GUIDANCE MATERIAL

Preamble

ICAO Guidance Material for the development of prescriptive fatigue management regulations has been circulated to States and is referenced in ICAO Annex 6. IFALPA had input into the drafting process and supported the draft ICAO proposals because they provided a regulatory framework and example not previously available to assist States in formulating regulations.

IFALPA strongly endorsed the inclusion of scientific knowledge and understanding of human physiology when formulating prescriptive rules for fatigue management. However, no numerical values are shown for limitations in the draft ICAO guidance material. It is being left to States to decide what values to insert taking into account the results of relevant scientific principles and knowledge, past experience in administering such regulations, cultural issues and the nature of the operations intended to be undertaken.

IFALPA believes there is a sufficient body of scientific information to provide appropriate values for limitations for prescriptive fatigue management regulations. The following guidance material adopts the draft ICAO framework and is intended to provide guidance and appropriate values which take into account available science and the performance decrements that are known to arise from sleep loss, circadian disruption and workload engendered by current flight and duty practices. Whilst science cannot provide the answer to every conceivable situation that may arise the following guidance should provide an adequate level of crew alertness that ensures safe operations under most circumstances. Complementary risk assessment and mitigation strategies can also be provided by supplementing prescriptive fatigue management with a well-developed fatigue risk management system.

In general, the guidance material contained in paragraph 1.1 through paragraph 4.5.2 has been taken directly from the ICAO documentation circulated to States without change, with the exception of some definitions which have been added to section 4.2. Subsequent paragraphs have retained the framework provided by ICAO, and have had values inserted, which IFALPA believes to be appropriate based on scientific studies of flight crew operations. In addition to the Model Scheme, there are also four appendixes; Appendix 1 is an application flowchart, Appendix 2 has an illustration of acclimatised time bands and a rest and recovery flowchart, Appendix 3 is some worked examples and Appendix 4 is the background to the development of the scheme along with references.

In common with other FTL Schemes, this guidance material should be viewed as a package of measures that will limit fatigue to an acceptable level. Individual limits, whether higher or lower, and different practices in this scheme are therefore not interchangeable with individual limits or practices in other schemes as this may significantly erode the protection given as a whole. In particular, lower limits in established alternative schemes should not be increased without a full scientific re-evaluation of the complete scheme.

Operator Requirements for Fatigue Management

Fatigue management. An operator shall establish flight and duty time limitations and a rest scheme that enable it to manage the fatigue of all its crew members. This scheme shall comply with the regulations established by the State of the Operator, or approved by that State, and shall be included in the operations manual.

Should variations from the fatigue regulations become necessary, an Operator shall establish a means, acceptable to the State of the Operator, to permit such variations. Any variations shall employ FRMS or other scientific methods to ensure predicted pilot alertness levels that provide an equivalent level of safety and take into account any objections based on safety grounds.

Note — It is acknowledged that regulations may not cover every eventuality encountered in a dynamic operational environment. This provision is intended to permit the operator a degree of flexibility, in a means acceptable to the State of the Operator, in making adjustments in its fatigue management scheme to account for changing circumstances.

To comply with the regulations established by the State of the Operator, an operator shall maintain records for all its crew members of variables such as duty periods, flight duty periods, rest periods and flight time. Such records shall be retained for a period determined by the State of the Operator.

1. Purpose and scope

1.1 Flight time, flight duty period, duty period limitations and rest requirements are established for the sole purpose of ensuring that the flight crew members are performing at an adequate level of alertness for safe flight operations.

1.2 In order to accomplish this, two types of fatigue should be taken into account, namely, transient fatigue and cumulative fatigue. Transient fatigue may be described as fatigue that is dispelled by a single sufficient period of rest or sleep. Cumulative fatigue occurs after incomplete recovery from transient fatigue over a period of time.

1.3 Limitations based upon the provisions of this Part will provide safeguards against both kinds of fatigue because they will recognize:

a) the necessity to limit flight duty periods with the aim of preventing both kinds of fatigue;

b) the necessity to limit the duty period where additional tasks are performed immediately prior to a flight or at intermediate points during a series of flights in such a way as to prevent transient fatigue;

c) the necessity to limit total flight time and duty periods over specified time spans, in order to prevent cumulative fatigue;

d) the necessity to provide flight crew members with adequate rest opportunity to recover from fatigue before commencement of the next flight duty period; and

e) the necessity of taking into account other related tasks the flight crew member may be required to perform in order to guard particularly against cumulative fatigue.

2. Operational concepts

2.1 Flight time

Flight time, in the context of flight time limitations, is intended to apply to flight crew members.

2.2 Duty periods

All time spent on duty can induce fatigue in flight crew members and should therefore be taken into account when arranging rest periods for recovery. Standby should be included as duty.

2.3 Flight duty periods

2.3.1 The definition of flight duty period is intended to cover a continuous period of duty that always includes a flight or series of flights for a flight crew member. It is meant to include all duties a flight crew member may be required to carry out from the moment he or she reports for duty until he or she completes the flight or series of flights and the aeroplane finally comes to rest and the engines are shut down. It is considered necessary that a flight duty period should be subject to limitations because a flight crew member's activity over extended periods would eventually induce fatigue – transient or cumulative – which could adversely affect the safety of a flight.

2.3.2 A flight duty period does not include the period of travelling time from home to the point of reporting for duty. It is the responsibility of the flight crew member to report for duty in an adequately rested condition.

2.3.3 Time spent positioning at the behest of the operator is part of a flight duty period when this time immediately precedes (i.e., without an intervening rest period) a flight duty period in which that person participates as a flight crew member.

2.3.4 An important safeguard is for States and operators to recognise the responsibility of a flight crew member to refuse further flight duty when suffering from fatigue of such a nature as to adversely affect the safety of flight.

2.4 Rest periods

The definition of rest period requires that flight crew members be relieved of all duties for the purpose of recovering from fatigue. The way in which this recovery is achieved is the responsibility of the flight crew member. Extended rest periods should be given on a regular basis. Rest periods do not include standby when this imposes constraints that conflict with the ability to recover from fatigue. Suitable accommodation on the ground is required at places where rest periods are taken in order to allow effective recovery.

3. Types of limitations

3.1 Limitations are broadly divided by time. For example, many ICAO Contracting States prescribe daily, monthly and yearly flight time limitations, and a considerable number also prescribe quarterly flight time limitations. In addition, many States also prescribe cumulative duty limitations for specified periods such as consecutive days and seven-day periods. It must be understood, however, that these limitations will vary considerably taking into account a variety of situations.

3.2 To take account of unexpected delays once a flight duty period that has been planned within the allowable limitations has commenced, provision should be made for minimising the extent to which exceeding the limits may be permitted. Similarly, provision should be made for controlling the extent to which any reduction of rest below that ordinarily required may be allowed in cases where flexibility to recover a delayed schedule is sought. The authority to extend a flight duty period or reduce a rest period within the limitations established is vested in the pilot-in-command.

Note. — See paragraphs 4.9.2 and 4.11.2.3 for reporting requirements.

3.3 In formulating regulations or rules governing flight time limitations, the crew complement and the extent to which the various tasks to be performed can be divided among the flight crew members should be taken into account. In the case where additional flight crew members are carried and facilities in the aeroplane are such that a flight crew member can obtain recuperative rest in a comfortable reclining seat, or in a bunk, separated and screened from the flight deck and passengers, and reasonably free from disturbance, planned flight duty periods could be extended.

3.4 States should consider all relevant factors, which include: the number and direction of time zones crossed; the time at which a flight duty period is scheduled to begin; the number of planned and/or actual sectors within the flight duty period; the pattern of working and sleeping relative to the circadian rhythm, or 24-hour physiological cycle of the flight crew; the scheduling of days off; the sequence of early reporting times and late releases from duty; mixing early/late/night duties; and flight operation characteristics.

4. Guidelines for establishing prescriptive limitations for fatigue management

4.1 Purpose and scope

4.1.1 The following material comprises a set of parameters that should be considered for inclusion in the development of prescriptive limitations for fatigue management.

4.1.2 States should assess the adequacy of the breadth and scope of all limitations proposed by each operator as applicable to operations before they approve an operator's flight and duty time limitations and rest scheme.

4.2 Definitions

Acclimatised. The physiological and mental state of a crew member whose bio-rhythms and bodily functions are considered aligned with local time. At home base, a crewmember should be considered to be acclimatised after spending the number of consecutive nights in home base given in Table F (Paragraph 4.8.3.4.). The crew member should be considered to be acclimatised to a new location, when the crew member has spent sufficient time at that location to enable Table A and local time to be applied, using the rules given in Paragraph 4.7.3.1. Once the crew member is acclimatised at a particular location, they may be considered to remain acclimatised to that same location, if the crew member remains within a time band that is two hours wide and which includes that location. This is defined as two hours one side of the home base, or acclimatised location, or one hour either side. For purposes of determining the maximum allowable flight duty period for an acclimatised crew member, the home base time should be used, except when two local nights have been spent in the new time band and then local time should be used. A crew member ceases to be acclimatised when a duty ends at a location outside the acclimatised time band.

Augmented flight crew. A flight crew that comprises more than the minimum number required to operate the aeroplane and in which each flight crew member can leave their assigned post and be replaced by another fully qualified flight crew member for the purpose of in-flight rest.

