelines for Safety Audits Manual* (Doc 9806), Chapter 2.
2. Refer to the *Human Factors Training Manual* (Doc 9683) for a more comprehensive coverage of the theoretical and practical aspects of Human Factors.

origin, understanding normal human performance capabilities, limitations and behaviour in the operational context is central to understanding safety management. An intuitive approach to Human Factors is no longer appropriate.

4.5.11 The human element is the most flexible and adaptable part of the aviation system, but it is also the most vulnerable to influences that can adversely affect its performance. With the majority of accidents resulting from less than optimum human performance, there has been a tendency to merely attribute them to human error. However, the term "human error" is of little help in safety management. Although it may indicate *where* in the system the breakdown occurred, it provides no guidance as to *why* it occurred.

4.5.12 An error attributed to humans may have been design-induced or stimulated by inadequate equipment or training, badly designed procedures, or a poor layout of checklists or manuals. Furthermore, the term "human error" allows concealment of the underlying factors that must be brought to the fore if accidents are to be prevented. In modern safety thinking, human error is the starting point rather than the stopping point. Safety management initiatives seek ways of preventing human errors that might jeopardize safety, and ways of minimizing the adverse safety consequences of the errors that will inevitably occur. This requires an understanding of the operating context in which humans err (i.e. an understanding of the factors and conditions affecting human performance in the workplace).

SHEL model

4.5.13 The workplace typically involves a complex set of interrelated factors and conditions, which may affect human performance. The SHEL model (sometimes referred to as the SHELL model) can be used to help visualize the interrelationships among the various components of the aviation system. This model is a development of the traditional *"man-machine-environment"* system. It places emphasis on the human being and the human's interfaces with the other components of the aviation system. The SHEL model's name is derived from the initial letters of its four components:

a) ***Liveware (L)*** (humans in the workplace);

b) ***Hardware (H)*** (machine and equipment);

c) ***Software (S)*** (procedures, training, support, etc.); and

d) ***Environment (E)*** (the operating circumstances in which the rest of the L-H-S system must function).

4.5.14 Figure 4-4 depicts the SHEL model. This building block diagram is intended to provide a basic understanding of the relationship of the human to other factors in the workplace.

4.5.15 ***Liveware***. In the centre of the SHEL model are those persons at the front line of operations. Although people are remarkably adaptable, they are subject to considerable variations in performance. Humans are not standardized to the same degree as hardware, so the edges of this block are not simple and straight. People do not interface perfectly with the various components of the world in which they work. To avoid tensions that may compromise human performance, the effects of irregularities at the interfaces between the various SHEL blocks and the central Liveware block must be understood. The other components of the system must be carefully matched to humans if stresses in the system are to be avoided.

4.5.16 Several different factors put the rough edges on the Liveware block. Some of the more important factors affecting individual performance are listed below:

a) ***Physical factors:*** These include the individual's physical capabilities to perform the required tasks, e.g. strength, height, reach, vision and hearing.

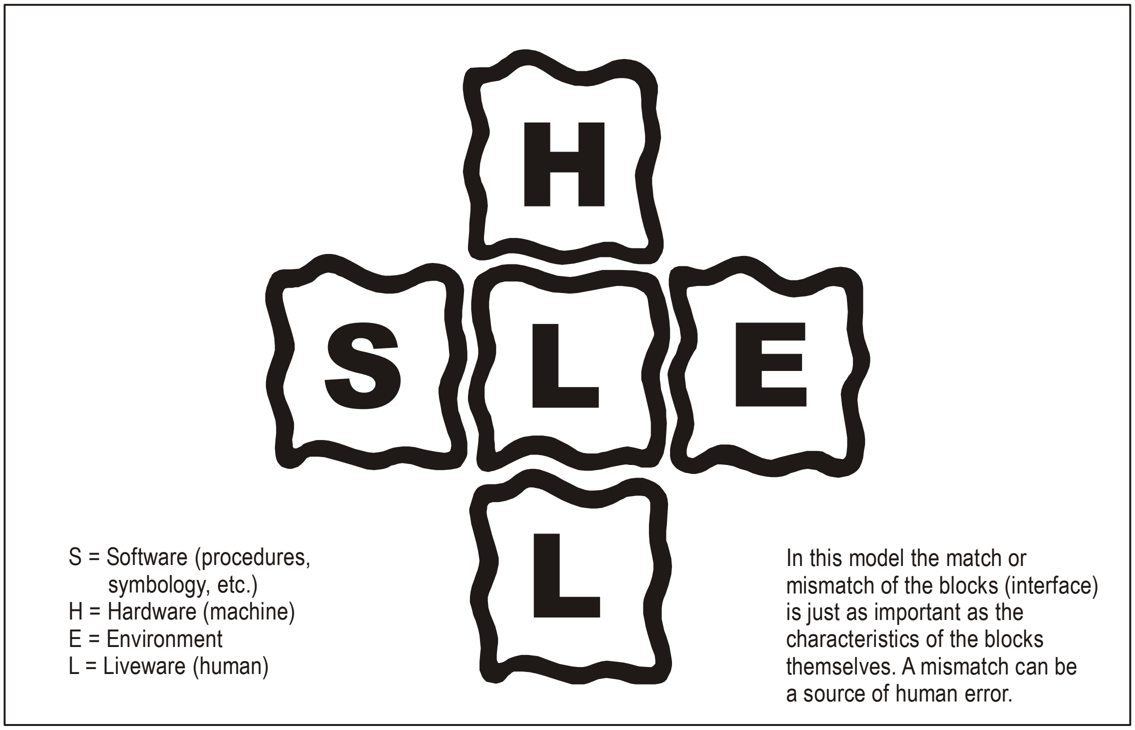

Figure 4-4. SHEL model

b) ***Physiological factors:*** These include those factors which affect the human's internal physical processes, which can compromise a person's physical and cognitive performance, e.g. oxygen availability, general health and fitness, disease or illness, tobacco, drug or alcohol use, personal stress, fatigue and pregnancy.

c) ***Psychological factors:*** These include those factors affecting the psychological preparedness of the individual to meet all the circumstances that might occur, e.g. adequacy of training, knowledge and experience, and workload. The individual's psychological fitness includes motivation and judgement, attitude towards risky behaviour, confidence and stress.

d) ***Psycho-social factors:*** These include all those external factors in the social system of individuals that bring pressure to bear on them in their work and non-work environments, e.g. an argument with a supervisor, labour-management disputes, a death in the family, personal financial problems or other domestic tension.

4.5.17 The SHEL model is particularly useful in visualizing the interfaces between the various components of the aviation system. These include:

- ***Liveware-Hardware (L-H)***. The interface between the human and the machine (ergonomics) is the one most commonly considered when speaking of Human Factors. It determines how the human interfaces with the physical work environment, e.g. the design of seats to fit the sitting characteristics of the human body, displays to match the sensory and information processing characteristics of the user, and proper movement, coding and location of controls for the user. However, there is a natural human tendency to adapt to L-H mismatches. This tendency may mask serious deficiencies, which may only become evident after an accident.

- ***Liveware-Software (L-S)***. The L-S interface is the relationship between the individual and the supporting systems found in the workplace, e.g. the regulations, manuals, checklists, publications, SOPs and computer software. It includes such *"user friendliness"* issues as currency, accuracy, format and presentation, vocabulary, clarity and symbology.

- ***Liveware-Liveware (L-L)***. The L-L interface is the relationship between the individual and other persons in the workplace. Flight crews, ATCOs, AMEs and other operational personnel function as groups, and group influences play a role in determining human behaviour and performance. This interface is concerned with leadership, cooperation, teamwork and personality interactions. The advent of crew resource management (CRM) has resulted in considerable focus on this interface. CRM training and its extension to ATS (team resource management (TRM)) and maintenance (maintenance resource management (MRM)) promote teamwork and focus on the management of normal human errors. Staff/management relationships are also within the scope of this interface, as are corporate culture, corporate climate and company operating pressures, which can all significantly affect human performance.

- ***Liveware-Environment (L-E)***. This interface involves the relationship between the individual and the internal and external environments. The internal workplace environment includes such physical considerations as temperature, ambient light, noise, vibration and air quality. The external environment (for pilots) includes such things as visibility, turbulence and terrain. Increasingly, the 24/7 aviation work environment includes disturbances to normal biological rhythms, e.g. sleep patterns. In addition, the aviation system operates within a context of broad political and economic constraints, which in turn affect the overall corporate environment. Included here are such factors as the adequacy of physical facilities and supporting infrastructure, the local financial situation, and regulatory effectiveness. Just as the immediate work environment may create pressures to take short cuts, inadequate infrastructure support may also compromise the quality of decision-making.

4.5.18 Care needs to be taken in order that problems (hazards) do not "fall through the cracks" at the interfaces. For the most part, the rough edges of these interfaces can be managed, for example:

a) The designer can ensure the performance reliability of the equipment under specified operating conditions.

b) During the certification process, the regulatory authority can define the conditions under which the equipment may be used.

c) The organization's management can specify SOPs and provide initial and recurrent training for the safe use of the equipment.

d) Individual equipment operators can ensure their familiarity and confidence in using the equipment safely under all required operating conditions.

Cultural factors[3]

4.5.19 Culture influences the values, beliefs and behaviours that we share with the other members of our various social groups. Culture serves to bind us together as members of groups and to provide clues as to how to behave in both normal and unusual situations. Some people see culture as the "collective programming of the mind". Culture is the complex, social dynamic that sets the rules of the game, or the

3. Adapted from the *Human Factors Guidelines for Safety Audits Manual* (Doc 9806).

framework for all our interpersonal interactions. It is the sum total of the way people conduct their affairs in a particular social milieu. Culture provides a context in which things happen. For safety management, understanding this context called culture is an important determinant of human performance and its limitations.

4.5.20 The Western world's approach to management is often based on an emotionally detached rationality, which is considered to be *"scientifically"* based. It assumes that human cultures in the workplace resemble the laws of physics and engineering, which are universal in application. This assumption reflects a Western cultural bias.

4.5.21 Aviation safety must transcend national boundaries, including all the cultures therein. On a global scale, the aviation industry has achieved a remarkable level of standardization across aircraft types, countries and peoples. Nevertheless, it is not difficult to detect differences in how people respond in similar situations. As people in the industry interact (the Liveware-Liveware (L-L) interface), their transactions are affected by the differences in their cultural backgrounds. Different cultures have different ways of dealing with common problems.

4.5.22 Organizations are not immune to cultural considerations. Organizational behaviour is subject to these influences at every level. The following three levels of culture have relevance to safety management initiatives:

a) ***National culture*** recognizes and identifies the national characteristics and value systems of particular nations. People of different nationalities differ, for example, in their response to authority, how they deal with uncertainty and ambiguity, and how they express their individuality. They are not all attuned to the collective needs of the group (team or organization) in the same way. In collectivist cultures, there is acceptance of unequal status and deference to leaders. Such factors may affect the willingness of individuals to question decisions or actions — an important consideration in CRM. Work assignments that mix national cultures may also affect team performance by creating misunderstandings.

b) ***Professional culture*** recognizes and identifies the behaviour and characteristics of particular professional groups (e.g. the typical behaviour of pilots vis-à-vis that of ATCOs or AMEs). Through personnel selection, education and training, on-the-job experience, etc., professionals (e.g. doctors, lawyers, pilots and ATCOs) tend to adopt the value system of, and develop behaviour patterns consistent with, their peers; they learn to *"walk and talk"* alike. They generally share a pride in their profession and are motivated to excel in it. On the other hand, they frequently have a sense of personal invulnerability, e.g. they feel that their performance is not affected by personal problems and that they do not make errors in situations of high stress.

c) ***Organizational culture*** recognizes and identifies the behaviour and values of particular organizations (e.g. the behaviour of members of one company versus that of another company, or government versus private sector behaviour). Organizations provide a shell for national and professional cultures. In an airline, for example, pilots may come from different professional backgrounds (e.g. military versus civilian experience, and bush or commuter operations versus development within a large carrier). They may also come from different organizational cultures due to corporate mergers or layoffs.

   Generally, personnel in the aviation industry enjoy a sense of belonging. They are influenced in their day-to-day behaviour by the values of their organization. Does the organization recognize merit? Promote individual initiative? Encourage risk taking? Tolerate breeches of SOPs? Promote open two-way communications, etc.? Thus the organization is a major determinant of employee behaviour.

The greatest scope for creating and nourishing a culture of safety is at the organizational level. This is commonly referred to as ***corporate safety culture*** and is discussed further below.

4.5.23 The three cultural sets described above determine, for example, how juniors will relate to their seniors, how information is shared, how personnel will react under stress, how particular technologies will be embraced, how authority will be acted upon and how organizations react to human errors (e.g. punish offenders or learn from experience). Culture will be a factor in how automation is applied; how procedures (SOPs) are developed; how documentation is prepared, presented, and received; how training is developed and delivered; how work assignments are made; relationships between pilots and Air Traffic Control (ATC); relationships with unions, etc. In other words, culture impacts on virtually every type of interpersonal transaction. In addition, cultural considerations creep into the design of equipment and tools. Technology may appear to be culture-neutral, but it reflects the biases of the manufacturer (e.g. consider the English language bias implicit in much of the world's computer software). Yet, there is no right and no wrong culture; they are what they are and they each possess a blend of strengths and weaknesses.

Corporate safety culture[4]

4.5.24 As seen above, many factors create the context for human behaviour in the workplace. Organizational or corporate culture sets the boundaries for accepted human behaviour in the workplace by establishing the behavioural norms and limits. Thus, organizational or corporate culture provides a cornerstone for managerial and employee decision-making — *"This is how we do things here!"*

4.5.25 Safety culture is a natural bi-product of corporate culture. The corporate attitude towards safety influences the employees' collective approach to safety. Safety culture consists of shared beliefs, practices and attitudes. The tone for safety culture is set and nurtured by the words and actions of senior management. Corporate safety culture then is the atmosphere created by management that shapes workers' attitudes towards safety.

4.5.26 Safety culture is affected by such factors as:

a) management's actions and priorities;

b) policies and procedures;

c) supervisory practices;

d) safety planning and goals;

e) actions in response to unsafe behaviours;

f) employee training and motivation; and

g) employee involvement or "buy-in".

4.5.27 The ultimate responsibility for safety rests with the directors and management of the organization — whether it is an airline, a service provider (e.g. airports and ATS) or an approved

4. Refer to the *Human Factors Guidelines for Safety Audits Manual* (Doc 9806) for a more comprehensive discussion of safety culture.

maintenance organization (AMO). The safety ethos of an organization is established from the outset by the extent to which senior management accepts responsibility for safe operations and for the management of risk.

4.5.28 How line management deals with the day-to-day activities is fundamental to a sound safety culture. Are the correct lessons being drawn from actual line experiences and the appropriate actions taken? Are the affected staff constructively involved in this process, or do they feel they are the victims of management's unilateral action?

4.5.29 The relationship that line management has with the representatives of the regulatory authority is also indicative of a healthy safety culture or not. This relationship should be marked by professional courtesy, but with enough distance so as not to compromise accountability. Openness will lead to better safety communications than strict enforcement of regulations. The former approach encourages constructive dialogue, while the latter encourages concealing or ignoring the real safety problems.

Positive safety culture

4.5.30 Although compliance with safety regulations is fundamental to safety, contemporary thinking is that much more is required. Organizations that simply comply with the minimum standards set by the regulations are not in a good position to identify emerging safety problems.

4.5.31 An effective way to promote a safe operation is to ensure that an operator has developed a positive safety culture. Simply put, all staff must be responsible for, and consider the impact of, safety on everything they do. This way of thinking must be so deep-rooted that it truly becomes a *"culture"*. All decisions (for example, whether by the Board of Directors, by a driver on the ramp, or by an AME) need to consider the implications on safety.

4.5.32 A positive safety culture must be generated from the *"top down"*. It relies on a high degree of trust and respect between workers and management. Workers must believe that they will be supported in any decisions made in the interests of safety. They must also understand that intentional breaches of safety that jeopardize operations will not be tolerated.

4.5.33 There is also a significant degree of interdependence between the safety culture and other aspects of an SMS. A positive safety culture is essential for the effective operation of an SMS. However, the culture of an organization is also shaped by the existence of a formal SMS. An organization should therefore not wait until it has achieved an ideal safety culture before introducing an SMS. The culture will develop as exposure to, and experience with, safety management increases.

Indications of a positive safety culture

4.5.34 A positive safety culture demonstrates the following attributes:

a) Senior management places strong emphasis on safety as part of the strategy of controlling risks (i.e. minimizing losses).

b) Decision-makers and operational personnel hold a realistic view of the short- and long-term hazards involved in the organization's activities.

c) Those in senior positions:

   1) foster a climate in which there is a positive attitude towards criticisms, comments and feedback from lower levels of the organization on safety matters;

   2) do not use their influence to force their views on subordinates; and

   3) implement measures to contain the consequences of identified safety deficiencies.

d) Senior management promotes a non-punitive working environment. Some organizations use the term “just culture” instead of “non-punitive”. As discussed in 4.5.35 d), the term non-punitive **does not** imply blanket immunity.

e) There is an awareness of the importance of communicating relevant safety information at all levels of the organization (both within and with outside entities).

f) There are realistic and workable rules relating to hazards, safety and potential sources of damage.

g) Personnel are well trained and understand the consequences of unsafe acts.

h) There is a low incidence of risk-taking behaviour, and a safety ethic that discourages such behaviour.

4.5.35 Positive safety cultures typically are:

a) ***Informed cultures***. Management fosters a culture where people understand the hazards and risks inherent in their areas of operation. Personnel are provided with the necessary knowledge, skills and job experience to work safely, and they are encouraged to identify the threats to their safety and to seek the changes necessary to overcome them.

b) ***Learning cultures***. Learning is seen as more than a requirement for initial skills training; rather it is valued as a lifetime process. People are encouraged to develop and apply their own skills and knowledge to enhance organizational safety. Staff are updated on safety issues by management, and safety reports are fed back to staff so that everyone can learn the pertinent safety lessons.

c) ***Reporting cultures***. Managers and operational personnel freely share critical safety information without the threat of punitive action. This is frequently referred to as creating a corporate reporting culture. Personnel are able to report hazards or safety concerns as they become aware of them, without fear of sanction or embarrassment.

d) ***Just cultures***. While a non-punitive environment is fundamental for a good reporting culture, the workforce must know and agree on what is acceptable and what is unacceptable behaviour. Negligence or deliberate violations must not be tolerated by management (even in a non-punitive environment). A just culture recognizes that, in certain circumstances, there may be a need for punitive action and attempts to define the line between acceptable and unacceptable actions or activities.

4.5.36 Table 4-1 summarizes three corporate responses to safety issues that range from a poor safety culture, through the indifferent (or bureaucratic) approach (which only meets minimum acceptable requirements), to the ideal positive safety culture.

Table 4-1. Characteristics of different safety cultures

Safety Culture: ⇨ ***Characteristics*** ⇩	***Poor***	***Bureaucratic***	***Positive***
Hazard information is:	Suppressed	Ignored	Actively sought
Safety messengers are:	Discouraged or punished	Tolerated	Trained and encouraged
Responsibility for safety is:	Avoided	Fragmented	Shared
Dissemination of safety information is:	Discouraged	Allowed but discouraged	Rewarded
Failures lead to:	Cover-ups	Local fixes	Inquiries and systemic reform
New ideas are:	Crushed	Considered as new problems (not opportunities)	Welcomed

Blame and punishment

4.5.37 Once an investigation has identified the *cause* of an occurrence, it is usually evident who *"caused"* the event. Traditionally, blame (and punishment) could then be assigned. While the legal environments vary widely between States, many States still focus their investigations on determining blame and apportioning liability. For them, punishment remains a principal safety tool.

4.5.38 Philosophically, punishment is appealing from several points of view, such as:

a) seeking retribution for a breach of trust;

b) protecting society from repeat offenders;

c) altering individual behaviour; and

d) setting an example for others.

4.5.39 Punishment may have a role to play where people intentionally contravene the "rules". Arguably, such sanctions may deter the perpetrator of the violation (or others in similar circumstances).

4.5.40 If an accident was the result of an error in judgement or technique, it is almost impossible to effectively punish for that error. Changes could be made in selection or training processes, or the system could be made more tolerant of such errors. If punishment is selected in such cases, two outcomes are almost certain. Firstly, no further reports will be received of such errors. Secondly, since nothing has been done to change the situation, the same accident could be expected again.

4.5.41 Perhaps society needs to use punishment in order to mete out justice. However, the global experience suggests that punishment has little, if any, systemic value on safety. Except in wilful cases of negligent behaviour with deliberate violations of the norms, punishment serves little purpose from a safety perspective.

4.5.42 In much of the international aviation community, a more enlightened view of the role of punishment is emerging. In part, this parallels a growing understanding of the causes of human errors (as opposed to violations). Errors are now being viewed as the *results* of some situation or circumstance, not necessarily the *causes* of them. As a result, managers are beginning to seek out the unsafe conditions that facilitate such errors. They are beginning to find that the systematic identification of organizational weaknesses and safety deficiencies pays a much higher dividend for safety management than punishing individuals. (That is not to say that these enlightened organizations are not required to take action against individuals who fail to improve after counselling and/or extra training.)

4.5.43 While many aviation operations are taking this positive approach to the management of safety, others have been slow to adopt and implement effective “non-punitive policies”. Others have been slow to extend their non-punitive policies on a corporate-wide basis. (See comments in 4.5.35 d) regarding a just culture.)

4.6 HUMAN ERROR

4.6.1 Human error is cited as being a causal or contributing factor in the majority of aviation occurrences. All too often competent personnel commit errors, although clearly they did not plan to have an accident. Errors are not some type of aberrant behaviour; they are a natural bi-product of virtually all human endeavours. Error must be accepted as a normal component of any system where humans and technology interact. *“To err is human.”*

4.6.2 The factors discussed in 4.5 create the context in which humans commit errors. Given the rough interfaces of the aviation system (as depicted in the SHEL model), the scope for human errors in aviation is enormous. Understanding how *normal* people commit errors is fundamental to safety management. Only then can effective measures be implemented to minimize the effects of human errors on safety.

4.6.3 Even if not altogether avoidable, human errors are *manageable* through the application of improved technology, relevant training, and appropriate regulations and procedures. Most measures aimed at error management involve front-line personnel. However, the performance of pilots, ATCOs, AMEs, etc. can be strongly influenced by organizational, regulatory, cultural and environmental factors affecting the workplace. For example, organizational processes constitute the breeding grounds for many predictable human errors, including inadequate communication facilities, ambiguous procedures, unsatisfactory scheduling, insufficient resources, and unrealistic budgeting — in fact, all processes that the organization can control. Figure 4-5 summarizes some of the factors contributing to human errors — and to accidents.

Error types

4.6.4 Errors may occur at the planning stage or during the execution of the plan. ***Planning errors*** lead to ***mistakes***; either the person follows an inappropriate procedure for dealing with a routine problem or builds a plan for an inappropriate course of action to cope with a new situation. Even when the planned action is appropriate, errors may occur in the execution of the plan. The Human Factors literature on such errors in execution generally draws a distinction between slips and lapses. A ***slip*** is an action which is not carried out as planned and will therefore always be observable. A ***lapse*** is a failure of memory and may not necessarily be evident to anyone other than the person who experienced the lapse.

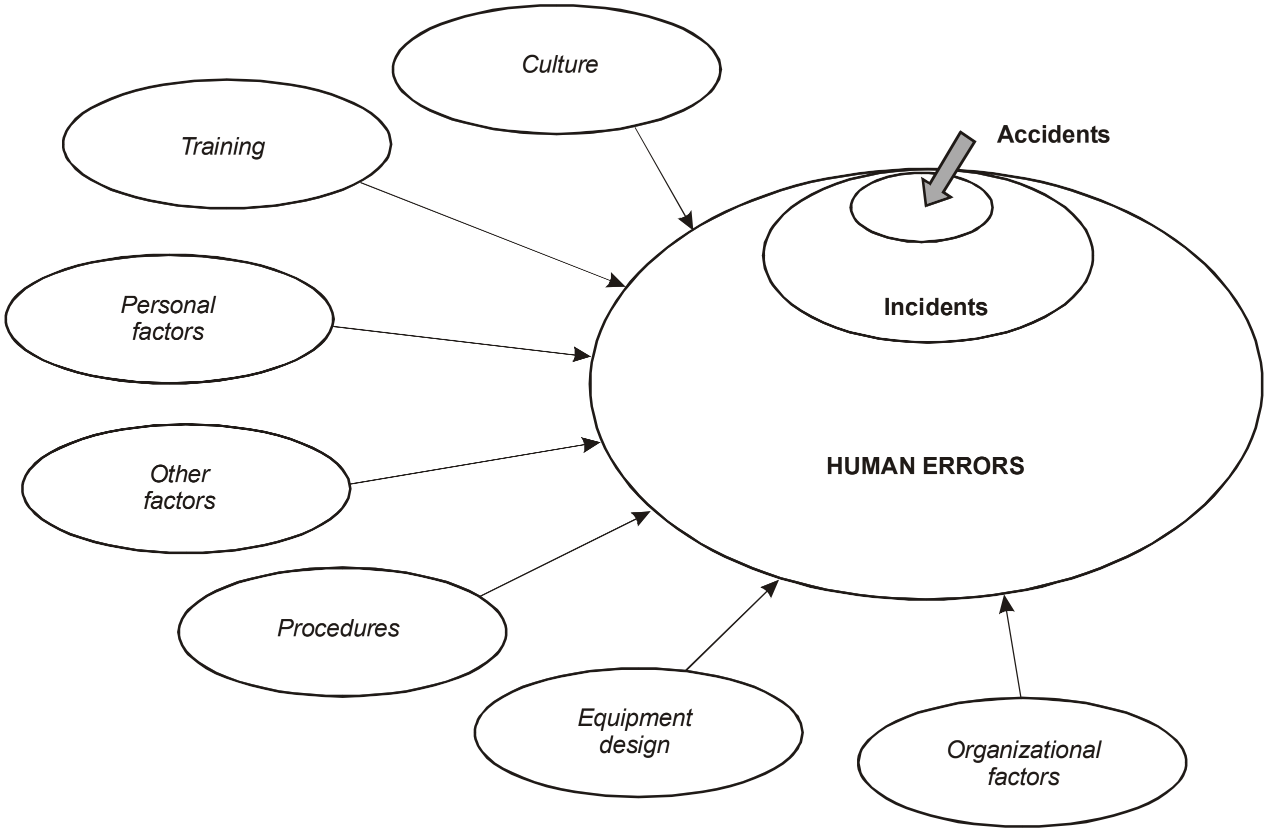

Figure 4-5. Contributing factors to human error

Planning errors (mistakes)

4.6.5 In problem solving, we intuitively look for a set of rules (SOPs, rules of thumb, etc.) that are known and have been used before and that will be appropriate to the problem in hand. Mistakes can occur in two ways: the application of a rule that is not appropriate to the situation, or the correct application of a rule that is flawed.

4.6.6 *Misapplication of good rules*. This usually happens when an operator is faced with a situation that exhibits many features common to the circumstances for which the rule was intended, but with some significant differences. If the significance of the differences is not recognized, an inappropriate rule may be applied.

4.6.7 *Application of bad rules*. This involves the use of a procedure that past experience has shown to work but that contains unrecognized flaws. If such a solution works in the circumstances under which it was first tried, it may become part of the individual's regular approach to solving that type of problem.

4.6.8 When a person does not have a ready-made solution based on previous experience and/or training, that person draws on personal knowledge and experience. Developing a solution to a problem using this method will inevitably take longer than applying a rule-based solution, as it requires reasoning based on knowledge of basic principles. Mistakes can occur because of a lack of knowledge or because of faulty reasoning. The application of knowledge-based reasoning to a problem will be particularly difficult in circumstances where the individuals are busy, as their attention is likely to be diverted from the reasoning process to deal with other issues. The probability of a mistake occurring becomes greater in such circumstances.

Execution errors (slips and lapses)

4.6.9 The actions of experienced and competent personnel tend to be routine and highly practiced; they are carried out in a largely automatic fashion, except for occasional checks on progress. Slips and lapses can occur as the result of:

a) *Attentional slips.* These occur as the result of a failure to monitor the progress of a routine action at some critical point. They are particularly likely when the planned course of action is similar, but not identical, to a routinely used procedure. If attention is allowed to wander or a distraction occurs at the critical point where the action differs from the usual procedure, the result can be that the operator will follow the usual procedure rather than the one intended in this instance.

b) *Memory lapses.* These occur when we either forget what we had planned to do, or omit an item in a planned sequence of actions.

c) *Perceptual errors.* These are errors in recognition. They occur when we believe we saw or heard something which is different from the information actually presented.

Errors versus violations

4.6.10 Errors (which are a normal human activity) are quite distinct from violations. Both can lead to a failure of the system. Both can result in a hazardous situation. The difference lies in the intent.

4.6.11 A violation is a deliberate act, while an error is unintentional. Take, for example, a situation in which an ATCO allows an aircraft to descend through the level of a cruising aircraft when the DME distance between them is 18 NM, and this occurs in circumstances where the correct separation minimum is 20 NM. If the ATCO made a mistake in calculating the difference in the DME distances advised by the pilots, this would be an error. If the ATCO calculated the distance correctly and allowed the descending aircraft to continue through the level of the cruising aircraft knowing that the required separation minimum did not exist, this would be a violation.

4.6.12 Some violations are the result of poor or unrealistic procedures where people have developed “work arounds” to accomplish the task. In such cases, it is very important that they be reported as soon as they are encountered in order that the procedures can be corrected. In any event, violations should not be tolerated. There have been accidents where a corporate culture that tolerated or, in some cases, encouraged the taking of short cuts rather than the following of published procedures was identified as a contributory cause.

Control of human error

4.6.13 Fortunately, few errors lead to adverse consequences, let alone accidents. Typically, errors are identified and corrected with no undesirable outcomes, for example, selecting an incorrect frequency or setting the altitude bug to the wrong altitude. On the understanding that errors are normal in human behaviour, the total elimination of human error would be an unrealistic goal. The challenge then is not merely to prevent errors but to learn to safely manage the inevitable errors.

4.6.14 Three strategies for managing errors in aircraft maintenance are briefly discussed below:[5]

a) ***Error reduction*** strategies intervene directly at the source of the error by reducing or eliminating the contributing factors to the error. Examples of error reduction strategies include improving the access to an aircraft component for maintenance, improving the lighting in which the task is to be performed, reducing environmental distractions and providing better training. Most error management strategies used in aircraft maintenance fall into this category.

b) ***Error capturing*** assumes the error has already been made. The intent is to *"capture"* the error before any adverse consequences of the error are felt. Error capturing is different from error reduction in that it does not directly serve to reduce or eliminate the error. Examples of error-capturing strategies include cross-checking to verify correct task completion and functional test flights.

c) ***Error tolerance*** refers to the ability of a system to accept an error without serious consequence. Examples of measures to increase error tolerance are the incorporation of multiple hydraulic or electrical systems on an aircraft to provide redundancy, and a structural inspection programme that provides multiple opportunities to detect a fatigue crack — before it reaches critical length.

4.7 SAFETY CYCLE

4.7.1 Given the number and potential relationships of the factors that may affect safety, an effective SMS is required. An example of the type of systematic process required is shown in Figure 4-6. A brief description of the safety cycle follows.

4.7.2 Hazard identification is the critical first step in managing safety. Evidence of hazards is required and may be obtained in a number of ways from a variety of sources, for example:

a) hazard and incident reporting systems;

b) investigation and follow-up of reported hazards and incidents;

c) trend analysis;

d) feedback from training;

e) flight data analysis;

f) safety surveys and operational oversight safety audits;

g) monitoring of normal operations;

h) State investigation of accidents and serious incidents; and

i) information exchange systems.

5. From the *Human Factors Training Manual* (Doc 9683).

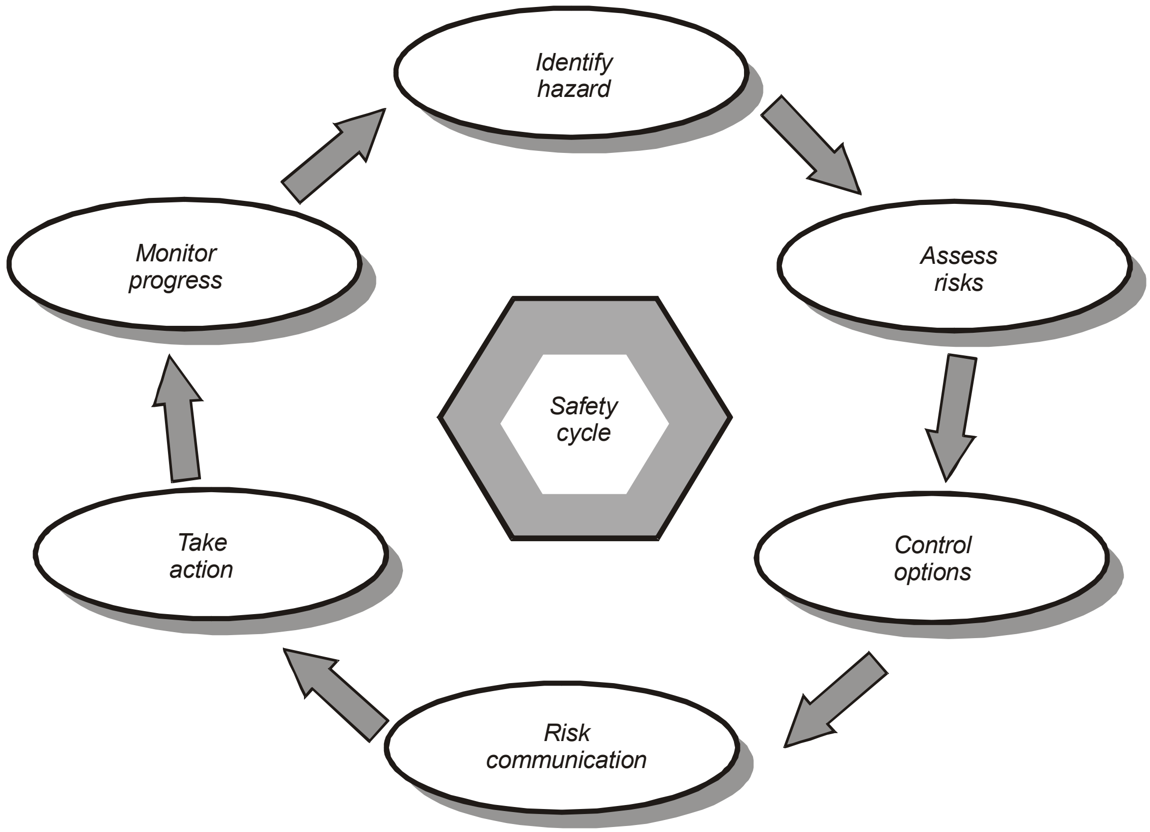

Figure 4-6. Safety cycle

4.7.3 Each hazard identified must be evaluated and prioritized. This evaluation requires the compilation and analysis of all available data. The data is then assessed to determine the extent of the hazard; is it a "one-of-a-kind" or is it systemic? A database may be required to facilitate the storage and retrieval of the data. Appropriate tools are needed to analyse the data.

4.7.4 Having validated a safety deficiency, decisions must then be made as to the most appropriate action to avoid or eliminate the hazard or reduce the associated risks. The solution must take into account the local conditions, as "one size" does not fit all situations. Care must be taken that the solution does not introduce new hazards. This is the process of risk management.

4.7.5 Once appropriate safety action has been implemented, performance must be monitored to ensure that the desired outcome has been achieved, for example:

a) The hazard has been eliminated (or at least the associated risks have been reduced in probability or severity).

b) The action taken permits coping satisfactorily with the hazard.

c) No new hazards have been introduced into the system.

4.7.6 If the outcome is unsatisfactory, the whole process must be repeated.

4.8 COST CONSIDERATIONS

4.8.1 Operating a profitable, yet safe airline or service provider requires a constant balancing act between the need to fulfil production goals (such as departures that are on time) versus safety goals (such as taking extra time to ensure that a door is properly secured). The aviation workplace is filled with potentially unsafe conditions which will not all be eliminated; yet, operations must continue.

4.8.2 Some operations adopt a goal of *"zero accidents"* and state that *"safety is their number one priority".* The reality is that operators (and other commercial aviation organizations) need to generate a profit to survive. Profit or loss is the immediate indicator of the company's success in meeting its production goals. However, safety is a prerequisite for a sustainable aviation business, as a company tempted to cut corners will eventually realize. For most companies, safety can best be measured by the absence of accidental losses. Companies may realize they have a safety problem following a major accident or loss, in part because it will impact on the profit/loss statement. However, a company may operate for years with many potentially unsafe conditions without adverse consequence. Without effective safety management to identify and correct these unsafe conditions, the company may assume that it is meeting its safety objectives, as evidenced by the *"absence of losses".* In reality, it has been lucky.

4.8.3 Safety and profit are not mutually exclusive. Indeed, quality organizations realize that expenditures on the correction of unsafe conditions are an investment towards long-term profitability. Losses cost money. As money is spent on risk reduction measures, costly losses are reduced (as shown in Figure 4-7). However, by spending more and more money on risk reduction, the gains made through reduced losses may not be in proportion to the expenditures. Companies must balance the costs of losses and expenditures on risk reduction measures. Some level of loss may be acceptable from a straight profit and loss point of view; however, few organizations can survive the economic consequences of a major accident. Hence, there is a strong economic case for an effective SMS to manage the risks.

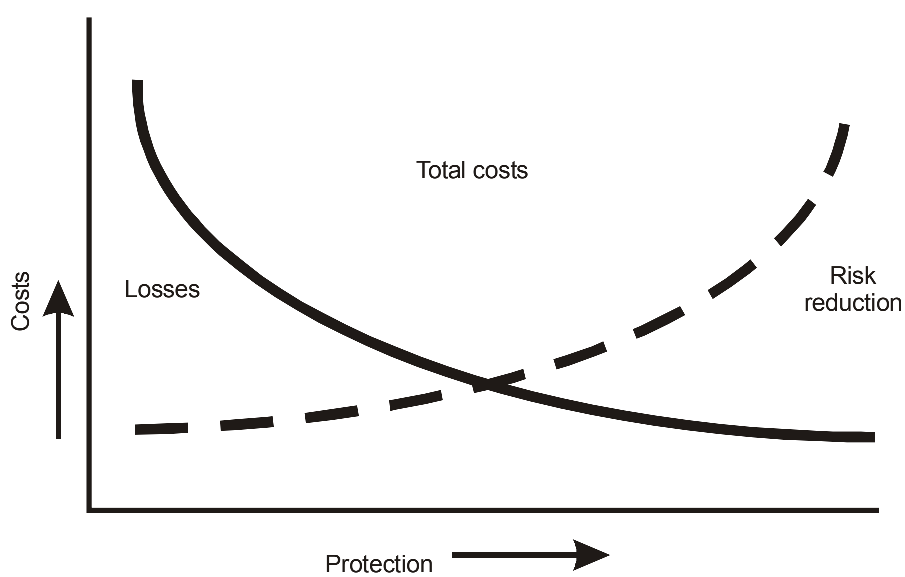

Figure 4-7. Safety versus costs

Costs of accidents

4.8.4 There are two basic types of costs associated with an accident or a serious incident: direct and indirect.

Direct costs

4.8.5 These are the obvious costs which are fairly easy to determine. They mostly relate to physical damage and include rectifying, replacing or compensating for injuries, aircraft equipment and property damage. The high costs of an accident can be reduced by insurance coverage. (Some large organizations effectively self-insure by putting funds aside to cover their risks.)

Indirect costs

4.8.6 While insurance may cover specified accident costs, there are many uninsured costs. An understanding of these uninsured costs (or indirect costs) is fundamental to understanding the economics of safety.

4.8.7 Indirect costs include all those items that are not directly covered by insurance and usually total much more than the direct costs resulting from an accident. Such costs are sometimes not obvious and are often delayed. Some examples of uninsured costs that may accrue from an accident include:

a) ***Loss of business and damage to the reputation of the organization.*** Many organizations will not allow their personnel to fly with an operator with a questionable safety record.

b) ***Loss of use of equipment.*** This equates to lost revenue. Replacement equipment may have to be purchased or leased. Companies operating a one-of-a-kind aircraft may find that their spares inventory and the people specially trained for such an aircraft become surplus.

c) ***Loss of staff productivity.*** If people are injured in an accident and are unable to work, many States require that they continue to be paid. Also, these people will need to be replaced at least for the short term, incurring the costs of wages, overtime (and possibly training), as well as imposing an increased workload on the experienced workers.

d) ***Investigation and clean-up.*** These are often uninsured costs. Operators may incur costs from the investigation including the costs of their staff involvement in the investigation, as well as the costs of tests and analyses, wreckage recovery, and restoring the accident site.

e) ***Insurance deductibles.*** The policyholder's obligation to cover the first portion of the cost of any accident must be paid. A claim will also put a company into a higher risk category for insurance purposes and therefore may result in increased premiums. (Conversely, the implementation of a comprehensive SMS could help a company to negotiate a lower premium.)

f) ***Legal action and damage claims.*** Legal costs can accrue rapidly. While it is possible to insure for public liability and damages, it is virtually impossible to cover the cost of time lost handling legal action and damage claims.

g) ***Fines and citations.*** Government authorities may impose fines and citations, including possibly shutting down unsafe operations.

Costs of incidents

4.8.8 Serious aviation incidents, which result in minor damage or injuries, can also incur many of these indirect or uninsured costs. Typical cost factors arising from such incidents can include:

a) flight delays and cancellations;

b) alternate passenger transportation, accommodation, complaints, etc.;

c) crew change and positioning;

d) loss of revenue and reputation;

e) aircraft recovery, repair and test flight; and

f) incident investigation.

Costs of safety

4.8.9 The costs of safety are even more difficult to quantify than the full costs of accidents — partly because of the difficulty in assessing the value of accidents that have been prevented. Nevertheless, some operators have attempted to quantify the costs and benefits of introducing an SMS. They have found the cost savings to be substantial. Performing a cost-benefit analysis is complicated; however, it is an exercise that should be undertaken, as senior management is not inclined to spend money if there is no quantifiable benefit. One way of addressing this issue is to separate the costs of the SMS from the costs of correcting safety deficiencies, by charging the safety management costs to the safety department, and the safety deficiency costs to the line management most responsible. This exercise requires senior management's involvement in considering the costs and benefits of an SMS.

Chapter 5

BASICS OF SAFETY MANAGEMENT

5.1 THE PHILOSOPHY OF SAFETY MANAGEMENT

Core business function

5.1.1 In successful aviation organizations, safety management is a core business function — as is financial management. Effective safety management requires a realistic balance between safety and production goals. Thus, a coordinated approach in which the organization's goals and resources are analysed helps to ensure that decisions concerning safety are realistic and complementary to the operational needs of the organization. The finite limits of financing and operational performance must be accepted in any industry. Defining acceptable and unacceptable risks is therefore important for cost-effective safety management. If properly implemented, safety management measures not only increase safety but also improve the operational effectiveness of an organization.

5.1.2 Experience in other industries and lessons learned from the investigation of aircraft accidents have emphasized the importance of managing safety in a systematic, proactive and explicit manner. These terms are explained below:

- ***Systematic*** means that safety management activities will be conducted in accordance with a predetermined plan and applied in a consistent manner throughout the organization.

- ***Proactive*** means the adoption of an approach which emphasizes prevention through the identification of hazards and the introduction of risk mitigation measures before the risk-bearing event occurs and adversely affects safety performance.

- ***Explicit*** means that all safety management activities should be documented, visible and performed independently from other management activities.

5.1.3 Addressing safety in a systematic, proactive and explicit manner ensures that on a long-term basis safety becomes an integral part of the day-to-day business of the organization and that the safety-related activities of the organization are directed to the areas where the benefits will be greatest.

Systems approach

5.1.4 Modern approaches to safety management have been shaped by the concepts introduced in Chapter 4 and, in particular, by the role of organizational issues as contributory factors in accidents and incidents. Safety cannot be achieved simply by introducing rules or directives concerning the procedures to be followed by operational staff.

5.1.5 The scope of safety management encompasses most of the activities of the organization. For this reason, safety management must start at the senior management level, and the effects on safety must be examined at all levels of the organization.

System safety

5.1.6 System safety was developed as an engineering discipline for aerospace and missile defence systems in the 1950s. Its practitioners were safety engineers, not operational specialists. As a result, their focus tended to be on designing and building fail-safe systems. On the other hand, civil aviation tended to focus on flight operations, and safety managers often came from the ranks of pilots. In pursuing improved safety, it became necessary to view aviation safety as more than just the aeroplane and its pilots. Aviation is a total system that includes everything needed for safe flight operation. The “system” includes the airport, air traffic control, maintenance, cabin crew, ground operational support, dispatch, etc. Sound safety management must address all parts of the system.

5.2 FACTORS AFFECTING SYSTEM SAFETY

5.2.1 The factors affecting safety within the defined system can be looked at two ways: first, by discussing those factors which may result in situations in which safety is compromised; and second, by examining how an understanding of these factors can be applied to the design of systems in order to reduce the likelihood of occurrences which may compromise safety.

5.2.2 The search for factors that could compromise safety must include all levels of the organization responsible for operations and the provision of supporting services. As outlined in Chapter 4, safety starts at the highest level of the organization.

Active failures and latent conditions

5.2.3 *Active failures* are generally the result of equipment faults or errors committed by operational personnel. *Latent conditions*, however, always have a human element. They may be the result of undetected design flaws. They may be related to unrecognized consequences of officially approved procedures. There have also been a number of cases where latent conditions have been the direct result of decisions taken by the management of the organization. For example, latent conditions exist when the culture of the organization encourages taking short cuts rather than always following approved procedures. The direct consequence of a condition associated with taking short cuts would materialize at the operational level by non-adherence to correct procedures. However, if there is general acceptance of this sort of behaviour among operational personnel, and management is either unaware of this or takes no action, there is a latent condition in the system at the management level.

Equipment faults

5.2.4 The likelihood of system failures due to equipment faults is in the domain of reliability engineering. The probability of system failure is determined by analysing the failure rates of individual components of the equipment. The causes of the component failures may include electrical, mechanical and software faults.

5.2.5 A safety analysis is required to consider both the likelihood of failures during normal operations and the effects of continued unavailability of any one element on other aspects of the system. The analysis should include the implications of any loss of functionality or redundancy as a result of equipment being taken out of service for maintenance. It is therefore important that the scope of the analysis and the definition of the boundaries of the system for purposes of the analysis be sufficiently broad so that all necessary supporting services and activities are included. As a minimum, a safety analysis should consider the elements of the SHEL model outlined in Chapter 4.

5.2.6 The techniques for estimating the probability of overall system failure as a result of equipment faults and for estimating parameters, such as availability and continuity of service, are well established and are described in standard texts on reliability and safety engineering. These issues will not be addressed further in this manual.

Human error

5.2.7 An error occurs when the outcome of a task being performed by a human is not the intended outcome. The way in which a human operator approaches a task depends on the nature of the task and on how familiar the operator is with it. Human performance may be skill-based, rule-based or knowledge-based. Errors may be the consequence of lapses in memory, slips in doing what was intended, or the result of mistakes which are conscious errors in judgement. A distinction should also be made between honest or normal errors committed in the fulfilment of assigned duties, and deliberate violations of prescribed procedures or accepted safe practices. As discussed in Chapter 4, some organizations use the concept of a "just culture" to assist in defining what errors are "acceptable".

System design

5.2.8 Given the complex interplay of human, material and environmental factors in operations, the complete elimination of risk is an unachievable goal. Even in organizations with the best training programmes and a positive safety culture, human operators will occasionally make errors. The best designed and maintained equipment will occasionally fail. System designers must therefore take into account the inevitability of errors and failures. It is important that the system be designed and implemented in such a way that, to the maximum extent possible, errors and equipment failures will not result in an accident. In other words, the system is *"error-tolerant"*.

5.2.9 The hardware and software components of a system are generally designed to meet specified levels of availability, continuity and integrity. The techniques for estimating system performance in terms of these parameters are well established. When necessary, redundancy can be built into the system to provide alternatives in the event of failure of one or more elements of the system.

5.2.10 The performance of the human element cannot be specified as precisely; however, it is essential that the possibility of human error be considered as part of the overall design of the system. This requires an analysis to identify potential weaknesses in the procedural aspects of the system, taking into account the normal shortcomings in human performance. The analysis should also take into account the fact that accidents rarely, if ever, have a single cause. As noted earlier, they usually occur as part of a sequence of events in a complex situational context. Therefore, the analysis needs to consider combinations of events and circumstances in order to identify sequences that could possibly result in safety being compromised.

5.2.11 Developing a safe and error-tolerant system requires that the system contain multiple defences to ensure that, as much as possible, no single failure or error will result in an accident, and that when a failure or error occurs, it will be recognized and remedial action taken before a sequence of events leading to an accident can develop. The need for a series of defences rather than just a single defensive layer arises from the possibility that the defences themselves may not always work perfectly. This design philosophy is called "defences-in-depth".

5.2.12 For an accident to occur in a well-designed system, gaps must develop in all the defensive layers of the system at the critical time when that defence should have been capable of detecting the earlier error or failure. An illustration of how an accident event must penetrate all defensive layers is in Figure 5-1.

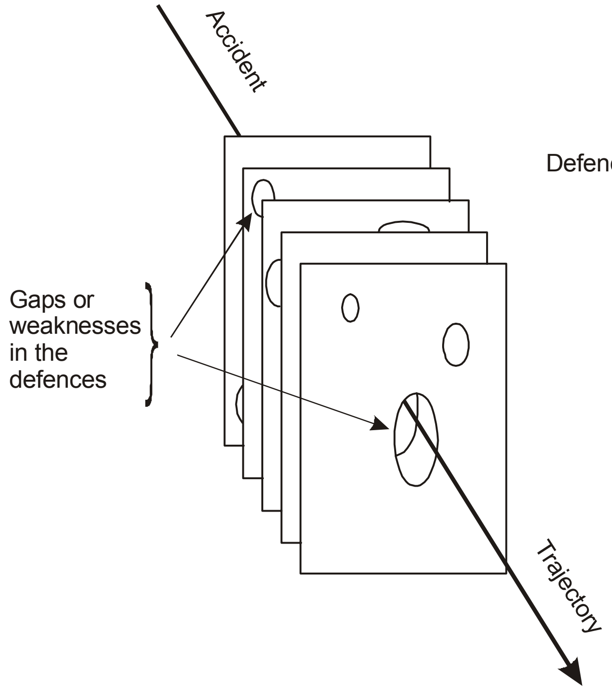

Figure 5-1. Defences-in-depth

5.3 SAFETY MANAGEMENT CONCEPTS

Cornerstones of safety management

5.3.1 In its most simple terms, safety management involves hazard identification and the closing of any gaps in the defences of the system. Effective safety management is multidisciplinary, requiring the systematic application of a variety of techniques and activities across the aviation spectrum. It builds upon three defining cornerstones, namely:

a) *A comprehensive* ***corporate approach*** *to safety.* This sets the tone for the management of safety. The corporate approach builds upon the safety culture of the organization and embraces the organization's safety policies, objectives and goals, and, most importantly, senior management's commitment to safety.

b) *Effective* ***organizational tools*** *to deliver safety standards.* Effective organizational tools are needed to deliver the necessary activities and processes to advance safety. This cornerstone includes how the organization arranges its affairs to fulfil its safety policies, objectives and goals, and how it establishes standards and allocates resources. The principal focus is on hazards and their potential effects on safety-critical activities.

c) *A formal system for* ***safety oversight****.* This is needed to confirm the organization's continuing fulfilment of its corporate safety policy, objectives, goals and standards. The term safety oversight refers specifically to the activities of the State as part of its safety programme. For an operator or service provider, the term safety performance monitoring is often used to cover these activities under its safety management system (SMS).

5.3.2 A more detailed examination of each of these cornerstones is provided in Appendix 1 to this chapter.

Strategies for safety management

5.3.3 The strategy that an organization adopts for its SMS will reflect its corporate safety culture and may range from purely reactive, responding only to accidents, through to strategies that are highly proactive in their search for safety problems. The traditional or reactive process is dominated by retrospective repairs (i.e. fixing the stable door after the horse has bolted). Under the more modern or proactive approach, prospective reform plays the leading part (i.e. making a stable from which no horse could run away or even want to). Depending on the strategy adopted, different methods and tools need to be employed.

Reactive safety strategy*: Investigate accidents and reportable incidents*

5.3.4 This strategy is useful for situations involving failures in technology, or unusual events. The utility of the reactive approach for safety management purposes depends on the extent to which the investigation goes beyond determining the causes to include an examination of all the contributory factors. The reactive approach tends to be marked by the following characteristics:

a) Management's safety focus is on compliance with minimum requirements.

b) Safety measurement is based on reportable accidents and incidents with such limitations in value as:

   1) any analysis is limited to examining actual failures;

   2) insufficient data is available to accurately determine trends, especially those attributable to human error; and

   3) little insight is available into the *"root causes"* and latent unsafe conditions, which facilitate human error.

c) Constant "catching up" is required to match human inventiveness for new types of errors.

Proactive safety strategy*: Aggressively seeking information from a variety of sources which may be indicative of emerging safety problems*

5.3.5 Organizations pursuing a proactive strategy for safety management believe that the risk of accidents can be minimized by identifying vulnerabilities before they fail and by taking the necessary actions to reduce those risks. Consequently, they actively seek systemic unsafe conditions using such tools as:

a) hazard and incident reporting systems that promote the identification of latent unsafe conditions;

b) safety surveys to elicit feedback from front-line personnel about areas of dissatisfaction and unsatisfactory conditions that may have accident potential;

c) flight data recorder analysis for identifying operational exceedances and confirming normal operating procedures;

d) operational inspections or audits of all aspects of operations to identify vulnerable areas before accidents, incidents or minor safety events confirm a problem exists; and

e) a policy for consideration and embodiment of manufacturers' service bulletins.

Key safety management activities

5.3.6 Those organizations which manage safety most successfully practice several common activities. Some of those specific activities are outlined below:

a) ***Organization***. They are organized to establish a safety culture and to reduce their accidental losses. Organizations will normally have a formal SMS as outlined in Chapters 12 to 15.

b) ***Safety assessments***. They systematically analyse proposed changes to equipment or procedures to identify and mitigate weaknesses before change is implemented.

c) ***Occurrence reporting***. They have established formal procedures for reporting safety occurrences and other unsafe conditions.

d) ***Hazard identification schemes***. They employ both reactive and proactive schemes for identifying safety hazards throughout their organization, such as voluntary incident reporting, safety surveys, operational safety audits, and safety assessments. Chapters 16 and 17 outline several safety processes that are effective in the identification of safety hazards, for example, Flight Data Analysis (FDA), Line Operations Safety Audit (LOSA) and Normal Operations Safety Survey (NOSS).

e) ***Investigation and analysis***. They follow up on reported occurrences and unsafe conditions and, if necessary, initiate competent safety investigations and safety analyses.

f) ***Performance monitoring***. They actively seek feedback necessary to close the loop of the safety management process using such techniques as trend monitoring and internal safety audits.

g) ***Safety promotion***. They actively disseminate the results of safety investigations and analyses, sharing safety lessons learned both within the organization and outside, if warranted.

h) ***Safety oversight***. The State (regulator) and regulated organization both have systems in place to monitor and assess safety performance.

All these activities are described in more detail elsewhere in this manual.

Safety management process

5.3.7 Conceptually, the safety management process parallels the safety cycle described in Figure 4-6. Both involve a continuous loop process as represented in Figure 5-2.

5.3.8 Safety management is evidence-based, in that it requires the analysis of data to identify hazards. Using risk assessment techniques, priorities are set for reducing the potential consequences of the hazards.

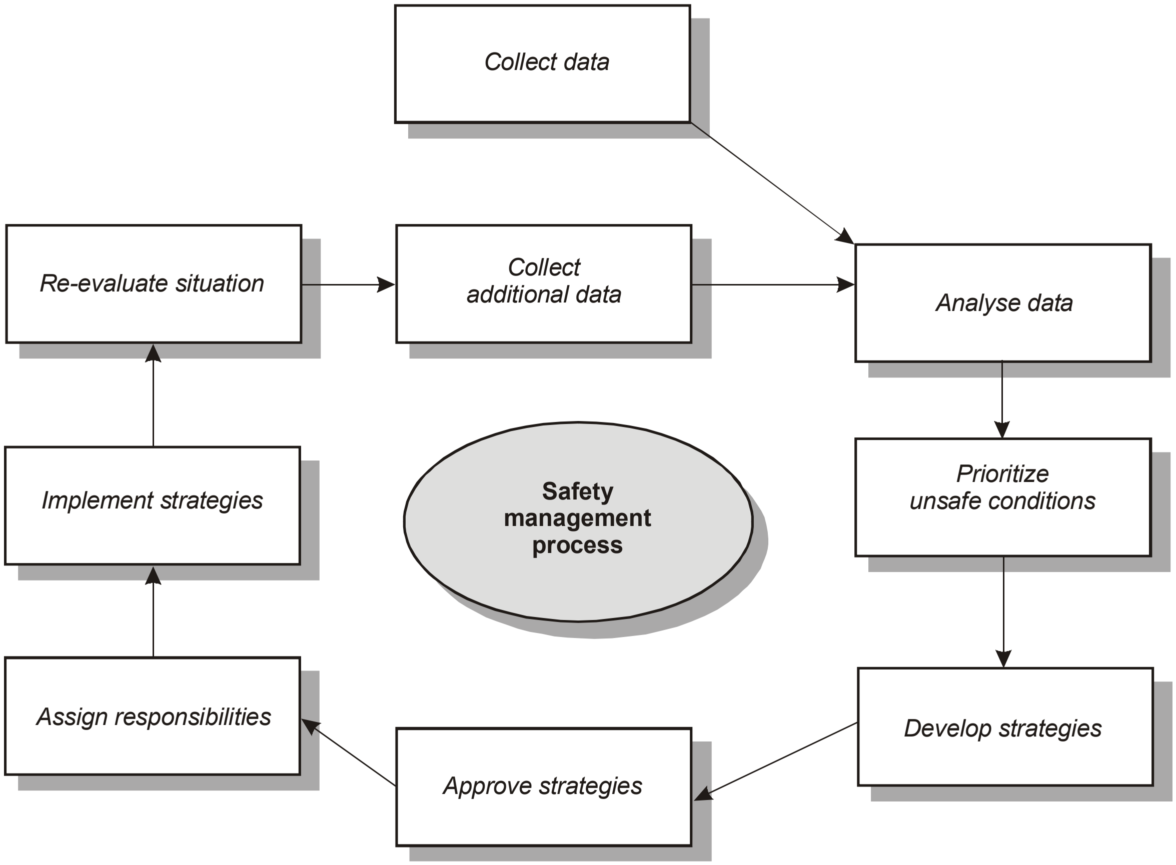

Figure 5-2. Safety management process

Strategies to reduce or eliminate the hazards are then developed and implemented with clearly established accountabilities. The situation is reassessed on a continuing basis, and additional measures are implemented as required.

