

TABLE OF CONTENTS

	<i>Page</i>
Chapter 3. FLIGHT CREW INCAPACITATION.....	I-3-1
3.1 Introduction	I-3-1
Controlling the risk of pilot incapacitation	I-3-1
The “1% Rule”	I-3-3
Causes of incapacitation	I-3-4
Pilot incapacitation training.....	I-3-5
“Fail-safe crew”.....	I-3-7
Crew resource management	I-3-8
Medical standards and prevention of pilot incapacitation	I-3-8
Evidence-based decision making	I-3-9
3.2 Conclusions.....	I-3-9
References	I-3-10

Chapter 3

FLIGHT CREW INCAPACITATION

3.1 INTRODUCTION

3.1.1 The impressive growth of international civil aviation during the past decades has been accompanied by a continued concern for safety in air travel. The number of air carrier accidents per year will increase if industry growth continues and accident rates remain unchanged. It is, therefore, essential to continue to examine all areas which have an impact on flight safety. One such area is that of in-flight pilot incapacitation, which can be defined as any reduction in medical fitness to a degree or of a nature that is likely to jeopardize flight safety.

3.1.2 This might be regarded as a “medical definition” focusing as it does on medical fitness. Note, however, that incapacitation can also occur in a medically fit individual, e.g., smoke inhalation or effects of a laser beam on vision. A doctor practicing aviation medicine should be familiar with the relevant operational environment and of the wide variety of possible causes of incapacitation.

3.1.3 Minor degrees of reduced medical fitness may go undetected by other crew members during normal flight operations and lowered levels of proficiency may be rationalized, e.g., poor handling may be attributed to lack of recent handling experience. However, when abnormal conditions or an emergency occurs, flight crew may have to perform complex physical and mental tasks under time constraints, and in such circumstances even a minor deficiency in performance could be operationally significant.

3.1.4 Some effects of mild incapacitation include a reduced state of alertness, a mental preoccupation which may result in a lack of appreciation of significant factors, increased reaction time, and impaired judgement.

Controlling the risk of pilot incapacitation

3.1.5 Pilot incapacitation has been of concern for as long as powered flight has existed. It represents an operational risk, and it can therefore be defined operationally as “any physiological or psychological state or situation that adversely affects performance.”

3.1.6 There are sound reasons for considering an operational definition. From the operational standpoint, it is irrelevant whether degraded performance is caused by a petit mal episode, preoccupation with a serious personal problem, fatigue, problematic use of psychoactive substances or a disordered cardiac function. The effects may be similar, and often other crew members will not know the difference.

3.1.7 A great deal about pilot incapacitation has been learned over the past decades. One of the most important things is that the risk to aviation safety in situations where a pilot is physically incapacitated can be virtually eliminated in air transport (multi-crew) operations by training the pilots to cope with such events.

3.1.8 In 1984 the medical director of a major British airline reported the results of a study of pilot incapacitation that remains the most comprehensive to date (see Chapman, 1984). It included over 1 300 “subtle” incapacitations which were simulated to occur at critical phases of flight during routine competency checks in a simulator.

3.1.8.1 Five hundred of these incapacitations were deliberately planned to occur with other major failures in a “worst case” scenario. Major failures were not included in the remaining 800 incapacitations so that “the simulation was of a subtle incapacitation, still taking place at a critical phase of flight, but as an event in itself and not complicated by other major failures.” This latter scenario is the more realistic, since the risk of an incapacitation occurring simultaneously with a major technical failure is extremely remote.

3.1.8.2 In the simulator it was found that only 1 in 400 “uncomplicated” incapacitations resulted in a simulator “crash”, because the second pilot successfully took control on the 399 other occasions. If certain assumptions about a typical multi-crew flight are made, this knowledge can be used to calculate an acceptable risk of incapacitation for an individual pilot. These assumptions (see Figure I-3-1) are:

1. Each flight lasts one hour.
2. Only 10 per cent of the flight time is critical, viz. take-off and initial climb, approach and landing (in a one-hour flight this comprises the first and last three minutes).
3. Pilot incapacitations occur randomly during a flight.
4. 1 in 100 real-life incapacitations occurring in the critical periods would result in a fatal accident, a more pessimistic view than that suggested by the simulator studies mentioned above (1 in 400), where simulated incapacitations could be anticipated by the flight crew.