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

Duty. Any task that flight crew members are required by the operator to perform, including but not limited to flight duty, post flight duty, standby, administrative work, training, and positioning.

Duty period. A period which starts when flight crew members or crew members are required by an operator to report for or to commence a duty and ends when that person is free from all duties.

Fatigue. A physiological state of reduced mental or physical performance capability resulting from sleep loss or extended wakefulness and/or physical activity that can impair a flight crew member's alertness and ability to safely operate an aircraft or perform safety related duties.

Fatigue Risk Management System (FRMS) - A FRMS comprises a comprehensive range of procedures which are both scientifically based and data-driven, allowing a cooperative and flexible means of managing fatigue as part of an operator's Safety Management System.

Note: See IFALPA-ICAO-IATA FRMS Implementation Guide for Operators Fatigue Management Guide for Airline Operators 2nd Edition, 2015 (IFALPA website, Publications, Fatigue Resource Library) for full details of FRMS.

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

Flight duty period. A period which commences when a flight crew member is required to report for duty that includes a flight or a series of flights and which finishes when the aeroplane finally comes to rest and the engines are shut down at the end of the last flight on which he/she is a flight crew member.

Note: The duration of Flight Duty Periods as defined in this scheme are designed to allow the

safety related duties required at the end of an FDP to be completed without crew members being unacceptably fatigued. In alternative schemes, dependent on the operation, the flight duty period may not terminate when the aeroplane comes to rest and the engines are shut down. In such cases the definition of an FDP may need to include an allowance for this additional flight duty to ensure the avoidance of fatigue.

Flight time – aeroplanes. The total time from the moment an aeroplane first moves for the purpose of taking off until the moment it finally comes to rest at the end of the flight.

Note: "Flight time" as here defined is synonymous with the term "block to block" time or "chock to chock" time in general usage which is measured from the time an aeroplane first moves for the purpose of taking off until it finally stops at the end of the flight.

Home Base. The location nominated by the operator to the crew member from where the crew member normally starts and ends a duty period or a series of duty periods.

Local night. The period between 2200 hours and 0759 hours local time.

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

Positioning. The transferring of a non-operating crew member from place to place as a passenger at the behest of the operator, excluding "travelling time".

Note. — "Positioning" as here defined is synonymous with the term "Deadheading".

Recovery period. A sufficient period of time provided at home base for crew members who are not acclimatised that allows a flight crew member's body clock and bio-rhythms to return to normal by aligning with home base time before starting the next duty cycle.

Reporting time. The time at which crew members are required by an operator to report for duty.

Rest period. A continuous and defined period of time, subsequent to and/or prior to duty, during which crew members are free of all duties including standby duties.

Roster. A list provided by an operator of the times when a crew member is required to undertake duties.

Note: "Roster" as here defined is synonymous with "Schedule", "Line of Time", "Pattern", and "Rotation".

Standby. A defined period of time, at the airport, at the hotel, or at home, during which a crew member is required by the operator to be available to receive an assignment for a specific duty without an intervening rest period.

Suitable accommodation. A suitably furnished bedroom on the ground, with single occupancy, which is subject to minimum noise, is well ventilated and has the facility to control the levels of light and temperature, which provides for the opportunity of undisturbed rest.

Traveling time. The time taken travelling from place of rest to place of report for duty or vice versa. Where place of rest is provided by the operator, additional travelling time in excess of one hour shall count as positioning.

Ultra-Long Range (ULR) operations. A ULR operation consists of two consecutive duty periods each consisting of a nonstop flight between a designated city pair where each flight departs the designated city within a specified time window, and where either of these duty periods involves a scheduled block time exceeding 16 hours or a scheduled duty time exceeding 18 hours. If only one sector in a city pair exceeds either of these times then both flights are deemed to be ULR flights and deemed to form part of the city pair ULR operation.

Note: Note: See IFALPA-ICAO-IATA FRMS Implementation Guide for Operators Fatigue Management Guide for Airline Operators 2nd Edition, 2015 (IFALPA website, Publications, Fatigue Resource Library) for full details of FRMS.

Unforeseen operational circumstance. An infrequent and irregular operational circumstance, such as not forecasted weather, equipment malfunction, or air traffic delay, that is beyond the control of the operator, where the pilot in command may exercise his sole discretion to extend a flight duty period or reduce a rest period as provided for in paragraphs 4.7.3.6 and 4.8.3.1.

Window of Circadian Low (WOCL). The period between 02:00 hours and 05:59 hours referred to a crewmember's acclimatised location.

4.3 The State's responsibilities

4.3.1 The objective of any prescriptive limitations for fatigue management regulations is to ensure that flight crew members remain sufficiently alert so that they can operate to a satisfactory level of performance and safety under all circumstances. The fundamental principle is for every crew member to be adequately rested when he/she begins a flight duty period, and whilst flying be sufficiently alert to operate to a satisfactory level of performance and safety in all normal and abnormal situations.

4.3.2 The purpose of this model scheme is to illustrate how limitations might be defined regarding variables likely to influence crew alertness (e.g., allowable flight hours, duty and flight duty periods, and minimum rest periods) that may be applied when flight crew rosters are planned. Provision can be made so that some of these limitations could be exceeded, but only on such occasions as could not reasonably have been foreseen when the flight was planned.

4.3.3 This model scheme is only one example of how prescriptive limitations for fatigue management may be defined. However, any alternative scheme should achieve an equivalent level of protection from fatigue. As the science regarding fatigue management continues to evolve, prescriptive limitations for fatigue management should be reviewed and updated to take account of new knowledge.

4.4 The operator's responsibilities

4.4.1 Operators should reflect in their operations manuals those elements of this example that are appropriate to the operations they undertake. If operations are planned that cannot be managed within the limitations published in the example, a variation may be requested. In this case, and before a variation is approved, an operator should demonstrate to the State of the Operator that the variation provides an equivalent level of safety and that objections on grounds of safety are taken into account.

4.4.2 Duty rosters should be prepared and published sufficiently in advance to provide crew members the opportunity to plan adequate rest. Consideration should be given to the cumulative effects of undertaking long duty hours interspersed with minimum rest, and of avoiding rosters that result in the serious disruption of an established pattern of working and sleeping.

4.4.3 Flights should be planned to be completed within the allowable flight duty period taking into account the time necessary for pre-flight duties, the flight and turn-around times, and the nature of the operation. Minimum rest periods needed to provide adequate rest should be based upon the actual operation.

4.4.4 In order to avoid any detriment to a crew member's performance, opportunities to consume a meal must be arranged when the flight duty period exceeds 6 hours.

4.4.5 The operator should nominate a home base for each crew member, from where the crew member will normally start and end a duty period or a series of duty periods. The home base should be assigned with a degree of permanence.

4.4.6 The operator must not require a crew member to operate an aeroplane if it is known or suspected that the crew member is fatigued to the extent that the safety of flight may be adversely affected.

4.5 Crew members' responsibilities

4.5.1 A crew member must not operate an aeroplane when he or she knows that he or she is fatigued or feels unfit to the extent that the safety of flight may be adversely affected.

4.5.2 Crew members should make best use of the facilities and opportunities that are provided for rest and for the consumption of meals, and should plan and use rest periods to ensure that they are fully rested.

4.6 Flight crew member limitations

The text that follows specifies limitations that apply to operations by flight crew members.

4.7 Limitations for flight times and duty periods

4.7.1 Maximum flight time

4.7.1.1 The maximum flight time may not exceed:

a) 100 hours in any 28 consecutive days; and

b) 900 hours in any 365 consecutive days.

4.7.2 Maximum duty hours for flight crew members

4.7.2.1 Cumulative Duty hours may not exceed:

	Type of Schedule		
	none disruptive	partially disruptive	disruptive
Consecutive 7 days	55	52 ½	50
Consecutive 14 days	95	83 ½	72
Consecutive 28 days	190	155	120

Note 1: A disruptive schedule is one in which at least 50% of the duty periods are disruptive. A partially disruptive schedule is one in which between 20% and 50% of the duties are disruptive.

Note 2: A disruptive duty is a flight duty period, which either encroaches on the WOCL (for an acclimatised crewmember) or starts or ends (or both) at a location to which a crewmember is not acclimatised.

4.7.2.2 Duty includes all tasks carried out at the behest of the operator. These include but are not limited to: pre-flight preparation; conduct of the flight (whether or not this is commercial air transport); post-flight actions; training given or received (classroom, flight simulator or aeroplane); rostered office/management time; positioning and standby.