5.3.9 The steps of the safety management process outlined in Figure 5-2 are briefly described below:

a) ***Collect the data***. The first step in the safety management process is the acquisition of relevant safety data — the evidence necessary to determine safety performance or to identify latent unsafe conditions (safety hazards). The data may be derived from any part of the system: the equipment used, the people involved in the operation, work procedures, the human/equipment/procedures interactions, etc.

b) ***Analyse the data***. By analysing all the pertinent information, safety hazards can be identified. The conditions under which the hazards pose real risks, their potential consequences and the likelihood of occurrence can be determined; in other words, *What* can happen? *How?* and *When?* This analysis can be both qualitative and quantitative.

c) ***Prioritize the unsafe conditions***. A risk assessment process determines the seriousness of hazards. Those posing the greatest risks are considered for safety action. This may require a cost-benefit analysis.

d) ***Develop strategies***. Beginning with the highest priority risks, several options for managing the risks may be considered, for example:

1) **S*pread*** the risk across as large a base of risk-takers as practicable. (This is the basis of insurance.)

2) ***Eliminate*** the risk entirely (possibly by ceasing that operation or practice).

3) ***Accept*** the risk and continue operations unchanged.

4) ***Mitigate*** the risk by implementing measures to reduce the risk or at least facilitate coping with the risk.

When selecting a risk management strategy, care is required to avoid introducing new risks that result in an unacceptable level of safety.

e) ***Approve strategies***. Having analysed the risks and decided on an appropriate course of action, management's approval is required to proceed. The challenge in this step is the formulation of a convincing argument for (perhaps expensive) change.

f) ***Assign responsibilities and implement strategies***. Following the decision to proceed, the *"nuts and bolts"* of implementation must be worked out. This includes a determination of resource allocation, assignment of responsibilities, scheduling, revisions to operating procedures, etc.

g) ***Re-evaluate situation***. Implementation is seldom as successful as initially envisaged. Feedback is required to close the loop. What new problems may have been introduced? How well is the agreed strategy for risk reduction meeting performance expectations? What modifications to the system or process may be required?

h) ***Collect additional data***. Depending on the re-evaluation step, new information may be required and the full cycle reiterated to refine the safety action.

5.3.10 Safety management requires analytical skills that may not be routinely practiced by management. The more complex the analysis, the more important is the need for the application of the most appropriate analytical tools. The closed loop process of safety management also requires feedback to ensure that management can test the validity of its decisions and assess the effectiveness of their implementation. (Chapter 9 provides guidance on safety analysis.)

Safety oversight

5.3.11 As mentioned in 5.3.1 c), the term safety oversight refers to the activities of a State under its safety programme, while safety performance monitoring refers to the activities of an operator or service provider under its SMS.

5.3.12 Safety oversight or safety performance monitoring activities are an essential component of an organization's safety management strategy. Safety oversight provides the means by which a State can verify how well the aviation industry is fulfilling its safety objectives.

5.3.13 Some of the requirements for a safety performance monitoring system will already be in place in many organizations. For example, States would normally have regulations relating to mandatory reporting of accidents and incidents.

5.3.14 Identifying weaknesses in the system's defences requires more than just collecting retrospective data and producing summary statistics. The underlying causes of reported occurrences are not necessarily immediately apparent; therefore, investigation of safety occurrence reports and any other information concerning possible hazards should go hand in hand with safety performance monitoring.

5.3.15 The implementation of an effective safety oversight programme requires that States and organizations:

a) determine relevant safety performance indicators (see 5.3.17 to 5.3.21);

b) establish a safety occurrence reporting system;

c) establish a system for the investigation of safety occurrences;

d) develop procedures for the integration of safety data from all available sources; and

e) develop procedures for the analysis of the data and the production of periodic safety performance reports.

5.3.16 Chapter 10 provides guidance on the safety oversight function.

Safety performance indicators and targets

5.3.17 As described in 5.3.7 to 5.3.10, the safety management process is a closed loop. The process requires feedback to provide a baseline for assessing the system's performance so that necessary adjustments can be made to effect the desired levels of safety. This requires a clear understanding of how results are to be evaluated. For example, what quantitative or qualitative indicators will be employed to determine that the system is working. Having decided on the factors by which success can be measured, safety management requires the setting of specific safety goals and objectives (targets). For the purposes of this manual, the following terminology is used:

- ***Safety performance indicator***. A measure (or metric) used to express the level of safety performance achieved in a system.

- ***Safety performance target***. The required level of safety performance for a system. A safety performance target comprises one or more safety performance indicators, together with desired outcomes expressed in terms of those indicators.

5.3.18 A distinction should be made between the criteria used to assess operational safety performance through monitoring, and the criteria used for the assessment of planned new systems or procedures. The process for the latter is known as safety assessments (see Chapter 13).

Safety performance indicators

5.3.19 In order to set safety performance targets, it is necessary to first decide on appropriate safety performance indicators. Safety performance indicators are generally expressed in terms of the frequency of occurrence of some event causing harm. Typical measures that could be used include:

a) aircraft accidents per 100 000 flight hours;

b) aircraft accidents per 10 000 movements;

c) fatal aircraft accidents per year; and

d) serious incidents per 10 000 flight hours.

5.3.20 There is no single safety performance indicator that is appropriate in all circumstances. The indicator chosen to express a safety performance target must be matched to the application in which it will be used, so that it will be possible to make a meaningful evaluation of safety in the same terms as those used in defining the safety performance target.

5.3.21 The safety performance indicator(s) chosen to express global, regional and national targets will not generally be appropriate for application to individual organizations. Since accidents are relatively rare events, they do not provide a good indication of safety performance — especially at the local level. Even at the global level, accident rates vary considerably from year to year. An increase or decrease in accidents from one year to the next does not necessarily indicate a change in the underlying level of safety.

Safety performance targets

5.3.22 Having decided on appropriate safety indicators, it is then necessary to decide on what represents an acceptable outcome or goal. For example, ICAO has set global safety performance targets in the objectives of the Global Aviation Safety Plan (GASP). These are:

a) to reduce the number of accidents and fatalities worldwide irrespective of the volume of air traffic; and

b) to achieve a significant decrease in accident rates, particularly in regions where these remain high.

5.3.23 The desired safety outcome may be expressed either in absolute or relative terms. ICAO's global targets are examples of relative targets. A relative target could also incorporate a desired percentage reduction in accidents or particular types of safety occurrences within a defined time period. For example, under a State safety programme, a regulatory oversight authority may determine that an acceptable level of safety will be achieved by specifying the following safety performance targets:

a) for airline operators: less than 0.2 fatal accidents per 100 000 hours. A further target may be that the number of EGPWS warnings be reduced by 30 per cent in the next 12 months;

b) for aircraft maintenance organizations: less than 200 major aircraft defects per 100 000 hours flown;

c) for aerodrome operators: less than 1.0 bird strike per 1 000 aircraft movements; and

d) for ATS providers: less than 40 airspace incidents per 100 000 flights.

In each sector of the industry, various safety requirements would be utilized to achieve the required safety performance, as measured by safety indicators.

5.3.24 The graphs in Figures 5-3 to 5-5 may help to explain the relationship between safety performance indicators and safety performance targets. Figure 5-3 depicts the airspace incident rate (safety indicators) of two categories of aircraft over a defined period. In this graph, no targets are set, but the graph indicates a slight reduction in both rates over the period.

5.3.25 The graph in Figure 5-4 could indicate the number of bird strikes (or any other metric) over a defined period. A trend line is shown. In this case, the trend line and final figure have remained below the target line — a desirable situation.

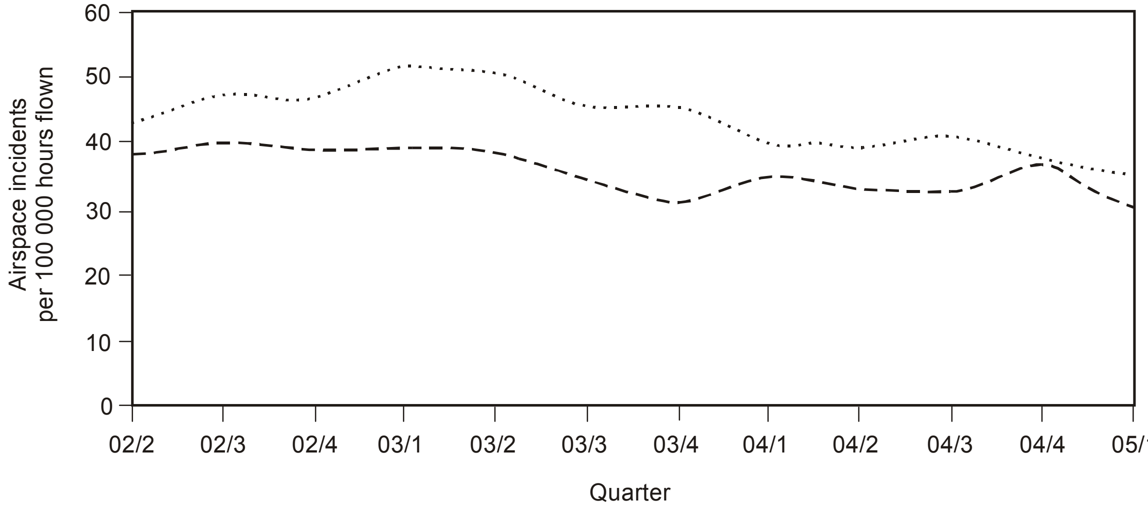

Figure 5-3. Airspace incident rate (safety indicators) 12-month moving average

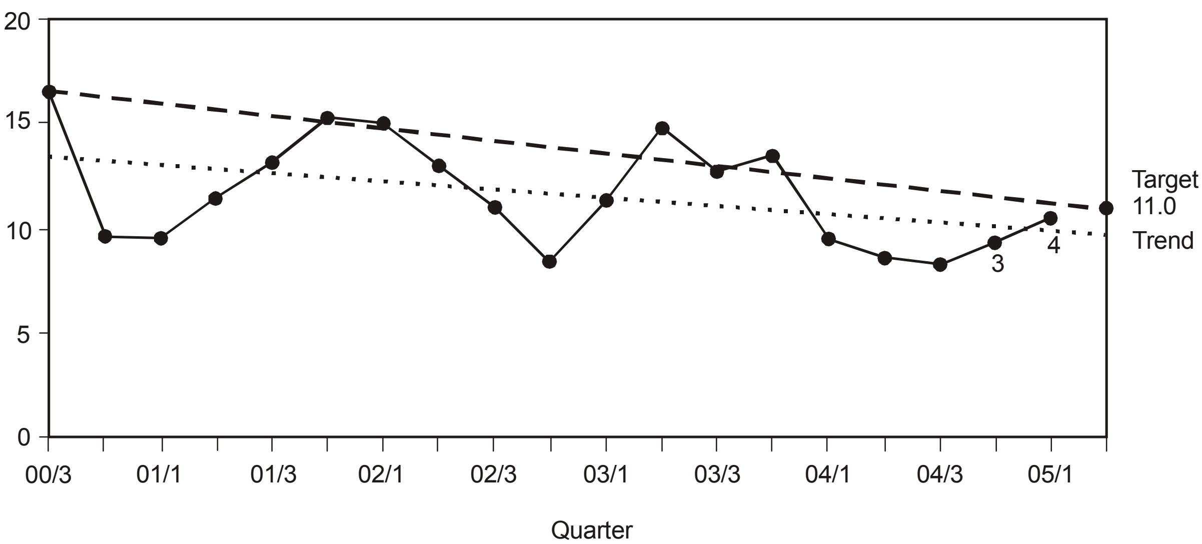

Figure 5-4. Occurrence rate showing trend below target — a desirable situation

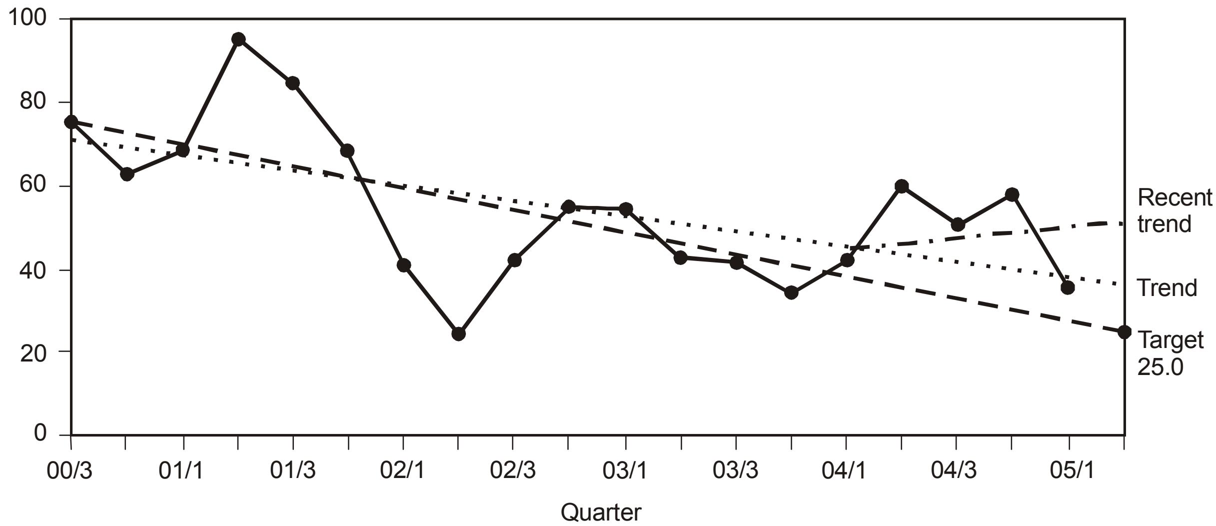

Figure 5-5. Occurrence rate showing recent trend moving above target — an undesirable situation

5.3.26 The graph in Figure 5-5 is similar to the one in Figure 5-4 except that in this case the trend is above the target level — an undesirable state. Even worse, the graph indicates that for the last several quarters, the general downward trend has reversed and the trend is now upwards. Depending on the period being monitored, this could result in the safety performance indicator being considerably worse than the desired safety target.

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Appendix 1 to Chapter 5

THREE CORNERSTONES OF SAFETY MANAGEMENT

1. Effective safety management comprises three defining cornerstones. These cornerstones and their characteristics are listed below:

a) *A comprehensive **corporate approach** to safety* — This provides for such things as:

1) ultimate accountability for corporate safety which is assigned to the Board of Directors and Chief Executive Officer (CEO) showing evidence of corporate commitment to safety from the highest organizational levels;

2) a clearly enunciated safety philosophy, with supporting corporate policies, including a non-punitive policy for disciplinary matters;

3) corporate safety goals, with a management plan for meeting these goals;

4) well-defined roles and responsibilities with specific accountabilities for safety that are published and available to all personnel involved in safety;

5) a requirement for an independent safety manager;

6) demonstrable evidence of a positive safety culture throughout the organization;

7) commitment to a safety oversight process which is independent of line management;

8) a system of documentation of those business policies, principles, procedures and practices with safety implications;

9) regular review of safety improvement plans; and

10) formal safety review processes.

b) *Effective **organizational tools** to deliver safety standards* — For example, this includes the following:

1) risk-based resource allocation;

2) effective selection, recruitment, development and training of personnel;

3) implementation of SOPs developed in cooperation with affected personnel;

4) corporate definition of specific competencies (and safety training requirements) for all personnel with duties relating to safety performance;

5) defined standards for, and auditing of, asset purchases and contracted services;

6) controls for the early detection of, and action on, any deterioration in the performance of safety-significant equipment, systems or services;

7) controls for monitoring and recording the overall safety standards of the organization;

8) the application of appropriate hazard identification, risk assessment and effective management of resources to control identified risks;

9) provision for the management of major changes in such areas as the introduction of new equipment, procedures or types of operation, turnover of key personnel, mass layoffs or rapid expansion, mergers and acquisitions;

10) arrangements enabling staff to communicate significant safety concerns to the appropriate level of management for resolution and feedback on actions taken;

11) emergency response planning and simulated exercises to test the plan's effectiveness; and

12) assessment of commercial policies with regard to their impact on safety.

c) *A formal system for* ***safety oversight*** — This includes such elements as:

1) a system for analysing flight recorder data for the purpose of monitoring flight operations and for detecting unreported safety events;

2) an organization-wide system for the capture of reports on safety events or unsafe conditions;

3) a planned and comprehensive safety audit system which has the flexibility to focus on specific safety concerns as they arise;

4) a system for the conduct of internal safety investigations, the implementation of remedial actions and the dissemination of safety information to all affected personnel;

5) systems for the effective use of safety data for performance analysis and for monitoring organizational change as part of the risk management process;

6) systematic review and assimilation of best safety practices from other operations;

7) periodic review of the continued effectiveness of the SMS by an independent body;

8) monitoring by line managers of work in progress in all safety-critical activities to confirm compliance with all regulatory requirements, company standards and procedures, with particular attention given to local practices;

9) a comprehensive system for documenting all applicable aviation safety regulations, corporate policies, safety goals, standards, SOPs, safety reports, etc. and for making such documentation readily available to all affected personnel; and

10) arrangements for ongoing safety promotion based on measured internal safety performance.

2. It is important that the scope of the SMS be appropriate to the size and complexity of the operation. Large operations will require a more complex SMS, while smaller operations with less complex structures should be well served by a more basic SMS.

Chapter 6

RISK MANAGEMENT

> ***Risk management serves to focus safety efforts on those hazards posing the greatest risks.***

6.1 GENERAL

6.1.1 The aviation industry faces a diversity of risks every day, many capable of compromising the viability of an operator, and some even posing a threat to the industry. Indeed, risk is a by-product of doing business. Not all risks can be eliminated, nor are all conceivable risk mitigation measures economically feasible. The risks and costs inherent in aviation necessitate a rational process for decision-making. Daily, decisions are made in real time, weighing the probability and severity of any adverse consequences implied by the risk against the expected gain of taking the risk. This process is known as *"risk management".* For the purposes of this manual, *risk management* can be defined as follows:

- ***Risk management****. The identification, analysis and elimination (and/or mitigation to an acceptable or tolerable level) of those hazards, as well as the subsequent risks, that threaten the viability of an organization.*

6.1.2 In other words, risk management facilitates the balancing act between assessed risks and viable risk mitigation. Risk management is an integral component of safety management. It involves a logical process of objective analysis, particularly in the evaluation of the risks.

6.1.3 An overview of the process for risk management is summarized in the flow chart in Figure 6-1. As the figure indicates, risk management comprises three essential elements: hazard identification, risk assessment and risk mitigation. The concepts of risk management have equal application in decision-making in flight operations, air traffic control, maintenance, airport management and State administration.

6.2 HAZARD IDENTIFICATION

6.2.1 The concept of hazard identification was introduced in Chapter 5. Given that a hazard may involve any situation or condition that has the potential to cause adverse consequences, the scope for hazards in aviation is wide. The following are some examples:

a) ***Design factors***, including equipment and task design;

b) ***Procedures and operating practices***, including their documentation and checklists, and their validation under actual operating conditions;

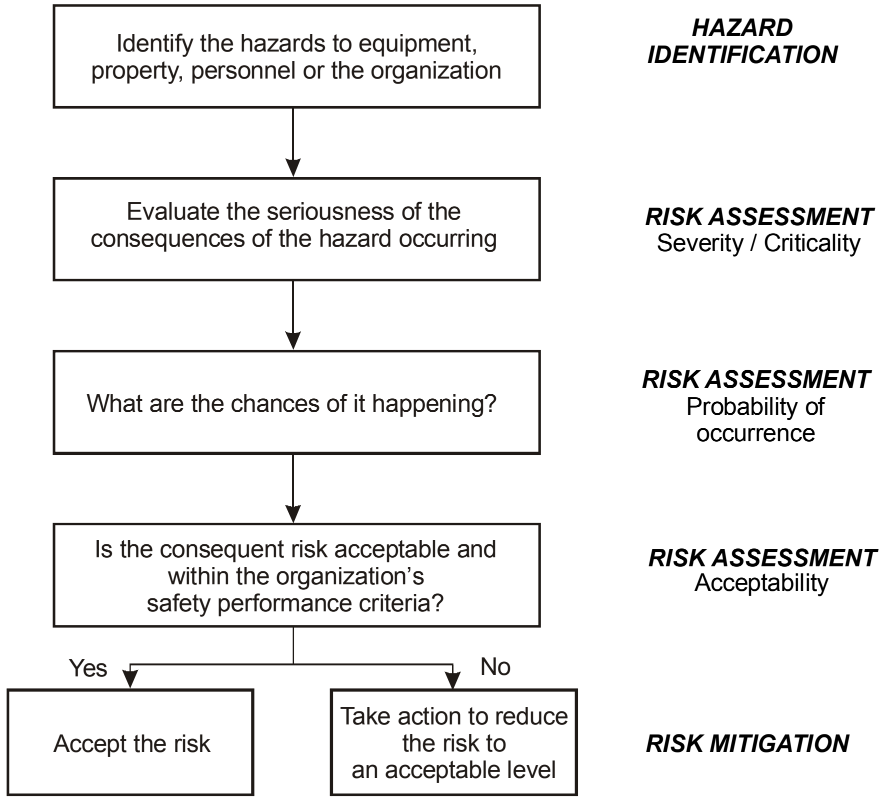

Figure 6-1. Risk management process

c) ***Communications***, including the medium, terminology and language;

d) ***Personnel factors***, such as company policies for recruitment, training and remuneration;

e) ***Organizational factors***, such as the compatibility of production and safety goals, the allocation of resources, operating pressures and the corporate safety culture;

f) ***Work environment factors***, such as ambient noise and vibration, temperature, lighting and the availability of protective equipment and clothing;

g) ***Regulatory oversight factors***, including the applicability and enforceability of regulations; the certification of equipment, personnel and procedures; and the adequacy of surveillance audits; and

h) ***Defences***, including such factors as the provision of adequate detection and warning systems, the error tolerance of equipment and the extent to which the equipment is hardened against failures.

6.2.2 As seen in Chapters 4 and 5, hazards may be recognized through actual safety events (accidents or incidents), or they may be identified through proactive processes aimed at identifying hazards before they precipitate an occurrence. In practice, both reactive measures and proactive processes provide an effective means of identifying hazards.

6.2.3 Safety events are clear evidence of problems in the system and therefore provide an opportunity to learn valuable safety lessons. Safety events should therefore be investigated to identify the hazards putting the system at risk. This involves investigating all the factors, including the organizational factors and the Human Factors that played a role in the event. Guidance for investigating safety events is included in Chapter 8. Several proactive methods of hazard identification are discussed in Chapters 16 and 17.

6.2.4 In a mature safety management system, hazard identification should arise from a variety of sources as an ongoing process. However, there are times in an organization's life when special attention to hazard identification is warranted. Safety assessments (discussed in Chapter 13) provide a structured and systemic process for hazard identification when:

a) there is an unexplained increase in safety-related events or safety infractions;

b) major operational changes are planned, including changes to key personnel or other major equipment or systems;

c) the organization is undergoing significant change, such as rapid growth or contraction; or

d) corporate merger, acquisition or downsizing is planned.

6.3 RISK ASSESSMENT

6.3.1 Having confirmed the presence of a safety hazard, some form of analysis is required to assess its potential for harm or damage. Typically, this assessment of the hazard involves three considerations:

a) the ***probability*** of the hazard precipitating an unsafe event (i.e. the probability of adverse consequences should the underlying unsafe conditions be allowed to persist);

b) the ***severity*** of the potential adverse consequences, or the outcome of an unsafe event; and

c) the rate of ***exposure*** to the hazards. The probability of adverse consequences becomes greater through increased exposure to the unsafe conditions. Thus, exposure may be viewed as another dimension of probability. However, some methods of defining probability may also include the exposure element, for example, a rate of 1 in 10 000 hours.

6.3.2 ***Risk*** is the assessed potential for adverse consequences resulting from a hazard. It is the likelihood that the hazard's potential to cause harm will be realized.

6.3.3 ***Risk assessment*** involves consideration of both the probability and the severity of any adverse consequences; in other words, the loss potential is determined. In carrying out risk assessments, it is important to distinguish between *hazards* (the potential to cause harm) and *risk* (the likelihood of that harm being realized within a specified period of time). A risk assessment matrix (such as the one provided in Table 6-1) is a useful tool for prioritizing the hazards most warranting attention.

6.3.4 There are many ways — some more formal than others — to approach the analytical aspects of risk assessment. For some risks, the number of variables and the availability of both suitable data and mathematical models may lead to credible results with quantitative methods (requiring mathematical analysis of specific data). However, few hazards in aviation lend themselves to credible analysis solely through numerical methods. Typically, these analyses are supplemented qualitatively through critical and logical analysis of the known facts and their relationships.

6.3.5 Considerable literature is available on the types of analysis used in risk assessment. For the risk assessments discussed in this manual, sophisticated methods are not required; a basic understanding of a few methods will suffice.

6.3.6 Whatever methods are used, there are various ways in which risks may be expressed, for example:

a) number of deaths, loss of revenue or loss of market share (i.e. absolute numbers);

b) loss rates (e.g. number of fatalities per 1 000 000 seat kilometres flown);

c) probability of serious accidents (e.g. 1 every 50 years);

d) severity of outcomes (e.g. injury severity); and

e) expected dollar value of losses versus annual operating revenue (e.g. U.S.$1 million loss per U.S.$200 million revenue).

Problem definition

6.3.7 In any analytical process, the problem must first be defined. In spite of identifying a perceived hazard, defining the characteristics of the hazard into a problem for resolution is not always easy. People from different backgrounds and experience will likely view the same evidence from different perspectives. Something that poses a significant risk will reflect these different backgrounds, exacerbated by normal human biases. Thus, engineers will tend to see problems in terms of engineering deficiencies; medical doctors as medical deficiencies; psychologists as behavioural problems; etc. The anecdote in the following box exemplifies the multifaceted nature of defining a problem:

Charlie's Accident

Charlie has an emotional argument with his wife and proceeds to the local bar where he consumes several drinks. He leaves the bar and drives away in his car at high speed. Minutes later, he loses control on the highway and is fatally injured. We know WHAT happened; we must now determine WHY it happened.

The investigation team consists of six specialists, each of whom has a completely different perspective on the root safety deficiency.

The sociologist identifies a breakdown in interpersonal communications within the marriage. An enforcement officer from the Liquor Control Board notes the illegal sale of alcoholic beverages by the bar on a "two-for-one" basis. The pathologist determines that Charlie's blood alcohol was in excess of the legal limit. The highway engineer finds inadequate road banking and protective barriers for the posted speed. An automotive engineer determines that Charlie's car had a loose front end and bald tires. The policeman determines that the automobile was travelling at excessive speed for the prevailing conditions.

Each of these perspectives may result in a different definition of the underlying hazard.

6.3.8 Any or all of the factors cited in this example may be valid, underlining the nature of multi-causality. How the safety issue is defined, however, will affect the course of action taken to reduce or eliminate the hazards. In assessing the risks, all potentially valid perspectives must be evaluated and only the most suitable pursued.

Probability of adverse consequences

6.3.9 Regardless of the analytical methods used, the probability of causing harm or damage must be assessed. This probability will depend on answers to such questions as:

a) Is there a history of similar occurrences, or is this an isolated occurrence?

b) What other equipment or components of the same type might have similar defects?

c) How many operating or maintenance personnel are following, or are subject to, the procedures in question?

d) What percentage of the time is the suspect equipment or the questionable procedure in use?

e) To what extent are there organizational, management or regulatory implications that might reflect larger threats to public safety?

6.3.10 Based on these considerations, the likelihood of an event occurring can be assessed, for example, as:

a) ***Unlikely to occur***. Failures that are "unlikely to occur" include isolated occurrences, and risks where the exposure rate is very low or the sample size is small. The complexity of the circumstances necessary to create an accident situation may be such that it is unlikely the same chain of events will happen again. For example, it is unlikely that independent systems would fail concurrently. However, even if the possibility is only remote, the consequences of concurrent failures may warrant follow-up.

   Note.— There is a natural tendency to attribute unlikely events to "coincidence". Caution is advised. While coincidence may be statistically feasible, coincidence should not be used as an excuse for the absence of due analysis.

b) ***May occur***. Failures that "may occur" derive from hazards with a reasonable probability that similar patterns of human performance can be expected under similar working conditions, or that the same material defects exist elsewhere in the system.

c) ***Probably will occur***. Such occurrences reflect a pattern (or potential pattern) of material failures that have not yet been rectified. Given the design or maintenance of the equipment, its strength under known operating conditions, etc., continued operations will likely lead to failure. Similarly, given the empirical evidence on some aspects of human performance, it can be expected with some certainty that normal individuals operating under similar working conditions would likely commit the same errors or be subject to the same undesirable performance outcome.

Severity of the consequences of occurrence

6.3.11 Having determined the probability of occurrence, the nature of the adverse consequences if the event does occur must be assessed. The potential consequences govern the degree of urgency attached to the safety action required. If there is significant risk of catastrophic consequences, or if the risk of serious injury, property or environmental damage is high, urgent follow-up action is warranted. In assessing the severity of the consequences of occurrence, the following types of questions could apply:

a) How many ***lives are at risk****? (Employees, passengers, bystanders and the general public.)*

b) What is the likely extent of ***property*** or ***financial damage****? (Direct property loss to the operator, damage to aviation infrastructure, third party collateral damage, financial impact and economic impact for the State.)*

c) What is the likelihood of ***environmental impact****? (Spill of fuel or other hazardous product, and physical disruption of natural habitat.)*

d) What are the likely ***political implications*** and/or ***media interest****?*

Risk acceptability

6.3.12 Based on the risk assessment, the risks can be prioritized relative to other, unresolved safety hazards. This is critical in making rational decisions to allocate limited resources against those hazards posing the greatest risks to the organization.

6.3.13 Prioritizing risks requires a rational basis for ranking one risk vis-à-vis other risks. Criteria or standards are required to define what is an *acceptable* risk and what is an *unacceptable* risk. By weighing the likelihood of an undesirable outcome against the potential severity of that outcome, the risk can be categorized within a risk assessment matrix. Many versions of risk assessment matrices are available from literature. While the terminology or definitions used for the different categories may vary, such tables generally reflect the ideas summarized in Table 6-1.

6.3.14 In this version of a risk assessment matrix:

a) ***Severity*** of risk is ranked as *Catastrophic, Hazardous, Major, Minor* or *Negligible* with a descriptor for each indicating the potential severity of consequences. As mentioned in 6.3.13, other definitions can be used, reflecting the nature of the operation being analysed.

b) ***Probability*** (or ***likelihood***) of occurrence is also ranked through five different levels of qualitative definitions, and descriptors are provided for each likelihood of occurrence.

c) ***Values*** may be assigned numerically to weigh the relative importance of each level of severity and probability. A composite assessment of risk, to assist in comparing risks, may then be derived by multiplying the severity and probability values.

6.3.15 Having used a risk matrix to assign values to risks, a range of values may be assigned in order to categorize risks as acceptable, undesirable or unacceptable. These terms are explained below:

- ***Acceptable*** means that no further action needs to be taken (unless the risk can be reduced further at little cost or effort).

- ***Undesirable*** (or ***tolerable***) means that the affected persons are prepared to live with the risk in order to have certain benefits, in the understanding that the risk is being mitigated as best as possible.

- ***Unacceptable*** means that operations under the current conditions must cease until the risk is reduced to at least the *Tolerable* level.

Table 6-1. Risk assessment matrix

SEVERITY OF CONSEQUENCES			***LIKELIHOOD OF OCCURRENCE***		
Aviation definition	***Meaning***	***Value***	***Qualitative definition***	***Meaning***	***Value***
Catastrophic	Equipment destroyed. Multiple deaths.	5	Frequent	Likely to occur many times	5
Hazardous	A large reduction in safety margins, physical distress or a workload such that the operators cannot be relied upon to perform their tasks accurately or completely. Serious injury or death to a number of people. Major equipment damage.	4	Occasional	Likely to occur sometimes	4
Major	A significant reduction in safety margins, a reduction in the ability of the operators to cope with adverse operating conditions as a result of an increase in work-load, or as a result of conditions impairing their efficiency. Serious incident. Injury to persons.	3	Remote	Unlikely, but possible to occur	3
Minor	Nuisance. Operating limitations. Use of emergency procedures. Minor incident.	2	Improbable	Very unlikely to occur	2
Negligible	Little consequence	1	Extremely improbable	Almost inconceivable that the event will occur	1

6.3.16 A less numeric approach to determining the *acceptability* of particular risks includes consideration of such factors as:

a) ***Managerial***. Is the risk consistent with the organization's safety policy and standards?

b) ***Affordability***. Does the nature of the risk defy cost-effective resolution?

c) ***Legal***. Is the risk in conformance with current regulatory standards and enforcement capabilities?

d) ***Cultural***. How will the organization's personnel and other stakeholders view this risk?

e) ***Market***. Will the organization's competitiveness and well-being vis-à-vis other organizations be compromised by not reducing or eliminating this risk?

f) ***Political***. Will there be a political price to pay for not reducing or eliminating this risk?

g) ***Public***. How influential will the media or special interest groups be in affecting public opinion regarding this risk?

6.4 RISK MITIGATION

6.4.1 Where risk is concerned, there is no such thing as absolute safety. Risks have to be managed to a level "as low as reasonably practicable" (***ALARP***). This means that the risk must be balanced against the time, cost and difficulty of taking measures to reduce or eliminate the risk.

6.4.2 When the *acceptability of the risk* has been found to be *Undesirable* or *Unacceptable*, control measures need to be introduced — the higher the risk, the greater the urgency. The level of risk can be lowered by reducing the severity of the potential consequences, by reducing the likelihood of occurrence or by reducing the exposure to that risk.

6.4.3 The optimum solution will vary depending on the local circumstances and exigencies. In formulating meaningful safety action, an understanding of the adequacy of existing defences is required.

Defence analysis

6.4.4 A major component of any safety system is the defences put in place to protect people, property or the environment. These defences can be used to:

a) reduce the probability of unwanted events occurring; and

b) reduce the severity of the consequences associated with any unwanted events.

6.4.5 Defences can be categorized into two types, namely:

a) ***Physical defences***. These include objects that discourage or prevent inappropriate action, or that mitigate the consequences of events (for example, squat switches, switch covers, firewalls, survival equipment, warnings and alarms).

b) ***Administrative defences***. These include procedures and practices that mitigate the probability of an accident (for example, safety regulations, SOPs, supervision and inspection, and personal proficiency).

6.4.6 Before selecting appropriate risk mitigation strategies, it is important to understand *why* the existing system of defences was inadequate. The following line of questioning may pertain:

a) Were defences provided to protect against such hazards?

b) Did the defences function as intended?

c) Were the defences practical for use under actual working conditions?

d) Were affected staff aware of the risks and the defences in place?

e) Are additional risk mitigation measures required?

Risk mitigation strategies

6.4.7 There is a range of strategies available for risk mitigation, for example:

a) ***Exposure avoidance***. The risky task, practice, operation or activity is avoided because the risk exceeds the benefits.

b) ***Loss reduction***. Activities are taken to reduce the frequency of the unsafe events or the magnitude of the consequences.

c) ***Segregation of exposure*** (separation or duplication). Action is taken to isolate the effects of the risk or build in redundancy to protect against the risks, i.e. reduce the severity of the risk (for example, protecting against collateral damage in the event of a material failure, or providing back-up systems to reduce the likelihood of total system failure).

Brainstorming

6.4.8 Generating the ideas necessary to create suitable risk mitigation measures poses a challenge. Developing risk mitigation measures frequently requires creativity, ingenuity and, above all, an open mind to consider all possible solutions. The thinking of those closest to the problem (usually with the most experience) is often coloured by set ways and natural biases. Broad participation, including by representatives of the various stakeholders, tends to help overcome rigid mindsets. Thinking *"outside the box"* is essential to effective problem solving in a complex world. All new ideas should be weighed carefully before rejecting any of them.

Evaluating risk mitigation options

6.4.9 In evaluating alternatives for risk mitigation, not all have the same potential for reducing risks. The effectiveness of each option needs to be evaluated before a decision can be taken. It is important that the full range of possible control measures be considered and that trade-offs between measures be considered to find an optimal solution. Each proposed risk mitigation option should be examined from such perspectives as:

a) ***Effectiveness***. Will it reduce or eliminate the identified risks? To what extent do alternatives mitigate the risks? Effectiveness can be viewed as being somewhere along a continuum, as follows:

   1) ***Level One*** (Engineering actions): The safety action **eliminates** the risk, for example, by providing interlocks to prevent thrust reverser activation in flight;

   2) ***Level Two*** (Control actions): The safety action accepts the risk but adjusts the system to **mitigate** the risk by reducing it to a manageable level, for example, by imposing more restrictive operating conditions; and

   3) ***Level Three*** (Personnel actions): The safety action taken accepts that the hazard can neither be eliminated (Level One) nor controlled (Level Two), so personnel must be taught how to **cope** with it, for example, by adding a warning, a revised checklist and extra training.

b) ***Cost/benefit***. Do the perceived benefits of the option outweigh the costs? Will the potential gains be proportional to the impact of the change required?

c) ***Practicality***. Is it **doable** and appropriate in terms of available technology, financial feasibility, administrative feasibility, governing legislation and regulations, political will, etc.?

d) ***Challenge***. Can the risk mitigation measure withstand critical scrutiny from all stakeholders (employees, managers, stockholders/State administrations, etc.)?

e) ***Acceptability*** to each stakeholder. How much buy-in (or resistance) from stakeholders can be expected? (Discussions with stakeholders during the *risk assessment* phase may indicate their preferred risk mitigation option.)

f) ***Enforceability***. If new rules (SOPs, regulations, etc.) are implemented, are they enforceable?

g) ***Durability***. Will the measure withstand the test of time? Will it be of temporary benefit or will it have long-term utility?

h) ***Residual risks***. After the risk mitigation measure is implemented, what will be the residual risks relative to the original hazard? What is the ability to mitigate any residual risks?

i) ***New problems***. What new problems or new (perhaps worse) risks will be introduced by the proposed change?

6.4.10 Obviously, preference should be given to corrective actions that will completely eliminate the risk. Regrettably, such solutions are often the most expensive. At the other end of the spectrum, when there is insufficient organizational will or resources, the problem is often deferred to the training department to teach staff to cope with the risks. In such cases, management may be avoiding hard decisions by delegating responsibility for the risk to subordinates.

6.5 RISK COMMUNICATION

6.5.1 Risk communication includes any exchange of information about risks, i.e. any public or private communication that informs others about the existence, nature, form, severity or acceptability of risks. The information needs of the following groups may require special attention:

a) Management must be apprised of all risks that present loss potential to the organization.

b) Those exposed to the identified risks must be apprised of their severity and likelihood of occurrence.

c) Those who identified the hazard need feedback on action proposed.

d) Those affected by any planned changes need to be apprised of both the hazards and the rationale for the action taken.

e) Regulatory authorities, suppliers, industry associations, the general public, etc. have potential information needs regarding specific risks.

f) The stakeholders can assist the decision-maker(s) if the risks are communicated early in a fair, objective and understandable way. Effective communication of the risks (and plans for their resolution) adds value to the risk management process.

6.5.2 Failure to communicate the safety lessons learned in a clear and timely fashion will undermine management's credibility in promoting a positive safety culture. For safety messages to be credible, they must be consistent with the facts, with previous statements from management and with the messages from other authorities. These messages need to be expressed in terms the stakeholders understand.

6.6 RISK MANAGEMENT CONSIDERATIONS FOR STATE ADMINISTRATIONS

6.6.1 Risk management techniques have implications for State administrations in areas ranging from policy development through to the *"go/no-go"* decisions confronting front-line State civil aviation inspectors, for example:

a) ***Policy****.* To what extent should a State accept the certification paperwork of another State?

b) ***Regulatory change****.* From the many (often-conflicting) recommendations made for regulatory change, how are decisions made?

c) ***Priority setting****.* How are decisions made for determining those areas of safety warranting emphasis during safety oversight audits?

d) ***Operational management****.* How are decisions made when insufficient resources are available to carry out all planned activities?

e) ***Operational inspections****.* At the front line, how are decisions made when critical errors are discovered outside of normal working hours?

Occasions warranting risk management by State administrations

6.6.2 Some situations should alert State aviation administrations to the possible need for applying risk management methods, for example:

a) start-up or rapidly expanding companies;

b) corporate mergers;

c) companies facing bankruptcy or other financial difficulties;

d) companies facing serious labour-management difficulties;

e) introduction of major new equipment by an operator;

f) certification of a new aircraft type, new airport, etc.;

g) introduction of new communication, navigation or surveillance equipment and procedures; and

h) significant change to air regulations or other laws potentially impacting on aviation safety.

6.6.3 Risk management by State administrations will be affected by such factors as:

a) *time available* to make the decision (grounding an aircraft, revoking a certificate, etc.);

b) *resources available* to effect the necessary actions;

c) *number of people* affected by required actions (company-wide, fleet-wide, regional, national, international, etc.);

d) *potential impact* of the State's decision for action (or inaction); and

e) *cultural and political will* to take the action required.

Benefits of risk management for State administrations

6.6.4 Applying risk management techniques in decision-making offers benefits for State administrations, including:

a) avoiding costly mistakes during the decision-making process;

b) ensuring that all aspects of the risk are identified and considered when making decisions;

c) ensuring that the legitimate interests of affected stakeholders are considered;

d) providing decision-makers with a solid defence in support of decisions;

e) making decisions easier to explain to stakeholders and the general public; and

f) providing significant savings in time and money.

Chapter 7

HAZARD AND INCIDENT REPORTING

7.1 INTRODUCTION TO REPORTING SYSTEMS

7.1.1 Safety management systems involve the reactive and proactive identification of safety hazards. Accident investigations reveal a great deal about safety hazards; but fortunately, aviation accidents are rare events. They are, however, generally investigated more thoroughly than incidents. When safety initiatives rely exclusively on accident data, the limitations of not having many case samples apply. As a result, the wrong conclusions may be drawn, or inappropriate corrective actions taken.

7.1.2 Research leading to the 1:600 Rule showed that the number of incidents is significantly greater than the number of accidents for comparable types of occurrences. The causal and contributory factors associated with incidents may also culminate in accidents. Often, only good fortune prevents an incident from becoming an accident. Unfortunately, these incidents are not always known to those responsible for reducing or eliminating the associated risks. This may be due to the unavailability of reporting systems, or people not being sufficiently motivated to report incidents.

Value of safety reporting systems

7.1.3 Recognizing that knowledge derived from incidents can provide significant insights into safety hazards, several types of incident reporting systems have been developed. Some safety databases contain a large quantity of detailed information. The systems containing the information obtained from accident and incident investigations and safety databases can be grouped under the general term “safety data collection and processing systems” (SDCPS). SDCPS refers to processing and reporting systems, databases, schemes for exchange of information, and recorded information and include records pertaining to accident and incident investigations, mandatory incident reporting systems, voluntary incident reporting systems, and self-disclosure reporting systems (including automatic data capture systems and manual data capture systems). Although incidents may not be investigated in any depth, the anecdotal information they provide can offer meaningful insight into the perceptions and reactions of pilots, cabin crew, AMEs, ATCOs and aerodrome personnel.

7.1.4 Safety reporting systems should not just be restricted to incidents but should include provision for the reporting of hazards, i.e. unsafe conditions that have not yet caused an incident. For example, some organizations have programmes for reporting conditions deemed unsatisfactory from the perspective of experienced personnel (Unsatisfactory Condition Reports for potential technical faults). In some States, Service Difficulty Reporting (SDR) systems are effective in identifying airworthiness hazards. Aggregating data from such hazard and incident reports provides a rich source of experience to support other safety management activities.

7.1.5 Data from incident reporting systems can facilitate an understanding of the causes of hazards, help to define intervention strategies and help to verify the effectiveness of interventions. Depending on the depth to which they are investigated, incidents can provide a unique means of obtaining first-hand evidence on the factors associated with mishaps from the participants. Reporters can describe the relationships between stimuli and their actions. They may provide their interpretation of the effects of various factors affecting their performance, such as fatigue, interpersonal interactions and distractions. Furthermore, many reporters are able to offer valuable suggestions for remedial action. Incident data have also been used to improve operating procedures, and display and control design, as well as to provide a better understanding of human performance associated with the operation of aircraft, ATC and aerodromes.

ICAO requirements[1]

7.1.6 ICAO requires that States establish a mandatory incident reporting system to facilitate the collection of information on actual or potential safety deficiencies. In addition, States are encouraged to establish a voluntary incident reporting system and adjust their laws, regulations and policies so that the voluntary programme:

a) facilitates the collection of information that may not be captured by a mandatory incident reporting system;

b) is non-punitive; and

c) affords protection to the sources of the information.

7.2 TYPES OF INCIDENT REPORTING SYSTEMS

7.2.1 In general, an incident involves an unsafe, or potentially unsafe, occurrence or condition that does not involve serious personal injury or significant property damage, i.e. it does not meet the criteria for an accident. When an incident occurs, the individual(s) involved may or may not be required to submit a report. The reporting requirements vary with the laws of the State where the incident occurred. Even if not required by law, operators may require reporting of the occurrence to the organization.

Mandatory incident reporting systems

7.2.2 In a mandatory system, people are required to report certain types of incidents. This necessitates detailed regulations outlining who shall report and what shall be reported. The number of variables in aviation operations is so great that it is difficult to provide a comprehensive list of items or conditions which should be reported. For example, the loss of a single hydraulic system on an aircraft with only one such system is critical, while on a type with three or four systems, it may not be. A relatively minor problem in one set of circumstances can in different circumstances result in a hazardous situation. However, the rule should be: ***"If in doubt — report it."***

7.2.3 Since mandatory systems deal mainly with "hardware" matters, they tend to collect more information on technical failures than on the human performance aspects. To help overcome this problem, States with well-developed mandatory reporting systems are introducing voluntary incident reporting systems aimed at acquiring more information on the Human Factors aspects of occurrences.

Voluntary incident reporting systems

7.2.4 Annex 13 recommends that States introduce voluntary incident reporting systems to supplement the information obtained from mandatory reporting systems. In such systems, the reporter, without any legal or administrative requirement to do so, submits a voluntary incident report. In a voluntary reporting system,

1. See Annex 13, Chapter 8.

regulatory agencies may offer an incentive to report. For example, enforcement action may be waived for unintentional violations that are reported. The reported information should not be used against the reporters, i.e. such systems must be non-punitive to encourage the reporting of such information.

Confidential reporting systems

7.2.5 Confidential reporting systems aim to protect the identity of the reporter. This is one way of ensuring that voluntary reporting systems are non-punitive. Confidentiality is usually achieved by de-identification, often by not recording any identifying information of the occurrence. One such system returns to the user the identifying part of the reporting form, and no record is kept of these details. Confidential incident reporting systems facilitate the disclosure of human errors, without fear of retribution or embarrassment, and enable others to learn from previous mistakes.

7.3 PRINCIPLES FOR EFFECTIVE INCIDENT REPORTING SYSTEMS

7.3.1 People are understandably reluctant to report their mistakes to the organization that employs them or to the government department that regulates them. Too often following an occurrence, investigators learn that many people were aware of the unsafe conditions before the event. For whatever reasons, however, they did not report the perceived hazards, perhaps because of:

a) embarrassment in front of their peers;

b) self-incrimination, especially if they were responsible for creating the unsafe condition;

c) retaliation from their employer for having spoken out; or

d) sanction (such as enforcement action) by the regulatory authority.

7.3.2 Use of the principles outlined in 7.3.3 to 7.3.12 helps to overcome the natural resistance to safety reporting.

Trust

7.3.3 Persons reporting incidents must trust that the receiving organization (whether the State or company) will not use the information against them in any way. Without such confidence, people will be reluctant to report their mistakes or other hazards they have noticed.

7.3.4 Trust begins with the design and implementation of the reporting system. Employee input into the development of a reporting system is therefore vital. A positive safety culture in the organization generates the kind of trust necessary for a successful incident reporting system. Specifically, the culture must be error-tolerant and just. In addition, incident reporting systems need to be perceived as being fair in how they treat unintentional errors or mistakes. (Most people do not expect an incident reporting system to exempt criminal acts or deliberate violations from prosecution or disciplinary action.) Some States consider such a process to be an example of a “just culture”.

Non-punitive

7.3.5 Non-punitive reporting systems are based on confidentiality. Before employees will freely report incidents, they must receive a commitment from the regulatory authority or from top management that reported information would not be used punitively against them. The person reporting the incident (or unsafe condition) must be confident that anything said will be kept in confidence. In some States, "Access to Information" laws make it increasingly difficult to guarantee confidentiality. Where this happens, reported information will tend to be reduced to the minimum to meet mandatory reporting requirements.

7.3.6 Sometimes reference is made to *anonymous* reporting systems. Reporting anonymously is not the same as confidential reporting. Most successful reporting systems have some type of *call-back* capability in order to confirm details or obtain a better understanding of the occurrence. Reporting anonymously makes it impossible to "call back" to ensure understanding and completeness of the information provided by the reporter. There is also a danger that anonymous reporting may be used for purposes other than safety.

Inclusive reporting base

7.3.7 Early voluntary incident reporting systems were targeted at flight crew. Pilots are in a position to observe a broad spectrum of the aviation system and are therefore able to comment on the system's health. Nonetheless, incident reporting systems that focus solely on the perspective of flight crew tend to reinforce the idea that everything comes down to *pilot error*. Taking a systemic approach to safety management requires that safety information be obtained from all parts of the operation.

7.3.8 In State-run incident reporting systems, collecting information on the same occurrence from different perspectives facilitates forming a more complete impression of events. For example, ATC instructs an aircraft to *"go around"* because there is a maintenance vehicle on the runway without authorization. Undoubtedly, the pilot, the ATCO and the vehicle operator would all have seen the situation from different perspectives. Relying on one perspective only may not provide a complete understanding of the event.

Independence

7.3.9 Ideally, State-run voluntary incident reporting systems are operated by an organization separate from the aviation administration responsible for the enforcement of aviation regulations. Experience in several States has shown that voluntary reporting benefits from a trusted *"third party"* managing the system. The third party receives, processes and analyses the incident reports and feeds the results back to the aviation administration and the aviation community. With mandatory reporting systems, it may not be possible to employ a third party. Nevertheless, it is desirable that the aviation administration give a clear undertaking that any information received will be used for safety purposes only. The same principle applies to an airline or any other aviation operator that uses incident reporting as part of its safety management system.

Ease of reporting

7.3.10 The task of submitting incident reports should be as easy as possible for the reporter. Reporting forms should be readily available so that anyone wishing to file a report can do so easily. They should be simple to compile, have adequate space for a descriptive narrative and should encourage suggestions on how to improve the situation or prevent a reoccurrence. To simplify completion, classifying information, such as the type of operation, light conditions, type of flight plan, and weather, can use a "tick-off" format.

Acknowledgment

7.3.11 The reporting of incidents requires time and effort by the reporter and should be appropriately acknowledged. To encourage further submission of reports, one State encloses a blank report form with its acknowledgment letter. In addition, the reporter naturally expects feedback about actions taken in response to the reported safety concern.

Promotion

7.3.12 The (de-identified) information received from an incident reporting system should be made available to the aviation community in a timely manner. This could be done in the form of monthly newsletters or periodic summaries. Ideally, a variety of methods would be used with a view to achieving maximum exposure. Such promotional activities may help to motivate people to report additional incidents.

7.4 INTERNATIONAL INCIDENT REPORTING SYSTEMS

ICAO Accident/Incident Data Reporting (ADREP) System

7.4.1 In accordance with Annex 13, States report to ICAO information on all aircraft accidents that involve aircraft of a maximum certified take-off mass of over 2 250 kg. ICAO also gathers information on aircraft incidents (involving aircraft over 5 700 kg) considered to be important for safety and accident prevention. This reporting system is known as ADREP. States report specific data in a predetermined (and coded) format to ICAO. When ADREP reports are received from States, the information is checked and electronically stored, constituting a databank of worldwide occurrences.

7.4.2 ICAO does not require States to investigate incidents. However, if a State does investigate a serious incident, it is requested to submit formatted data to ICAO. The types of serious incidents of interest to ICAO include:

a) multiple system failures;

b) fires or smoke on board an aircraft;

c) terrain and obstacle clearance incidents;

d) flight control and stability problems;

e) take-off and landing incidents;

f) flight crew incapacitation;

g) decompression; and

h) near collisions and other serious air traffic incidents.

European Co-ordination Centre for Aviation Incident Reporting Systems (ECCAIRS)[2]

7.4.3 Many aviation authorities in Europe have collected information about aviation accidents and incidents. However, the number of significant occurrences in individual States was usually not sufficient to give an early indication of potentially serious hazards or to identify meaningful trends. Since many States had incompatible data storage formats, pooling of safety information was almost impossible. To improve this situation, the European Union (EU) introduced occurrence-reporting requirements and developed the ECCAIRS safety database. The objective of these moves was to improve aviation safety in Europe through

2. For more information on ECCAIRS, visit their website at http://eccairs-www.jrc.it.

the early detection of potentially hazardous situations. ECCAIRS includes capabilities for analysing and presenting the information in a variety of formats. The database is compatible with some other incident reporting systems, such as ADREP. Several non-European States have also chosen to implement ECCAIRS to take advantage of common classification taxonomies, etc.

7.5 STATE VOLUNTARY INCIDENT REPORTING SYSTEMS

7.5.1 A number of States operate successful voluntary incident reporting systems that utilize common features. Two such systems are described in 7.5.2 to 7.5.5.

Aviation Safety Reporting System (ASRS)[3]

7.5.2 The United States operates a large aviation occurrence reporting system known as the Aviation Safety Reporting System (ASRS). The ASRS operates independently from the Federal Aviation Administration (FAA) and is administered by the National Aeronautics and Space Administration (NASA). Pilots, ATCOs, cabin crew, AMEs, ground personnel, and others involved in aviation operations may submit reports when aviation safety has been considered to be compromised. Samples of reporting forms are on the ASRS website.

7.5.3 Reports sent to the ASRS are held in strict confidence. All reports are de-identified before being entered into the database. All personal and organizational names are removed. Dates, times and related information, which might reveal an identity, are either generalized or eliminated. ASRS data are used to:

a) identify systemic hazards in the national aviation system for remedial action by appropriate authorities;

b) support policy formulation and planning in the national aviation system;

c) support research and studies in aviation, including Human Factors safety research; and

d) provide information to promote accident prevention.

7.5.4 The FAA recognizes the importance of voluntary incident reporting to aviation safety and offers ASRS reporters some immunity from enforcement actions by waiving penalties for unintentional violations. With over 300 000 reports now on file, this database supports research in aviation safety — especially relating to Human Factors.

Confidential Human Factors Incident Reporting Programme (CHIRP)[4]

7.5.5 CHIRP contributes to the enhancement of flight safety in the United Kingdom by providing a confidential reporting system for all individuals employed in aviation. It complements the United Kingdom's Mandatory Occurrence Reporting System. Noteworthy features of CHIRP include:

3. The ASRS website is at http://asrs.arc.nasa.gov.
4. Visit the CHIRP website at http://www.chirp.co.uk.

a) independence from the regulatory authority;

b) broad availability (including flight crew, ATCOs, licensed AMEs, cabin crew and the general aviation community);

c) confidentiality of reporters' identities;

d) analysis by experienced safety officers;

e) existence of newsletters with broad distribution to improve safety standards by sharing safety information; and

f) participation by CHIRP representatives on several aviation safety bodies to assist in resolving systemic safety issues.

7.6 COMPANY REPORTING SYSTEMS

In addition to State-operated incident reporting systems (both mandatory and voluntary), many airlines, ATS providers and airport operators have *"in-house"* reporting systems for the reporting of safety hazards and incidents. If reporting is available to all personnel (not just flight crew), company reporting systems help promote a positive company-wide safety culture. Chapter 16 includes a deeper examination of company hazard and incident reporting systems.

7.7 IMPLEMENTATION OF INCIDENT REPORTING SYSTEMS

7.7.1 If implemented in a non-punitive work environment, an incident reporting system can go a long way towards creating a positive safety culture. Depending on the size of the organization, the most expedient method for incident and hazard reporting is to use existing *"paperwork"* such as safety reports and maintenance reports. However, as the volume of reports increases, some sort of computerized system will be required to handle the task.

What to report?

7.7.2 Any hazard that has the potential to cause damage or injury or that threatens the organization's viability should be reported. Hazards and incidents should be reported if it is believed that:

a) something can be done to improve safety;

b) other aviation personnel could learn from the report; or

c) the system and its inherent defences did not work "as advertised".

7.7.3 In short, if in doubt as to an event's safety significance, it should be reported. (Those incidents and accidents that are required to be reported in accordance with State laws or regulations governing accident or incident reporting should also be included in an operator's reporting database.) Appendix 2 to Chapter 16 provides examples of the types of events that should be reported to an operator's incident reporting system.

Who should report?

7.7.4 To be effective, incident reporting systems should include a broad reporting base. For specific occurrences, the perceptions of different participants in, or witnesses to, an event may be quite different — yet all relevant. Thus, State systems for voluntary incident reporting should encourage the participation of flight and cabin crews, ATCOs, airport workers and AMEs.

Reporting method and format

7.7.5 The method and format chosen for a reporting system matters little as long as it encourages personnel to report all hazards and incidents. The reporting process should be as simple as possible and well documented, including details as to what, where and when to report.

7.7.6 In designing reporting forms, the layout should facilitate the submission of information. Sufficient space should be provided to encourage reporters to identify suggested corrective actions. Listed below are some other factors to be considered in designing a system and reporting forms:

a) Operational personnel are generally not prolific writers; therefore, the form should be kept as short as possible.

b) Reporters are not safety analysts; therefore, the questions should be written in simple, everyday language.

c) Non-directive questions should be used instead of leading questions. (Non-directive questions include: What happened? Why? How was it fixed? and What should be done?)

d) Prompts may be required for the reporter to think about "system failures" (for example: How close were they to an accident?) and to consider their error management strategies.

e) Focus should be on the detection and recovery from an unsafe situation or condition.

f) Reporters should be encouraged to consider the wider safety lessons inherent in the report, for example, how the organization and the aviation system could benefit from it.

7.7.7 Regardless of the source or method of submission, once the information is received, it must be stored in a manner suitable for easy retrieval and analysis.

7.7.8 Appendix 1 to this chapter contains guidance on limitations in the use of data from voluntary incident reporting systems.

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Appendix 1 to Chapter 7

LIMITATIONS IN THE USE OF DATA FROM VOLUNTARY INCIDENT REPORTING SYSTEMS

Care needs to be taken when using data from voluntary incident reports. When drawing conclusions based on such data, analysts should consider the following limitations:

a) ***Information not validated***. In some States, voluntary confidential reports can be fully investigated and information from other sources brought to bear on the incident. However, the confidentiality provisions of smaller programmes (such as company reporting systems) make it difficult to adequately follow up on a report without compromising the identity of the reporter. Thus, much of the reported information cannot be substantiated.

b) ***Reporter biases***. Two factors may bias voluntary incident data: *who* reports and *what* gets reported. Some of the factors contributing to the subjective nature of voluntary incident reports are listed below:

   1) Reporters must be familiar with the reporting system and have access to reporting forms or phone numbers.

   2) Reporters' motivation to report may vary due to the following factors:

      — level of commitment to safety;

      — awareness of the reporting system;

      — perception of the associated risks (local versus systemic implications);

      — operational conditions (some types of incidents receive more attention than others); and

      — denial, ignorance of safety implications, desire to hide the problem, or fear of recrimination or even disciplinary action (despite guarantees to the contrary).

   3) Different occupational groups see things differently, both in terms of interpreting the same event and in terms of deciding what is important.

   4) Reporters must be aware of an incident to submit a report. Errors that go undetected are not reported.

c) ***Report forms***. Typically, incident reporting forms induce bias (including bias against reporting at all), for example:

   1) A report form must be sufficiently short and easy to use so that operational personnel are encouraged to use it; thus, the number of questions must be limited.

   2) Completely open questions (i.e. narratives only) can fail to elicit useful data.

