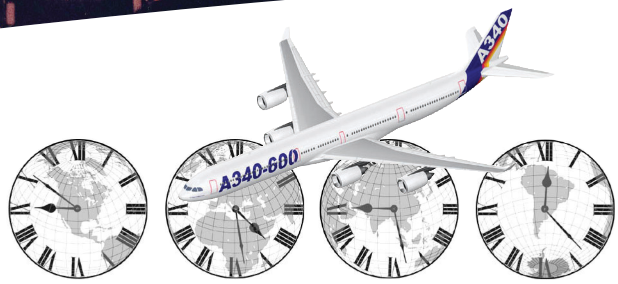

getting to grips with

fatigue and alertness management

Issue III - July 2004

AIRBUS

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Aircrew fatigue during long-haul flights is recognized as one of the major constraints that can impair performance. Using physiological recordings on 196 flights, previous work has shown that reductions in alertness are frequent during flights, including the descent and approach phase (Cabon et al, 1993). Most decreases in alertness occurred during the monotonous part of the cruise and were often observed simultaneously on both pilots in two person crews. Based on these results, specific operational recommendations have been designed. Further studies have shown the positive effects of these recommendations (Cabon et al, 1995a). These recommendations were gathered into a booklet for the use of long-haul aircrews (Cabon et al, 1995b, Mollard et al, 1995). There were initially issued in French by the DGAC and an English version has been issued by Airbus (Speyer et al, 1997), a Chinese version also being available. The English version was distributed by Airbus to more than 6000 samples. This is the third and most updated version including maiden recommendations for ULR flights still to be validated notwithstanding. A new edition will complete this aspect after validation.

Data collection on physiological behavior and crew functions and activities were the result of a joint effort by the Université René Descartes in Paris and Airbus's Training and Flight Operations Support & Line Assistance. Volunteer crews of COTAM, Sabena, Northwest, UTA, Aeromaritime, Air France and Lufthansa provided invaluable cooperation for this years-long effort that led to a solid set of practical recommendations.

Initiated and developed at Sabena (A310), Northwest (A320), UTA (DC-10, B747-200, B747-400) and Aeromaritime (B767) the following recommendations were tested and validated at Air France (B767-300, A340).

This guidebook consists of 3 parts:

- Practical recommendations concerning:

  - pre-flight and in flight rest and activity management,
  - layover rest for westward, eastward and north-south flights.

- Examples of the way to use these recommendations according to:

  - geographical zone
  - crew composition
  - number of time zones crossed
  - number of nights during the layover
  - the extent of adjustment to local-time during the layover
  - departure time for outbound and return flights.

- Syntheses on the terms alertness, fatigue, monotony, circadian rhythms, sleep and napping, jet lag and life hygiene.

This document provides an update version of practical set of recommendations for the use of long-range crewmembers. This version (issue II) aims to:

- take account of advances in the field,
- extent the pre- and in flight recommendations to all long-haul flight schedules (around the clock), including charters flights,
- consider all time zone (+12) for layover recommendations,
- simplify their use.

Indeed, the initial version of the recommendations (issue I) took into account the most frequent situations that aircrew may encounter in terms of flight schedules and time zone transitions. It comprised 20 different cards that the pilots had to adapt to fit their flight characteristics and destination. But, the timing of the flight and the number of time zones crossed was limited to the following categories:

- timing of the flight: Morning (10h) or Afternoon (14h) versus Night (18h),

- the number of time zones crossed: -6 for westward flights and + 8 for eastward flights,

We now take account of the time at which the crew member has to leave their home or hotel, as opposed to the timing of the flight, since it is this that will determine when they have to terminate their sleep and when they are able to nap.

Layover recommendations on arrival depend on base-time, which corresponds to biological time. In addition, the layover recommendations take account of the number of local nights and the number of time zones crossed. The adjustment to local-time depends more on the number of local nights than on its duration in hours. In some cases short layover duration may exceeds 48 hours while the number of local nights remains less than 3.

We also aimed to simplify the use of cards by reducing the total number of cards.

Finally, we plan to develop software based on the various algorithms with a view to implementing the recommendations on a laptop. This would enable the crewmember to simply enter their flight details in order to obtain a detailed set of recommendations that could be tailored to take account of any known individual differences such as morningness-eveningness, sleep quality and quality before and during the flight, the pattern of rest during layover.

During long-haul rotations, partial or complete compliance with the recommendations should allow pilots to:

- better manage their levels of alertness in flight,
- limit sleep loss related to nights and morning flights,
- facilitate, if applicable, adaptation to local layover time, depending on time zone differences

They were successively compiled, structured and written by the following authors: J-J SPEYER, Airbus and S. BOURGEOIS-BOUGRINE, P. CABON, S. FOLKARD, V. NORMIER and R. MOLLARD, Université René Descartes, Laboratoire d'Anthropologie Appliquée, Paris, France.

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Aeronautical

ACARS :	Aircraft Communications Addressing and Reporting System
AFS :	Automatic Flight System
APP :	Approach
ATC :	Air Traffic Control
ATIS :	Air Terminal Information Service
ATS :	Autothrust System
A/T :	Autothrottle
BRG :	Bearing
CM :	Crew Member
CM1 :	Aircraft Captain or left-seated pilot
CM2 :	Aircraft First Officer or right-seated pilot
C/L :	Checklist
CDU :	Control & Display Unit (cathode ray tube)
CRM :	Crew Resource Management
ECAM :	Electronic Centralized Aircraft Monitor
EICAS :	Engine Indicating Caution & Advisory System
EFIS :	Electronic Flight Instrument System
ELS :	Electronic Library System
ETOPS :	Extended Twin Operations
ETP :	Equitime Point
FAC :	Flight Augmentation Computer
FFCC :	Forward Facing Crew Cockpit
FBW :	Fly-By-Wire
FCOM :	Flight Crew Operating Manual
FCU :	Flight Control Unit
FD :	Flight Director
FMS :	Flight Management System
FMGS :	Flight Management and Guidance System
FWC :	Flight Warning Computer
GA :	Go Around
G/S :	Glideslope
HF :	High Frequency
IMC :	Instrument Meteorological Conditions
ILS :	Instrument Landing System
LOC :	Localizer
MCDU :	Multipurpose Control & Display Unit
MCP :	Mode Control Panel
NAV :	Navigation
ND :	Navigation Display

PF	:	Pilot Flying
PFD	:	Primary Flight Display
PNF	:	Pilot Not Flying
PROF	:	Profile
SD	:	System Display
SOP's	:	Standard Operating Procedures
SSR	:	Secondary Surveillance Radar
VHF	:	Very High Frequency
VMC	:	Visual Meteorological Conditions
VNAV	:	Vertical Navigation
VOR	:	VHF Omni Range
WD	:	Warning Display

General

ADL	:	Aircrew Data Logging System
AWM	:	Airbus Workload Measure
DGAC	:	Direction Générale de l'Aviation Civile
DUNLAP	:	Dunlap & Associates, Inc, Norwalk, Connecticut, USA
OCV	:	Organisme de Contrôle en Vol
PC	:	Personal Computer
FAA	:	Federal Aviation Administration
NASA	:	National Aeronautics & Space Administration

Medical

α	:	Alpha
β	:	Beta
δ	:	Delta
θ	:	Theta
ECG	:	Electro-cardiography
EEG	:	Electro-encephalography
EOG	:	Electro-oculography
GERPA	:	Groupe d'Etude et de Recherche en Physiologie Ambulatoire
LAA	:	Laboratoire d'Anthropologie Appliquée, Université René Descartes – Paris V
LPA	:	Laboratoire de Physiologie des Adaptations, Faculté de Médecine Cochin – Port Royal Université René Descartes – Paris V
RR	:	Time interval between two ventricular heart contractions

1. INTRODUCTION AND BACKGROUND

Initial flights starting at Sabena on A310 in 1990

Initial flights on A340 at Airbus Flight Test in 1992

Far Eastern flights on B747-400 at UTA in 1990

North American flights on B767-300 at Air France in 1993

This document provides a practical set of recommendations for the use of long-range crewmembers:

- alertness decrement,
- sleep,
- napping,
- life hygiene.

During long-haul rotations, partial or complete compliance with these recommendations should allow pilots to:

- better manage their levels of alertness in flight,
- limit sleep loss related to night flights,
- facilitate, if applicable, adaptation to local layover times, depending on time zone differences.

The choice of recommendations will of course have to be adapted to the circumstances. Partial reliance on these recommendations is therefore also acceptable.

To help the reader we should refer to two synonyms regularly used:

- **alertness** for level of arousal or wakefulness
- **jet-lag effects** for circadian desynchronosis.

This guidebook consists of three parts:

- A brief summary of research conducted by LAA-GERPA of the René Descartes University (Paris V) in cooperation with AIRBUS on alertness and sleep with long-haul flight crews,

- Practical cards concerning:
  - pre-flight rest and flights,
  - layover rest for westward eastward and north-south flights.

- Short summaries concerning alertness levels, alertness decrement, sleep, jet-lag effects, etc.

Summaries are provided to help with adapting or customizing recommendations, keeping all personal or cultural sleeping habits and social rhythms in mind. They can be used as a basis for adapting recommendations to cope with extreme cases, as for example, very early departures and/or very short layovers (cargo flights).

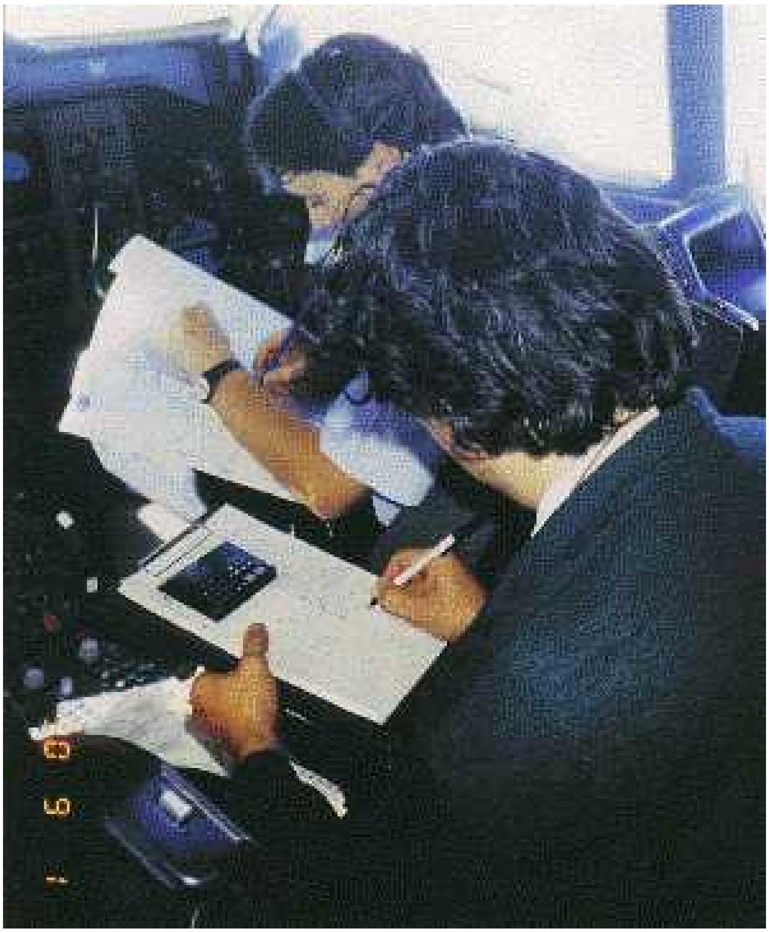
The preventive aspect of these practical suggestions must be emphasized. Their validity is not only based on most recent scientific knowledge but, above all, they reflect experimental validations conducted with long-haul technical crews.

Better sleep management through knowledge of one's own biological rhythms is a genuine personal undertaking. Once committed to, it should rapidly improve general well-being in one's professional activities and extra-professional life.

This approach provides a real contribution to improve health for air crew and air transport safety.

North American Flights on DC-10-30 at UTA in 1990

Delivery Flights to Northwest on A320 in 1991

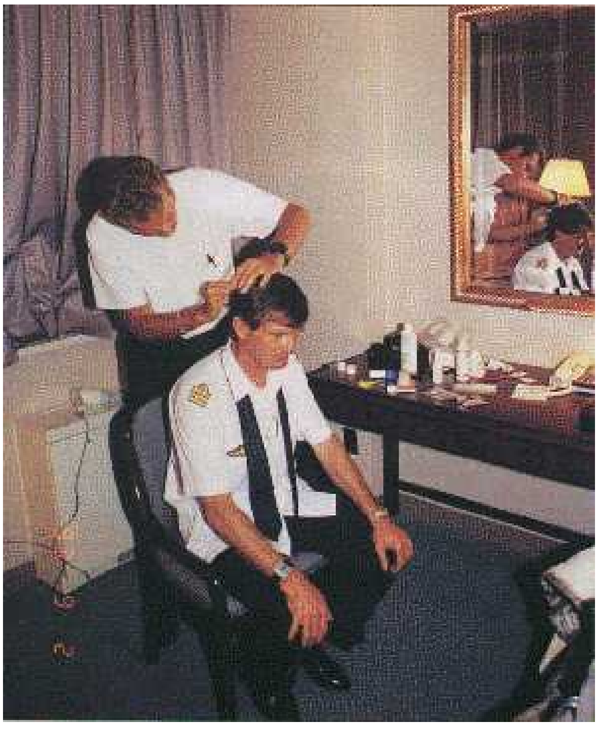


Taking handwritten flight logs at Sabena in 1990

Aircrew Data Logging with laptop computer at Air France in 1993

2. DEVELOPING AND VALIDATING RECOMMENDATIONS: MAIN RESULTS

Preparing Sabena pilots for ambulatory monitoring before departure

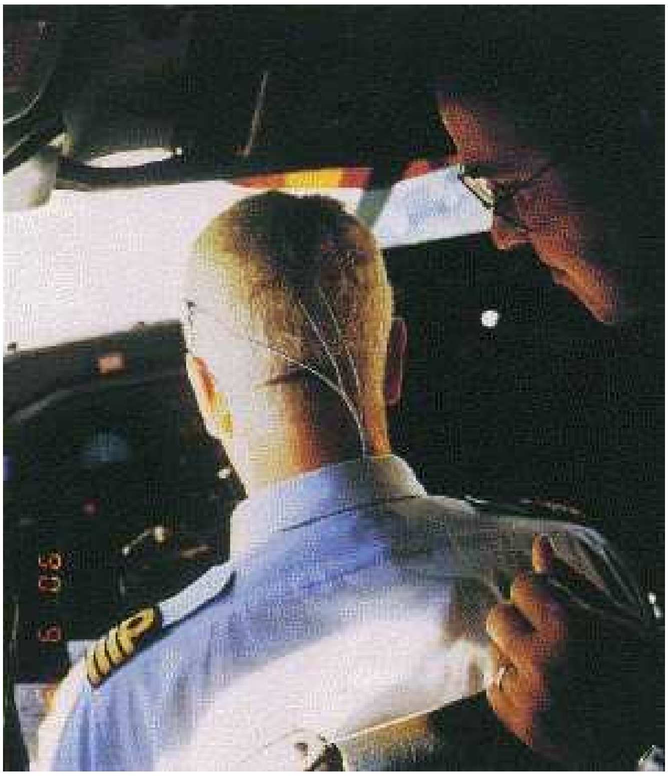


Preparing Air France pilots for ambulatory monitoring before departure

Preparing Sabena pilots for ambulatory monitoring before departure

Sabena pilots equipped for ambulant monitoring preparing their flight


Air France pilots equipped for ambulant monitoring at Crew Briefing



Checking EEG encephalographic recording before take-off at Sabena

Checking EKG heart rate recording during cruise at Air France

Pre-Take off Briefing during Taxi on A340-200

Top of Descent Briefing at the end of Cruise on A310-200

The recommendations concerning the alertness and sleep of long-haul aircraft crews were developed following research conducted by LAA-GERPA. This endeavor, grant-aided by DGAC, was performed in three stages:

1 - Objective measurements of alertness decrement occurrences and sleep loss for pilots engaged in long- and very long-haul flights.

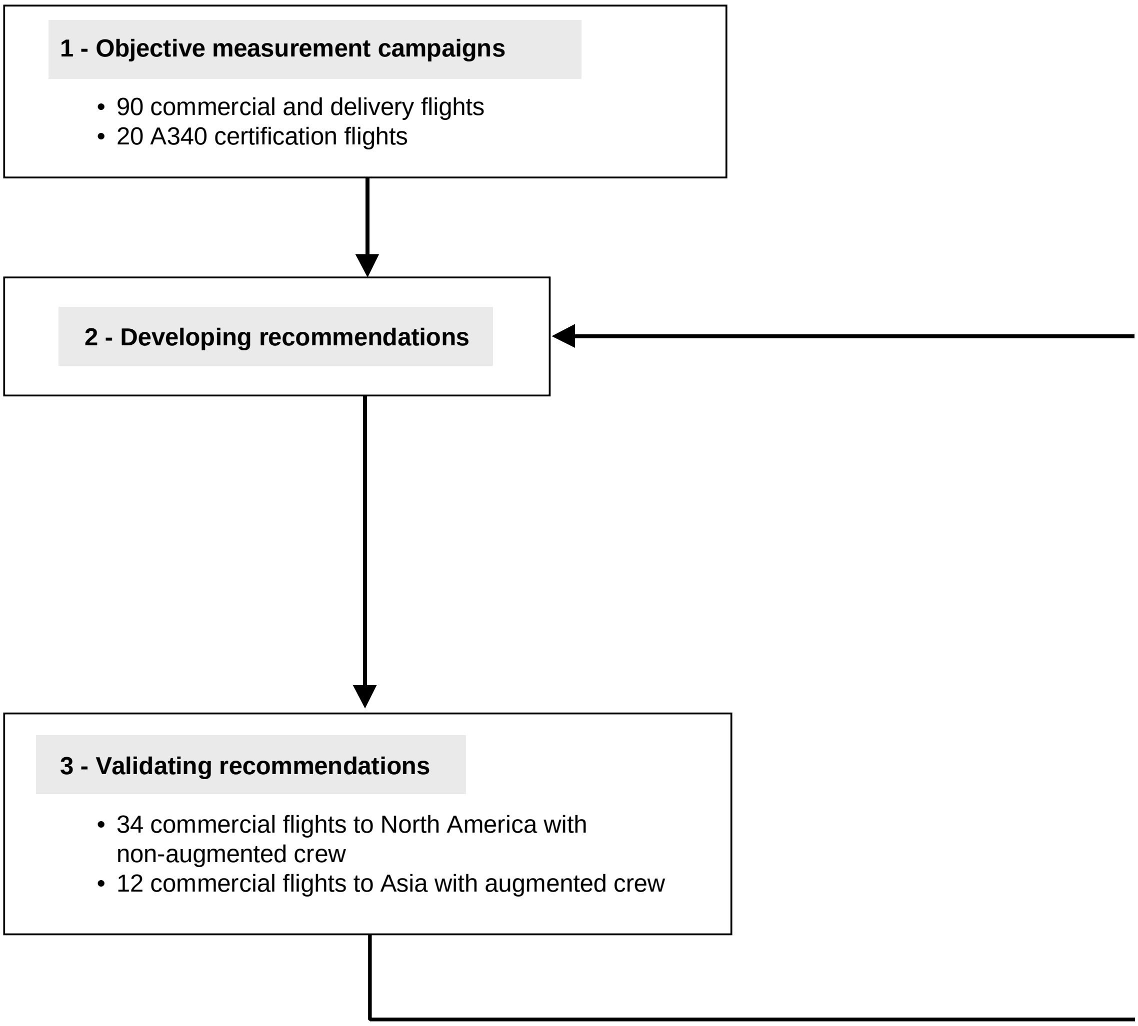
2 - Developing recommendations.