Based on these four assumptions, the so-called “1% rule” has been developed.

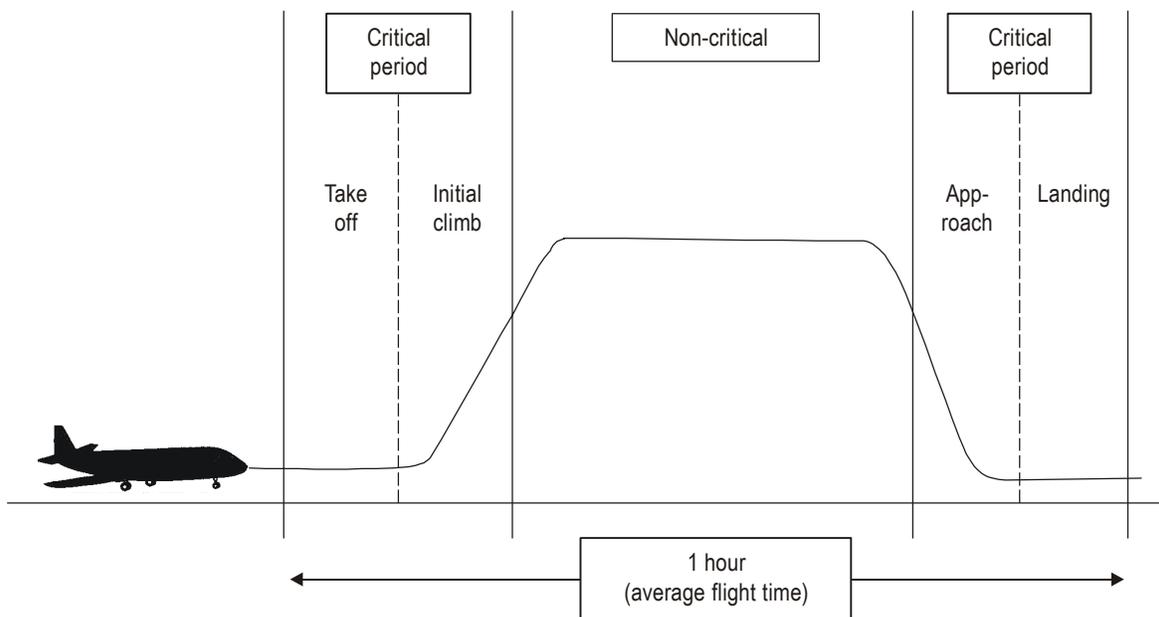


Figure I-3-1. Critical and non-critical phases of flight in a flight of one hour¹

¹ From Rainford, D.J. and D.P. Gradwell (eds.) *Ernsting's Aviation Medicine*, Hodder Arnold, 2006.

The 1% rule

3.1.9 During the last decades of the 20th century, a number of Contracting States were approaching a fatal accident² rate of one in 10^7 flying hours. Some Contracting States therefore set as their target *all cause* maximum fatal accident rate a figure of one in 10^7 flying hours, with human “failure” constituting one tenth of the risk and human failure caused by medical incapacitation comprising one tenth of the human failure risk, or one hundredth of the total risk, i.e., medical incapacitation should not result in a fatal accident more often than one in 10^9 hours. Based on the assumptions stated above, a pilot flying a two-pilot aircraft can have an incapacitation risk of no more than one in 10^6 hours, and the operation will achieve the target medical cause fatal accident rate of no more than one in 10^9 hours, since the presence of a second pilot reduces the risk by a factor of 1 000. This is because:

- In a multi-pilot aircraft only 10 per cent of flight time is critical (risk reduced by a factor of 10) as incapacitations are assumed to occur randomly. Therefore only one in ten in-flight incapacitations will occur during a critical stage of flight and thus pose a flight safety risk.
- Only one in 100 incapacitations occurring at a critical stage of flight is likely to result in a fatal accident (risk further reduced by a factor of 100).
- Therefore the total risk reduction with the addition of a second pilot is $1/10 \times 1/100 = 1/1\ 000$, i.e., the risk is one 1 000th of the risk of single pilot operations.
- For a pilot with an incapacitation risk of one in 10^6 hours, a second pilot therefore reduces the risk of a fatal accident from pilot incapacitation from one in 10^6 hours to one in 10^9 hours.