3) Questions can guide the reporter, but they can also distort perceptions by leading the reporter to biased conclusions.

4) The range of possible events is so broad that a standard structured form cannot capture all information. (Therefore, analysts may have to contact the reporter to gain specific information.)

d) ***Incident reporting databases***. Information must be categorized in accordance with a predetermined structure of keywords or definitions for entry into the database for later retrieval. Typically, this introduces bias into the databases, compromising their utility, for example:

1) Unlike objective physical flight parameters, descriptions of events and any causal attributions are more subjective.

2) Categorization requires a system of predetermined keywords or definitions, therefore biasing the database, for example:

— Reports are analysed to *"fit"* the keywords. Details that do not fit are ignored.

— It is impossible to create an exhaustive list of keywords for classifying information.

— Keywords are either present or not present, providing a poor approximation of the real world.

— Information is retrieved according to how it is stored; hence categorization determines the output parameters. For example, if there is no keyword called "technical failure", then "technical failure" will never be found to be the cause of incidents from that database.

— The categorization system creates a "self-fulfilling prophecy". For example, many incident reporting systems bias the keyword categorization towards CRM. Consequently, CRM is often cited as both the cause of the problem and its cure (more CRM training will redress the perceived CRM deficiency).

3) Much of the information in the databases is never retrieved once it is entered.

4) Given the generality of keywords, the analyst must frequently go back to the original report to understand contextual details.

e) ***Relative frequency of occurrence***. Since voluntary incident reporting systems do not receive information of the type needed to compute useful rate figures, any attempt to put the incident in the perspective of a frequency of occurrence vis-à-vis other occurrences will be an educated guess at best. For valid frequency comparisons, three types of data are required: the number of persons actually experiencing similar incidents (not just the reported incidents), the size of the population at risk of similar occurrences, and a measurement of the time period under consideration.

f) ***Trend analysis***. Meaningful trend analysis of the more subjective parameters recorded in incident reporting databases have not been particularly successful. Some of the reasons for this are listed below:

1) difficulties in using structured information;

2) limitations in capturing the context of the incident through keywords;

3) inadequate levels of detail and accuracy of recorded data;

4) poor inter-reliability of one report against another;

5) difficulties in merging data from different databases; and

6) difficulties in formulating meaningful queries for the database.

Chapter 8

SAFETY INVESTIGATIONS

> **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, when appropriate, the making of safety recommendations.*
>
> Annex 13

8.1 INTRODUCTION

8.1.1 Effective safety management systems depend on the investigation and analysis of safety issues. The safety value of an accident, a hazard or an incident is largely proportional to the quality of the investigative effort.

State investigations

Accidents

8.1.2 Accidents provide compelling and incontrovertible evidence of the severity of hazards. Too often it takes the catastrophic and grossly expensive nature of accidents to provide the spur for allocating resources to reduce or eliminate unsafe conditions to an extent otherwise unlikely.

8.1.3 By definition, accidents result in damage and/or injury. If we concentrate on investigating only the results of accidents, not the hazards or risks that cause them, we are being reactive. Reactive investigations are rather inefficient from a safety perspective in that latent unsafe conditions posing significant safety risks may be overlooked.

8.1.4 The focus of an accident investigation should therefore be directed towards effective risk control. With the investigation directed away from *"the chase for the guilty party"* and towards effective risk mitigation, cooperation will be fostered among those involved in the accident, facilitating the discovery of the underlying causes. The short-term expediency of finding someone to blame is detrimental to the long-term goal of preventing future accidents.

Serious incidents

8.1.5 The term *"serious incident"* is used for those incidents which good fortune prevented from becoming accidents, for example, a near collision with another aircraft or with the ground. Due to the seriousness of such incidents, they should be thoroughly investigated. Some States treat these serious incidents as if they had been accidents. Thus they use an accident investigation team to carry out the investigation, including the publication of a final report and the forwarding to ICAO of an ADREP incident data report. This type of full-scale incident investigation has the advantage of providing hazard information to the same standard as that of an accident investigation.

In-house investigations

8.1.6 Most occurrences do not warrant investigations by either the State investigative or regulatory authorities. Many incidents are not even required to be reported to the State. Nevertheless, such incidents may be indicative of potentially serious hazards — perhaps systemic problems that will not be revealed unless the occurrence is properly investigated.

8.1.7 For every accident or serious incident, there will likely be hundreds of minor occurrences, many of which have the potential to become an accident. It is important that all reported hazards and incidents be reviewed and a decision taken on which ones should be investigated and how thoroughly.

8.1.8 For in-house investigations, the investigating team may require the assistance of specialists, depending on the nature of the occurrence being investigated, for example:

a) cabin safety specialists for in-flight turbulence encounters, smoke or fumes in the cabin, galley fire, etc.;

b) experts in air traffic services for loss of separation, near collisions, frequency congestion, etc.;

c) maintenance engineers for incidents involving material or system failures, smoke or fire, etc.; and

d) experts able to provide airport management advice for incidents involving foreign object damage (FOD), snow and ice control, airfield maintenance, vehicle operations, etc.

8.2 SCOPE OF SAFETY INVESTIGATIONS

8.2.1 How far should an investigation look into minor incidents and hazard reports? The extent of the investigation should depend on the actual or potential consequences of the occurrence or hazard. Hazard or incident reports that indicate high-risk potential should be investigated in greater depth than those with low-risk potential.

8.2.2 The depth of the investigation should be that which is required to clearly identify and validate the underlying hazards. Understanding ***why*** something happened requires a broad appreciation of the context for the occurrence. To develop this understanding of the unsafe conditions, the investigator should take a systems approach, perhaps drawing on the SHEL model outlined in Chapter 4. Resources are normally limited, thus the effort expended should be proportional to the perceived benefit in terms of potential for identifying systemic hazards and risks to the organization.

8.2.3 Although the investigation should focus on the factors that are most likely to have influenced actions, the dividing line between relevance and irrelevance is often blurred. Data that initially may seem to be unrelated to the investigation could later prove to be relevant once relationships between different elements of the occurrence are better understood.

8.3 INFORMATION SOURCES

Information relevant to a safety investigation can be acquired from a variety of sources, including:

a) Physical ***examination*** of the equipment used during the safety event. This may include examining the front-line equipment used, its components, and the workstations and equipment used by supporting personnel (e.g. ATCOs, maintenance and servicing personnel).

b) ***Documentation*** spanning a broad spectrum of the operation, for example:

   1) maintenance records and logs;

   2) personal records/logbooks;

   3) certificates and licences;

   4) in-house personnel and training records and work schedules;

   5) operator’s manuals and SOPs;

   6) training manuals and syllabi;

   7) manufacturers’ data and manuals;

   8) regulatory authority records;

   9) weather forecasts, records and briefing material; and

   10) flight planning documents.

c) ***Recordings*** (flight recorders, ATC radar and voice tapes, etc.). These may provide useful information for determining the sequence of events. In addition to traditional flight data recordings, maintenance recorders in new generation aircraft are a potential additional source of information.

d) ***Interviews*** conducted with individuals directly or indirectly involved in the safety event. These can provide a principal source of information for any investigation. In the absence of measurable data, interviews may be the only source of information.

e) ***Direct observation*** of actions performed by operating or maintenance personnel in their work environment. This can reveal information about potential unsafe conditions. However, the persons being observed must be aware of the purpose of the observations.

f) ***Simulations***. These permit reconstruction of an occurrence and can facilitate a better understanding of the sequence of events that led up to the occurrence, and the manner in which personnel responded to the event. Computer simulations can be used to reconstruct events using data from on-board recorders, ATC tapes, radar recordings and other physical evidence.

g) ***Specialist advice***. Investigators cannot be experts in every field related to the operational environment. It is important that they realize their limitations. When necessary, they must be willing to consult with other professionals during an investigation.

h) ***Safety databases***. Useful supporting information may come from accident/incident databases, in-house hazard and incident reporting systems, confidential reporting programmes, systems for monitoring line operations (e.g. flight data analysis, LOSA and NOSS programmes), manufacturers' databases, etc.

8.4 INTERVIEWS

8.4.1 Information acquired through interviews can help clarify the context for unsafe acts and conditions. It can be used to confirm, clarify or supplement information learned from other sources. Interviews can help to determine *"what"* happened. More importantly, interviews are often the only way to answer the important *"why"* questions which, in turn, can facilitate appropriate and effective safety recommendations.

8.4.2 In preparation for an interview, the interviewer must expect that individuals will perceive and recall things differently. The details of a system defect reported by operational personnel may differ from those observed by maintenance personnel during a service check. Supervisors and management may perceive issues differently than line personnel. The interviewer must accept all views as worthy of further exploration. However, even qualified, experienced and well-intentioned witnesses could be mistaken in their recollection of events. In fact, it may be grounds to suspect the validity of the information being received if during interviews of a number of people concerning the same event, the interviewees are not presenting different perspectives.

Conducting interviews

8.4.3 The effective interviewer adapts to these differing views, remaining objective and avoiding making an early evaluation of the content of the interview. An interview is a dynamic situation, and the skilled interviewer knows when to continue a line of questioning and when to back off.

8.4.4 To achieve the best results, interviewers will likely employ a process as follows:

a) carefully preparing and planning for the interview;

b) conducting the interview in accordance with a logical, well-planned structure; and

c) assessing the information gathered in the context of all other known information.

Appendix 1 to this chapter provides further guidance for conducting effective interviews.

Caveat regarding witness interviews

8.4.5 Reconciling the often-conflicting nature of witness interviews requires caution. Intuitively, an interviewer may weigh the value of an interview depending on the background and experience of the person being interviewed. However, persons judged as *"good witnesses"* may allow their perceptions to be influenced by their experience (i.e. they see and hear what they would "expect"). Consequently, their description of events may be biased. On the other hand, people who have no knowledge of an occurrence they have witnessed are often able to accurately describe the sequence of events. They may be more objective in their observations.

8.4.6 The skilled interviewer does not overly rely on a single witness — even the testimony of an expert. Rather, information from as many sources as practical needs to be integrated to form an accurate perception of the situation.

8.5 INVESTIGATION METHODOLOGY

8.5.1 The field phase of an investigation is used to identify and validate perceived safety hazards. Competent safety analysis is required to assess the risks, and effective communications are required to control the risks. In other words, effective safety management requires an integrated approach to safety investigations.

8.5.2 Some occurrences and hazards originate from material failures or occur in unique environmental conditions. However, the majority of unsafe conditions are generated through human errors. When considering human error, an understanding of the conditions that may have affected human performance or decision-making is required. These unsafe conditions may be indicative of systemic hazards that put the entire aviation system at risk. Consistent with the systems approach to safety, an integrated approach to safety investigations considers all aspects that may have contributed to unsafe behaviour or created unsafe conditions.

8.5.3 The logic flow for an integrated process for safety investigations is depicted in Figure 8-1 — Integrated Safety Investigation Methodology (ISIM). Using this type of model can guide the safety investigator from the initial hazard or incident notification through to the communication of safety lessons learned.

8.5.4 Effective investigations do not follow a simple step-by-step process that starts at the beginning and proceeds directly through each phase to completion. Rather, they follow an iterative process that may require going back and repeating steps as new data are acquired and/or as conclusions are reached.

8.6 INVESTIGATING HUMAN PERFORMANCE ISSUES

8.6.1 Investigators have been quite successful in analysing the measurable data pertaining to human performance, e.g. strength requirements to move a control column, lighting requirements to read a display, and ambient temperature and pressure requirements. Unfortunately, the majority of safety deficiencies derive from issues that do not lend themselves to simple measurement and are thus not entirely predictable. As a result, the information available does not always allow an investigator to draw indisputable conclusions.

8.6.2 Several factors typically reduce the effectiveness of a human performance analysis. These include:

a) the lack of normative human performance data to use as a reference against which to judge observed individual behaviour;

   Note.— FDA, LOSA and NOSS data provide a baseline to better understand normal day-to-day performance in aviation operations.

b) the lack of a practical methodology for generalizing from the experiences of an individual (crew or team member) to an understanding of the probable effects on a large population performing similar duties;

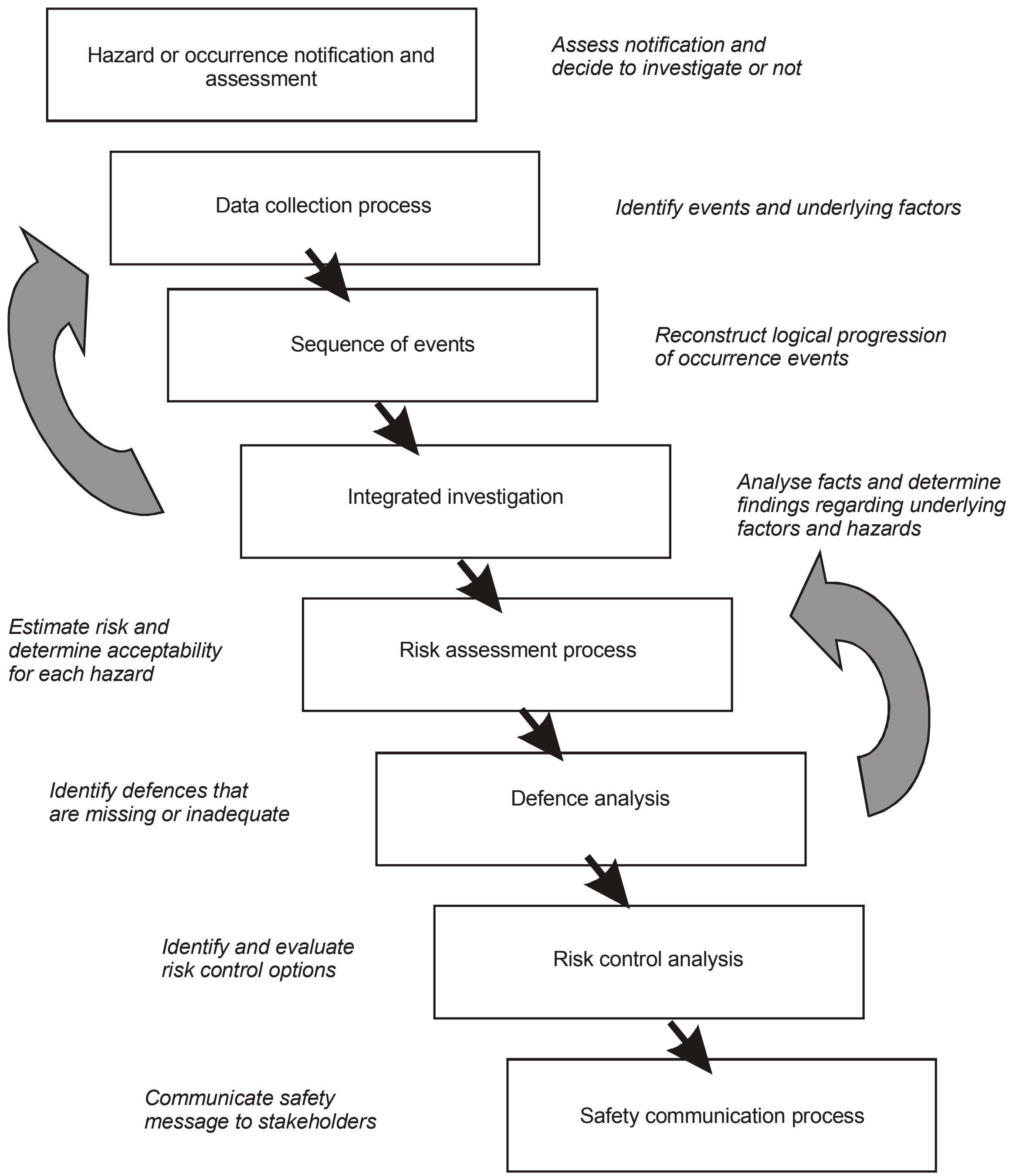

Figure 8-1. Integrated Safety Investigation Methodology (ISIM)

c) the lack of a common basis for interpreting human performance data among the many disciplines (e.g. engineering, operations and management) that make up the aviation community; and

d) the ease with which humans can adapt to different situations, further complicating the determination of what constitutes a breakdown in human performance.

8.6.3 The logic necessary to convincingly analyse some of the less tangible human performance phenomena is different from that required for other aspects of an investigation. Deductive methods are relatively easy to present and lead to convincing conclusions. For example, a measured wind shear produced a calculated aircraft performance loss, and a conclusion could be reached that the wind shear exceeded the aircraft's performance capability. Such straight cause/effect relationships cannot be so easily established with some human performance issues such as complacency, fatigue, distraction or judgement. For example, if an investigation revealed that a crew member made an error leading to an occurrence under particular conditions (such as complacency, fatigue or distraction), it does not necessarily follow that the error was made because of these preconditions. There will inevitably be some degree of speculation involved in such a conclusion. The viability of such speculative conclusions is only as good as the reasoning process used and the weight of evidence available.

8.6.4 Inductive reasoning involves probabilities. Inferences can be drawn from the most probable or most likely explanations of behavioural events. Inductive conclusions can always be challenged, and their credibility depends on the weight of evidence supporting them. Accordingly, they must be based upon a consistent and accepted reasoning method.

8.6.5 Analysis of human performance issues needs to take into account the objective of the investigation (i.e. understanding *why* something happened). Occurrences are seldom the result of a single cause. Although individual factors when viewed in isolation may seem insignificant, in combination they can result in a sequence of events and conditions that culminate in an accident. The SHEL model provides a systematic approach to examining the constituent elements of the system, as well as the interfaces between them.

8.6.6 Understanding the context in which humans err is fundamental to understanding the unsafe conditions that may have affected their behaviour and decision-making. These unsafe conditions may be indicative of systemic risks posing significant accident potential.

8.7 SAFETY RECOMMENDATIONS

8.7.1 When an investigation identifies hazards or unmitigated risks, safety action is required. The need for action must be communicated by means of safety recommendations to those with the authority to expend the necessary resources. Failure to make appropriate safety recommendations may leave the risk unattended. For those formulating safety recommendations, the following considerations may apply:

a) ***Action agency***. Who can best take the necessary corrective action? Who has the necessary authority and resources to intervene? Ideally, problems should be addressed at the lowest possible level of authority, such as the departmental or company level as opposed to the national or regulatory level. However, if several organizations are exposed to the same unsafe conditions, extending the recommended action may be warranted. State and international authorities, or multinational manufacturers may best be able to initiate the necessary safety action.

b) ***What versus how***. Safety recommendations should clearly articulate *what* should be done, not *how* to do it. The focus is on communicating the nature of the risks requiring control measures. Detailed safety recommendations which spell out exactly *how* the problem should be fixed, should be avoided. The responsible manager should be in a better position to judge the specifics of the most appropriate action for the current operating conditions. The effectiveness of any recommendation will be measured in terms of the extent to which the risks have been reduced, rather than strict adherence to the wording in the recommendation.

c) ***General versus specific wording***. Since the purpose of the safety recommendation is to convince others of an unsafe condition putting some or all of the system at risk, specific language should be used in summarizing the scope and consequences of the identified risks. On the other hand, since the recommendation should specify *what* is to be done (not *how* to do it), concise wording is preferable.

d) ***Recipient's perspective***. In recommending safety action, the following considerations pertain to the recipient's perspective:

1) The safety recommendation is addressed to the *most appropriate action authority* (i.e. the one having the jurisdiction and authority to effect the necessary change).

2) There are no surprises (i.e. there has been prior dialogue concerning the nature of the assessed risks).

3) It articulates *what* should be done, while leaving the action authority with the latitude to determine *how* best to meet that objective.

8.7.2 Formal safety recommendations warrant written communications. This ensures that the recommendations are not misunderstood and provides the necessary baseline for evaluating the effectiveness of implementation. However, it is important to remember that safety recommendations are only effective if they are implemented.

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Appendix 1 to Chapter 8

INTERVIEWING TECHNIQUES

Additional guidance for conducting effective interviews is listed below:

a) The interviewer's role is to obtain information from the interviewee that is as accurate, complete and detailed as possible.

b) Interviews, particularly those involving human performance factors, must go beyond the *"what"* and *"when"* of the occurrence; they must also attempt to find out *"how"* and *"why"* it occurred.

c) The success of the interview will closely relate to personal preparation. Tailor the preparations to the interview.

d) In the follow-up to an incident or safety event, interviews should be conducted as soon as practicable. If an immediate interview is impracticable, request a written statement to ensure information is recorded while fresh in the interviewee's mind.

e) The success of the interview will depend on the timing and the structure of the questions. Begin the interview with a *"free-recall"* question, letting the individual talk about what he or she knows of the occurrence or subject matter. As the interview progresses, use a mixture of other types of questions, for example:

   1) **open-ended** or "trailing-off" questions. This type of question evokes rapid and accurate descriptions of the events, and leads to more participation by the interviewee (for example, "You said earlier that your training was …?").

   2) **specific** questions. This type of question is necessary to obtain detailed information and may also prompt the person to recollect further details.

   3) **closed** questions. This type of question produces "yes" or "no" answers (providing little insight beyond the response).

   4) **indirect** questions. This type of question might be useful in delicate situations (for example, "You mentioned that the first officer was uneasy about flying that approach. Why?").

f) When asking a question, avoid leading questions, i.e. any question that contains the answer. Instead, use neutral sentences.

g) Do not accept any information gained in an interview at face value. Use it to confirm, clarify or supplement information from other sources.

h) In some circumstances, there may be many witnesses to be interviewed. The resultant (often-conflicting) information must be summarized, sorted and compiled in a useful format.

i) Good interviews require good listening skills.

j) Each interview should be documented for future reference. Records may consist of transcripts, interview summaries, notes and/or tape recordings.

Chapter 9

SAFETY ANALYSIS AND SAFETY STUDIES

9.1 INTRODUCTION

9.1.1 After collecting and recording voluminous safety data through safety investigations and various hazard identification programmes, meaningful conclusions can only be reached through safety analysis. Data reduction to simple statistics serves little useful purpose without evaluation of the practical significance of the statistics in order to define a problem that can be resolved.

ICAO requirement[1]

9.1.2 ICAO recognizes the linkages between safety analysis and safety management, and it promotes the analysis of accident and incident data and the exchange of safety information. Having established safety databases and incident reporting systems, States should analyse the information contained in their accident/incident reports and their databases to determine any preventive actions required. ICAO also recognizes the value of safety studies to help in developing safety recommendations.

Safety analysis — what is it?

9.1.3 Analysis is the process of organizing facts using specific methods, tools or techniques. Among other purposes, it may be used to:

a) assist in deciding what additional facts are needed;

b) ascertain causal and contributory factors; and

c) assist in reaching valid conclusions.

9.1.4 Safety analysis is based on factual information, possibly originating from several sources. Relevant data must be collected, sorted and stored. Analytical methods and tools suitable to the analysis are then selected and applied. Safety analysis is often iterative, requiring multiple cycles. It may be quantitative or qualitative. The absence of quantitative baseline data may force a reliance on more qualitative methods of analysis.

Objectivity and bias

9.1.5 Consideration needs to be given to all relevant information; however, not all safety information is reliable. Time constraints do not always permit the collection and evaluation of sufficient data to ensure objectivity. Intuitive conclusions may sometimes be reached which are not consistent with the objectivity required for credible safety analysis.

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1. See Annex 13 — *Aircraft Accident and Incident Investigation.*

9.1.6 We are all subject to some level of bias in our judgement. Past experience will often influence our judgement, as well as our creativity, in establishing hypotheses. One of the most frequent forms of judgement error is known as "confirmation bias". This is the tendency to seek and retain information that confirms what we already believe to be true. Appendix 1 to this chapter provides more information on understanding bias and how it is relevant to the drawing of conclusions in safety analysis.

9.2 ANALYTICAL METHODS AND TOOLS

There are different methods used in safety analysis; some are automated, some are not. In addition, several software-based tools (requiring different levels of expertise for effective application) exist. Listed below are some analytical methods and tools that are available:

a) ***Statistical analysis***. Many of the analytical methods and tools used in safety analysis are based on statistical procedures and concepts, for example, risk analysis utilizes concepts of statistical probability. Statistics play a major role in safety analysis by helping to quantify situations, thereby providing insight through numbers. This generates more credible results for a convincing safety argument.

   The type of safety analysis conducted at the level of company safety management systems requires basic skills for analysing numeric data, for identifying trends and for making basic statistical computations such as arithmetic means, percentiles and medians. Statistical methods are also useful for graphical presentations of analyses.

   Computers can handle the manipulation of large volumes of data. Most statistical analysis procedures are available in commercial software packages (e.g. Microsoft Excel). Using such applications, data can be entered directly into a pre-programmed procedure. While a detailed understanding of the statistical theory behind the technique is not necessary, the analyst should understand what the procedure does and what the results are intended to convey.

   While statistics are a powerful tool for safety analysis, they can also be misused and, consequently, can lead to erroneous conclusions. Care must be taken in the selection and use of data in statistical analysis. To ensure appropriate application of the more complex methods, the assistance of specialists in statistical analysis may be required.

b) ***Trend analysis***. By monitoring trends in safety data, predictions may be made about future events. Emerging trends may be indicative of embryonic hazards. Statistical methods can be used to assess the significance of perceived trends. The upper and lower limits of acceptable performance against which to compare current performance may be defined. Trend analysis can be used to trigger *"alarms"* when performance is about to depart from accepted limits.

c) ***Normative comparisons***. Sufficient data may not be available to provide a factual basis against which to compare the circumstances of the event or situation under examination with everyday experience. The absence of credible normative data often compromises the utility of safety analyses. In such cases, it may be necessary to sample real world experience under similar operating conditions. FDA, LOSA and NOSS programmes provide useful normative data for the analysis of aviation operations. These programmes are discussed in Chapters 16 and 17.

d) ***Simulation and testing***. In some cases, the underlying safety hazards may become evident through testing, for example, laboratory testing may be required for analysing material defects. For suspect operational procedures, simulation in the field under actual operating conditions, or in a simulator may be warranted.

e) ***Expert panel***. Given the diverse nature of safety hazards, and the different perspectives possible in evaluating any particular unsafe condition, the views of others, including peers and specialists, should be sought. A multidisciplinary team formed to evaluate evidence of an unsafe condition can also assist in identifying and evaluating the best course for corrective action.

f) ***Cost-benefit analysis***. The acceptance of recommended risk control measures may be dependent on credible cost-benefit analyses. The costs of implementing the proposed measures are weighed against the expected benefits over time. Sometimes, cost-benefit analysis may suggest that accepting the risk is preferable to the time, effort and cost necessary to implement corrective action.

9.3 SAFETY STUDIES

9.3.1 Some complex or pervasive safety issues can best be understood through an examination in the broadest possible context. Safety concerns of a global nature may be addressed on an industry- or State-wide scale. For example, the industry has been concerned with the frequency and severity of approach and landing accidents and has undertaken major studies, made many safety recommendations and implemented global measures to reduce the risks of accidents during the critical approach and landing phases of flight. The convincing argument necessary to achieve large-scale or global changes requires significant data, appropriate analysis and effective communication. Safety arguments based on isolated occurrences and anecdotal information will not succeed.

9.3.2 In this manual, these larger, more complex safety analyses are referred to as “safety studies”. The term includes many types of studies and analyses conducted by State authorities, airlines, manufacturers, and professional and industry associations. ICAO recognizes that safety recommendations may arise not only from the investigation of accidents and serious incidents but also from safety studies.[2] Safety studies have application to hazard identification and analysis in flight operations, maintenance, cabin safety, air traffic control, airport operations, etc.

9.3.3 Safety studies of industry-wide concerns generally require a major sponsor. The Flight Safety Foundation, in collaboration with major aircraft manufacturers, ICAO, NASA and other key industry stakeholders, has taken a leading role in many such studies. Civil aviation authorities of specific States have also conducted major safety studies, thereby identifying safety risks of global interest. In addition, several State authorities have used safety studies to identify and resolve hazards in their national aviation systems. Although it is unlikely that small or medium-sized operators would undertake a major safety study, large operators and regulatory officials may be involved in identifying systemic safety issues.

Selecting study issues

9.3.4 Large operators, manufacturers, safety organizations and regulatory authorities may maintain significant safety issues lists (SILs). (The topic of maintaining SILs can be found in 9.4.) These lists may be based on the accident and incident record in such areas as runway incursions, ground proximity warnings, and traffic alert and collision avoidance system (TCAS) advisories. The safety issues may be prioritized in terms of the risks to the organization or the industry.

9.3.5 Given the degree of collaboration and sharing of information necessary to conduct an effective safety study, issues selected for study must have a broad base of support among participants and contributors.

2. See Annex 13, Chapter 8.

Information gathering

9.3.6 The methods outlined below are available for acquiring the information to support a safety study:

a) ***Review of occurrence records***. Investigated occurrences may be reviewed by selecting those occurrences which meet some pre-defined characteristics, such as runway incursions or crew fatigue. By reviewing all available material on file, specific elements may be identified that are suitable for further analysis.

b) ***Structured interviews***. Useful information can be acquired through structured interviews. While they can be time-consuming, interviews offer the potential for acquiring quality information, even if there is not a statistically representative sample. Success will depend on the ability of the analyst to reduce large amounts of anecdotal information to useful data.

c) ***Directed field investigations***. Investigations of relatively insignificant occurrences (which might normally not be investigated) may uncover sufficient additional information to permit a more in-depth analysis. Although not many of these investigations when considered individually contribute much to the collective knowledge of the factors contributing to such occurrences, collectively they may reveal behavioural patterns which compromise safe operations.

d) ***Literature search***. Whether the safety issues under examination have to do with particular equipment, technology, maintenance, human performance, environmental factors, or organizational and management issues, undoubtedly a great deal has already been written on the subject. Prior to commencing a safety study, it may be appropriate to carry out a literature search on the issue under consideration. Careful use of the Internet can provide a wealth of information.

e) ***Experts' testimony***. Direct contact with recognized subject matter experts may be warranted. Experts may be contacted informally or be invited to provide more formal input through submissions to a hearing or public inquiry.

f) ***Public inquiries***. For major safety issues that must be considered from many perspectives, State authorities may convene some form of public inquiry. This provides an opportunity for all stakeholders (individually or as representatives of particular interest groups) to present their views through an open, impartial process.

g) ***Hearings***. Less formal meetings than public inquiries may be convened with a view to *hearing* the different (and often divergent) views of the major aviation stakeholders. As opposed to a public inquiry, the stakeholders are heard *in camera* (or private); in this way, they may be more candid in stating their positions.

9.4 SIGNIFICANT SAFETY ISSUES LISTS (SILs)

9.4.1 Some State regulatory authorities, investigative agencies and large operators have found that maintaining a list of high priority safety issues is an effective means for highlighting areas warranting further study and analysis. These lists are known as significant safety issues lists (SILs); however, they are sometimes referred to as the *"Top Ten"* or the *"Most Wanted"* lists. Such lists prioritize those safety issues that put the aviation system (or the organization) at risk. As a result, they may be useful in identifying issues for safety assessment, safety survey or safety study. If SILs are to be of value in guiding the work of those involved in safety management, they must not chronicle every perceived hazard. They should be limited to ten issues.

9.4.2 Typical issues that may warrant inclusion on a SIL are listed below:

a) frequency of ground proximity warning system (GPWS) warnings;

b) frequency of TCAS advisories;

c) runway incursions;

d) altitude deviations (busts);

e) call sign confusion;

f) unstabilized approaches; and

g) air proximities (near misses) at selected aerodromes.

9.4.3 SILs should be reviewed and updated annually, adding new high-risk issues and deleting lesser-risk issues.

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Appendix 1 to Chapter 9

UNDERSTANDING BIAS[1]

Everyone's judgement is shaped by personal experience. Notwithstanding the quest for objectivity, time does not always permit the collection and careful evaluation of sufficient data to ensure objectivity. Based on a lifetime of personal experiences, we all develop mental models that generally serve us well in evaluating everyday situations *"intuitively",* without having all the facts. Unfortunately, many of these mental models reflect personal bias. ***Bias*** is the tendency to apply a particular response regardless of the situation. The following are some of the basic biases that can affect the validity of safety analyses:

a) ***Frequency bias****.* We tend to over- or underestimate the probability of occurrence of a particular event because our evaluation is based solely on our personal experience. We assume that our limited experience is representative of the global situation.

b) ***Selectivity bias****.* Our personal preferences cause a tendency to select items based on a restricted core of facts. We have a tendency to ignore those facts which do not quite fit the pattern we expect. We may focus our attention on physically important characteristics, or obvious evidence (e.g. loud, bright and recent) and ignore cues that might provide more relevant information about the nature of the situation.

c) ***Familiarity bias****.* In any given situation, we tend to choose the most familiar solutions and patterns. Those facts and processes which match our own mental models (or preconceived notions) are more easily assimilated. We tend to do things in accordance with the patterns of our previous experience, even if they are not the optimum solutions for the current situation, e.g. the route we pick to go somewhere may not always be the most efficient under changing circumstances.

d) ***Conformity bias****.* We have a tendency to look for results that support our decision rather than information that would contradict it. As the strength of our mental model increases, we are reluctant to accept facts that do not line up nicely with what we already "know". Time pressures can lead to erroneous assumptions that do not accurately reflect the current reality.

e) ***Group conformity or "group think" bias****.* A variation on conformity bias is *"group think"*. Most of us have a tendency to agree with majority decisions; we yield to group pressures to bring our own thinking in line with that of the group. We do not want to break the group's harmony by upsetting the prevalent mental model. In the interests of expediency, it is a natural pattern to fall into.

f) ***Overconfidence bias****.* There is a tendency for people to overestimate their knowledge of the situation and its outcome. The result is that attention is placed only on information that supports their choice and contradictory evidence gets ignored.

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1. Adapted from the *Human Factors Guidelines for Safety Audits Manual* (Doc 9806).

Chapter 10

SAFETY PERFORMANCE MONITORING

10.1 INTRODUCTION

10.1.1 Safety management requires feedback on safety performance to complete the safety management cycle. Through feedback, system performance can be evaluated and any necessary changes effected. In addition, all stakeholders require an indication of the level of safety within an organization for various reasons, for example:

a) Staff may need confidence in their organization's ability to provide a safe work environment.

b) Line management requires feedback on safety performance to assist in the allocation of resources between the often-conflicting goals of production and safety.

c) Passengers are concerned with their own mortality.

d) Senior management seeks to protect the corporate image (and market share).

e) Shareholders wish to protect their investment.

10.1.2 Although the stakeholders in an organization's safety process want feedback, their individual perspectives as to "what is safe?" vary considerably. Deciding what reliable indicators exist for acceptable safety performance depends largely upon how one views "safety", for example:

a) Senior management may seek the unrealistic goal of *"zero accidents".* Unfortunately, as long as aviation involves risk, there will be accidents, even though the accident rate may be very low.

b) Regulatory requirements normally define minimum *"safe"* operating parameters, e.g. cloud base and flight visibility limitations. Operations within these parameters contribute to "safety"; however, they do not guarantee it.

c) Statistical measures are often used to indicate a level of safety, e.g. the number of accidents per hundred thousand hours, or fatalities per thousand sectors flown. Such quantitative indicators mean little by themselves, but they are useful in assessing whether safety is getting better or worse over time.

10.2 SAFETY HEALTH

10.2.1 Recognizing the complex interactions affecting safety and the difficulty in defining what is safe and what is not, some safety experts make reference to the "safety health" of an organization. The term safety health is an indication of an organization's resistance to unexpected conditions or acts by individuals. It reflects the systemic measures put in place by the organization to defend against the unknown. Furthermore, it is an indication of the organization's ability to adapt to the unknown. In effect, it reflects the safety culture of the organization.

10.2.2 Although the absence of safety-related events (accidents and incidents) does not necessarily indicate a “safe” operation, some operations are considered to be “safer” than others. Safety deals with risk reduction to an acceptable (or at least a tolerable) level. The level of safety in an organization is unlikely to be static. As an organization adds defences against safety hazards, its safety health may be considered to be improving. However, various factors (hazards) may compromise that safety health, requiring additional measures to strengthen the organization’s resistance to misadventure. The concept of the safety health of an organization varying during its life cycle is depicted in Figure 10-1.

Assessing safety health

10.2.3 In principle, the characteristics and safety performance of the “safest” organizations can be identified. These characteristics, which reflect industry’s best practices, can serve as benchmarks for assessing safety performance.

Symptoms of poor safety health

10.2.4 Poor safety health may be indicated by symptoms that put elements of the organization at risk. Appendix 1 to this chapter provides examples of symptoms that may be indicative of poor safety health. A weakness in any one area may be tolerable; however, weaknesses in many areas indicate serious systemic risks, compromising the safety health of the organization.

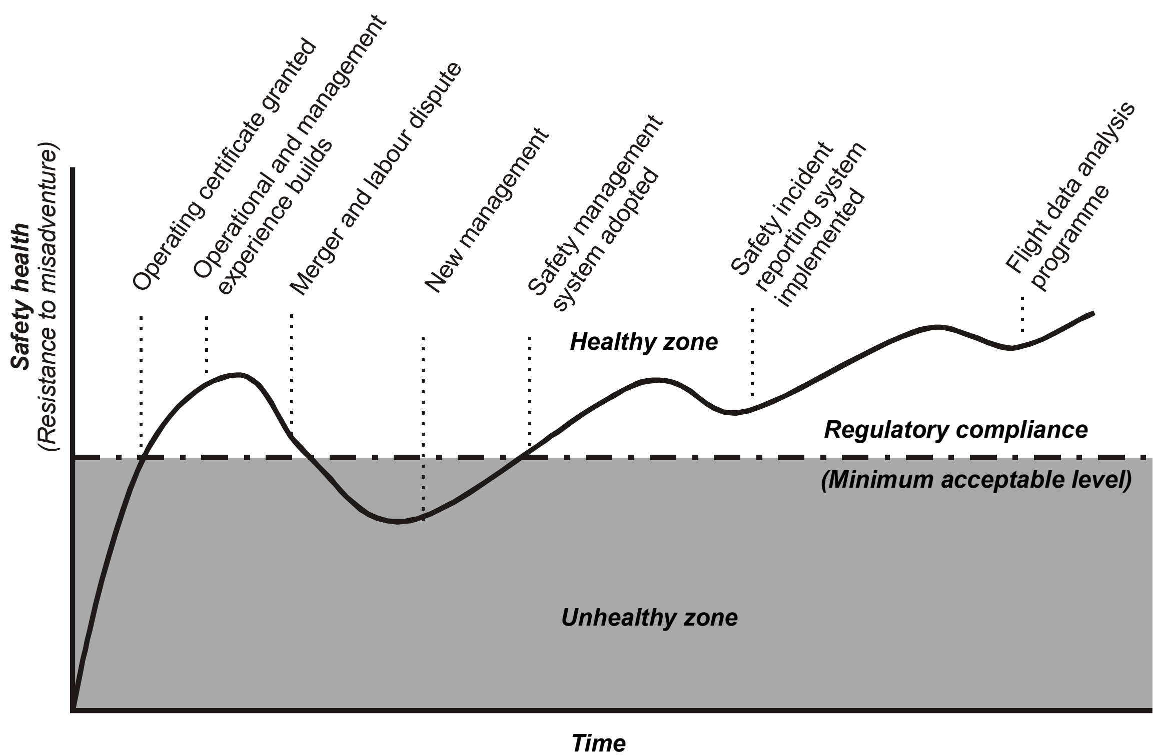

Figure 10-1. Variation in safety health

Indicators of improving safety health

10.2.5 Appendix 1 also provides indicators of improving safety health. These reflect the industry's best practices and a good safety culture. Organizations with the best safety records tend to *"maintain or improve their safety fitness"* by implementing measures to increase their resistance to the unforeseen. They consistently do more than just meet the minimum regulatory requirements.

10.2.6 Identifying the symptoms may provide a valid impression of an organization's safety health; however, information may still be lacking for effective decision-making. Additional tools are required to measure safety performance in a systematic and convincing way.

Statistical safety performance indicators

10.2.7 Statistical safety performance indicators illustrate historic safety achievements; they provide a "snapshot" of past events. Presented either numerically or graphically, they provide a simple, easily understood indication of the level of safety in a given aviation sector in terms of the number or rate of accidents, incidents or casualties over a given time frame. At the highest level, this could be the number of fatal accidents per year over the past ten years. At a lower (more specific) level, the safety performance indicators might include such factors as the rate of specific technical events (e.g. losses of separation, engine shutdowns, TCAS advisories and runway incursions).

10.2.8 Statistical safety performance indicators can be focused on specific areas of the operation to monitor safety achievement, or on identifying areas of interest. This *"retrospective"* approach is useful in trend analysis, hazard identification, risk assessment, as well as in the choice of risk control measures.

10.2.9 Since accidents (and serious incidents) are relatively random and rare events in aviation, assessing safety health based solely on statistical safety performance indicators may not provide a valid predictor of safety performance, especially in the absence of reliable exposure data. Reviewing the past does little to assist organizations in their quest to be proactive and to put in place those systems most likely to protect against the unknown.

Acceptable levels of safety

10.2.10 Aviation organizations must meet regulatory requirements to ensure acceptable levels of safety. The organizations that just meet these minimal requirements, however, may not be *healthy* from a safety point of view. Although they have reduced their vulnerabilities to the unsafe acts and conditions most conducive to accidents, they have only taken minimum precautionary measures.

10.2.11 Weak organizations that fail to meet the acceptable levels of safety will be removed from the aviation system either proactively, by the regulator revoking their operating certificate, or reactively, in response to commercial pressures such as the high cost of accidents or serious incidents, or consumer resistance. Chapters 1, 4 and 5 contain additional information on acceptable levels of safety.

10.3 SAFETY OVERSIGHT

10.3.1 One of the cornerstones for effective safety management is a formal system for safety oversight. Safety oversight involves regular (if not continuous) monitoring of all aspects of an organization's operations. On the surface, safety oversight demonstrates compliance with State and organization rules, regulations, standards, procedures, etc. However, its value goes much deeper. Monitoring provides another method for proactive hazard identification, validation of the effectiveness of safety actions taken, and the continuing evaluation of safety performance.

10.3.2 As mentioned in 5.3.1 c), safety oversight is considered to be a function of the State as the regulator, while safety performance monitoring is carried out by operators and service providers. The "monitoring" functions of safety oversight take many forms with varying degrees of formality.

International level

10.3.3 At the international level, the ICAO Universal Safety Oversight Audit Programme (USOAP) (described in 10.4) monitors the safety performance of all Contracting States. International organizations, such as IATA, also engage in the safety oversight of airlines through an audit programme.

State level

10.3.4 At the State level, effective safety oversight can be maintained through a mix of some of the following activities:

a) conducting no-notice inspections to sample the actual performance of various aspects of the national aviation system;

b) conducting formal (scheduled) inspections that follow a protocol which is clearly understood by the organization being inspected;

c) discouraging non-compliant behaviour through enforcement actions (sanctions or fines);

d) monitoring quality of performance associated with all licensing and certification applications;

e) tracking the safety performance of the various sectors of the industry;

f) responding to occasions warranting extra safety vigilance (such as major labour disputes, airline bankruptcies, and rapid expansion or contraction of activity); and

g) conducting formal safety oversight audits of airlines or service providers such as ATC, approved maintenance organizations, training centres and airport authorities.

Organizational level

10.3.5 The size and complexity of the organization will determine the best methods for establishing and maintaining an effective safety performance monitoring programme. Organizations providing adequate safety oversight employ some or all of the following methods:

a) Their first-line supervisors maintain vigilance (from a safety perspective) by monitoring day-to-day activities.

b) They regularly conduct inspections (formal or informal) of day-to-day activities in all safety-critical areas.

c) They sample employees' views on safety (from both a general and a specific point of view) through safety surveys.

d) They systematically review and follow up on all reports of identified safety issues.

e) They systematically capture data which reflect actual day-to-day performance (using programmes such as FDA, LOSA and NOSS).

f) They conduct macro-analyses of safety performance (safety studies).

g) They follow a regular operational audit programme (including both internally and externally conducted safety audits).

h) They communicate safety results to all affected personnel.

Inspections

10.3.6 Perhaps the simplest form of safety oversight involves carrying out informal "walk-arounds" of all operational areas of the organization. Talking to workers and supervisors, witnessing actual work practices, etc. in a non-structured way provides valuable insights into safety performance *"at the coal face".* The resulting feedback should help to fine-tune the safety management system (SMS).

10.3.7 To be of value to the organization, the focus of an inspection should be on the quality of the "end product". Unfortunately, many inspections simply follow a tick-box format. Using a tick-box format may be helpful for verifying compliance with particular requirements, but it is less effective for assessing systemic safety risks. Alternatively, a checklist can be used as a guide to help ensure that parts of the operation are not overlooked.

10.3.8 Management and line supervisors may also conduct safety inspections to assess adherence to organizational requirements, plans and procedures. However, such inspections may only provide a spot check of the operations, with little potential for systemic safety oversight.

Surveys

10.3.9 Surveys of operations and facilities can provide management with an indication of the levels of safety and efficiency within its organization. Understanding the systemic hazards and inherent risks associated with everyday activities allows an organization to minimize unsafe acts and respond proactively by improving the processes, conditions and other systemic issues that lead to unsafe acts. Safety surveys are one way to systematically examine particular organizational elements or the processes used to perform a specific operation — either generally or from a particular safety perspective. They are particularly useful in assessing attitudes of selected populations, e.g. line pilots for a particular aircraft type, or ATCOs working a particular position.

10.3.10 In attempting to determine the underlying hazards in a system, surveys are usually independent of routine inspections by government or company management. Surveys completed by operational personnel can provide important diagnostic information about daily operations. They can provide an inexpensive mechanism to obtain significant information regarding many aspects of the organization, including:

a) perceptions and opinions of operational personnel;

b) level of teamwork and cooperation among various employee groups;

c) problem areas or bottlenecks in daily operations;

d) corporate safety culture; and

e) current areas of dissent or confusion.

10.3.11 Safety surveys usually involve the use of checklists, questionnaires and informal confidential interviews. Surveys, particularly those using interviews, may elicit information that cannot be obtained any other way.

10.3.12 Typically, specific data that are suitable for assessing safety performance can be acquired through well structured and managed surveys. However, the validity of all survey information obtained may need to be verified before corrective action is taken. Similar to voluntary incident reporting systems, surveys are subjective, reflecting individuals' perceptions. Consequently, they are subject to the same kinds of limitations, for example, the biases of the author, the biases of the respondents, and biases in interpreting the data.

10.3.13 The activities associated with safety surveys can span the complete risk management cycle from hazard identification, through risk assessment, to safety oversight. They are most likely to be conducted by organizations that have made the transition from a reactive to a proactive safety culture. Chapter 15 includes guidance on the conduct of safety surveys.

Quality assurance

10.3.14 A quality assurance system (QAS) defines and establishes an organization's quality policy and objectives. It ensures that the organization has in place those elements necessary to improve efficiency and reduce risks. If properly implemented, a QAS ensures that procedures are carried out consistently and in compliance with applicable requirements, that problems are identified and resolved, and that the organization continuously reviews and improves its procedures, products and services. A QAS should identify problems and improve procedures in order to meet corporate objectives.

10.3.15 A QAS helps ensure that the requisite systemic measures have been taken to meet the organization's safety goals. However, quality assurance does **not** "assure safety". Rather, quality assurance measures help management ensure the necessary standardization of the systems within its organization to reduce the risk of accidents.

10.3.16 A QAS contains procedures for monitoring the performance of all aspects of an organization, including such elements as:

a) well designed and documented procedures (e.g. SOPs);

b) inspection and testing methods;

c) monitoring of equipment and operations;

d) internal and external audits;

e) monitoring of corrective actions taken; and

f) the use of appropriate statistical analysis, when required.

10.3.17 A number of internationally accepted quality assurance standards are currently in use. The most appropriate system depends on the size, complexity and product of the organization. ISO 9000 is one set of international standards used by many organizations to implement an in-house quality system. Using such systems also ensures that the organization's suppliers have appropriate quality assurance systems in place.

Safety audits

10.3.18 Safety auditing is a core safety management activity. Similar to financial audits, safety audits provide a means for systematically assessing how well the organization is meeting its safety objectives. The safety audit programme, together with other safety oversight activities (safety performance monitoring), provides feedback to managers of individual units and senior management concerning the safety performance of the organization. This feedback provides evidence of the level of safety performance being achieved. In this sense, safety auditing is a proactive safety management activity, providing a means of identifying potential problems before they have an impact on safety.

10.3.19 Safety audits may be conducted internally by the organization, or by an external safety auditor. Demonstrating safety performance for State regulatory authorities is the most common form of external safety audit. Increasingly, however, other stakeholders may require an independent audit as a precondition to providing a specific approval, such as for financing, insurance, partnerships with other airlines, and entry into foreign airspace. Regardless of the driving force for the audit, the activities and products from both internal and external audits are similar. Safety audits should be conducted on a regular and systematic basis in accordance with the organization's safety audit programme. Guidance on the conduct of safety audits is included in Chapter 14.

10.4 ICAO UNIVERSAL SAFETY OVERSIGHT AUDIT PROGRAMME (USOAP)

10.4.1 ICAO recognizes the need for States to exercise effective safety oversight of their aviation industries. Thus, ICAO has established the Universal Safety Oversight Audit Programme (USOAP).[1] The primary objectives of USOAP are:

a) to determine the degree of conformance by States in implementing ICAO Standards;

b) to observe and assess the States' adherence to ICAO Recommended Practices, associated procedures, guidance material and safety-related practices;

c) to determine the effectiveness of States' implementation of safety oversight systems through the establishment of appropriate legislation, regulations, safety authorities and inspections, and auditing capabilities; and

d) to provide Contracting States with advice in order to improve their safety oversight capabilities.

10.4.2 A first USOAP audit cycle of most ICAO Contracting States addressing Annex 1 — *Personnel Licensing*, Annex 6 — *Operation of Aircraft* and Annex 8 — *Airworthiness of Aircraft* has been completed. Summary reports of the audits containing an abstract of the findings, recommendations and the proposed

1. Guidance material is available from ICAO to assist States in preparing for USOAP audits. See the *Safety Oversight Audit Manual* (Doc 9735) and the *Human Factors Guidelines for Safety Audits Manual* (Doc 9806).

State corrective actions are published and distributed by ICAO to enable other Contracting States to form an opinion on the status of aviation safety in the audited State. Future USOAP audit cycles will use a systemic approach, focusing on safety-critical SARPs of all safety-related Annexes. The audit findings to date have revealed many shortcomings in the compliance of individual States with ICAO SARPs.

10.5 REGULATORY SAFETY AUDITS

For some States, the ICAO USOAP audits are the only assessment made of their aviation safety oversight performance. However, many States do carry out a programme of safety audits to ensure the integrity of their national aviation system. Audits conducted by a safety regulatory authority should take a broad view of the safety management procedures of an organization as a whole. The key issues in such audits are listed below:

a) ***Surveillance and compliance***. The regulatory authority needs to ensure that the required international, national or local standards are complied with prior to issuing any licence or approval and that the situation will be maintained for the duration of the licence or approval. The regulator determines an acceptable means for demonstrating compliance. The organization being audited is then required to provide documentary evidence that the regulatory requirements can and will be met.

b) ***Areas and degree of risk***. A regulatory safety audit should ensure that the organization's SMS is based on sound principles and procedures. Organizational systems need to be in place to periodically review procedures to ensure that all safety standards are being continuously met. Assessments should be made of how risks are identified and how any necessary changes are made. The audit should confirm that the individual parts of the organization are performing as an integrated system. Therefore, regulatory safety audits must be of sufficient depth and scope to ensure that the organization has considered the various interrelationships in its management of safety.

c) ***Competence***. The organization should have adequate staff that are trained to ensure that the SMS functions as intended. In addition to confirming the competency of all staff, the regulatory authority needs to assess the capabilities of personnel in key positions. The possession of a licence granting specific privileges does not necessarily measure the competence of the holder to perform managerial tasks. For example, competence as an ATCO may not equate to managerial acumen. Where there are short-term skills gaps, the organization will need to satisfy the regulator that it has a viable plan to mitigate the situation as soon as practicable. In addition, the regulator should determine the senior manager accountable for safety.

d) ***Safety management***. An SMS needs to be in place to ensure that safety issues are managed effectively and that the organization is generally meeting its safety performance targets.

10.6 SELF-AUDIT

10.6.1 Critical self-assessment (or self-audit) is a tool that management can employ to measure safety margins. A comprehensive questionnaire to assist management in conducting a self-audit of those factors affecting safety is included in Appendix 2 to this chapter. This self-audit checklist is designed for use by senior management to identify organizational events, policies, procedures or practices that may be indicative of safety hazards.

10.6.2 There are no right or wrong answers in all situations, nor are all the questions relevant to all types of operations. However, the response to a certain line of questioning may help reveal the organization's safety health.

10.6.3 Although the self-audit in Appendix 2 was originally designed for use in flight operations, the line of questioning is relevant for the management of most operational aspects of civil aviation. Thus, this self-audit checklist can be adapted for application in a variety of situations.

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Appendix 1 to Chapter 10

SAMPLE INDICATORS OF SAFETY HEALTH

POOR SAFETY HEALTH

CAA

- Inadequate governing legislation and regulations;
- Potential conflicts of interest (such as the regulator also being the service provider);
- Inadequate civil aviation infrastructure and systems;
- Inadequate fulfilment of regulatory functions (such as licensing, surveillance and enforcement);
- Inadequate resources and organization for the magnitude and complexity of regulatory requirements;
- Instability and uncertainty within the CAA, compromising quality and timeliness of regulatory performance;
- Absence of formal safety processes such as incident reporting and safety oversight; and
- Stagnation in safety thinking (such as reluctance to embrace proven best practices).

Operational Organization

- Inadequate organization and resources for current operations;
- Instability and uncertainty due to recent organizational change;
- Poor financial situation;
- Unresolved labour-management disputes;
- Record of regulatory non-compliance;
- Low operational experience levels for type of equipment or operations;
- Fleet inadequacies such as age and mix;
- Poorly defined (or no) corporate safety function;
- Inadequate training programmes;
- Corporate complacency regarding safety record, current work practices, etc.; and
- Poor safety culture.

IMPROVING SAFETY HEALTH

CAA

- National incident reporting programmes (both mandatory and voluntary);
- National safety monitoring programmes, including incident investigations, accessible safety databases and trend analysis;
- Regulatory oversight, including routine surveillance, regular safety audits and monitoring of best industry practices;
- Risk-based resource allocation for all regulatory functions; and
- Safety promotion programmes to assist operators.

Operational Organization

- Proactive corporate safety culture;
- Investment in human resources in such areas as non-mandatory training;
- Formal safety processes for maintaining safety database, incident reporting, investigation of incidents, safety communications, etc.;
- Operation of a comprehensive safety management system (i.e. appropriate corporate approach, organizational tools and safety oversight);
- Strong internal two-way communications in terms of openness, feedback, reporting culture and dissemination of lessons learned; and
- Safety education and awareness in terms of data exchange, safety promotion, participation in safety fora, and training aids.

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Appendix 2 to Chapter 10

MANAGEMENT SELF-AUDIT

1. OBJECTIVE

This self-audit checklist may be used by management to identify administrative, operational and other processes, and training requirements that might indicate safety hazards. The results can be used to focus management's attention on those issues possibly posing a safety risk.

2. MANAGEMENT AND ORGANIZATION

Management structure

1) Does the organization have a formal written statement of corporate safety policies and objectives?

2) Are the corporate safety policies and objectives adequately disseminated throughout the organization? Is there visible senior management support for these safety policies?

3) Does the organization have a safety department or a designated safety manager (SM)?

4) Is this department or SM effective?

5) Does the departmental SM report directly to senior corporate management?

6) Does the organization support the periodic publication of a safety report or newsletter?

7) Does the organization distribute safety reports or newsletters from other sources?

8) Is there a formal system for regular communication of safety information between management and employees?

9) Are there periodic safety meetings?

10) Does the organization participate in industry safety activities and initiatives?

11) Does the organization formally investigate incidents and accidents? Are the results of these investigations disseminated to managers and operational personnel?

12) Does the organization have a confidential, non-punitive hazard and incident reporting programme?

13) Does the organization maintain an incident database?

14) Is the incident database routinely analysed to determine trends?

15) Does the organization operate a Flight Data Analysis (FDA) programme?

16) Does the organization operate a Line Operations Safety Audit (LOSA) programme?

17) Does the organization conduct safety studies?

18) Does the organization use outside sources to conduct safety reviews or audits?

19) Does the organization solicit input from aircraft manufacturers’ product support groups?

Management and corporate stability

1) Have there been significant or frequent changes in ownership or senior management within the past three years?

2) Have there been significant or frequent changes in the leadership of operational divisions within the past three years?

3) Have any managers of operational divisions resigned because of disputes about safety matters, operating procedures or practices?

4) Are safety-related technological advances implemented before they are directed by regulatory requirement, i.e. is the organization proactive in using technology to meet safety objectives?

Financial stability of the organization

1) Has the organization recently experienced financial instability, a merger, an acquisition or other major reorganization?

2) Was consideration given to safety matters during and following the period of instability, merger, acquisition or reorganization?

Management selection and training

1) Are there well-defined management selection criteria?

2) Is operational background and experience a requirement in the selection of management personnel?

3) Are first-line operational managers selected from operationally qualified candidates?

4) Do new management personnel receive formal safety indoctrination and training?

5) Is there a well-defined career path for operational managers?

6) Is there a formal process for the annual evaluation of managers?

Workforce

1) Have there been recent layoffs by the organization?

2) Are there a large number of personnel employed on a part-time or contractual basis?

3) Does the company have formal rules or policies to manage the use of contract personnel?

4) Is there open communication between management, the workforce and unions about safety issues?

5) Is there a high rate of personnel turnover in operations or maintenance?

6) Is the overall experience level of operations and maintenance personnel low or declining?

7) Is the distribution of age or experience level within the organization considered in long-term organizational planning?

8) Are the professional skills of candidates for operations and maintenance positions evaluated formally during the selection process?

9) Are multicultural processes and issues considered during employee selection and training?

10) Is special attention given to safety issues during periods of labour-management disagreements or disputes?

11) Have there been recent changes in salaries, work rules or pensions?

12) Does the organization have a corporate employee health maintenance programme?

13) Does the organization have an employee assistance programme that includes treatment for drug and alcohol abuse?

Relationship with the regulatory authority

1) Are safety standards set primarily by the organization or by the appropriate regulatory authority?

2) Does the organization set higher standards than those required by the regulatory authority?

3) Does the organization have a constructive, cooperative relationship with the regulatory authority?

4) Has the organization been subject to recent safety-enforcement action by the regulatory authority?

5) Does the organization consider the differing experience levels and licensing standards of other States when reviewing applications for employment?

6) Does the regulatory authority routinely evaluate the organization's compliance with required safety standards?

Chapter 11

EMERGENCY RESPONSE PLANNING

11.1 INTRODUCTION

11.1.1 Perhaps because aviation accidents are rare events, few organizations are prepared when one occurs. Many organizations do not have effective plans in place to manage events during or following an emergency or crisis. How an organization fares in the aftermath of an accident or other emergency can depend on how well it handles the first few hours and days following a major safety event. An emergency plan outlines in writing what should be done after an accident and who is responsible for each action. In aerodrome operations, such a plan is referred to as an Aerodrome Emergency Plan (AEP). However, in this chapter, the generic term Emergency Response Plan (ERP) is used.

11.1.2 While it is normal to associate emergency response planning with aircraft or aerodrome operations in case of an aircraft accident, the concept can equally be applied to other service providers. Emergency response planning is necessary for ATS providers in case of a major power outage, loss of radar, communications or other major facilities, etc. A maintenance organization needs emergency response planning in case of a hangar fire, major fuel spill, etc. In this context, an emergency is considered to be an event that could cause major harm or disruption to an organization.