3 - Validating recommendations.

The part related to observation of flight management activities and workload measurement was performed in cooperation with AIRBUS operations engineers who participated activity to all flights.

Voluntary crews from several airlines, SABENA, NORTHWEST, UTA, Aeromaritime, LUFTHANSA, AIR FRANCE participated in this project. A total of 156 flights was made to various destinations on different types of aircraft: Boeing 747-200 and 747-400, Boeing 767, Mac Donnell Douglas DC-10, Airbus A310, Airbus A320 (delivery flights), and Airbus A340.

Our recommendations are also based on recent data from scientific literature in the aeronautical field and on the work conducted at LAA. This relates to alertness, sleep and rest-activity scheduling for personnel involved in supervisory activities and engaged in shift work and irregular working hours.


1 - Objective measurement campaigns
• 90 commercial and delivery flights
• 20 A340 certification flights
2 - Developing recommendations
3 - Validating recommendations
• 34 commercial flights to North America with non-augmented crew
• 12 commercial flights to Asia with augmented crew

Literature

- Main work:
  - resynchronization of biological rhythms after transmeridian flights (Klein and Wegmann, 1974)
  - sleep and jet lag (Nicholson et al. 1986; Sasaki et al., 1986)
  - cockpit napping effects (Graeber et al., 1990)

(refer to syntheses)

LAA work

- Impact of monotony breaks on alertness and operators' performance (Cabon, 1992):
  - laboratory work
  - validation with military air surveillance operators
  - findings with control room operators in nuclear powerplants.
- Use of bright light to prevent disorders related to changes in sleep-wake schedules (Bougrine, 1994):
  - laboratory work
  - validation with operators working on offshore barges
  - prevention of jet-lag in top-level sportsmen who travel.

(refer to syntheses)

Recommendations booklet

- Recommendation cards
  - Pre-flight rest
  - In-flight rest and activities management
  - Layover sleep management
- Syntheses: alertness levels, circadian rhythms, sleep, napping, etc.

2.1. OBJECTIVE MEASUREMENT CAMPAIGNS

2.1.1. ALERTNESS LEVELS AND DECREMENTS IN LONG-HAUL TECHNICAL CREWS

PERIODS CHARACTERIZED BY ALERTNESS DECREMENTS OCCUR FREQUENTLY:
UP TO 15 % OF ACTIVE DUTY TIME SPENT IN COCKPIT

These periods are predominantly observed:

– during transatlantic (Europe-North America) and north-south flights with non-augmented crews, somewhat less frequently on transcontinental flights (Europe-Asia),
– during quiet cruise phases, when the crew is not engaged in any specific activity (monitoring),
– immediately after meals or snacks,
– during periods favouring sleep (11pm – 1am and 1pm – 3pm).

They often occur:

– simultaneously for both pilots, <u>even for basic non-augmented crews</u>,
– during critical phases (e.g. descent) or when the crew <u>is performing tasks related to flight management</u> (i.e. radar control, etc.).

These are reduced under certain circumstances:

– verbal communications,
– motor activities associated with mental tasks, for example, navigation management (i.e. FMS).

Observing the crew's activity reveals a spontaneous tendency to synchronize periods of activity and rest which can explain the occurrence of simultaneous alertness decrements. In addition, the mutual knowledge that the pilots may have of the aircraft and the sector may contribute towards reducing the alertness levels.

2.1.2. LAYOVER SLEEP DURATION AND QUALITY

SLEEPING DURATION AND QUALITY ARE REDUCED BY JET-LAG AND NIGHT FLIGHTS

The following is observed:

– extensive sleep loss related to night flights,
– layover sleep, timing, duration and quality are not significantly affected on transatlantic rotations when the outbound flights are made during daytime,
– rebound effects on layover sleep for rotations comprising night-time outbound flights eastwards-westwards. An increase in the duration and a reduction in the quality of sleep leading to very frequent awakenings typically characterize a rebound effect.

2.1.3. DURATION AND QUALITY OF IN-FLIGHT SLEEP WITH AUGMENTED CREWS

THE DURATION AND QUALITY OF IN-FLIGHT SLEEP DEPEND ON THE PREVIOUS PERIOD SLEEP AND ON THE REST TIME SCHEDULING IN FLIGHT

The following is observed:

– absence of crew coordination in the days preceding the flight and, therefore, insufficient preparation for the rotation not taking into account in-flight rest schedules.

This results in:

– short sleeps of poor quality for rests taken during the early part of the night flight,
– longer duration and better quality of sleep during the latter parts of the flight.

2.2. DEVELOPING RECOMMENDATIONS

AIMS:
TO REDUCE ALERTNESS DECREMENT EPISODES IN FLIGHT, MAINLY THOSE OCCURRING SIMULTANEOUSLY FOR BOTH PILOTS THROUGH:
- **GOOD SLEEP MANAGEMENT,**
- **ORGANIZATION OF ACTIVITIES REDUCING MONOTONY IN THE COCKPIT,**
- **OPTIMAL FLIGHT REST ORGANIZATION.**

The recommendations:

- Sleep and nap management before the rotation as a function of in-flight rest times, when this can be planned in advance.
- Management of in-flight activities and rest:
  - desynchronization of activity and rest periods for the two pilots: alternating passive and active vigilance phases every 20 to 40 minutes with formal handover between pilots; this recommendation should contribute to enhance crew cooperation,
    - alternating meals,
    - mainly for night flights: making use of passive vigilance phases to take a nap of 20 to 40 minutes,
    - for flights with augmented crew, modulation of rest time according to its timeframe: in particular, increasing rest duration when taken during first part of flight.
- Layover rest :
  - adjustment to local time or not, depending on the number of the nights during the layover and the number of time zones crossed,
  - sleep and nap management,
  - exposure to daylight, moderate physical exercise,
  - food hygiene (drinking of coffee, tea, etc.)

These recommendations have been devised to be adaptable to all long-haul flights. Their strict application pertains mainly to extreme situations, in particular for cargo flights, with very early departures (6am) and including very short layovers (less than 24 hours).

2.3. VALIDATING RECOMMENDATIONS

Validation was carried out in two stages:

- validation on 34 transatlantic long-haul flights, flight times varying between 8 and 11 hours,
- validation on 12 very long-haul flights to Asia, with augmented crew, including flights of 12 to 16 hours.

Recommendations proved their efficiency by significantly reducing rates of alertness decrements for both outbound and return flights.

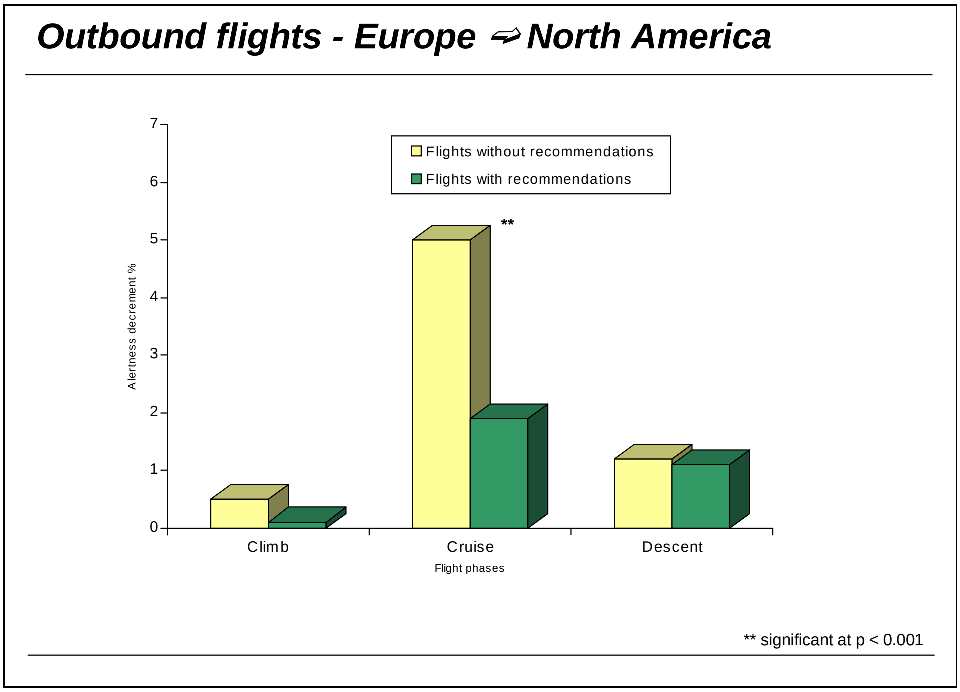
This reduction was particularly noticeable for cruise phases and could be attributed to a drop in sleep pressure and monotony in the cockpit.

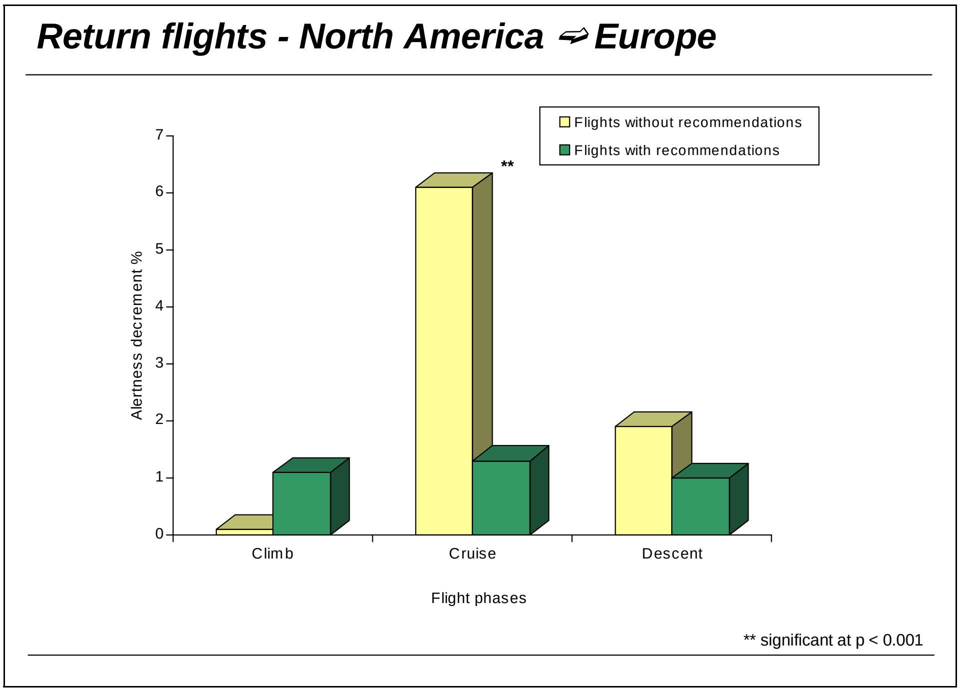
Validating Recommendations at UTA on B747-400 in 1991

Validating Recommendations at Sabena on A310 in 1993

2.3.1. RESULTS

2.3.1.1. LONG-HAUL TRANSATLANTIC ROTATIONS





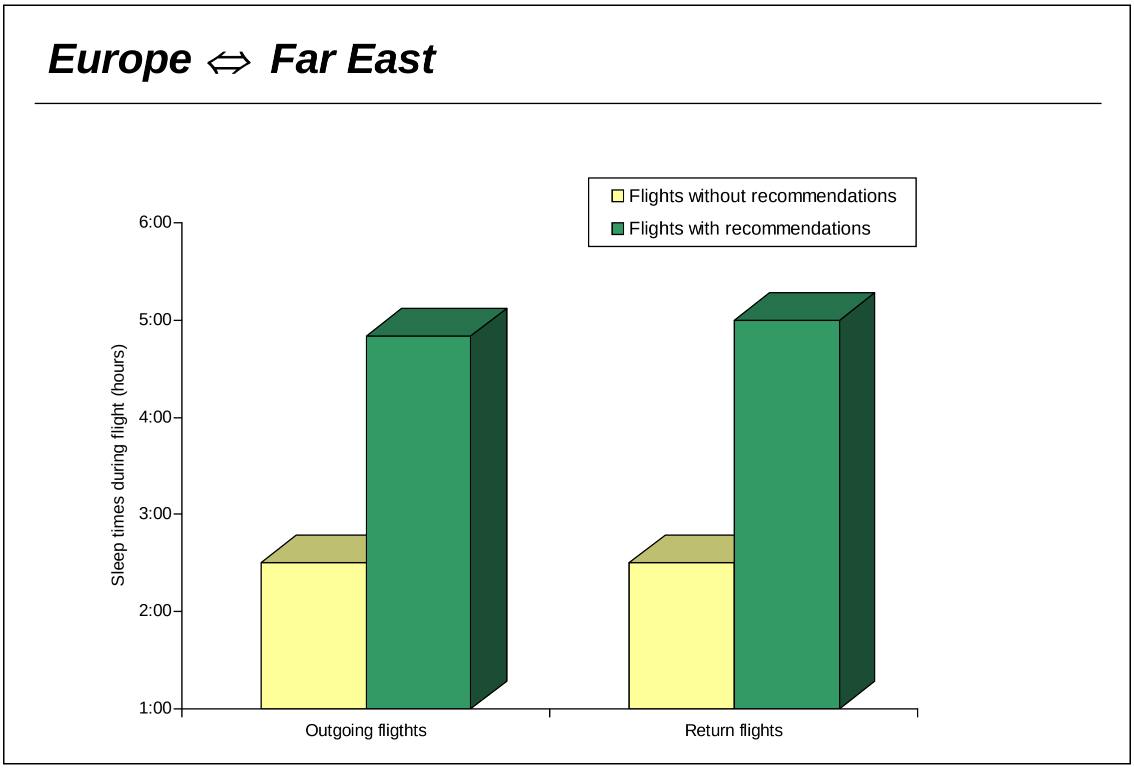
The alertness decrement percentage (%) was determined for each flight period. It was calculated taking into account the effective active presence of pilots in the cockpit.

2.3.1.2. VERY LONG-HAUL FLIGHTS TO ASIA WITH AUGMENTED CREW

2.3.1.2.1. Sleep duration and quality during flight

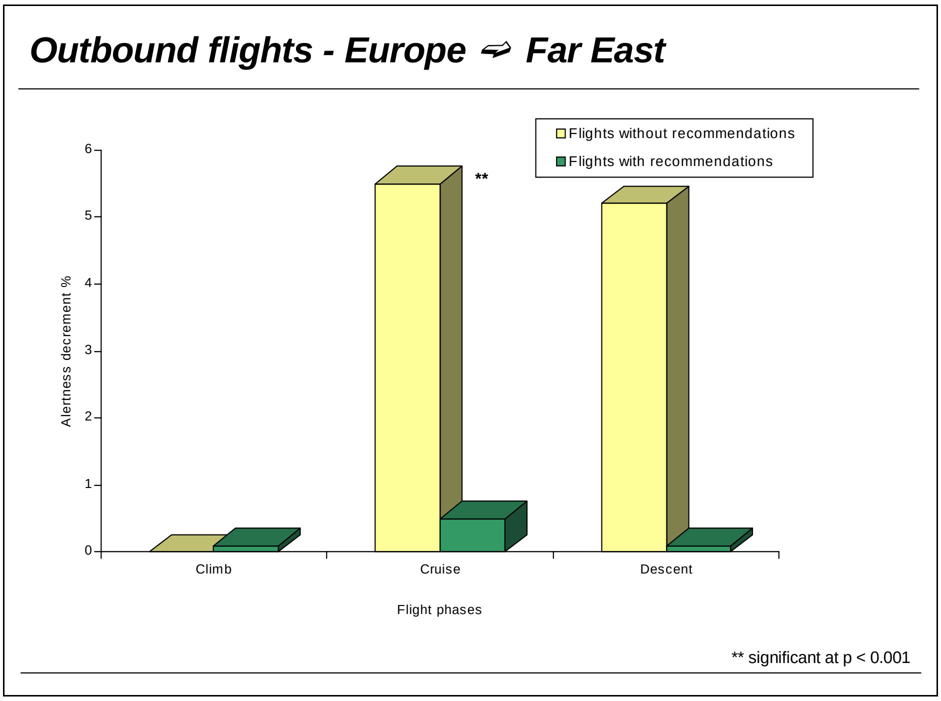
The recommendations contribute towards:

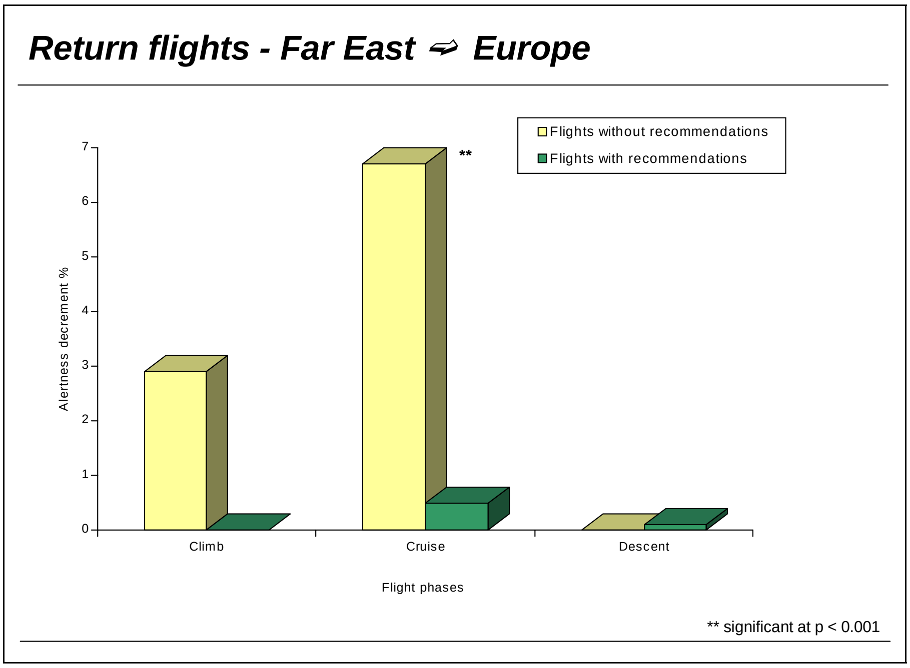
- better distribution of sleeping times, irrespective of rest schedule,
- significant increases in sleep duration and quality during in-flight rest periods.