3.1.10 In other words, only one fatal accident in one thousand in-flight pilot incapacitations would be expected to result in a fatal accident, because the other pilot would take over safely in the other 999 times. For an individual pilot flying a multi-crew aircraft the acceptable risk of incapacitation may therefore be increased by a factor of 1 000 from one in 10^9 to one in 10^6 hours.³

3.1.11 An incapacitation rate of one in 10^6 hours approximates to a rate of one per cent (or one in 10^2) per annum (since there are 8 760 - close to 10 000 (or 10^4) - hours in one year). More explicitly:

- 1 in 10^6 hours = 0.01 in 10^4 hours (dividing both figures by 100)
- 0.01 in 10^4 hours = 1% in 10^4 hours
- 1% in 10^4 hours approximates to 1 per cent in one year (because there are 8 760 hours per year).

3.1.12 The acceptable maximum incapacitation rate of one per cent per annum outlined above has become known as the “1% rule”. This rule specifies a predicted annual medical incapacitation rate which, if exceeded, would exclude a pilot from flying in a multi-crew aircraft. This is widely regarded as an acceptable risk level and was adopted by the European Joint Aviation Authorities as the basis of aeromedical risk assessment.

3.1.13 The “1% rule” cannot apply to a solo pilot flying in public transport operations, because it is derived from two pilot operations and the availability of a second pilot to take over in the event of one pilot becoming incapacitated. However, the “1% rule” has also been applied to the private pilot population by some States, on a pragmatic basis, such that a private

2 A fatal accident is an accident in which one or more persons are fatally injured as a result of being in the aircraft, or being struck by an aircraft or its parts.

3 It should be noted that if two pilots with a 1% risk per annum of incapacitation happen to be flying together, the chance of one of them becoming incapacitated in a one-hour flight is 2 in 10^6 hours.

pilot who develops a medical problem may be permitted to continue to fly as a solo pilot if his risk of an incapacitation is 1 per cent per annum or less. This acceptance of an increased risk of incapacitation in a private pilot seems reasonable since the overall level of safety demanded of private operations is less than that of commercial operations, and it would therefore be out of place to demand a professional pilot medical standard for private pilot operations.

3.1.14 The “1% rule” provides a rational, objective method of assessing the fitness of applicants. However, other limits of acceptable incapacitation risk, such as 2 per cent per annum, or even greater, have been suggested. The important point is that States should endeavour to define objective fitness criteria to encourage consistency in decision-making and to assist in improving global harmonization of medical standards. The practical application of the “1% rule” is discussed in many of the chapters of Part III, in particular Chapter 1 (Cardiovascular System) and Chapter 15 (Malignant Disease).

Causes of incapacitation

3.1.15 A dramatic form of pilot incapacitation, although not necessarily its most hazardous, is death in the cockpit. A survey (1993-1998) of flight crew incapacitation on United States scheduled airlines recorded five deaths in the cockpit, all owing to cardiovascular diseases. The youngest pilot was 48 years of age when he died. No case resulted in aircraft damage or operational incident. It should be noted that ICAO introduced the requirement for incapacitation training in two-pilot operations in the 1970s and this has undoubtedly reduced the risk to flight safety from pilot incapacitation.

3.1.16 Incapacitations from self-limiting illness may be less dramatic but are considerably more frequent. In two studies of airline pilots, in 1968 and again in 1988, more than 3 000 airline pilots completed an anonymous questionnaire survey including questions about whether they had ever experienced an incapacitation during a flight. In both studies, which revealed remarkably consistent results, about 30 per cent answered “yes”. However, only about 4 per cent considered their incapacitation a direct threat to flight safety. In both studies the most frequently cited cause of incapacitation was acute gastroenteritis (see Table I-3-1).