4.7.3 Maximum flight duty period for flight crew members

4.7.3.1 Maximum Flight Duty Period and Acclimatisation Determination Matrix 2- Pilot Operations

For a pilot who is acclimatised at home base, Table A and home base time are applicable. For other circumstances, the matrix at figure 1 should be utilised to determine the applicability of Table A or Table B to a particular flight duty period. (See Appendix 1 and 2 for application flowchart)

Figure 1

time-zone transitions from acclimatised location		elapsed time since crewmember was last acclimatised (h)							
east	west	12-36	36-60 (returning to base)	36-60 (not returning to base)	60-84	84-108	108-132	132-156	156+
2	2-4	Table B (home time)	Table B (home time)	Table B (local time)	Table A (local time)	Table A (local time)	Table A (local time)	Table A (local time)	Table A (local time)
3-4	5-6	Table B (home time)	Table B (home time)	Table B (local time)	Table B (local time)	Table A (local time)	Table A (local time)	Table A (local time)	Table A (local time)
5-6	7-8	Table B (home time)	Table B (home time)	9h less 45 min/ sector	9h less 45 min/ sector	Table B (local time)	Table A (local time)	Table A (local time)	Table A (local time)
7-8	9-11	Table B (home time)	Table B (home time)	9h less 45min/ sector	9h less 45 min/ sector	9h less 45min/ sector	Table B (local time)	Table A (local time)	Table A (local time)
9-12+	12+	Table B (home time)	Table B (home time)	9h less 45min/ sector	9h less 45min/ sector	9h less 45min/ sector	9h less 45 min/ sector	Table B (local time)	Table A (local time)

Note 1: A crewmember's elapsed time since being acclimatised begins when a crewmember ends a duty at a non-acclimatised location.

Note 2: If Table A and local time become applicable in the above matrix, the matrix should then be applied from the new location. The shaded boxes in the matrix designate when a crewmember would be considered acclimatised.

Note 3: While the matrix in Figure 1 attempts to address most scenarios, the complexity of more than four sectors transitioning multiple time zones or time zone transitions that exceed 12 hours from the acclimatised location create scenarios that may benefit from a FRMS approach to determine that an adequate level of alertness will be maintained thus ensuring a safe operation

4.7.3.2 Table A – Maximum Flight Duty Periods Acclimatised 2-Pilot Crew

For acclimatised flight crews the maximum flight duty period should be in accordance with the provisions of Table A below. This table allows for factors known to impact fatigue such as number of planned sectors and local time at which the flight duty period begins. For allowable increase in flight duty period where crews are augmented see paragraph 4.7.5

Table A Maximum Flight Duty Period Acclimatised 2-Pilot Operations

Local time of start	Sectors					
	1	2	3	4	5	6
0100-0259	9	8¼	7½	6¾	6	5¼
0300-0459	10	9¼	8½	7¾	7	6¼
0500-0559	11	10¼	9½	8¾	8	7¼
0600-0659	12	11¼	10½	9¾	9	8¼
0700-0959	13	12¼	11½	10¾	10	9¼
1000-1359	13	12½	12	11½	11	10½
1400-1659	12	11½	11	10½	10	9½
1700-2159	11	10½	10	9½	9	8½
2200-2259	11	10¼	9½	8¾	8	7¼
2300-0059	10	9¼	8½	7¾	7	6¼

4.7.3.3 For crew members that are not acclimatised the maximum flight duty period should be in accordance with the provisions of Table B below. This table allows for additional factors which are known to impact fatigue, namely the pattern of resting and sleeping relative to the crew member's circadian rhythm. For allowable increase in flight duty period where basic crew is augmented see the Maximum Flight Duty Period Determination Matrix- Augmented Pilot Operations (paragraph 4.7.5.1).

Table B Maximum Flight Duty Periods not acclimatised 2-Pilot Operations

Local time of start	Sectors					
	1	2	3	4	5	6
0500-0559	10	9¼	8½	7¾	7	6¼
0600-0659	11	10¼	9½	8¾	8	7¼
0700-0959	12	11¼	10½	9¾	9	8¼
1000-1359	12	11½	11	10½	10	9½
1400-1659	11	10½	10	9½	9	8½
1700-2159	10	9½	9	8½	8	7½
2200-2259	10	9¼	8½	7¾	7	6¼
2300-0459	9	8¼	7½	6¾	6	5¼

4.7.3.4 Crew report times should realistically reflect the time required to complete pre-flight duties, both safety- and service-related and a recommended standard allowance of 30 minutes is to be added at the end of flight time to allow for the completion of checks and records. The period allowed for completion of post flight duties must be sufficient to represent the actual time taken to complete required tasks. For record purposes, the pre-flight report time should count both as duty and as flight duty, and the post-flight allowance should count as duty.

4.7.3.5 Flight duty periods may be extended in unforeseen operational circumstances by no more than 2 hours during normal hours of wakefulness at the sole discretion of the pilot-in-command. A reduced period of extension should be considered for night operations / back of the clock operations because of the increased risk of crew impairment during these periods. Before exercising discretion, the pilot-in-command should be satisfied that all members of the crew required to operate the aeroplane consider themselves fit to do so.

4.7.4 Flights operated by augmented crews and the provision of in-flight relief

4.7.4.1 The composition and number of flight crew members carried to provide in-flight relief, and the quality of rest facilities provided should determine the amount by which the basic flight duty period limitations may be extended. A sensible balance should be kept between the division of in-flight duty and rest.

4.7.4.2 The operator should ensure that crew members are notified prior to commencement of the rest period preceding the flight of the rest pattern they are required to undertake so that they can plan their pre-flight rest accordingly.

4.7.5 Extension of Flying Duty Period by in-flight relief

4.7.5.1 Maximum Flight Duty Period and Acclimatisation Determination Matrix- Augmented Pilot Operations

For a pilot who is acclimatised at home base, Table C and home base time are applicable. For other circumstances, the matrix shown at figure 2 should be utilised to determine the applicability of Table C to a particular flight duty period. (See Appendix 1 and 2 for application flowchart)

Maximum Flight Duty Period Determination Matrix- Augmented Pilot Operations

Figure 2

Time-zone transitions from acclimatized location		Elapsed time since crewmember was last acclimatised (h)						
east	**west**	**12-36**	**36-60 (returning to base)**	**36-60 (not returning to base)**	**60-84**	**84-108**	**108-132**	**132+**
2	2-4	Table C (home time)	Table C (home time)	Table C (local time)	Table C (local time)	Table C (local time)	Table C (local time)	Table C (local time)
3-4	5-6	Table C (home time)	Table C (home time)	Table C (local time)	Table C (local time)	Table C (local time)	Table C (local time)	Table C (local time)
5-6	7-8	Table C (home time)	Table C (home time)	10	10	Table C (local time)	Table C (local time)	Table C (local time)
7-8	9-11	Table C (home time)	Table C (home time)	10	10	10	Table C (local time)	Table C (local time)
9-12+	12+	Table C (home time)	Table C (home time)	10	10	10	10	Table C (local time)

Note 1: A crewmember's elapsed time since being acclimatised begins when a crewmember completes a duty at a non-acclimatised location.

Note 2: If Table C and local time become applicable in the above matrix, the matrix should then be applied from the new location.

Note 3: While the matrix in Figure 2 attempts to address most scenarios, the complexity of more than four sectors transitioning multiple time zones or time zone transitions that exceed 12 hours from the acclimatised location create scenarios that may benefit from a FRMS approach to determine that an adequate level of alertness will be maintained thus ensuring a safe operation.

4.7.5.2 An extension to the maximum flight duty period for 2 pilot operations should be based on the duration of the rest period(s) available to the pilot and on the quality of the in-flight rest facility. This allowable extension should also be based on whether the pilot is acclimatised or not acclimatised. For purposes of determining the maximum augmented flight duty period, Table C should be used to determine the maximum FDP prior to augmentation. This value will then be used to enter either Table D or Table E to determine the maximum single sector FDP utilising in-flight relief. These Tables and any subsequent calculation for determination of a two sector FDP are valid only with a reasonable distribution of the rest periods.

Table C Maximum Flight Duty Period for calculating augmented maximum Flight Duty Period

Time of Start	Unaugmented FDP
0500-0559	11
0600-0659	12
0700-1359	13
1400-1659	12
1700-2159	11
2200-2259	11
2300-0459	10

Note 1. The above table is for single sector augmentation. For augmented operations involving multiple sectors within a duty period a Fatigue Risk Management Approach is recommended

4.7.5.3 For acclimatised flight crews the maximum single sector flight duty period utilising in-flight relief should be in accordance with the provisions of Table D below.

Table D Maximum Flight Duty Periods Acclimatised 3 or 4 Pilot Augmented Operations - Single Sector

Acclimatised	Category 1		Category 2		Category 3		Category 4	
Max FDP (Table C)	3 Pilot	4 Pilot	3 Pilot	4 Pilot	3 Pilot	4 Pilot	3 Pilot	4 Pilot
10	12 ¼	14 ¼	11 ½	12 ¾	10 ½	11	10	10
11	13 ½	15 ¾	12 ¾	14 ½	11 ¾	12 ¼	11	11
12	15	17 ½	14	15 ½	12 ¾	13 ¼	12	12
13	16	18	15 ¼	16 ¾	14	14 ½	13	13

Note 1: FDPs in excess of the computed values may be available if a FRMS approach is utilised to determine that an adequate level of crew alertness will be maintained thus ensuring a safe operation.

4.7.5.4 For flight crew members that are not acclimatised the maximum single sector flight duty period utilizing in-flight relief should be in accordance with the provisions of Table E below.