2.3.1.2.2. Alertness decrement percentages during flight

As with flights made with basic non-augmented crew, recommendations reduced the alertness decrement percentages both for the outbound and return flights. This reduction can be attributed to an increase in sleeping times during in-flight rest periods and to a reduction in monotony in the cockpit.





The alertness decrement percentage (%) was determined for each flight period concerned. It was calculated taking into account the effective active presence of pilots in the cockpit.

2.4. PARALLEL COMPANION STUDIES

Companion studies on crew workload and crew observation were carried out in parallel to the ambulatory monitoring work described in the above. Initiated with minimum crew studies as from the early 1980's, crew workload was first estimated by means of subjective rating and subsequently resulted in an objective measure to be described in 4.1. Likewise, the observation of crew functions and activities was first performed by paper and pencil, subsequently complemented by coding grids and ultimately resulted in a dedicated computer software to be described in 2.4.2.

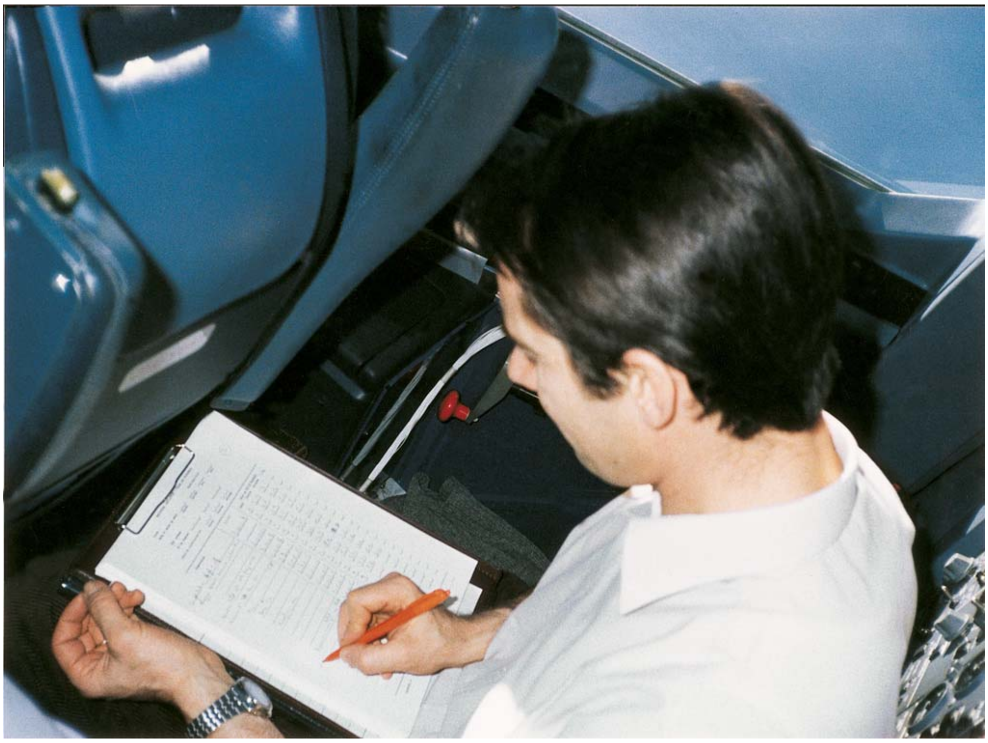
2.4.1. WORKLOAD MEASURE

The Airbus Workload Measure is based on a statistical model that predicts the rating a pilot would have given on the seven point Airbus Rating Scale (values two through eight). This scale is the core of the Airbus dynamic workload assessment technique, which was used for the certifications of the A300 FF, A310 and A320 aircraft. The Minimum Crew Campaign of the A320 certification in January 1988 was the first opportunity to use the Airbus Workload Measure in parallel with actual pilot ratings to demonstrate the workload characteristics of a new aircraft. It showed excellent correspondence between the Airbus Workload Measure values and the actual subjective quotations given by the pilots during the certification flights. The whole AWM-project resulted in a patent held by Airbus, Dunlap & Associates and the Laboratory of Adaptation Physiology at Cochin Faculty of Medecine in Paris.

The success of the Airbus Workload Measure in the A320 certification led to its use in this ongoing study of vigilance and workload in long range airline flights on a variety of aircraft types. In turn, this led to an agreement to use it as the primary workload measure during the A340 Minimum Crew and Route-Proving Campaigns which were conducted in late 1992.

A specific value of the Airbus Workload Measure for one pilot at a particular second of flight is calculated from a combination of aircraft flight parameter data, such as airspeed, angle of attack and roll angle, heart rate variability data on *both* pilots and flight status measures such as whether or not a checklist was being run by the crew. The flight status data are derived from observations of the crew either directly or via video and audio from the cockpit and recorded on paper or by using the Aircrew Data Logging System (ADL).

Pilot and Observer rating of flight scenarios on the 7 points Airbus Rating Scale in 1983



Observer Logging of Cockpit Pilot Activities in the Cockpit in 1982

Observer Logging from closed circuit television in the Cabin in 1981

2.4.2. AIRCREW DATA LOGGING SYSTEM

The Aircrew Data Logging System (ADL) is a computer-based tool to be used by observers to create a record of selected system events. The ADL record forms a timeline of the observed events, which can be integrated with other time-based records of system events, as well as with external time-based records.

Because it is computer based, ADL is a highly structured system, and this structure directly affects how and how well it can be applied to a system of interest. In our case this consisted in defining a script involving variables pertaining to crew behaviors, vigilance and alertness, crew activity and flight functions.

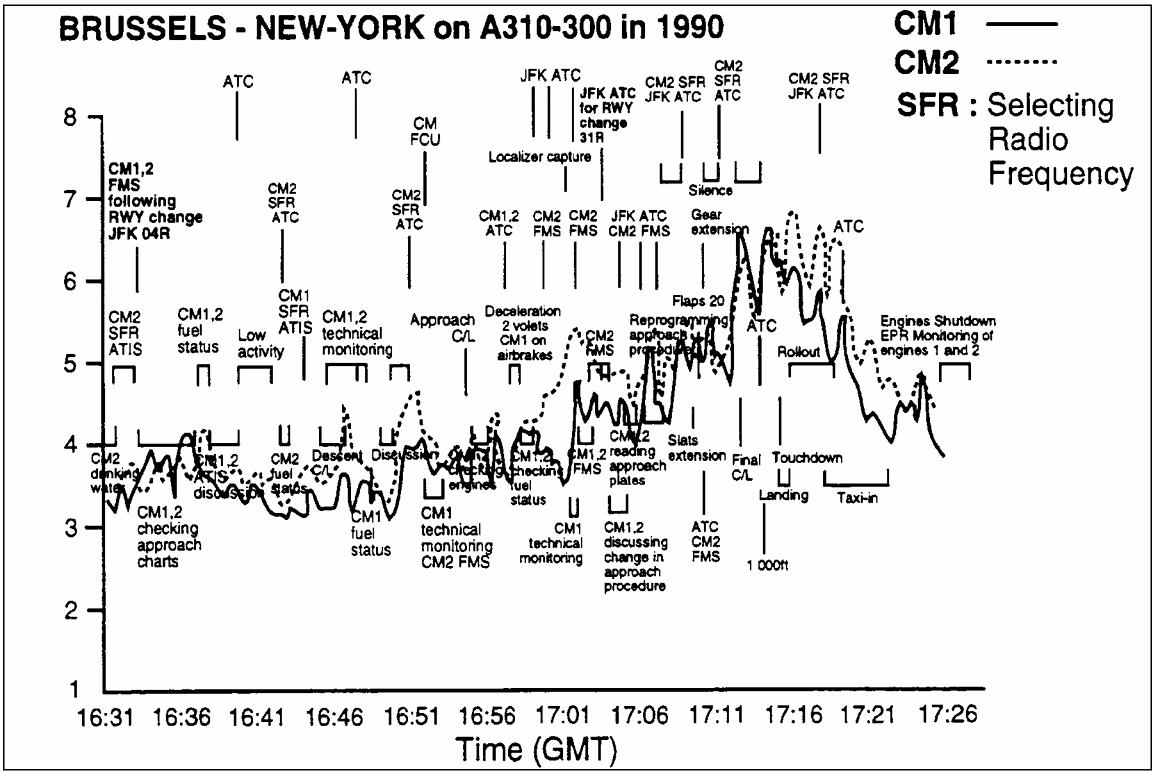
ADL (which runs on a standard notebook computer) was developed to support:

- the preparation of a narrative description of each flight,
- the collection of the status data needed by the Airbus Workload Measure
- the collection of information required to analyze a data base of physiological measures taken on those pilots who volunteered.

2.4.3. RESULTS FROM WORKLOAD MEASUREMENT

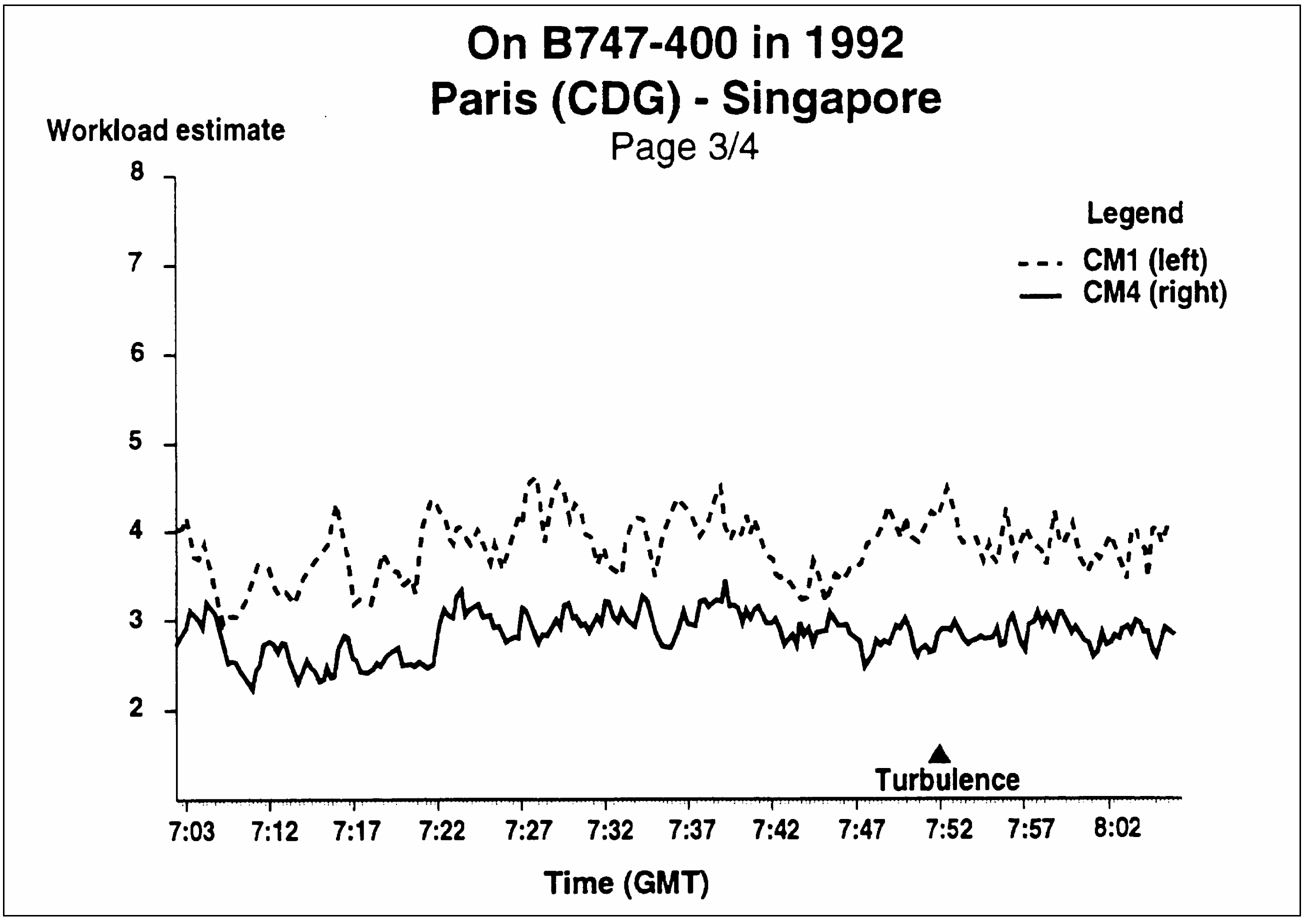
Examination of crew workload timelines shows several interesting patterns. First, the high workload imposed on pilots from flying into busy or unfamiliar airports and at the end of long night-time flights is suggested by many of the landings.

Measuring crew workload in airline operations: approach & landing example



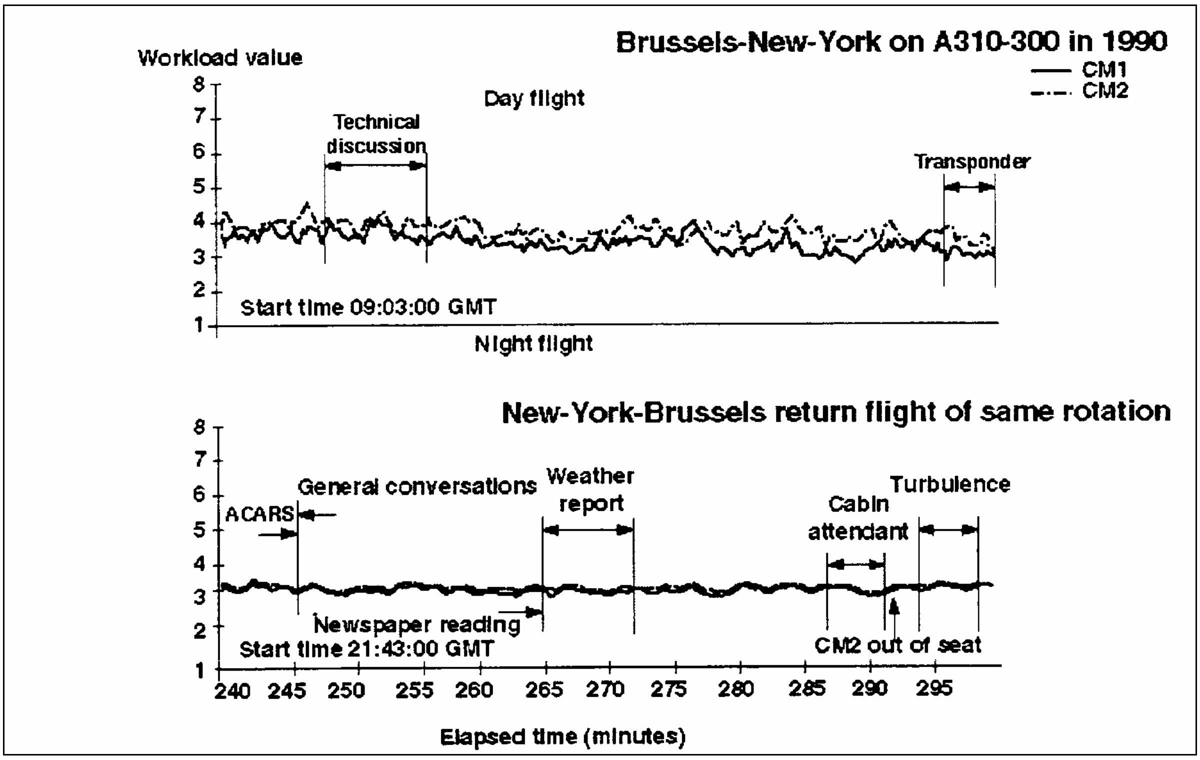
Second, there are several periods of relatively higher workload evident in some of the timelines. These do not appear to correlate with logged stressful events. They may be the result of additional transient data artifacts, which eluded the various screens in the processing programs. Alternatively, they could be real periods of elevated subjective mental workload, which are internally generated by the pilots as a result of cognitive activities (related or unrelated to the flight).

Measuring crew workload in airline operations: cruise segment example



Third, the cruise portions of those flights occurring at night seem to show a lower second-to-second variability of workload than the corresponding parts of day-time flights even though the average level of workload is about the same.

Measuring crew workload in airline operations: cruise segment example



This is indicated by their relatively flat timeline curves compared with the "sawtooth" appearance of the timelines for the daytime flights. This suggests that workload variability measures may be a viable predictor of episodes of low crew alertness. Underload may represent the shedding of "discretionary workload" (e.g. loss non-flying tasks, no conversation) which pilots may choose not to generate. This can result in reduced activation levels and increased chances of alertness decrement.