**Table I-3-1. Causes of incapacitation in airline pilots, in order of frequency.
(Adapted from Buley, 1969; Green and James, 1991)**

1.	Uncontrollable bowel action (21%) and “other” gastrointestinal symptoms (54%)	75%
2.	Earache/blocked ear	8%
3.	Faintness/general weakness	7%
4.	Headache, including migraine	6%
5.	Vertigo/disorientation	4%

3.1.17 As can be seen, most of these incapacitations are caused by gastrointestinal upsets which are usually impossible to predict. Whilst they may represent little more than varying degrees of discomfort and inconvenience, they can also be completely incapacitating. Here is an example taken from a pilot’s report:

Trip was normal up to time of incident. Approximately half-way between LAS and LAX, shortly after reaching cruise, I experienced severe abdominal pains which soon rendered me incapable of operating a safe flight. I turned command over to the First Officer and put the Second Officer in the First Officer’s seat while I lay in great pain on the cockpit floor.

Trip landed safely at LAX with First Officer . . . at the controls. An ambulance was requested by the crew... I was taken to the Daniel Freeman Hospital in LAX where . . . (I was given) . . . a diagnosis of gastroenteritis. I think that spells food poisoning in our language. After some medication I felt wonderfully relieved and was released from the hospital.

Fortunately, gastroenteritis rarely occurs so suddenly as to prevent a planned handover of control, thereby minimizing the flight safety risk.

3.1.18 Pilot incapacitation is clearly both a traditional aeromedical problem and a straightforward training problem. As long ago as 1970, a past Chief of ICAO's Aviation Medicine Section, wrote:

“. . . It is suggested that acknowledgement of pilot on-duty incapacitation . . . as a permanent part of the air transport industry scene in the foreseeable future constitutes a constructive rather than a defeatist medical position. Further, it appears essential that the design, management, operational, training, and licensing disciplines should recognize that pilot incapacitation must be given due weight . . . in the overall judgement of what level of safety is practically available.”

3.1.19 Medical screening, by itself, cannot be relied upon to reduce the hazard of incapacitation to an acceptable minimum level, even if significantly more rigorous medical standards were to be applied. Other important aspects include pilot education in the causes of incapacitation, pilot training for safe handover of controls in such an event and, especially, good food hygiene and low-risk, separate meals for the flight crew. From the operational/training viewpoint, the maxim that “any pilot can become incapacitated at any time” is apposite.

Pilot incapacitation training

3.1.20 Pilot training in the early recognition of incapacitation and in safe handover of controls, pioneered in the United States, has been highly effective in preventing accidents from physical incapacitation. It seems less effective in the case of mental incapacitation. Because the majority of accidents result from human failure of some sort, degradation of performance from commonly occurring sub-clinical conditions such as mild anxiety and depression, sleep loss and circadian rhythm disturbance is an important factor in this area of relative incapacitation. Although mostly a small problem amongst flight crew, the problematic use of psychoactive substances is likely to become more important as their general use in society increases.

3.1.21 Incapacitations can be divided into two operational classifications: “obvious” and “subtle”. Obvious incapacitations are those immediately apparent to the other crew members. The time course of onset can be “sudden” or “insidious” and complete loss of function can occur. Subtle incapacitations are frequently partial in nature and can be insidious because the affected pilot may look well and continue to operate but at a less than optimum level of performance. The pilot may not be aware of the problem or capable of rationally evaluating it. Subtle incapacitations can create significant operational problems.

3.1.22 A series of 81 simulated obvious and subtle incapacitations showed that pilots needed help in two areas: their first need was for a method of detecting subtle incapacitations before they became operationally critical; their second need was for an organized method of handling the incapacitations once they were recognized. It was learned that all pilot incapacitations create three basic problems for the remaining crew. This is true whether the incapacitation is obvious or subtle and whether there is a two- (or more) member crew. Although this study was carried out many years ago, its recommendations are still valid. If an in-flight incapacitation occurs, the remaining flight crew has to:

- a) maintain control of the aircraft;

- b) take care of the incapacitated crew member;
(An incapacitated pilot can become a flight deck hazard and, in any case, is a major distraction to the remaining crew. For this reason, responsibility for the incapacitated pilot, who should preferably be removed from the flight deck, should be given to the cabin crew.)
- c) reorganize the cockpit and bring the aircraft to a safe landing.