Table E Maximum Flight Duty Periods non-acclimatised 3 or 4 Pilot Augmented Operations - Single Sector

Not	Category 1		Category 2		Category 3		Category 4	
Max FDP (Table C)	3 Pilot	4 Pilot	3 Pilot	4 Pilot	3 Pilot	4 Pilot	3 Pilot	4 Pilot
10	11 ¾	13	11 ¼	12	10 ½	10 ¾	10	10
11	13	14 ½	12 ½	13 ¼	11 ½	11 ¾	11	11
12	14 ¼	15 ¾	13 ½	14 ½	12 ½	13	12	12
13	15 ½	17 ¼	14 ¾	15 ¾	13 ¾	14 ¼	13	13

Note 1: FDPs in excess of the computed values may be available if a FRMS approach is utilised to determine that an adequate level of crew alertness will be maintained thus ensuring a safe operation.

4.7.5.5 In-flight rest facility quality is divided into four categories:

Category	Description
1	This must be a bunk or "sleeper" seat that should provide horizontal rest as a bed. It should recline to at least 80° back angle to the vertical. Examples are "lie flat" seats or "flat bed" seats. The seat should be separated from the cockpit and passengers, by curtains or panels, and should include provisions for darkening the sleep environment and free of intrusion from exterior noise.
2	Commonly known as a "normal" business class seat. This seat must be outside the cockpit and separated from passengers by, as a minimum, a dark curtain. A common row of seats may be shared only by another crewmember. Under no circumstance should the row be shared by a crewmember with a passenger. Minimum seat requirements are: a. Reclining to at least 45° back angle to the vertical; b. Seat pitch at least 55 inches; c. Seat width at least 20 inches;
3	Flight deck or cabin seat which reclines by at least 40° back angle to the vertical and offers sufficient leg and foot rest.
4	Normal economy class seat

Note: Seat pitch is the distance between the rows of seats and is measured from the back of one seat to the back of the seat behind, the measurements being taken from the same position on each seat.

4.7.5.6 For the fully acclimatised crew member, and based on the bunk/seat classification in paragraph 4.7.5.5, the following flight duty period extensions are permitted:

Categor	Allowable FDP Extension
1	75% of the rest period
2	56% of the rest period
3	25% of the rest period
4	No extension

Note 1: The duration of rest period for this chart is determined by subtracting 3 hours from the planned FDP for a single sector flight. This will allow for duties pre-top of climb, handoff between flight crew members, and duties post top of descent. For flight duty periods consisting of more than one sector, time for duties pre-top of climb, handoff between crew members, and duties post top of descent must also be subtracted from the planned FDP to determine the duration of rest period.

4.7.5.7 For operations where a flight crew member is not acclimatised, allow 80% of the acclimatised extension.

4.7.5.8 The planned maximum flight duty period permitted utilizing in-flight relief is limited to an upper limit of 18 hours. If augmentation is only by one additional pilot, the maximum planned FDP is 16 hours.

4.8 Minimum rest periods

4.8.1 The minimum rest period for an acclimatised crewmember immediately before commencing a flight duty period may not be less than 12 hours. The duration of a rest period for an acclimatised crewmember that overlaps the WOCL by less than two hours must be at least 14 hours. If it overlaps the WOCL by at least two hours, but less than four hours, the minimum is 13 hours. Otherwise the minimum is 12 hours. The minimum rest period should provide an eight-hour sleep opportunity, at the place of rest, plus sufficient time for sustenance / the consumption of meals, and normal hygiene requirements. If the pilot in command has exercised discretion in extending the maximum time on duty, or reducing a rest period, the discretion cannot result in a minimum rest period less than 10 hour at the place of rest

4.8.2 The minimum rest period for a pilot who is not acclimatised is 14 hours.

4.8.3 At home base, travelling time spent by a crew member between the place of rest and the place of reporting for duty is not counted as duty, even though it is a factor contributing to fatigue. Excessive travelling time undertaken immediately before commencing a flight duty period could therefore detract from a crew member's ability to counter fatigue arising whilst on duty, and should therefore be taken into account when deciding where pre-flight rest should be taken.

4.8.3.1 Minimum rest periods may be reduced in unforeseen operational circumstances by no more than 2 hours only at the discretion of the pilot-in-command (see 4.8.1 above). Where the pilot in command uses discretion to reduce a rest period, the subsequent maximum duty period limitation shall be reduced by the corresponding amount of time. In such cases the subsequent rest period may not be reduced below 12 hours.

4.8.3.2 Longer rest periods should be granted on a regular basis to preclude cumulative fatigue. It is recommended that once in every 7-day period a minimum rest period of 36 hours is provided extended as necessary to include two local nights of recovery rest to minimise the effects of sleep loss and fatigue. Two local nights of normal sleep is the minimum requirement to stabilise rest patterns and return waking performance and alertness to usual levels

4.8.3.3 When an acclimatised crew member returns to base following a period of consecutive night duty periods that include duty during any part of the WOCL, the crew member should be provided with two local nights rest in accordance with the provisions of paragraph 4.10.4.

4.8.3.4 Where crew members are not acclimatised, upon return to home base, a recovery period should be provided that ensures a crew member's body clock has recovered to home base local time before the start of the next duty. The time necessary to ensure complete recovery of the circadian rhythm varies as a function of the elapsed time away from base and the maximum time difference from home base. The following Table F can be used to determine the number of local nights required to readapt within an hour of home base.

Table F – Number of Local Nights for Recovery on Return to Home Base

Elapsed Time Since Leaving Home base(h)	Maximum Time Difference from Home Base (h)						
	3	4	5	6	7	8-9	10-12+
60-84h	1*	1*	2*	2*	2*	2*	3
84-108h	2*	2*	2*	3	3	3	3
108-132h	2*	3	3	4	4	4	5
132-156h	3	3	3	4	4	5	5
156+h	3	3	4	4	5	5	6

*Note 1: The values in Table F refer to eastward transitions (eastward outbound / westward homebound) only. * denotes that for westward transitions (westward outbound / eastward homebound) one extra day is required to be added to the value depicted.*

Note 2: When the elapsed time away from home base is less than 60 hours one full local night's recovery rest should be provided on return to base, except when the returning flight duty period encroaches the WOCL, then an additional local night's rest will be added [as per paragraph 4.10.4].

4.9 Discretion that may be exercised by the pilot-in-command

4.9.1 The pilot-in-command, at his/her discretion in consideration of special circumstances that could lead to unforeseen levels of fatigue and after discussion with crew members affected, may reduce an actual flight duty period and/or increase a minimum rest period [see paragraph 4.8.1] in order to remove any adverse effect on flight safety.

4.9.2 The pilot-in-command should report to the operator the use of discretion to extend or reduce duty or rest.

4.10 Miscellaneous provisions

4.10.1 Standby

4.10.1.1 The start time and end time of standby should be defined and notified at least 12 hours in advance, and the maximum length of any standby should not exceed the flight duty period outlined in Table A for commencement of the standby duty. (See paragraph 4.7.3.1)

4.10.1.2 Where airport standby is immediately followed by a flight duty period, the cumulative time spent on standby and the assigned flight duty shall not exceed the flight duty period outlined in Table A based on the commencement of the standby duty.

4.10.1.3 On other than airport standby, the allowable flight duty period should be based upon the commencement of the standby duty and may be extended by a maximum of 3 hours.

4.10.1.4 When crew members are required to be on standby at an accommodation arranged by the operator, then adequate rest facilities should be provided.

4.10.1.5 For the purposes of cumulative duty limits; airport standby shall count fully, other standby should be counted at 50%.

4.10.2 Availability

4.10.2.1 When crew members are required to be available for contact over a brief period of time to receive instructions concerning a possible change of roster or assignment of a duty, that requirement must not prevent that person from having a rest period before reporting for duty. When assigning flight duty, the crew member must be given a protected eight-hour sleep opportunity. This sleep opportunity should not vary more than 3 hours on subsequent days to ensure circadian stability. This sleep opportunity should be protected from interruption. Time spent being available should not be counted as duty.

4.10.3 Positioning

All time spent positioning counts as duty, and positioning followed by operating without an intervening rest period also counts as flight duty. However, positioning should not count as an operating sector when planning or calculating a flight duty period.

4.10.4 Consecutive night duties for acclimatised crews

No more than three consecutive duties may overlap the period 0100-0659.

Note 1: Four consecutive duties are permitted if the FDP of each is at least one hour less than the maximum for that start time in Table A, and five consecutive duties are permitted if the FDP of each is at least two hours less than the maximum for that start time in Table A.

4.11 Records

4.11.1 To enable the operator to ascertain that the fatigue management scheme is functioning as intended and as approved, records should be kept for 36 months of the duties performed and rest periods achieved so as to facilitate inspection by the operator's authorized personnel and audit by the State of the Operator.