2.4.4. RESULTS FROM AIRCREW LOGGING

Timewise logging of flight events to produce a narrative description of the flights allowed to regroup sequences where both crew-members PF and PNF would actively cooperate.
Two categories emerged:

- long regroupings or **blocks** where both pilots would execute strings of coordinated tasks linked with increased cross-monitoring (e.g. descent preparation),
- short regroupings or **knots** where both pilots would promptly act in concert with each other in short transactions (e.g. navigation monitoring after an ATC message).
- These operational stimuli cause a flight to be structured around a series of blocks and knots where vigilance and cross-monitoring can be expected accrued as compared to routine conditions. These formal meeting periods or points, distinguish themselves from periods, where crew-members' interaction is more lax.

Overall sequence regroupings were found to be naturally related to operational requirements (ATC, FMS, fuel, navigation, systems), key events (weather, traffic, incidents/failures) and crew resource management behaviors (communications, decision-marking and planning, workload and vigilance management).

Comparing workload measurements with a subset of flights where alertness measures (EEG/EOG) were recorded allowed us to observe that:

- alertness decrements would tend to concur with flat workload curves and be located between blocks and knots discussed in the above, with little or no crew conversation,
- variable workload profiles would rarely concur with decreased alertness encounters.

The combined workload and reduced alertness data effectively suggest that periods of high and highly variable workload often seem to prevent or stop brief alertness decrements. Extended periods of low workload are often punctuated by low alertness episodes. Workload for both crewmembers appears to decrease during extended periods of low alertness associated with planned rest or napping.

Flights do really consist of a succession of blocks and knots where workload continually increases and subsides; high peak being dealt with until they return to normal, unless situations or particular flight phases militate against this.

Afterwards alertness decrements may arise until the progressive accumulation of new potential tasks whose regrouping into sequences will, in turn, suspend the alertness phenomenon. These crew regulation cycles are inevitable and need to be managed. Contrary to some expectations, levels of crewmember cross monitoring are not necessarily continuously maintained.

This is how the observation of alternating crewmember activity patterns led us towards the concept of active/non-active monitoring cycles since these were proven to exist implicitly. But the process had to be formalized to result in a practical recommendation: active/passive vigilance largely explained in the other sections.

Aircrew Logging reveal functional behaviors such as alternating crewmember activity patterns

Alternating crewmember activity patterns led us towards the concept of active/non-active monitoring cycles to create monotony ruptures

2.4.5. PRACTICAL PROCEDURES

Possible remedies in crew-generated workload are defined as operational countermeasures and relate to the following:

- Long-range navigation monitoring such as:
  - flight log updating
  - navigation chart plotting (FMS position)
  - course and distance between waypoints
  - IRS drift rate monitoring
  - crosschecking position BRG and/or DME dist with navaids.

- Long-range fuel monitoring such as:
  - extra fuel monitoring (FMS)
  - secondary flight plan/reclearance (ATC)
  - step prediction (ATC)
  - ETP monitoring (ETOPS)
  - weather en route/altitude winds (ACARS or HF)

- Systems monitoring
  - pre-advisory parameter trend checks on ECAM system display pages (every 30 minutes)
  - zooming function (electronic library system).

2.4.6. PRACTICAL PROCEDURES RECOMMENDED ON A340

Based upon the preceding results, the following procedures are now available for cruise operations in the flight crew operating manual of the A340.

They were developed for this aircraft having in mind the low workload/reduced alertness context prevailing in cruise. And they provide practical guidance to support the active/passive vigilance recommendation. Dedicated adaptation to other aircraft types remains necessary however.

A340 FLIGHT CREW OPERATING MANUAL	STANDARD OPERATING PROCEDURES	3.03.15	P 1
	CRUISE	SEQ 001	REV 24

CRUISE

– **ECAM MEMO** . . . . **REVIEW**

– **ECAM SYS PAGES** . . . . **REVIEW**
Periodically review the system display pages and, in particular, ENG oil pressure and temperature.

Note : *Oil quantity variation is not linear during cruise. A rapid decrease can be noted, especially at the beginning of the flight.*
This is due to an oil temperature decrease leading to a longer oil transit time in the sumps (more oil retained in the sumps).

BLEED : BLEED parameters.
ELEC : Parameters, GEN loads.
HYD : Fluid quantity. Green system is lower than on ground, following landing gear retraction.
COND : Duct temperature, compared with zone temperature.
Avoid large differences for passenger comfort.
FLT CTL : Note any unusual control surface position.
FUEL : Fuel distribution, trim tank quantity, and CG.

– **FLIGHT PROGRESS** . . . . **CHECK**

Note : *VLS shown on the PFD ensures a 0.3 g buffet margin and, therefore, no additional margin is necessary in cruise.*

Monitor flight progress in the conventional way.
When overflying a waypoint :
· Check track and distance to the next waypoint.
R When overflying a waypoint, or every 30 minutes :
· Check fuel : Check FOB (ECAM), and fuel prediction (FMGC), and compare with the computer flight plan or the in-cruise quick-check table (Refer to 3.05.20).
· Check that the sum of the fuel on board and the fuel used is consistent with the fuel
R on board at departure. If the sum is either unusually smaller than the fuel on board at
R departure, or if it decreases, suspect a fuel leak.

> CAUTION
> This check must also be performed each time a FUEL IMBALANCE procedure is necessary. Perform the check before applying the FUEL IMBALANCE procedure. If a fuel leak is confirmed, apply the FUEL LEAK procedure.

– **STEP FLIGHT LEVEL** . . . . **AS APPROPRIATE**
(Refer to 3.05.15).

A340 FLIGHT CREW OPERATING MANUAL	STANDARD OPERATING PROCEDURES	3.03.15	P 2
	CRUISE	SEQ 001	REV 25

– **NAVIGATION ACCURACY** . . . . **CHECK**
On aircraft equipped with GPS primary, no navigation accuracy check is required, as long as GPS PRIMARY is available.
Otherwise, navigation accuracy must be monitored, at all times but especially when any of the following occurs :
· IRS only navigation
· The PROG page displays LOW accuracy.
· "NAV ACCUR DOWNGRAD" appears on the MCDU.
Methods for checking accuracy :
· Manually tune VOR (VOR/DME or ADF) to a station that is within range on the RAD NAV page and select associated needles on the ND.
Check that the needle (raw data) overlies the corresponding blue navaid symbol (FM computed) and that the DME distance is equal to the distance showing between the aircraft symbol and the navaid symbol on the ND.
· Or insert a VOR/DME ident in BRG/DIST TO field on the PROG page and compare the computed BRG (DIST) with the raw data on the ND. This method allows the FM error to be quantified.
If the check is positive (error $\leq$ 3NM) : FM position is reliable.
– Use ND (ARC or NAV) and managed lateral guidance.
If the check is negative (error $>$ 3NM) : FM position is not reliable.
– Use raw data for navigation and monitor it.
– If there is a significant mismatch between the display and the real position : disengage MANAGED NAV mode and use raw data navigation (possibly switching to ROSE VOR, so as not to be misled by FM data).

– **RADAR TILT** . . . . **ADJUST**
Below 20000 feet : Start with tilt near zero, then adjust. If using different ranges on the two NDs, set the tilt down for the shorter ND range (in order to monitor and detect weather activity) and near zero for the longer ND range (in order to monitor course changes).
Above 20000 feet : A slight downward tilt is recommended.

– **CABIN TEMP** . . . . **MONITOR**
Pay regular attention to the ECAM CRUISE page, in order to monitor passenger cabin temperatures and adjust them, as necessary.

R ● **If the oxygen mask has been used :**
R
R – **OXYGEN MASK** . . . . **CHECK**
R Check that the oxygen mask has been properly stowed, as indicated in the FCOM
R 1.35.20.

Preparing Capt. Pierre Baud for ambulatory recording before the A340's maiden flight

The A340 on its first climbout on October 25th, 1991

Double logging from remote video on board A340 route proving flight at Air France in November 1992

Landing at Quito with Lufthansa in A340 route proving campaign in November 1992

2.4.7. REVIEW OF FLIGHT & DUTY TIME REGULATIONS

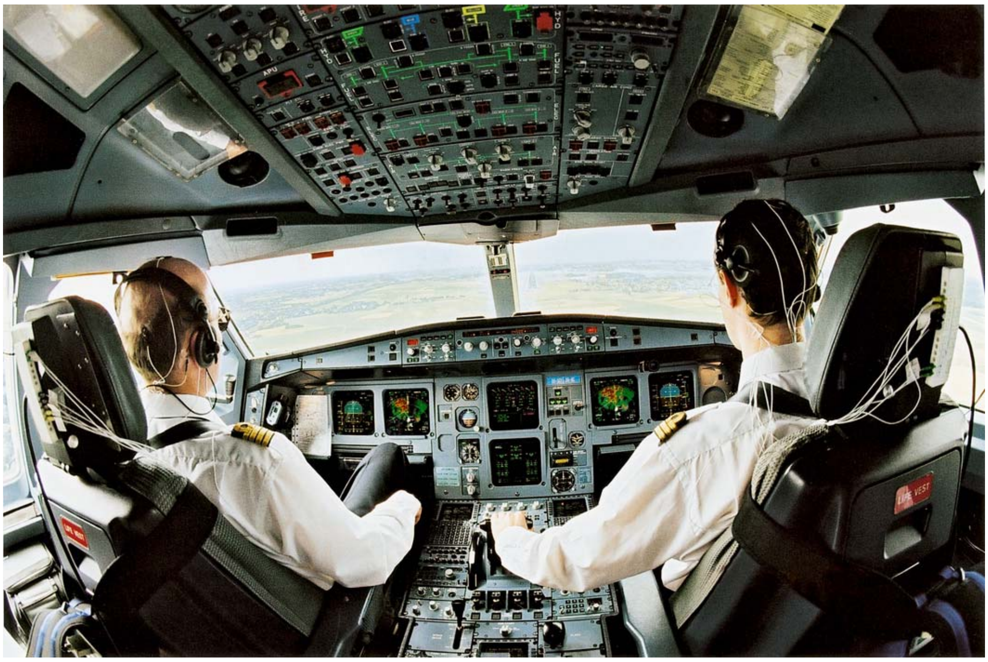
A review of flight and duty time regulations (Cabon et al, 2002) and a survey by questionnaires on fatigue and stress (Bourgeois-Bougrine, 1999, 2002) was also conducted to identify causes and manifestations of fatigue and to propose recommendations or specifications to be included in the definition of work-rest schedules for airlines pilots. Indeed, fatigue reported by short- and long-range (SRF and LRF) pilots corresponds to an acute fatigue related to sleep deprivation due mainly to work schedules: night flights, jet-lag, successive early wake-ups... For SRF, work constraints (time pressure, number of legs per day and consecutive days on) contribute to increase fatigue. The results of this study emphasize first, the need to introduce chrono-biological rules in aircrew scheduling to prevent fatigue or at least to limit its impact ; second, that flight and duty time limitations have to take into account the flight categories because of the additional fatigue effect of multi-leg flights and work constraints in SRF.

2.4.8. ELECTRONIC PILOT ALERTNESS MONITORING STUDIES

Initially, the EPAM concept was aimed at detecting and increasing aircrew alertness by monitoring aircrew activity. The concept was based on the simple assumption that sleepiness tends to decrease the activity of the pilot. Monitoring the number of actions of the aircrew was therefore thought to be a good indicator of a pilot's alertness variations. Below a certain activity threshold, a visual and an aural warning would be triggered in order to increase pilot awareness of possible decrease in alertness. Its former name was the Pilot Guard System (PGS). BAW Captain Adrian Elsey developed the PGS with Page Aerospace (Speyer and Elsey, 1995, Elsey and Speyer, 1996) but a more direct measure of alertness has been subsequently added to the concept. The privacy and acceptability requirements for this system should not comprise any overly intrusive aspects since pilots do not particularly want to be equipped with sensors. The only useable parameter is ocular activity as measured by means of video processing provided the data is de-identified and even erased post-flight. Furthermore, an early review of existing systems in other industries, in particular car driving, shows that ocular activity is very sensitive to alertness variations.

The aim of an EPAM system is also to facilitate napping in the cockpit to decrease sleep pressure. But, as cockpit napping is more and more being allowed by airlines, the risk of sleep inertia in the napping pilot is increased as well as impaired alertness in the non-napping pilot because of increased monotony (reduced communications, lower light intensity). Monitoring of the non-napping pilot should hence contribute to avoid simultaneous sleepiness in the two pilots. The concept is supposed to achieve this. The initial definition of this evolved concept and its early evaluation study was presented in the dissertation of Jean-Jacques Speyer for the Human Factors in Aviation degree of the University Paris 5 (Speyer, 1999). Through an internship at Airbus the following year, Sylvie Denuit and Lieven Caboor and ENSICA performed a further study on different eye and gaze tracking systems available on the market. The common dissertation for their VUB (Vrije Universiteit Brussel) Engineering degree led to a preliminary system specification (Denuit, Caboor 2002) as well as to obtaining the 2002 annual BARCO Award for best inventiveness. Gradually developed over 28 flight trials at the late Sabena between 1999 and 2001, a prototype system was evaluated during a Toulouse-Hong Kong A340-600 Route Proving return flight in June 2002 with further evaluation work to be performed during 2004 and 2005 in the frame of an EC contract called Drive Safe as well as through Airbus France cockpit studies Preface 3. The EPAM system should really be considered as a “safety net” to support controlled cockpit napping, also preventing extreme cases from occurring, i.e. both pilots closing their eyes for an extended period of time. The purpose is not at all to incite crewmembers to be at a high level of wakefulness throughout the flights, but rather to help them to manage their fatigue and alertness in the most appropriate operational way. This need is not just considered for ULR issues (A340-500, A340-600 and A380) but even more so and for prevention purposes on less long, yet still very demanding night long haul or extended medium haul flights on other aircraft (A300/A310, A320/A330/A340).

The EPAM system study as a day & night "safety net" concept



The EPAM system concept to prevent extreme cases from occurring, i.e. both pilots closing their eyes for an extended period of time

EPAM Concept evaluation during a Toulouse-Hong Kong A340-600 Route Proving flight in June 2002 pilots no longer having to be wired up

Crew observation as an essential link between measurements and operational activities to adapt EPAM concept detection algorithms and warning thresholds

2.4.9. OTHER ASPECTS UNDER DEVELOPMENTS

Other aspects of Fatigue and Alertness Management Solutions (FAMS) that we actually promote include critical aspects such as rostering and scheduling, rest area design and life hygiene recommendations, all issues to be considered as real priorities for the efficient prevention of aircrew fatigue and for the maintenance of flight safety.

3. PRACTICAL RECOMMENDATIONS

3.1. CARDS ORGANIZATION

This guidebook consists in 2 parts:

- Practical recommendations concerning:
  - pre-flight and in flight rest and activity management,
  - layover rest for westward, eastward and north-south flights.

- Examples of the way to use these recommendations according to:
  - geographical zone
  - crew composition
  - number of time zones crossed
  - number of nights during the layover
  - the extent of adjustment to local-time during the layover
  - departure time for outbound and return flights.

This document provides an update version of practical set of recommendations for the use of long-range crewmembers, the first issue having been issued in November 1995. This second issue aims to:

- take account of advances in the field,
- extent the pre- and in flight recommendations to all long-haul flight schedules (around the clock), including charters flights,
- consider all time zone ($\pm$12) for layover recommendations,
- simplify their use.

Indeed, the initial version of the recommendations (issue I) took into account the most frequent situations that aircrew may encounter in terms of flight schedules and time zone transitions. It comprised 20 different cards that the pilots had to adapt to fit their flight characteristics and destination. But, the timing of the flight and the number of time zones crossed was limited to the following categories:

- timing of the flight: Morning (10h) or Afternoon (14h) versus Night (18h),
- the number of time zones crossed: -6 for westward flights and + 8 for eastward flights

We now take account of the time at which the crew member has to leave their home or hotel, as opposed to the timing of the flight, since it is this that will determine when they have to terminate their sleep and when they are able to nap.

Layover recommendations on arrival depend on base-time, which corresponds to biological time. In addition, the layover recommendations take account of the number of local nights and the number of time zones crossed. The adjustment to local-time depends more on the number of local nights than on its duration in hours.
In some cases shorter layover duration may exceeds 48 hours while the number of local nights remains less than 3.

We also aim to simplify the use of cards by reducing the total number of cards.
Finally, we plan to develop software based on the various algorithms with a view to implementing the recommendations on a laptop. This would enable the crewmember to simply enter their flight details in order to obtain a detailed set of recommendations that could to tailored to take account of any known individual differences such as morningness-eveningness, the sleep quality and quality before and during the flight, the pattern of rest during layover.

During long-haul rotations, partial or complete compliance with the recommendations should allow pilots to:

- better manage their levels of alertness in flight,
- limit sleep loss related to nights and morning flights,
- facilitate, if applicable, adaptation to local layover time, depending on time zone differences.

3.2. PRACTICAL RECOMMENDATIONS

The recommendations concerning rest and activity management are organized according to the phases of the rotation:

- pre-flight and in flight phases,
- layover phase.

3.2.1. GENERAL REVIEW OF RECOMMENDATIONS PRINCIPLES

Pre- and in flight recommendations aim to reduce alertness decrement episodes during the flight, and in particular those occurring simultaneously for both pilots, through:

- good sleep and nap management before the rotation as a function of the timing of the flight and of the in-flight rest time, when this can be planned in advance (for augmented crew),
- management of in-flight activities to reduce monotony in the cockpit and the optimization of in-flight rest:
  - desynchronisation of activity and rest for the two pilots by alternating passive and active vigilance phases* every 20 and 40 minutes with formal handover between the pilots,
  - alternating meals,
  - for night or when you are sleep deprivated,: making use of passive vigilance phases to take a nap of 20 to 40 minutes,
  - for flights with augmented crew, modulation of rest time according to its timeframe: You should plan a longer rest period or divide your rest into 2 or 3 periods spread out over the flight when taken during unfavorable periods for sleep.