These three steps became the organized plan for handling in-flight incapacitation. They should be taken separately and in order.

“Two communication” rule

3.1.23 The “two communication” rule was developed to meet the need for a method of detecting subtle incapacitations before they become operationally critical. The rule states: “Flight crew members should have a high index of suspicion of a ‘subtle’ incapacitation any time a crew member does not respond appropriately to two verbal communications, or any time a crew member does not respond appropriately to any verbal communication associated with a significant deviation from a standard operating procedure or a standard flight profile.” This rule is easy, straightforward and effective.

Cognitive incapacitation

3.1.24 A particular category of incapacitations has been identified as “cognitive.” The problem created by these incapacitations is how to deal with a pilot who is “mentally disoriented, mentally incapacitated or obstinate, while physically able and vocally responsive.” In this category, the captain presents the most difficult case.

3.1.25 While cognitive incapacitations may seem to be psychologically based, in some cases the underlying causes are pathological, as with a brain tumour, causing an erratic performance. Retrospectively, there often seems to have been ample warning of an impending problem. In most cases of cognitive incapacitation, the pilot demonstrates manifestly inappropriate behaviour involving action or inaction, and the inappropriate behaviour is associated with failures of comprehension, perception, or judgement.

3.1.26 These kinds of incidents seldom occur in isolation because, in most cases, they represent a pattern of behaviour. Two excerpts from reports to NASA’s ASRS (National Aeronautics and Space Administration’s Aviation Safety Reporting System) illustrate the repetitive nature — or pattern — of what may be examples of this grey, but important, problem area.

- a) “On two occasions we descended through our assigned altitude. I was the non-flying pilot and made all the call-outs . . . On both occasions, in addition to the required call-outs, I informed the flying pilot that we were descending through our assigned altitude. His corrections were slow and on one occasion we went 400 feet below, and on the other, 500 feet below the assigned altitude. In addition, his airspeed and heading control were not precise . . .”

The reporter elaborated further in a telephone call:

- “ . . . Captain reacted almost catatonically to his altitude call-outs and the additional call-outs that they were descending through the cleared altitudes. Definitely very delayed reactions. Other aspects of the trip were reasonably normal except that Captain missed several radio transmissions. ‘It was as if he simply didn’t hear them’ . . .”

- b) From a telephone call to a pilot reporting a different incident:

“Reporter believes Captain has serious and persistent ‘subtle’ incapacitation problem. Reported incident (which included successive altitude deviations) . . . happened on first trip of the month . . . Remainder of month with Captain has had same pattern with many cases of very poor performance . . . Seems to be increasingly slow thinker in the aeroplane. Has to be reminded of things several times, even including getting his signature on required papers . . .”

3.1.27 The deliberate failure to follow established rules and procedures is a very old problem and the “maverick” pilot is by no means a new phenomenon. One Chief Medical Officer commented on the difficulties with dealing with aberrant behaviour in the medical context. The following paragraph is taken from his paper given at an aeromedical examiner symposium in the 1980s:

Psychiatric disturbances giving rise to unusual behaviour are . . . like alcoholism . . . often covered up. There is, however, genuine difficulty here, for aviation attracts eccentrics — indeed, aviation has only reached its present state because of eccentrics. It is often very difficult to define the boundaries between normality, eccentricity, and psychiatric disorder, and individuals, not uncommonly, cross over these boundaries from day to day. The ICAO definition — ‘manifested by repeated overt acts’ — is a useful indicator of the need for, at least, investigation.

3.1.28 The nature of air transport operations is such that the individuals in the best position to observe repeated overt acts and, from a practical standpoint, the only ones situated to do so, are other crew members. This creates a different sort of resource management problem. It is an obvious challenge for management. It is also a challenge for pilot-representative organizations.