4.11.2 The operator should ensure that these records include for each flight crew member, at least:

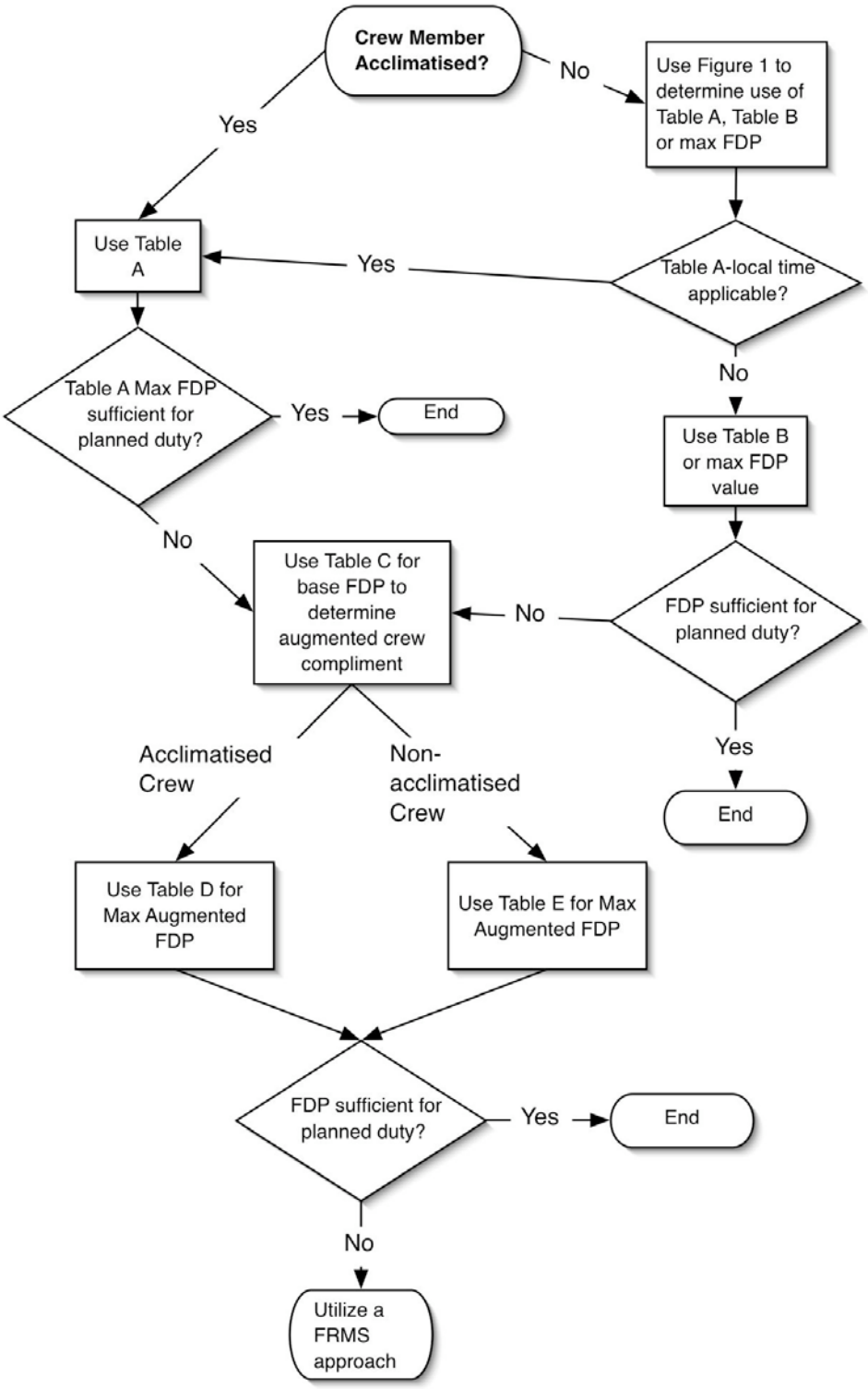
a) the start, duration and end of each flight duty period;
b) the start, duration and end of each duty period;
c) rest periods; and
d) flight time.

4.11.2.2 The operator should also keep records of occasions when a pilot-in-command has exercised his discretion (as described in paragraph 4.9.2). If discretion has to be applied for similar reasons on more than 20 percent of occasions when a particular route or route pattern is flown, it is likely that the intention of this guidance is not being met and undue fatigue may result. Arrangements should be made to change the schedule or the crewing arrangements so as to reduce the frequency at which such events occur. A State may require that, in addition, copies of certain records should be submitted.

4.11.3 Flight crew members should maintain a personal record of their daily flight time.

Appendix 1

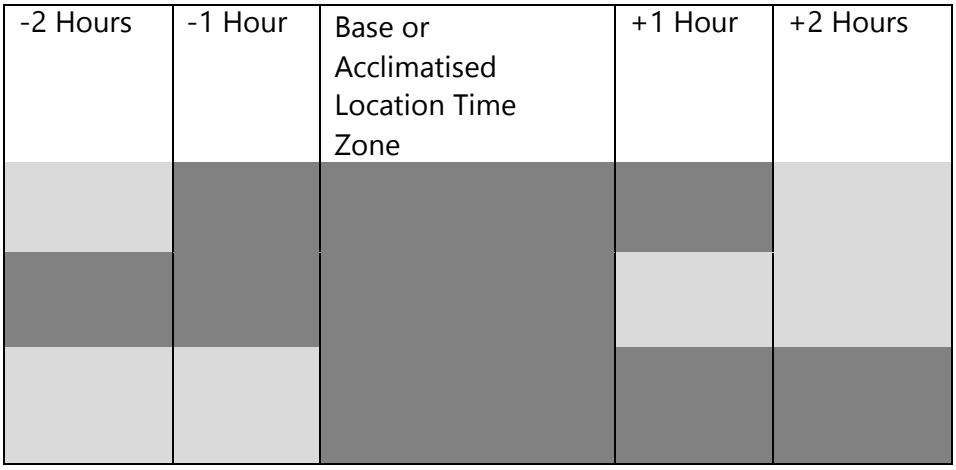
Application Flowchart



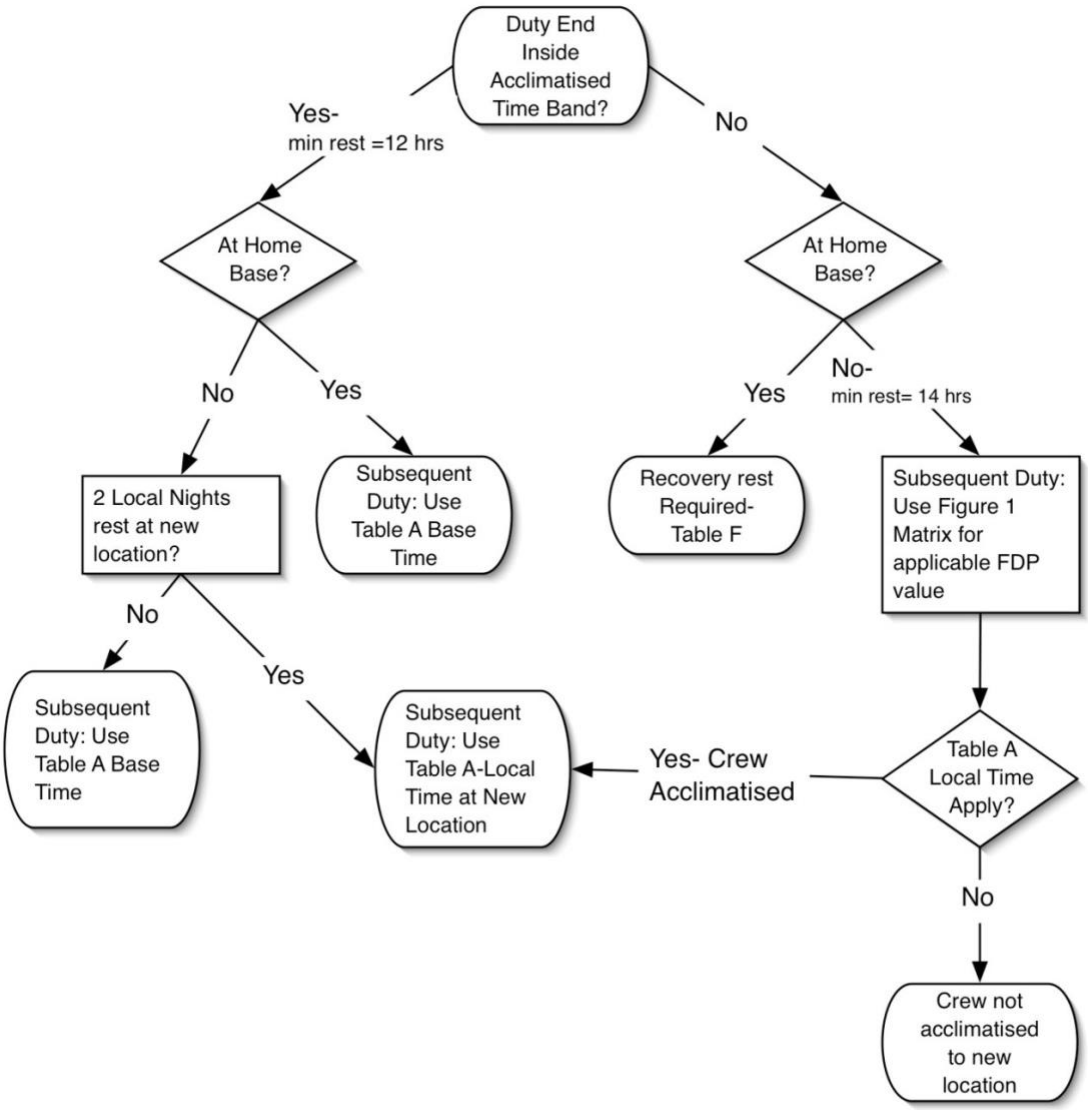
Appendix 2

Acclimatisation and Rest/ Recovery Flowcharts

ACCLIMATISED TIME ZONE BANDS DEPICTION
(Highlighted in Darker Grey)



Note: Darker grey bands denote variance from home time zone to be considered acclimatised


Duty End Inside Acclimatised Time Band?
Yes-
min rest =12 hrs
No
At Home Base?
At Home Base?
No
Yes
Yes
No-
min rest= 14 hrs
2 Local Nights rest at new location?
Subsequent Duty: Use Table A Base Time
Recovery rest Required- Table F
Subsequent Duty: Use Figure 1 Matrix for applicable FDP value
No
Yes
Subsequent Duty: Use Table A Base Time
Subsequent Duty: Use Table A-Local Time at New Location
Yes- Crew Acclimatised
Table A Local Time Apply?
No
Crew not acclimatised to new location

Appendix 3

Worked Examples

Application of Table A

The following 3-day schedule is planned within the United Kingdom. The crew is acclimatised to local time, and will remain so throughout this schedule. The maximum flight duty periods for each duty period is determined solely by reference to Table A for 2-pilot operations. The reporting time at which duty commences is 1:15 prior to ETD, and a post flight period of 30 minutes is allowed from scheduled on blocks time at the last flight of each day.