* The active vigilance phases are characterized by:

- verbal exchanges and tasks related to flight management,
- varied motor activities associated with mental tasks, e.g. navigation (FMS) and system (ECAM/EICAS) management,
- no meals during this period.

* The passive vigilance phases are characterized by more dispersed supervision of the flight:

- promote the eating of meals or snacks, if possible at the start of these phases,
- encourage activities not related to the flight (e.g. reading papers),
- if possible take a nap

The alternation between active and passive vigilance phases is mainly justified during the quiet cruise periods. The end of each active-passive vigilance phase must be expressed verbally to the other crewmember so that they will be sure to know which phase you are in.

The *layover recommendations* concern:

- adjustment to local-time or not, depending on the number of nights during the layover and the number of time zones crossed,
- sleep and nap management on arrival at the hotel and before the return flight,
- exposure to daylight, moderate physical exercise,
- food hygiene (drinking of tea, coffee, etc.)

These recommendations depends on:

- geographical zones:

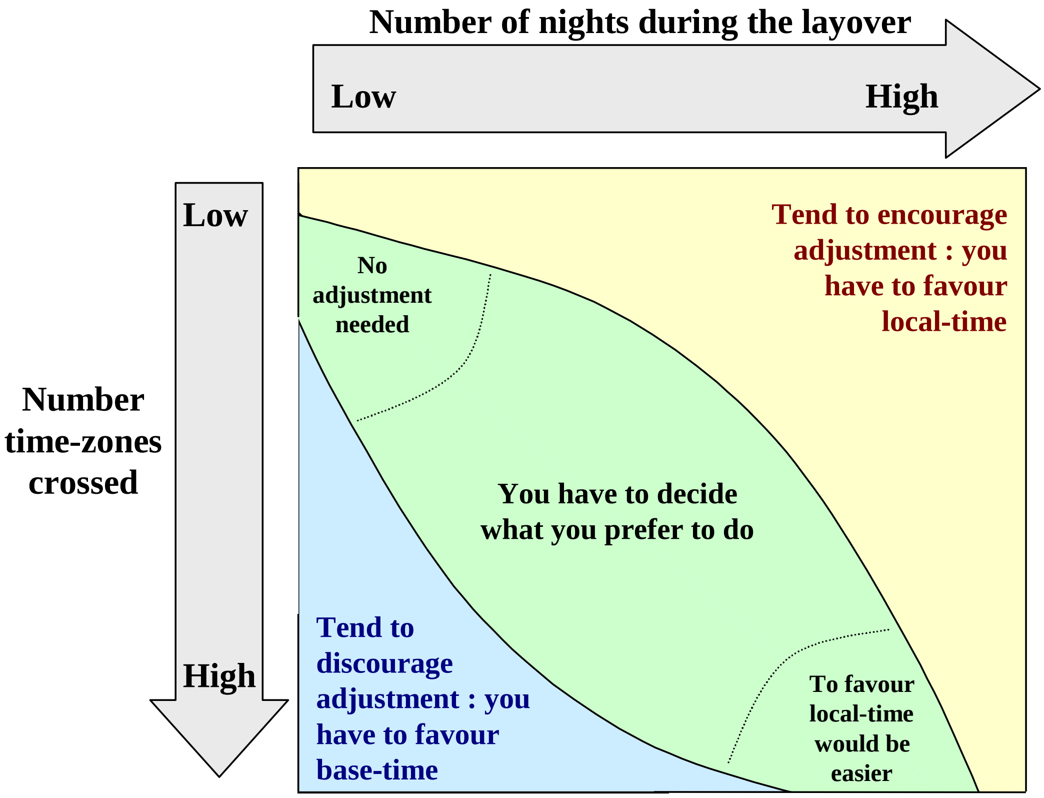
• Westward rotations (WR): time difference travelling, (sup=) base-time – 4,
• Eastward rotations (ER): time difference travelling, (sup=) base-time + 4
• North-South rotations (NSR): 0 to $\pm$3 time differences.

- arrival time, according to base-time, determines sleep and nap management on arrival at the hotel.
- layover duration for WR and ER: the adjustment or not to local-time depends on the duration of the layover in terms of the number of local nights and the number of time zones crossed. (cf figure)

  A high number of nights during the layover and a low number of time zones crossed tends to encourage the adjustment of the biological clock to the local-time. The aim of the recommendations during the layover is to facilitate this adjustment, by favoring the local-time for rest and activities.

  A low number of nights during the layover with a high number of time zones crossed tends to discourage this adjustment. The aim of the recommendations is to prevent the adjustment to the local-time by favoring the base-time for rest and activities.

In the other conditions you will have to decide if you prefer to facilitate the adjustment to local-time or not, with your experience and your subjective feelings (depending on the ease with which you can adjust, what you prefer to do during the layover…)



GEOGRAPHICAL

TIME ZONES

East-West Rotations (EWR)

Time Zone Change (TZC) $\geq$ BT – 4

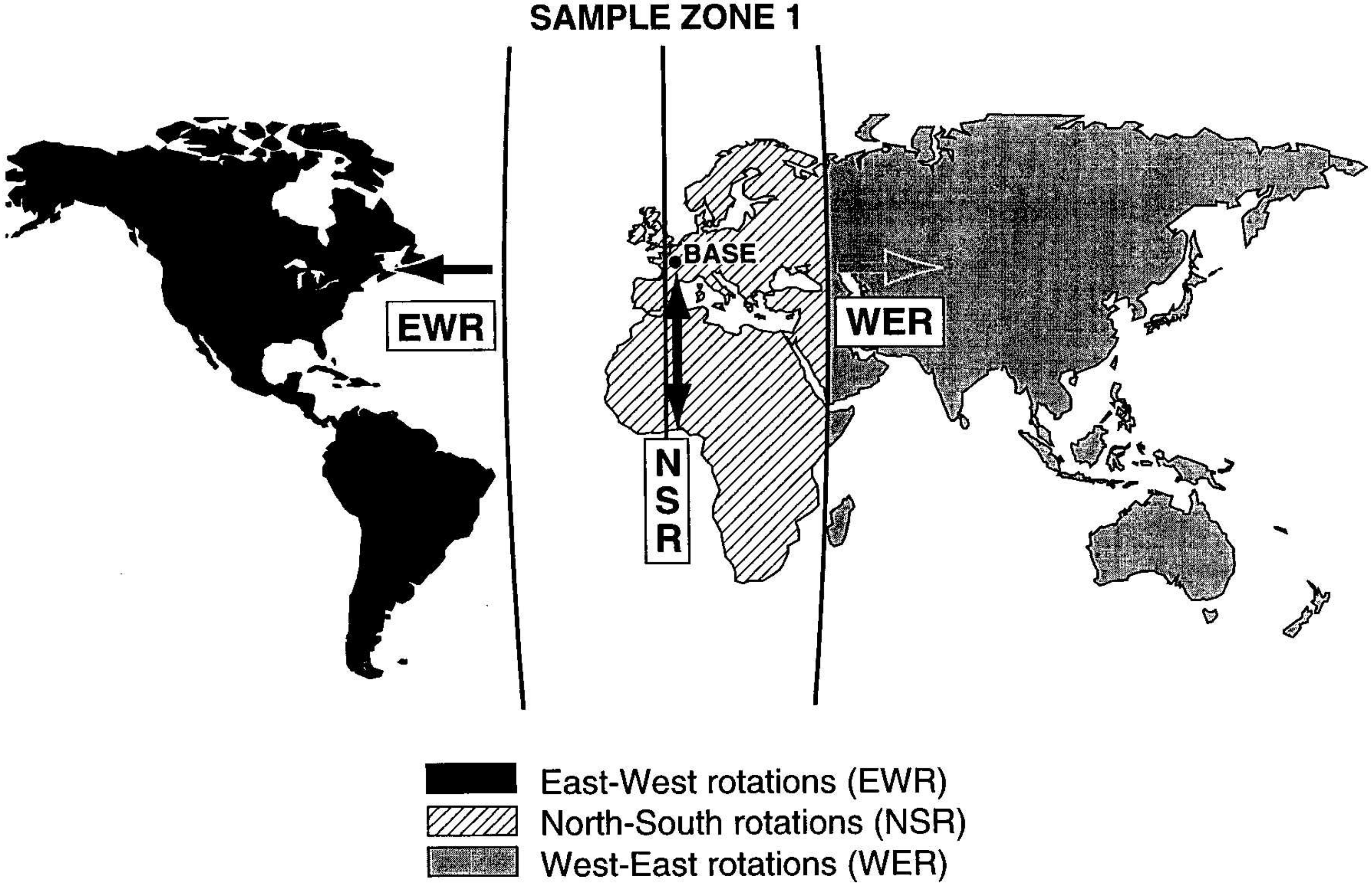
North-South Rotations (NSR)

BT – 3 $\geq$ TZC $\leq$ BT + 3

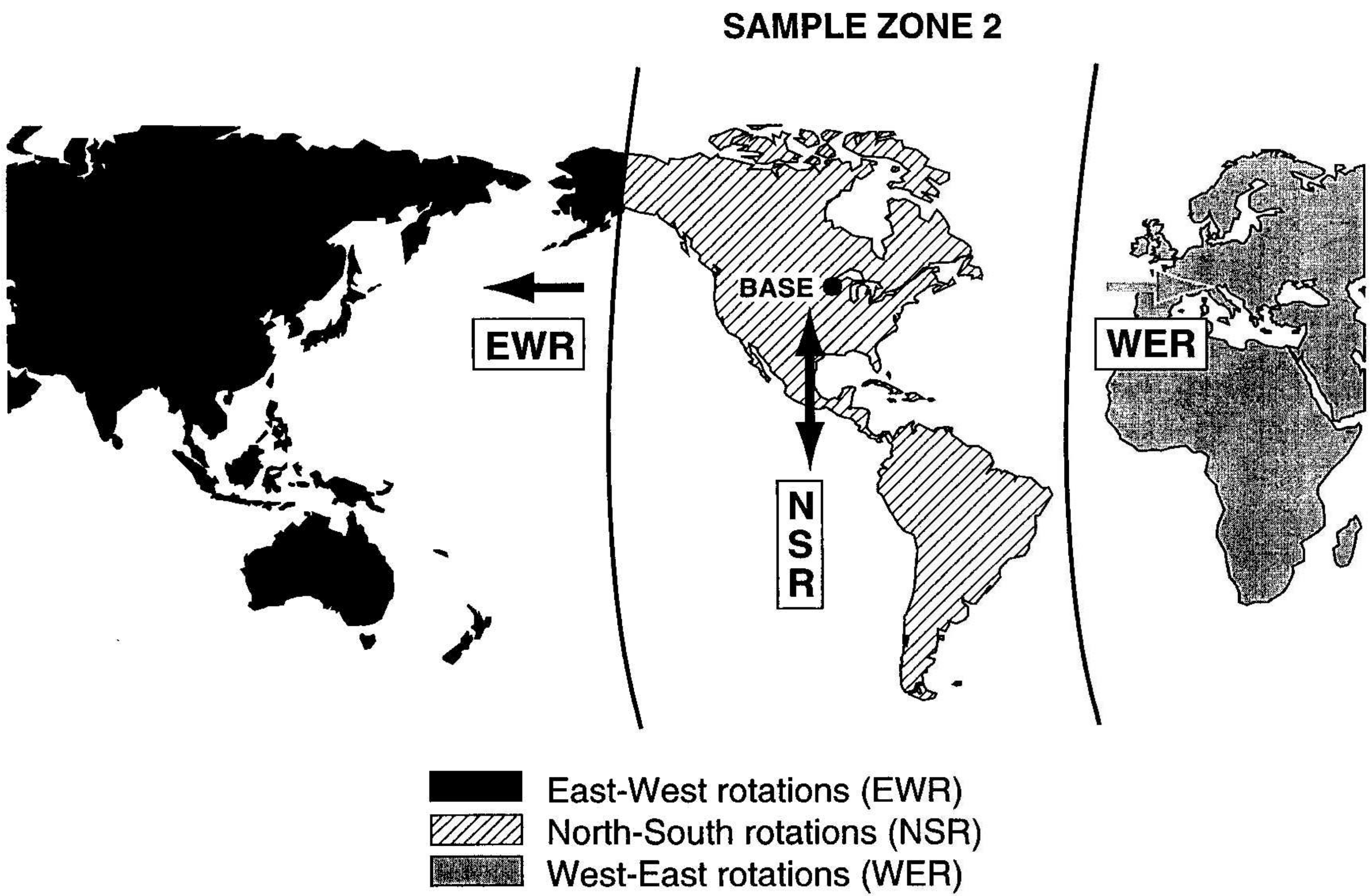
West-East Rotations (WER)

TZC $\geq$ BT + 4

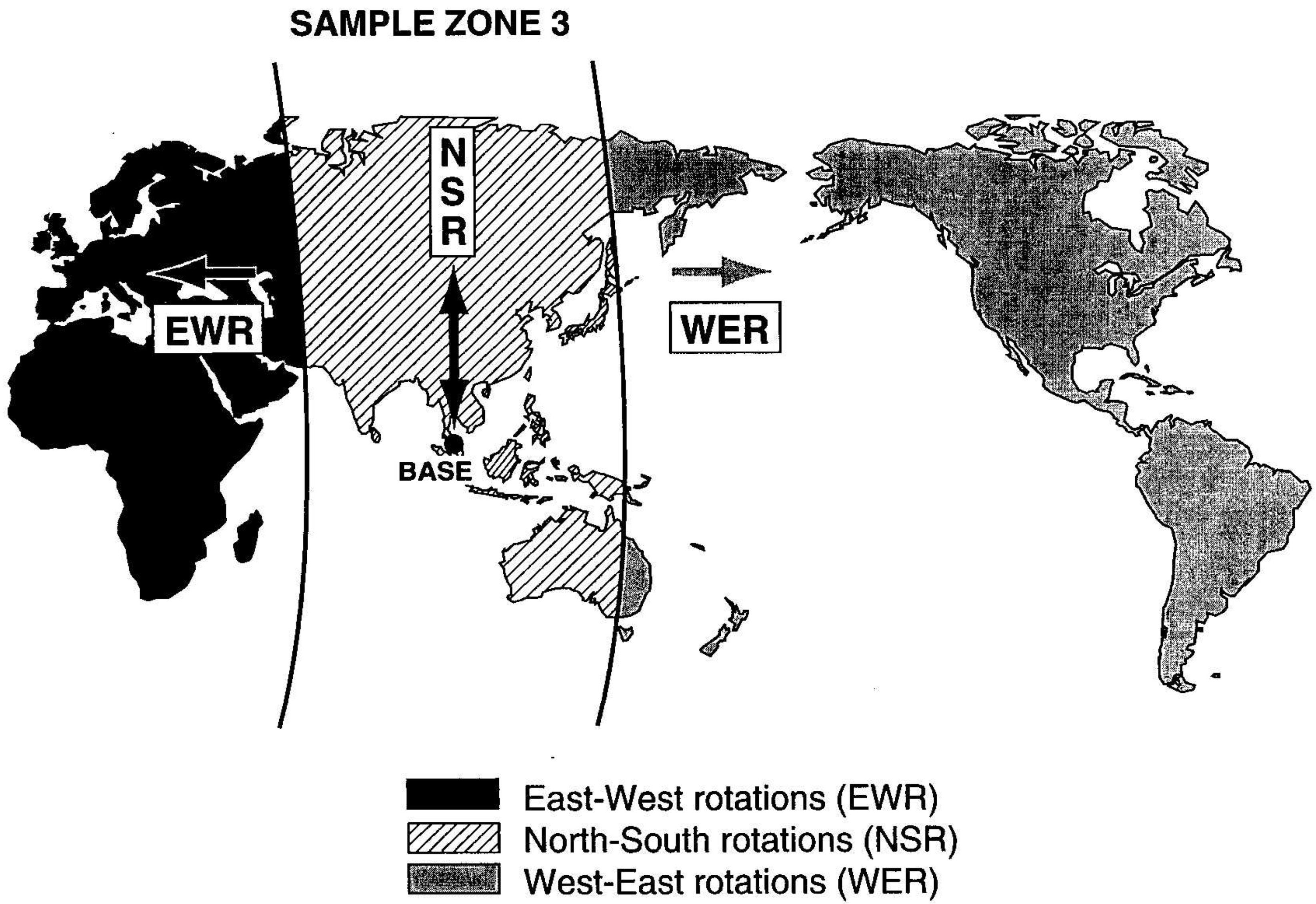
Geographical zone delimitations for European and African crews



Geographical zone delimitations for North & South American crews



Geographical zone delimitations for Asian and Australian crews



3.2.2. DETAILED REVIEW OF RECOMMENDATIONS

3.2.2.1. PRE-FLIGHT AND IN FLIGHT RECOMMENDATIONS

These recommendations are organized into 6 categories, valid for outbound and return flights whatever the geographical zone (figure 1, table 1). To select the optimal recommendations, you have to consider the following factors:

- the crew composition , basic or augmented, corresponding to long-haul flights and very long-haul flights respectively. For augmented crews, in-flight rest can be planned in advance,
- the departure time from home or hotel * :
    - between [04:00 and 12:59]
    - between [13:00 and 17:59]
    - between [18:00 and 03 :59]

Figure 1: pre and during flight recommendations diagram

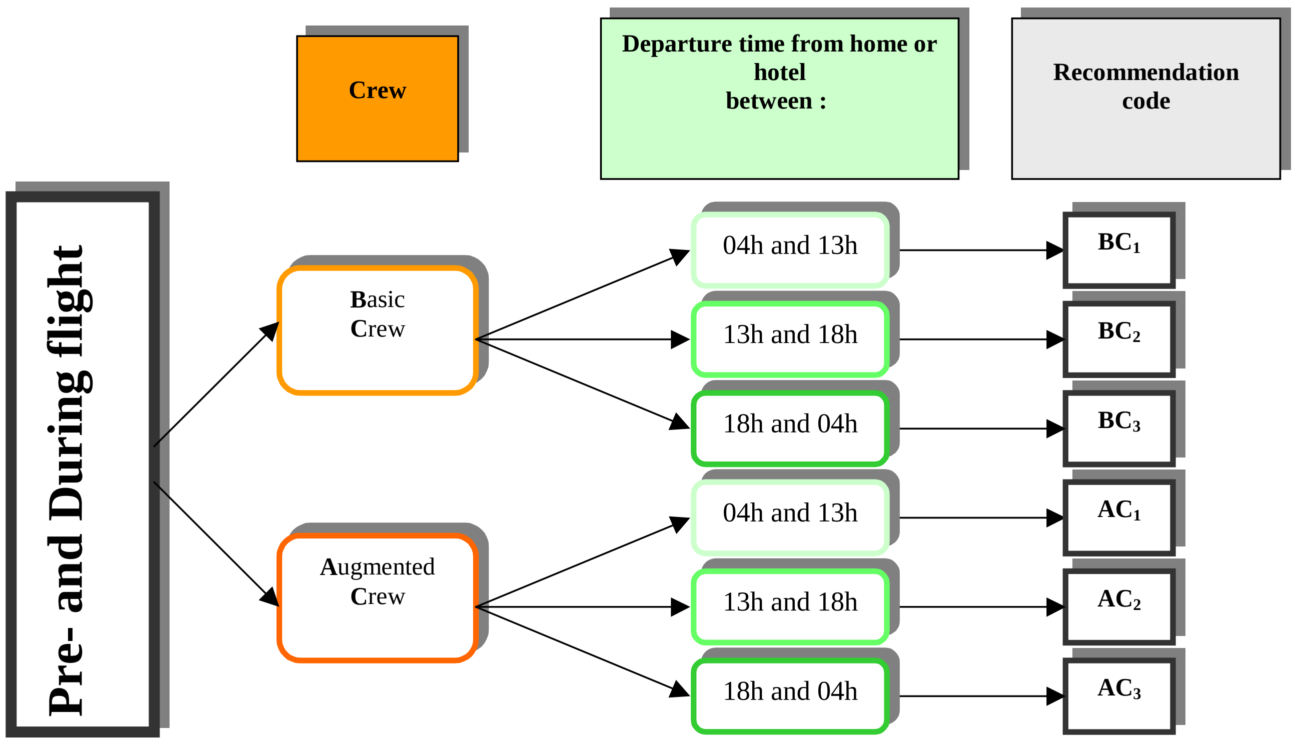


Table 1: Pre- and During flight Recommendations. These recommendations are valid for outbound and return flights whatever the geographical zone.