3.1.29 Control of the incapacitation risk is dependent upon effective operational monitoring. A basic requirement for that monitoring is that all flight crew members must know what should be happening with and to the aeroplane at all times. This is one of the most important reasons for following standard operating procedures (SOPs) and flying standard flight profiles. The real importance of SOPs lies as much in the area of information transfer as it does with respect to the issue of the proper way to fly the aircraft. Routine adherence to SOPs helps to maximize information transfer in much the same way that the use of standard phraseology does in air traffic control communications.

3.1.30 Detection of subtle incapacitation may be indirect, i.e., as a result of a pilot not taking some anticipated action. If, for example, the pilot conducting the approach to land silently loses consciousness and his body position is maintained, the other pilot may not be aware of his colleague’s predicament until the expected order of events becomes interrupted. Regular verbal communication, built into standard operating procedures, and use of the “two communication rule” are helpful to detect subtle incapacitation, especially when physical control inputs are unnecessary, e.g. automatic approach.

“Fail-safe crew”

3.1.31 The object of “fail-safe crewing” is to provide an adequate number of crew members to cope with flight crew workloads, and to make it possible fully to integrate the flight crew members into a flight crew team so as to establish a crew in which there is always at least one fully competent pilot at the controls. Ideally the actions of each crew member should continuously be monitored by his fellow crew member(s). The concept aims at achieving maximum safety in the operation of the aircraft and equitable distribution of cockpit workload so as to ensure the crew can cope with all requirements including peak demands in adverse weather or under emergency conditions — such as in-flight pilot incapacitation.

3.1.32 The “fail-safe crew” concept is the key ingredient for successfully dealing with any form of pilot incapacitation. Support at all levels of management and pilot representation is needed for the “fail-safe crew” to, in practice, do justice to the concept. Meaningful simulator training, reinforced with a suitable education programme, is a requirement.

3.1.33 The story of controlling the incapacitation risk in air transport is the story of a progress made in a series of small but important steps. Learning to manage the cognitive incapacitation risk remains an important goal.

Crew resource management

3.1.34 In modern flight operations, line-oriented flight training (LOFT) emphasizes that resource management is making a substantial contribution to flight safety.

3.1.35 A captain representing a pilots association explained the concept as follows:

“ . . . One of the basic fundamentals of this philosophy is that it is the inherent responsibility of every crew member, if he be unsure, unhappy or whatever, to question the pilot-in-command as to the nature of his concern. Indeed, it would not be going too far to say that if a pilot-in-command were to create an atmosphere whereby one of his crew members would be hesitant to comment on any action, then he would be failing in his duty as pilot-in-command . . . ”

3.1.36 Training in crew cooperation, called crew resource management (CRM), is now provided by most major airlines but frequently not to the same extent by smaller operators. In smaller companies, procedures are less standardized and a greater degree of individuality is tolerated, so behavioural problems can be expected to be more common, and experience has shown that this is the case. Over several years CRM has been expanded to include the interaction between flight and cabin crew in recognition of the fact that cabin crew members can sometimes have operationally relevant knowledge that flight crew do not have. This was dramatically demonstrated in the United Kingdom in 1989 when a flight crew shut down the wrong engine of a Boeing 737. Although the pilots believed their action was correct, the cabin crew had seen flames issuing from the other engine, but unfortunately this information was not communicated to the flight crew. In the ensuing crash several passengers and crew members were killed or severely injured.

3.1.37 While most would agree that CRM training is helpful in promoting flight safety, its assessment is more controversial. Interpersonal relationships are not particularly amenable to measurement, and there is much suspicion among pilots about any process which attempts, or seems to attempt, to measure personality.

Medical standards and prevention of pilot incapacitation

3.1.38 One of the major purposes of medical examinations and determination of medical fitness of an applicant is to assess the probability of a medical condition resulting in in-flight incapacitation. Based only on such an assessment can the authority objectively consider certification that is compatible with generally accepted flight safety standards. In this context a discussion of the “1% rule” can be found above.