Day		Depart	Arrive	Block	Duty	Table A Max FDP
1	**Report 1400**	LHR 1515	MAN 1615	1:00		**11:00**
		MAN 1705	LHR 1805	1:00		
		LHR 1905	GLA 2030	1:25		
	Layover 15:45			3:25	7:00	
2	**Report 1245**	GLA 1400	LHR 1520	1:20		**11:30**
		LHR 1605	NCL 1715	1:10		
		NCL 1750	LHR 1900	1:10		
		LHR 2010	NCL 2120	1:10		
	Layover 16:15			4:50	9:05	
3	**Report 1350**	NCL 1505	LHR 1620	1:15		**12:00**
		LHR 1715	EDI 1840	1:25		
		EDI 1920	LHR 2040	1:20		
Min Rest required 12:00				4:00	7:20	

From Table A determine the Maximum allowable FDP for each day of the above schedule: Enter table A with local report time and number of sectors to derive maximum FDP.

Day	Report Time	Sectors	Max FDP	Scheduled FDP	Scheduled Duty Time
1	1400	3	11:00	6:30	7:00
2	1245	4	11:30	8:35	9:05
3	1350	3	12:00	6:50	7:20

Application of Table B

Table B is applicable any time a crew member finishes a duty period outside their acclimatised time band.

The following schedule is planned from LHR London Heathrow (GMT) to ISB Istanbul Turkey (GMT
+ 5 hours) where a 28-hour layover is scheduled prior to returning to LHR. Report time is 1:30 prior to departure time and a post-flight duty time of 30 minutes is allowed following scheduled on blocks time.

Day	Depart (LT)	Arrive (LT)	Block	FDP	Max FDP
1 **Report 1540**	LHR 1710	ISB 0600	7:50		**12:00** Table A
			7:50	9:20	
Layover time 28:00					
2 **Report 1030** ISB or **0530 home base (LHR) time**	ISB 1130	LHR 1445	8:15		**10:00** Table B
			8:15	9:15	

Determine the maximum FDP applicable for each sector.

For departure from LHR, the crew is acclimatised, so Table A is applicable. With a report time of 1540 a max FDP of 12 hours is derived. If the flight operates to the scheduled times, then the actual FDP for the LHR-ISB sector will be 9:20 and duty time allowing for post-flight period of 30 minutes is 9:50. At the end of this duty period (0630 local time ISB) the crew having ceased duty at a location outside their acclimatised zone ceases to be acclimatised.

For the return sector the crew is no longer acclimatised because they have finished duty in a time zone which is beyond their acclimatised time zone band, and there is insufficient layover time to acclimatize to local time in Istanbul (Table A is not applicable) The matrix at Figure 1 to paragraph 4.7.3.1 is therefore used to determine which table to use and the time (local or home base time) which should be applied for the return flight to LHR based on the elapsed time since last acclimatised (layover duration) in ISB.

The layover time in ISB is 28 hours. With ISB having a time zone of 5 hours eastwards from LHR and elapsed time since acclimatised at report for duty of 28 hours, the matrix at Figure 1 indicates that Table B (home time i.e. LHR time) should be used for determining the maximum allowable FDP. The local report time at ISB is 1030 (0530 home base time). From Table B a max FDP of 10 hours for the single sector return flight to LHR is determined. Scheduled block time for the return is 8:15 making the scheduled FDP 9:15 and scheduled duty period for the return 9:45.

Augmented Operations

Where the scheduled FDP exceeds the maximum FDP in Table A, Table B, or the max FDP given in the matrix, the flight will need to be augmented with additional crew.

The following schedule is planned from Auckland to San Francisco and return:

	Day	Depart (LT)	Arrive (LT)	Block	FDP	Max FDP
1	**Report 1830**	AKL 1930	SFO 1045	12:15		**13:30** Table D acclimatised
	Layover 125:45			12:15	13:15	
7	**Report 1800**	SFO 1900	AKL 0510	13:10		**15:45** Table D acclimatised
				13:10	14:10	

Determine the crew complement required and maximum FDP applicable for the crew based on time of reporting for duty and on-board category 1 rest facilities. SFO is located 3 time zones to the east of AKL.

For departure from AKL, the crew is acclimatised, so Table A is applicable. With a report time of 1830 a max FDP of 12 hours is derived which is insufficient to complete the planned schedule. The crew will need to be augmented to extend the max FDP. For augmented operations Table C is applicable and with a report time of 1830 a value of 11 is derived for the single sector flight which is used to enter Table D (acclimatised crew). From Table D a maximum FDP of 13 ½ hours is derived for a 3-pilot crew using category 1 rest facilities which is sufficient to complete the flight.

The crew has a layover time in SFO of 125:45. The matrix at Figure 1 to paragraph 4.7.3.1 is entered to determine which table to apply. With SFO having a 3-hour time zone transition to the east of AKL, and a layover time of 125:45 from Figure 1 Table A (local time) is applicable. This indicates the crew is now acclimatised to SFO time.

With a local report time of 1800 from Table A, a maximum FDP of 11 which is insufficient time for the single sector return flight for a non-augmented crew. Table C is entered with a report time of 1800 and a value of 11 obtained to enter Table D (acclimatised crew). A maximum FDP for category 1 rest facilities of 13 ½ hours for 3 pilot operation and 15 ¾ hours for 4 pilot operations is required. The scheduled FDP for the return flight is 14:10 thus requiring a crew complement of 4 pilots for the return flight. Note – referring to Figure 1 had the layover time in SFO been less than 84 hours then the crew would have had insufficient layover time to become acclimatised and therefore Tables C and E would be used to derive the maximum FDP.

Operations across Multiple Time Zones, other than out and back operations from home base

Following is an example of a multiple sector operation across multiple time zones. Dakar (DKR) is 4 hours east of home base ATL, and JNB is a further 2 hours east being 6 hours east of ATL.

Day		Depart (LT)	Arrive (LT)	Block	FDP	Max FDP
1	Report **1415**	ATL 1545	DKR 0440	8:55		**12:00** Table A
Layover 23:20				8:55	10:25	2- pilot crew
3	Report 0430 LT or **0030 base time**	DKR 0600	JNB 1635	8:35		**11:45** Tables C & E
Layover 24:05				8:35	10:05	3- pilot crew
4	Report 1710	JNB 1840	DKR 0120	8:40		**11:45** Tables C & E
Layover 23:30				8:40	10:10	3- pilot crew
6	Report **0120** LT	DKR 0250	ATL 0815	9:25		**12:15** Tables A & D
Recovery rest on return to base 3 local nights Table F				9:25	10:55	

ATL-DKR

On Day 1 the crew reports at home base Atlanta (ATL) and being acclimatised Table A is applicable. Entering Table A with a report time of 1415 a max FDP is obtained for the single sector flight to Dakar Senegal. The time in Dakar is 4 hours to the east of ATL and therefore on completion of duty on arrival at DKR the crew is outside their acclimatised time zone and therefore ceases to be acclimatised on completion of duty after arriving at DKR.

DKR-JNB

At report 0430 local, the elapsed time since last acclimatised is 23:20. Figure 1 is entered with this elapsed time and a time zone transition of 4 hours east, and from the matrix it is determined at the time of reporting for duty for the flight to JNB that Table B base time is applicable. The report time of 0430 in DKR equates to a base time back in ATL of 0030, and this time is used to enter Table B where a maximum FDP of 9 hours is derived. This is insufficient for the schedule and therefore the flight must be augmented for the flight to JNB. Figure 2 indicates Table C base time is applicable. Table C is entered with this time and a value of 10 obtained for the single sector flight which is then used to enter Table E (the crew remains unacclimatised as Table A local time does not apply). From Table E a max FDP of 11 ¾ hours for category 1 rest facilities is obtained for 3-pilot crew which is sufficient for the flight.