11.1.3 At first glance, emergency response planning may appear to have little to do with safety management. However, effective emergency response planning provides an opportunity to learn, as well as to apply, safety lessons aimed at minimizing damage or injury.

11.1.4 To be able to respond successfully to an emergency, it is necessary to start with effective planning. An ERP provides the basis for a systematic approach to managing the organization's affairs in the aftermath of a significant unplanned event — in the worst case, a major accident.

11.1.5 The purpose of an ERP is to ensure that there is:

a) orderly and efficient transition from normal to emergency operations;

b) delegation of emergency authority;

c) assignment of emergency responsibilities;

d) authorization by key personnel for actions contained in the plan;

e) coordination of efforts to cope with the emergency; and

f) safe continuation of operations or return to normal operations as soon as possible.

11.2 ICAO REQUIREMENTS

11.2.1 Any organization conducting or supporting flight operations should have an ERP. The following documents stipulate ICAO's requirements or provide guidance material concerning emergency response planning:

a) Annex 14 — *Aerodromes* states that an aerodrome emergency plan shall be established at an aerodrome, commensurate with the aircraft operations and other activities conducted at an airport. The plan shall provide for the coordination of the actions to be taken in an emergency occurring at an aerodrome or in its vicinity.

b) The *Preparation of an Operations Manual* (Doc 9376) states that the operations manual of a company should give instructions and guidance on the duties and obligations of personnel following an accident. It should include guidance on the establishment and operation of a central accident/emergency response centre — the focal point for crisis management. In addition to guidance for accidents involving company aircraft, guidance should also be provided for accidents involving aircraft for which the company is the handling agent (for example, through code-sharing agreements or contracted services). Larger companies may choose to consolidate all this emergency planning information in a separate volume of their operations manual.

c) The *Airport Services Manual* (Doc 9137), Part 7 — *Airport Emergency Planning*, gives guidance to both airport authorities and aircraft operators on pre-planning for emergencies, as well as on coordination between the different airport agencies, including the operator.

11.2.2 To be effective, an ERP should:

a) be relevant and useful to the people who are likely to be on duty at the time of an accident;

b) include checklists and quick reference contact details of relevant personnel;

c) be regularly tested through exercises; and

d) be updated when changes occur.

11.3 ERP CONTENTS

An ERP would normally be documented in the format of a manual. It should set out the responsibilities, roles and actions for the various agencies and personnel involved in dealing with emergencies. An ERP should take into account such considerations as:

a) ***Governing policies***. The ERP should provide direction for responding to emergencies, for example, governing laws and regulations for investigations, agreements with local authorities, and company policies and priorities.

b) ***Organization***. The ERP should outline management's intentions with respect to the responding organizations by:

   1) designating who will be assigned to the response teams and specifying who will be the leader(s);

2) defining the roles and responsibilities for personnel assigned to the response teams;

3) clarifying the reporting lines of authority;

4) providing instructions for the setting up of a Crisis Management Centre (CMC);

5) establishing procedures for receiving a large number of requests for information, especially during the first few days after a major accident;

6) designating the corporate spokesperson for dealing with the media;

7) defining what resources will be available, including financial authorities for immediate activities;

8) designating the company representative with respect to any formal investigations undertaken by State officials; and

9) defining a call-out plan for key personnel.

An organization chart or flow chart could be used to show organizational functions and communication relationships.

c) ***Notifications***. The ERP should specify who in the organization should be notified of an emergency, and who will make external notifications and by what means. The notification needs of those listed below should be considered:

1) management;

2) State authorities (Search and Rescue, regulatory authority, accident investigation board, etc.);

3) local emergency response services (airport authorities, firefighters, police, ambulance services, medical agencies, etc.);

4) relatives of victims (a sensitive issue that is handled by the police in many States);

5) company personnel;

6) the media; and

7) legal, accounting and insurance representatives.

d) ***Initial response***. Depending on the circumstances, an initial response team may be dispatched to the accident site to augment local resources and oversee the organization's interests. Some factors to be considered for an initial response team are listed below:

1) Who should lead the initial response team?

2) Who should be included on the initial response team?

3) Who should speak for the organization at the accident site?

4) What would be required with respect to special equipment, clothing, documentation, transportation, accommodation, etc.?

e) ***Additional assistance***. Employees with appropriate training and experience can provide useful support during the preparation, exercising and updating of an organization's ERP. Their expertise may be useful in planning and executing such tasks as:

1) acting as passengers in crash exercises;

2) assisting survivors; and

3) dealing with next of kin.

f) ***Crisis Management Centre (CMC)***. A CMC should be established at the organization's headquarters once the activation criteria have been met. In addition, a command post (CP) may be established at or near the accident site. The ERP should address how the following requirements are to be met:

1) staffing (perhaps for 24 hours a day, 7 days per week during the initial response period);

2) communications equipment (telephones, fax, Internet, etc.);

3) maintenance of emergency activity logs;

4) impounding of company records that are relevant to the emergency;

5) office furnishings and supplies; and

6) reference documents (such as emergency response checklists and procedures, company manuals, AEPs and telephone lists).

The services of a crisis centre may need to be contracted out from an airline or other specialist organization to look after the operator's interests in a crisis away from home base. Company personnel would normally supplement the contracted centre as soon as possible.

g) ***Records***. In addition to the organization's need to maintain logs of events and activities, the organization will be required to provide information to a State investigation team. The ERP should allow for the following types of information to be available to investigators:

1) all relevant records on the aircraft, the flight crew, the operation, etc.;

2) lists of points of contact and any personnel associated with the occurrence;

3) notes of interviews with, and statements by, anyone associated with the event; and

4) photographic or other evidence.

h) ***Accident site***. After a major accident, representatives from many jurisdictions have legitimate reasons for accessing the site, for example, police, firefighters, medics, airport authorities, coroners, State accident investigators, relief agencies (e.g. the Red Cross) and the media. Although coordination of the activities of these stakeholders is the responsibility of the State's police and/or investigating authority, the aircraft operator should clarify the following aspects of activity at the accident site:

1) nomination of a senior company representative at the accident site (wherever the accident occurs);

2) management of surviving passengers;

3) responding to the needs of the victims' relatives;

4) provision of security of wreckage;

5) handling of human remains and personal property of the deceased;

6) preservation of evidence;

7) provision of assistance (as required) to the investigation authorities; and

8) removal and disposal of wreckage.

i) ***News media***. How the company responds to the media may affect how well the company recovers from the event. Clear instructions are required with respect to such matters as:

1) what information is protected by statute (Flight Data Recorder (FDR) data, Cockpit Voice Recorder (CVR) and ATC recordings, witness statements, etc.);

2) who may speak on behalf of the parent organization at head office and at the accident site (Public Relations Manager, Chief Executive Officer or other senior executive, manager or owner);

3) direction regarding a prepared statement for immediate response to media queries;

4) what information may or may not be released;

5) the timing and content of the company's initial statement; and

6) provisions for regular updates to the media.

j) ***Formal investigations***. Guidance for company personnel dealing with State accident investigators and police should be provided in the ERP.

k) ***Family assistance***. The ERP should also include guidance on the organization's approach to assisting the families of accident victims (crew and passengers). This guidance may cover such matters as:

1) State requirements for the provision of family assistance services;

2) travel and accommodation arrangements to visit the accident location and survivors;

3) assignment of a programme coordinator and point(s) of contact for each family;

4) provision of up-to-date information;

5) grief counselling;

6) immediate financial assistance to victims and their families; and

7) memorial services.

Some States define the types of assistance to be provided by an operator.

l) ***Post-critical incident stress counselling***. The ERP should provide guidance for personnel working in stressful situations. This may include specifying duty limits and providing for post-critical incident stress counselling.

m) ***Post-occurrence review***. Direction should be provided to ensure that following the emergency key personnel carry out a full debriefing and record all significant lessons learned. This may result in amendments being made to the ERP and associated checklists.

11.4 AIRCRAFT OPERATOR'S RESPONSIBILITIES

11.4.1 The aircraft operator's ERP should be coordinated with the aerodrome emergency plan (AEP) so that the operator's personnel know what responsibilities the airport will assume and what response is required by the operator. [1] As part of their emergency response planning, aircraft operators in conjunction with the airport operator are expected to:[2]

a) provide training to prepare personnel for emergencies;

b) make arrangements to handle incoming telephone queries concerning the emergency;

c) designate a suitable holding area for uninjured passengers and *"meeters and greeters";*

d) provide a description of duties for company personnel (e.g. person in command, and receptionists for receiving passengers in holding areas);

e) gather essential information on passengers and coordinate fulfilment of their needs;

f) develop arrangements with other operators and agencies for the provision of mutual support during the emergency; and

g) prepare and maintain an emergency kit containing:

   1) necessary administrative supplies (forms, paper, name tags, computers, etc.); and

   2) critical telephone numbers (of doctors, local hotels, linguists, caterers, airline transport companies, etc.).

11.4.2 In the event of an aircraft accident at or near the airport, an aircraft operator will be expected to take certain actions, for example:

a) report to airport command post to coordinate the aircraft operator's activities;

b) assist in the location and recovery of any flight recorders;

c) assist investigators with the identification of aircraft components and ensure that hazardous components are made safe;

1. See Chapter 18 for additional information on airport emergency response planning.
2. Also see the *Airport Services Manual* (Doc 9137), Part 7 — *Airport Emergency Planning*.

d) provide information regarding passengers, flight crew and the existence of any dangerous goods on board;

e) transport uninjured persons to the designated holding area;

f) make arrangements for any uninjured persons who may intend to continue their journey or who need accommodation or other assistance;

g) release information to the media in coordination with the airport public information officer and police; and

h) remove the aircraft and/or wreckage upon the authorization of the investigation authority.

Although the information in this paragraph is oriented towards an aircraft accident, some of the concepts also apply to emergency response planning by aerodrome operators and ATS providers.

11.5 CHECKLISTS

Everyone involved in the initial response to a major aircraft accident will experience some degree of shock. Therefore, the emergency response process lends itself to the use of checklists. These checklists can form an integral part of the company's Operations or Emergency Response Manuals. To be effective, checklists must be regularly:

a) reviewed and updated (for example, call-out lists and contact details); and

b) tested through realistic exercises.

11.6 TRAINING AND EXERCISES

An ERP is a written indication of intent. Hopefully, much of an ERP will never be tested under actual conditions. Training is required to ensure that the intentions in the ERP are backed by operational capabilities. Since training has a short *"shelf life",* regular drills and exercises are advisable. Some portions of the ERP, such as the call-out and communications plans, can be tested by "desktop" exercises. Other aspects, such as "on-site" activities involving other agencies, need to be practised at regular intervals. Conducting exercises has the advantage of demonstrating deficiencies in the plan, which can be rectified before an actual emergency occurs.

Chapter 12

ESTABLISHING A SAFETY MANAGEMENT SYSTEM

12.1 INTRODUCTION

12.1.1 Effective safety management requires a systems approach to the development of safety policies, procedures and practices to allow the organization to achieve its safety objectives. Similar to other management functions, safety management requires planning, organizing, communicating and providing direction. Safety management integrates diverse activities into a coherent whole. Follow-up will be required to evaluate and validate the appropriateness and effectiveness of the organization's safety management practices, thereby closing the safety loop.

12.1.2 There are several ways of meeting an organization's needs for safety management. There is no single model that "fits all". Size, complexity and the type of operation, as well as the corporate safety culture and operating environment, will influence the structure most suited for individual organizations and their unique circumstances. Some organizations will require a formal safety management system (SMS) (as described in Chapter 5). Others may require most of the same functions to be performed, but with a less structured approach. Some may also face resource limitations and be able to carry out only selected safety management activities.

12.1.3 This chapter focuses on the factors to be considered in establishing an SMS. The degree of formality and rigidity in the SMS should be a reflection of the organization's needs, rather than blind adherence to doctrine. It is important that the size and complexity of the SMS be appropriate for each organization. Chapter 15 discusses some of the more practical considerations for operating an SMS.

12.1.4 Before an organization can implement an effective SMS, it needs to possess an appropriate safety culture. Cultural aspects are discussed in Chapter 4. However, because of the importance of safety culture to the success of an SMS, the relevant aspects of a safety culture are further discussed in 12.2.

12.2 SAFETY CULTURE

12.2.1 Effective safety management requires more than establishing an appropriate organizational structure and promulgating rules and procedures to be followed. It requires a genuine commitment to safety on the part of senior management. The attitudes, decisions and methods of operation at the policy-making level demonstrate the priority given to safety. The initial indication of corporate commitment to safety is in the organization's stated safety policy and objectives and whether staff believe that concerns for safety might, on occasion, override production objectives.

12.2.2 A key indicator of management's commitment to safety is the adequacy of resource allocations. Establishing an appropriate management structure, assigning responsibilities and accountabilities, and allocating appropriate resources must be consistent with the organization's stated safety objectives. Sufficient experienced staff, relevant and timely training, and funding for the necessary equipment and facilities are fundamental to creating a working environment in which everyone takes safety seriously.

12.2.3 In effective safety cultures, there are clear reporting lines, clearly defined duties and well-understood procedures. Personnel fully understand their responsibilities and know what to report, to whom and when. Senior management reviews not only the financial performance of the organization but also its safety performance.

12.2.4 Safety culture, then, is both attitudinal and structural, relating to individuals and organizations. It concerns the requirement to not only perceive safety issues but match them with appropriate action. Safety culture relates to such intangibles as personal attitudes and the style of the organization. It is therefore difficult to measure, especially when the principal criterion for measuring safety is the absence of accidents and incidents. Yet, personal attitudes and corporate style enable or facilitate the unsafe acts and conditions that are the precursors to accidents and incidents.

12.3 TEN STEPS TO AN SMS

12.3.1 Starting and operating an effective process for safety management can be a daunting task. Taking a systems approach will help ensure that the elements necessary for building an effective system are present. Ten steps for integrating the various elements into a coherent SMS are discussed in this section. It would be an overwhelming, if not impossible task to implement all the functions of an SMS simultaneously. Rather, the steps may be addressed gradually. This would allow the organization to adapt to, and become acquainted with, the requirements and results of each step before proceeding.

12.3.2 While there is a certain logic to the sequence of the steps as outlined, it is not prescriptive. Particular steps may be delayed pending a more suitable time. As the various steps are implemented, progress may be monitored using the confirmation checklist provided at each step to highlight the necessary actions.

STEP 1: PLANNING

Consistent with general management practice, safety management begins with careful planning. An organization striving to improve its safety management processes may be well served by appointing a group of key line managers and the person most likely to be designated as the organization's safety manager (SM) to conduct this planning phase.

Review

The planning (or establishment) group may be able to build upon existing strengths by taking stock of the organization's current capabilities for safety management (including experience, knowledge, processes, procedures, resources, etc.). Shortcomings in safety management experience must be recognized and resources to assist in development and implementation of the SMS identified. Many operational units may already have internal procedures in place for the investigation of incidents, hazard identification, safety monitoring, etc. These should be reviewed and perhaps modified for integration within the SMS. It is important that the organization re-use as many existing procedures as practicable, as there is no need to replace known and effective procedures and processes. By building on such an experience base, the development of an SMS will be less disruptive. During this review process, the planning group should also examine best industry practices for safety management by consulting with other organizations of similar size and mission.

Safety assessment

The design and implementation of an SMS will likely be a major change to the organization, which is capable of generating new safety hazards. One tool that may assist the planning group at this time is the safety assessment (as described in Chapter 13). The synergy of a group of experienced managers systematically questioning and challenging all aspects of the organization's current and planned approach to safety management should reduce the risk of surprises in implementing the SMS, enhance the group's knowledge of the current situation and requirements, and prepare the way for effectively implementing change.

Safety performance indicators and safety targets

The planning group should define safety performance indicators and set safety performance targets for the organization (as discussed in Chapters 1 and 5). These indicators and targets must be realistic — taking into account the organization's size, complexity, type of operation, resource base, etc. A realistic time line for meeting the targets must also be agreed upon. Even though setting the indicators and targets may be difficult, they provide the basis for evaluating the success of the SMS.

Safety strategy

Based on the agreed safety targets, the planning group can develop a realistic strategy for meeting those needs. The strategy should combine both reactive and proactive elements (as described in Chapter 5). Consideration should be given to the types of safety processes and safety activities that will be sought (as outlined in the following steps). Depending on the number of new initiatives being considered and the resource availability, a phased approach may be desirable. The strategy may also define the degree of formality the organization requires with respect to its *"system for managing safety"*. Senior management's input is required during the development of the strategy.

The plan

The planning phase should result in a detailed plan for the development and implementation of the SMS. Typically, the planning time frame will be one to three years. The plan should consider such aspects as safety objectives, safety strategy, safety management processes and activities, resource implications and time lines.

Confirmation Checklist #1
PLANNING

- A safety planning group and safety manager have been designated.
- The planning group:

  — comprises an appropriate experience base;
  — meets regularly with senior management; and
  — receives resources (including time for meetings).

- The planning group develops a realistic strategy and implementation plan for an SMS that will meet the organization's safety needs.
- Senior management endorses the plan.

STEP 2: SENIOR MANAGEMENT'S COMMITMENT TO SAFETY

The ultimate responsibility for safety rests with the directors and senior management of the organization. The whole ethos of an organization's attitude to safety — its safety culture — is established from the outset by the extent to which senior management accepts responsibility for safe operations, particularly the proactive management of risk.

Regardless of the size, complexity or type of operation, the success of the SMS depends on the extent to which senior management devotes the necessary time, resources and attention to safety as a core management issue. Here, actions speak louder than words. What management visibly does for safety will determine the safety culture (and hence the safety performance) of the organization.

Safety policies and objectives set out what the organization is striving to achieve and how it is going to get there. Management's commitment to safety is first demonstrated to all personnel of the organization through its stated safety policy and objectives.

Safety policy

Management's commitment to safety should be formally expressed in a statement of the organization's *safety policy.* This should reflect the organization's philosophy of safety management and become the foundation on which the organization's SMS is built. The safety policy outlines the methods and processes that the organization will use to achieve desired safety outcomes, and it serves as a reminder as to *"how we do business here"*. The creation of a positive safety culture begins with the issuance of a clear, unequivocal direction.

A safety policy may take different forms but will typically include statements concerning:

— the overall safety objective of the organization;

— the commitment of senior management to the goal of ensuring that all aspects of the operation meet safety performance targets;

— a commitment by the organization to provide the necessary resources for the effective management of safety;

— a commitment by the organization to make the maintenance of safety its highest priority; and

— the organization's policy concerning responsibility and accountability for safety at all levels of the organization.

The safety policy should be a written document that is issued under the authority of the highest level of management of the organization, approved by the regulator and communicated to all staff. A sample corporate safety policy statement is included in Appendix 1 to this chapter. This statement presents a tangible indication of senior management's commitment to safety. An alternative to this type of safety policy is a statement of commitment by the Chief Executive Officer (CEO) to the maintenance of the highest standards of safety. An example of topics that might be included in a CEO's statement of commitment to safety is included in Appendix 2 to this chapter.

In preparing a safety policy, senior management should consult widely with key staff members in charge of safety-critical areas. Consultation ensures that the document is relevant to staff and gives them a sense of ownership in it. Corporate safety policy must also be consistent with relevant State regulations.

Safety objectives

Related closely to safety policy (and safety culture) is how an organization sets its safety objectives. Clearly stated objectives can lead to a commitment to action that will enhance the safety of the organization. Exceptional organizations set their objectives formally — clearly enunciating their vision, defining desired outcomes, spelling out the attainable steps for meeting the objectives, and documenting the process. They have agreed to relevant safety performance indicators and have adopted realistic safety performance targets.

Confirmation Checklist #2
SENIOR MANAGEMENT'S COMMITMENT TO SAFETY

- Senior management is involved in, and committed to, the SMS.
- Senior management has approved the organization's safety policy and safety objectives, the SMS implementation plan and operational safety standards.
- These are communicated to all staff, with visible endorsement by senior management.
- The safety policy has been developed by management and staff and signed by the CEO. The safety policy:
  - — enjoys the commitment and involvement of all staff;
  - — aligns with other operational policies;
  - — provides direction for implementing the policy;
  - — states the responsibilities and accountabilities for directors, managers and employees;
  - — is reflected in the actions and decisions of all staff;
  - — has been communicated to all staff; and
  - — is reviewed periodically.
- Safety objectives and goals are practical and achievable, and they are regularly reviewed for relevance.
- Performance standards (including deadlines) are established.
- Responsibilities for actions are clearly understood.
- Managers follow through and hold those responsible to account for their progress towards the safety goals.
- Appropriate resources are allocated to support the safety manager.
- Senior management commits resources to correct hazards posing unacceptable risks.
- Senior management has established an appropriate reporting chain for safety issues.
- Senior management actively encourages participation in the various safety programmes of the SMS.
- Senior management promotes a positive safety culture whereby:
  - — safety information is actively sought;
  - — personnel are trained for their safety responsibilities;
  - — safety is a shared responsibility;
  - — safety-related information is disseminated to all affected personnel;
  - — potential system failures and hazards lead to prompt managerial inquiries and any necessary reforms;
  - — a formal programme is in place to regularly assess safety performance; and
  - — new ideas related to safety are welcomed.

STEP 3: ORGANIZATION

How an organization arranges its method of conducting business and managing safety will influence its resilience to misadventure (or hazardous situations) and its ability to reduce risks. Several considerations are fundamental to establishing an effective organization that will support the SMS, for example:

— appointing an SM;

— having an organizational structure that facilitates safety management;

— having a statement of responsibilities and accountabilities;

— creating a safety committee; and

— ensuring training and competency.

Safety manager (SM)

One of the first tasks in establishing an SMS is to appoint an SM. Safety management activities need a focal point (or champion) as the driving force for the systemic changes necessary to effect safety across the entire organization. In most organizations, this function is best accomplished by the appointment of a full-time SM as part of the organization's management team. The SM's responsibilities include promoting safety awareness and ensuring that safety management has the same level of priority throughout the organization as any other process. However, in small organizations, the SM's role may fall within the responsibilities of the manager of the organization.

Safety management is a responsibility that is shared by each line manager and supported by the SM. Specific safety activities are the line managers' responsibilities. Senior management must not hold the SM accountable for line managers' responsibilities; rather, the SM is accountable for rendering effective staff support to all line managers to ensure the success of the organization's SMS. While the SM may be held accountable for any deficiencies in the SMS itself, the SM should not be accountable for the safety performance of the organization.

Ideally, the SM should have no responsibilities other than safety. This would generally be the case in large organizations where a full-time SM position can be justified. In smaller organizations, safety management may have to be the responsibility of a manager who also has other duties. In such cases, in order to avoid possible conflicts of interest, it would be preferable that the person responsible for safety management did not also have direct responsibility for any of the operational or engineering areas. Whether the SM position is a full-time one or forms only part of the responsibilities of the designated manager, the duties and responsibilities of the position will be the same. Regardless, the SM is a member of the overall management team of the organization and needs to be at a sufficiently high level in the management hierarchy to be able to communicate directly with other senior managers.

The SM should be responsible for managing all aspects of the operation of the SMS. This would include ensuring that safety documentation accurately reflects the current environment, monitoring the effectiveness of corrective actions, providing periodic reports on safety performance, and providing independent advice to the CEO, senior managers and other personnel on safety-related matters.

A sample job description for an SM is included in Appendix 1 to Chapter 15.

Organizational structure and statement of responsibilities and accountabilities

Two approaches to an operator's organizational structure that are consistent with the requirements for managing safety are outlined in Figures 12-1 and 12-2. Both are designed to support a coherent SMS.

Sample A in Figure 12-1 is typical of many organizations with good safety records. The Flight Safety Officer (FSO) reports directly to the Director of Flight Operations. However, the FSO does not have responsibilities for safety management in other departments. To cover considerations of safety in maintenance, a Maintenance Safety Officer, reporting directly to the Director of Maintenance, coordinates informally with the FSO through the *"safety office"*. Although the organizational chart depicts an informal reporting relationship from the safety office to the executive level, this structure does not truly promote a systems approach to safety management. Rather, the organization focuses on safety issues from the perspectives of flight operations and maintenance only.

In Sample B depicted in Figure 12-2, both the SM and the Quality Manager perform the SMS functions. However, they both have a direct reporting line to the CEO. The safety functions are dispersed throughout the organization to the Operations, Maintenance and other departments. The SM and the Quality Manager then coordinate with each other and the departmental chiefs, assisting them in the fulfilment of their safety management functions. Sample B broadens the focus over that of Sample A and is more consistent with the systems approach to safety management.

Changes to the organizational structure should be assessed to determine whether there is any effect on safety responsibilities and accountabilities. Any necessary amendments to previous responsibilities and accountabilities should be properly documented.

Safety committee

In addition to the need for a group of line managers to carry out the initial planning for an SMS (Step 1), it may also be desirable to establish a safety committee. The need for, and structure of, safety committees depend on the size of the organization. In small organizations, where there are relatively few levels in the organizational structure between the working and senior management levels, there may be less need to establish a safety committee.

A safety committee would typically be established at the senior management level and should include the SM as well as other senior managers. The objective of the safety committee is to provide a forum to discuss issues related to the safety performance of the organization and the health of the SMS. The safety committee makes recommendations concerning safety policy decisions, and reviews safety performance results. During the initial implementation phase of an SMS, the safety committee would also review progress of the implementation process. The terms of reference for the safety committee should be documented in the organization's safety management manual.

Additional guidance on safety committees is included in Chapter 15.

Training and competency

Having staff who are competent for the jobs they are performing is a fundamental prerequisite for safety. Competency requirements and, where appropriate, licensing requirements should be documented in the job description for each safety-related position. These requirements should then be reflected in the recruitment requirements and internal training for these positions.

All line managers should be accountable for ensuring the continuing competence of the personnel in safety-related positions within their areas of responsibility. This includes ensuring that any recurrent training requirements are met.

All training programmes should include training in those aspects of the SMS and associated procedures that are relevant to the position in question.

Guidance on safety management training is included in Chapter 15.

Confirmation Checklist #3
ORGANIZATION

- The organizational structure facilitates:
  - lines of communication between the SM and the CEO and with the line managers;
  - a clear definition of authorities, accountabilities and responsibilities, thereby avoiding misunderstanding, overlap and conflict (e.g. between the SM and line management); and
  - hazard identification and safety oversight.
- An SM (with appropriate competencies and capacity) has been appointed.
- The roles and responsibilities of the SM (and any staff) are clearly defined and documented.
- A safety committee meets regularly to review safety results and make recommendations to senior management.
- The SM (and any staff) has (have) received appropriate safety training.
- Staff and management understand and support the roles of the SM, and the SM receives the CEO's support.

STEP 4: HAZARD IDENTIFICATION

The risks and costs inherent in commercial aviation necessitate a rational process for decision-making. Implementation of risk management processes is critical to an effective safety management programme. Risks cannot always be eliminated, nor are all conceivable safety management measures economically feasible. Risk management facilitates this balancing act, beginning with hazard identification.

As outlined in Chapter 5, the creation and operation of effective hazard identification programmes are fundamental to effective safety management. An organization may draw from a broad choice of safety activities to identify hazards or safety issues warranting further action. Some of these issues may derive from specific safety hazards that place a part of the operation in jeopardy. Other issues warranting attention may derive from organizational shortcomings, whereby systemic safety defences that should be working are not.

Hazard identification may be reactive or proactive in nature. Trend monitoring, occurrence reporting and investigations are essentially reactive. Other hazard identification processes actively seek feedback by

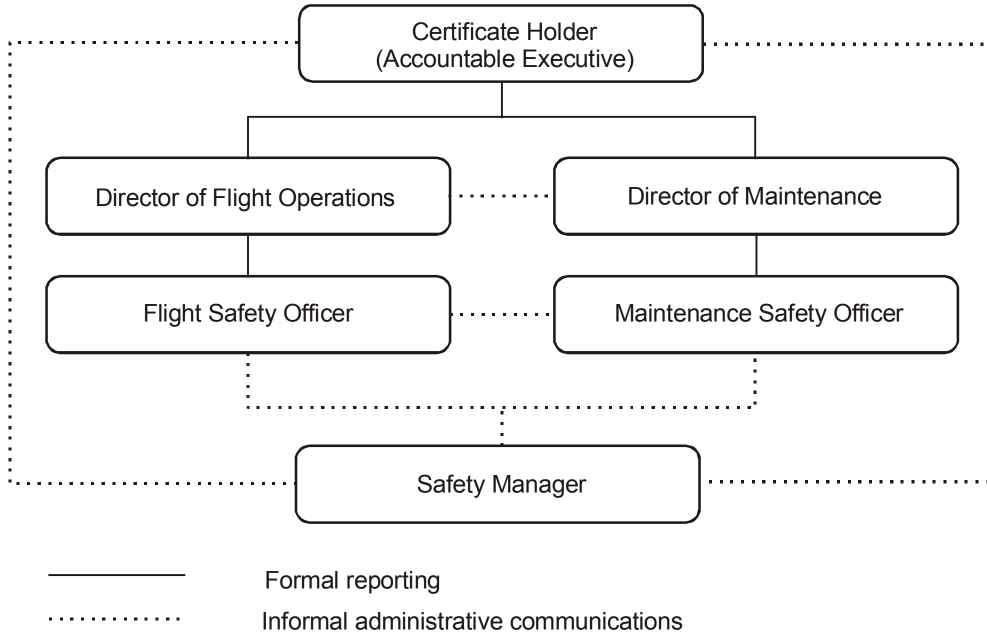

Figure 12-1. An operator's organization for safety management: Sample A

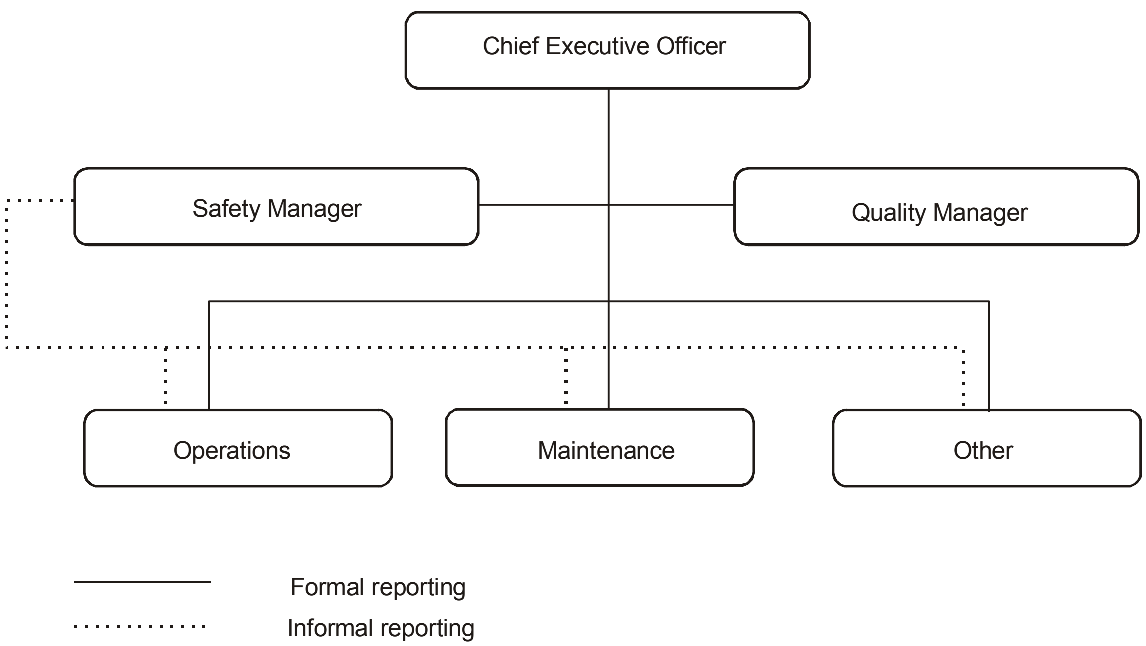

Figure 12-2. An operator's organization for safety management: Sample B

observing and analysing routine day-to-day operations. Some of the more common safety activities that might be subject to formal processes within the organization are listed below:

— safety assessments;

— trend monitoring;

— incident reporting;

— safety surveys and audits; and

— proactive hazard identification processes (such as FDA, LOSA and NOSS).

Chapters 16 and 17 outline several safety processes known to be effective in hazard identification. An organization's willingness to utilize several different hazard identification processes is an example of its commitment to safety.

To be successful, the hazard identification process must take place within a non-punitive (or just) safety culture. Management's interest is in learning of potential weaknesses in the system's safety net that could lead to an accident or otherwise compromise the efficiency of the operation. Blame is only an issue when individuals are culpable of reckless or negligent behaviour. If workers operate in a climate of fear of punishment for normal slips, lapses and mistakes in their daily duties, errors and unsafe conditions are likely to remain hidden.

Confirmation Checklist #4
HAZARD IDENTIFICATION

- Formal mechanisms (such as safety assessments and safety audits) are in place for the systematic identification of hazards.
- An occurrence reporting system is in effect, including a voluntary incident reporting system.
- Management has provided adequate resources for hazard identification.
- Staff receive necessary training to support the hazard identification programmes.
- Competent personnel administer the hazard identification programmes, keeping them relevant to current operations.
- Staff involved in any recorded or reported incidents are aware that they will not be penalized for normal errors; a non-punitive (just) environment is fostered by management.
- All identified hazard data are systematically recorded, stored and analysed.
- Security measures are in place to protect sensitive material.

STEP 5: RISK MANAGEMENT

Risk management comprises three essential elements: hazard identification, risk assessment and risk mitigation. It requires the analysis and elimination (or at least a reduction to an acceptable level) of those hazards that threaten the viability of an organization. Risk management serves to focus safety efforts on those hazards posing the greatest risks. All identified hazards are critically assessed and ranked in order of their risk potential. They may be assessed subjectively by experienced personnel, or they may be assessed using more formal techniques, often requiring analytical expertise.

Factors to consider are the likelihood of the occurrence and the severity of the consequences should there be an occurrence. In assessing risks, the defences that have been put in place to protect against hazards need to be evaluated. These defences can, through their absence, misuse, poor design, or conditions, contribute to the occurrence or exacerbate the risks. Through such a risk assessment process, a determination can be made as to whether the risk is being appropriately managed or controlled. If the risks are acceptable, the operation may continue. If the risks are unacceptable, then steps should be taken to increase the defences or to remove or avoid the hazard.

Typically, there is a range of risk control measures that may help limit exposure to identified risks. Each risk control option needs to be evaluated, the residual risks need to be assessed and the cost-benefits need to be analysed. Having decided upon a course of action, management must then communicate its safety concerns and planned actions to all affected persons.

Risk management is discussed more fully in Chapter 6.

Confirmation Checklist #5
RISK MANAGEMENT

- Criteria are established for assessing risks.
- Risks are analysed and ranked by competent personnel (including experienced staff representatives).
- Viable risk control measures are evaluated.
- Management takes action to reduce, eliminate or avoid the risks.
- Staff are aware of the actions taken to avoid or eliminate identified hazards.
- Procedures are in place to confirm that the actions taken are working as intended.

STEP 6: INVESTIGATION CAPABILITY

The investigation of safety occurrences often reveals that there had been a number of warning signs or precursors. Investigations of occurrences can identify the warning signs, enabling similar warning signs to be recognized in the future before they lead to safety occurrences.

While the State may investigate mandatorily reportable accidents and serious incidents, an effective SMS includes the capability to investigate such occurrences from an organization's perspective. The safety management value of these investigations is proportional to the quality of the investigative effort. Without a structured methodology, it is difficult to integrate and analyse all pertinent information from such investigations in order to efficiently assess and prioritize the risks and to recommend any necessary actions to advance safety. Determination of blame is not relevant to such safety investigations.

Identifying the lessons to be learned from a safety occurrence requires an understanding of not just *what* happened, but *why* it happened. A complete understanding of why an occurrence happened requires an investigation that looks beyond the obvious causes and focuses on identifying all the contributory factors, some of which may be related to weaknesses in the system's defences or other organizational issues.

Chapter 8 contains further information on safety investigations.

Confirmation Checklist #6
INVESTIGATION CAPABILITY

- Key operational staff have received formal training in safety investigations.
- Each hazard and incident report is evaluated with further safety investigation as necessary.
- Management supports the acquisition and analysis of safety information.
- Management takes an active interest in investigation findings and applies risk management procedures for identified hazards.
- Safety lessons learned are widely disseminated.
- The regulatory authority is apprised of significant safety concerns potentially affecting other operators or requiring action by the regulatory authority.

STEP 7: SAFETY ANALYSIS CAPABILITY

Safety analysis is the process of organizing and evaluating facts objectively. Following the basic rules of logic and drawing upon recognized methodologies and analytical tools, facts are considered in a systematic way in order that valid conclusions can be made. Safety analysis differs from the adversarial argument of the courts in that all sides of any situation are evaluated. When done well, others following the same line of reasoning will reach the same conclusions.

Safety analysis has application in such areas as:

a) trend analysis;

b) occurrence investigation;

c) hazard identification;

d) risk assessment;

e) evaluation of risk mitigation measures; and

f) monitoring of safety performance.

Safety analysis requires particular skills and experience. Providing convincing arguments for change depends on solid analytical capabilities. Chapter 9 contains further information on safety analysis.

Confirmation Checklist #7
SAFETY ANALYSIS CAPABILITY

- The SM is experienced or has received training in analytical methods, or has access to competent safety analysts.
- Analytical tools (and specialist support) are available to support safety analyses.
- The organization maintains a credible safety database.
- Other information sources are accessible.
- Hazard information and performance data are routinely monitored (trend analysis, etc.).
- Safety analyses are subject to a challenge process (peer review).
- Safety recommendations are made to management, and corrective actions are taken and tracked to ensure that they are appropriate and effective.

STEP 8: SAFETY PROMOTION AND TRAINING

Keeping staff informed about current safety issues through relevant training, safety literature, participation in safety courses and seminars, etc. improves the safety health of the organization. The provision of appropriate training to all staff (regardless of their professional discipline) is an indication of management's commitment to an effective SMS. (Weak management may see training as an expense rather than as an investment in the future viability of the organization.)

New employees need to know what is required of them and how the organization's SMS functions. Initial training should emphasize "how we do business here". More experienced employees may need refresher training for particular safety processes where their direct involvement may be required, such as FDA, LOSA or NOSS. Regardless of their experience level, all employees benefit from feedback on hazards identified, safety actions taken, safety lessons learned, etc.

The SM is the logical resource person for providing a corporate perspective on the organization's approach to safety management. A variety of tools are available to assist the SM with respect to the safety promotional role. (See Chapter 15 for guidance in this area.)

Confirmation Checklist #8
SAFETY PROMOTION AND TRAINING

- Management recognizes that all levels of the organization require training in safety management and that the needs vary across the organization.
- Job descriptions reflect competency requirements.
- All personnel receive safety indoctrination training and participate in specific ongoing training for safety management.
- The organization has an effective programme for the timely promotion of safety issues.
- Staff are aware of their role in the elements of the SMS pertinent to their duties.
- Additional safety awareness training is provided when the operating environment changes (seasonal changes and changes in operational conditions, regulatory requirements, etc.).
- Staff understand that safety management has nothing to do with attributing blame.

STEP 9: SAFETY MANAGEMENT DOCUMENTATION AND INFORMATION MANAGEMENT

To ensure responsible safety management, successful organizations follow a disciplined approach to documentation and information management. Formal documentation is required to provide the authoritative basis for the SMS — clarifying the relationship of safety management to the other functions of the organization, the way in which safety management activities integrate with these other functions and how the safety management activities relate to the organization's safety policy. Typically, this information is documented in a safety management manual.

Operating an SMS generates significant amounts of information — some as documents and some as data in electronic format, for example, occurrence reports and hazard identification notices. With careful management, this information can serve the SMS well, particularly the risk management process. Without the tools and skills to record, store, secure and retrieve the necessary information, such information is essentially useless and its collection a waste of time. (Chapters 9 and 15 include guidance for the use and management of safety data and information.)

It is important that the organization maintain a record of the measures taken to fulfil the objectives of the SMS. A record of the measures taken to control risks and to ensure that adequate levels of safety are maintained may be required in the event of a State investigation of an accident or serious incident. These records should be maintained in sufficient detail to ensure traceability of all safety-related decisions.

The organization's safety management manual should provide the guidance necessary for incorporating the organization's safety activities into a coherent, integrated safety system. It provides management with the instrument for communicating the organization's approach to safety of the whole organization. The manual should document all aspects of the SMS, including the safety policy, individual safety accountabilities, safety procedures, etc.

Confirmation Checklist #9
SAFETY MANAGEMENT DOCUMENTATION AND INFORMATION MANAGEMENT

- Management supports the need for careful documentation and data control.
- The SMS is well documented in a safety management manual.
- Documents are updated regularly and are readily available to those who need them.
- Credible measures have been taken for the protection of sensitive safety information.
- Appropriate equipment and technical support are available for managing safety information.
- Safety databases are used to support safety analyses and performance monitoring.
- Appropriate staff have access to safety databases.
- Staff have received the necessary training for using and maintaining the safety information management system.

STEP 10: SAFETY OVERSIGHT AND SAFETY PERFORMANCE MONITORING

A systems approach to safety management requires *"closing the loop"*. Feedback is necessary to assess how well the first nine steps are working. This is achieved through safety oversight and safety performance monitoring.

Safety oversight can be achieved through inspections, surveys and audits. Are people doing what they are supposed to be doing? In many large organizations, formal safety audits are regularly conducted as a method of providing oversight of day-to-day operations. Safety audits assure staff and management that the organization's activities are being performed as required (i.e. safely). Smaller organizations may acquire the necessary feedback less formally, e.g. through informal observations and discussions with personnel.

Safety performance monitoring validates the SMS, confirming not only that people were doing what they were supposed to be doing but also that their collective efforts have achieved the organization's safety objectives. Through regular review and evaluation, management can pursue continuous improvements in safety management and ensure that the SMS remains effective and relevant to the organization's operation.

Chapter 10 provides guidance on fulfilling safety oversight and safety performance monitoring.

Confirmation Checklist #10
SAFETY OVERSIGHT AND SAFETY PERFORMANCE MONITORING

- Safety performance indicators are agreed upon and realistic safety targets established.
- Adequate resources are allocated to the safety oversight and safety performance monitoring functions.
- Staff input is sought and provided without fear of repercussion.
- Regular safety audits are conducted in all operational areas of the organization (including the activities of contracting agencies).
- Safety oversight includes the systematic review of all available feedback, for example, safety assessments, quality assurance programme results, safety trend analyses, safety surveys and safety audits.
- Findings are communicated to staff, and reform measures are implemented as required to strengthen the system.

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Appendix 1 to Chapter 12

SAMPLE SAFETY POLICY STATEMENT

Safety is the first priority in all our activities. We are committed to implementing, developing and improving strategies, management systems and processes to ensure that all our aviation activities uphold the highest level of safety performance and meet national and international standards.

Our commitment is to:

a) Develop and embed a safety culture in all our aviation activities that recognizes the importance and value of effective aviation safety management and acknowledges at all times that safety is paramount;

b) Clearly define for all staff their accountabilities and responsibilities for the development and delivery of aviation safety strategy and performance;

c) Minimize the risks associated with aircraft operations to a point that is as low as reasonably practicable/achievable;

d) Ensure that externally supplied systems and services that impact upon the safety of our operations meet appropriate safety standards;

e) Actively develop and improve our safety processes to conform to world-class standards;

f) Comply with and, wherever possible, exceed legislative and regulatory requirements and standards;

g) Ensure that all staff are provided with adequate and appropriate aviation safety information and training, are competent in safety matters and are only allocated tasks commensurate with their skills;

h) Ensure that sufficient skilled and trained resources are available to implement safety strategy and policy;

i) Establish and measure our safety performance against realistic objectives and/or targets;

j) Achieve the highest levels of safety standards and performance in all our aviation activities;

k) Continually improve our safety performance;

l) Conduct safety and management reviews and ensure that relevant action is taken; and

m) Ensure that the application of effective aviation safety management systems is integral to all our aviation activities, with the objective of achieving the highest levels of safety standards and performance.

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Appendix 2 to Chapter 12

SUGGESTED TOPICS TO BE INCLUDED IN A CEO STATEMENT OF CORPORATE SAFETY COMMITMENT

Listed below are topics that are frequently covered in statements of corporate safety commitment. Following each topic are subjects that are commonly addressed to amplify the corporate position on that topic.

a) **Core values**. Among our core values, we will include:

   1) safety, health and the environment;

   2) ethical behaviour; and

   3) valuing people.

b) **Fundamental safety beliefs**. Our fundamental safety beliefs are:

   1) Safety is a core business and personal value.

   2) Safety is a source of our competitive advantage.

   3) Our business will be strengthened by making safety excellence an integral part of all aviation activities.

   4) All accidents and serious incidents are preventable.

   5) All levels of line management are accountable for our safety performance, starting with the Chief Executive Officer (CEO)/Managing Director.

c) **Core elements of our safety approach**. The five core elements of our safety approach include:

   1) ***Top management commitment:***

      — Safety excellence will be a component of our mission.

      — Senior management will hold line management and all employees accountable for safety performance.

   2) ***Responsibility and accountability of all employees:***

      — Safety performance will be an important part of our management/employee evaluation system.

      — We will recognize and reward safety performance.

      — Before any work is done, we will make everyone aware of the safety rules and processes, as well as each one's personal responsibility to observe them.

3) ***Clearly communicated expectations of zero accidents:***

— We will have a formal written safety goal, and we will ensure that everyone understands and accepts that goal.

— We will have a communications and motivation system in place to keep our employees focused on the safety goal.

4) ***Auditing and measuring performance for improvement:***

— Management will ensure that regular safety audits are conducted.

— We will focus our audits on the behaviour of people, as well as on the conditions of the workplaces.

— We will establish performance indicators to help us evaluate our safety performance.

5) ***Responsibility of all employees:***

— Each of us will be expected to accept responsibility and accountability for our own behaviour.

— Each of us will have an opportunity to participate in developing safety standards and procedures.

— We will openly communicate information about safety incidents and will share the lessons learned with others.

— Each of us will be concerned for the safety of others in our organization.

d) **Objectives of the safety process.** Our objectives include:

1) ALL levels of management will be clearly committed to safety.

2) We will have clear employee safety metrics, with clear accountability.

3) We will have open safety communications.

4) We will involve all relevant staff in the decision-making process.

5) We will provide the necessary training to build and maintain meaningful safety leadership skills.

6) The safety of our employees, customers and suppliers will be a strategic issue of the organization.

Signed: ____________________________________
CEO/Managing Director/or as appropriate

Chapter 13

SAFETY ASSESSMENTS

13.1 OVERVIEW

13.1.1 Safety management provides the means by which organizations can control the processes that could lead to hazardous events, in order to ensure that the risk of harm or damage is limited to an acceptable level. Much of this activity focuses on hazards as they are identified through such processes and activities as the investigation of safety occurrences, incident reporting systems and safety oversight programmes. Safety assessments provide another proactive mechanism for identifying potential hazards and finding ways to control the risks associated with them.

13.1.2 A safety assessment should be undertaken prior to the implementation of any major change potentially affecting the safety of operations in order to demonstrate that the change meets an acceptable level of safety. For example, when major changes involving operating procedures, equipment acquisition or configuration, organizational working relationships, etc. are planned, a safety assessment may be warranted. Annex 11 — *Air Traffic Services* requires that any significant safety-related change to the ATC system shall be implemented only after a safety assessment has demonstrated that an acceptable level of safety will be maintained.[1] Similar requirements in respect of any change in an aerodrome operating environment exist in Annex 14 — *Aerodromes,* Volume I — *Aerodrome Design and Operations*, and in the guidance material provided in the *Manual on Certification of Aerodromes* (Doc 9774). The scope of a safety assessment must be wide enough to cover all aspects of the system that may be affected by the change, either directly or indirectly, and should include human, equipment and procedural elements.

13.1.3 If the result of an assessment is that the system under review does not satisfy the safety assessment criteria, it will be necessary to find some means of modifying the system in order to reduce the risk. This process is called *risk mitigation*. The development of mitigation measures becomes an integral part of the assessment process. The adequacy of proposed mitigation measures should be tested by re-evaluating what the risk would be with the mitigation measures in place. (Chapter 6 provides further guidance on the risk management process.)

13.1.4 The process of safety assessment aims to answer the following three fundamental questions:

a) What could go wrong?

b) What would be the consequences?

c) How often is it likely to occur?

13.1.5 Once a safety assessment is completed, it should be signed-off by the responsible manager, indicating that the manager is satisfied that the assessment has been properly performed and that the level

1. More specific information on the circumstances in which a safety assessment could be required in ATS can be found in the *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM, Doc 4444), Chapter 2, Section 2.6.

of risk is acceptable. For the manager to be able to make an informed decision concerning this, the safety assessment must be well documented. The documentation should be retained to provide a record of the basis on which the acceptance decision was made.

13.1.6 The implementation of a safety assessment programme requires the organization to:

a) identify requirements as to when safety assessments must be performed;

b) develop procedures for performing safety assessments;

c) develop organizational risk classification criteria for identified hazards;

d) develop acceptance criteria for safety assessments; and

e) develop documentation requirements and processes for retaining and disseminating safety information acquired through the assessments.

13.2 THE SAFETY ASSESSMENT PROCESS

13.2.1 Chapter 6 introduced the two-dimensional concept of risk: the perceived risk associated with a hazardous event depends on both the ***likelihood*** of occurrence of the event, and the ***severity*** of its consequences. The safety assessment process addresses both these factors. Safety assessments are a particular application of the risk management process, building upon the systematic processes of risk management described in Chapter 6. The safety assessment process can be divided into seven steps as outlined in Table 13-1.

13.2.2 Figure 13-1 illustrates the safety assessment process diagrammatically, and shows the possible need to perform a number of cycles of the process until a satisfactory method of risk mitigation is found.

Table 13-1. Seven steps for safety assessment

Step 1:	Development (or procurement) of a complete description of the system to be evaluated and of the environment in which the system is to be operated;
Step 2:	Identification of hazards;
Step 3:	Estimation of the severity of the consequences of a hazard occurring;
Step 4:	Estimation of the likelihood of a hazard occurring;
Step 5:	Evaluation of risk;
Step 6:	Mitigation of risk; and
Step 7:	Development of safety assessment documentation.

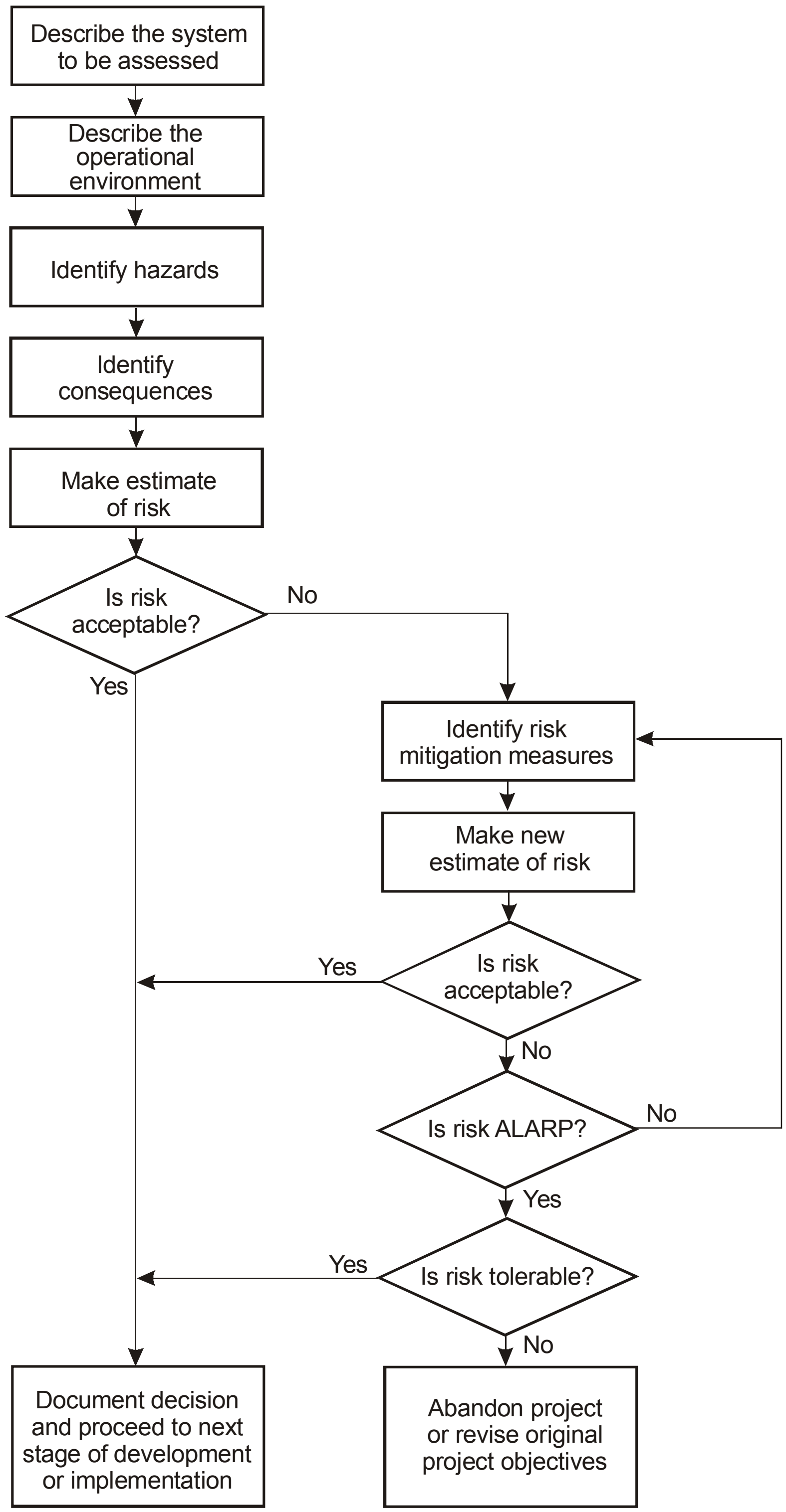

Figure 13-1. The safety assessment process

13.2.3 Not surprisingly, the safety assessment process closely parallels the risk management process described in Chapter 6. The remainder of this chapter will examine each of the seven steps of a safety assessment in more detail.

STEP 1: DEVELOPMENT OF A COMPLETE DESCRIPTION OF THE SYSTEM TO BE EVALUATED AND OF THE ENVIRONMENT IN WHICH THE SYSTEM IS TO BE OPERATED

The "system", as defined for the purpose of safety assessment, will always be a sub-component of some larger system. For example, even if the assessment encompasses all services provided within an aerodrome, this can be considered a sub-component of a larger regional system, which in turn is a sub-component of the global aviation system.

If all potential hazards are to be identified, the persons involved in the safety assessment must have a good understanding of the proposed new system or change, and how it will interface with the other components of the overall system, of which it is a part. This is why the first step in the safety assessment process is to prepare a description of the proposed system or change.

The hazard identification process can only identify hazards that come within the scope of the system description. The boundaries of the system must therefore be sufficiently wide to encompass all possible impacts that the system could have. In particular, it is important that the description include the interfaces with the larger system, of which the system being assessed is a part.

A detailed description of the system should include:

a) the purpose of the system;

b) how the system will be used;

c) the system's functions;

d) the system's boundaries and the external interfaces; and

e) the environment in which the system will operate.

The safety impact of a potential loss or degradation of the system will be determined, in part, by the characteristics of the operational environment in which the system will be integrated. The description of the environment should therefore include any factors that could have a significant effect on safety. These factors will vary from one case to another. They could include, for example, traffic characteristics, airport infrastructure and weather-related factors.

The description of the system should also address contingency procedures and other non-normal operations, for example, failure of communications or navigation aids.

For large-scale projects, the system description should address the strategy for transition from the old to the new system. For example, will the existing system be de-commissioned and replaced immediately with the new system, or will the two be operated in parallel for a period of time?

STEP 2: IDENTIFICATION OF HAZARDS

The hazard identification step should consider all possible sources of system failure. Depending on the nature and size of the system under consideration, these could include the following:

a) equipment (hardware and software);

b) operating environment (e.g. physical conditions, airspace and air route design);

c) human operators;

d) human/machine interface;

e) operational procedures;

f) maintenance procedures; and

g) external services.

All possible configurations of the system should be considered. It is important to also analyse the impact that any construction will have on daily operations. A list of the types of issues to be taken into consideration in the development phase of an aerodrome, where construction may have an impact on daily operations, is provided in Table 13-2.

Table 13-2. Typical impact of aerodrome construction on operations

Examples of impact issues
▪ How will the various airport surfaces, and those of the navigation and electronic equipment, be protected from the construction work, vehicles and storage areas?
▪ What temporary operating, ATC and engineering procedures need to be established?
▪ What will be the daily/nightly start, control and completion of the work procedures? These should include: — reference to an inspection of the works prior to return to operation, if applicable, and who is to be responsible on behalf of the aerodrome for ensuring that this is carried out; — the chosen method of communication between ATC tower and the site; and — how long after the last departure and before the first arrival will the work commence and cease respectively.
▪ What procedures will be adopted should the weather deteriorate, and what actions need to be considered prior to the onset of low visibility procedures?
▪ What action will be taken should an emergency occur?

All persons involved in the hazard identification process should be aware of the significance of latent conditions (described in Chapter 4), as these are not usually obvious. The process should specifically address questions such as, "how might staff misinterpret this new procedure?" or "how might a person misuse this new function/system (intentionally or unintentionally)?"

The hazard identification step should be initiated at the earliest possible stage in the project. For large-scale projects, there may be several hazard identification sessions at different stages of the project development. The level of detail required depends on the complexity of the system under consideration and the stage of the system life cycle at which the assessment is being done. In general, it could be expected that less detail would be required for an assessment carried out during the operational requirement definition stage than for one during the detailed design stage.

Hazard identification sessions

A structured approach to the identification of hazards ensures that, as much as possible, all potential hazards are identified. Suitable techniques for ensuring such a structured approach might include:

a) ***Checklists.*** Review experience and available data from accidents, incidents or similar systems and draw up a hazard checklist. Potentially hazardous areas will require further evaluation.

b) ***Group review.*** Group sessions may be used to review the hazard checklist, to brainstorm hazards more broadly, or to conduct a detailed scenario analysis.

Hazard identification sessions require a range of experienced operational and technical personnel, and are usually done through a form of managed group discussion. A facilitator who is familiar with the techniques should manage the group sessions. A safety manager, if appointed, would normally fill this role. Appendix 1 to this chapter includes further guidance on the conduct of group sessions for hazard analysis.

The role of the facilitator is not an easy one. The facilitator must guide the discussions towards a consensus, but at the same time ensure that all participants have the opportunity to express their views, and allow sufficiently wide-ranging discussions to ensure that all possible hazards are identified.

The other group participants should be chosen for their expertise in fields relevant to the project being assessed. The range of expertise needs to be sufficiently broad to ensure that all aspects of the system are addressed; however, it is also important to keep the group to a manageable size. The number of participants needed for the hazard identification sessions depends on the size and complexity of the system under consideration. Apart from the facilitator, the participants do not necessarily need prior experience in hazard identification.

Note.— While the use of group sessions has been addressed here in the context of hazard identification, the same group would also address the assessment of the likelihood and severity of the hazards they have identified.