	Time of leaving home or hotel*	code	Pre-flight	During flight
Basic Crew	04:00 to 12:59	BC1:	During the day: normal activities, exposure to daylight in the afternoon, avoid coffee and tea after 16h. Do not take a nap during the day. In the evening: take a light meal and go to bed as early as possible.	- If early wake up, alertness decrement may occur between 13h and 16h. - Alternate active and passive phases. - Avoid taking your meals or snacks at the same time as the other crewmember.
	13:00 to 17:59	BC2:	- During the day: normal activities, exposure to daylight in the afternoon, avoid coffee and tea after 16h. - In the evening take a light meal and go bed at your normal time. - Avoid getting up early. If possible take a nap before leaving. Appropriate time to take moderate coffee or tea if needed. If not, take advantage of waiting times during hotel-airport transfers to relax or take a nap, even a very short one.	- The end of the flight may be difficult because it corresponds to a period favoring sleep. - Alternate active and passive phases. - Avoid taking your meals or snacks at the same time as the other crewmember
	18:00 to 03:59	BC3:	- During the day: normal activities, exposure to daylight in the afternoon, avoid coffee and tea after 16h. - In the evening, take a light meal and go bed at your normal time. - Avoid getting up early. Take a long nap before leaving. Appropriate time to take moderate coffee or tea if needed. - Take advantage of waiting times during hotel-airport transfers to relax or take a nap, even a very short one.	- Alertness decrements may occur more frequently after midnight if no nap before departure. - Alternate active and passive phases. - Avoid taking your meals or snacks at the same time as the other crewmember.
Augmented crew	04:00 to 12:59	AC1:	- During the day: normal activities, exposure to daylight in the afternoon, avoid coffee and tea after 16h. - Do not take a nap during the day. - In the evening: take a light meal and go to bed as early as possible. - In the morning: if your rest during the flight is planned in the first part of the flight, you should limit your coffee and tea intake	- If early weak up, alertness decrement may occur between 13h and 16h. - Alternate active and passive phases. - Avoid taking your meals or snacks at the same time as the other crewmember. - *Rest starts between 9h and 12h*. - This part of the flight is unfavorable for sleep. - You should plan a longer rest period or divide your rest into 2 or 3 periods spread out over the flight.
	13:00 to 17:59	AC2:	- *Rest during the first part of the flight*. In the evening take a light meal and go to bed as early as possible. The following day: normal activity, avoid coffee and tea after 12h. Do not take a nap. - *Rest during the other parts of the flight*. In the evening take a light meal and go bed at your normal time, avoid coffee and tea after 16h. Avoid getting up early. If possible, take a nap before leaving. Appropriate time to take moderate coffee or tea if needed. - *Absence of crew coordination*. Follow the recommendation n°2 above.	- The end of the flight may be difficult because it corresponds to a period favoring sleep. - Alternate active and passive phases. - Avoid taking your meals or snacks at the same time as the other crewmember - *Rest starts between 16h and 21h.* This part of the flight is unfavorable for sleep. You should plan a longer rest period or divide your rest into 2 or 3 periods spread out over the flight.
	18:00 to 03:59	AC3:	- *Rest during the flight between 18h and 22h*. In the evening: take a light meal and go to bed as early as possible. The following day: normal activity, avoid coffee and tea after 12h, do not take a nap. - *Rest during the flight after 22h.* In the evening take a light meal and go bed at normal time, avoid coffee and tea after 16h. Avoid getting up early. Take a long nap before leaving. Appropriate time to take moderate coffee or tea if needed. - *Absence of crew coordination.* Follow the recommendation n°2 above.	- Alertness decrements may occur more frequently after midnight if no nap before departure. - Alternate active and passive phases. - Avoid taking your meals or snacks at the same time as the other crewmember - *Rest starts between 18h and 21h.* This part of the flight is unfavorable for sleep. You should plan a longer rest period or divide your rest into 2 or 3 periods spread out over the flight.

* Departure times from home or hotel are expressed in base-time for outbound flights. For the return flight, its depends on the layover's duration and the pattern of sleep during the layover:

- after shorter layover, you should use base-time when following the recommendations for your return flight,
- after longer layover, you will need to decide whether to use local or base-time when following the recommendations for your return flight. It depends to what extent you have adjusted to local time. The following questionnaire may help you to assess your body clock phase (LAAQ).

LAYOVER ASSESSMENT ADJUSTMENT QUESTIONNAIRE (LAAQ)

Please answer the following items according to your last sleep, nap, etc, during the layover by circling the most appropriate option. If you are unaware of the timing of these activities on base-time the Body Clock Questionnaire (BCQ) may be of help (see next page).

	At normal base-time	A lot closer to base-time	A bit closer to base-time	A bit closer to local-time	A lot closer to local-time	At normal local-time
When did you take your main sleep?	1	2	3	4	5	6
When did you start to feel tired?	1	2	3	4	5	6
When did you feel like taking a nap?	1	2	3	4	5	6
When did you have your bowel movement?	1	2	3	4	5	6
When did you have your meals?	1	2	3	4	5	6
When did you feel most alert?	1	2	3	4	5	6

Now please calculate your overall score by adding up the numbers that you have circled.

If you scored between 6 and 17, your body clock is largely on base-time. You should use base-time when following the recommendations for your return flight.

If you scored between 18 and 24, your body clock has started to adjust to local time, but has not fully done so. You will need to decide whether to use local or base-time when following the recommendations for your return flight

If you scored between 25 and 36, your body clock is largely on local time. You should use local-time when following the recommendations for your return flight.

BODY CLOCK QUESTIONNAIRE (BCQ)

If you are unaware as to what your base-time is to sleep, eat, etc. this questionnaire may help you to determine a baseline body clock phase. You should complete the following questionnaire with the appropriate times for several days.

You should complete this questionnaire when you are at home and well adjusted to your base-time (i.e. after several days at home or on holidays for example). You should complete it for several days and then average your results of these activities on base-time to give you an idea of your normal timing.

	Approximate time							
	Day 1	Day 2	Day3	Day 4	Day 5	Day 6	Day 7	Average
When do you take your main sleep ?								
When do you start to feel tired ?								
When do you feel like taking a nap ?								
When do you have your bowel movement ?								
When do you have your meals ?								
When do you feel most alert ?								

When you have determined your normal base time for these activities, you can use these values to help you to complete the LAAQ.

3.2.2.2. LAYOVER REST FOR WESTWARD, EASTWARD AND NORTH-SOUTH FLIGHTS

Layover recommendations includes 15 categories depending on (figure 2, Tables 2 to 4):

- geographical zones: Westward (WR), Eastward (ER) and North-South Rotations (NSR),
- the number of time zones crossed,
- the number of nights during the layover,
- arrival time to the hotel (base-time): between [16:00 and 23:59], between [00:00 and 07:59] and between [08:00 and 15:59]

Figure 2: layover recommendations diagram

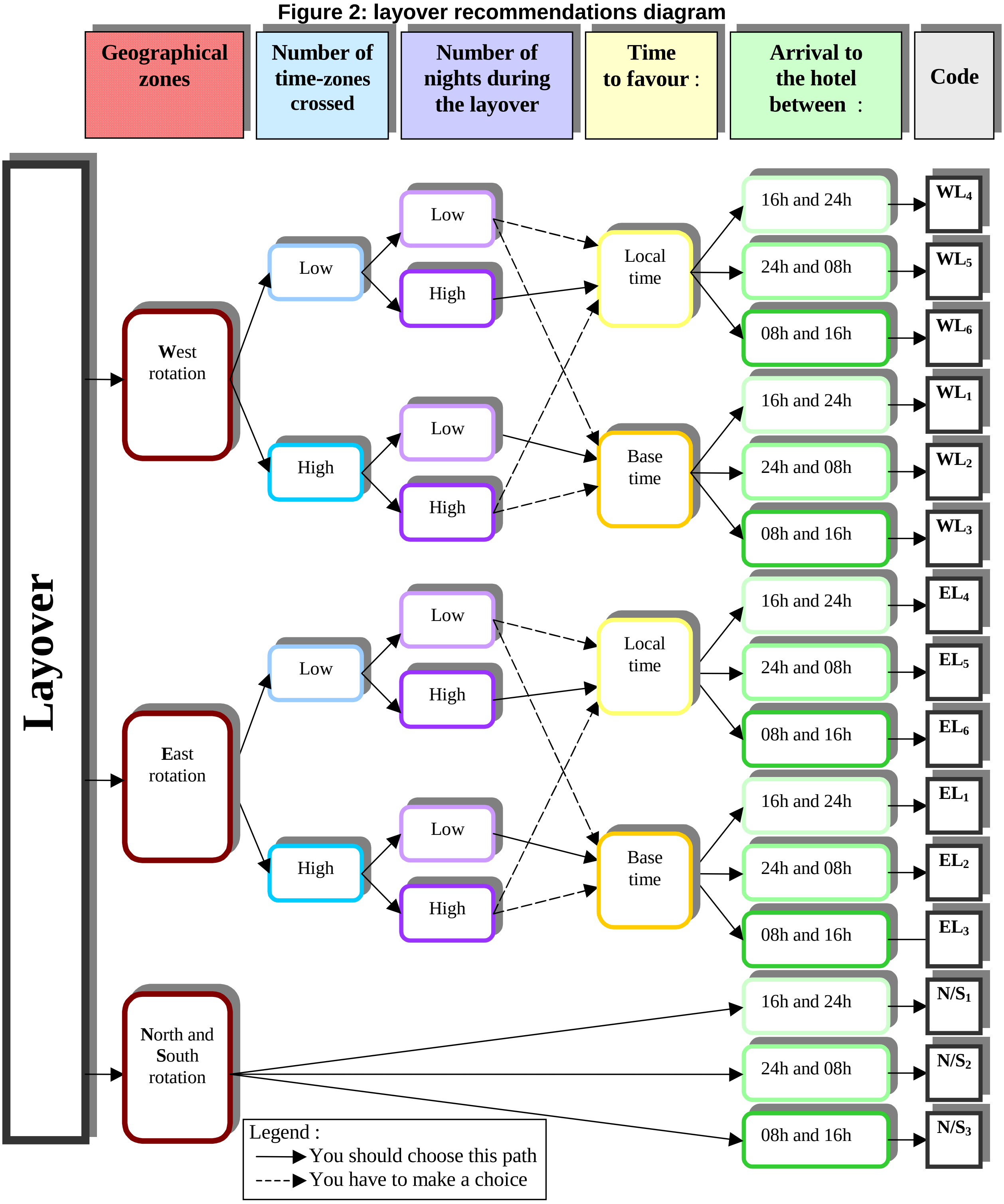


Table 2: Layover Recommendations for westward rotations

	Time of arrival to the hotel (HB)	Code	**Westward rotations**
Favour base-time	16:00 to 23:59	WL1	On arrival: Avoid napping, if possible expose yourself to daylight, and take a light meal. Avoid coffee or tea. If the hotel does not provide around-the-clock room service make the necessary arrangements for breakfast. Have dinner at base-time and go to bed at your normal base-time. If you wake up in the early morning take breakfast and try to stay in bed. In the morning, eat a meal corresponding to lunch on your base-time.
Favour base-time	00:00 to 17:59	WL2	- On arrival: have a light meal, avoid coffee and tea. If the hotel does not provide around-the-clock room service make the necessary arrangements for breakfast. Go to bed as soon as possible. - If you wake up in the early morning take breakfast and try to stay in bed. - In the morning, eat a meal corresponding to lunch on your base-time. - Avoid coffee and tea after 16h base-time. - Have dinner at base-time and go to bed at your normal base-time
Favour base-time	08:00 to 15:59	WL3	On arrival: have a light meal, avoid coffee and tea, and take a nap as soon as possible. In the afternoon: expose yourself to daylight, have light physical exercise (walk). Avoid coffee and tea after 16h base-time. If the hotel does not provide around-the-clock room service, make the necessary arrangements for breakfast. Have dinner at base-time and go to bed at your normal base-time. If you wake up in the early morning take breakfast and try to stay in bed. In the morning, eat a meal corresponding to lunch on your base-time.
Favour local-time	16:00 to 23:59	WL4	- On arrival: you may have lot of time before local bedtime. Avoid napping (or limit its duration to 30 minutes) and expose yourself to daylight, take a light meal. Appropriate time to take moderate coffee or tea if needed. If the hotel does not provide around-the-clock room service, make the necessary arrangements for breakfast. - In the evening: have dinner and then go to bed from 22h onwards. - If you wake up in the early morning take breakfast and try to stay in bed. - Have a meal around midday and nap in the early afternoon. - In the afternoon: expose yourself to daylight and have light physical exercise (walk). Appropriate time to take moderate coffee or tea if needed. - In the evening: have dinner and then go to bed from 22h onwards. - Same recommendations for the following days
Favour local-time	00:00 to 17:59	WL5	- On arrival: have a light meal, avoid coffee and tea. If the hotel does not provide around-the-clock room service, make the necessary arrangements for breakfast. Go to bed from 22h onwards. - If you wake up in the early morning take breakfast and try to stay in bed. - Have a meal around midday and nap in the early afternoon. - In the afternoon: expose yourself to daylight and have light physical exercise (walk). Appropriate time to take moderate coffee or tea if needed. - In the evening: have dinner and then go to bed from 22h onwards. - Same recommendations for the following days.
Favour local-time	08:00 to 15:59	WL6	- On arrival: have a light meal, avoid coffee and tea, and take a nap as soon as possible. Have a meal around midday. - In the afternoon: expose yourself to daylight, have light physical exercise (walk). Appropriate time to take moderate coffee or tea if needed. If the hotel does not provide around-the-clock room service, make the necessary arrangements for breakfast. - In the evening: have dinner and then go to bed from 22h onwards. - If you wake up in the early morning take breakfast and try to stay in bed. - Have a meal around midday and nap in the early afternoon. - In the afternoon: expose yourself to daylight and have light physical

Table 3: Layover Recommendations for Eastward rotations

	Time of arrival to the hotel (HB)	code	Eastward rotations
Favour base-time	16:00 to 23:59	EL1	- On arrival: have a light meal, avoid coffee and tea. Go to bed at your normal base bedtime. - Upon wake up: breakfast, it is recommended that you take light physical exercise, walk… Appropriate time to take moderate coffee or tea if needed. - Lunch around 12h base-time. Avoid napping. - If the hotel does not provide around-the-clock room service, make necessary arrangement for a light meal (dinner). - Go to bed as late as possible so that you will be asleep at a time corresponding to your normal base bedtime.
Favour base-time	00:00 to 17:59	EL2	- On arrival: have a light meal, avoid coffee and tea, and go to bed as soon as possible. - Lunch around 12h base-time. Avoid napping. - If the hotel does not provide around-the-clock room service, make necessary arrangement for a light meal (dinner). - Go to bed as late as possible so that you will be asleep at a time corresponding to your normal sleep time in base-time. - Upon wake up: breakfast, it is recommended that you take light physical exercise, walk… Appropriate time to take moderate coffee or tea if needed.
Favour base-time	08:00 to 15:59	EL3	- On arrival: Avoid taking a nap after 18h local time, light meal. Appropriate time to take moderate coffee or tea if needed. - If the hotel does not provide around-the-clock room service, make necessary arrangement for light meal (dinner). - Go to bed as late as possible so that you will asleep at a time corresponding to your normal sleep time in base-time. - Upon wake up: breakfast, it is recommended that you take light physical exercise, walk… Appropriate time to take moderate coffee or tea if needed. - Lunch around 12h base-time. Avoid napping.
Favour local-time	16:00 to 23:59	EL4	On arrival: have a light meal, avoid coffee and tea, and go to bed as soon as possible. Upon wake up: breakfast, it is recommended that you take light physical exercise, walk… Appropriate time to take moderate coffee or tea if needed. Have a meal around midday and nap in the early afternoon. In the afternoon: expose yourself to daylight and have light physical exercise (walk).. Appropriate time to take moderate coffee or tea if needed. In the evening: have dinner and then go to bed from 22h onwards. Same recommendations for the following days.
Favour local-time	00:00 to 17:59	EL5	- On arrival: have a light meal, avoid coffee and tea, and take a long nap as soon as possible. - Have a meal around midday and nap in the early afternoon. - In the afternoon: expose yourself to daylight and have light physical exercise (walk). Appropriate time to take moderate coffee or tea if needed. - In the evening: have dinner and then go to bed from 22h onwards - Upon wake up: breakfast, appropriate time to take moderate coffee or tea if needed, avoid morning daylight. - Same recommendations for the following days.
Favour local-time	08:00 to 15:59	EL6	- On arrival : Avoid napping. Appropriate time to take moderate coffee or tea if needed.. Have a light meal. If possible, expose yourself to daylight. - In the evening: have dinner and then go to bed from 22h onwards. - Upon wake up: breakfast, appropriate time to take moderate coffee or tea if needed., avoid morning light - Have a meal around midday and nap in the early afternoon. - In the afternoon: expose yourself to daylight and have light physical exercise (walk). Appropriate time to take moderate coffee or tea if needed. - Same recommendations for the following days.