JNB-DKR

At the time of reporting for duty on the third flight from JNB to DKR the elapsed time since last acclimatised is 58 hours. Entering Figure 1 with this value and a time zone transition of 6 hours east a max FDP of 9 hours is obtained from the matrix for a single sector flight. Again the flight requires augmenting, and from Figure 2 a value of 10 is obtained (flight not returning to base). This value is used to enter Table C and the same value derived for single sector flight is used again to enter Table E (crew still not acclimatised). Again, a max FDP of 11 ¾ hours is obtained which is sufficient to the return flight to DKR.

DKR-ATL

At report time for duty 92:10 has elapsed since the crew was last acclimatised, and the crew is again 4 hours east of base. From Figure 1 Table A local time is applicable and the crew is now acclimatised. With a local report time of 0120 Table A provides a max FDP of 9 hours, so the flight must be augmented. From Figure 2 Table C local time applies and a value of 10 obtained for the single sector flight which is used to enter Table D (acclimatised crew). For category 1 rest facility a max FDP of 12
¼ hours is derived.

On return to ATL the crew having transited 4 time zones from DKR is no longer acclimatised and therefore recovery rest on return to base is required as determined from Table F. 3 calculations are required as follows:

1. On arrival DKR at the end of the first leg the elapsed time from departure ATL to arrival back in ATL is 112:30. DKR is 4 hours east of ATL and from Table F 3 local nights recovery are required.
2. On arrival JNB the elapsed time from departure DKR to arrival back in ATL is 78:15. JNB is 6 hours east of ATL and from Table F 2 local nights recovery back at base are required.
3. On arrival DKR the second time the elapsed time from departure JNB until arrival back at ATL is 43:35. DKR is 4 hours east of ATL and from Table F 1local nights recovery is required.
4. The number of local nights recovery required for crew to be acclimatised to home base is the greatest number calculated above – i.e. three local nights.

The following is a further example of a more complex schedule across multiple time zones over 10 days which is required to comply with duty time limitations for disruptive schedules. The crew ceases to be acclimatised on finishing duty in HKG on the outbound leg. HKG is 4 hours west of AKL and LHR 11 hours west of AKL.

Day	Depart	Arrive	Block	Duty	Max FDP
1 **Report 2230 LT**	AKL 2330	HKG 0645	11:15		**13:30 3-pilot crew**
Layover 48:30			11:15	12:45	
4 **Report 0745 LT**	HKG 0845	LHR 1435	12:50		**15:30 3-pilot crew**
Layover 53 hours			12:50	14:20	
7 **Report 2005 LT**	LHR 2105	HKG 15:50	11:45		**13:00 4-pilot crew**
Layover 48:50			11:45	13:15	
9 **Report 1710 LT**	HKG 1810	AKL 0900	10:50		
Recovery Rest on return to base 5 local nights Table F			10:50	12:20	

AKL-HKG

From Table A max allowable FDP is 11 hours. Insufficient allowable FDP for basic crew. From Table C value of 11 derived. Enter Table D – Category 1 rest facilities 13 ½ max FDP for 3 pilots and 15 ¾ hours for 4 pilots. First sector AKL-HKG can be completed with a crew of 3 pilots.

HKG – LHR

Layover time in HKG scheduled 48:30, and HKG 4 hours west of AKL. From figure 1 Table B local time is applicable. As Table A local time not applicable crew is not acclimatised and clearly insufficient FDP is available from Table B. Therefore, flight has to be augmented. From figure 2 (4.7.5.1) Table C local time is applicable i.e. HKG time. Local report time at HKG is 0745 and from Table C a value of 13 is derived for the single sector to LHR using a time since last acclimatised not returning to home base of 48:30. As crew not acclimatised Table E entered with value of 13 obtained from table C and a max FDP of 15 ½ is derived which is sufficient to operate this leg as scheduled hours is derived.

LHR-HKG

Layover time in LHR is 53 hours and entering figure 1 with time zone transition from last acclimatised location (11 hours west from AKL) and elapsed time since last acclimatized (i.e. end of duty on AKL- LHR leg) from figure 1 we find that Table A local time is not applicable and crew continues to remain unacclimatised. Entering Figure 2 we derive a value of 10 with which to enter Table C and subsequently Table E (not acclimatised) which gives a max FDP of 11 ¾ hours for a 3-pilot crew and 13 hours for 4- pilot operation. With a schedule FDP of 12:55 for this sector a 4-pilot crew is required to operate the flight.

HKG-AKL

Layover time in HKG is 48:50. At time of report for duty in HKG elapsed time since acclimatised is 190:25 and time zone transition from last acclimatised location is again 4 hours. From figure 1 Table A local time is now applicable for the first time since leaving New Zealand, and the crew is now considered acclimatised to Hong Kong time zone. For the return to New Zealand Table A does not allow sufficient FDP to complete this sector with a basic crew, so Tables C and D are entered using a local report time of 1710. From Table C a value of 11 is derived for the single sector, and Table D indicates a max FDP of 13 ½ hours which is sufficient to complete the final leg home.

On arrival in New Zealand the crew has transited more than two time zones outside the last acclimatised location (i.e. HKG), and therefore cease to be acclimatised on arrival back in New Zealand. A recovery period (Table F) before the crew can be considered acclimatised to home base location.

As this schedule contains more than two legs prior to return to base, there are 3 separate calculations which need to be made using Table F to determine recovery time for re-adaptation of the body clock to local time based on elapsed time from arrival in each port until return to home base and time zone transitions between home base and the arrival port.

For this example:

1. On arrival HKG at the end of the first leg the elapsed time from departure AKL until arrival back at AKL is 201:30. HKG has a time zone difference of 4 hours west of AKL. From Table F three local nights recovery are required.

2. On arrival LHR the elapsed time since departing HKG until arrival back at AKL is 140:15. LHR has a time zone difference of 12 hours west of AKL. From Table F five local nights are required on return to home base.
3. On arrival HKG (second time) the elapsed time from departure LHR until arrival back at AKL is 72:55 hours. HKG has a time zone difference of 4 hours west of AKL. From Table F two local nights recovery are required.
4. The number of local nights recovery required for crew to be acclimatised to home base is the greatest number calculated above – i.e. five local nights.

Appendix 4

Background & References

Introduction

Appendix Four presents a brief account of the derivation of much of the guidance material in Attachment I. Some of the background information comes from the laboratory studies of sleep and wakefulness, which have contributed to our basic understanding of the physiology of individuals during irregular patterns of work and rest. This is supplemented by information from many investigations of the aircrew themselves, including of their sleep, alertness, performance and circadian rhythms, on various types of operation.

The basic FDP limits (Table A)

These limits have been derived from a study carried out of aircrew on the Haj operation between Indonesia and Saudi Arabia [1]. In this study, crews were asked to rate their level of fatigue on the seven- point Samn-Perelli (SP) scale [2] on six separate occasions during each duty period. The FDPs were generally between 11 and 11.5 hours, and flights departed at all times of the day and night. The reasons for choosing this study as the basis for Table A were:

(i) It is the only available study of flights carried out under similar conditions at all times of day. It therefore provides a direct comparison between levels of fatigue on flights starting at different times.

(ii) The trends in fatigue are consistent with those observed in laboratory simulations of irregular work-rest patterns, which have formed the basis for the mathematical models of alertness that have been developed from the 1980s onwards [3,4].

The data from the initial outward flights, where the aircrew were assumed to be acclimatized prior to departure, have been re-analyzed specifically to derive suitable limits for Table A. An average value of five on the SP scale was chosen as representing a reasonable practical limit. At this level, according to the original report by Samn and Perelli [2], 'some performance impairment [is] probably occurring. Flying duty [is] permissible but not recommended'.

Based on data collected from over 250 aircrew on long-haul routes between the Far East and both Europe and North America [5], a functional relationship has been derived between the SP scale and the nine- point Karolinska Sleepiness Scale (KSS). The KSS is a measure of sleepiness [6] that has been validated with respect to decrements in performance and objective measures of sleepiness [6,7]. According to the derived relationship, an average score of five on Samn-Perelli corresponds closely to a probability of 10% that both pilots are at level eight or more on the KSS. Scores of eight or more are known to be associated with a high frequency of microsleeps.

With one exception, the single-sector values in Table A have been derived from the time, rounded to the nearest hour, when the trends in the alertness data from the Haj study reach the value of five on the seven-point SP scale. The exception is between the times of 0800h and 1159h, where the derived 14- hour limit has been reduced by an hour to 13 hours. It was considered that an extrapolation to 14 hours, based on duties that rarely exceeded 12 hours, would be difficult to justify.

As an illustration of the impact of the exercise of commander's discretion, an increase of one hour throughout the table is approximately equivalent to a doubling of the probability, from 10% to 20%, that both pilots are at level eight or more on the KSS.

The multi-sector limits

The correction for multiple sectors has been based on the combined results from three separate studies of short-haul and charter operations [8,9,10]. These studies were carried out with three major short-haul operators based in the UK. The duties involved a maximum of three, five and six sectors respectively, although the large majority of duties included no more than four sectors.

After correcting for all other confounding factors, the increase in fatigue associated with each additional sector was equivalent to approximately 37.5 minutes of extra duty, averaged over all times of day. As the effect of this increase is greater during the night, i.e. between 2200h and 1000h, than during the day, the reduction for multiple sectors has been rounded down to 30 minutes per sector for daytime duties, and rounded up to 45 minutes per sector for night-time duties.