The assessment of hazards should take into consideration all possibilities, from the least to the most likely. It has to make adequate allowance for *"worst case"* conditions, but it is also important that the hazards to be included in the final analysis be *"credible"* hazards. It is often difficult to define the boundary between a *worst* credible case and one so dependent on coincidence that it should not be taken into account. The following definitions can be used as a guide in making such decisions:

> ***Worst case**:* The most unfavourable conditions expected, e.g. extremely high levels of traffic, and extreme weather disruption.
>
> ***Credible case**:* This implies that it is not unreasonable to expect that the assumed combination of extreme conditions will occur within the operational life cycle of the system.

The assessment should always consider the most critical phase of flight within which an aircraft could be affected by the system failure under consideration, but it should not generally be necessary to assume that simultaneous **unrelated** failures will occur.

It is, however, important to identify any potential *common mode failure*, which occurs when a single event causes multiple failures within the system.

All identified hazards should be assigned a hazard number, and be recorded in a *hazard log*.

The hazard log should contain a description of each hazard, its consequences, the assessed likelihood and severity, and any required mitigation measures. It should be updated as new hazards are identified, and proposals for mitigation are introduced.

STEP 3: ESTIMATION OF THE SEVERITY OF THE CONSEQUENCES OF A HAZARD OCCURRING

Prior to the commencement of this step, the consequences of each hazard identified in Step 2 should have been recorded in the hazard log. Step 3 involves the assessment of the severity of each of these consequences.

Risk classification schemes have been developed for a large number of applications where hazard analysis is regularly used. An example of one such scheme can be found in the *Joint Aviation Requirements — Large Aeroplanes* (JAR-25), developed by the Joint Aviation Authorities (JAA).

JAR-25 is recognized by many Civil Aviation Authorities as an acceptable basis for showing compliance with their national airworthiness codes. JAR 25.1309 and the associated advisory material, AMJ 25.1309, specify risk classification criteria to be used to determine acceptable levels for the risk associated with various failure conditions in aircraft systems. The levels of acceptability take into account historical accident rates, and the need for there to be an inverse relationship between the probability of loss of function(s) and the severity of the hazards to the aircraft and its occupants arising from such an event.

While the criteria as specified in JAR-25 relate specifically to airworthiness of aircraft systems, they can be used as a guide to the development of similar classification schemes for other purposes. A number of States have already done this. Table 13-3 shows an example of a severity classification scheme based on the JAR-25 approach, but adapted for ATS application, taken from the U.K. CAA CAP 670, *Air Traffic Services Safety Requirements*.

The same group that performed the hazard identification would be most appropriate to assess the severity of the consequences. The guidelines for the conduct of the group sessions contained in Appendix 1 to this chapter apply equally to the assessment of the severity of the consequences as to hazard identification.

Table 13-3. Severity classification scheme

	Severity classification				
	Catastrophic	***Hazardous***	***Major***	***Minor***	***Negligible***
Results in one or more of the following effects	ATC issues instruction or information which can be expected to cause loss of one or more aircraft (no reasonable means exist for the aircrew to check the information or to mitigate against hazards). Continued safe flight or landing prevented.	The ATC separation service provided to aircraft that are airborne or are inside a runway protected area in one or more sectors is suddenly, and for a significant period of time, completely unavailable. Provision of instructions or information which may result in a critical near mid-air collision or a critical near collision with the ground.	The ATC separation service provided to aircraft that are airborne or are inside a runway protected area in one or more sectors is suddenly, and for a significant period of time, severely degraded or compromised (e.g. contingency measures required, or controller workload significantly increased such that the probability of human error is increased). The ATC separation service provided to aircraft on the ground outside a runway protected area is suddenly, and for a significant period of time, completely unavailable. Provision of instructions or information which may result in the separation between aircraft or aircraft and the ground being reduced below normal standards. No ATS action possible to support aircraft emergency.	The ATC separation service provided to aircraft that are airborne or are inside a runway protected area in one or more sectors is suddenly, and for a significant period of time, impaired. The ATC separation service provided to aircraft on the ground outside a runway protected area is suddenly, and for a significant period of time, severely degraded. ATS emergency support ability is severely degraded.	No effect on ATC separation service provided to aircraft. Minimal effect on ATC separation service provided to aircraft on the ground outside a runway protected area. Minimal effect on ATS emergency support ability.

While the assessment of the severity of the consequences will always involve some degree of subjective judgement, the use of structured group discussions, guided by a standard risk classification scheme, and with participants who have extensive experience in their respective fields, should ensure that the outcome will be an informed judgement.

Once the assessment of severity has been completed for all the identified hazards, the results, including the rationale for the severity classification chosen, should be recorded in the hazard log.

STEP 4: ESTIMATION OF THE LIKELIHOOD OF A HAZARD OCCURRING

The estimation of the likelihood of a hazard occurring uses a similar approach to that adopted in Steps 2 and 3, i.e. by means of structured discussions using a standard classification scheme as a guide. Table 13-4 shows an example of a classification scheme for this purpose, based on JAR-25, taken from the U.K. CAA CAP 670, *Air Traffic Services Safety Requirements*.

Table 13-4 specifies the likelihood as qualitative categories, but also includes numerical values for the probabilities associated with each category. In some cases, data may be available that will allow the making

Table 13-4. Probability classification scheme

	Probability of Occurrence Definitions				
	Extremely improbable	**Extremely remote**	**Remote**	**Reasonably probable**	**Frequent**
Qualitative definition	Should virtually never occur in the whole fleet life.	Unlikely to occur when considering several systems of the same type, but nevertheless has to be considered as being possible.	Unlikely to occur during the total operational life of each system but may occur several times when considering several systems of the same type.	May occur once during total operational life of one system.	May occur once or several times during operational life.
Quantitative definition	$< 10^{-9}$ per flight hour	10^{-7} to 10^{-9} per flight hour	10^{-5} to 10^{-7} per flight hour	10^{-3} to 10^{-5} per flight hour	1 to 10^{-3} per flight hour

of direct numerical estimates of the likelihood of failure. For example, for the hardware elements of a system, extensive data are often available on historical component failure rates.

The estimation of the likelihood of occurrence of hazards associated with human error will generally involve a degree of subjective assessment (and it should be borne in mind that even when assessing hardware, there is always the possibility of failures due to human error, for example, incorrect maintenance procedures). However, as with the estimation of severity, the use of structured group discussions with participants who have extensive experience in their respective fields, and the adoption of a standard risk classification scheme should ensure that the outcome will be an informed judgement.

Once the assessment of likelihood has been completed for all the identified hazards, the results, including the rationale for the classification chosen, should be recorded in the hazard log.

STEP 5: EVALUATION OF RISK

Since the acceptability of a risk is dependent on both its likelihood and the severity of its consequences, the criteria used to judge acceptability will always be two-dimensional. Acceptability is therefore usually based on comparison with a severity/probability matrix.

Table 13-5 shows an example of a matrix for the assessment of acceptability of risk in ATS. This was taken from the U.K. CAA CAP 670, *Air Traffic Services Safety Requirements*, and adapted from the risk classification scheme in JAR-25.

As discussed in Chapter 6, there is a zone between *acceptable* and *unacceptable* risk where the decision concerning acceptability is not clear-cut. These latter risks form a third category, where the risk may be tolerable if it is reduced to a level as low as reasonably practicable (ALARP). Where a risk is classed as ALARP, mitigation measures will always have been attempted, and those mitigation measures classed as feasible will have been implemented.

In Table 13-5, the risks that fall in the middle are marked “Review”. Risks in this category are not automatically classed as tolerable. Every case must be reviewed on its merits, taking into account the benefits that will result from implementation of the proposed changes as well as the risk.

Table 13-5. Risk classification scheme

		Probability of Occurrence				
		Extremely improbable	**Extremely remote**	**Remote**	**Reasonably probable**	**Frequent**
Severity	**Catastrophic**	Review	Unacceptable	Unacceptable	Unacceptable	Unacceptable
	Hazardous	Review	Review	Unacceptable	Unacceptable	Unacceptable
	Major	Acceptable	Review	Review	Review	Review
	Minor	Acceptable	Acceptable	Acceptable	Acceptable	Review

STEP 6: MITIGATION OF RISK

As noted in Step 5, if the risk does not meet the predetermined acceptability criteria, an attempt should always be made to reduce it to a level which is acceptable, or if this is not possible, to a level as low as reasonably practicable, using appropriate mitigation procedures.

The identification of appropriate risk mitigation measures requires a good understanding of the hazard and the factors contributing to its occurrence, since any mechanism that will be effective in reducing risk will have to modify one or more of these factors.

Risk mitigation measures may work through reducing the probability of occurrence, or the severity of the consequences, or both. Achieving the desired level of risk reduction may require the implementation of more than one mitigation measure.

The possible approaches to risk mitigation include:

a) revision of the system design;

b) modification of operational procedures;

c) changes to staffing arrangements; and

d) training of personnel to deal with the hazard.

The earlier in the system life cycle that hazards are identified, the easier it is to change the system design if necessary. As the system nears implementation, changing the design becomes more difficult and costly. This could reduce the available mitigation options for those hazards which are not identified until a late stage of the project.

The effectiveness of any proposed risk mitigation measures must be assessed by first examining closely whether the implementation of the mitigation measures might introduce any new hazards, then repeating Steps 3, 4 and 5 to evaluate the acceptability of the risk with the proposed mitigation measures in place.

Once the system is implemented, particular attention should be paid, when evaluating the results of safety performance monitoring, to verifying that the mitigation measures are working as intended. For further guidance on risk mitigation, refer to Chapter 6.

STEP 7: DEVELOPMENT OF SAFETY ASSESSMENT DOCUMENTATION

The purpose of the safety assessment documentation is to provide a permanent record of the final results of the safety assessment, and the arguments and evidence demonstrating that the risks associated with the implementation of the proposed system or change have been eliminated, or have been adequately controlled and reduced to a tolerable level.

Note.— This presentation of the arguments and evidence to demonstrate safety is referred to in many references on safety management as a safety case. The term safety argument is also sometimes used with a similar meaning.

While the documentation of the safety assessment is listed here as the last step, a significant amount of the documentation will already have been produced during the previous steps.

In addition to describing the outcome of the safety assessment, the documentation should contain a summary of the methods used, the hazards identified, and mitigation measures which are required to meet the safety assessment criteria. The hazard log should always be included. The documentation should be prepared in sufficient detail so that anyone reading it will be able to see not just what decisions were reached, but what the justification was for classifying risks as acceptable or tolerable. It should also include the names of the personnel involved in the assessment process.

The individual who is responsible for ensuring that safety assessment is undertaken and for signing the final acceptance of the safety assessment will vary depending on the size and complexity of the project, and the policy of the organization. In some cases it will be the project manager. Where no project manager has been appointed, it could be the line manager who is responsible for the system concerned. In some organizations, the acceptance may require the approval of a higher level of management in cases where the residual risk cannot be reduced to the acceptable level, but is to be accepted as tolerable and ALARP.

The signing of the safety assessment documentation by the responsible manager, to indicate acceptance, is the final action in the assessment process.

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Appendix 1 to Chapter 13

GUIDANCE ON THE CONDUCT OF GROUP HAZARD IDENTIFICATION AND ASSESSMENT SESSIONS

1. THE ROLE OF THE ASSESSMENT GROUP

1.1 It is usually best to initiate the assessment process in a group session, involving representatives of the various organizations concerned with the specification, development and use of the system. The interactions between participants with varying experience and knowledge tend to lead to a broader, more comprehensive and balanced consideration of safety issues than if the assessment is conducted by an individual.

1.2 While group sessions are usually good at generating ideas, identifying issues and making an initial assessment, they do not always produce these outputs in a logical order. Also, it is difficult for a group to analyse the ideas and issues in detail — it is hard to consider all the implications and interrelationships between issues when these have only just been raised. It is therefore recommended that:

a) the group session be used to generate ideas and undertake preliminary assessment only;

b) the findings be collated and analysed after the session. One or two individuals with sufficient breadth of expertise to understand all the issues raised, and a good appreciation of the purposes of the assessment should do this; and

c) the collated results be fed back to the group to check that the analysis has correctly interpreted their input and to provide an opportunity to reconsider any aspects once the "whole picture" can be seen.

2. ASSESSMENT SESSION PARTICIPANTS

The sessions need to involve representatives of all the main parties with an interest in the system and its safety. Typically, a session should involve:

a) **System users** — those primary user groups most directly involved in order to assess the consequences of failure(s) from an operational perspective (e.g. ATCOs and flight crew);

b) **System technical experts** to explain the system purpose, interfaces and functions;

c) **Safety and Human Factors experts** to guide in the application of the methodology and to bring wider understanding of the causes and effects of hazards;

d) A "**moderator**" or "**facilitator**" to lead and control the session; and

e) A **meeting secretary** to record the findings and assist the facilitator in ensuring that all aspects have been covered.

3. SESSION PSYCHOLOGY

3.1 Some consideration of the individual and group psychology involved in the assessment session is helpful in understanding how to run a successful session. The mental processes required in order to produce the desired outputs can be categorized under two broad kinds of thinking:

a) ***Creative (inductive) thinking.*** This is important in the identification of failure(s), sequence of events and the hazards that may result. The basic type of question being asked is: *"What could go wrong?"*

b) ***Judgemental (deductive) thinking.*** This is important in classifying the severity of hazards and in setting the safety objectives. The basic question is: *"How severe are the effects of this sequence of events?"*

3.2 The above are cognitive processes, undertaken by each participant, but the ***group dynamics*** of the session are also important in determining its success.

The creative process — identifying what could go wrong

3.3 Creative thinking is necessary to ensure that the identification of potential failures and the potential resulting hazards is as comprehensive as possible. It is important to encourage participants to think widely and imaginatively about the subject, initially without analysis or criticism.

3.4 Typically, this is achieved through a process of structured brainstorming. The structure should both ensure completeness and encourage (not constrain) wide-ranging thinking about the system.

Judgemental thinking — classifying risks and setting safety objectives

3.5 The aim of this part of the assessment session is to elicit subjective judgements in such a way as to make the best use of people's knowledge and experience, and to minimize — or at least reveal — any biases or uncertainties.

3.6 Where the functions and hazards are complex and closely interlinked, session designers should consider running the judgemental part of the session some time after the creative part in order to give time to collate the results into a concise form. If this is not possible, the session leaders should make sure that they have an opportunity (during a break, for example) to do some preliminary collation of the findings.

Group dynamics

3.7 The following statements apply to both the creative and the judgemental aspects of the session:

a) ***Understanding of the process and motivation for attendance***. It is important that participants have a common purpose.

b) ***Group size***. The size of the group is principally determined by the areas of expertise required. However, groups of more than ten can be very difficult to control.

c) ***Dominance and reticence***. Some individuals may dominate the conversation; others may be reticent, especially about dissenting from a perceived consensus view.

d) ***Defensiveness***. Participants closely involved with the development of a system or its equivalent may find it hard to admit that things could go wrong.

e) ***Feedback***. Giving positive feedback during the session is important. All contributions should be seen to be valuable.

f) ***Confidentiality***. Where representatives from different organizations are present, the facilitator should be aware of possible issues that may affect what participants feel able to say.

Chapter 14

SAFETY AUDITING

14.1 INTRODUCTION

Safety audits are one of the principal methods for fulfilling the safety performance monitoring functions outlined in Chapter 10. They are a core activity of any safety management system (SMS). Safety audits may be performed by an external audit authority, such as the State regulatory authority, or they may be carried out internally as part of an SMS. Regulatory audits are discussed briefly in Chapter 10. This chapter focuses on the internal safety auditing programme.

14.2 SAFETY AUDITS

14.2.1 Safety audits are used to ensure that:

a) the structure of the SMS is sound in terms of appropriate levels of staff; compliance with approved procedures and instructions; and a satisfactory level of competency and training to operate equipment and facilities and to maintain their levels of performance;

b) equipment performance is adequate for the safety levels of the service provided;

c) effective arrangements exist for promoting safety, monitoring safety performance and processing safety issues; and

d) adequate arrangements exist to handle foreseeable emergencies.

14.2.2 Ideally, safety audits should be conducted regularly, following a cycle that ensures each functional area is audited as a part of the organization's plan for evaluating overall safety performance.[1] Safety audits should entail a periodic detailed review of the safety performance, procedures and practices of each unit or section with safety responsibilities. Thus, in addition to an organization-wide audit plan, a detailed audit plan should be prepared for each individual unit/section.

14.2.3 Safety audits should go beyond just checking compliance with regulatory requirements and conformance with the organization's standards. The audit team should assess whether the procedures in use are appropriate and whether there are any work practices that could have unforeseen safety consequences.

14.2.4 The scope of a safety audit may vary from an overview of all activities of the unit or section, to a specific activity. The criteria against which the audit will be conducted should be specified in advance.[2]

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1. For ATS centres, the organization should develop an organization-wide safety audit plan. This safety audit plan should be revised annually and should provide for all units or sections to be audited at regular intervals. Typically, this would be every two to three years.
2. For audits of ATS units, these criteria should include those items listed in Section 2.5 of the PANS-ATM (Doc 4444) which are relevant to the unit or section being audited.

Checklists may be used to identify what is to be reviewed during the audit in sufficient detail in order to ensure that all intended tasks and functions are covered. The extent and elaboration of the checklists will depend on the size and complexity of the organization being audited.

14.2.5 For an audit to be successful, the cooperation of the personnel of the unit or section concerned is essential. The safety audit programme should be based on the following principles:

a) It must never appear to be a "witch hunt". The objective is to gain knowledge. Any suggestions of blame or punishment will be counterproductive.

b) The auditee should make all relevant documentation available to the auditors and arrange for staff to be available for interview as required.

c) Facts should be examined in an objective manner.

d) A written audit report describing the findings and recommendations should be presented to the unit or section within a specified period.

e) The staff of the unit or section, as well as the management, should be provided with feedback concerning the findings of the audit.

f) Positive feedback should be provided by highlighting in the report the good points observed during the audit.

g) While deficiencies must be identified, negative criticism should be avoided as much as possible.

h) The need to develop a plan to resolve deficiencies should be required.

14.2.6 Following an audit, a monitoring mechanism may be implemented to verify the effectiveness of any necessary corrective actions. Follow-up audits should concentrate on aspects of the operations where the need for corrective action was identified. Audits to follow up previous safety audits where corrective action was proposed or because an undesirable trend in safety performance was identified cannot always be scheduled in advance. The overall annual audit programme should make allowance for such unscheduled audits.

14.2.7 Figure 14-1 illustrates the safety audit process diagrammatically. The procedures involved in each step of the safety audit process are discussed in more detail later in this chapter.

14.3 THE SAFETY AUDIT TEAM

14.3.1 Safety audits may be undertaken by a single individual or a team, depending on the scale of the audit. Depending on the size of the organization and the availability of resources, experienced and trained individuals within the organization may perform safety audits or they may assist external auditors. The staff selected to conduct an audit should have practical experience in disciplines relevant to the area to be audited, a good knowledge of the relevant regulatory requirements and the organization's SMS, and they should have been trained in auditing procedures and techniques. An audit team comprises an audit team leader and one or more auditors.

14.3.2 Those chosen to undertake an audit must be credible to those being audited. In short, they must be qualified and trained for the audit function in the appropriate areas of expertise. As much as

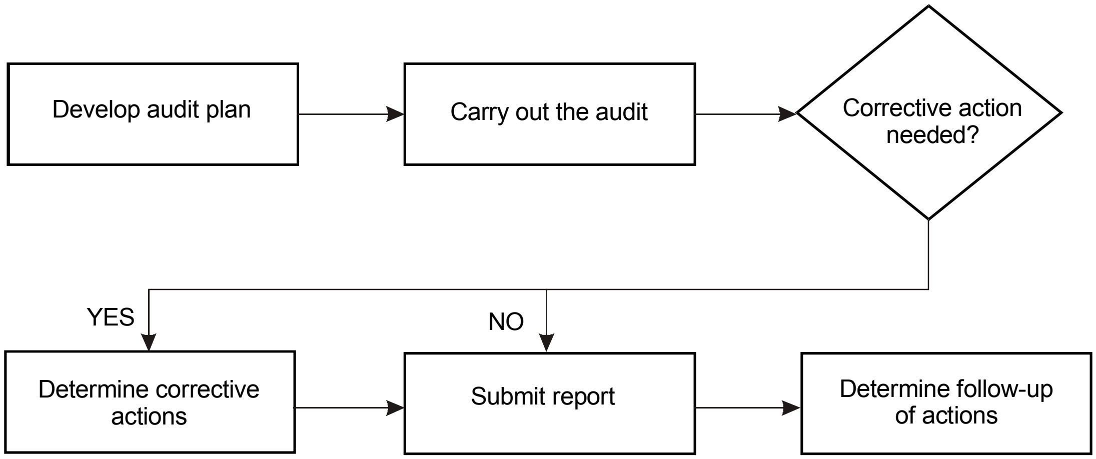

Figure 14-1. The safety audit process

possible, the audit team members should be independent of the area being audited. Wherever practical and having regard to the size of the organization, these functions should be undertaken by persons who are not responsible for, and have not been involved in, the design or performance of the tasks and functions being audited. In this way, the evaluation is neutral and independent from the operational aspects of the organization. It is also preferable that the audit team not be composed exclusively of management level staff. This can help to ensure that the audit will not be viewed as threatening. Staff with current operational experience may also be better at identifying possible problems. A specialist from outside the audit authority may be required to participate in the audit.

The role of the audit team leader

14.3.3 An audit team leader should be appointed if more than one auditor is involved. The audit team leader is responsible for the overall conduct of the audit. In addition, the audit team leader undertakes some of the general tasks of an auditor (described in 14.3.4). The audit team leader must be an effective communicator and must be able to earn the trust of the organization being audited.

The role of the auditors

14.3.4 The tasks to be undertaken by each audit team member will be assigned by the audit team leader. These tasks may include conducting interviews with staff of the unit or section being audited, reviewing documentation, observing operations and writing material for the audit report.

14.4 PLANNING AND PREPARATION

14.4.1 A formal notification of intention to perform the audit should be forwarded to the unit or section to be audited in adequate time for any necessary preparations to be made. As part of the audit preparation process, the audit authority may consult with senior management of the organization to be audited. The organization may be requested to provide preparatory material in advance of the actual audit, for example, selected records, a completed pre-audit questionnaire, and manuals. The organization being audited must have a clear understanding of the purpose, scope, resource requirements, audit and follow-up processes, etc. before the auditors arrive.

Pre-audit activity

14.4.2 Among the initial steps in planning an audit will be to verify the feasibility of the proposed schedule and to identify the information that will be needed before commencement of the audit. It will also be necessary to specify the criteria against which the audit will be conducted and to develop a detailed audit plan together with checklists to be used during the audit.

14.4.3 The checklists consist of a comprehensive series of questions grouped under topic headings, which are used to ensure that all relevant topics are covered. For the purposes of a safety audit, the checklists should address the following areas in an organization:

a) national safety regulatory requirements;

b) organizational safety policies and standards;

c) structure of safety accountabilities;

d) documentation, such as:

  — safety management manual; and

  — operational documentation (including its local instructions);

e) safety culture (reactive or proactive);

f) hazard identification and risk management processes;

g) safety oversight capabilities (monitoring, inspections, audits, etc.); and

h) provisions for assuring safety performance of contractors.

The audit plan

14.4.4 An outline of a typical audit plan is shown in Table 14-1.

14.5 CONDUCT OF THE AUDIT

14.5.1 The conduct of the actual audit is essentially a process of inspection or fact-finding. Information from almost any source may be reviewed as part of the audit.

Table 14-1. Example of a typical structure for an audit plan

AUDIT PLAN

INTRODUCTION

[This section should introduce the audit plan and the background for the audit.]

PURPOSE

[The purpose, objectives, scope and the criteria against which the audit will be conducted should be specified.]

UNIT/SECTION TO BE AUDITED

[This section should clearly specify which area is to be audited.]

PLANNED ACTIVITIES

[This section should identify and describe the activities to be performed, the areas of interest, and how the different subjects will be addressed. It should also specify the documents that should be available for the audit team. If the audit is to involve interviews, the areas to be addressed during the interviews should be listed.]

SCHEDULE

[This section should include a detailed schedule for each of the activities planned.]

AUDIT TEAM

[This section should introduce the audit team members.]

14.5.2 In conducting a safety audit, there is often a tendency to limit observations to items of regulatory non-compliance. Auditors must realize that such inspections have limited value for the following reasons:

a) The organization may rely exclusively upon the audit authority to ensure that it is meeting the standards.

b) The standards may only be met while the auditor is undertaking the inspection.

c) An audit report will only highlight those areas of deficiency found at the time of the inspection.

d) The audit will not encourage the organization to be proactive, and often, only issues raised by the auditor will be verified.

Opening meeting

14.5.3 At the opening meeting, the audit team leader should briefly present the background for the audit, its purpose, and any specific issues that will be addressed by the audit team. The practical arrangements, including the availability of staff for interview, should be discussed and agreed upon with the manager of the unit or section being audited.

Audit procedures

14.5.4 The techniques for gathering the information on which the audit team's assessment will be made include:

a) review of documentation;

b) interviews with staff; and

c) observations by the audit team.

14.5.5 The audit team should work systematically through the items on the relevant checklist. Observations should be noted on standardized observation sheets.

14.5.6 If a particular area of concern is identified during the audit, this should be the subject of a more thorough investigation. However, the auditor must keep in mind the need to complete the rest of the audit as planned and therefore must avoid spending an excessive amount of time exploring a single issue and so risk missing other problems.

Audit interviews[3]

14.5.7 The principal way in which auditors obtain information is by asking questions. This method provides additional information to that available in written material. It also gives the staff involved an opportunity to explain the system and work practices. Face-to-face discussions also permit the auditors to make an assessment of the level of understanding as well as the degree of commitment of the staff of the unit or section to safety management. The persons to be interviewed should be drawn from a range of management, supervisory and operational positions. The purpose of audit interviews is to elicit information, not to enter into discussions.

Audit observations

14.5.8 Once the audit activities are completed, the audit team should review all audit observations and compare them against the relevant regulations and procedures in order to confirm the correctness of observations noted as nonconformities, deficiencies or safety shortcomings.

14.5.9 An assessment should be made of the seriousness with respect to all items noted as nonconformities, deficiencies or safety shortcomings.

14.5.10 It should be borne in mind that the audit should not focus only on negative findings. An important objective of the safety audit is also to highlight good practice within the area being audited.

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3. For further guidance on interviewing techniques, see Chapter 8.

Closing meeting

14.5.11 Management may require regular progress reports throughout the audit. Nevertheless, a closing meeting should be held with the management of the unit or section at the conclusion of the audit activities to brief them on the audit observations and any resulting recommendations. Factual accuracy can be confirmed and significant findings highlighted.

14.5.12 Prior to this meeting, the audit team should:

a) agree on the audit conclusions;

b) prepare recommendations, such as proposing appropriate corrective action, if required; and

c) discuss whether there is a need for follow-up action.

14.5.13 The audit findings may fall into three categories:

a) serious discrepancies of non-compliance warranting action to suspend a licence, certificate or approval;

b) any discrepancy or non-compliance that must be rectified within an agreed time limit; and

c) observations on issues that are likely to impact on safety or become a regulatory issue before the next audit.

14.5.14 At the closing meeting, the audit team leader should present the observations made during the audit and give the representatives of the unit or section being audited the opportunity to correct any misunderstandings. Dates for issuing an interim audit report and for receiving comments on it should be mutually agreed upon. A draft copy of the final report is often left with management.

Corrective action plan

14.5.15 At the completion of an audit, planned remedial actions should be documented for all identified areas of safety concern. The management of the unit or section has the responsibility for developing a corrective action plan setting out the action(s) to be taken to resolve identified deficiencies or safety shortcomings within the agreed time period.

14.5.16 When completed, the corrective action plan should be forwarded to the audit team leader. The final audit report will include this corrective action plan and detail any follow-up audit action proposed. The manager of the area being audited is responsible for ensuring the timely implementation of the appropriate corrective actions.

Audit reports

14.5.17 The audit report should be an objective presentation of the results of the safety audit. As soon as possible after completion of the audit, an interim audit report should be forwarded to the manager of the unit or section for review and comments. Any comments received should be taken into consideration in the preparation of the final report, which constitutes the official report of the audit.

14.5.18 The key principles to be observed in the development of the audit report are:

a) consistency of observations and recommendations in the closing meeting, interim audit report and final audit report;

b) conclusions substantiated with references;

c) observations and recommendations stated clearly and concisely;

d) avoidance of generalities and vague observations;

e) objective presentation of the observations;

f) use of widely accepted aviation terminology, avoiding acronyms and jargon; and

g) avoidance of criticism of individuals or positions.

14.5.19 An outline of a typical audit report is provided in Table 14-2.

14.6 AUDIT FOLLOW-UP

14.6.1 Audit follow-up involves the management of change. Upon receipt of the final audit report, management must ensure that progress is made to reduce or eliminate the attendant risks. The primary purpose of an audit follow-up is to verify the effective implementation of the corrective action plan. Follow-up is also required to ensure that any action taken pursuant to the audit does not in any way degrade safety. In other words, new hazards with potentially higher risks must not be allowed to enter the system as a consequence of the audit.

14.6.2 Failure by the auditor to follow up on lapses in implementing necessary (and agreed) safety actions will compromise the validity of the entire safety audit process. Follow-up action may be effected through monitoring the status of implementation of accepted corrective action plans or through follow-up audit visits. Where a follow-up visit has been made, a further report of this visit should be prepared. This report should clearly indicate the current status of the implementation of the agreed corrective actions. If any non-compliance, deficiency or safety shortcoming remains unresolved, the audit team leader should highlight this in the follow-up report.

14.7 ISO QUALITY STANDARDS

Many aviation organizations have been certified under the International Organization for Standardization (ISO) standards for products and services (usually the ISO 9000 series of standards relating to quality management). As part of the ISO certification process, organizations are subjected to stringent initial and ongoing quality audits conducted by an independent auditing organization.

Table 14-2. Example of the contents of an audit report

CONTENTS OF AN AUDIT REPORT

INTRODUCTION

[This section should identify the audit, of which this report is the formal documentation, and introduce the different chapters included in the report.]

LIST OF REFERENCED DOCUMENTS

[This section should outline all documents that were used during the audit.]

BACKGROUND

[This section should describe the reason for the audit. This could be a regular audit, or there could be a specific reason for the audit (e.g. safety risk identified or safety incident observed).]

PURPOSE

[This section should state the objective and scope of the audit as described in the audit plan. Any event during the audit that led to problems in fulfilling the objective should be described.]

STAFFING

[This section should list the personnel included in the audit.]

OBSERVATIONS

[This section should describe the observations of the audit team in general terms. Both good points and points of concern should be covered. The details concerning the observations should be attached as observation sheets, including the agreed corrective actions.]

GENERAL CONCLUSION

[This section should present the general conclusions of the audit. It should not only focus on problems but highlight good points as well.]

ATTACHMENTS

[All observation sheets and associated corrective action sheets should be attached to the audit report.]

Chapter 15

PRACTICAL CONSIDERATIONS FOR OPERATING A SAFETY MANAGEMENT SYSTEM

15.1 INTRODUCTION

Beyond the theoretical and conceptual considerations for establishing a safety management system (SMS), a number of practical considerations need to be addressed. This chapter discusses some of them.

15.2 THE SAFETY OFFICE

15.2.1 In most States, there is no regulatory requirement for an operator to appoint a safety manager (SM). However, many medium- to large-sized operators choose to employ an SM and provide a safety office. The safety office serves as a focal point for safety-related activities, acts as a repository for safety reports and information, and provides expertise on safety management to line managers. Just as aircraft operators benefit from the creation of a dedicated safety office, major aviation service providers (such as ATC, aerodromes and aircraft maintenance organizations) would benefit from a similar office.

15.2.2 The SM requires a suitably equipped office. The physical presence of the safety office (size and location) says a lot about the importance that management attaches to safety management and the role of the SM.

15.2.3 The SM should be free to move around the organization — probing, questioning and observing. The SM needs to be readily accessible to anyone wishing to contact him, and he should not shut himself in an office and wait for information to come to him. If the physical location of the SM is remote from the day-to-day operations, communications will inevitably suffer.

15.2.4 Since the main source of safety information within an organization is its operational personnel, the SM should be located where these personnel can have ready access to him. This is particularly important in relation to human performance issues where the facility to discuss a problem, in confidence if necessary, immediately after a safety occurrence may be the deciding factor as to whether the information is reported at all.

Safety office functions

15.2.5 Regardless of its location within an organization, typically, a safety office fulfils a variety of corporate safety functions. Some of the more common functions include:

a) advising senior management on safety-related matters such as:

   1) setting safety policy;

   2) defining responsibilities and accountabilities for safety;

3) establishing an effective corporate SMS;

4) recommending resource allocations in support of safety initiatives;

5) disseminating public communications on safety issues; and

6) organizing emergency response planning;

b) assisting line managers in:

1) assessing identified risks; and

2) selecting the most appropriate risk mitigation measures for those risks deemed unacceptable;

c) overseeing hazard identification systems, for example:

1) occurrence investigations;

2) incident reporting systems; and

3) data analysis programmes;

d) managing safety databases;

e) conducting safety analyses, for example:

1) trend monitoring; and

2) safety studies;

f) providing training on safety management methods;

g) coordinating safety committees;

h) promoting safety by:

1) sustaining awareness and understanding of the organization's safety management processes across all operational areas;

2) disseminating safety lessons in-house; and

3) exchanging safety information with external agencies and similar operations;

i) monitoring safety performance measurement by:

1) conducting safety surveys; and

2) providing guidance on safety oversight;

j) participating in accident and incident investigations; and

k) reporting on safety to meet the requirements of:

1) management (e.g. annual/quarterly review of safety trends and identification of unresolved safety issues); and

2) the regulator (CAA).

15.3 SAFETY MANAGER (SM)

15.3.1 The SM is the focal point for the development and maintenance of an effective SMS. The SM is also likely to be the main point of contact with the regulatory authority for many safety issues. Having the SM report directly to the Chief Executive Officer (CEO) demonstrates that safety has an equivalent level of importance in the decision-making process as other major organizational functions.

15.3.2 The functions of the SM are discussed briefly in Chapter 12. Broadly, the SM is responsible for ensuring that safety documentation accurately reflects the current situation, monitoring the effectiveness of corrective actions, providing periodic reports on safety performance, and providing independent advice to the CEO, senior managers and other personnel on safety-related matters.

15.3.3 In many organizations, the SM holds a *"staff"* position and advises senior management on safety matters. A potential conflict of interest can arise if the SM also holds line management responsibilities. Safety management then is a responsibility shared by line managers and supported by the *"staff"* safety specialist, the SM. Senior management should not hold the SM accountable for line managers' responsibilities. Rather, the SM is accountable for rendering effective staff support to line managers to ensure the success of their safety management efforts.

15.3.4 Large organizations may require a small staff of dedicated safety specialists to assist the SM. These specialists would undertake a variety of tasks, such as maintaining safety documentation, reviewing safety assessments and taking part in safety audits.

15.3.5 Regardless of the organizational arrangement, a formal statement of responsibilities and accountabilities is advisable, even in small organizations. This statement clarifies the formal and informal reporting lines on the organizational chart and specifies accountabilities for particular activities.

SM selection criteria

15.3.6 Irrespective of the size of the organization, the SM should possess operational management experience and an adequate technical background to understand the systems that support operations. Operational skills alone will not be sufficient. The SM must have a good understanding of safety management principles that has been acquired through formal training and practical experience.

15.3.7 SMs require strength in several areas to complement their professional expertise. They should have:

a) a broad knowledge of aviation and the organization's functions and activities;

b) people skills (such as tact, diplomacy, objectivity and fairness);

c) analytical and problem-solving skills;

d) project management skills; and

e) oral and written communication skills.

15.3.8 A sample job description for an SM is contained in Appendix 1 to this chapter.

Leadership role

15.3.9 From the outset, the SM must establish a persona. The SM is seen as a subject matter expert on safety management. One of the SM's strengths is in convincing others of the need for change. This requires leadership skills. Some considerations for developing the most suitable leadership style in a particular organization are listed below:

a) ***Personal example***. The SM's personal value system must include setting an example for all personnel, service providers and management. The SM must be seen at all times to be upholding the highest standards of safety. The SM's example cannot be one of "Do as I say, not as I do."

b) ***Courage of convictions***. The SM must be willing to go against the tide if necessary. In some instances, the SM may be the lone voice for change. The need for change will not always be popular, either to management or to the affected personnel.

c) ***Consensus builder***. As a team builder, whether for office staff or in committee situations, the SM must build consensus, inspiring confidence while convincing key players of the need for change. Often this will require compromise and conflict-resolution skills.

d) ***Adaptable***. The SM needs to steer a fine course through ever-changing circumstances and priorities, judging when to speak out and when to give in. There is a fine line between perseverance and stubbornness, and between flexibility and lack of personal resolve.

e) ***Self-starter***. The effective SM does not wait for problems to present themselves. Consistent with a proactive safety culture, initiative is required to search out hazards, assess the associated risks and provide argument for change.

f) ***Innovative***. There are few new messages in safety. Too many lessons have been learned and relearned. The SM must find innovative approaches to such age-old problems as complacency, short cuts and "work arounds".

g) ***Firm but fair***. Effective leadership treats all people equitably — firmly in terms of what is required but fairly in being sensitive to unique circumstances.

SM in expanding or large organizations

15.3.10 As an organization expands, it will become increasingly difficult for an SM to function as a single entity. For example, an operator's expanding route network may mean an increase in fleet size and, perhaps, the introduction of different types of aircraft. As a result, the number of occurrences warranting the SM's attention will increase. In such circumstances, a minimally staffed safety management department may not be able to provide an adequate monitoring function. Additional specialists will likely be needed to assist the SM, perhaps through secondary duty assignments. For example, in the case of an airline, some specialists that may be needed include:

a) fleet flight safety officers (pilots qualified on type);

b) engineering safety officers (licensed ground engineers with broad experience); and

c) cabin safety officers (senior cabin crew members experienced in cabin crew training, safety equipment and operating procedures).

15.3.11 These specialists can assist with the monitoring of events peculiar to their own fleet or discipline and provide expert input during the investigation of occurrences.

SM's relationships

15.3.12 The SM's areas of interest are very broad, including external relations with service providers, contractors, suppliers, manufacturers and officials of the regulatory authority. The SM must foster effective working relationships across the whole spectrum of those influencing safety and at all levels. These relationships should be marked by:

a) competence and professionalism;

b) cordiality and courtesy;

c) fairness and integrity; and

d) openness.

15.3.13 The SM should be available to discuss safety management issues with anyone. A so-called "open-door" policy is not sufficient. The SM must be visible and approachable in all areas of operations and maintenance, and with external suppliers.

15.4 SAFETY COMMITTEES

15.4.1 Depending on the size and complexity of the organization, the SM may benefit from the support of a safety committee. Smaller organizations may best discuss and resolve safety matters in an informal way. As long as there is good communication and staff and management are willing to provide advice and assistance to the SM, a formal safety committee may not be necessary. Where no separate safety committee is established, safety performance and safety management should be a regular agenda item at general management meetings. The SM should participate in these meetings.

15.4.2 However, for larger organizations with several operational departments, communications are often "filtered" and better interdepartmental coordination is frequently required. Safety issues often require inputs from a variety of different fields. Safety committees can provide a forum for discussing safety-related issues from different perspectives, especially for safety issues requiring a broader viewpoint. Safety committees also ensure the active involvement of the senior management of the organization in the SMS. With such multidisciplinary expertise, safety committees are the natural forum for the "cross-pollination" of ideas and for assessing safety performance from a "system" perspective.

15.4.3 The focus of safety committees should be on “action”, as opposed to “dialogue”. The role of the safety committee may include to:

a) act as a source of expertise and advice on safety matters to senior management;

b) review the progress on identified hazards and actions taken following accidents and incidents;

c) make safety recommendations to address safety hazards;

d) review internal safety audit reports;

e) review and approve the audit response and the actions taken;

f) encourage lateral thinking about safety issues;

g) help identify hazards and defences; and

h) prepare and review safety reports to be presented to the CEO.

15.4.4 Safety committees do not normally have the authority to direct individual departments. (Such authority would interfere with the formal lines of authority.) Rather, safety committees make recommendations for action by the responsible managers. However, because of accountability issues, some organizations have introduced safety committees at the Board level, thus ensuring that corrective actions are taken.

Committee chairman

15.4.5 The safety committee is often chaired by a senior executive, with the SM acting as the Secretary. This arrangement helps ensure that discussions do not avoid controversial issues. To be effective, the safety committee must have the support of the CEO and departmental heads. Those managers with the capacity to make decisions and authorize expenditures should participate in the meetings for particular agenda items. Without the involvement of the decision-makers, the meetings may become “chat rooms” with much time wasted.

Membership

15.4.6 Safety committees generally comprise representatives from all key departments of the organization. Depending on the size of the organization, separate sub-committees may be required to address specific issues. The SM and the safety office coordinate activities and provide assistance to the safety committee and any sub-committees.

Agenda

15.4.7 All committee members should have the opportunity to submit potential agenda items. If there are insufficient agenda items to warrant a regular meeting, then the meeting should be cancelled. The SM, as meeting Secretary, should finalize the agenda with the Chairman, providing the necessary background material for each item. Items requiring decisions and action take precedence over standing (information) items.

The minutes

15.4.8 The SM, as the Secretary of the meeting, should prepare draft minutes immediately following the meeting (before memories lapse). Once the Chairman has signed the minutes, they become an action document. The minutes should be distributed within a few working days of the meeting while those responsible for action items remember their commitment. Copies of the minutes should be distributed widely throughout the organization — for both line personnel and management.

Follow-up

15.4.9 After the meeting, other priorities may capture the attention of the action addressees. The SM should discretely monitor the actions being taken (or not being taken) and review the progress made with those who have a commitment for action.

15.5 SAFETY MANAGEMENT TRAINING

15.5.1 The organization's safety culture is linked to the success of its safety management training programme. All personnel must understand the organization's safety philosophy, policies, procedures and practices, and they must understand their roles and responsibilities within that safety management framework. Safety training should begin with the initial indoctrination of employees and continue throughout their employment. Specific safety management training should be provided for staff who occupy positions with particular safety responsibilities. The training programme should ensure that the safety policy and principles of the organization are understood and adhered to by all staff, and that all staff are aware of the safety responsibilities of their positions.

Training needs

15.5.2 The SM should, in conjunction with the personnel department, review the job descriptions of all staff and identify those positions that have safety responsibilities. The details of the safety responsibilities should then be added to the job descriptions.

15.5.3 Once the job descriptions have been updated, the SM, in conjunction with the training manager, should conduct a training needs analysis to identify the training that will be required for each position.

15.5.4 Depending on the nature of the task, the level of safety management training required will vary from general safety familiarization to expert level for safety specialists, for example:

a) corporate safety training for all staff;

b) training aimed at management's safety responsibilities;

c) training for operational personnel (such as pilots, ATCOs, AMEs and apron personnel); and

d) training for aviation safety specialists (such as the SM and Flight Data Analysts).

15.5.5 During the initial implementation of an SMS, specific training will have to be provided for existing staff. Once the SMS is fully implemented, the safety training needs of those other than the safety specialists should be met by incorporating the appropriate safety content into the general training programme for their positions.

Initial safety training for all staff

15.5.6 One of the functions of safety management training is to create awareness of the objectives of the SMS of the organization and the importance of developing a safety culture. All staff should receive a basic introductory course covering:

a) basic principles of safety management;

b) corporate safety philosophy, safety policies and safety standards (including corporate approach to disciplinary action versus safety issues, integrated nature of safety management, risk management decision-making, safety culture, etc.);

c) importance of complying with the safety policy and with the procedures that form part of the SMS;

d) organization, roles and responsibilities of staff in relation to safety;

e) corporate safety record, including areas of systemic weakness;

f) corporate safety goals and objectives;

g) corporate safety management programmes (e.g. incident reporting systems, LOSA and NOSS);

h) requirement for ongoing internal assessment of organizational safety performance (e.g. employee surveys, safety audits and assessments);

i) reporting accidents, incidents and perceived hazards;

j) lines of communication for safety matters;

k) feedback and communication methods for the dissemination of safety information;

l) safety awards programmes (if applicable);

m) safety audits; and

n) safety promotion and information dissemination.

Safety training for management

15.5.7 It is essential that the management team understand the principles on which the SMS is based. Training should ensure that managers and supervisors are familiar with the principles of the SMS and their responsibilities and accountabilities for safety. It may also be of value to provide managers with training that addresses the legal issues involved, for example, their legal liabilities.

Specialist safety training

15.5.8 A number of safety-related tasks require specially trained personnel. These tasks include:

a) investigating safety occurrences;

b) monitoring safety performance;

c) performing safety assessments;

d) managing safety databases; and

e) performing safety audits.

15.5.9 It is important that staff performing these tasks receive adequate training in the special methods and techniques involved. Depending on the depth of training required and the level of existing expertise in safety management within the organization, it may be necessary to obtain assistance from external specialists in order to provide this training.

Safety training for operational personnel

15.5.10 In addition to the corporate indoctrination outlined above, personnel engaged directly in flight operations (flight crew, ATCOs, AMEs, etc.) will require more specific safety training with respect to:

a) procedures for reporting accidents and incidents;

b) unique hazards facing operational personnel;

c) procedures for hazard reporting;

d) specific safety initiatives, such as:

   1) FDA programme;

   2) LOSA programme; and

   3) NOSS programme;

e) safety committee(s);

f) seasonal safety hazards and procedures (winter operations, etc.); and

g) emergency procedures.

Training for safety managers

15.5.11 The person selected as the SM needs to be familiar with most aspects of the organization, its activities and personnel. These requirements may be met in-house or from external courses, however, much of the SM's knowledge will be acquired by self-education.

15.5.12 Areas where SMs may require formal training include:

a) familiarization with different fleets, types of operations, routes, etc.;

b) understanding the role of human performance in accident causation and prevention;

c) operation of SMS;

d) accident and incident investigation;

e) crisis management and emergency response planning;

f) safety promotion;

g) communication skills;

h) computer skills such as word-processing, spreadsheets and database management; and

i) specialized training or familiarization (such as CRM, FDA, LOSA and NOSS).

15.6 CONDUCTING A SAFETY SURVEY[1]

15.6.1 Safety surveys offer a flexible and cost-effective method for identifying hazards by sampling expert opinion. They may be used to review a particular area of safety concern where hazards appear or are suspected, or as a monitoring tool to confirm that an existing situation is satisfactory. In either case, the principles and procedures are the same, and they are equally applicable to large or small surveys.

Principles

15.6.2 The ***objectives*** of the survey should be clearly enunciated for all intended respondents.

15.6.3 The ***sample size*** should be sufficient to permit valid conclusions to be drawn from the information obtained. The level of formality, the breadth of participation, etc. will depend on the scope of the survey.

15.6.4 Surveys may be conducted through the use of checklists, questionnaires and interviews. All of these methods require skill in formulating questions that will provide a valid reference point, without leading the person being surveyed. Interviewing requires particular skill in keeping the questions ***neutral and unbiased***, avoiding negative feedback, encouraging openness, etc.

15.6.5 Randomly selecting those to be surveyed will reduce the ***risks of bias*** in information collected.

15.6.6 The same rigour as required for structured interviews is required in ***formulating and sequencing survey questions*** and their sequence. However, unlike in interviews, open-ended questions requiring narrative responses should be avoided in surveys. Rather, questions should elicit specific responses (which can be scored). These might include evaluating an opinion along some predetermined scale, e.g. from *strongly disagree*, through *neither agree nor disagree*, to *completely agree*.

15.6.7 Surveys require ***prior coordination*** with the authorities governing the target respondents. For example, a survey may be doomed from the outset without the support of the pertinent unions and professional associations.

15.6.8 Whatever method is used for the survey, the respondent must receive an ***assurance of confidentiality*** regarding the information volunteered through the survey.

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1. The principles behind safety surveys are discussed in Chapter 9.

15.6.9 Some ***other factors*** to be considered when conducting a survey are listed below:

a) The cooperation of the people involved in the survey should be obtained.

b) Any perception of a *"witch-hunt"* should be avoided. (The objective is to gain knowledge. Any suggestions of blame or punishment will be counterproductive.)

c) The experience of the target respondents should be respected. (The target respondents are usually more experienced in their specialty than the surveyor.)

d) Criticism (real or implied) can destroy the rapport with the person being interviewed.

e) Hearsay and rumour need to be substantiated before being accepted.

Survey frequency

15.6.10 Some organizations advocate conducting safety surveys at regular intervals as an integral component of their SMS. Surveys have a particular application when an organization is undergoing significant change, for example:

a) during rapid organizational change due to growth and expansion;

b) when major changes in the nature of the organization's operations are planned (such as the introduction of new equipment or corporate mergers);

c) during major labour-management differences (such as contract negotiations or strike action);

d) following the change of key personnel (such as the chief pilot or the unit supervisor); or

e) during the introduction of a major new safety initiative (such as TCAS, FDA, LOSA or NOSS).

Where to look

15.6.11 Typically, employees know where best to look for areas of risk. Line managers and front-line workers often have valid perceptions of where the greatest risks are in their areas of responsibility. Their input can be sought through focus groups, consultations with employee representatives, and interviews with subordinate managers and supervisors.

15.6.12 The information sources outlined in Chapter 9 can also contribute to an understanding of the potential risks facing the organization. Audit reports may provide a structured record of areas of concern. Since changing accountable managers has a tendency to shorten corporate memories, follow-up assessments of formal audit reports may reveal lingering safety hazards.

Concluding the survey

15.6.13 The gathering and analysis of the information, development of the recommendations and preparation of the final report of a survey will take time. It is therefore desirable to conduct a brief review with those responsible as soon as the survey has been completed. If any conclusions are immediately obvious, they should be discussed informally.

15.6.14 Recommendations should be practical and within the scope and ability of the organization concerned. Sensitive issues should not be avoided, but care should be taken to ensure that they are presented in a fair, constructive and diplomatic manner.

15.7 DISSEMINATING SAFETY INFORMATION

15.7.1 The SM should be the focal point for safety-related information — hazard reports, risk assessments, safety analyses, investigation reports, audit reports, meeting minutes, conference proceedings, etc. From all this information, the SM must sift the most relevant safety messages for dissemination. Some messages are urgent (before the next flight), some are directive, some are for background understanding, some are seasonal, etc. Most staff do not have time to read all this information, so the SM must distil the salient points into easily understood safety messages. Several considerations should guide the SM in disseminating safety information, for example:

a) criticality of the information;

b) the target audience;

c) best means for disseminating the information (e.g. briefings, directed letters, newsletters, organization's intranet, videos and posters);

d) timing strategy to maximize the impact of the message (e.g. winter briefings generate little interest during the summer);

e) content (e.g. how much background information should be given versus the core message); and

f) wording (e.g. most appropriate vocabulary, style and tone).

Safety critical information

15.7.2 Urgent safety information may be disseminated using such means as:

a) direct messages (oral or written) to responsible managers;

b) direct briefings (e.g. for the flight crew of a particular fleet, or for controllers in a specific unit);

c) shift changeover briefings (e.g. for AMEs and ATCOs); and

d) direct mail (post, facsimile or e-mail) — particularly for personnel who are away from home base.

"Nice-to-know" information

15.7.3 The aviation industry produces a considerable amount of literature — some of it targeted at particular operations. This material includes State accident/incident reports, safety studies, aviation journals, proceedings of conferences and symposia, manufacturers' reports, training videos, etc. Increasingly, this information is available electronically. Regardless of the format of the information, it may be made available to staff and/or management through:

a) an internal circulation system;

b) a safety library (probably the SM's office);

c) summaries (probably by the SM) notifying staff of the receipt of such information; and

d) directed distribution to selected managers.

Reporting to management

15.7.4 When reporting to management, the rule is to keep it simple. Management does not have the time to sift through large amounts of material, some of which is probably irrelevant. Management is interested in such basic questions as those listed below:

a) What is the problem?

b) How could it affect the organization?

c) How likely is it to happen?

d) What is the cost if it does happen?

e) How can the hazard be eliminated?

f) How can the risk be reduced?

g) How much will it cost to fix?

h) What are the downsides of such action?

15.8 WRITTEN COMMUNICATIONS

15.8.1 Documenting the SMS, recording and following up on significant safety actions, formulating meaningful safety recommendations, promoting safety, etc. all require strong written communications.

15.8.2 Since safety recommendations usually involve additional resources (or reallocation of existing resources), affected managers may understandably be resistant to taking action. Written communication offers an effective means for making the necessary argument for change as it reduces the likelihood of misunderstandings.

15.8.3 Regardless of the nature of any safety action being recommended, poorly written communications stand little chance of convincing the recipient to change. Therefore, written communications should meet the following criteria:

a) clarity of purpose;

b) simplicity of language;

c) attention to detail, yet concise;

d) relevance of words and ideas;

e) logic and accuracy of argument;

f) objective, balanced and fair consideration of facts and analysis;

g) neutral (non-blameworthy) tone; and

h) timeliness.

15.9 SAFETY PROMOTION

15.9.1 An ongoing programme of safety promotion will ensure that employees benefit from safety lessons learned and continue to understand the organization's SMS. Safety promotion is linked closely with safety training and the dissemination of safety information. It refers to those activities which the organization carries out in order to ensure that the staff understand why safety management procedures are being introduced, what safety management means, why particular safety actions are being taken, etc. Safety promotion provides the mechanism through which lessons learned from safety occurrence investigations and other safety-related activities are made available to all affected personnel. It also provides a means of encouraging the development of a positive safety culture and ensuring that, once established, the safety culture is maintained.

15.9.2 Publication of safety policies, procedures, newsletters and bulletins alone will not necessarily bring about the development of a positive safety culture. While it is important that staff be well informed, it is also important that they see evidence of the commitment of management to safety. The attitudes and actions of management will therefore be a significant factor in the promotion of safe work practices and the development of a positive safety culture.

15.9.3 Safety promotion activities are particularly important during the initial stages of the implementation of an SMS. However, safety promotion also plays an important role in the maintenance of safety, as it is the means by which safety issues are communicated within the organization. These issues may be addressed through staff training programmes or less formal mechanisms.

15.9.4 In order to propose solutions to identified hazards, staff must be aware of the hazards that have already been identified and the corrective actions that have already been implemented. The safety promotion activities and training programmes should therefore address the rationale behind the introduction of new procedures. When the lessons learned could also be significant to other States, operators or service providers, consideration should be given to wider dissemination of the information.

Promotion methods

15.9.5 If a safety message is to be learned and retained, the recipient first has to be positively motivated. Unless this is achieved, much well-intended effort will be wasted. Propaganda which merely exhorts people to avoid making errors, to take more care, etc. is ineffective as it does not provide anything substantial to which individuals can relate. This approach has sometimes been described as the *"bumper sticker"* approach to safety.

15.9.6 Safety topics should be selected for promotional campaigns based on their potential to control and reduce losses. Selection should therefore be based on the experience of past accidents or near misses, matters identified by hazard analysis, and observations from routine safety audits. In addition, employees should be encouraged to submit suggestions for promotional campaigns.

15.9.7 All methods of dissemination — the spoken and written word, posters, videos, slide presentations, etc. — require talent, skill and experience to be effective. Poorly executed dissemination may be worse than none at all. Professional input is therefore advisable when disseminating information to a critical audience.

15.9.8 Once a decision has been made to disseminate safety information, a number of important factors should be considered, including:

a) *the audience*. The message needs to be expressed in terms and vernacular that reflect the knowledge of the audience.

b) *the response*. What is expected to be accomplished?

c) *the medium*. While the printed word may be the easiest and cheapest, it is likely to be the least effective.

d) *the style of presentation*. This may involve the use of humour, graphics, photography and other attention-getting techniques.

15.9.9 Ideally, a safety promotion programme will be based on several different communication methods. The following methods are commonly used for this purpose:

a) *Spoken word.* This is perhaps the most effective method, especially if supplemented with a visual presentation. However, it is also the most expensive method, consuming time and effort to assemble the audience, aids and equipment. Some States employ safety specialists who visit various organizations, holding lectures and seminars.

b) *Written word.* This is by far the most popular method because of speed and economy. However, the proliferation of printed material tends to saturate our capacity to absorb it all. Printed safety promotion material competes for attention with considerable amounts of other printed material. In the digital era, the printed word has an even harder time competing for attention. Professional guidance or assistance may be desirable to ensure that the message is conveyed effectively.

c) *Videos.* Using videos offers the advantages of dynamic imagery and sound to reinforce particular safety messages efficiently. However, videos have two main limitations: expense of production and the need for special equipment for viewing. Nonetheless, they can be effective in getting a particular message disseminated throughout a widely dispersed organizational structure — minimizing the need for staff travel. Nowadays they may be distributed electronically or via compact disc (CD). A variety of safety videos are available commercially. Many are listed on safety sites on the Internet.

d) *Displays.* When a message is to be shown at a large gathering such as a conference, the display booth is a good *"self-briefing"* technique. Imagination and display expertise are required to present not only the message but also the image of the organization. The drawbacks of a display are the expense and, unless the display is manned, a static and somewhat uninteresting appearance. Professional guidance or assistance is needed to ensure that the message is conveyed effectively.

e) *Websites.* Many of the foregoing promotion methods may have little appeal to generations that have grown up with PCs, digital games and Internet access. The explosive growth of the Internet offers significant potential for improvement in the promotion of safety. Even small companies can establish and maintain a website to disseminate safety information.

f) *Conferences, symposia, seminars, workshops, etc.* Using this method provides ideal fora for promoting safety issues. The organization, the regulator, industry associations, safety institutes, universities, manufacturers, etc. may sponsor these meetings. The value of such fora often goes well beyond safety promotion by helping to establish contacts with others in the safety field.

15.9.10 When a major promotional programme is being contemplated, it is wise to seek advice from experienced communicators and knowledgeable representatives of the target groups involved.

15.10 MANAGEMENT OF SAFETY INFORMATION

> Databases contain a wealth of safety information;
> however, without the tools and skills
> necessary to access and analyse the data,
> the information is essentially useless.

General

15.10.1 Quality data are the lifeblood of safety management. Effective safety management is *"data-driven"*. Information collected from operational and maintenance reports, safety reports, audits, evaluations of work practices, etc. generate a lot of data — although not all of it is relevant for safety management. So much safety-related information is collected and stored that there is a risk of overwhelming responsible managers, thereby compromising the utility of the data. Sound management of the organization's databases is fundamental to effective safety management functions (such as trend monitoring, risk assessment, cost-benefit analyses, and occurrence investigations).

15.10.2 The argument necessary for safety change must be based on the analysis of consolidated and quality data. The establishment and maintenance of a safety database provide an essential tool for corporate managers, safety managers and regulatory authorities monitoring system safety issues. Unfortunately, many databases lack the data quality necessary to provide a reliable basis for adjusting safety priorities, evaluating the effectiveness of risk mitigation measures and initiating safety-related research. An understanding of data, databases and the use of appropriate tools is required to reach timely and valid decisions.

15.10.3 Increasingly, computer software is being used to facilitate the recording, storage, analysis and presentation of safety information. It is now possible to easily conduct sophisticated analysis on information in the databases. A wide range of relatively inexpensive electronic databases, capable of supporting the organization's data management requirements, are commercially available for desktop computers. These stand-alone systems have the advantage of not using the organization's main computer system, thus improving the security of the data.

ICAO recommendations

15.10.4 Annex 13 recommends that States establish an accident and incident database to facilitate the effective analysis of safety information, including that from its incident reporting systems. The database systems should use standardized formats to facilitate data exchange.