Table 4: Layover Recommendations North - South rotations

Time of arrival to the hotel (HB)	Code	North - South rotations
16:00 to 23:59	NSL1	- On arrival: Avoid napping, if possible expose yourself to daylight, take a light meal. Avoid coffee or tea. - Have dinner at base-time and go to bed at your normal base-time. - In the morning, take breakfast, possibly drinking coffee and tea. - Lunch at normal time. - Avoid coffee and tea after 16h base-time.
00:00 to 17:59	NSL2	- On arrival: have a light meal, avoid coffee and tea. - Go to bed as soon as possible. - In the morning, take breakfast, possibly drinking coffee and tea. - Avoid coffee and tea after 16h base-time. Have dinner at base-time and go to bed at your normal base-time.
08:00 to 15:59	NSL3	- On arrival: have a light meal, avoid coffee and tea, take a nap as soon as possible. In the afternoon: expose yourself to daylight, have light physical exercise (walk). - Avoid coffee and tea after 16h, base-time. - Have dinner at base-time and go to bed at your normal base-time. - In the morning take breakfast, possibly drinking coffee and tea. - Lunch at normal time.

4. EXAMPLES OF THE USE OF THESE RECOMMENDATIONS

Applying Recommendations in Airbus FANS flight on A340 in 2000

Applying Recommendations at Sabena on A340 in 2001

These examples consider the following criteria that you have to adapt to fit your rotation:

– duration of flight: 8 hours for long range flight with basic crew and 12 hours for very long flights with augmented crew,
– time zone: 0 for NSR, ± 6 for long-range flights, ± 8 for very long-range flights range;
– departure time from home or hotel is set 2hours30 before flight departure time: 1 hour for the transfer from home or hotel to the airport and 1hours30 for the preparation of the flight,
– the arrival time to the hotel is set 1hours 30 after landing: 30 minutes to complete the flight tasks and 1 hour for the transfer from the airport to the hotel.

To illustrate the use of these criteria, the table below shows an example of the main characteristics, and the corresponding recommendation codes, for a westward rotation (BT-8) with augmented crew and longer layover (4 local nights). Flight duration is 12 hours.

Main characteristics of the rotation		Recommendation code
Outbound Flight	Departure from home: 8h30 BT Flight departure: 11h BT	AC1
Time zone change	Base-time – 8	WR
layover	Arrival to the hotel: 0h30 BT (16h30 LT) Duration: 4 local nights	WL5
Return flight	Departure from hotel: 18h BT (10h LT) Flight departure: 20h30 BT (12h30LT)	AC3 or AC1 (depends of your score on the LAAQ)

BT: Base-time, LT: Local-time, AC: Augmented Crew,

W: Westward, L: layover, R: Rotation

Recommendations code:

- *Outbound flight*: Departure from home at 8h30 (BT): AC1 (table 1)
- *Layover*: Arrival to the hotel at 0h 30 (BT): WL5 (table 2)
- *Return flight*: after longer layover, two kinds of recommendation, AC3 and AC1, are presented for the return flight according to the extent to wish you adjust to local-time:
  - If your score on the LAAQ suggests that your body clock is largely on base-time (score between 6 and 17), use base-time departure from the hotel (18h) to follow the recommendation for your return flight (AC3, table 1),
  - If your score on the LAAQ suggests that you have adjusted to local time (score between 25 and 36), use local-time departure from the hotel (10h) to follow the recommendation for your return flight (AC1, table 1).
  - If your score on the LAAQ suggests that your body clock has started to adjust to local-time, but has not fully done so (score between 18 and 24), you will have to decide whether to use local or base-time when following the recommendations for your return flight. In other words, you will have to take account of your subjective feeling to decide if you feel that your body clock is adjusted to local-time or not.

The examples given below contain the following information:

- Identifier concerning: geographical zone / crew composition / number of nights during the layover (except for NSR) / number of time zones crossed,

- main flight characteristics and the corresponding recommendations code:
  - outbound flight: departure time from home / flight departure time (in base-time),
  - time zone
  - layover: arrival time (in base and local-time) / number of local nights,
  - return flight: departure time from hotel / flight departure time (in base and local-time),

- a schematic illustration of these recommendations:
  - habitual sleep time at home (“sleep gates”),
  - recommendations for layover sleep,
  - recommendations for exposure to daylight, for longer layover only,
  - recommendations for meals and snacks.

- A written part of the recommendations themselves
  - outbound flight: pre-flight and during the flight
  - layover
  - return flight: pre-flight and during the flight

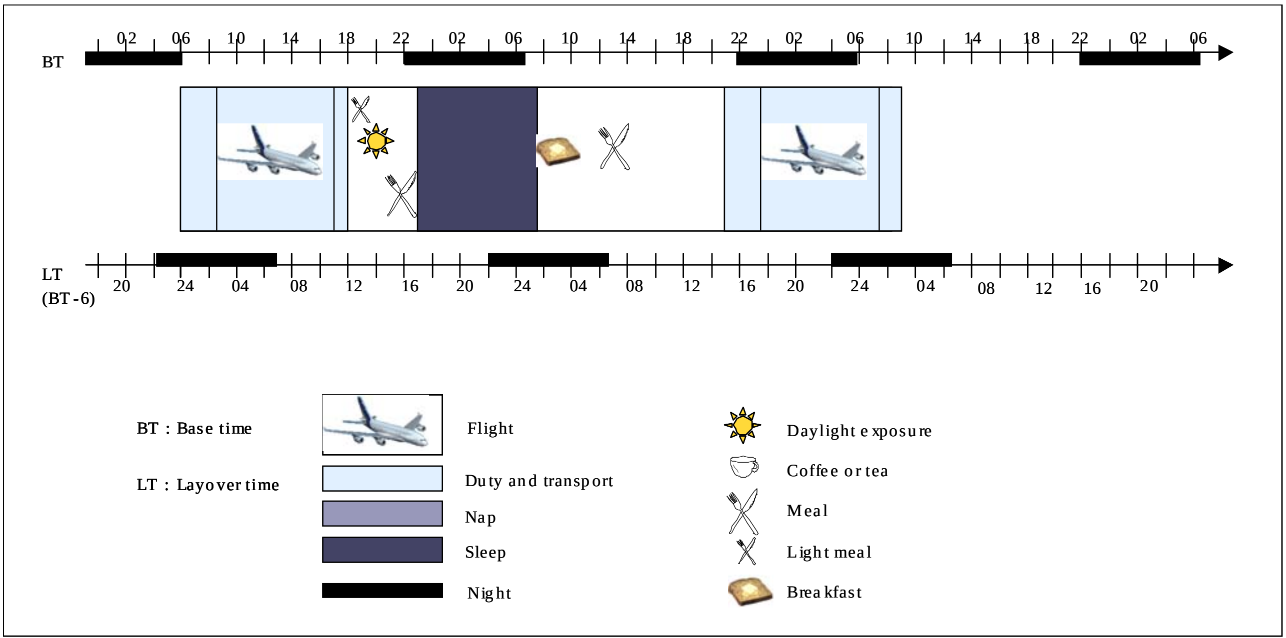
WESTWARD ROTATIONS (WR)

WR / Basic Crew / Shorter layover

Main characteristics of the rotation and recommendation codes:

Outbound Flight	Departure from home: 6h BT Flight departure: 8h30 BT	BC1
Time zone change	Base-time – 6	WR
layover	Arrival at the hotel: 18h BT (12h LT) Duration: 1 local night	WL1
Return flight	Departure from the hotel: 21h BT (15h LT) Flight departure: 23h30 BT (17h30LT)	BC3

BT: Base-time, LT: Local-time, BC: Basic Crew,
W: Westward, L: layover, R: Rotation



Recommendations

Outbound flight:

Pre-flight

- During the day: normal activities, exposure to daylight in the afternoon, avoid coffee and tea after 16h.
- Do not take a nap during the day.
- In the evening: take a light meal and go to bed as early as possible.

During flight

- If early wake up, alertness decrement may occur between 13h and 16h.
- Alternate active and passive phases.
- Avoid taking your meals or snacks at the same time as the other crew member.

Layover:

- On arrival: Avoid napping, if possible expose yourself to daylight, and take a light meal. Avoid coffee or tea.
- If the hotel does not provide around-the-clock room service make the necessary arrangements for breakfast.
- Have dinner at base-time and go to bed at your normal base-time.
- If you wake up in the early morning take breakfast and try to stay in bed.
- In the morning, eat a meal corresponding to lunch on your base-time.

Return flight

Pre-flight

- During the day: normal activities, exposure to daylight in the afternoon, avoid coffee and tea after 16h.
- In the evening, take a light meal and go bed at your normal time.
- Avoid getting up early. Take a long nap before leaving followed by coffee or tea.
- Take advantage of waiting times during hotel-airport transfers to relax or take a nap, even a very short one.

During flight

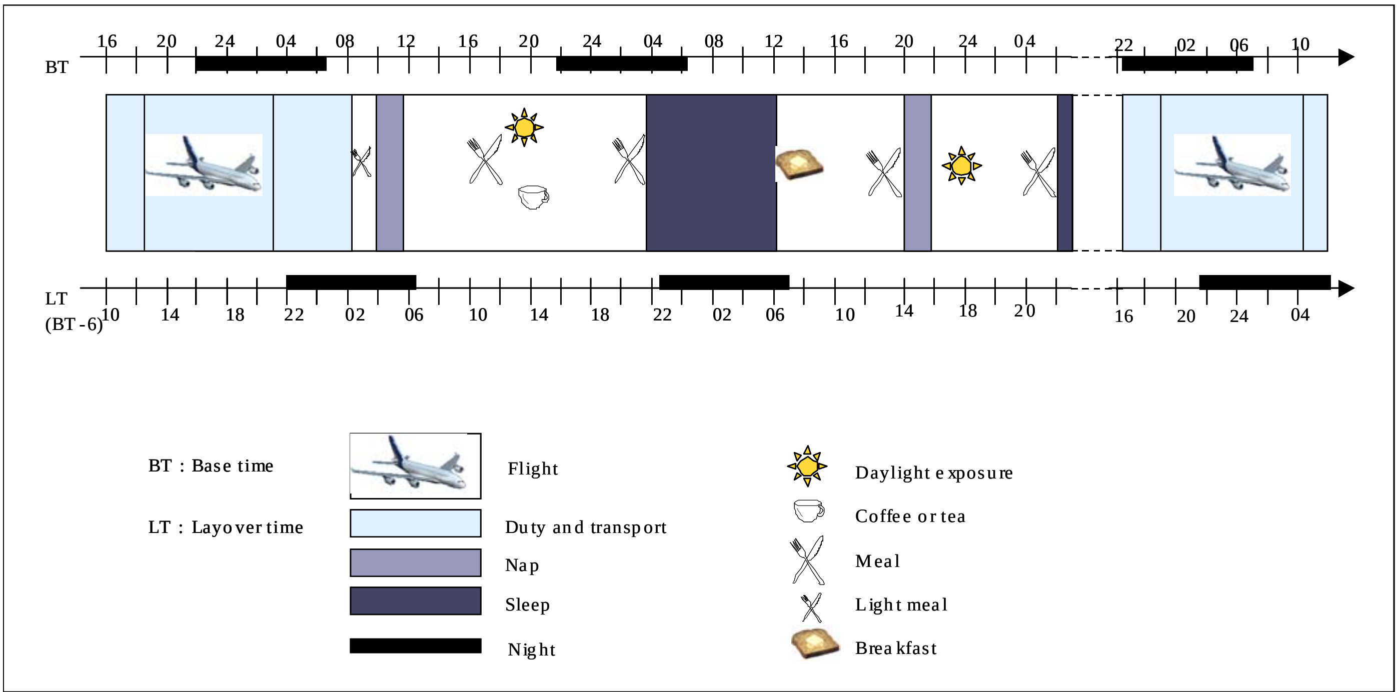
- Alertness decrements may occur more frequently after midnight if no nap before departure.
- Alternate active and passive phases.
- Avoid taking your meals or snacks at the same time as the other crewmember.

WR / Basic Crew / Longer layover

Main characteristics of the rotation and recommendation codes:

Outbound Flight	Departure from home: 16h BT Flight departure: 18h30 BT	BC2
Time zone change	Base-time – 6	WR
layover	Arrival at the hotel: 8h BT (02h LT) Duration: 4 local nights	WL6
Return flight	Departure from the hotel: 18h BT (12h LT) Flight departure: 20h30 BT (14h30LT)	BC3 or BC1 (depends on the score on the LAAQ)

BT: Base-time, LT: Local-time, BC: Basic Crew,
W: Westward, L: layover, R: Rotation



Recommendations

Outbound flight:

Pre-flight

- During the day: normal activities, exposure to daylight in the afternoon, avoid coffee and tea after 16h.
- In the evening take a light meal and go bed at your normal time.
- Avoid getting up early. If possible take a nap before leaving followed by coffee or tea. If not take advantage of waiting times during hotel-airport transfers to relax or take a nap, even a very short one.

During flight

- The end of the flight may be difficult because it corresponds to a period favoring sleep.
- Alternate active and passive phases.
- Avoid taking your meals or snacks at the same time as the other crewmember

Layover:

- On arrival: have a light meal, avoid coffee and tea, and take a nap as soon as possible. Have a meal around midday. In the afternoon: expose yourself to daylight, have light physical exercise (walk). Moderate coffee or tea is recommended. If the hotel does not provide around-the-clock room service, make the necessary arrangements for breakfast.
- In the evening: have dinner and then go to bed from 22h onwards.
- If you wake up in the early morning take breakfast and try to stay in bed.
- Have a meal around midday and nap in the early afternoon.
- In the afternoon: expose yourself to daylight and have light physical
- Same recommendations for the following days.

Return flight

Pre-flight

Your body clock is largely on base-time *(score on the LAAQ between 6 and 17)*	***You have adjusted to local-time*** *(score on the LAAQ between 25 and 36)*
- During the day: normal activities, exposure to daylight in the afternoon, avoid coffee and tea after 16h. - In the evening, take a light meal and go bed at your normal time. - Avoid getting up early. Take a long nap before leaving followed by coffee or tea. Take advantage of waiting times during hotel-airport transfers to relax or take a nap, even a very short one.	During the day: normal activities, exposure to daylight in the afternoon, avoid coffee and tea after 16h. Do not take a nap during the day. - In the evening: take a light meal and go to bed as early as possible.

During flight

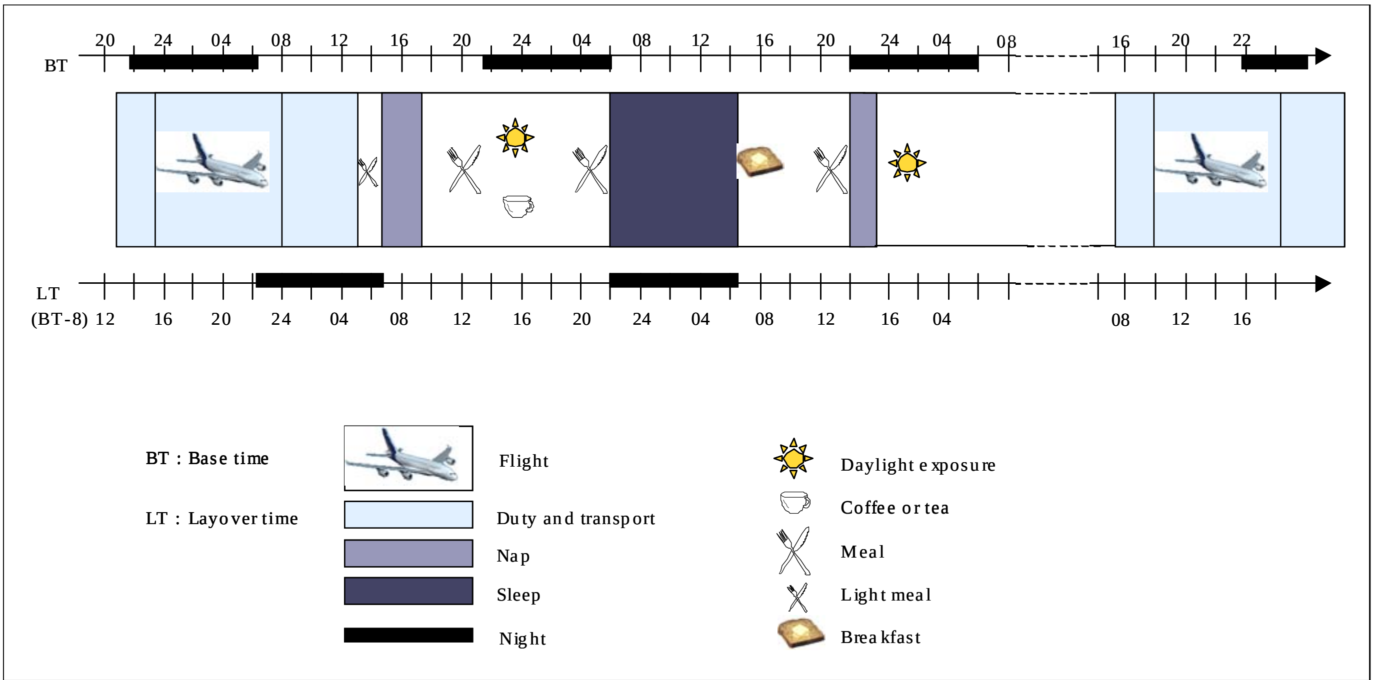
Your body clock is largely on base-time *(score on the LAAQ between 6 and 17)*	***You have adjusted to local-time*** *(score on the LAAQ between 25 and 36)*
- Alertness decrements may occur more frequently after midnight if no nap before departure.	- If early wake up, alertness decrement may occur between 13h and 16h.
- Alternate active and passive phases. - Avoid taking your meals or snacks at the same time as the other crewmember.	