3.1.39 The medical examiner is in many cases handicapped in making such an assessment, because adequate predictive epidemiological data are not available for the condition itself or, if they are, they cannot be readily applied to the flight environment. This situation is, however, improving. Figures for the risk of a future cardiac event in an individual recovering from a common cardiac problem such as myocardial infarction are available. Figures may also be available for certain other relatively common diseases, such as the risk of a cerebral metastasis from a recurrence of a surgically removed malignant melanoma, or the recurrence of an epileptic seizure after a first fit. It should be remembered that a medical condition in a pilot that might potentially result in only a loss of efficiency or a moderate decrease in safety in a multi-pilot aircraft might incur great risk in single-pilot operations.

3.1.40 However, more demanding medical requirements cannot alone adequately control the flight safety risk posed by the possibility of an in-flight incapacitation. Grounding older pilots who have medical problems may incur a high

price in terms of sacrifice of pilot expertise. This might, paradoxically, have the opposite effect of that desired because it is possible that flight safety would suffer if older experienced pilots with minor health problems were replaced by younger and healthier, but less experienced pilots. At the same time, it seems reasonable to assume that uneventful flying experience may breed complacency and also that experience, obtained many years ago in aircraft types no longer flown and with navigational systems and other equipment no longer in use, may be of little value today. Unfortunately, the data relating pilot experience to risk of accident are sparse, although there is little evidence to suggest that the risk changes much between 60 and 65 years of age, and in 2006, 65 years became the upper age limit for professional pilots in multi-crew aircraft (increased from 60 years).

3.1.41 It should also be mentioned that very demanding medical standards, at least ones that are perceived as unjust by licence holders, may result in applicants withholding important medical information from the medical examiner with a consequent decrease of flight safety. Since the medical history is usually more important than the medical examination in eliciting conditions of flight safety concern, it is desirable that an applicant believes he will be treated fairly, should he volunteer that he has a particular medical problem. In cooperation with all stakeholders, including representative bodies of licence holders, States should strive to develop the appropriate culture to minimize this risk.

Evidence-based decision making

3.1.42 A continued assessment of in-flight crew incapacitation as a flight safety hazard requires collection of related data. Reporting of incapacitation incidents to ICAO is an integral part of an accident/incident reporting system on a worldwide basis, but suffers from two major difficulties: firstly, the data are incomplete as not all Contracting States send information on accidents and incidents, and secondly, the data are rarely assessed and classified by personnel who understand the medical implications. Moreover, Contracting States which have their own reporting system are often hampered by the confidential nature of the information supplied. For example, a report following an incapacitation is often filed by another crew member who does not reveal the name of the incapacitated person, making follow-up difficult.

3.1.43 Further, incapacitation data classified by means of a layman's diagnosis may be incorrect or misleading: a pilot who collapses with abdominal pain may be suffering from one of a number of medical problems, but is likely to be diagnosed by other crew members as having a gastrointestinal upset. The diagnosis might not be relevant at the time of incapacitation, but is important for monitoring medical standards and in determining where the maximum benefit for a given effort is achieved with respect to reducing the incidence of in-flight incapacitation. Attention needs to be given to devising a more accurate, preferably international, method of recording and classifying data on in-flight incapacitations. In recent years ICAO has taken the initiative to require a Safety Management System (SMS) to be incorporated into the routine management of aerodromes, air traffic and airlines. An integral part of SMS is that of measuring and recording safety events, and of setting targets. In 2010 medical provisions became applicable in Annex 1 (1.2.4.2) that recommend the application of safety management principles to the medical assessment process of licence holders, including the routine analysis of in-flight incapacitation events. It is to be hoped that this development will provide the stimulus towards a more evidence-based application of aeromedical standards. Safety management principles as applied to the medical certification process are addressed in more detail in Part I, Chapter 1, of this Manual.

3.2 CONCLUSIONS

3.2.1 In-flight pilot incapacitation is a safety hazard and is known to have caused accidents. Such incapacitation occurs more frequently than many other emergencies that are routinely trained for, such as sudden decompression. Incapacitation can occur in many forms, ranging from sudden death to a not easily detectable partial loss of function, and has occurred in all pilot age groups and during all phases of flight.

3.2.2 It is important to recognize the operational ramifications of pilot incapacitation. Medical officers working for regulatory bodies should be fully aware of the operational aspects.