ICAO Accident/Incident Data Reporting (ADREP) system

15.10.5 To assist States to obtain safety data, ICAO maintains the ADREP system. ADREP is a database of information on aircraft accidents and serious incidents worldwide.

15.10.6 The ADREP system uses the ECCAIRS[2] software. This database programme is available to States wishing to establish their own databases in support of safety management. The ADREP system provides States with:

a) a significant database of international accident and incident experience for safety analysis and research;

b) an internationally developed system for coding safety data to facilitate the exchange of safety data; and

c) an analytical service in response to specific safety requests from States.

Information system needs

15.10.7 Depending on the size of their organizations, users require a system with a range of capabilities and outputs to manage their safety data. In general, users require:

a) a system with the capability of transforming large amounts of safety data into useful information that supports decision-making;

b) a system that will reduce workload for managers and safety personnel;

c) an automated system that is customizable to their own culture; and

d) a system that can operate at relatively low cost.

Understanding databases

15.10.8 To take advantage of the potential benefits of safety databases, a basic understanding of their operation is required.

What is a database?

15.10.9 Any information that has been grouped together in an organized manner can be considered a ***database***. Paper records can be maintained in a simple filing system (i.e. a manual "database"), but such a system will suffice only for the smallest of operations. Storage, recording, recall and retrieval of data are cumbersome tasks. Safety data of whatever origin should preferably be stored in an electronic database that facilitates the retrieval of this information in a variety of formats.

15.10.10 The capability to manipulate, analyse and retrieve information in a variety of ways is known as ***database management***. Most database management software packages incorporate the following organizational elements for defining a database:

a) ***Record**:* A grouping of information items that go together as a unit (such as all data concerning one occurrence);

2. The European Co-ordination Centre for Aviation Incident Reporting Systems (ECCAIRS) is described in Chapter 7.

b) ***Field**:* Each separate information item in a Record (such as the date or location of an occurrence); and

c) ***File**:* A group of Records having the same structure and an interrelationship (such as all engine-related occurrences for a specific year).

15.10.11 Databases are considered to be *"**structured**"* when each data field has a fixed length and its format type is clearly defined by a number, date, "yes/no" answer, character or text. Often only a fixed choice of values is available to the user. These values are stored in reference files, often referred to as *base tables* or *list value tables*, for example, a selection of aircraft make and model from a predetermined list. In order to facilitate quantitative analysis and systematic searches, free-form text entry in structured databases is minimized by confining it to a fixed field length. Often such information is categorized by a system of ***keywords***.

15.10.12 Databases are considered to be *"**text-based**"* when information holdings are primarily written documents (for example, accident and incident summaries or written correspondence). The data are indexed and stored in free-form text fields. Some databases contain large amounts of text and structured data; however, modern databases are much more than electronic filing cabinets.

Database limitations

15.10.13 There are limitations to be considered when developing, maintaining or using databases. Some of the limitations relate directly to the database system, while others relate to the usage of the data. If unsupportable conclusions and decisions are to be avoided, database users should understand these limitations. Database users should also know the purpose for which the database was assembled, and the credibility of the information entered by the organization which created and maintains it.

Database integrity

15.10.14 Safety databases are a strategic element of an organization's SMS. The data are vulnerable to corruption from many sources, and care must be taken to preserve the integrity of the data. Many employees may have access to the database for inputting data. Others will require access to the data for the performance of their safety duties. Access from multiple sites of a networked system can increase the vulnerability of the database.

15.10.15 The utility of a database will be compromised by inadequate attention to maintaining the data. Missing data, delays in inputting current data, inaccurate data entry, etc. corrupt the database. Even the application of the best analytical tools cannot compensate for bad data.

Database management

Protection of safety data

15.10.16 Given the potential for misuse of safety data that has been compiled strictly for the purpose of advancing aviation safety, database management must begin with protection of the data. Database managers must balance the need for data protection with that of making data accessible to those who can advance aviation safety. Protection considerations include:

a) adequacy of *"access to information"* laws vis-à-vis safety management requirements;

b) organization policies on the protection of safety data;

c) de-identification, by removing all details that might lead a third party to infer the identity of individuals (for example, flight numbers, dates/times, locations and aircraft type);

d) security of information systems, data storage and communication networks;

e) limiting access to databases to those with a "need to know"; and

f) prohibitions on unauthorized use of data.

Safety database capabilities

15.10.17 The functional properties and attributes of different database management systems vary, and each should be considered before deciding on the most suitable system for an operator's needs. Experience has shown that air safety-related incidents are best recorded and tracked using a PC-based database. The number of features available depends on the type of system selected. Basic features should enable the user to perform such tasks as:

a) log safety events under various categories;

b) link events to related documents (e.g. reports and photographs);

c) monitor trends;

d) compile analyses, charts and reports;

e) check historical records;

f) share data with other organizations;

g) monitor event investigations; and

h) flag overdue action responses.

Database selection considerations

15.10.18 The selection of commercially available database systems will depend upon the user's expectations, the data required, the computer operating system and the complexity of the queries to be handled. A variety of programmes with differing capabilities and skill demands is available. The choice of which type to use requires a balance of the considerations listed below:

a) *User-friendliness*. The system should be intuitively easy to use. Some programmes provide a wide range of features but require significant training. Unfortunately, there are often trade-offs between the user-friendliness and search power; the more user-friendly the tool, the less likely it will be able to handle complex queries.

b) *Access*. Although access to all details stored in the database would be ideal, not all users require such access. The structure and complexity of the database will influence the choice of any particular query tools.

c) *Performance* is a measure of how efficiently the system operates. It depends on such considerations as:

1) how well the data are captured, maintained and monitored;

2) whether the data is stored in formats that facilitate trend or other analyses;

3) the complexity of the database structure; and

4) the design of the host computer system (or network).

d) *Flexibility* is dependent on the system's ability to:

1) process a variety of queries;

2) filter and sort data;

3) use binary logic (i.e. the system can deal with "AND/OR" conditions such as "all pilots who are captains and have 15 000 hours of experience", or "all pilots who are captains or have 15 000 hours of experience");

4) perform basic analysis (counts and cross-tabulations);

5) produce user-defined outputs; and

6) connect with other databases to import or export data.

15.10.19 ***Costs*** vary with individual organization requirements. The price charged by some system vendors is a flat fee, which allows multiple users on any one licence. Alternatively, with other system vendors, the rate increases depending on the number of authorized users. The purchaser should take into consideration such associated cost factors as:

a) installation costs;

b) training costs;

c) software upgrade costs;

d) maintenance and support fees; and

e) other software licence fees that may be necessary.

15.11 SAFETY MANAGEMENT MANUAL

15.11.1 A safety management manual provides management with a key instrument for communicating the organization's approach to safety to the whole organization. The manual should document all aspects of the SMS, including the safety policy, safety procedures and individual safety accountabilities.

15.11.2 The safety management manual should include, *inter alia*:

a) document control procedures;

b) scope of the SMS;

c) safety policy;

d) safety accountabilities;

e) hazard identification schemes;

f) safety performance monitoring;

g) safety assessment;

h) safety auditing;

i) safety promotion; and

j) safety organizational structure.

15.11.3 The safety management manual should be a living document, reflecting the current status of the SMS. The SM will likely be responsible for the development of the safety management manual. The manual should be written so that it reflects the intent and processes of the SMS. Thus, a significant change to the SMS will require an update of the safety management manual.

15.11.4 The safety management manual should be kept as short and concise as possible. Any information that changes regularly should be put into appendices. This includes, for example, names of personnel assigned specific safety responsibilities.

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Appendix 1 to Chapter 15

SAMPLE JOB DESCRIPTION FOR SAFETY MANAGER

Overall purpose

1. The safety manager (SM) is responsible for providing guidance and direction for the operation of the organization's safety management system.

Dimension

2. The position requires the ability to cope with changing circumstances and situations with little supervision. The SM acts independently of other managers within the organization.

3. The SM is responsible for providing information and advice to senior management on matters relating to safe operations. Tact, diplomacy and a high degree of integrity are prerequisites.

4. The job requires flexibility as assignments may be undertaken with little or no notice and outside normal work hours.

Nature and scope

5. The SM must interact with operational personnel, senior managers and departmental heads throughout the organization. The SM should also foster positive relationships with regulatory authorities, agencies and service providers outside the organization. Other contacts will be established at a working level as appropriate.

Qualifications

6. The suggested attributes and qualifications include:

a) broad operational knowledge and experience in the functions of the organization (e.g. aircraft operations, air traffic management and aerodrome operations);

b) sound knowledge of safety management principles and practices;

c) good written and verbal communication skills;

d) well-developed interpersonal skills;

e) computer literacy;

f) the ability to relate to all levels, both inside and outside the organization;

g) organizational ability;

h) capable of working unsupervised;

i) good analytical skills;

j) leadership skills and an authoritative approach; and

k) worthy of respect among peers and management.

Authority

7. Regarding safety matters, the SM has direct access to the CEO and appropriate management.

8. The SM is authorized to conduct safety audits of any aspect of the operation.

9. The SM has the authority to convene an inquiry into an accident or incident in accordance with the procedures specified in the safety management manual.

Chapter 16

AIRCRAFT OPERATIONS

16.1 GENERAL

16.1.1 Annex 6 — *Operation of Aircraft,* Part I — *International Commercial Air Transport — Aeroplanes,* and Part III — *International Operations — Helicopters,* requires States to establish a safety programme in order to achieve an acceptable level of safety in the operation of aircraft. As part of their safety programme, States require operators to implement an accepted safety management system (SMS).

16.1.2 An SMS allows operators to integrate their diverse safety activities into a coherent system. Examples of safety activities that might be integrated into an operator's SMS include:

a) hazard and incident reporting;

b) Flight Data Analysis (FDA);

c) Line Operations Safety Audit (LOSA); and

d) cabin safety.

Each is described more fully below.

16.2 HAZARD AND INCIDENT REPORTING

16.2.1 The principles and operation of successful incident reporting systems are discussed in Chapter 7. There are few better examples of an organization's commitment to safety and its fostering of a positive safety culture than the implementation of a non-punitive incident reporting system. Nowadays, many operators have made this commitment to safety and, as a result, benefited not only from improved hazard identification but also from improved efficiencies in flight operations.

Benefits

16.2.2 Incident reporting systems are one of an operator's most effective tools for proactive hazard identification, a key element of effective safety management. Policies, procedures and practices developed within an organization sometimes introduce unforeseen hazards into aircraft operations. These latent conditions (hazards) may lie dormant for years. They are usually introduced unknowingly, often with the best of intentions. Examples include poor equipment design, inappropriate management decisions, ambiguously written procedures and inadequate communication between management and line personnel. Line management can also introduce such hazards by instituting operating procedures that do not work as intended under *"real world"* conditions. In short, hazards may have their origins far removed in space and time from the incidents that may eventually result from them.

16.2.3 An accident or incident may not result from these hazards immediately because “front-line personnel” (whether they be pilots, ATCOs or AMEs) often develop ways of coping with the hazard — sometimes described as *“work arounds”*. However, if the hazards are not identified and addressed, sooner or later the coping mechanisms fail and an accident or incident ensues.

16.2.4 A properly managed in-house reporting system can help companies identify many of these hazards. By collecting, aggregating and then analysing hazard and incident reports, safety managers can better understand problems encountered during operations. Armed with this knowledge, they can initiate systemic solutions, rather than short-term fixes that may only hide the real problems.

Encouraging the free flow of safety information

16.2.5 The trust of employees in the incident reporting system is fundamental to the quality, accuracy and substance of data reported. If hazard and incident data are collected in a corporate atmosphere where employees feel free to openly share safety information, the data will contain much useful detail. Since it will represent the actual environment, it will be helpful in determining contributing factors and areas of safety concern.

16.2.6 On the other hand, if the company uses incident reports for disciplinary purposes, the company incident reporting system will only receive the minimum information required to comply with company rules. Little useful information from a safety perspective could be expected.

16.2.7 The trust necessary for the free flow of safety information is very fragile. It may take years to establish; yet, one breach of that trust may undermine the effectiveness of the system for a long time. Building the necessary trust begins with a formal statement of company policy on its approach to open and free incident reporting. A sample of one company’s policy on non-punitive hazard reporting is in Appendix 1 to this chapter.

16.2.8 A perennial question asked with any new incident reporting system concerns *“what to report?”* As indicated in Chapter 7, the guiding credo should be ***“If in doubt, report it.”*** A sample list of the types of occurrences or events to be reported to an operator’s reporting system is in Appendix 2 to this chapter. To be effective, as a minimum, an operator’s reporting programme should include hazard and incident reports from flight operations personnel, AMEs and cabin crew.

Commercially available systems

16.2.9 An increasing number of commercially available incident reporting systems that run on personal computers (PCs) and are available at relatively low cost, have proven to be well suited for company reporting systems. These off-the-shelf software packages collect and store data, generate reports, and can be used for trend analysis and safety performance monitoring. Further information on database systems is contained in Chapter 15.

16.2.10 Three examples of such systems are listed below:

a) ***British Airways Safety Information System (BASIS)*** was created as a company incident reporting programme for flight crews. This PC-based programme has matured to become a quasi-industry standard for collecting and managing safety information. It is currently used by more than 100 airlines and aviation organizations. Systems being developed on-line are frequently designed to be compatible with BASIS. A number of BASIS modules cover a broad spectrum of activities relevant to safety management. Further information on BASIS can be obtained from their website at http://www.winbasis.com.

b) ***INDICATE*** *(Identifying Needed Defences in the Civil Aviation Transport Environment)* is a safety management programme developed in Australia to provide a simple, cost-effective and reliable means of capturing, monitoring and reporting information about safety hazards.

The INDICATE software was created in Microsoft Access and is easily installed on a Windows-compatible PC. It provides a logical and consistent methodology for recording and categorizing hazards; a means of quickly and easily recording recommendations and responses; a database on which safety hazards can be recorded and tracked; and an automated facility for producing reports about hazards so that information can be disseminated easily. It is also a useful tool for safety audit purposes. The Australian Transport Safety Bureau (ATSB) provides the INDICATE software at no cost. For further information on INDICATE, visit their website at http://www.atsb.gov.au.

c) ***Aircrew Incident Reporting System (AIRS)*** was developed by Airbus Industrie to help its customers establish their own confidential reporting systems. The focus of AIRS is on collecting and understanding the systemic implications of reported incidents, as well as the behavioural aspects. The analytical part of AIRS aims to provide answers to the *"how"* and *"why"* a certain incident occurred. In particular, AIRS aims to enhance an understanding of the underlying Human Factors contributing to occurrences. The AIRS software, which is compatible with BASIS, allows for the storing of standardized data from both flight and cabin operations.

16.3 FLIGHT DATA ANALYSIS (FDA) PROGRAMME

Introduction

16.3.1 Flight Data Analysis (FDA) programmes, sometimes referred to as Flight Data Monitoring (FDM), or Flight Operations Quality Assurance (FOQA), provide another tool for the proactive identification of hazards. FDA is a logical complement to hazard and incident reporting and to LOSA.

What is an FDA programme?

16.3.2 Initially, the principal use of flight recorders was to aid accident investigators, especially in those accidents with no surviving crew members. Early on, it was recognized that analysis of the recorded data was also useful for better understanding serious incidents. By routinely accessing the recorded flight parameters, much could be learned about the safety of flight operations and the performance of airframes and engines. Valuable data about the things that go right in day-to-day operations were available, putting accident and incident data into perspective. As well, analysis of this de-identified data could assist in the identification of safety hazards before a serious incident or accident occurred.

16.3.3 To capitalize on these benefits, a number of airlines set up systems to routinely analyse recorded flight data. Despite some initial problems, the aviation industry is increasingly analysing recorded data from normal operations in support of company safety programmes. FDA has provided management with another tool for proactively identifying safety hazards and mitigating the associated risks.

16.3.4 For the purposes of this manual, an FDA programme may be defined as:

- *A proactive and non-punitive programme for gathering and analysing data recorded during routine flights to improve flight crew performance, operating procedures, flight training, air traffic control procedures, air navigation services, or aircraft maintenance and design.*

16.3.5 Any FDA programme requires the cooperation of the pilot group. Prior to introducing an FDA programme, it is essential that agreement be reached on the processes to be followed, in particular the non-punitive aspects of such a programme. The details are normally contained in a formal agreement between management and its flight crew. An example of one such agreement is contained in Appendix 3 to this chapter.

Benefits of FDA programmes

16.3.6 FDA programmes are increasingly being used for the monitoring and analysis of flight operations and engineering performance. FDA programmes are a logical component of an SMS, particularly for larger operators. Successful programmes encourage adherence to SOPs, deter non-standard behaviour and so enhance flight safety. They can detect adverse trends in any part of the flight regime and thus facilitate the investigation of events other than those which have had serious consequences.

16.3.7 Flight data analysis can be used to detect flight parameter exceedences and to identify non-standard or deficient procedures, weaknesses in the ATC system, and anomalies in aircraft performance. FDA allows the monitoring of various aspects of the flight profile, such as the adherence to the prescribed take-off, climb, cruise, descent, approach and landing SOPs. Specific aspects of flight operations can be examined either retrospectively to identify problem areas, or proactively prior to introducing operational change and subsequently, to confirm the effectiveness of the change.

16.3.8 During incident analysis, flight recorder data for the incident flight can be compared with the fleet profile data, thereby facilitating analysis of the systemic aspects of an incident. It may be that the parameters of the incident flight vary only slightly from many other flights, possibly indicating a requirement for change in operating technique or training. For example, it would be possible to determine whether a tail-scrape on landing was an isolated event, or symptomatic of a wider mishandling problem, such as over-flaring on touchdown or improper thrust management.

16.3.9 Engine monitoring programmes may utilize the automated analysis of flight recorder data for reliable trend analysis as manually coded engine data are limited in terms of accuracy, timeliness and reliability. It is also possible to monitor other aspects of the airframe and systems.

16.3.10 In summary, FDA programmes offer a wide spectrum of applications for safety management, as well as improvements in operational efficiency and economy. Data aggregated from many flights may be useful to help:

a) determine day-to-day operating norms;

b) identify unsafe trends;

c) identify hazards in operating procedures, fleets, airports, ATC procedures, etc.;

d) monitor the effectiveness of specific safety actions taken;

e) reduce operating and maintenance costs;

f) optimize training procedures; and

g) provide a performance measurement tool for risk management programmes.

ICAO requirement

16.3.11 Annex 6, Part I, contains provisions for FDA programmes to be part of an operator's SMS. Operators of larger aircraft conducting international commercial air transport operations are required to have a non-punitive FDA programme, which contains adequate safeguards to protect the source(s) of the data. They may utilize the services of a specialist contractor to operate the programme.

> ***From 1 January 2005, an operator of an aeroplane of a maximum certificated take-off mass in excess of 27 000 kg shall establish and maintain a flight data analysis programme as part of its safety management system.***
>
> *Annex 6, Part 1, Chapter 3*

Using an FDA programme

16.3.12 Typically, FDA data are being used for:

a) exceedence detection;

b) routine measurements;

c) incident investigations;

d) continuing airworthiness; and

e) linked databases (or integrated safety analysis).

Exceedence detection

16.3.13 FDA programmes may be used for detecting exceedences or safety events, such as deviations from flight manual limits, SOPs, or good airmanship. A set of core events (usually provided by the FDA software vendor in consultation with the operator/manufacturer) establishes the main areas of interest to operators.

Examples: *High lift-off rotation rate, stall warning, GPWS warning, flap limit speed exceedence, fast approach, high/low on glide slope, and heavy landing.*

16.3.14 FDA provides useful information which can complement that provided in crew reports.

Examples: *Reduced flap landing, emergency descent, engine failure, rejected take-off, go-around, TCAS or GPWS warning, and system malfunctions.*

16.3.15 Companies may also modify the standard set of core events (in accordance with the agreement with their pilots) to account for unique situations they regularly experience, or the SOPs they use.

Example: *To avoid nuisance reports from a non-standard SID.*

16.3.16 They may also define new events (with the agreement of the pilots) to address specific problem areas.

Example: *Restrictions on the use of certain flap settings to increase component life.*

16.3.17 Care must be taken that, in order to avoid an exceedence, flight crew do not attempt to fly the FDA profile rather than follow SOPs. Such an action can quickly turn a poor situation into something worse.

Routine measurements

16.3.18 Increasingly, data are retained from all flights, not just the ones producing significant events. A selection of parameters is retained that is sufficient to characterize each flight and allow a comparative analysis of a wide range of operational variability. Trends may be identified before there are statistically significant numbers of events. Emerging trends and tendencies are monitored before the trigger levels associated with exceedences are reached.

Examples *of parameters monitored: take-off weight; flap setting; temperature; rotation and lift-off speeds versus scheduled speeds; maximum pitch rate and attitude during rotation; and gear retraction speeds, heights and times.*

Examples *of comparative analyses: pitch rates from high versus low take-off weights; good versus bad weather approaches; and touchdowns on short versus long runways.*

Incident investigation

16.3.19 Recorded data provide valuable information for follow-up to mandatory reportable incidents and other technical reports. Quantifiable recorded data have been useful in adding to the impressions and information recalled by the flight crew. The recorded data also provide an accurate indication of system status and performance, which may help in determining cause and effect relationships.

Examples *of incidents where recorded data could be useful:*

a) *emergencies, such as:*

   1) *high-speed rejected take-offs;*
   2) *flight control problems; and*
   3) *system failures;*

b) *high cockpit workload conditions as corroborated by such indicators as:*

   1) *late descent;*
   2) *late localizer and/or glide slope interception;*
   3) *large heading change below a specific height; and*
   4) *late landing configuration;*

c) *unstabilized and rushed approaches, glide path excursions, etc.;*

d) *exceedences of prescribed operating limitations (such as flap limit speeds, engine over-temperatures, Vspeeds, and stall onset conditions; and*

e) *wake vortex encounters, low-level wind shear, turbulence encounters or other vertical accelerations.*

Continuing airworthiness

16.3.20 Both routine and event data can be utilized to assist the continuing airworthiness function. For example, engine-monitoring programmes look at measures of engine performance to determine operating efficiency and predict impending failures.

***Examples** of continuing airworthiness uses: engine thrust level and airframe drag measurements; avionics and other system performance monitoring; flying control performance; and brake and landing gear usage.*

Integrated safety analysis

16.3.21 All the data gathered in an FDA programme should be kept in a central safety database. By linking the FDA database to other safety databases (such as incident reporting systems and technical fault reporting systems), a more complete understanding of events becomes possible through cross-referencing the various sources of information. Care must be taken, however, to safeguard the confidentiality of FDA data when linking the data to identified data.

***Example** of integration: A heavy landing results in a crew report, an FDA event and an engineering report. The crew report provides the context, the FDA event provides the quantitative description, and the engineering report provides the result.*

16.3.22 The integration of all available sources of safety data provides the operator’s SMS with viable information on the overall safety health of the operation.

FDA equipment

16.3.23 FDA programmes generally involve systems that capture flight data, transform the data into an appropriate format for analysis, and generate reports and visualization to assist in assessing the data. The level of sophistication of the equipment can vary widely. Typically, however, the following equipment capabilities are required for effective FDA programmes:

a) an on-board device to capture and record data on a wide range of in-flight parameters (such as altitude, airspeed, heading, aircraft attitude, and aircraft configuration);

b) a means to transfer the data recorded on board the aircraft to a ground-based processing station. In the past, this largely involved the physical movement of the memory unit from the quick access recorder (QAR) (either tape, optical disc, or solid state). To reduce the physical effort required, later transfer methods utilize wireless technologies;

c) a ground-based computer system (using specialized software) to analyse the data (from single flights and/or in an aggregated format), identify deviations from expected performance, generate reports to assist in interpreting the read-outs, etc.; and

d) optional software for a flight animation capability to integrate all data, presenting it as a simulation of in-flight conditions, thereby facilitating visualization of actual events.

Airborne equipment

16.3.24 Modern glass-cockpit and fly-by-wire aircraft are equipped with the necessary digital data buses from which information can be captured by a recording device for subsequent analysis. Older aircraft may be retrofitted to record additional parameters. However, for older (non-digital) aircraft, it is unlikely to be practical to record sufficient parameters to support a viable FDA programme.

16.3.25 The number of parameters recorded by the mandatory FDR may determine the scope of an FDA programme. Unfortunately, in some cases the number of parameters and recording capacity required by law to be recorded to support accident investigations may be insufficient to support an effective FDA programme. Thus many operators are opting for additional recording capacity, capable of being easily downloaded for analysis.

16.3.26 ***Quick access recorders (QARs).*** QARs are installed in the aircraft and record flight data onto a low-cost removable medium such as a tape cartridge, optical disk, or solid-state recording medium. The recording can be removed from the aircraft after a series of flights. New technology QARs are capable of supporting more than 2 000 parameters at much higher sampling rates than the FDR. The expanded data frame greatly increases the resolution and accuracy of the output from ground analysis programmes.

16.3.27 To eliminate the task of moving the data from the aircraft to the ground station by physically removing the recording medium of the QAR, newer systems automatically download the recorded information via secure wireless systems when the aircraft is in the vicinity of the gate. In still other systems, the recorded data is analysed on board while the aircraft is airborne. The encrypted data is then transmitted to a ground station using satellite communications. Fleet composition, route structure and cost considerations will determine the most cost-effective method of removing the data from the aircraft.

Ground replay and analysis equipment

16.3.28 Data are downloaded from the aircraft recording device into a ground-based replay and analysis department, where the data are held securely to protect this sensitive information. A variety of computer platforms, including networked PCs, are capable of hosting the software needed to replay the recorded data. Replay software is commercially available, however, the computer platform will require appropriate front-end interfaces (usually provided by the recorder manufacturers) to cope with the variety of recording inputs available today.

16.3.29 FDA programmes generate large amounts of data requiring specialized analytical tools. These tools, which are commercially available, facilitate the routine analysis of flight data in order to reveal situations that require corrective action.

16.3.30 The analysis software checks the downloaded flight data for abnormalities. The exceedence detection software typically includes a large number of trigger logic expressions derived from a variety of sources such as flight performance curves, SOPs, engine manufacturers' performance data, and airfield layout and approach criteria. Trigger logic expressions may be simple exceedences such as redline values. The majority, however, are composites which define a certain flight mode, aircraft configuration or payload-related condition. Analysis software can also assign different sets of rules dependent on airport or geography. For example, noise sensitive airports may use higher than normal glide slopes on approach paths over populated areas.

16.3.31 Events and measurements can be displayed on a ground computer screen in a variety of formats. Recorded flight data are usually shown in the form of colour-coded traces and associated engineering units, cockpit simulations or animations of the external view of the aircraft.

FDA in practice

FDA process

16.3.32 Typically, operators follow a closed-loop process in applying an FDA programme, for example:

a) ***Baseline established***. Initially, operators establish a baseline of operational parameters against which changes can be detected and measured.

Examples: *Rate of unstable approaches, or hard landings.*

b) ***Unusual or unsafe circumstances highlighted***. The user determines when non-standard, unusual or basically unsafe circumstances occur; by comparing them to the baseline margins of safety, the changes can be quantified.

Example*: Increases in unstable approaches (or other unsafe events) at particular locations.*

c) ***Unsafe trends identified***. Based on the frequency of occurrence, trends are identified. Combined with an estimation of the level of severity, the risks are assessed to determine which may become unacceptable if the trend continues.

Example: A new procedure has resulted in high rates of descent that are nearly triggering GPWS warnings.

d) ***Risks mitigated***. Once an unacceptable risk has been identified, appropriate risk mitigation actions are decided and implemented.

Example*: Having found high rates of descent, the SOPs are changed to improve aircraft control for optimum/maximum rates of descent.*

e) ***Effectiveness monitored***. Once a remedial action has been put in place, its effectiveness is monitored, confirming that it has reduced the identified risk and that the risk has not been transferred elsewhere.

Example*: Confirm that other safety measures at the airfield with high rates of descent do not change for the worse after changes in approach procedures.*

Analysis and follow-up

16.3.33 FDA data are usually compiled on a monthly basis. The data should then be reviewed by a working group to identify specific exceedences and emerging undesirable trends and to disseminate the information to flight crews.

16.3.34 If deficiencies in pilot handling technique are evident, the information is de-identified in order to protect the identity of the flight crew. The information on specific exceedences is passed to an agreed aircrew representative for confidential discussion with the pilot. The aircrew representative provides the necessary contact with the pilot in order to clarify the circumstances, obtain feedback, and give advice and recommendations for appropriate action, such as re-training for the pilot (carried out in a positive and non-punitive way); revisions to operating and flight manuals; changes to ATC and airport operating procedures; etc.

16.3.35 As well as reviewing specific exceedences, all events are archived in a database. The database is used to sort, validate and display the data in easy-to-understand management reports. Over time, this archived data can provide a picture of emerging trends and hazards which would otherwise go unnoticed. Where the development of an undesirable trend becomes evident (within a fleet, or at a particular phase of flight, or airport location), the fleet's training department can implement measures to reverse the trend through modification of training exercises and/or operating procedures. Likewise with other areas of the operation requiring action, the data can then be used to confirm the effectiveness of any action taken.

16.3.36 Lessons learned from the FDA programme may warrant inclusion in the company's safety promotion programmes. Care is required, however, to ensure that any information acquired through FDA is studiously de-identified before using it in any training or promotional initiative.

16.3.37 As in any closed-loop process, follow-up monitoring is required to assess the effectiveness of any corrective actions taken. Flight crew feedback is essential for the identification and resolution of safety problems and could comprise answering the following questions, for example:

a) Are the desired results being achieved soon enough?

b) Have the problems really been corrected, or just relocated to another part of the system?

c) Have new problems been introduced?

16.3.38 All successes and failures should be recorded, comparing planned programme objectives with expected results. This provides a basis for review of the FDA programme and the foundation for future programme development.

Conditions for effective FDA programmes

16.3.39 Several conditions that are fundamental to successful FDA programmes are discussed below.

Protection of FDA data

16.3.40 Airline management and pilots both have legitimate concerns regarding the protection of FDA data, for example:

a) use of data for disciplinary purposes;

b) use of data for enforcement actions against individuals or against the company, except in cases of criminal intent or intentional disregard of safety;

c) disclosure to the media and the general public under the provisions of State laws for access to information; and

d) disclosure during civil litigation.

16.3.41 The integrity of FDA programmes rests upon protection of the FDA data. Any disclosure for purposes other than safety management can compromise the voluntary provision of FDA data, thereby compromising flight safety. Thus, preventing the misuse of FDA data is a common interest of the State, the airlines and the pilots.

Essential trust

16.3.42 As with successful incident reporting systems, the trust established between management and its pilots is the foundation for a successful FDA programme. This trust can be facilitated by:

a) early participation of the pilots' association in the design, implementation and operation of the FDA programme;

b) a formal agreement between management and the pilots, identifying the procedures for the use and protection of data. (Appendix 3 to this chapter provides a sample agreement between an airline and its aircrew); and

c) Data security, optimized by:

   1) adhering to stringent agreements with the pilots' associations;

   2) strictly limiting data access to selected individuals within the company;

   3) maintaining tight control to ensure that identifying data are removed from the flight data records as soon as possible;

   4) ensuring that operational problems are promptly addressed by management; and

   5) destruction of all identified data as soon as possible.

16.3.43 Access to crew identification information during follow-up should be available only to specifically authorized persons and used only for the purpose of an investigation. Subsequent to the analysis, the data enabling this identification should be destroyed.

Requisite safety culture

16.3.44 Consistent and competent programme management characterizes successful FDA programmes. Indicators of an effective safety culture include:

a) top management's demonstrated commitment to promoting a proactive safety culture, championing the cooperation and accountability of all organizational levels and relevant aviation associations (pilots, cabin crew, AMEs, dispatchers, etc.);

b) a non-punitive company policy. (The main objective of the FDA programme must be to identify hazards, not to identify individuals who may have committed an unsafe act.);

c) FDA programme management by a dedicated staff within the safety or operations departments, with a high degree of specialization and logistical support;

d) potential risks are identified through the correlation of the results of the analysis by persons with appropriate expertise. (For example, pilots experienced on the aircraft type being analysed are required for the accurate diagnosis of operational hazards emerging from FDA analyses.);

e) focus on monitoring fleet trends aggregated from numerous operations, rather than on specific events. The identification of systemic issues adds more value for safety management than (perhaps isolated) events;

f) a well-structured, de-identification system to protect the confidentiality of the data; and

g) an efficient communication system for disseminating hazard information (and subsequent risk assessments) to relevant departments and outside agencies to permit timely safety action.

Implementing an FDA programme

16.3.45 Typically, the following steps are required to implement an FDA programme:

a) implementation of pilot association agreements;

b) establishment and verification of operational and security procedures;

c) installation of equipment;

d) selection and training of dedicated and experienced staff to operate the programme; and

e) commencement of data analysis and validation.

16.3.46 Bearing in mind the time required to obtain crew/management agreements and develop procedures, a start-up airline with no FDA experience would not likely achieve an operational system in less than twelve months. Another year may be required before any safety and cost benefits appear. Improvements in the analysis software, or the use of outside specialist service providers, may shorten these time frames.

16.3.47 Integrating the FDA programme with other safety monitoring systems into a coherent SMS will increase the potential benefits. Safety information gathered from other programmes of the SMS gives context to the FDA data. In turn, FDA can provide quantitative information to support investigations that otherwise would be based on less reliable subjective reports.

Aims and objectives of an FDA programme

16.3.48 ***Define objectives of programme***. As with any project there is a need to define the direction and objectives of the work. A phased approach is recommended so that the foundations are in place for possible subsequent expansion into other areas. Using a building block approach will allow expansion, diversification and evolution through experience.

Example*: With a modular system, begin by looking at basic safety-related issues only. Add engine health monitoring, etc. in the second phase. Ensure compatibility with other systems.*

16.3.49 ***Set goals***. A staged set of objectives starting from the first week's replay and moving through early production reports into regular routine analysis will contribute to a sense of achievement as milestones are met.

Examples*:*

Short-term goals:

a) *Establish data download procedures, test replay software and identify aircraft defects;*

b) *Validate and investigate exceedence data; and*

c) *Establish a user-acceptable routine report format to highlight individual exceedences and facilitate the acquisition of relevant statistics.*

Medium-term goals:

a) *Produce annual report — include key performance indicators;*

b) *Add other modules to analysis (e.g. Continuing Airworthiness); and*

c) *Plan for next fleet to be added to programme.*

Long-term goals:

a) *Network FDA information across all company safety information systems;*

b) *Ensure FDA provision for any proposed advanced training programme; and*

c) *Use utilization and condition monitoring to reduce spares holdings.*

16.3.50 Initially, focusing on a few known areas of interest will help prove the system's effectiveness. In contrast to an undisciplined *"scatter-gun"* approach, a focused approach is more likely to gain early success.

Examples*: Rushed approaches, or rough runways at particular airports; unusual fuel usage on particular flight segments; etc. Analysis of such known problem areas may generate useful information for the analysis of other areas.*

The FDA team

16.3.51 Experience has shown that the "team" required to run an FDA programme could vary in size from one person with a small fleet (five aircraft), to a dedicated section for large fleets. The descriptions below identify various functions to be fulfilled, not all of which need a dedicated position. For example, engineering may provide only part-time support.

- ***Team leader***. Team leaders must earn the trust and full support of both management and flight crews. They act independently of others in line management to make recommendations that will be seen by all to have a high level of integrity and impartiality. The individual requires good analytical, presentation and management skills.

- ***Flight operations interpreter***. This person is usually a current pilot (or perhaps a recently retired senior Captain or trainer), who knows the company's route network and aircraft. This team member's in-depth knowledge of SOPs, aircraft handling characteristics, airfields and routes will be used to place the FDA data in a credible context.

- ***Technical interpreter***. This person interprets FDA data with respect to the technical aspects of the aircraft operation and is familiar with the power plant, structures and systems departments' requirements for information and any other engineering monitoring programmes in use by the airline.

- ***Aircrew representative***. This person provides the link between the fleet or training managers and flight crew involved in circumstances highlighted by FDA. The position requires good people skills and a positive attitude towards safety education. The person is normally a representative of the flight crew association and should be the only person permitted to connect the identifying data with the event. The aircrew representative requires the trust of both crew members and managers for their integrity and good judgement.

- ***Engineering technical support***. This person is usually an avionics specialist, involved in the supervision of mandatory serviceability requirements for FDR systems. This team member must be knowledgeable about FDA and the associated systems needed to run the programme.

- ***Air safety coordinator***. This person cross-references FDA information with other air safety monitoring programmes (such as the company's mandatory or confidential incident reporting programme, and LOSA), creating a credible integrated context for all information. This function can reduce duplication of follow-up investigations.

- ***Replay operative and administrator***. This person is responsible for the day-to-day running of the system, producing reports and analysis. Methodical, with some knowledge of the general operating environment, this person keeps the programme moving.

16.3.52 All FDA team members require appropriate training or experience for their respective area of data analysis. Each team member must be allocated a realistic amount of time to regularly spend on FDA tasks. With insufficient human resources, the entire programme will underperform or even fail.

Off-the-shelf FDA packages

16.3.53 The QARs available on most large, modern aircraft can be analysed on a suitably configured replay and analysis system. Even though the operators themselves can configure the various event equations and exceedence levels, suppliers of ground replay software offer both starter packs and advanced FDA programmes for a variety of different aircraft types. It is not normally cost-effective for new operators to configure FDA systems themselves, although most suppliers will review the relevance and levels of event triggers with each new operator.

16.3.54 Some aircraft manufacturers actively support FDA programmes for their aircraft. They provide airlines with packages including tools and software, handbooks to support their FDA methods and procedures, and additional assistance for operators implementing their programme. (They see the sharing of data and information provided by the airline as a means for improving their aircraft, SOPs and training.)

16.3.55 Most system vendors provide one year of maintenance and support in the original package but charge an annual fee thereafter. In addition, other cost factors to be considered by prospective purchasers include:

a) installation costs;

b) training costs;

c) software upgrade costs (often included in the maintenance contracts); and

d) other software licence fees that may be necessary.

16.3.56 FDA programmes are often viewed as one of the most expensive safety systems in terms of the initial outlay, software agreements and personnel requirements. In reality, they have the potential to save the company considerable money by reducing the risk of a major accident, improving operating standards, identifying external factors affecting the operation and improving engineering monitoring programmes.

16.4 LINE OPERATIONS SAFETY AUDIT (LOSA) PROGRAMME

Introduction

16.4.1 As has been discussed earlier, the negative consequences of human behaviour can be proactively managed. Hazards can be identified, analysed and validated based on data collected through the monitoring of day-to-day operations. Line Operations Safety Audits (LOSA) are one method for monitoring normal flight operations for safety purposes. LOSA programmes then provide another proactive safety management tool.

16.4.2 Similar to FDA programmes, LOSA facilitates hazard identification through the analysis of actual in-flight performances. Whereas FDA provides accurate data on exceedences from expected aircraft performance, LOSA provides information on joint system and human performance. It facilitates understanding the context for the performance that may have precipitated the exceedence.

16.4.3 LOSA is a tool for the understanding of human errors in flight operations. It is used to identify the threats to aviation safety that lead to human errors, to minimize the risks that such threats may generate and to implement measures to manage these errors within the operational context. LOSA enables operators to assess their resistance to operational risks and errors by front-line personnel. Using a data-driven approach, they can prioritize these risks and identify actions to reduce the risk of accidents.

16.4.4 By observing normal day-to-day flight operations, data about flight crew performance and situational factors are collected. Thus, LOSA facilitates understanding both successful performance and failures. Hazards deriving from operational errors can be identified and effective countermeasures developed.

16.4.5 LOSA uses experienced and specially trained observers to collect data about flight crew performance and situational factors on *"normal"* flights. During audited flights, observers record error-inducing circumstances and the crew's responses to them. The audits are conducted under strict non-punitive conditions, without fear of disciplinary action for detected errors. Flight crews are not required to justify their actions.

16.4.6 Data from LOSA also provide a picture of system operations that can guide strategies in regard to safety management, training and operations. Like FDA programmes, data collected through LOSA can provide a rich source of information for the proactive identification of systemic safety hazards. A particular strength of LOSA is that it identifies examples of superior performance that can be reinforced and used as models for training. (Traditionally, the industry has collected information on failed performance and revised training programmes accordingly.) With LOSA, training interventions can be based on the most successful operational performance. For example, based on LOSA data, CRM training can be modified to reflect best practices for coping with particular types of unsafe conditions and for managing typical errors related to these conditions.

ICAO's role

16.4.7 ICAO endorses LOSA as a way to monitor normal flight operations. ICAO supports the industry's initiatives with LOSA, serving as an enabling partner in the programme. ICAO's role includes:

a) promoting the value of LOSA to the international civil aviation community;

b) facilitating research in order to collect necessary data; and

c) acting as a mediator in the culturally sensitive aspects of data collection.

16.4.8 ICAO has published a manual, *Line Operations Safety Audit (LOSA)* (Doc 9803), to provide guidance to operators regarding LOSA programmes.

Terminology

Threats

16.4.9 During normal flights, crews routinely face situations created outside the cockpit that they must manage. Such situations increase the operational complexity of their task and pose some level of safety risk. These *threats* may be relatively minor (such as frequency congestion), through to major (such as an engine-fire warning).

16.4.10 Some threats can be anticipated (such as a high workload situation during approach) and the crew may brief in advance, for example, *"In the event of a go-around ..."*. Other threats may be unexpected. Since they occur without warning, no advanced briefing is feasible (for example, a TCAS advisory).

Errors

16.4.11 Errors are a normal part of all human behaviour. Flight crew errors tend to reduce the margin of safety and increase the probability of accidents. Fortunately, humans are generally quite effective in balancing the conflicting demands between *"getting the job done"* and *"getting the job done safely*".

16.4.12 Any action or inaction by the flight crew that leads to deviations from expected behaviour is considered an error. Examples of crew errors might include non-compliance with regulations and SOPs, or unexpected deviation from company or ATC expectations. Errors may be minor (setting the wrong altitude, but correcting it quickly) or major (not completing an essential checklist item).

16.4.13 LOSA employs five categories of crew errors. These include:

a) ***Communication error:*** Miscommunication, misinterpretation, or failure to communicate pertinent information among the flight crew or between flight crew and an external agent (for example, ATC or ground operations personnel);

b) ***Proficiency error:*** Lack of knowledge or psychomotor *("stick and rudder")* skills;

c) ***Operational decision error:*** Decision-making error that is not standardized by regulation or operator procedures and that unnecessarily compromises safety (for example, a crew decision to fly through a known wind shear on approach instead of going around);

d) ***Procedural error:*** Deviation in execution of regulatory and/or operator procedures. The intention is correct but the execution is flawed. This category also includes errors where a crew forgot to do something; and

e) ***Intentional non-compliance error:*** Wilful deviation from regulations and/or operator procedures (i.e. violations).

Threat and error management

16.4.14 Since threats and errors are an integral part of daily flight operations, systematic understanding of them is required for safely dealing with them. LOSA offers an informed perspective on threats and errors from which suitable coping strategies can be developed. Specifically, quantifiable LOSA data are useful in answering such questions as:

a) What type of threats do flight crews most frequently encounter? When and where do they occur, and what types are the most difficult to manage?

b) What are the most frequently committed crew errors, and which ones are the most difficult to manage?

c) What outcomes are associated with mismanaged errors? How many result in the aircraft being in an "undesired" state (such as fast/slow on final approach)?

d) Are there significant differences between airports, fleets, routes or phases of flight vis-à-vis threats and errors?

Systemic countermeasures

16.4.15 Accepting that error is inevitable, the most effective countermeasures go beyond trying to simply prevent errors. They need to highlight unsafe conditions early enough to permit flight crews to take corrective action before adverse consequences result from the error. In other words, they *"trap"* the error.

16.4.16 The most effective countermeasures seek to improve the everyday work situation in which flight crews face the inevitable threats to safe performance, measures which give crews a *"second chance"* to recover from their errors. Such systemic countermeasures include changes in aircraft design, crew training, company operating procedures, management decisions, etc.

Defining characteristics of LOSA

16.4.17 The following characteristics of LOSA ensure the integrity of the methodology and its data:

a) ***Jump seat observations during normal flight operations:*** LOSA observations are limited to routine flights (as opposed to line checks, or other training flights). Check pilots add to an already high stress level, thus providing an unrealistic picture of performance. The best observers learn to be unobtrusive and non-threatening, recording minimum detail in the cockpit.

b) ***Joint management/pilot sponsorship:*** In order for LOSA to succeed as a viable safety programme, both management and pilots support the project. Joint sponsorship provides *"checks and balances"* for the project to ensure that any necessary change will be made as a result of LOSA data. As with the implementation of a successful FDA programme, a LOSA audit does not proceed without the endorsement of the pilots via a signed agreement with management. A LOSA steering committee with pilot and management representatives shares responsibility for the planning, scheduling, supporting observers and verifying the data.

c) ***Voluntary crew participation:*** Maintaining the integrity of LOSA within the airline is extremely important for long-term success. One way to accomplish this goal is to collect all observations with voluntary crew participation. Before conducting LOSA observations, an observer obtains the flight crew's permission. If an airline conducting LOSA has an unreasonably high number of refusals by pilots to be observed, this may indicate that there are critical *"trust"* issues to be dealt with first.

d) ***Collection of only de-identified, confidential safety data:*** LOSA observers do not record names, flight numbers, dates or any other data that can identify a crew. This allows for a high level of protection against disciplinary action. Airlines should not squander an opportunity to gain insight into their operations by having pilots fearful that a LOSA observation could be used against them in disciplinary proceedings. In other words, LOSA must not only be seen to be non-punitive, it must be non-punitive.

e) ***Targeted observations:*** All data are collected on a specifically designed LOSA Observation Form. (Examples of the forms are included in Doc 9803.) Typically, the following types of information are collected by the LOSA observer:

1) flight and crew demographics such as city pairs, aircraft type, flight time, years of experience in that position and with that airline, and crew familiarity;

2) written narratives describing what the crew did well and what they did poorly and how they managed threats or errors for each phase of the flight;

3) CRM performance ratings using validated behavioural markers;

4) technical worksheet for the descent/approach/landing phases that highlight the type of approach flown, the landing runway and whether the crew met the parameters of a stabilized approach;

5) threat management worksheet that details each threat and how it was handled;

6) error management worksheet that lists each error observed, how each error was handled and the final outcome; and

7) crew interview conducted during low workload periods of the flight, such as cruise, that asks pilots for their suggestions to improve safety, training, and flight operations.

f) ***Trusted, trained and standardized observers:*** Observers are primarily pilots drawn from the line, training department, safety department, management, etc. Experienced LOSA observers from a non-affiliated airline may be more objective and serve to provide an anchor point for company observers, especially for companies initiating a new LOSA programme. Regardless of the source, it is critical that the observers are respected and trusted to ensure acceptance of LOSA by the line pilots. The observers must be trained in concepts of threat and error management and in the use of the LOSA rating forms. Standardized rating is vital to the validity of the programme.

g) ***Trusted data collection site:*** In order to maintain confidentiality, airlines must have a trusted data collection site. No observations can be misplaced or improperly disseminated within the airline, without compromising LOSA integrity. Some airlines use a “third party” to provide a neutral party for objective analysis of results.

h) ***Data verification round-tables:*** Data-driven programmes like LOSA require data quality management procedures and consistency checks. For LOSA, round table discussions with representatives of management and the pilots’ association scan raw data for inconsistencies. The database must be validated for consistency and accuracy before a statistical analysis can proceed.

i) ***Data-derived targets for enhancement:*** As the data are collected and analysed, patterns emerge. Certain errors occur frequently, certain airports or activities are problematic, certain SOPs are ignored or modified, and certain manoeuvres pose particular difficulties. These patterns become targets for enhancement. The airline then develops an action plan and implements appropriate change strategies based on the input of expertise available to the airline. Through subsequent LOSA audits, the effectiveness of the changes can be measured.

j) ***Feedback of results to the line pilots:*** After a LOSA is completed; the airline's management team and the pilots' association have an obligation to communicate the findings to the line pilots. Pilots are interested not only in the results but also management's plan for improvement.

Safety change process

16.4.18 Like other tools for risk management, a closed-loop process is required to effect a safety change. Problems are identified and analysed, strategies developed, priorities established, remedial measures implemented, and effectiveness monitored to identify any residual problems.

16.4.19 LOSA directs organizational attention to the most important safety issues in daily operations. However, LOSA does not provide the solutions; they must come from organizational strategies. The organization must evaluate the data obtained through LOSA, identify those hazards posing the greatest risks to the organization and then take the necessary actions to address them. LOSA can only reach its full potential if the organizational willingness and commitment exist to act upon the lessons of LOSA. Without meaningful safety action, LOSA data will join the tremendous banks of unused safety data already available within the international civil aviation community.

16.4.20 Following are some typical safety change strategies for airlines following a LOSA audit:

a) redefining operational philosophies and guidelines;

b) modifying existing procedures or implementing new ones;

c) arranging specific training in threat and error management and crew countermeasures;

d) reviewing checklists to ensure relevance of the content and then issuing clear guidance for their initiation and execution; and

e) defining tolerances for stabilized approaches, as opposed to the "perfect approach" parameters promoted by existing SOPs.

16.4.21 Early successes with LOSA have been most noticeable with respect to:

a) improvement in error management by flight crew;

b) reduction in checklist performance errors; and

c) reduction in unstabilized approaches.

Implementing LOSA

16.4.22 Undertaking a LOSA audit is a major safety initiative. It cannot be undertaken lightly. While LOSA is very suitable for application in larger airlines with mature SMS, it is increasingly being adopted by medium and smaller sized operations. Like successful FDA and CRM training programmes, the knowledge and experience of specialists are required for the design and conduct of an effective LOSA.

16.4.23 Organizations wishing to implement a LOSA programme should consult the *Line Operations Safety Audit (LOSA)* (Doc 9803) manual and an airline experienced in operating LOSA. In particular, formal training in the methodology and the use of the specialized LOSA tools and in the handling of the highly sensitive data collected is essential.

16.4.24 Since the support of all parties is required for a successful LOSA programme, representatives from flight operations, training and safety departments, as well as representatives from the pilots' union should meet at the outset and agree on such issues as:

a) operational requirement for a LOSA and the likelihood of conducting a successful audit;

b) programme goals;

c) resources available to guide the conduct of the audit;

d) creation of a LOSA Steering Committee to assist in planning and obtaining buy-in to the programme (including but not limited to flight operations, training, safety department and pilots' union);

e) suitable department to be responsible for administering the programme (for example, the safety department);

f) selection and training of credible observers;

g) scheduling, targeted concerns (e.g. stabilized approaches), fleet coverage, etc.;

h) protocols to be followed by flight crew and observers;

i) protocols for the protection of data;

j) analysis process;

k) formal reporting requirements;

l) communication of results; and

m) process for implementing changes necessary to reduce or eliminate hazards identified.

16.4.25 The best results are obtained when LOSA is conducted in an environment of trust. Line pilots must believe that there will be no repercussions at the individual level; otherwise their behaviour will not reflect daily reality and LOSA will be little more than an elaborate line check. In this regard, the Memorandum of Understanding in Appendix 3 to this chapter, which relates to FDA, may be instructive.

16.5 CABIN SAFETY PROGRAMME

General

16.5.1 Cabin safety is aimed at minimizing risks to the occupants of the aircraft. By reducing or eliminating hazards with the potential for creating injuries or causing damage, cabin safety focuses on providing a safer environment for the occupants of the aircraft.

16.5.2 The range of threats to the aircraft and its occupants include:

a) in-flight turbulence;

b) smoke or fire in the cabin;

c) decompression;

d) emergency landings;

e) emergency evacuations; and

f) unruly passengers.

16.5.3 The work environment and working conditions for cabin crew are influenced by a diverse set of human performance issues that may affect how cabin crew respond to threats, errors and other undesirable states. Some of the more common human performance issues affecting the performance of cabin crew are outlined in Appendix 4 to this chapter.

16.5.4 The cabin crew are usually the only company representatives that passengers see while in the aircraft. From the passengers' perspective, the cabin crew are there to provide in-flight service. From the perspective of senior management, the cabin crew may have more to do with creating a favourable corporate image. From a regulatory and operational perspective, cabin crew are on board to manage adverse situations that may develop in the aircraft cabin and to provide direction and assistance to passengers during an emergency.

16.5.5 Following a major aviation accident, investigative attention will likely focus initially on flight operations. As guided by the evidence, the investigation may then expand to include other issues. The triggering event for an accident rarely begins in the passenger compartment. However, improper response by cabin crew to events in the cabin may have more serious consequences. For example:

a) incorrect loading of passengers (e.g. weight and balance considerations);

b) failure to properly secure the cabin and galleys for take-off and landing and in turbulence;

c) delayed reaction to warnings (e.g. of in-flight turbulence);

d) inappropriate response to events in the cabin (e.g. electrical short-circuits, smoke, fumes, or an oven fire); and

e) failure to report significant observations (such as fluid leaks, or wings contaminated by snow or ice) to the flight crew.

16.5.6 With much of the cabin crew members' routine activities focused on cabin service, extra effort is required to ensure that cabin service is not provided at the expense of fulfilling their primary responsibilities for passenger safety. It is essential that training and operating procedures for cabin crew address the full range of issues that could have safety consequences.

ICAO requirements

16.5.7 Although ICAO does not require cabin crew to be licensed, Chapter 12 of Annex 6 — *Operation of Aircraft* specifies requirements with respect to:

a) assignment of emergency duties;

b) role during emergency evacuations;

c) use of emergency equipment;

d) flight- and duty-time limits; and

e) training.

16.5.8 Operators are required to establish and maintain an approved training programme (including recurrent training) to be completed by all persons before being assigned as cabin crew. This training is aimed at ensuring the competence of cabin crew to perform in emergency situations.

16.5.9 The *Preparation of an Operations Manual* (Doc 9376) provides further guidance for training of cabin crew including:

a) joint training with flight crew in handling of emergencies; and

b) training in assisting flight crew (of two-pilot crews) in the event of flight crew incapacitation.

16.5.10 The *Human Factors Guidelines for Safety Audits Manual* (Doc 9806) also provides guidance for training about human performance relating to passenger cabin safety duties including flight crew — cabin crew coordination.

16.5.11 The *Human Factors Digest No. 15 — Human Factors in Cabin Safety* (Cir 300) provides guidance on Human Factors in teams with an emphasis on working in the cabin environment. Other chapters address communication and coordination aspects, as well as handling abnormal events.

Operator's Flight Safety Handbook (OFSH) — Cabin Safety Compendium

16.5.12 Recognizing the challenge of initiating a cabin safety programme, several major operators and key industry representatives developed a systematic approach to the management of cabin safety. The *Cabin Safety Compendium* to the OFSH extends safety management systems to include the cabin. The Compendium documents proven safety practices built on worldwide experience. In addition to outlining routine and emergency safety procedures, it includes several appendices containing reference material, examples of checklists, minimum equipment lists, etc.

Managing cabin safety

Commitment

16.5.13 The provision of cabin service may be viewed as a marketing or customer service function; however, cabin safety is clearly an operational function. Corporate policy should reflect this, and management needs to demonstrate its commitment to cabin safety with more than words. Common indicators of management's commitment to cabin safety include:

a) allocation of sufficient resources (adequate staffing of cabin crew positions, initial and recurrent training, training facilities, etc.);

b) clearly defined responsibilities, including the setting, monitoring and enforcing of practical SOPs for safety; and

c) fostering of a positive safety culture.

Positive safety culture

16.5.14 Creating a positive safety culture for cabin crew begins with departmental organization. If, as in many airlines, the cabin crew receive their principal direction from marketing rather than from the flight operations department, the focus of cabin crew will probably not be on cabin safety. Other considerations for the promotion of a positive safety culture include:

a) the relationship between flight crew and cabin crew, for example:

   1) spirit of cooperation, marked by mutual respect and understanding;

   2) effective communications between flight crew and cabin crew[1];

   3) regular review of SOPs to ensure compatibility between flight deck and cabin procedures;

   4) joint pre-flight briefings for flight crew and cabin crew; and

   5) joint debriefings following safety-related occurrences, etc.; and

b) cabin crew participation in safety management:

   1) involvement of the safety manager in cabin safety issues;

   2) avenues for offering cabin safety expertise and advice (safety committee meetings, etc.);

   3) participation in developing policies, objectives and SOPs affecting cabin safety; and

   4) participation in company's incident reporting system, etc.

SOPs, checklists and briefings

16.5.15 As in flight deck operations, cabin safety requires strict adherence to well-thought-out and practical SOPs, including the use of checklists and briefings of cabin crew. Procedures include, but are not limited to the following: passenger boarding; seat assignment; stowage of carry-on baggage; emergency exit accessibility and availability; passenger safety briefing; service equipment storage and use; emergency medical equipment storage and use (oxygen, defibrillator, first aid kit, etc.); handling of medical emergencies; non-medical emergency equipment storage and use (fire extinguishers, protective breathing equipment, etc.); in-flight emergency procedures (smoke, fire, etc.); cabin crew announcements; turbulence procedures (including securing the cabin); handling unruly passengers; emergency evacuations; and routine deplaning.

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1. As a result of security measures requiring the flight deck door to be locked during flight, extra effort is required to maintain effective on-board communications between the flight crew and cabin crew.

16.5.16 *Procedures for Air Navigation Services — Aircraft Operations* (PANS-OPS, Doc 8168) includes guidance material on SOPs, checklists and crew briefings. The OFSH *Cabin Safety Compendium* also includes guidance for establishing safe procedures for both normal and emergency operations.

Hazard and incident reporting[2]

16.5.17 Cabin crews must be able to report hazards, incidents and safety concerns as they become aware of them without fear of embarrassment, incrimination or disciplinary action. Cabin crew, their supervisors and the SM should have no doubts about:

a) the types of hazards that should be reported;

b) the appropriate reporting mechanisms;

c) their job security (following the reporting of a safety concern); and

d) any safety actions taken to follow up on identified hazards.

Training for cabin safety

16.5.18 Cabin crew duties and responsibilities are safety-related, and cabin crew training should clearly reflect this fact. While training can never duplicate all the types of situations that may confront cabin crew, training can instil basic knowledge, skills, attitudes and confidence that will allow cabin crew to handle emergency situations. Cabin crew training should therefore include:

a) initial indoctrination covering basic theory of flight, meteorology, physiology of flight, psychology of passenger behaviour, aviation terminology, etc.;

b) hands-on training (if practicable using cabin simulators for fire, smoke and evacuation drills);

c) in-flight supervision (on-job-training);

d) annual recurrent training and re-qualification;

e) knowledge and skills in CRM, including coordinating activities with the flight crew;

f) joint training exercises with flight crew to practice drills and procedures used in flight and in emergency evacuations; and

g) indoctrination in function and use of selected aspects of the company's SMS (such as hazard and incident reporting); etc.

16.5.19 In an emergency, the expertise of the cabin crew will be required with little or no warning. Thus, effective safety training for cabin crew requires practice to maintain the sharpness necessary in an emergency.

16.5.20 The *Training Manual* (Doc 7192), Part E-1 — *Cabin Attendants' Safety Training*, addresses safety training for cabin crew.

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2. Chapter 7 provides guidance on the set-up and use of incident reporting systems.

Cabin safety standards

16.5.21 Safety inspections, safety surveys and safety audits are tools that can be used to ensure that requisite cabin safety standards are being maintained. Once an operator is certificated, cabin safety standards may be confirmed through an ongoing programme of:

a) aircraft inspections (e.g. emergency exits, emergency equipment, and galleys);

b) pre-flight (ramp) inspections;

c) in-flight cabin inspections (e.g. passenger briefings and demonstrations, crew briefings and use of checklists, crew communications, discipline, and situational awareness);

d) training inspections (e.g. facilities, quality of instruction, and records); and

e) base inspections (e.g. crew scheduling, dispatch, safety incident reporting and response), etc.