Minimum rest

The basis for the proposed requirement for minimum rest is that sufficient time should be provided to permit an eight-hour sleep period before the start of the following duty. In normal circumstances, allowing for commuting and essential activities such as eating, washing, and so on, twelve hours should be sufficient. If good quality accommodation is provided close to the airport, then this might be reduced by an hour. However, it is unlikely that a further reduction to ten hours would normally provide enough time for a full recovery sleep for the large majority of aircrew.

The 12-hour requirement for minimum rest should apply irrespective of the length of the previous duty, as the length of that duty would not, in itself, extend the requirement for recovery sleep beyond eight hours. However, the timing of the rest period is important. It is well-established that the length of sleep is much reduced during the day due to both physiological and environmental factors [10], and crews are unlikely to achieve eight hours' total sleep even in a daytime rest period of 16 hours. It has therefore been proposed, as a reasonable compromise, to extend the length of minimum rest to 14 hours for a daytime rest period (defined by the extent to which it overlaps the WOCL. The 13-hour limit has been introduced for some rest periods that are mainly during the day, to ensure a smoother transition between 12 and 14 hours.

It is reasonable that the minimum rest after a time-zone transition should depend on the time of day at the departure airport, rather than on the local time of day, as the phase of the body clock is unlikely to have shifted significantly in such a short time. However, for unacclimatised crews, the desychronisation of the body clock with the local environment will make it more difficult to obtain adequate sleep. In these circumstances, a 'worst case' minimum of 14 hours is recommended.

Some provision, in the form of a weekly rest period, is recommended in order to recover from the cumulative fatigue that tends to build up over consecutive periods of duty [11]. In addition, consecutive night duties are associated with a reduced duration and quality of sleep, and sufficient time should be provided for the recovery of the normal sleep-wake pattern before other flight duties are resumed.

Unacclimatised crews

When crews become unacclimatised to the local environment, an alternative to Table A is required. However, after only a single day in a new location, it is unlikely that the body clock will have adjusted by more than a couple of hours. In that case, it is still reasonable to base the duty limits on the base time of day, as long as a small reduction is applied to Table A to allow for some sleep disruption and for some small shift in the rhythm. This is the reasoning behind the use of Table B, in which a reduction of one hour, to a minimum of nine hours, has been applied to Table A.

After a layover of two days, it is still proposed to use Table B, applied to the base time of day, if the crews are returning to base. This is because, even after a long time-zone transition, crews tend to adjust their work-rest patterns keeping in mind home time, and this appears to limit the extent of their circadian adaptation [12].

The method for calculating the maximum FDP following layovers of any duration is given by the table in paragraph 4.7.3.1. For the longer layovers, there will be a period of great uncertainty, where the circadian phase can change very rapidly and where the amplitude of the circadian rhythm can be greatly reduced. As has been shown both in laboratory simulations of a ten-hour eastward shift [13], and by aircrew following an eight-hour eastward transition [14], individuals may respond by either a phase advance or a phase delay, and their patterns of adaptation may vary considerably. During this period of uncertainty, the conservative approach, which has been adopted here, is to assume the worst case and limit single-sector duties to the minimum value of nine hours.

The rates of adaptation implicit in the table have been derived from the circadian model underlying the SAFE program [15]. This is based on the output from a forced van der Pol oscillator [16], where the parameters have been chosen for consistency with the results from laboratory and field studies [17,18].

Other features of the table are:

(i) When the layover is sufficiently long to assume that adaptation is almost complete ('partial acclimatisation'), Table B is applied based on local time. When adaptation is assumed to be complete, Table A is applied based on local time.

(ii) The table reflects the longer time required to re-adapt after an eastward than after a westward transition [e.g. 19].

(iii) The layover time bands are deliberately centred on multiples of 24 hours, as this corresponds to the duration of the majority of layover periods.

If a series of duties is undertaken without re-acclimatisation being achieved at any intervening point, then the simple application of the table to the current layover may not be appropriate. The simplified approach that has been adopted is to use the current layover only if the crewmember had at least partially adapted to the previous location. Otherwise the calculation should be based on the location to which the crewmember was last acclimatised, or partially acclimatised.

Recovery

The same methodology used to determine acclimatisation rates on layover, namely the output from the SAFE model, has been used here to estimates rates of recovery on return to base. However, because of the large individual variation, particularly after long time-zone transitions, it should not be assumed that all aircrew will adapt within these times. On the other hand, many will adapt more rapidly.

The values in Table F relate to the re-adaptation of the body clock. In most cases, the sleep-wake pattern will adjust more rapidly than this, and the circadian desynchronisation may not be immediately apparent to the individual concerned. However, unanticipated changes in the structure of sleep, particularly in the balance between REM and non-REM sleep, have sometimes been observed several days after the sleep pattern had apparently returned to normal [13,14]. In addition, after short periods away from home base, the circadian rhythm may recover much more rapidly than the sleep-wake rhythm. Therefore, where the return flight is overnight, at least two nights free of duty are recommended before other flight duties are undertaken.

If the return to base follows layovers in multiple locations, then it may not be sufficient to consider the recovery from only the final stop-over point and the disruption at all previous locations needs to be taken into account.

Augmentation

A considerable number of studies have been carried out of the in-flight sleep of aircrew during augmented flights. Some of these have involved the polysomnographic monitoring of sleep in the bunk compartments, and these have shown that, in many situations, crews are able to obtain good recuperative sleep [20,21]. Other studies have used subjective data from a large number of different flights to derive predictions for the quantity and quantity of bunk sleep, dependent on the time of day and the length of the rest period [22,23].

A recent evaluation of the results from the various studies has led to specific recommendations for the extension of the FDP for augmented crews [24], and these form the basis of the current proposed scheme. Depending on the time of day, it was concluded that crews are generally able to sleep on average for at least 33% of their allotted rest period. This value was adjusted downwards to 25% to allow for the possibility of less restful sleep than the ideal, due to environmental factors such as aircraft noise, turbulence, etc. This amount of sleep would allow for an extension to the unaugmented maximum FDP of 75% of the duration of the rest period. This is on the basis of one hour of sleep enabling two hours of wakefulness (cf. eight hours sleep, 16 hours wake, in 24 hours).

An example will illustrate how this approach has been used to derive the values in Tables D and E. Consider the case of a three-crew operation where the maximum unaugmented FDP is 12 hours. If the augmented duty is 15 hours, and the total time available for the crews to take bunk rest during the flight is 12 hours, then each crew member could be allocated a rest period of four hours. On the basis of the 75% rule, the FDP could be extended by 4 x 0.75 = 3 hours, and an extension from 12 hours to 15 hours is permitted.

An adjustment to this rule is required for aircrew who are unacclimatised, as it has been shown that the recuperative effect of bunk sleep is less pronounced for crews on a return flight after a short layover.

Various adjustments are also required if the rest facilities do not meet the standards of a 'good quality' bunk. There have been some studies that have investigated the extent to which aircrew are able to rest and recuperate in seating accommodation. From these, it has been concluded that rest in a 'normal' business class seat separated from the passengers (Class 2 rest facility) is 75% effective compared with bunk rest [25], and rest in a flight deck seat that meets certain minimal standards (Class 3 rest facility) is 33% effective [26]. No data have been collected from aircrew resting in normal economy seating (Class 4 rest facility), and it is not recommended that any increase in maximum FDP be allowed in that case.

Cumulative limits

The definition of acceptable limits for periods of 7, 14 and 28 days is difficult because the development of cumulative fatigue will depend on the extent of the physiological disruption arising from the pattern of work. Limits that are appropriate for daytime operations will inevitably be much too generous for schedules that include a large quantity of night flights or flights across multiple time zones.

A further difficulty is the lack of data on which suitable limits can be based. As a result, any attempt to define such limits has to rely on practical experience and is therefore always open to challenge. One published study from the early 1970s used subjective data collected from B-707 operations to derive limits on the flight duty hours of aircrew that are associated with an acceptable sleep pattern [27]. These restrict flight duty over 7, 14 and 28 days to 50, 72 and 120 hours respectively, and are defined by the so-called 'Nicholson Curve'. However, these limits only apply where the schedules involve the continual disruption of sleep and/or circadian rhythms.

Where the schedules involve little or no disruption, there is even less information available, and it is therefore proposed to adopt the existing limits of CAP371, namely 55, 95 and 190 hours, which at least have the advantage that they have been in place for many years. In addition to the categories of 'disruptive' and 'non-disruptive' schedules, a third category of 'partially disruptive' schedules have been defined, with limits mid-way between the other two. The extent of the disruption is determined by the percentage of the duty periods where there is either some form of circadian disruption (i.e. the crews are unacclimatised) or of sleep disruption (i.e. the duties encroach into the WOCL).

Consecutive earliest/latest/nights

The development of cumulative fatigue tends to be increased during consecutive periods of duty, such as early starts, late finishes or overnight duties, that disrupt the normal pattern of sleep [8,10]. It is sensible therefore to limit the number of these consecutive duties to three, at least where they are close to the maximum FDP limits. However, it is reasonable to allow consecutive periods of four or five duties, as long as the duty limits are reduced to compensate for the possible increased levels of fatigue.

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