3.2.3 Instruction and training of flight crew concerning action in the event of in-flight pilot incapacitation should include early recognition of incapacitation as well as the appropriate action to be taken by other flight crew members.

REFERENCES

- Booze, C.F., "Sudden in-flight incapacitation in general aviation," Federal Aviation Administration, Report Number DOT/FAA/AM/87/7, August 1987.
- Buley, L.E., "Incidence, causes and results of airline pilot incapacitation while on duty," *Aerospace Medicine*, January 1969, Vol. 40, No. 1, pp. 64-70.
- Chapman, P.J., "The consequences of in-flight incapacitation in civil aviation," *Aviation, Space, and Environmental Medicine*, June 1984, Vol. 55, No. 6, pp. 497-500.
- Cooper, Capt., quoted by Gordon Vette, *Impact Erebus*, Hodder and Stoughton, Auckland, 1983, p. 246.
- Eastburn, Mack, "World-wide jet transport experience," Flight Safety Foundation International Air Safety Seminar, Johannesburg, South Africa, 6-9 September 1982.
- Evans, A.D.B., "International regulation of medical standards," in *Ernsting's Aviation Medicine*, D.J. Rainford, and D.P. Gradwell (eds.), Hodder Arnold, London, 2006.
- Green, R. and M.R. James, "In-flight incapacitation survey," *Aviation, Space, and Environmental Medicine*, November 1991, Vol. 62, No. 11, pp. 1 068-1 072.
- Lauber, J.K., "Information Transfer in Flight Operations," International Federation of Air Line Pilots Symposium on Human Factors, Washington, D.C., 8-10 February 1977.
- Lederer, Jerome, "Subtle pilot incapacitation," 29th Annual SAFE Symposium, Las Vegas, Nevada, 6-8 December 1982.
- "Psychology of co-pilot assertiveness," Proceedings of the Second Symposium on Aviation Psychology, Columbus, Ohio, 25-28 April 1983.
- Li, G., "Pilot-related factors in aircraft crashes: a review of epidemiologic studies," *Aviation, Space, and Environmental Medicine*, October 1994, Vol. 65, No.10, Part 1, pp. 944-52.
- Manual on Laser Emitters and Flight Safety* (Doc 9815), International Civil Aviation Organization, Montréal, Canada, 2003.
- Manual on Prevention of Problematic Use of Substances in the Aviation Workplace* (Doc 9654), International Civil Aviation Organization, Montréal, Canada, 1995.
- Mitchell, S.J., and A.D.B. Evans, "Flight safety and medical incapacitation risk of airline pilots," *Aviation, Space, and Environmental Medicine*, March 2004, Vol. 75, No. 3, pp. 260-68.
- Orlady, H.W., "On-duty Incapacitation," *Air Line Pilot*, January 1968.
- "Operational aspects of pilot incapacitation in a multicrew airliner," presented at the Bethesda Conference, American College of Cardiology, 27 April 1975, Bethesda, Maryland, and published in the *American Journal of Cardiology*, 31 October 1975, Vol. 36, Issue 5, pp. 584-88.

——— “Pilot Incapacitation Revisited,” 1984 SAE Aerospace Congress and Exposition, Long Beach, CA, 15-18 October 1984.

——— “Resource Management Training for the Small Operator,” Proceedings of the Second Symposium on Aviation Psychology, Columbus, Ohio, 25-28 April 1983.

Pinkle, Irving, quoted in United Airlines Flight Safety Information Bulletin No. 80-1, 4 February 1980.

Tunstall-Pedoe, H., “Risk of a coronary heart attack in the normal population and how it might be modified in flyers,” *European Heart Journal*, 1984, Vol. 5 (Supplement A), pp. 43-49.

——— “Cardiovascular risk and risk factors in the context of aircrew certification,” *European Heart Journal*, 1992, Vol. 13 (Supplement H), pp.16-20.

“United Airlines DC-8, Portland, OR, 28 December 1978,” National Transportation Safety Board Aircraft Accident Report, NTSB-AAR-79-7, 7 June 1979.