16.5.22 A company's internal safety audit programme should include the cabin crew department. The audit process should include a review of all cabin operations, as well as an audit of cabin safety procedures, training, the cabin crew's operating manual, etc.

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Appendix 1 to Chapter 16

SAMPLE COMPANY POLICY ON NON-PUNITIVE HAZARD REPORTING

XYZ AIRLINE'S NON-PUNITIVE REPORTING POLICY

1. XYZ Airline is committed to the safest flight operating standards possible. To achieve this, it is imperative that we have uninhibited reporting of all incidents and occurrences which may compromise the safe conduct of our operations. To this end, every employee is responsible for communicating any information that may affect the integrity of flight safety. Such communication must be completely free of any form of reprisal.

2. XYZ Airline will not take disciplinary action against any employee who discloses an incident or occurrence involving flight safety. This policy shall not apply to information received by the Company from a source other than the employee, or which involves an illegal act, or a deliberate or wilful disregard of promulgated regulations or procedures.

3. The primary responsibility for flight safety rests with line managers, however, flight safety is everyone's concern.

4. Our method of collecting, recording and disseminating information obtained from Air Safety Reports has been developed to protect, to the extent permissible by law, the identity of any employee who provides flight safety information.

5. I urge all staff to use our flight safety programme to help XYZ Airline become a leader in providing our customers and employees with the highest level of flight safety.

Signed: ________________________________

Chairman and CEO

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Appendix 2 to Chapter 16

EXAMPLES OF ITEMS TO BE REPORTED TO AN AIRLINE OCCURRENCE REPORTING SYSTEM

Following is a listing of the types of occurrences or safety events to be reported under the company's incident reporting system. The list is neither exhaustive nor in any order of importance. (Some items may be required to be reported under State laws or regulations.)

- Any ***system defect*** which adversely affects the handling or operation of the aircraft;
- Warning of ***smoke*** or ***fire,*** including the activation of ***toilet smoke detectors*** and ***galley fires****;*
- An ***emergency*** is declared;
- The aircraft is ***evacuated*** by means of the emergency exits/slides;
- ***Safety equipment*** or ***procedures*** are defective, inadequate or used;
- Serious deficiencies in ***operational documentation****;*
- ***Incorrect loading*** of fuel, cargo or dangerous goods;
- Significant deviation from ***SOPs****;*
- A ***go-around*** is carried out from below 1 000 ft above ground level;
- An ***engine is shut down or fails at any stage of the flight****;*
- ***Ground damage*** occurs;
- A ***take-off*** is ***rejected*** after take-off power is established;
- The aircraft leaves the ***runway*** or ***taxiway*** or ***other hardstanding****;*
- A ***navigation error*** involving a significant deviation from track;
- An ***altitude excursion*** of more than 500 ft occurs;
- ***Unstabilized approach*** under 500 ft;
- ***Exceeding the limiting parameters*** for the aircraft configuration;
- ***Communications fail*** or are impaired;
- A ***stall warning*** occurs;

- ***GPWS*** activation;
- A ***heavy landing check*** is required;
- ***Hazardous surface conditions***, e.g. icy, slush and poor braking;
- Aircraft lands with ***reserve fuel or less*** remaining;
- A ***TCAS RA event;***
- A serious ***ATC incident***, e.g. near mid-air collision, runway incursion and incorrect clearance;
- Significant ***wake turbulence, turbulence, wind shear*** or other ***severe weather;***
- Crew or passengers become ***seriously ill***, are ***injured***, become ***incapacitated*** or ***deceased;***
- ***Violent, armed*** or ***intoxicated passengers***, or when restraint is necessary;
- ***Security procedures*** are breached;
- ***Bird strike*** or ***Foreign Object Damage (FOD);*** and
- ***Any other event*** considered likely to have an effect on safety or aircraft operations.

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Appendix 3 to Chapter 16

SAMPLE MEMORANDUM OF UNDERSTANDING BETWEEN AN AIRLINE AND A PILOTS' ASSOCIATION FOR THE OPERATION OF A FLIGHT DATA ANALYSIS (FDA) PROGRAMME

1. BACKGROUND

The flight data analysis programme, FDA PROGRAMME, forms part of THE AIRLINE's safety management system. Recorded flight data can contain information that has the potential to improve flight safety, but also has the potential, if used inappropriately, to be detrimental to individual crew members or to the airline as a whole. This document describes protocols that will enable the greatest safety benefit to be obtained from the data while satisfying the company's need to be seen to be managing safety, and simultaneously ensuring fair treatment of employees.

The FDA PROGRAMME conforms with the intent of THE AIRLINE's Standing Instruction Number X (SIN X), Reporting of Safety Incidents, in that "The purpose of an investigation of any accident or incident is to establish the facts and cause, and therefore prevent further occurrence. The purpose is not to apportion blame or liability."

It also conforms with the intent of Annex 6 (Part 1, Chapter 3) "A flight data analysis programme shall be non-punitive and contain safeguards to protect the source(s) of the data".

2. GENERAL INTENTIONS

2.1 It has long been accepted by both THE AIRLINE and THE PILOTS' ASSOCIATION that the greatest benefit will be derived from the FDA PROGRAMME by working in a spirit of mutual cooperation towards improving flight safety. A rigid set of rules can, on occasion, be obstructive, limiting or counterproductive, and it is preferred that those involved in the FDA PROGRAMME be free to explore new avenues by mutual consent, always bearing in mind that the FDA PROGRAMME is a safety programme, not a disciplinary one. The absence of rigid rules means that the continued success of the FDA PROGRAMME depends on mutual trust – indeed this has always been a key feature of the programme.

2.2 The primary purpose of monitoring operational flight data by the FDA PROGRAMME is to enhance flight safety. Therefore the intention of any remedial action following discovery, through the FDA PROGRAMME, of a concern, is to learn as much as possible in order to:

a) prevent a recurrence; and

b) add to our general operational knowledge.

2.3 A general intention is that concerns raised by the FDA PROGRAMME should, where possible, be resolved without identifying the crew concerned. However, there may be occasions when anonymity is not appropriate, and this document gives protocols to be followed on such occasions in order to be in accordance with SIN X.

2.4 It is recognized that THE AIRLINE requires an audit trail of actions taken following FDA PROGRAMME investigations. It is intended that this audit trail will be held within THE AIRLINE in a manner that satisfies THE AIRLINE's requirements without being placed on a crew member's file.

2.5 A further intention is to provide recorded flight data to outside parties (CAA, FAA, universities, manufacturers, etc.) for research into flight safety. THE PILOTS' ASSOCIATION will be informed of each such provision and, if the data are only useful if identified (i.e. can be linked to a specific flight) then THE AIRLINE will agree with THE PILOTS' ASSOCIATION to the confidentiality terms under which the data are provided.

3. CONSTITUTION

The constitution and responsibilities of the Flight Data Recording Group (the "FDA PROGRAMME Group") are defined in FCO Y. The Group meets once a month. Membership consists of:

- the Chairman (Flight Manager of the FDA PROGRAMME);
- a representative from each Fleet's training section;
- a representative from Flight Data Recording (Engineering);
- a representative from Flight Technical Support;
- a Flight Data Analyst from Flight Operations; and
- representatives from THE PILOTS' ASSOCIATION (currently two short-haul representatives and one long-haul representative).

The constitution and responsibilities of the Operational Flight Data Recording Working Group are defined in FCO Y. The Group meets bimonthly. Membership consists of:

- the Chairman (Flight Manager of the FDA PROGRAMME);
- a Flight Data Analyst from Flight Operations;
- Manager Flight Data Recording (Engineering);
- a representative from Flight Technical Support;
- a representative from Safety Services;
- a representative from the CAA Safety Group; and
- a representative from THE PILOTS' ASSOCIATION.

4. HANDLING

4.1 Scope

This section applies to "events" discovered by the routine running of the FDA PROGRAMME. If a pilot files an Air Safety Report (ASR) or reports an event to his Manager, then the responsibility for investigation lies with the Fleet, although the FDA PROGRAMME group may provide assistance. In this case the pilot is, of course, identified.

4.2 The list below gives some of the possible follow-up actions that may be used to investigate a concern raised by the FDA PROGRAMME. It is not intended to be exhaustive and does not preclude any other action agreed between THE AIRLINE and THE PILOTS' ASSOCIATION which is in accordance with the general intentions above.

Which action is most appropriate in given circumstances will be discussed and agreed between THE AIRLINE, represented by the Flight Manager of the FDA PROGRAMME and the Fleet FDA PROGRAMME representative, and THE PILOTS' ASSOCIATION, represented by the relevant PILOTS' ASSOCIATION representative.

A Fleet Manager may request follow-up action. The Fleet Manager will make the request to the Fleet FDA PROGRAMME representative who will consult with the Flight Manager of the FDA PROGRAMME and the relevant PILOTS' ASSOCIATION representative, as above.

4.2.1 THE PILOTS' ASSOCIATION may be asked to telephone the crew members to debrief an "event". The nature of the call can be praise for a well-handled situation, enquiry to elicit more information about the event and its causes, or a reminder of a relevant Standard Operating Procedure.

The Fleet Management may ask for specific questions or points to be put to the pilots during such a call or calls.

In this case, the pilots remain unidentified, and a record of the debriefing will be held in accordance with Section 5 of this agreement.

4.2.2 THE PILOTS' ASSOCIATION may be asked to contact a pilot who has a higher than average FDA PROGRAMME event rate, to advise the pilot and to seek any underlying reason.

Again, Fleet Management may ask for specific questions or points to be put to the pilots during such a call or calls.

In this case too, the pilots remain unidentified, and a record of the debriefing will be held in accordance with Section 5 of this agreement.

4.2.3 The enquiries of 4.2.1 and 4.2.2 above may indicate that "closure" may not be possible without further action being taken. The following are examples of possible further action:

— the filing of an ASR — see 4.2.4 below;

— a request for the pilot to speak directly to Fleet Management — see 4.2.5 below; and

— a requirement for the pilot to undertake some training to regain the required standard in a particular area — see 4.2.6 below.

4.2.4 If the "event" clearly warrants an ASR, but none has been filed, then THE PILOTS' ASSOCIATION may be asked to request that the pilot(s) files one.

An ASR filed under these circumstances will be treated as if it were filed at the time of the event.

4.2.5 THE PILOTS' ASSOCIATION may be asked to invite a pilot to be debriefed by Fleet Management. If the pilot agrees to this, then the pilot will be deemed to have reported the event unprompted so that paragraph 10.1 of SIN X applies: "It is not normally the policy of THE AIRLINE to institute disciplinary proceedings in response to the reporting of any incident affecting air safety."

A record of any such debriefing will be sent to the pilot concerned and a copy held in THE AIRLINE in accordance with Section 5 of this document.

If the pilot declines the above invitation, then THE PILOTS' ASSOCIATION debriefing will be continued until closure can be achieved. A record of this debriefing will be kept in accordance with Section 5 of this document.

4.2.6 A pilot may be required to undertake such extra training as may be deemed necessary after consultation with the Fleet concerned. THE AIRLINE will arrange the training, and THE PILOTS' ASSOCIATION will liaise with the pilot.

A record of any such training will be sent to the pilot concerned and a copy will be held in THE AIRLINE in accordance with Section 5 of this document.

4.3 If an event or sequence of events is considered serious enough to have hazarded the aircraft or its occupants, then THE PILOTS' ASSOCIATION will be asked to withdraw anonymity of the pilots. THE PILOTS' ASSOCIATION recognizes that, in the interest of flight safety, it cannot condone unreasonable, negligent or dangerous pilot behaviour and will normally accede to such a request.

Removal of anonymity will be effected by the senior PILOTS' ASSOCIATION representative after consultation with THE PILOTS' ASSOCIATION chair. The pilot will be notified by the senior PILOTS' ASSOCIATION representative that anonymity is being withdrawn, and advised that he or she may be accompanied at any subsequent interview by a PILOTS' ASSOCIATION representative.

If agreement cannot be reached between THE AIRLINE Flight Operations and THE PILOTS' ASSOCIATION as to whether an event is sufficiently serious to warrant withdrawal of anonymity, then a final decision will be taken by a nominated person. This person will be either THE AIRLINE Head of Safety or another nominated senior AIRLINE Manager, and he/she will be confirmed in this role by THE PILOTS' ASSOCIATION who will reaffirm this acceptability each year.

4.4 Wilful disregard of SOPs

If a pilot is discovered, through the FDA PROGRAMME only, to have wilfully disregarded THE AIRLINE SOPs, then the pilot will be treated as follows:

— If the breach of SOP did not endanger the aircraft or its occupants, then debriefing may be carried out by THE PILOTS' ASSOCIATION representative, thus preserving anonymity; but the pilot will be sent a letter containing a clear warning that a second offence will result in withdrawal of anonymity.

— If the breach of SOP did endanger the aircraft or its occupants, then THE AIRLINE will request withdrawal of anonymity as in 4.3 above.

4.5 If a pilot fails to cooperate with THE PILOTS' ASSOCIATION with regard to the provisions of this agreement, then THE AIRLINE will receive THE PILOTS' ASSOCIATION's approval to assume responsibility for contact with that pilot, and any subsequent action.

Such a pilot will be reminded by THE PILOTS' ASSOCIATION that SIN X cautions: "In the event of an employee failing to report a safety-related incident that they have caused or discovered, they will be exposed to full disciplinary action."

5. CLOSURE

Most FDA PROGRAMME events are not serious enough to warrant follow-up action and so are automatically "closed". Those events for which follow-up action is required are deemed "open", and then need a positive closure when the action is complete.

A record will be kept in THE AIRLINE of all events for which action is required. For each such event, the actions taken will be recorded along with the date of closure. This record will be kept in the FDA PROGRAMME database against the event itself.

No record will be kept on an individual pilot's file.

A letter will be sent, by Fleet Management, to each pilot involved in follow-up action, unless that action consisted only of a telephone debriefing by THE PILOTS' ASSOCIATION representative for a single event. Such a letter will record the original concern, the subsequent discussion and/or action, and the expectation for the future.

The letter will not be addressed to the pilot by name, but will be handed to THE PILOTS' ASSOCIATION for forwarding to the pilot concerned.

Contents of record in FDA PROGRAMME DATABASE (FPD):

The following will be recorded in the FPD against the event:

a) a record of any telephone debrief by THE PILOTS' ASSOCIATION;

b) a record of any debrief by Fleet Management;

c) a copy of any letter sent to the pilot;

d) a record of any extra training given to the pilot; and

e) any other relevant document.

The record will not contain anything that could identify the pilot by name.

Visibility of record and pilot identity:

Flight Operations Management's access level to FPD will reveal only that action is "open" or "closed" for each event – the actual action record is not visible. Events are not identifiable to a particular flight or pilot.

The level of access of the Flight Manager of the FDA PROGRAMME to FPD will reveal the actual actions taken, and can associate a pilot, by the pilot's 5-digit FDA PROGRAMME number, with that event. Actual pilot identity is not available.

THE PILOTS' ASSOCIATION representative's access to FPD is the same as that of the Flight Manager of the FDA PROGRAMME, but in addition THE PILOTS' ASSOCIATION representative has a decode disk to identify a pilot from the pilot's 5-digit FDA PROGRAMME number.

It is the responsibility of the Flight Manager of the FDA PROGRAMME to detect pilots with more than one action recorded against their 5-digit FDA PROGRAMME number within a reasonable time, and bring this to the attention of the Fleet.

6. SAFETY DATA REQUEST (SDR)

Flight data for the first 15 minutes and the last 15 minutes of every flight are stored in a database known as SDR. The data are available for viewing by a Flight Manager if, and only if:

a) an ASR has been filed for that portion of that flight, or

b) the Captain of the flight has given specific permission for the data to be viewed.

In order to view data in SDR, the Flight Manager needs to indicate, in the SDR itself, the reason for looking at the data. The reason is recorded in each case, and THE PILOTS' ASSOCIATION representatives are able to view these records.

7. RETENTION OF DATA

For each FDA PROGRAMME event, FPD stores the raw flight data which can be viewed as a trace or as an instrument animation. In addition, but not visible to Flight Operations Management, FPD stores information which identifies the flight (by date and registration) and the pilot (by a 5-digit FDA PROGRAMME number).

The data and information are required to analyse the event and to monitor, anonymously over a period of time, individual pilots' event rates.

Furthermore, SDR stores some raw flight data from each flight, as described in Section 6 above.

THE AIRLINE will not retain data any longer than is necessary, and will in any case delete all flight data, and all means of identifying flights and crew, within 2 years of the flight.

For flights more than 2 years old, the FDA PROGRAMME database (FPD) will continue to contain a record of the FDA PROGRAMME events, but with all flight and crew identification removed.

8. THE PILOTS' ASSOCIATION REPRESENTATIVES' ACCESS TO CONFIDENTIAL INFORMATION

In order to fulfil FDA PROGRAMME obligations, THE PILOTS' ASSOCIATION representative will need access to information which is confidential to THE AIRLINE, and may be subject to the Data Protection Act. Upon appointment, a representative will be required to sign a Confidentiality

Agreement which specifies the terms under which information obtained from THE AIRLINE may be used. Breach of this agreement will lead to suspension from the FDA PROGRAMME group, and may be the subject of THE AIRLINE's disciplinary procedures.

In order to contact the crew involved in an FDA PROGRAMME event (see Section 4), THE PILOTS' ASSOCIATION representative will need:

— the identity of the flight (date, registration and flight number);

— the ability to identify the crew of that flight, and how to contact them; and

— an electronic copy of the flight data and a means of viewing it.

THE AIRLINE will provide each PILOTS' ASSOCIATION representative with a laptop computer pre-loaded with software to meet the requirements below:

— The identity of the flight will be provided by e-mail from the FDA PROGRAMME Group.

— The identity of the crew, and their contact details, will be determined by remote access to THE AIRLINE flight crew scheduling system.

— The flight data will be e-mailed by the FDA PROGRAMME group and will be viewed using the pre-loaded software.

In order to identify a pilot from the pilot's 5-digit FDA PROGRAMME number (see 4.2.2), THE PILOTS' ASSOCIATION representative will be provided with a decode disk, for use with FPD.

Upon finishing work with the FDA PROGRAMME group, THE PILOTS' ASSOCIATION representative will return the laptop and disk to THE AIRLINE. No copy of THE AIRLINE-provided software may be retained.

Signed on behalf of THE AIRLINE:	Signed on behalf of THE PILOTS' ASSOCIATION:
______________________________	______________________________
Name: ______________________	Name: ______________________
Date: ______________________	Date: ______________________

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Appendix 4 to Chapter 16

HUMAN PERFORMANCE ISSUES AFFECTING CABIN SAFETY[3]

The work environment and working conditions for cabin crew are influenced by a diverse set of Human Factors. Some of the more common factors to consider in developing a cabin safety programme include:

a) ***Crew Resource Management (CRM)***. With ever-larger cabin crews, the cabin crew must work together as a team. CRM training for cabin crew could include:

   1) *Communications and interpersonal skills*. Hesitancy to communicate important data to other team members could jeopardize a flight. Polite assertiveness is required for effective teamwork;

   2) *Situational awareness*. Maintaining an accurate perception of evolving events requires questioning, cross-checking, refinement and updating of perception;

   3) *Problem solving, decision-making skills and judgement* may be critical in the event of an in-flight emergency or in a situation requiring emergency evacuation or ditching; and

   4) *Leadership/followership skills.* While in charge, cabin crew require well-developed leadership skills, but individual cabin crew members must respect command authority during an emergency.

b) ***Fatigue***. Circadian disrhythmia (i.e. jet lag) and other disturbances to normal sleep patterns are a part of the job. Yet, fatigue can seriously compromise the response of cabin crew in an emergency. Maximum alertness is required during the approach and landing phase, often at the end of a long duty period.

c) ***Personality factors***. Cabin crew require skill in handling diverse personality types. In addition, cultural diversity can influence outcomes in an emergency, not only among the passengers, but also in culturally mixed crews.

d) ***Workload and stress***. The pace of cabin duties varies widely, especially during long-haul operations. Learning to cope with the stress of intense workloads and boredom are fundamental to maintaining situational awareness and the mental acuity required in an emergency.

e) ***Competence***. A function of experience and currency is vital to maximizing effectiveness. Multiple-type currencies resulting in transferring from one aircraft type to another may compromise effective emergency response due to difficult and possibly inappropriate habit transfer.

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3. For further understanding of Human Factors relevant to cabin safety programmes, see *Human Factors Training Manual* (Doc 9683), *Human Factors Guidelines for Safety Audits Manual* (Doc 9806) and *Human Factors Digest No. 15 — Human Factors in Cabin Safety* (Cir 300).

f) ***Equipment design***. During safety audits, attention should be paid to equipment design factors that may compromise safe performance of duties by cabin crew (strength requirements, reach, user-friendliness, etc.).

Chapter 17

AIR TRAFFIC SERVICES (ATS)

17.1 ATS SAFETY

General

17.1.1 While aviation accidents caused by shortcomings in ATS are rare, the consequences of such accidents are potentially disastrous. Safety in ATS requires a systematic approach to safety management, and current ATS systems provide multilayered defences through such things as:

a) rigid selection criteria and training for controllers;

b) clearly defined performance standards, e.g. separation criteria;

c) strict adherence to proven SOPs;

d) significant international cooperation;

e) utilization of technological advances; and

f) ongoing system of evaluation, monitoring and improvement.

17.1.2 Keeping aircraft safely separated while expediting the flow of traffic in a highly dynamic situation presents unique challenges. Controller workload, traffic density and complexity increasingly pose significant risks to aviation. The frequency of air proximities, near mid-air collisions, runway incursions, technical losses of required separation, etc. are indicative of the continuing accident potential in the provision of ATS.

17.1.3 As traffic volumes and complexity continue to increase, ATS supervisors, investigators of ATS occurrences and safety managers will be required to learn more about the effects of human performance on the actions of ATS personnel. (Appendix 1 to this chapter lists some of the more common Human Factors issues potentially affecting human performance in the provision of ATS.)

17.1.4 Delivery of ATS is being further challenged by organizational change. Although State authorities have traditionally provided ATS in a growing number of States, service delivery is being corporatized. Other States are joining regional consortia, such as EUROCONTROL, for the delivery of services.

17.1.5 From a regulatory perspective, safety oversight for aerodromes and ATS units has traditionally been conducted through a prescriptive process where detailed requirements were published and compliance was confirmed through inspection. This approach encouraged a safety culture of compliance, with little thought being given to proactive safety management. In view of increasing volumes of air traffic and a flat accident rate, efforts to improve safety through the implementation of safety management systems (SMS) are also increasing, including SMS for aerodromes and ATS units.

17.1.6 The approach to safety management outlined in this manual is based on "best practices" in industries where safety management has long been an integrated part of their operations. While this chapter is devoted specifically to ATS, a solid understanding of the material in the rest of the manual will be helpful in implementing an effective SMS for ATS.

ICAO requirements

17.1.7 Annex 11 — *Air Traffic Services* requires that ATS providers implement an accepted SMS to ensure safety in the provision of ATS. Such an SMS shall ensure that actual and potential safety hazards can be identified, necessary remedial actions implemented and that continued monitoring ensures that an acceptable level of safety is being achieved.

17.1.8 The *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM, Doc 4444) provides guidance for safety management in ATS. *Inter alia,* safety management in ATS should include the following:

a) monitoring of overall safety levels and detection of any adverse trends, including:

   1) collection and evaluation of safety-related data; and

   2) review of incident and other safety-related reports;

b) safety reviews of ATS units, including:

   1) regulatory issues;

   2) operational and technical issues; and

   3) licensing and training issues;

c) safety assessments in respect of the planned implementation of airspace reorganization, the introduction of new equipment, systems or facilities, and new or changed ATS procedures; and

d) mechanisms for identifying the need for safety-enhancing measures.

Functions of the ATS regulatory authority

17.1.9 As outlined in Chapter 3, a State requires a regulatory authority to oversee the implementation of its legislation and regulations governing air safety. The core functions of the regulatory authority with respect to ATS safety are:

a) developing and updating the necessary regulations;

b) setting national safety performance targets; and

c) providing oversight of ATS providers.

Safety manager (SM)

17.1.10 The principles for organizing for safety management, and the functions and roles of an SM are outlined in Chapter 12.

17.1.11 Ideally, the SM for an ATS unit should have no responsibilities other than safety. The SM should be a member of the management team of the organization, and needs to be at a sufficiently high level in the management hierarchy to be able to communicate directly with other senior managers. Examples of tasks to be included in an ATS SM's terms of reference include:

a) to develop, maintain and promote an effective SMS;

b) to monitor the operation of the SMS and to report to the Chief Executive Officer on the performance and effectiveness of the system;

c) to bring to senior management's attention any identified changes needed to maintain or improve safety;

d) to act as the focal point for dealings with the safety regulatory authority;

e) to provide specialist advice and assistance regarding safety issues;

f) to develop a safety management awareness and understanding throughout the entire organization; and

g) to act as a proactive focal point for safety issues.

17.2 ATS SAFETY MANAGEMENT SYSTEMS

17.2.1 Chapter 12 provides ten steps for "getting started" in setting up an SMS. The ten steps have equal application to safety management in ATS, and that chapter should be read in conjunction with this section. In addition, the considerations discussed below apply to managing safety in ATS.

Safety performance indicators and safety targets

17.2.2 The notion of safety performance indicators and safety targets is introduced in Chapters 1 and 5. Before attempting to determine whether the safety performance of a system, or the safety impact of planned changes to it, is acceptable, a decision must be made concerning what criteria will be used to judge acceptability. ICAO provisions relating to safety management for aircraft operators, aerodrome operators and ATS providers incorporate requirements pertaining to achieving an acceptable level of safety. The acceptable level of safety shall be determined by the State(s) concerned.

17.2.3 Annex 11 requires States to establish an acceptable level of safety applicable to the provision of ATS within their airspace and at their aerodromes.

17.2.4 In order to determine what is an acceptable level of safety, it is first necessary to decide on appropriate safety performance indicators and then on what represents an acceptable outcome. The safety performance indicators chosen need to be appropriate for the application. Typical measures which could be used in safety management in ATS include:

a) maximum probability of an undesirable event, such as a collision, loss of separation or runway incursion;

b) maximum number of incidents per 10 000 aircraft movements;

c) maximum acceptable number of separation losses per 10 000 trans-Atlantic crossings; and

d) maximum number of short-term conflict alerts (STCAs) per 10 000 aircraft movements.

17.2.5 Since aviation accidents are rare events, accident rates are not good indicators of safety performance. They may be of limited value at the global, regional or national level. However, the absence of accidents may belie many unsafe conditions in the system, creating situations *"ripe for an accident"*. Accident rates are even less useful as an indicator of safety when applied to individual aerodromes or flight information regions (FIRs). For any given FIR, for example, the expected time between en-route accidents could be in excess of 100 years.

17.2.6 Incident rates may be more useful indicators of ATS safety performance, for example, reported air proximities, technical losses of separation, TCAS warning and alert messages, losses of radar coverage and power outages.

17.2.7 Indicators based on safety occurrences are only as good as the reporting or monitoring systems through which such occurrences are recorded and tracked. For this to be effective, the culture of the organization must encourage the filing and recording of the required reports. The importance of an organization's safety culture is discussed in Chapter 4, and potential limitations on the use of information from voluntary incident reporting systems are addressed in Chapter 7.

17.2.8 Whenever quantitative safety performance targets are set, it must be possible to measure, or estimate, the achieved level of safety in quantitative terms. If a target of this type is to be applied to en-route operations within a single FIR, or instrument approaches at a single aerodrome, then the expected frequency of accidents is so low that data on actual accidents will not give a valid indication of whether the target is being met.

17.2.9 Quantitative targets are used, for example, in assessing the safety of operations in reduced vertical separation minimum (RVSM) airspace. However, in this case, the assessment of the achieved level of safety is done using mathematical collision risk models which can estimate the expected rate of accidents from data on aircraft height deviations that did not result in an accident. Similar models are used in the estimation of collision risk as the result of lateral deviations from track in the North Atlantic minimum navigation performance specifications (MNPS) airspace, and oceanic airspace where required navigation performance (RNP) based separation minima are used.

17.2.10 The techniques used in this form of safety assessment are beyond the scope of this manual. Further information on collision risk models can be found in the *Manual on Airspace Planning Methodology for the Determination of Separation Minima* (Doc 9689).

Safety organization

17.2.11 How an ATS centre or unit is organized for safety management will to a large extent depend on the volume and complexity of its activities. For example, at a large centre, such as at an international airport, there are several discrete ATS activities (en-route, terminal, arrival and departure, tower, ground, etc.). The effectiveness of the safety decision-making processes will be largely dependent on how the diverse interests of all the service providers are integrated into a coherent "system".

17.2.12 The Centre Manager or Unit Chief alone will not be able to implement an SMS. In addition to the cooperation and commitment of other managers and staff, the Centre Manager or Unit Chief will probably depend on the guidance and assistance of a dedicated SM. In appointing an SM, management must avoid the temptation to delegate accountability for safety to the SM rather than to all managers and employees.

Risk management

17.2.13 As in other aviation activities, the provision of ATS requires a risk-based approach to decision-making. The same processes described elsewhere in this manual are required for reducing or eliminating risks in the provision of ATS. Risk management requires a coherent system for identifying hazards, assessing the risks and implementing viable measures for controlling the risks. (See Chapters 6 and 13.)

17.2.14 The *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM, Doc 4444) requires that all reports of incidents, or reports concerning the serviceability of ATS facilities and systems (such as failures or degradation of communications, surveillance and other safety significant systems and equipment) be systematically reviewed by the appropriate ATS authority in order to detect any trends in the operation of such systems which may have an adverse effect on safety.

Incident reporting systems[1]

17.2.15 As part of an ATS SMS, a confidential voluntary incident reporting system provides one of the best tools for hazard identification. Doc 4444 requires a formal incident reporting system for ATS personnel to facilitate the collection of information on actual or potential safety hazards or deficiencies related to the provision of ATS.

17.2.16 In addition to mandatory State requirements for reporting accidents and incidents, the ATS organization may define the types of hazards, events or occurrences with risk potential that staff are expected to report. An effective reporting system makes provision for the voluntary reporting of any situation or condition that an employee believes poses accident potential in a blame-free, non-punitive environment.

Emergency response[2]

17.2.17 ATS personnel must be prepared to continue to provide services through emergency situations, such as following an accident, a power or communication failure, loss of radar coverage, and security threat. Emergency procedures must be in place to guide operations without further compromising safety. The appropriate response of the unit requires a sound Emergency Response Plan (ERP).

17.2.18 The ERP should reflect a collaborative effort between management and the operational personnel who will have to execute it, in particular the controllers. Backup procedures must be in place and be regularly tested to ensure the continued provision of services to maintain the safe, expeditious and orderly flow of air traffic — perhaps at a degraded level, for example, shifting to procedural control in the event of a radar failure.

Safety investigations[3]

17.2.19 When an accident or serious incident occurs, competent investigators must be available to conduct an investigation in order to:

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1. Chapter 7 provides further information on the principles and operation of effective incident reporting systems.
2. See Chapter 11 for guidance on emergency response planning for dealing with an accident or a major incident with ATS involvement.
3. See Chapter 8 for guidance on the conduct of safety investigations.

a) better understand the events leading up to the occurrence;

b) identify hazards and conduct risk assessments;

c) make recommendations to reduce or eliminate unacceptable risks; and

d) communicate the safety messages to the appropriate stakeholders.

17.2.20 The investigation of minor incidents, such as losses of separation, may yield evidence of systemic hazards. For maximum effectiveness, management should focus on determining risks rather than identifying persons to discipline. How this is done will be influenced by the safety culture of the organization. The credibility of the investigative process will largely hinge on the technical competence and objectivity of the investigators.

Safety oversight[4]

17.2.21 Maintenance of high standards in ATS implies a programme of monitoring and surveillance of the activities of all controllers and supporting staff, as well as of the reliability and performance of their equipment.

17.2.22 The objective of the safety oversight of ATS providers is to verify compliance with relevant:

a) ICAO SARPs and procedures;

b) national legislation and regulations; and

c) national and international best practices.

17.2.23 The methods of safety oversight may include safety inspections and/or safety audits of the organizations concerned. Safety oversight should also involve a systematic review of significant safety occurrences. As outlined in Chapter 5, one of the core elements of an SMS is safety audits. The safety oversight procedures need to be standardized and documented to ensure consistency in their application.

17.2.24 The staff responsible for this oversight function require a good knowledge of, and preferably, practical experience in, safety management procedures. Doc 4444 requires that qualified personnel having a full understanding of relevant procedures, practices and factors affecting human performance, conduct safety reviews of ATS units on a regular and systematic basis.

17.2.25 Doc 4444 also requires that data used in safety monitoring programmes be collected from as wide a range of sources as possible, as the safety-related consequences of particular procedures or systems may not be realized until after an incident has occurred. Thus, the audit programme should include the safety interfaces with all users of the ATS system, operators, airport management and any contracted service providers.

Managing change

17.2.26 The provision of ATS is a dynamic activity. Doc 4444 requires that a ***safety assessment*** be carried out in respect of any proposals for significant airspace reorganizations, for significant changes in the

4. See Chapters 10 and 14 for further guidance on safety oversight in ATS.

provision of ATS procedures applicable to a defined airspace or an aerodrome, and for the introduction of new equipment, systems or facilities. Examples of significant changes include:

a) reduced separation minima;

b) new operating procedures, including arrival and departure procedures (STARs and SIDs);

c) reorganization of the ATS route structure;

d) re-sectorization of an airspace; and

e) implementation of new communications, surveillance or other safety-significant systems and equipment, including those providing new functionality and/or capabilities.

17.2.27 In brief, a safety assessment involves a multidisciplinary group of experts who systematically identify hazards and recommend measures to reduce or eliminate the inherent risks to an acceptable level. Further information on conducting safety assessments is contained in Chapter 13.

17.2.28 Factors to consider in conducting a safety assessment include:

a) types of aircraft and their performance characteristics, including their navigation capabilities and performance;

b) traffic density and distribution;

c) airspace complexity, ATS route structure and the classification of the airspace;

d) aerodrome layout, including runway and taxiway configurations and preferences;

e) air-ground communications capabilities and usage;

f) surveillance and alerting systems; and

g) significant local topography or weather phenomena.

17.3 CHANGING ATS PROCEDURES

17.3.1 Air traffic systems are particularly vulnerable during periods of changing procedures, whether modifying existing procedures or introducing new ones. Risk management techniques are used in working through the effects of proposed changes. The principles of risk management are outlined in Chapter 6. Chapter 13 outlines seven useful steps in assessing new equipment or procedures.

17.3.2 The objective of assessing ATS procedures is to provide assurance that, as far as reasonably practicable, potential hazards associated with the control of aircraft have been identified and actions to mitigate the significant risks associated with the hazards have been put in place. Typically, this risk management process involves the following:

a) hazard identification (HAZid);

b) hazard analysis, including likelihood of occurrence;

c) consequence identification and analysis; and

d) assessment against risk criteria.

17.3.3 When management proposes to develop, validate, change or introduce operational procedures, where practicable they should:

a) utilize hazard identification, risk assessment and risk management techniques prior to the introduction of the procedures;

b) use simulation to develop and evaluate the new procedures;

c) implement changes in small, easily manageable steps to allow confidence to be gained that the procedures are suitable; and

d) commence changes in periods of low traffic density.

17.3.4 As outlined in Chapter 13, risk assessment of ATS procedures is best conducted by a group including:

a) those responsible for procedure design;

b) staff with current knowledge and experience of the procedural area under assessment, i.e. system users — ATS personnel and pilots to assess the procedures from an operational perspective;

c) engineering specialist — to provide expert opinion on equipment performance;

d) safety/risk specialist — to guide the application of the methodology; and

e) Human Factors specialist.

17.3.5 Appendix 1 to Chapter 13 provides guidance for the conduct of group hazard identification and assessments sessions which are particularly effective in the identification and analysis of potential hazards in ATS procedures.

17.3.6 Appendix 2 to this chapter provides further guidance for the risk assessment of ATS procedures.

17.4 THREAT AND ERROR MANAGEMENT

17.4.1 As discussed in Chapter 16, the Threat and Error Management (TEM) framework assists in understanding, from an operational perspective, the interrelationship between safety and human performance in dynamic and challenging operational contexts. While threats to operational safety have long been recognized, the principles of TEM make it possible to manage the three basic components of the TEM framework: threats, errors and undesired states.

17.4.2 Threats and errors are a normal part of everyday operations. To prevent them from degenerating into undesired states, ATCOs must routinely manage such threats and errors. To maintain safety margins in ATC operations, ATCOs must also manage any undesired state that may arise from such threats and errors. These actions may offer the last opportunity to avoid an unsafe outcome.

17.4.3 Threats, errors and undesired states must all be managed within a set of contextual complexities. For example, controllers must deal with adverse meteorological conditions, airports surrounded by high mountains, congested airspace, aircraft malfunctions, and errors committed by other people outside of the ATC room such as flight crew, ground staff or maintenance workers. The TEM model considers these complexities as threats because they all have the potential to negatively affect ATC operations by reducing margins of safety.

17.4.4 Appendix 3 to this chapter examines TEM in ATS in more detail.

17.5 NORMAL OPERATIONS SAFETY SURVEY (NOSS)

17.5.1 Until recently, safety monitoring relied on staff identifying actual or potential hazards to the safe operation of the system, and submitting reports. If unsafe practices have become part of the normal method of operating, it is unlikely that the staff involved would recognize these as being unsafe and file reports through the safety occurrence reporting system.

17.5.2 Observation-based methods provide an additional means of gathering data that does not rely on the individuals involved. Several airlines have introduced a programme called Line Operations Safety Audit (LOSA) to monitor flight operations under normal operating conditions. (LOSA is described more fully in Chapter 16.)

17.5.3 LOSA is a proven method for identifying hazards and for developing coping strategies for normal flight deck operations. The aim of the monitoring is to gather data on operational threats, crew errors, and their management. The observations are made by observers, trained in LOSA techniques, sitting in the jump seat on regular scheduled flights. By monitoring normal operations, much can be learned about pilots' successful strategies for managing normal threats, errors and undesirable states.

17.5.4 The lessons of LOSA are being applied to ATC. However, because ATC operations differ significantly from flight operations, the evolving methodology, known as Normal Operations Safety Survey (NOSS), will differ too. The idea behind NOSS is to provide the ATC community with a means for obtaining robust data on threats, errors and undesired states. Analysis of NOSS data, together with safety data from conventional sources, should make it possible to focus the safety change process on the areas that need attention the most.

17.5.5 NOSS builds on the TEM framework. In its simplest form, NOSS involves over-the-shoulder observations during normal shifts. Analysis of these normative data in conjunction with data acquired through other means (such as incident reporting schemes and occurrence investigations) should provide ATC management with a means for focusing the safety change process on those threats which most erode the margins of safety in the ATC system.

17.5.6 NOSS recognizes that controllers routinely manage the threats, errors and undesired states that they face each day during the course of normal operations. Their timely intervention preserves the desired margins of safety — before an unsafe outcome (i.e. an accident or incident arises). Understanding how effective controllers deal with the evolving situation is vital to developing the necessary countermeasures to preserve defences within the ATS system. Since safety management strategies are best directed against systemic threats rather than individual errors, the primary objective of NOSS must be to identify threats, not just to count errors.

17.5.7 At the time of writing this manual, the protocols for applying NOSS in an actual work environment have yet to be determined.

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Appendix 1 to Chapter 17

HUMAN FACTORS ISSUES AFFECTING HUMAN PERFORMANCE IN AIR TRAFFIC SERVICES[1]

1. Listed below are some of the more common Human Factors issues affecting human performance in the provision of ATS:

a) ***Physiological limitations:***

1) vision — the ability to physically see events unfolding (e.g. from a control tower);

2) hearing — the ability to discriminate different speech patterns in a noisy environment; and

3) chronic fatigue affecting judgement, cognitive skills and memory;

b) ***Psychological variables:***

1) memory (essential to maintaining a three-dimensional picture of a dynamic situation);

2) vigilance versus distractions and boredom;

3) operating pressures (e.g. from supervisors, management and peers);

4) motivation and frame of mind (perhaps affected by domestic or other outside pressures);

5) stress tolerance (and consequential stress-related illnesses);

6) judgement;

7) habit patterns (e.g. taking procedural shortcuts); and

8) cultural diversity of the many users of the ATS system (such as military versus civilian, different companies, foreign versus domestic, and different languages and behavioural patterns) — all potentially capable of affecting the controllers' expectancy;

c) ***Equipment factors:***

1) display design and workstation layout;

2) user-friendliness of software, including flexibility to adapt to changing situations; and

3) use of automation;

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1. See the *Human Factors Training Manual* (Doc 9683) for a more complete discussion of human performance in ATS.

d) ***Information transfer problems:***

1) frequency congestion;

2) call sign confusion;

3) hearing expectancy;

4) language comprehension and accent; and

5) use of non-standard phraseology;

e) ***Workload considerations:***

1) volume and complexity of traffic;

2) number of sectors in use;

3) situational awareness (maintaining the *"big picture");*

4) mental models used in decision-making (e.g. *"rules of thumb");*

5) time since last break;

6) impact of shift work, scheduling and overtime; and

7) chronic fatigue; and

f) ***Organizational factors:***

1) corporate safety culture;

2) approach to teamwork (and use of team resource management (TRM));

3) adequacy of training;

4) controller experience, competence and currency;

5) quality of first-line supervision;

6) controller/management relationship;

7) effective standardization of procedures and phraseology; and

8) effective monitoring of day-to-day operations.

2. As traffic volumes and complexity continue to increase, ATS supervisors, investigators of ATS occurrences and safety managers will be required to learn more about the effects of such Human Factors on the performance of ATS personnel.

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Appendix 2 to Chapter 17

RISK ASSESSMENT OF ATS PROCEDURES

1. PURPOSE

1.1 The objective of assessing ATS procedures is to ensure that, as far as reasonably practicable, potential hazards associated with the control of aircraft have been identified and actions to mitigate the associated risks have been put in place.

1.2 This appendix provides general guidance on hazard identification and risk assessment processes that are useful in the development or modification of ATS procedures.

2. HAZARD IDENTIFICATION (HAZid)

2.1 HAZid is a relatively thorough "top-down" technique that breaks down activities associated with the implementation of ATS procedures into smaller components and identifies their potential failure modes and their effect on ATS safety. Specifically, the HAZid technique is used to identify:

a) ***ATS-related hazards***. A hazard is defined as a source of potential harm or a situation with a potential to cause loss. Basic ATS-related hazards include:

   1) mid-air collisions;

   2) collisions on the ground;

   3) wake vortex encounters;

   4) turbulence events; and

   5) collisions with the ground.

b) ***Hazardous scenarios***. Hazardous scenarios describe the specific hazard under consideration. For example, when considering the mid-air collision hazard at an airport, hazardous scenarios might be:

   1) a mid-air collision between a departing and an arriving aircraft; and

   2) a mid-air collision between aircraft on parallel approach.

c) ***Initiating events***. The initiating events describe the generic reasons for the hazardous scenario occurring. This may be a deviation from a flight path. For example, various initiating events for the hazardous scenarios of a mid-air collision between a departing and an arriving aircraft include an aircraft busting a level restriction, or an aircraft deviating from a SID or STAR.

d) ***Hazard causes***. The hazard causes describe how the initiating event started. Initiating events may be caused by external influences, human error, equipment failure or procedure design mistakes that can start a chain of events which could lead to a hazard. For an aircraft deviating from a SID, the cause could be an equipment failure such as a control system failure, or human error such as a pilot selecting the wrong SID in the flight management system (FMS).

e) ***Recovery factors***. The recovery factors describe the systems available to prevent or reduce the likelihood of initiating events becoming hazardous scenarios. For a mid-air collision, the recovery factors include the provision of ATC, the use of TCAS, pilot *“see and avoid”*, and the flight path geometry.

f) ***Recovery factor failures***. Recovery factors might fail to prevent a mid-air collision. Recovery factor failures for TCAS could include a transponder not being fitted to one of the aircraft, or the pilot not reacting to the alerts.

2.2 The HAZid method uses keywords or prompt words to systematically generate possible deviations from the norm for ATS and flying tasks. The procedure then examines the effect of each deviation on ATS-related safety.

External influences

2.3 HAZid begins by considering the external influences on a single aircraft on a fixed flight path. The sources of these external influences could be, for example:

a) meteorological;

b) topographical;

c) environmental; and

e) man-made.

Possible deviations from planned flight path

2.4 Once external influences to safe flight are identified and recorded, the HAZid technique considers possible deviations from the planned flight path and how these may be caused by internal operational events. These deviations may become initiating events for hazardous scenarios. Typical sources of internal operational events include:

a) ATC separation;

b) navigation aids;

c) airport design — runway;

d) airspace design;

e) aircraft design and maintenance; and

f) aircraft operation.

2.5 Keywords or prompt words are used to systematically identify possible deviations from planned flight paths. Possible deviations are examined through a “bottom-up” consideration of:

a) ***Procedures in use***. The procedures in use relate to the design of airspace and airports, ATC procedures and flight procedures. These procedures can lead to hazardous scenarios without additional system failures, i.e. hazardous scenarios can exist without requiring deviations from normal flight paths. For example, the vertical separation buffer for the base of CTA can be 150 m (500 ft). However, wake turbulence separation is applied when an aircraft is operating up to 300 m (1 000 ft) below.

b) ***Human tasks***. Human tasks may fail through various types of human error. This is a specialist area of analysis, and advice should be sought from appropriate Human Factors specialists.

c) ***Equipment functionality***. A failure modes and effects analysis (FMEA) is normally used to analyse the influences of equipment failures on the ATS system. The method is applied at the functional level to all ATS equipment, aircraft communication equipment, and navigation, surveillance, flight control and power plant equipment.

d) ***Geometric factors***. There may be other factors that are not related to human error or equipment failure but are still necessary for the hazard to occur. This is usually a description of the geometry of encounter.

3. HAZARD ANALYSIS

3.1 Having identified particular hazards, several techniques are available for assessing them, both qualitatively and quantitatively. Some techniques require specialist expertise in their application. Typically, the hazard analysis process involves:

a) development of fault schedules;

b) construction of fault trees; and

c) quantification of the likelihood of human error, equipment failure and operational factors.

Fault schedules

3.2 Fault schedules are used to record the results of the HAZid process for each hazardous scenario. An example of a hazardous scenario might be a mid-air collision between an arriving and a departing aircraft when the arriving aircraft fails to intercept the localizer.

3.3 The initiating event for this scenario would be that the arriving aircraft heads into the flight path of the departing aircraft. The fault schedule would record possible causes for the initiating event, including airborne or ground equipment faults, and human error by either the pilot or ATC (for example, call sign confusion). Recovery factors include existing or missing defences designed to reduce the likelihood of the initiating event becoming a hazardous scenario. Each recovery factor is examined as to why it failed to prevent the situation from developing.

Fault trees

3.4 Information contained in the fault schedules may be used to construct a fault tree. The level of analysis for the fault tree will depend on the situation. However, as a general guide, a simple pessimistic model should be used initially to determine the likelihood of human error, equipment failure and operational factors and thus the operational risk exposure. This risk exposure is then compared with the risk criteria for the target level of safety. If the pessimistic model produces a result that is lower than the target criteria, then further resource allocation is not required as it would not alter the risk management decision.

Consequence analysis

3.5 The amount of loss for ATS-related risk assessments is normally measured as the number of fatalities that would result from the most drastic possible outcome. For example, a simple analysis of mid-air collisions and collisions with the ground assumes that all people on board the aircraft will die as the result of a mid-air collision and most collisions with the ground.

4. RISK ASSESSMENT

4.1 As outlined in Chapter 6, a key phase of risk management involves the assessment of identified risks. Formal risk assessments must be performed:

a) for significant changes to ATS procedures compared with current operations;

b) for significant changes to equipment used to execute ATS tasks compared with current operations; and

c) when changing circumstances, such as increased traffic levels, and different aircraft performance, indicate that existing procedures may not be appropriate.

4.2 Table 17-APP 2-1 offers several steps for assessing risks inherent in hazards found in ATS procedures.

Risk analysis

4.3 Risk is calculated as the product of the likelihood of a hazardous event and the consequences of the event happening. Risk analysis may be quantitative or qualitative depending on the risk information and data readily available, the magnitude of the hazard, and other factors. Use of quantitative data helps clarify most decisions and should be used where available; however, some of the most important factors in a decision can be impractical to quantify. (For example, often when examining people and procedures in the provision of a separation service, qualitative descriptions and comparison scales are all that are available.) Care should be taken to consider these factors also.

Risk management

4.4 The principles and steps of risk management are outlined in Chapter 6. Management must decide if:

a) the risk is so great that it must be refused altogether;

b) the risk is, or has been made, so small as to be insignificant (however, any actions that reduce risk and require little effort or resources must be implemented); or

c) the risk falls between the two states in a) and b) **and** has been reduced to the lowest level practicable, bearing in mind the benefits derived from its acceptance and taking into account the costs of any further reduction.

Table 17-APP 2-1. ATS risk assessment procedures

Step 1	Identify whether the change involves a change in control procedure, in equipment, or in both.
Step 2	Break down the procedures into manageable components. For example, control procedures might be divided into: a) transfer of control procedures; b) coordination procedures; c) radar procedures; d) holding procedures; e) speed control procedures; and f) runway procedures. Equipment user procedures might be divided into: a) set-up procedures; b) operations under normal and emergency conditions; and c) operations under equipment failure or partial failure conditions.
Step 3	Identify potential hazards that affect the ability to maintain safe separation. This is best achieved by asking "What can go wrong?" and "What if ...?" in relation to the identified divisions in Step 2. It is necessary to consider the impact of the procedure on all levels of controller ability and experience.
Step 4	Identify the circumstances or incident sequence under which a hazard might occur, together with the likelihood of occurrence. Having considered the likelihood and consequences of occurrence, some identified hazards may be discounted as unrealistic. The reasons for discounting must be recorded.
Step 5	Make an assessment of the hazard severity.
Step 6	Examine the hazard and incident circumstances and identify essential and desirable measures that, when implemented, will mitigate or eliminate the hazard.

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Appendix 3 to Chapter 17

THREAT AND ERROR MANAGEMENT (TEM) IN ATS

1. GENERAL

Under the TEM framework, a threat is not a problem as such, but it could develop into one if not managed properly. Not every threat leads to an error, and not every error leads to an undesired state, yet the potential is there and so should be recognized. For example, visitors in an ATC operations room are a "threat" — their presence in itself is not a dangerous situation, but if the visitors engage in discussions with the ATC crew or otherwise distract them, they might lead the controller to make an error. Recognizing this situation as a threat will enable the controllers to manage it accordingly, thereby minimizing or preventing any distraction and thus not allowing the safety margins in the operational context to be reduced.

2. CATEGORIES OF THREATS IN AIR TRAFFIC CONTROL

2.1 Threats in ATC can be grouped into the following four broad categories:

a) internal to the ATS provider;

b) external to the ATS provider;

c) airborne; and

d) environmental.

2.2 Since awareness about these threats assists the deployment of both individual and organizational countermeasures to maintain margins of safety during normal ATC operations, the following paragraphs elaborate on the sources and nature of conditions which "threaten" safe air traffic services.

Internal threats to the ATS provider

2.3 ***Equipment*** is a frequent source of threat for ATC. Malfunctions and design compromises are among the conditions that controllers have to cope with to varying degrees during everyday operations. Other threats under this category include radio communications that may be of poor quality, and telephone connections to other ATC centres that may not always be functioning correctly. An input to an automated system may become a threat if the desired input is rejected by the system, and the controller has to find out why the input was not accepted and how to remedy the situation. The lack of proper equipment is a threat in ATC facilities in many parts of the world. A significant threat in ATC is maintenance work (scheduled or unannounced) concurrent with normal ATC operations. In addition, maintenance activity may produce threats that only manifest themselves when the equipment concerned is next put into service.

2.4 ***Workspace factors*** include glare, reflections, room temperature, non-adjustable chairs, background noise, etc. A controller's work is more difficult if there are reflections from the room lighting on the screens. A tower controller may have problems visually acquiring traffic at night if there are reflections from the interior lighting in the windows of the tower. A high background noise level, e.g. from fans necessary to cool the equipment, may make it more difficult to accurately understand incoming radio messages. Similarly, it may make outgoing messages harder to understand for the receiving parties.

2.5 ***Procedures*** may also constitute threats for ATC. This applies not only to procedures for the handling of traffic but also to procedures for internal and external communication and/or coordination. Cumbersome or apparently unnecessary procedures may lead to shortcuts with the intent to help the traffic but with the potential to generate errors or undesired states.

2.6 ***Other controllers*** from the same unit may be a threat as well. Proposed solutions for traffic situations may not be accepted, intentions may be misunderstood or misinterpreted, and internal coordination may be inadequate. Other controllers may engage in social conversation, creating a distraction from the traffic. Relief staff may be late. Other controllers in the unit may be handling traffic less efficiently than expected, and consequently, they cannot accept the additional traffic a controller wants to pass to them.

External threats to the ATS provider

2.7 ***Airport layout and configuration*** can be a source of threat to ATC operations. A basic airport with just a short taxiway connecting the ramp with the middle of the runway will require ATC to arrange for backtracking of the runway by most of the arriving and departing traffic. If a taxiway parallel to the runway were available, with intersections at both ends as well as in between, there would be no requirement for aircraft to backtrack the runway. Some airports are designed and/or operated in such a way that frequent runway crossings are necessary, both by aircraft under their own power, and by towed aircraft or other vehicles.

2.8 ***Navigational aids*** that become unexpectedly unserviceable (e.g. because of maintenance) can pose a threat for ATC since they may cause inaccuracy in navigation and affect separation of aircraft. Instrument Landing Systems (ILS) available for both directions of the same runway are another example of this category of threat. Usually only one of the ILS is active, so with a runway change, the ILS for the current runway direction may not yet be activated when ATC is already clearing aircraft to intercept it.

2.9 ***Airspace infrastructure/design*** is another potential source of threat for ATC. If manoeuvring space is restricted, it becomes more difficult to handle a high volume of traffic. Restricted or Danger Areas that are not permanently active may be a threat if the procedures for communicating the status of the areas to the controllers are inadequate. Providing an ATC service to traffic in Class A airspace is less open to threats than, for example, in Class E airspace where there can be unknown traffic that interferes with the traffic controlled by ATC.

2.10 ***Adjacent units***. Controllers from adjacent units may forget to coordinate a traffic handover. The handover may be coordinated correctly, but incorrectly executed. The airspace boundaries may not be respected. A controller from the adjacent centre may not accept a proposal for a non-standard handover, forcing the need for another solution. Adjacent centres may not be able to accept the amount of traffic that a unit wants to transfer to them. There may be language difficulties between controllers from different countries.

Airborne threats

2.11 ***Pilots*** who are unfamiliar with the airspace or airport can pose a threat to ATC. Pilots may not advise ATC of certain manoeuvres that they may need to make (e.g. when avoiding weather) which can be a threat to ATC. Pilots may forget to report passing a waypoint or altitude, or they may acknowledge doing something that they subsequently will not do. In the TEM framework, an error by a pilot is a threat to ATC.

2.12 ***Aircraft performance***. Controllers are familiar with the normal performance of most aircraft types or categories they handle, but sometimes the performance may be different to that expected. A Boeing 747 with a destination close to the point of departure will climb much faster and steeper than one with a destination that is far away. It will also require a shorter take-off roll. Some new-generation turboprop aircraft will outperform medium jet aircraft in the initial stages after take-off. Derivative aircraft types may have a significantly higher final approach speed than earlier series.

2.13 ***Radiotelephony (R/T) communication***. Readback errors by pilots are threats to ATC. (Similarly, a hearback error by a controller is a threat to the pilot.) R/T procedures are designed with the aim to detect and correct such errors (thus avoiding threats), but in actual practice, this does not always work to perfection. Communications between pilots and controllers may be compromised by language issues. The use of two languages on the same frequency, or two or more ATC units sharing the same frequency are also considered threats under this category.

2.14 ***Traffic*** controllers are familiar with the normal traffic flows in their areas and how these are usually handled. Additional traffic such as aerial photography flights, survey flights, calibration flights (navaids), parachute jumping activities, road traffic monitoring flights and banner towing flights are threats to the handling of normal traffic. The earlier a controller is aware of the additional traffic, the better the opportunity to adequately manage the threat.

Environmental threats

2.15 ***Weather*** is perhaps the most common category of threat to all aspects of aviation, including ATC operations. Managing this threat is made easier by knowing the current weather and the forecast trend for at least the duration of a controller's shift. For example, changes in wind direction may involve runway changes. The busier the traffic, the more crucial becomes the timing for a runway change. A controller will plan strategies to make the change with a minimal disruption to the traffic flow. For en-route controllers, knowing areas of significant weather will help to anticipate requests for re-routings or circumnavigation.

2.16 Appropriate knowledge of local weather phenomena (e.g. turbulence over mountainous terrain, fog patterns and intensity of thunderstorms) and/or sudden weather occurrences such as wind shear or microbursts contributes towards successful weather threat management.

2.17 ***Geographical environment***. Threats in this category comprise high terrain or obstacles in the controller's area of responsibility. Less obvious threats can be posed by, for example, residential areas that must not be overflown below certain altitudes or during certain hours. At some airports, runway changes are mandatory at specified times of the day for environmental reasons.

3. ERRORS IN AIR TRAFFIC CONTROL

3.1 Errors may be defined here as "actions or inactions by the ATCO that lead to deviations from organizational or ATCO intentions or expectations". Unmanaged and/or mismanaged errors frequently lead to undesired states. Errors in the operational context thus tend to reduce the margins of safety and increase the probability of adverse events.

3.2 Errors can be spontaneous (i.e. without direct linkage to specific, obvious threats), linked to threats, or part of an error chain. Examples of errors would include not detecting a readback error by a pilot; clearing an aircraft or vehicle to use a runway that was already occupied; selecting an inappropriate function in an automated system; and data entry errors.

4. UNDESIRED STATES IN AIR TRAFFIC CONTROL

Undesired states are defined as "operational conditions where an unintended traffic situation results in a reduction in margins of safety". Undesired states that result from ineffective threat and/or error management may lead to compromising situations and reduce margins of safety in ATC operations. Often considered the last stage before an incident or accident, undesired states must be managed by ATCOs. Examples of undesired states would include an aircraft climbing or descending to another level than it should, or an aircraft turning in another direction than it should. Events such as equipment malfunctions or flight crew errors can also reduce margins of safety in ATC operations, but these would be considered threats. Undesired states can be managed effectively, restoring margins of safety, or the ATCO's response(s) can induce an additional error, incident or accident.

An undesired state is often the first indication to a controller that an earlier threat or error was not adequately managed.

5. THREAT AND ERROR COUNTERMEASURES

5.1 As part of the normal discharge of their operational duties, ATCOs employ countermeasures to keep threats, errors and undesired states from reducing margins of safety in ATC operations. Examples of countermeasures would include checklists, briefings and SOPs, as well as personal strategies and tactics. Flight crews dedicate significant amounts of time and energy to the application of countermeasures to ensure margins of safety during flight operations. Empirical observations during training and checking suggest that as much as 70 per cent of flight crew activities may be countermeasures-related activities. A similar scenario is likely in ATC.

5.2 All countermeasures are necessarily ATCO actions. However, some countermeasures to threats, errors and undesired states that ATCOs employ build upon "hard" resources provided by the aviation system. These resources are already in place in the system before ATCOs report for duty and are therefore considered as systemic-based countermeasures. The following would be examples of "hard" resources that ATCOs employ as systemic-based countermeasures:

a) minimum safe altitude warning (MSAW);

b) short-term conflict alert (STCA);

c) SOPs;

d) briefings; and

e) training.

5.3 Other countermeasures are more directly related to the human contribution to the safety of ATC operations. These are personal strategies and tactics, and individual and team countermeasures, which typically include canvassed skills, knowledge and attitudes developed by human performance training, most notably, by TRM training.

6. INTEGRATING TEM IN SAFETY MANAGEMENT

6.1 The distinction between the different categories of threats may be trivial to operational controllers — threats exist and need to be managed during everyday shifts. On the other hand, training managers may wish to note which categories of threats are being addressed in the curriculum for their unit (although they are most likely not presented as threats in the training). Some of the threats are often addressed in a less formal way, e.g. as anecdotal information during on-the-job training.

6.2 An airport with a basic layout where backtracking on the runway is required for movements is an example. Controllers working on that airport will have received training (in the classroom, in the simulator or on the job) to enable them to control the traffic at that airport, and they will be used to managing the threat. Nevertheless, every backtracking aircraft poses a threat to the ATC operation and needs to be managed by the controllers.

6.3 From the perspective of an ATC safety manager, it is relevant to know how this particular threat is managed by the controllers on a day-to-day basis. Are they able to manage it without any significant problems, or are the difficulties to managing it so common that they go unreported? In case of the former, there might be no requirement for the safety manager to take specific action. In case of the latter, there obviously is a need for safety management action.

Chapter 18

AERODROME OPERATIONS

18.1 AERODROME SAFETY — GENERAL

18.1.1 Safety, regularity and efficiency of aircraft operations at aerodromes are of paramount importance. To this end, Annex 14, Volume I, requires States to certify aerodromes used for international operations and recommends certification of aerodromes available for public use. The aerodrome certification process includes approval/acceptance of an aerodrome manual that outlines the aerodrome's safety management system (SMS). Although the potential for a catastrophic accident during aircraft operations on the ground exists, the likelihood of a minor accident while the aircraft is on the ground, particularly during a turnaround, is high. Each year, aircraft operators incur significant financial losses associated with accidents during ground operations.

18.1.2 Accidents and incidents occurring in flight are generally well reported and investigated. However, ground accidents do not always receive the same level of attention. Minor accidents and incidents may not be reported to the aerodrome management by the operators, tenants and service providers based at the aerodrome. These minor accidents and incidents may be a breeding ground for more serious accidents (see Chapter 4, 4.4.16 to 4.4.18 on the 1:600 Rule). Understanding the conditions that create hazards to safety at aerodromes is vital to effective safety management.

18.1.3 Safety at aerodromes requires much the same approach to safety management as that required for safe flight operations. The concentration of many different activities at aerodromes creates unique circumstances with significant accident potential.

18.1.4 Ground occurrences must be seen within the overall context of aerodrome operations. Aerodromes bring together a volatile mixture of activities with high-risk potential. Some of the factors contributing to this risk potential include:

a) traffic volume and mixture (including domestic and international, scheduled and non-scheduled, charter and specialty operations, commercial and recreational aviation, fixed and rotary wing, etc.);

b) vulnerability of aircraft on the ground (awkward, fragile, etc.);

c) abundance of high-energy sources (including jet blast, propellers, fuels, etc.);

d) extremes of weather (temperatures, winds, precipitation and poor visibility);

e) wildlife (birds and animals) hazards;

f) aerodrome layout (especially taxiway routings, congested apron areas, and building and structure design limiting line of sight, possibly leading to a runway incursion);

g) inadequacy of visual aids (e.g. signs, markings and lighting);

h) non-adherence to established procedures (especially at uncontrolled aerodromes);

i) vehicles on the apron;

j) problems in information transfer (communications) with those operating on the airside;

k) runway usage (including simultaneous multiple runway usage, intersection departures and preferential runways);

l) ground and apron control (sometimes compromised by frequency congestion, use of non-standard phraseology, language difficulties, mistaken call signs, etc.);

m) inadequacy and unreliability of visual and non-visual aids for landing;

n) airspace limitations (topography, obstructions, noise abatement requirements, etc.);

o) security issues;

p) construction activities at an operational aerodrome; and

q) capacity enhancement procedures and use of existing facilities not designed for newer generation aircraft.

18.1.5 Within its operating context, an aerodrome provides a diverse set of services to support flight operations. Some of these include:

a) flight planning, including weather services;

b) navigation, approach and landing aids;

c) communication services;

d) air traffic, ground and apron control;

e) runway and apron maintenance (including snow and ice removal, bird and wildlife control, FOD removal, etc.);

f) aircraft servicing of all types;

g) aerodrome security;

h) aerodrome emergency services (i.e. rescue and firefighting services);

i) management of tenants (aviation operators, service contractors, etc.); and

j) customer management (passengers, freight shippers, etc.).

18.1.6 Given the complexity of the aerodrome environment, a systematic approach to safety is required in order to coordinate the various activities for the safe delivery of services. An SMS provides such a coherent approach. In so doing, the safety philosophy and the supporting policies are developed, operating procedures are coordinated and implemented, and day-to-day operational practices are systematically monitored. In short, an SMS helps create an aerodrome safety culture conducive to safe operations.

18.2 REGULATORY FRAMEWORK

ICAO requirements for aerodrome safety management

18.2.1 The SARPs relating to the implementation of SMS for aerodrome operators are contained in Annex 14 — *Aerodromes,* Volume I — *Aerodrome Design and Operations.* Chapter 1, Section 1.4 requires that the aerodrome manual submitted for approval and granting of an aerodrome certificate contain details of the aerodrome SMS.

18.2.2 The *Manual on Certification of Aerodromes* (Doc 9774) contains, in Appendix I, the particulars to be included in an aerodrome manual. Part 5 of this Appendix contains the essential features of an aerodrome SMS.

18.2.3 Doc 9774 states that an aerodrome operator's SMS should include the safety policy, structure of the organization and individual and group responsibilities for safety issues, setting of safety performance targets and internal safety audit and review systems, with a view to ensuring that operations are carried out in a demonstrably controlled way.

State responsibilities

18.2.4 Implementing the ICAO provisions has implications for both aerodrome operators and the State regulatory body. Increasingly, aerodromes are operated as corporate or privatized companies, which are not under the direct control of the State. However, the State, as the signatory to the Chicago Convention, is responsible for the implementation of ICAO SARPs. The safety management principles outlined in this manual do not replace the obligation to comply with ICAO SARPs and/or national regulations, but are guidance material.

18.2.5 To discharge this responsibility, the State must put in place the legislative and regulatory provisions needed to require aerodrome operators to implement systematic safety management practices and procedures. It will also be necessary for States to establish appropriate oversight mechanisms to ensure that providers comply with these legislative and regulatory requirements, and that they maintain an acceptable level of safety in their operations. The establishment of a regulatory framework is described in Doc 9774.

18.2.6 States need to establish an entity within the CAA, with the responsibility to ensure that the requirements with respect to aerodromes are met. The organizational structure and staffing of this entity (sometimes referred to as the *Directorate of Aerodromes Standards and Safety* (DASS)) should suit the national environment and the complexity of the civil aviation system. Doc 9774 describes in detail the establishment and the responsibilities of a DASS.

18.2.7 It is especially important that where the regulatory function and the aerodrome operation are both under the control of the one body (e.g. a civil service department or a State controlled authority) a clear distinction be maintained between these two functions, i.e. safety oversight and service delivery.

18.2.8 The State's safety programme for aerodromes can be seen as having two components: a safety regulatory and oversight function, which will always be the direct responsibility of the State, and a safety management component, implemented through the SMS of the aerodrome operator(s).

Approaches to the discharge of regulatory responsibilities

18.2.9 As outlined in Chapter 3, the State may adopt either an active role in the discharge of its regulatory responsibilities, involving close supervision of the safety-related activities of the aerodrome operator, or a passive role, whereby greater responsibility is delegated to the aerodrome operator, with the State retaining oversight responsibilities. Considerable merit exists in a State regulatory system which falls between the active and passive extremes and which should:

a) represent a balanced allocation of responsibility between the State and the aerodrome operator for the safe operation of the aerodrome;

b) be capable of economic justification within the resources of the State;

c) enable the State to maintain continuing regulation and supervision of the activities of the aerodrome operator without unduly inhibiting the aerodrome operator's direction and control of the organization; and

d) result in the establishment and maintenance of harmonious relationships between the State and the aerodrome operator.

18.3 AERODROME SAFETY MANAGEMENT

18.3.1 Traditionally, aerodromes were owned and operated by the State. Increasingly, this is changing as aerodromes are corporatized (or privatized) and the management is turned over from government officials to aerodrome authorities or private entities. Regardless of whether the aerodrome is managed by the State or a private entity, safety remains a primary concern. A robust SMS can facilitate safe aircraft operations at an aerodrome. However, the adoption of an SMS does not obviate the need to comply with the SARPs in Annex 14, Volume I, and applicable national regulations.Within the framework of an aerodrome SMS, the aerodrome management must oversee the activities of all the service providers, tenants, contractors and others to ensure the safest and most efficient performance of the aerodrome.

18.3.2 An effective aerodrome SMS begins with a strong corporate knowledge of the aviation business. The aerodrome management must promote a positive safety culture. In part this will depend on the resources dedicated to safety management; the feedback mechanisms in place — and how they are managed on a day-to-day basis; the promotion of sharing of safety-related information among stakeholders in the aerodrome's operation; and a constant striving for improvement.

18.3.3 Chapters 12 to 15 provide guidance on the principles and practices for establishing an effective SMS. The ten steps outlined in Chapter 12 apply equally to aerodromes.

Scope for aerodrome safety management

18.3.4 An aerodrome SMS can only provide a means of controlling those hazards which originate within the aerodrome system, or in which some element of the aerodrome system could be a contributory factor.

18.3.5 As an example of the latter, the aerodrome safety system cannot directly address the causes of an emergency landing due to an aircraft system malfunction; it can only address the consequences of an emergency landing at that aerodrome. However, it is important that the aerodrome procedures for handling an emergency do not increase the severity of the emergency.

18.3.6 Within this manual, the term a*erodrome system* includes all of the people, technology and procedures required for the operation of an aerodrome, and the interfaces between them.

Aerodrome operator SMS

18.3.7 While it is the responsibility of the State to promulgate appropriate legislative and regulatory provisions concerning aerodromes, the aerodrome operator is responsible for the day-to-day management at the aerodrome.

18.3.8 Given the complexity of the factors creating risk potential at aerodromes, the aerodrome management must coordinate the activities of the diverse stakeholders at an aerodrome — often with conflicting expectations and priorities. The sharing of a common focus among the stakeholders, most of whom are employees of agencies other than the aerodrome authority, needs to be fostered. In addition, resource commitments from the airlines and other service providers must be obtained.

18.3.9 The aerodrome's SMS begins with the development of appropriate safety policies and operating procedures. These policies and operating procedures are more likely to be implemented if stakeholders participate in their development and if they are included in appropriate contractual documents, such as leases and operating authorities. A high degree of cooperation by all stakeholders will also be necessary to achieve the desired level of standardization and interoperability required for safe ground operations. Appendix 1 to this chapter provides an example of a safety policy for an aerodrome operator.

18.3.10 It must be ensured that commercial interests, upon which the financial viability of the aerodrome depends, are not accorded priority over operational safety issues. For example, increasing the number of aircraft gates may increase aerodrome revenue; however, it may also increase apron congestion, presenting additional safety risks. Many large aerodromes have a strong users' group or consultative committee, formed with representatives of aerodrome tenants, operators, service providers, etc., which can assist the aerodrome management in decisions related to airport operations.

Safety manager and safety committee(s)

18.3.11 Large aerodromes would benefit from the appointment of a dedicated safety manager (SM). The appointment of an SM, however, does not relieve the aerodrome director/manager from accountability for effective safety management.

18.3.12 In addition, large aerodromes may require a safety committee. Such a safety committee, involving participation by the users' group referred to in 18.3.10, is an effective vehicle for integrating their diverse views. For example, such a committee would be essential in preparing the Aerodrome Emergency Plan (discussed in 18.4).

18.3.13 An aerodrome SM would logically coordinate the activities of the aerodrome safety committee. Furthermore, given the requirement to integrate many, often-conflicting interests, several safety sub-committees may be required. For example, separate groups may be formed to address particular areas of safety concern, such as aerodrome security, apron safety, vehicle operations airside, snow and ice removal, and runway incursions.

18.3.14 Further guidance on the role and practices of the SM and safety committees is provided in Chapters 12 and 15.

Safety occurrence reporting

18.3.15 Hazards can only be controlled if their existence is known. One powerful tool for proactively identifying safety hazards is through safety occurrence reporting. Through a non-punitive, occurrence reporting system, the aerodrome manager can tap the diversity of views available at an aerodrome in identifying underlying situations or conditions with the potential for endangering the safety of aircraft operations.

18.3.16 As described in Chapter 7, there are two basic types of reporting schemes. They are:

a) ***mandatory*** reporting of accidents and incidents required by State regulations; and

b) ***voluntary*** reporting of safety occurrences which may not be reported under the mandatory reporting provisions.

18.3.17 All organizations at the aerodrome, including aircraft operators, ground handling agencies and other organizations, need to actively participate in the occurrence reporting system. However, given the number of stakeholder groups involved, with their diverse interests and priorities, establishing and running an effective occurrence reporting system on an aerodrome presents a considerable challenge. Furthermore, some of them, e.g. aviation refueling companies, may have their own established methods of managing the safety of their operations.

18.3.18 In implementing an occurrence reporting system, aerodrome employees, contractors and tenants should all be clear on:

a) the types of hazards that should be reported;

b) the reporting mechanisms;

c) their job security; and

d) actions taken in following up on identified hazards.

Safety oversight

18.3.19 Given the diverse activities of many different agencies, the maintenance of high safety standards at aerodromes implies a regular programme of monitoring and surveillance. At the interfaces between stakeholders (for example, aerodrome employees versus the employees of airlines, or contracted service providers), there may be a tendency to shift responsibilities, stating that *"it is not my problem"*. For this reason, it is essential that roles and responsibilities are clearly defined.

18.3.20 Change is everywhere as aerodromes expand to meet increasing demand. New runways and taxiways, terminal buildings, shops and warehouses, etc., have the potential to introduce new safety hazards. The aerodrome manager may require that a safety assessment be carried out in respect of any proposals for significant changes in the level of facilities, services and operation of the aerodrome.

18.3.21 An effective SMS for an aerodrome should also incorporate a safety audit programme which covers all the activities conducted at the aerodrome. Such safety reviews would also cover the apron activities of service providers and operators. A good understanding of Human Factors issues involving groups of employees, such as maintenance personnel, baggage handlers and vehicle operators, will provide insights into safety hazards. Cooperative arrangements with the management of a like-sized aerodrome may provide the opportunity to gain additional expertise and experience for effective safety reviews and audits.

Safety audits

18.3.22 Safety auditing is a core safety management activity, providing a means of identifying potential problems before they have an impact on safety. Chapter 14 outlines the principles and practices for establishing a safety audit programme.

18.3.23 The *Manual on Certification of Aerodromes* (Doc 9774) indicates that an aerodrome operator should arrange for an audit of the aerodrome SMS, including an inspection of the aerodrome facilities and equipment. The aerodrome operator should also arrange an external audit for the evaluation of aerodrome users, including aircraft operators, ground handling agencies and other organizations working at the aerodrome. Such external audits should be conducted by suitably qualified safety experts.

18.4 AERODROME EMERGENCY PLANNING

18.4.1 Many accidents occur on or in the vicinity of aerodromes, creating a strain on the resources of aerodromes. Responding appropriately and in a timely fashion to an aircraft emergency is one of the most critical challenges facing aerodrome management. To ensure an appropriate response at such times of high stress, a sound Aerodrome Emergency Plan (AEP) is essential. Annex 14, Volume I, Chapter 9, Section 9.1, has detailed requirements regarding the establishment and maintenance of an AEP. This includes the necessary coordination with other agencies involved in meeting such emergency needs. The AEP reflects a collaborative effort between aerodrome management, the resident stakeholders and those who will have to execute the plan. The following section elaborates on planning for an aerodrome emergency.

18.4.2 The objective of aerodrome emergency planning is to minimize the effects of an emergency, particularly with regard to saving lives and maintaining aircraft operations. The AEP outlines the procedures for coordinating the response of different aerodrome agencies (or services) and those agencies in the surrounding community that could be of assistance in responding to the emergency.

18.4.3 The *Airport Services Manual* (Doc 9137), Part 7 — *Airport Emergency Planning*, states that an AEP should be implemented irrespective of whether an occurrence is an “on-airport”, or an “off-airport” accident/incident. The AEP should take into account operations in all weather conditions and make provision for potential accident locations in difficult terrain surrounding the aerodrome, i.e. bodies of water, roads, depressions and other problem areas. Chapter 11 of this manual provides guidance on the preparation of an AEP.

Coordinated response

18.4.4 The AEP should outline the response, or participation, of those agencies which, in the opinion of the aerodrome operator, would be actively involved in an emergency. Examples of such agencies are:

a) On the aerodrome:

    1) rescue and firefighting services;

    2) medical services;

    3) police and/or security services; and

    4) aerodrome administrations, ATS, maintenance organizations and aircraft operators; and

b) Off the aerodrome:

1) police;

2) local fire departments;

3) medical services;

4) hospitals;

4) government authorities;

6) military;

7) harbour patrol and coast guard; and

8) other relevant agencies.

Aerodrome emergency exercises

18.4.5 The AEP provides the theoretical framework for a coordinated response to emergencies occurring on or in the vicinity of aerodromes. However, periodic testing of the AEP is crucial for determining where gaps may exist in the plan, for example, resolving misunderstandings among participants about the workability of the procedures in place, and unrealistic estimates of requirements (time, resources, etc.). Testing the plan also allows participants to get to know each other, familiarize themselves with the airport facilities, etc. and to learn how other services operate. It also confirms the vital communication links.

18.4.6 There are three methods of testing an AEP:

a) ***Full-scale exercises***. Realistic, comprehensive simulations for testing all capabilities, facilities and agencies participating in an emergency response should be conducted at least once every two years.

b) ***Partial exercises***. Simulations for selected emergency response functions, such as firefighting, should be conducted at least once each year in which a full-scale exercise is not conducted, or as required to maintain proficiency.

c) ***Table-top exercises***. This method for updating procedures, checklists, telephone lists, etc. and for integrating emergency response resources with little expense should be coordinated at least semi-annually.

18.4.7 Some of the more important considerations in preparing an exercise plan for the AEP are listed below:

a) aerodrome emergency service personnel are regularly tested on:

1) emergency response procedures, first aid, etc.;

2) firefighting; and

3) emergency evacuations, including knowledge of relevant aircraft systems and evacuation routes; etc.;

b) communication and call-out procedures are tested and kept up to date;

c) crash and fire routes are well understood, kept clear and inspected regularly;

d) command post is designated, equipped and tested;

e) temporary morgue facilities are available;

f) procedures are in place (and regularly tested) for:

   1) crowd control;

   2) media access; and

   3) receiving families and next of kin of accident victims;

g) clearing of aircraft wreckage, or recovery of aircraft; and

h) provision for restoration of service or continued operation of the aerodrome, etc.

18.5 AERODROME APRON SAFETY

18.5.1 Apron accidents often involve relatively minor damage, although at times they may lead to more serious damage. Aircraft skin and ground-servicing equipment may be damaged and/or employees may be injured. Sometimes, contact between a catering truck or ground-servicing vehicle and an aircraft may cause minor damage that may go unnoticed or unreported, but may contribute to a subsequent in-flight emergency.

18.5.2 Aircraft are easy to damage and expensive to repair. Even minor ground handling accidents are expensive as they incur such indirect costs as schedule disruptions and passenger accommodations. Yet, because such occurrences may not fall within the definition of an aviation accident, aviation organizations frequently view them from the perspective of occupational health and safety or environmental safety — as opposed to a critical aspect of maintaining safe and efficient flight operations. The concept of creating and fostering a positive safety culture on the apron is often not well developed.

Apron work environment

18.5.3 The apron work environment is often less than ideal for safe operations from a human performance perspective. Difficulties can arise from the variety of activities, congestion in a restricted environment, tight time pressures, and often poor weather or lighting conditions. Appendix 2 to this chapter outlines some of the factors which can contribute to hazards in the apron work environment.

18.5.4 All things considered, the potential for accidents and injuries in the apron environment is high. Reducing that potential requires a multidisciplinary effort by many departments of the aerodrome and the staff of airlines, service providers and contractors.

Causes of apron accidents

18.5.5 Although many aircraft operators have their own internal accident/incident databases, there are few public sources for data on apron accidents. Many ground occurrences are not reported to any State authority. Nevertheless, based on industry experience, the following general statements can be made about the causes of apron accidents:

a) ***Regulations or Standard Operating Procedures (SOPs)*** are inadequate or not followed.

b) ***Poor discipline and inadequate supervision*** set up many accidents (particularly those involving excessive vehicle speed).

c) ***Equipment***. Incorrect use or abuse of the ground handling equipment may lead to apron accidents.

d) ***Dynamic environment*** with constant motion (and commotion) makes maintenance of situational awareness difficult even for experienced personnel.

e) ***Weather*** limits human performance.

f) ***Training versus exposure to risk***. Organizations generally train their skilled employees adequately. However, a high proportion of relatively unskilled workers on the apron, who are exposed to significant risk daily, usually receive little safety training and supervision.

g) ***Human performance***. Apron accidents often involve Human Factors arising from such things as misjudgement, obscured vision, stress, distraction, time (or peer) pressures, complacency, ignorance, fatigue, and insufficient supervision or oversight.

Safety management on the apron

18.5.6 Apron operations present scenarios with often-conflicting goals that require rapid risk management decisions. Balancing the requirement for safety against operating pressures to provide a quick turnaround of the aircraft to avoid delays and disruptions calls for trade-offs. Shortcuts in following SOPs may be taken to facilitate on-time departures, usually without adverse consequences. Workers may be chastised (perhaps even penalized) for failure to keep things moving. Yet, they may be “punished” if the practices they followed contributed to an accident. How can this vicious cycle be broken?

18.5.7 The three cornerstones for an effective SMS and the corresponding activities are discussed in Chapter 5. With minor modifications, these apply to preventing apron accidents. Some factors warranting special consideration include:

a) structured training geared to staff capabilities, including:

   1) orientation for safety;

   2) safe operation of ground support equipment;

   3) need for compliance with SOPs; and

   4) skills training such as marshalling signals, and seasonal skills such as de-icing;

b) clear practical SOPs which are understood, practiced and enforced;

c) hazard and incident reporting system which encourages input from ground servicing personnel;

d) competent investigation of apron mishaps, with particular emphasis on the human performance aspects;

e) effective collection and analysis of relevant ground safety data;

f) fostering of a positive safety culture for all apron workers, whereby they take “ownership” for their safety record;

g) representation of ground handlers and servicing personnel on safety committees, perhaps including a separate sub-committee for ground safety;

h) feedback to workers regarding identified hazards and actions taken to reduce or eliminate them;

i) ongoing programme of safety awareness; and

j) monitoring of ground system safety (through regular assessments and audits).

Vehicle operations

18.5.8 Servicing/ground handling of an aircraft on the apron involves many activities. Vehicles such as catering trucks, refueling trucks, baggage/cargo handling equipment, and cleaning vehicles all converge on the aircraft nearly simultaneously in order to meet the planned turnaround time. In such conditions, the risk of collision is ever-present and the potential for serious consequences is great. Excessive speed in confined areas and in close proximity to aircraft is a major cause of apron accidents. A systems approach is required for organizing and controlling vehicular traffic on the apron in order to reduce the risk of accidents.

18.5.9 Most vehicle operators on the apron are not aerodrome operator’s employees. They may work for service providers, such as airlines, refuelling companies, and catering and cleaning companies. Many of these personnel are beyond the control of the aerodrome operator. However, they normally require some form of approval issued by the aerodrome operator to drive on the apron. The following are some methods for safely controlling vehicles that aerodrome safety committees and SMs should consider:

a) ***Vehicle control plan***. This plan is usually developed by the aerodrome operator and applies to all apron areas and vehicles operated on them. All aerodrome tenants are expected to be aware of and follow this plan which should prescribe traffic flow, vehicle operating rules, and signs and markings for vehicles and traffic control devices.

b) ***Vehicle operating standards***. These are the basic “rules of the road” for how vehicles are to be operated on the aerodrome — including limits on speed and proximity to aircraft, right of way, etc. They are normally developed by the aerodrome authority with the advice and assistance from major users.

c) ***Vehicle limitations***. A basic rule is to limit the number of vehicles on the ramp to the minimum number needed to do the job. Each vehicle has to be justified. All vehicles should be company-owned with no privately owned vehicles authorized.

d) ***Vehicle operator training***. All drivers on the apron must be trained (and perhaps certified) before they are allowed to operate vehicles there. This programme may be administered by the aerodrome operator or by major aerodrome tenants in accordance with guidelines from the aerodrome operator.

e) ***Enforcement***. The success of any airside vehicle operations and plan is dependent upon the implementation of, and compliance with, operating standards. Close supervision and monitoring are required to ensure that all users of the apron uphold required safety standards. This includes enforcement action against those who do not comply.

18.6 ROLE OF AERODROME SAFETY MANAGERS IN GROUND SAFETY

18.6.1 An aerodrome SM can make a significant contribution to ground safety and operational effectiveness. Ground safety merits the same systematic approach and attention to detail as flight safety. The aerodrome's programme for preventing accidents on the ground should therefore embody all the elements of an SMS (hazard and incident reporting systems, safety committees, risk management processes, competent investigations, safety oversight, etc.). A successful aerodrome SMS requires a solid working relationship between the various users of the aerodrome and the SM. The SM should be interested in the adequacy of aerodrome defences against ground accidents in such areas as:

a) routine aerodrome maintenance (paved and unpaved surfaces, lighting, signs, markings, etc.);

b) planned new construction;

c) aerodrome and apron inspections, including control of FOD;

d) control of vehicle operations;

e) wildlife hazard control, especially birds;

f) runway incursions;

g) snow and ice removal;

h) occurrence reporting and investigation procedures;

i) emergency planning;

j) safety committees, especially the apron safety committee; and

k) communications of safety information at the local level.

18.6.2 Figure 18-1 illustrates the use of an SMS at an aerodrome and the SM's role in the process.

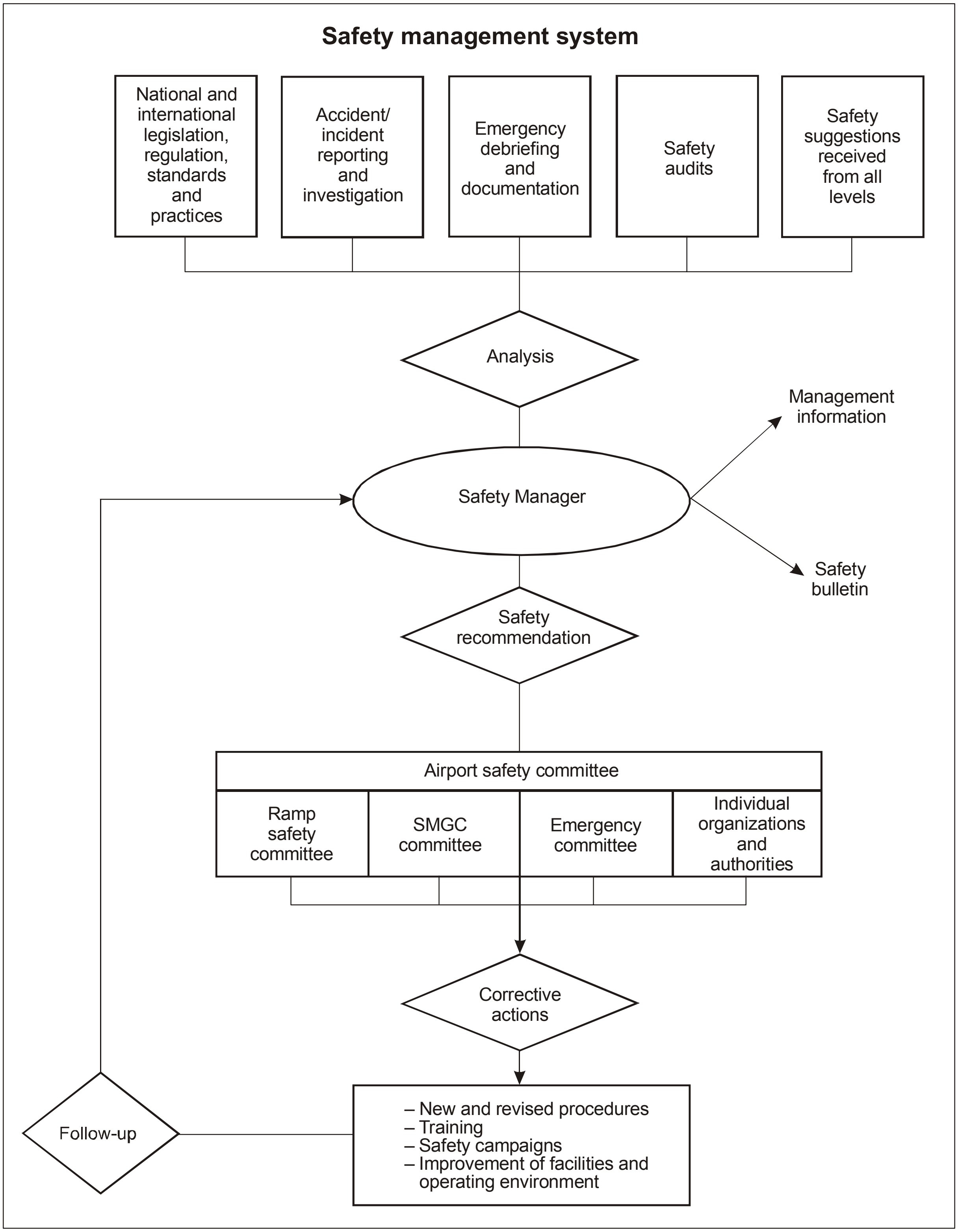

Figure 18-1. Example of an aerodrome SMS

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Appendix 1 to Chapter 18

EXAMPLE OF A SAFETY POLICY FOR AN AERODROME OPERATOR

1. The <*aerodrome operator's*> principal safety objective is to minimize, as much as is reasonably practicable, the risk of an aircraft accident at or in the vicinity of the aerodrome. Thus, safety shall be afforded the highest priority throughout the activities of the <*aerodrome operator*> and take priority over commercial, environmental and social considerations.

2. To achieve its principal safety objective, the <*aerodrome operator*> shall apply a formalized and proactive approach to systematic safety management within the aerodrome operation. A safety management system shall be implemented in respect of all activities and supporting services which are under the managerial control of the <*aerodrome operator*>*.*

3. Everyone involved in the operation aspects of the <*aerodrome operator*> has an individual safety responsibility for his/her own actions. As safety is an integral function of management, all line managers are accountable for the safety performance of their areas of responsibility, and for ensuring that safety requirements are complied with.

4. The <*aerodrome operator*> shall comply with all statutory obligations and with the safety management requirements of the <*regulatory authority*>.

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Appendix 2 to Chapter 18

FACTORS CONTRIBUTING TO HAZARDS IN THE APRON WORK ENVIRONMENT

The following points illustrate some of the factors which contribute to a hazardous work environment on an aerodrome apron.

a) Aircraft ground handling comprises the activities required to turn an aircraft around, including:

   1) marshalling and chocking arriving aircraft;

   2) refuelling;

   3) correcting maintenance defects and performing routine aircraft maintenance;

   4) de-icing and anti-icing of aircraft;

   5) aircraft catering, cleaning cabins and servicing water and toilets;

   6) passenger embarkation/disembarkation;

   7) loading and unloading of baggage and freight; and

   8) aircraft towing and pushback.

b) In addition to the complexity of apron operations, the nature of ground handling poses significant potential for safety hazards due in part to:

   1) aircraft size and shape versus vehicle driver's susceptibility to misperceptions and misjudgements of distance and location;

   2) the aircraft's fragile skin and appendages, e.g. aerials and probes which are easily damaged;

   3) need to preserve the aerodynamic and structural integrity of the aircraft;

   4) constraints of space and time; and

   5) number of unskilled, low-paid and poorly motivated workers.

c) Several Human Factors exacerbate the accident potential of the foregoing. The following factors typically characterize the workplace and content of ground handling duties:

   1) hostile work environment (noise, jet-blast, diverse weather and difficult light conditions);

   2) working in limited (often height-restricted) space in the midst of congestion of other servicing vehicles, personnel and adjoining aircraft movements;

3) time pressures for on-time departures (or to make up for late running);

4) cyclical workload with peak demands followed by lulls between transiting aircraft;

5) frequent shift work;

6) requirement to operate a variety of expensive, specialized servicing equipment;

7) workforce (especially for loaders) often comprises casual unskilled labour;

8) apron workers are often employed by organizations other than the aerodrome authority (e.g. airlines, service providers and catering companies); and

9) organizational factors deriving from management's failure to provide a similar level of attention to ground safety as it does to flight safety.

Chapter 19

AIRCRAFT MAINTENANCE

19.1 MAINTENANCE SAFETY — GENERAL

19.1.1 Until recently, less attention had been paid to systematically reducing risks arising from aircraft maintenance activities than from flight operations. Yet, maintenance and inspection errors are cited as a factor in a number of accidents and serious incidents worldwide each year.

19.1.2 The safety of flight is dependent on the airworthiness of the aircraft. Safety management in the areas of maintenance, inspection, repair and overhaul are therefore vital to flight safety. Maintenance organizations need to follow the same disciplined approach to safety management as is required for flight operations. Adhering to such a discipline in maintenance can be difficult. Maintenance activities may be conducted by the airline itself, or they may be contracted out to approved maintenance organizations, and as a result, these activities may take place well away from the airline's home base.

19.1.3 Conditions for maintenance-related failures may be set in place long before an eventual failure. For example, an undetected fatigue crack may take years to progress to the point of failure. Unlike flight crews who have near real-time feedback on their errors, maintenance personnel usually receive little feedback on their work until a failure occurs. During this time lag, maintenance workers may continue to create the same latent unsafe conditions. As a consequence, the maintenance world incorporates a combination of safety defences, including multiple redundancies of aircraft systems, to strengthen the system. These defences also include such things as certification of maintenance organizations, licensing of AMEs, airworthiness directives, detailed SOPs, job cards, inspection of work, and sign-offs and records of work completed.

19.1.4 Risk potential may be created by the conditions under which maintenance is often conducted, including such variables as organizational issues, work site conditions and human performance issues pertinent to aircraft maintenance. Some of the broader issues in maintenance potentially affecting safety are outlined in Appendix 1 to this chapter.

19.1.5 The term "safety" in an aircraft maintenance context is often considered to have two connotations. One is an emphasis on industrial safety and hygiene for the protection of AMEs, facilities and equipment. The second is the process for ensuring that AMEs provide airworthy aircraft for flight operations. Although the two may be inextricably linked, this chapter concentrates on the latter, with little reference to Occupational Safety and Health (OSH) issues.

19.2 MANAGING SAFETY IN MAINTENANCE

19.2.1 Given the nature of the maintenance function, the working environment for AMEs, and the many Human Factors issues which may compromise their expected performance, a systematic approach to safety is called for, i.e. a safety management system (SMS). Chapter 5 describes how system-wide safety management recognizes organizational interdependencies and interactions, with the need to integrate safety efforts across the entire operation. Successful SMS are built upon the following three cornerstones:

a) ***corporate approach*** to safety;

b) effective ***tools for programme delivery***; and

c) formal system for ***safety oversight and programme evaluation***.

19.2.2 Each of these aspects of an SMS is discussed below.

Corporate approach to safety

19.2.3 The corporate approach to safety sets the tone for how the organization develops its safety philosophy and its safety culture. In deciding on the approach the organization wishes to take towards safety management, the following factors may be relevant:

a) size of the maintenance organization (large operators tend to require more structure);

b) nature of the operations (e.g. around-the-clock, international or scheduled operations versus domestic or unscheduled operations);

c) organizational status (e.g. department of an airline versus an independent enterprise);

d) maturity of the organization and its workforce (e.g. corporate stability and experience);

e) labour-management relationships (e.g. recent history and complexity);

f) current corporate culture (versus desired safety culture); and

g) scope of maintenance work (e.g. line servicing versus heavy overhaul of aircraft or major systems).

Organizing for safety

19.2.4 Chapter 12 (see Figures 12-1 and 12-2) provides two sample organizational structures for an airline, both of which reflect direct and informal reporting lines between operations, safety and maintenance. Such communication channels depend on the trust and respect established in the day-to-day working relationships of those involved.

19.2.5 For an aircraft operator, the safety manager (SM) must have clearly defined responsibilities and reporting lines with respect to safety management in maintenance. The maintenance organization may require a technical specialist to work with the SM. As a minimum, the SM will require specialist advice from the maintenance department.

19.2.6 The company's safety committee should include representation from the maintenance department. In large operators, a dedicated sub-committee for maintenance safety issues may be warranted.

Documentation and records management

19.2.7 Maintenance departments depend heavily on systems for systematically acquiring, storing and retrieving the voluminous information required for safety management. Some examples follow:

a) Technical libraries must be kept current (for such things as engineering orders, type certifications, airworthiness directives and service bulletins).

b) Maintenance defects and work completed must be recorded in detail.

c) Performance and system monitoring data must be retained for trend analysis.

d) Corporate safety policies, objectives and goals must be formally documented and distributed.

e) Records must be kept on personnel training, qualification and currency, etc.

f) Information on component history, life, etc. must be kept.

19.2.8 In a large operator, much of this information will be computerized. Therefore, the success of an SMS in a maintenance organization will largely depend on the quality and timeliness of its document and records management systems.

Resource allocations

19.2.9 The best SMS on paper will be useless without adequate resources. To protect against losses due to an accident, expenditures will be required. For example, resources need to be allocated for:

a) personnel with expertise to design and implement the maintenance safety system;

b) training in safety management for all staff; and

c) information management systems to store safety data, and expertise to analyse the data.

Safety culture

19.2.10 A poor safety culture in a maintenance organization can lead to unsafe work practices not being corrected — possibly creating latent unsafe conditions that may not cause a problem for years. Management's success in fostering a positive safety culture in the maintenance department will derive in large measure from how the foregoing issues are addressed and from how the SMS is implemented.

Principal tools for safety management in maintenance

19.2.11 Effective operation of an SMS for maintenance builds upon risk-based decision-making, a concept that has long been integral to maintenance practices. For example, maintenance cycles are built upon probabilities that systems and components would not fail for the period of the cycle. Components are often replaced because they are "time expired", even though they may remain functionally serviceable. Based on knowledge and experience, risks of unexpected failure are reduced to acceptable levels.

19.2.12 Some of the principal tools for operating an SMS for the maintenance function include:

a) clearly defined and enforced SOPs;

b) risk-based resource allocations;

c) hazard and incident reporting systems;

d) flight data analysis programmes;

e) trend monitoring and safety analyses (including cost-benefit analyses);

f) competent investigation of maintenance-related occurrences;

g) training in safety management; and

h) communication and feedback systems (including information exchange and safety promotion).

Safety oversight and programme evaluation

19.2.13 As with any "system", feedback is required to ensure that the individual elements of the maintenance SMS are functioning as intended. Continuing high standards of safety in a maintenance organization imply regular monitoring and surveillance of all maintenance activities. This is especially so at the interfaces between workers (such as between maintenance personnel and flight crews, between personnel of different trades, or between staff on changing work shifts) to avoid problems *"falling through the cracks"*. Chapter 10 discusses methods for maintaining safety oversight, including the conduct of regular safety audits.

19.2.14 Change is inevitable in the aviation industry, and the maintenance area is no exception. The Director of Maintenance may require that a safety assessment be carried out in respect of any significant changes in the maintenance organization. Circumstances that might warrant a safety assessment include a corporate merger, and introduction of a new fleet, equipment, systems or facilities. Consequently, the need for any adjustments can be identified and corrected.

19.2.15 The maintenance SMS should be regularly evaluated to ensure that expected results are being achieved. Programme evaluation should provide satisfactory responses to such questions as:

a) To what extent has management succeeded in establishing a positive safety culture?

b) What are the trends in hazard and incident reporting (by technical trade, by aircraft fleet, etc.)?

c) Are hazards being identified and resolved?

d) Have adequate resources been provided for the maintenance SMS?

19.3 MANAGING PROCEDURAL DEVIATIONS IN MAINTENANCE

19.3.1 The maintenance system includes not only the AMEs on the shop floor but also all the other technicians, engineers, planners, managers, stores keepers and other persons that contribute to the maintenance process. In such a broad system, procedural deviations and errors in maintenance are inevitable and pervasive.

19.3.2 Accidents and incidents attributable to maintenance are more likely to be caused by the actions of humans than by mechanical failure. Often, they involve a deviation from established procedures and practices. Even mechanical failures may reflect errors in observing (or reporting) minor defects before they progress to the point of failure.

19.3.3 Maintenance errors are often facilitated by factors beyond the control of the AME, for example:

a) information required to do the job;

b) equipment and tools required;

c) aircraft design limitations;

d) job or task requirements;

e) technical knowledge or skill requirements;

f) factors affecting individual performance (i.e. SHEL factors);

g) environmental or workplace factors;

h) organizational factors such as corporate climate; and

i) leadership and supervision.

19.3.4 Safe maintenance organizations foster the conscientious reporting of maintenance errors, especially those that jeopardize airworthiness, so that effective action can be taken. This requires a culture in which staff feel comfortable reporting errors to their supervisor once the errors are recognized.

19.3.5 New systems are being developed for managing procedural deviations (and errors) in aircraft maintenance. Typically, these systems are a subset of an overall maintenance SMS and exhibit the following characteristics:

a) They encourage uninhibited reporting of occurrences that would not otherwise be required to be reported.

b) They provide training for staff on the purpose and procedures for using the maintenance SMS, including clear definition of departmental disciplinary policies (e.g. *disciplinary action should only be necessary for instances of recklessness or wilful disregard of promulgated instruction on procedures)*.

c) They conduct competent safety investigations of reported errors.

d) They seek appropriate safety action in follow-ups to identified safety deficiencies.

e) They provide feedback to the workforce.

f) They provide data suitable for trend analysis.

Maintenance Error Decision Aid (MEDA)

19.3.6 One tool for managing procedural deviations in maintenance is the Maintenance Error Decision Aid (MEDA) developed by The Boeing Company. MEDA provides the first-line supervisor (and the SM) with a structured method for analysing and tracking the factors leading to maintenance errors and for recommending error prevention strategies.

19.3.7 In the MEDA process there are five basic steps, namely:

a) ***Event***. Following an event, it is the responsibility of the maintenance organization to select the error-caused aspects that will be investigated.

b) ***Decision***. After fixing the problem and returning the aircraft to service, the operator decides if the event was maintenance-related. If yes, the operator performs a MEDA investigation.

c) ***Investigation***. Following a structured form (specifically designed for MEDA), the operator carries out an investigation. The investigator records general information with respect to the aeroplane, when the maintenance and the event occurred, the event that precipitated the investigation, the error that caused the event, the factors that contributed to the error and possible prevention strategies.

d) ***Prevention Strategies***. Management reviews, prioritizes, implements and then tracks prevention strategies (process improvements) in order to avoid or reduce the likelihood of similar errors occurring in the future.

e) ***Feedback*** is provided to the maintenance workforce in order for AMEs to know that changes have been made to the maintenance system as a result of the MEDA process. Management is responsible for affirming the effectiveness of employees' participation and validating their contribution to the MEDA process by sharing investigation results with them.

19.3.8 Appendix 2 to this chapter provides a more detailed description of MEDA.

19.4 SAFETY MANAGER'S CONCERNS

19.4.1 A company SM will often face challenges in providing sound advice to senior management on the maintenance portion of the SMS — especially if the SM's background is not in aircraft maintenance. Some challenges include:

a) understanding safety management in the context in which maintenance work is carried out;

b) developing personal credibility, especially in acquiring sufficient knowledge of accepted safe industry work practices and maintaining currency with respect to industry developments in aircraft maintenance. (One way for the SM to better understand the complex nature of aircraft maintenance is to consult with maintenance managers and become familiar with the various facets of the MEDA checklist.);

c) developing and maintaining effective working relationships with:

   1) managers accountable for aircraft maintenance and for integrating maintenance safety into the overall corporate SMS; and

   2) potential technical advisers;

d) developing a synergy among maintenance personnel and other participants in the SMS;

e) developing a spirit of cooperation and routine coordination of activities between flight operations and maintenance, particularly on such matters as adequacy of discrepancy reporting, or operating an FDA system;

f) providing timely and credible analysis of safety data gathered through the various tools used for hazard identification; and

g) obtaining the participation and commitment of the maintenance department on company safety committees.

19.4.2 In reviewing the effectiveness of safety management in maintenance, SMs should pay particular attention to such issues as:

a) adequacy of maintenance documentation;

b) quality of communications up and down, as well as laterally within the maintenance organization;

c) environmental factors affecting human performance;

d) quality of training, both for job-related knowledge and technical skills;

e) error reporting and trend analysis systems aimed at the identification of systemic hazards;

f) the means for effecting any necessary changes to reduce or eliminate identified safety deficiencies; and

g) the existence of an error-tolerant and non-punitive safety culture.

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Appendix 1 to Chapter 19

MAINTENANCE WORKING CONDITIONS

1. Listed below are some of the typical issues impacting on the working conditions under which aircraft maintenance is carried out:

a) ***Organizational issues:***

1) time pressures to sustain on-time departures and around-the-clock operations;

2) ageing aircraft requiring intensive inspections for fatigue, corrosion, overall condition, etc.;

3) new technologies requiring new tools, new work procedures, costly retraining, etc.;

4) "fix-it" focus to stay on schedule (e.g. replacing broken parts without determination as to *why* they failed — perhaps due to poor design or incorrect assembly);

5) airline expansions and mergers (e.g. combining maintenance departments with different work practices and safety cultures);

6) outsourcing of services to subcontractors (e.g. for heavy maintenance and overhaul);

7) unwitting introduction of (lower cost, substandard) bogus parts, etc.; and

8) licensing of AMEs for different aircraft, aircraft generations, types and manufacturers;

b) ***Work site conditions:***

1) aircraft designs that are not user-friendly from a maintenance perspective (for example, cramped access to components and inappropriate height off the ground);

2) control of aircraft configurations (which are continually subject to modifications) versus standardization of maintenance tasks and procedures;

3) availability (and accessibility) of spares, tools, documentation, etc.;

4) requirements for having ready access to voluminous technical information, and the need for maintaining detailed work records;

5) variable environmental factors (for example, conditions on the ramp versus in the technical workshop versus on the hangar floor);

6) unique operating conditions created by concurrent activities and inclement weather on the ramp; and

7) shortcomings in the provision of timely, accurate, understandable discrepancy reports by flight crews, etc.; and

c) ***Human Factors in maintenance:***

1) organizational and working conditions (as described above);

2) environmental factors (e.g. temperature, lighting and noise);

3) individual factors (e.g. workload, physical demands and maintenance);

4) scheduling (e.g. shift work, night work and overtime) versus adequacy of rest periods;

5) appropriateness of SOPs (e.g. correctness, understandability and usability);

6) quality of supervision;

7) proper use of job cards, etc. (i.e. do actual floor practices comply with SOPs?);

8) adequacy of formal training, on-the-job training (OJT), recurrent training and Human Factors training;

9) adequacy of handovers at shift changes and record keeping;

10) boredom; and

11) cultural factors (e.g. AME's professionalism and openness to report errors and hazards).

2. The *Human Factors Guidelines for Aircraft Maintenance Manual* (Doc 9824) provides information on the control of human error and the development of countermeasures to error in aviation maintenance. It is targeted at managers in maintenance organizations, aircraft operators and Civil Aviation Administrations.

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Appendix 2 to Chapter 19

MAINTENANCE ERROR DECISION AID (MEDA)

1. The Maintenance Error Decision Aid (MEDA) provides a structured framework for documenting contributing factors to errors and for recommending suitable error prevention strategies. MEDA is founded on the following basic tenets:

a) Maintenance errors are not made on purpose.

b) Most maintenance errors result from a series of contributing factors.

c) Many of these contributing factors are part of an operator's processes and therefore can be managed.

2. The traditional approach in following up on maintenance errors was all too often to identify the event caused by a maintenance error and then to administer discipline to whoever made that error. The MEDA process goes much further (without the disciplinary follow-up unless there has been a deliberate violation of procedures). Having investigated the event caused by a maintenance error and identifying who made the error, MEDA facilitates the following actions:

a) determining those factors which contributed to the error;

b) interviewing the responsible persons (and others if necessary) to obtain all the pertinent information;

c) identifying those organizational or system barriers which failed to prevent the error (and the contributing factors as to why they failed);

d) gathering ideas for process improvement from the responsible persons (and others as applicable);

e) maintaining a maintenance error database;

f) analysing patterns in maintenance errors;

g) implementing process improvements based on error investigations and analyses; and

h) providing feedback to all employees affected by these process improvements.

3. MEDA checklists facilitate the interview process (i.e. data acquisition) and data storage in a maintenance error database. With a view to understanding the context in which maintenance errors are committed, listed below are ten areas where data should be collected:

a) ***Information***. This category includes work cards, maintenance procedures manuals, service bulletins, engineering orders, illustrated parts catalogues and any other written or computerized information provided either internally or by the manufacturer that is considered necessary for the fulfilment of the AME's job. Some of the contributing factors as to why the information was problematic or was not used include:

1) understandability (including format, level of detail, use of language, clarity of illustrations and completeness);

2) availability and accessibility;

3) accuracy, validity and currency; and

4) conflicting information.

b) ***Equipment/tools***. This category includes all the tools and materials necessary for the correct completion of the maintenance or inspection task. In addition to routine drills, wrenches, screwdrivers, etc., it includes non-destructive test equipment, work-stands, test boxes and special tools identified in the maintenance procedures. Some of the contributing factors as to how equipment or tools can compromise the performance of the AME include:

1) unsafe for use by the AME (e.g. protective devices missing or unstable);

2) unreliable, damaged or worn out;

3) poor layout of controls or displays;

4) mis-calibrated or incorrect scale readings;

5) unsuitable for task;

6) unavailable;

7) cannot be used in intended environment (e.g. space limitations or presence of moisture);

8) instructions missing; and

9) too complicated.

c) ***Aircraft design/configuration/parts***. This category includes those aspects of individual aircraft design or configuration which limit the AME's access for maintenance. In addition, it includes replacement parts that are either incorrectly labelled or not available, leading to the use of substitute parts. Contributing factors here that may lead to errors by the AME include:

1) complexity of installation or test procedures;

2) bulk or weight of component;

3) inaccessibility;

4) configuration variability (e.g. due to different models of the same aircraft type or modifications);

5) parts not available or incorrectly labelled; and

6) easy to install incorrectly (e.g. due to inadequate feedback, absence of orientation or flow direction indicators, or identical connectors).

d) ***Job/task****.* This category covers the nature of the work to be completed including the combination and sequence of the various tasks comprising the job. Some of the contributing factors conducive to facilitating maintenance errors in this area include:

1) repetitive or monotonous task;

2) complex or confusing task (e.g. long procedure with multiple or concurrent tasks, and exceptional mental or physical effort required);

3) new or changed task; and

4) task or procedure varies by aircraft model or maintenance location.

e) ***Technical knowledge/skills****.* This category includes the operator process knowledge, aircraft system knowledge and maintenance task knowledge, as well as the technical skills to perform the assigned tasks or sub-tasks without error. Some of the related contributing factors compromising job performance are:

1) inadequate skills in spite of training, trouble with memory items, or poor decision-making;

2) inadequate task knowledge due to insufficient training or practice;

3) inadequate task planning leading to interrupted procedures or too many scheduled tasks for time available (e.g. failure to get all necessary tools and materials first);

4) inadequate operator process knowledge, perhaps due to inadequate training and orientation (e.g. failure to order necessary parts on time); and

5) inadequate aircraft system knowledge (e.g. incomplete post-installation test and fault isolation).

Many of the foregoing deficiencies call for improved tracking and measuring of the AME's technical performance on the job.

f) ***Individual factors****.* This category includes the factors affecting individual job performance that vary from person to person, such as those things brought to the job by the individual (e.g. body size/strength, health and personal events), as well as those caused by interpersonal or organizational factors (e.g. peer pressure, time constraints, and fatigue due to the job itself, scheduling or shift work). The MEDA checklist includes the following possible factors contributing to maintenance errors:

1) physical health, including sensory acuity, pre-existing disease or injury, chronic pain, medications, and drug or alcohol abuse;

2) fatigue due to task saturation, workload, shift scheduling, lack of sleep or personal factors;

3) time constraints due to fast work pace, resource availability for assigned workload, pressures to meet aircraft gate time, etc.;

4) peer pressures to follow group's unsafe practices, disregard for written information, etc.;

5) complacency (e.g. due to overfamiliarity with repetitive task, or hazardous attitudes of invulnerability or overconfidence);

6) body size or strength not suitable for reach or strength requirements (e.g. in confined spaces);

7) personal events such as a death of a family member, marital problems, and a change in financial well-being; and

8) workplace distractions (e.g. due to interruptions in a dynamically changing work environment).

g) ***Environment/facilities****.* This category includes all those factors which can not only affect the comfort of the AME but also create health or safety concerns which may become a distraction to the AME. Some of the environmental factors that MEDA identifies as being potentially contributory to maintenance errors include:

1) high noise levels that compromise communications or feedback, affect concentration, etc.;

2) excessive heat affecting the AME's ability to physically handle parts or equipment, or causing personal fatigue;

3) prolonged cold that affects the sense of touch or smell;

4) humidity or rain that affects aircraft, part or tool surfaces, including use of paper documents;

5) precipitation affecting visibility or necessitating bulky protective clothing;

6) insufficient lighting for reading instructions or placards, conducting visual inspections or performing tasks;

7) wind affecting ability to hear or communicate, or irritating eyes, ears, nose or throat;

8) vibrations making instrument reading difficult or inducing fatigue in hands or arms;

9) cleanliness affecting ability to perform visual inspections, compromising footing or grip, or reducing available workspace;

10) hazardous or toxic substances affecting sensory acuity, causing headaches, dizziness or other discomfort, or requiring wearing of awkward protective clothing;

11) power sources that are inadequately protected or marked;

12) inadequate ventilation causing personal discomfort or fatigue; and

13) workspace too crowded or inefficiently organized.

h) ***Organizational factors****.* This category includes such factors as internal communication with support organizations, the level of trust that is established between management and AMEs, awareness and buy-in to management's goals, and union activities. All these factors can affect the quality of work — and therefore the scope for maintenance error. The following are some of the organizational factors that MEDA identifies as being potentially contributory to maintenance errors:

1) quality of support from technical organizations that is inconsistent, late or otherwise poor;

2) company policies that are unfair or inconsistent in their application, inflexible in considering special circumstances, etc.;

3) company work processes, including inappropriate SOPs, inadequate work inspections and outdated manuals;

4) union action that becomes a distraction; and

5) corporate change (e.g. restructuring) creating uncertainty, relocations, layoffs, demotions, etc.

i) ***Leadership and supervision****.* This category is tightly linked to the category on organizational factors. Although supervisors do not normally perform the maintenance tasks, they can contribute to maintenance errors through poor planning, prioritizing and organizing of job tasks. Supervisors and management must provide a vision of where the maintenance function is headed and how it is going to get there; in their daily activities they must *"walk the talk",* i.e. their acts must match their words. Some areas where weaknesses in leadership and supervision can create a work environment conducive to maintenance errors include:

1) inadequate planning or organization of tasks affecting the availability of time or resources to complete work properly;

2) inadequate prioritization of work;

3) inadequate delegation or assignment of tasks;

4) unrealistic attitude or expectations leading to inadequate time to complete the job;

5) excessive or inappropriate supervisory style, second-guessing AMEs or failing to involve them in decisions affecting them; and

6) excessive or aimless meetings.

j) ***Communication****.* This category refers to any breakdown in (written or oral) communication that prevents the AME from getting the correct information regarding a maintenance task in a timely manner. Listed below are some MEDA examples of interfaces between employees where breakdowns in communication occur, thereby creating the potential for maintenance errors:

1) *Between departments* — vague or incomplete written directions, incorrect routing of information, personality conflicts, or failure to pass on timely information;

2) *Between AMEs* — failure to communicate at all; miscommunication due to language barriers, use of slang or acronyms, etc.; failure to ask questions when understanding is in doubt; or failure to offer suggestions when change is needed;

3) *Between shifts* — inadequate turnovers due to poor (or rushed) verbal briefings, or inadequate maintenance of records (job boards, check-off lists, etc.);

4) *Between maintenance crew and lead* — when the lead fails to pass important information to the crew (including inadequate briefing at start of shift, or feedback on performance); when the crew fails to report problems or opportunities to the lead; or when roles and responsibilities are unclear;

5) *Between lead and management* — when management fails to pass important information to the lead (including discussion of goals and plans, feedback on work completed, etc.); when the lead fails to report problems or opportunities to management; etc.; and

6) *Between the flight crew and maintenance crew* — vague or incomplete logbook write-up; late notification of defect; aircraft communications addressing and reporting system (ACARS)/data link not used; etc.

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The following summary gives the status, and also describes in general terms the contents of the various series of technical publications issued by the International Civil Aviation Organization. It does not include specialized publications that do not fall specifically within one of the series, such as the Aeronautical Chart Catalogue *or the* Meteorological Tables for International Air Navigation.

International Standards and Recommended Practices are adopted by the Council in accordance with Articles 54, 37 and 90 of the Convention on International Civil Aviation and are designated, for convenience, as Annexes to the Convention. The uniform application by Contracting States of the specifications contained in the International Standards is recognized as necessary for the safety or regularity of international air navigation while the uniform application of the specifications in the Recommended Practices is regarded as desirable in the interest of safety, regularity or efficiency of international air navigation. Knowledge of any differences between the national regulations or practices of a State and those established by an International Standard is essential to the safety or regularity of international air navigation. In the event of non-compliance with an International Standard, a State has, in fact, an obligation, under Article 38 of the Convention, to notify the Council of any differences. Knowledge of differences from Recommended Practices may also be important for the safety of air navigation and, although the Convention does not impose any obligation with regard thereto, the Council has invited Contracting States to notify such differences in addition to those relating to International Standards.

Procedures for Air Navigation Services (PANS) are approved by the Council for worldwide application. They contain, for the most part, operating procedures regarded as not yet having attained a sufficient degree of maturity for adoption as International Standards and Recommended Practices, as well as material of a more permanent character which is considered too detailed for incorporation in an Annex, or is susceptible to frequent amendment, for which the processes of the Convention would be too cumbersome.

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The following publications are prepared by authority of the Secretary General in accordance with the principles and policies approved by the Council.

Technical Manuals provide guidance and information in amplification of the International Standards, Recommended Practices and PANS, the implementation of which they are designed to facilitate.

Air Navigation Plans detail requirements for facilities and services for international air navigation in the respective ICAO Air Navigation Regions. They are prepared on the authority of the Secretary General on the basis of recommendations of regional air navigation meetings and of the Council action thereon. The plans are amended periodically to reflect changes in requirements and in the status of implementation of the recommended facilities and services.

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