WR / Augmented crew / Shorter layover

Main characteristics of the rotation and recommendation codes:

Outbound Flight	Departure from home: 21h BT Flight departure: 23h30 BT	AC3
Time zone change	Base-time – 8	WR
layover	Arrival at the hotel: 13h BT (5h LT) Duration: 2 local nights	WL6
Return flight	Departure from the hotel: 15h BT (7h LT) Flight departure: 17h30 BT (10h30 LT)	AC2

BT: Base-time, LT: Local-time, AC: Augmented Crew,
W: Westward, L: layover, R: Rotation



Recommendations

Outbound flight:

Pre-flight

- *Rest during the flight between 18h and 22h.*
  - In the evening: take a light meal and go to bed as early as possible. The following day: normal activity, avoid coffee and tea after 12h, do not take a nap.
- *Rest during the flight after 22h.*
  - In the evening take a light meal and go bed at normal time, avoid coffee and tea after 16h. Avoid getting up early. Take a long nap before leaving followed by coffee or tea.
- *Absence of crew coordination:* Follow the recommendation n°2 above.

During flight

- Alertness decrements may occur more frequently after midnight if no nap before departure.
- Alternate active and passive phases.
- Avoid taking your meals or snacks at the same time as the other crewmember
- *Rest starts between 18h and 21h.* This part of the flight is unfavorable for sleep. You should plan a longer rest period or divide your rest into 2 or 3 periods spread out over the flight.

Layover:

- On arrival: have a light meal, avoid coffee and tea, and take a nap as soon as possible. Have a meal around midday. In the afternoon: expose yourself to daylight, have light physical exercise (walk). Moderate coffee or tea is recommended. If the hotel does not provide around-the-clock room service, make the necessary arrangements for breakfast.
- In the evening: have dinner and then go to bed from 22h onwards.
  If you wake up in the early morning take breakfast and try to stay in bed.
  Have a meal around midday and nap in the early afternoon.
- In the afternoon: expose yourself to daylight and have light physical

Retun flight

Pre-flight

- *Rest during the first part of the flight.*
  - In the evening take a light meal and go to bed as early as possible. The following day: normal activity, avoid coffee and tea after 12h. Do not take a nap.
- *Rest during the other parts of the flight.*
  - In the evening take a light meal and go bed at your normal time, avoid coffee and tea after 16h. Avoid getting up early. If possible, take a nap before leaving followed by coffee or tea.
- *Absence of crew coordination*: Follow the recommendation n°2 above.

During flight

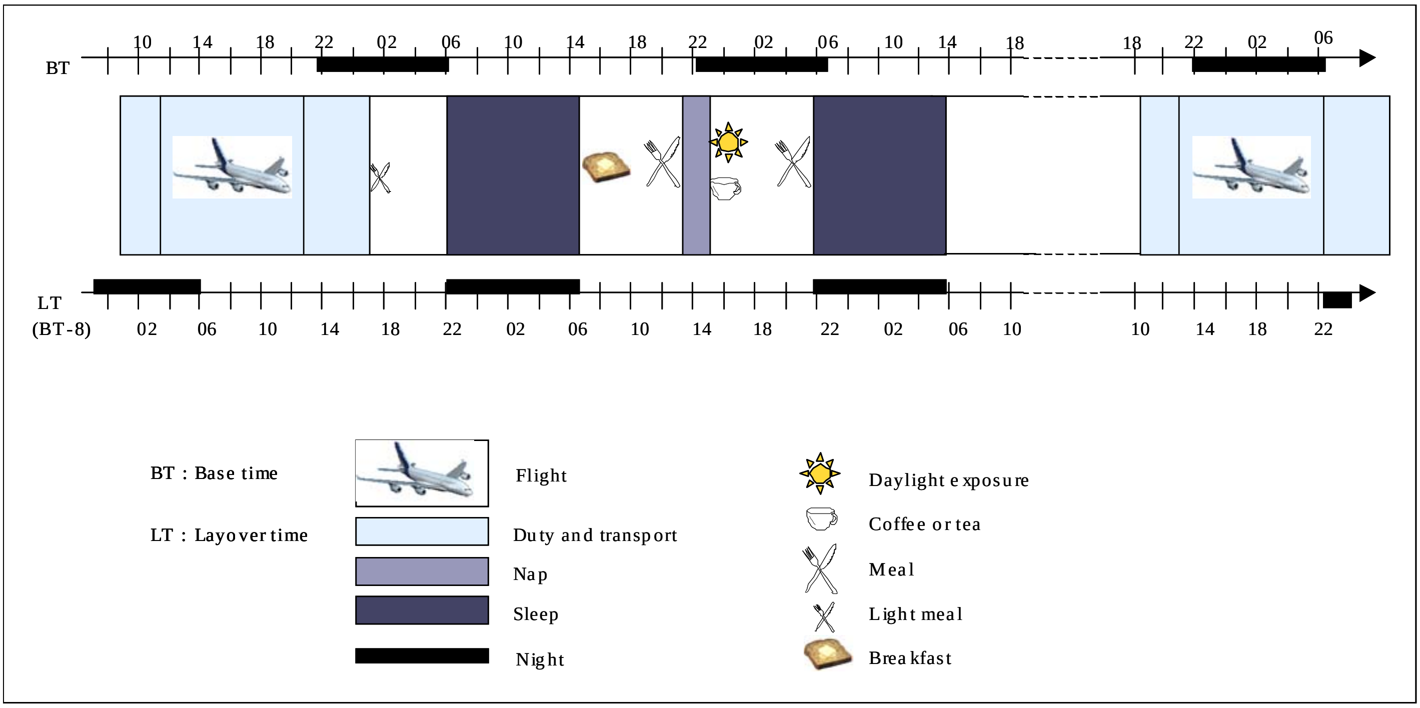
- The end of the flight may be difficult because it corresponds to a period favoring sleep.
- Alternate active and passive phases.
- Avoid taking your meals or snacks at the same time as the other crewmember
- *Rest starts between 16h and 21h.*
- This part of the flight is unfavorable for sleep. You should plan a longer rest period or divide your rest into 2 or 3 periods spread out over the flight.

WR / Augmented crew / Longer layover

Main characteristics of the rotation and recommendation codes:

Outbound Flight	Departure from home: 8h30 BT Flight departure: 11h BT	AC1
Time zone change	Base-time – 8	WR
layover	Arrival at the hotel: 0h30 BT (16h30 LT) Duration: 4 local nights	WL5
Return flight	Departure from the hotel: 18h BT (10h LT) Flight departure: 20h30 BT (12h30 LT)	AC3 or AC1 (depends on your score on the LAAQ)

BT: Base-time, LT: Local-time, AC: Augmented Crew,
W: Westward, L: layover, R: Rotation



Recommendations

Outbound flight:

Pre-flight

- During the day: normal activities, exposure to daylight in the afternoon, avoid coffee and tea after 16h.
- Do not take a nap during the day.
- In the evening: take a light meal and go to bed as early as possible.
- In the morning: if your rest during the flight is planned in the first part of the flight, you should limit your coffee and tea intake

During flight

- If early wake up, alertness decrement may occur between 13h and 16h.
- Alternate active and passive phases.
- Avoid taking your meals or snacks at the same time as the other crewmember.
- *Rest starts between 9h and 12h*: This part of the flight is unfavorable for sleep. You should plan a longer rest period or divide your rest into 2 or 3 periods spread out over the flight.

Layover:

- On arrival: have a light meal, avoid coffee and tea. If the hotel does not provide around-the-clock room service, make the necessary arrangements for breakfast. Go to bed from 22h onwards.
- If you wake up in the early morning take breakfast and try to stay in bed.
- Have a meal around midday and nap in the early afternoon.
- In the afternoon: expose yourself to daylight and have light physical exercise (walk). Moderate coffee or tea is recommended.
- In the evening: have dinner and then go to bed from 22h onwards.

Same recommendations for the following days.

Retun flight

Pre-flight

Your body clock is largely on base-time *(score on the LAAQ between 6 and 17)*	***You have adjusted to local-time*** *(score on the LAAQ between 25 and 36)*
- *Rest during the flight between 18h and 22h.* In the evening: take a light meal and go to bed as early as possible. The following day: normal activity, avoid coffee and tea after 12h, do not take a nap. - *Rest during the flight after 22h.* In the evening take a light meal and go bed at normal time, avoid coffee and tea after 16h. Avoid getting up early. Take a long nap before leaving followed by coffee or tea. - *Absence of crew coordination.* Follow the recommendation n°2 above.	- During the day: normal activities, exposure to daylight in the afternoon, avoid coffee and tea after 16h. - Do not take a nap during the day. - In the evening: take a light meal and go to bed as early as possible. - In the morning: if your rest during the flight is planned in the first part of the flight, you should limit your coffee and tea intake

During flight

Your body clock is largely on base-time *(score on the LAAQ between 6 and 17)*	***You have adjusted to local-time*** *(score on the LAAQ between 25 and 36)*
- Alertness decrements may occur more frequently after midnight if no nap before departure. - *Rest starts between 18h and 21h:* This part of the flight is unfavorable for sleep. You should plan a longer rest period or divide your rest into 2 or 3 periods spread out over the flight.	- If early wake up, alertness decrement may occur between 13h and 16h (LT). - Rest starts between 9h and 12h (LT): This part of the flight is unfavorable for sleep. You should plan a longer rest period or divide your rest into 2 or 3 periods spread out over the flight.
- Alternate active and passive phases. - Avoid taking your meals or snacks at the same time as the other crewmember.	

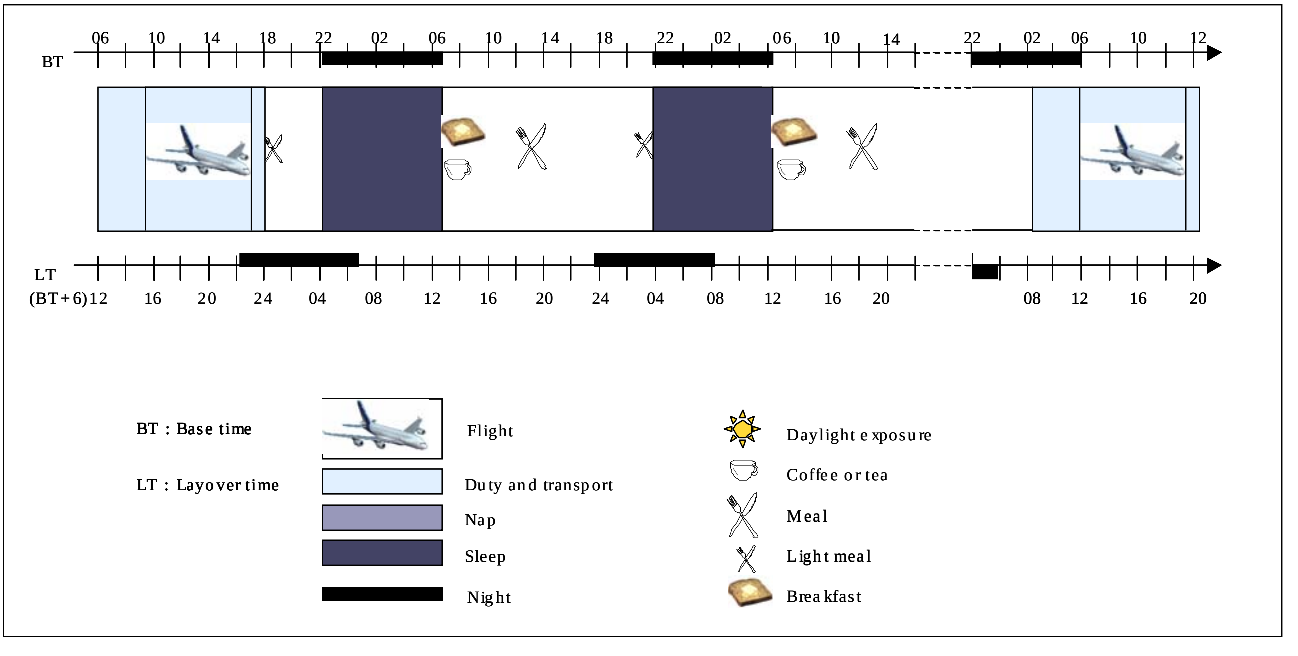
EASTWARD ROTATIONS (ER)

ER / Basic Crew / Shorter layover

Main characteristics of the rotation and recommendation codes:

Outbound Flight	Departure from home: 6h BT Flight departure: 8h30 BT	BC1
Time zone change	Base-time + 6	ER
layover	Arrival at the hotel: 18h BT (0h LT) Duration: 2 local nights	EL1
Return flight	Departure from the hotel: 2h BT (8h LT) Flight departure: 4h30 BT (10h30 LT)	BC3

BT: Base-time, LT: Local-time, BC: Basic Crew,
E: Eastward, L: layover, R: Rotation



Recommendations

Outbound flight:

Pre-flight

- During the day: normal activities, exposure to daylight in the afternoon, avoid coffee and tea after 16h.
- Do not take a nap during the day.
- In the evening: take a light meal and go to bed as early as possible.

During flight

- If early wake up, alertness decrement may occur between 13h and 16h.
- Alternate active and passive phases.
- Avoid taking your meals or snacks at the same time as the other crewmember.

Layover:

- On arrival: have a light meal, avoid coffee and tea. Go to bed at your normal base bedtime.
- Upon wake up: breakfast, it is recommended that you drink coffee or tea, favor light physical exercise, walk…
- Lunch around 12h base-time. Avoid napping.
- If the hotel does not provide around-the-clock room service, make necessary arrangement for a light meal (dinner).
- Go to bed as late as possible so that you will be asleep at a time corresponding to your normal base bedtime.

Retun flight:

Pre-flight

- During the day: normal activities, exposure to daylight in the afternoon, avoid coffee and tea after 16h.
- In the evening, take a light meal and go bed at your normal time.
- Avoid getting up early. Take a long nap before leaving followed by coffee or tea.
- Take advantage of waiting times during hotel-airport transfers to relax or take a nap, even a very short one.

During flight

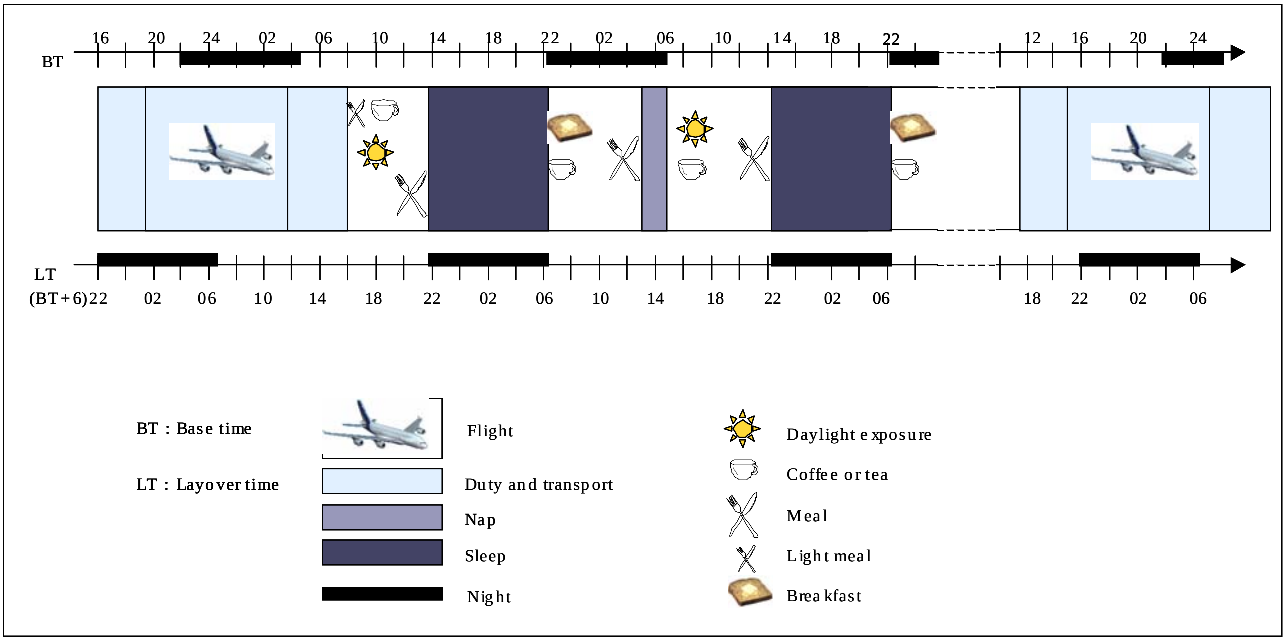
- Alertness decrements may occur more frequently after midnight if no nap before departure.
- Alternate active and passive phases.
- Avoid taking your meals or snacks at the same time as the other crewmember.

ER / Basic Crew / Longer layover

Main characteristics of the rotation and recommendation codes:

Outbound Flight	Departure from home: 16h BT Flight departure: 18h30 BT	BC2
Time zone change	Base-time + 6	ER
layover	Arrival at the hotel: 8h BT (14h LT) Duration: 4 local nights	EL6
Return flight	Departure from the hotel: 12h BT (18h LT) Flight departure: 14h30 BT (20h30 LT)	BC1 or BC3 (depends on your score on the LAAQ)

BT: Base-time, LT: Local-time, BC: Basic Crew,
E: Eastward, L: layover, R: Rotation



Recommendations

Outbound flight:

Pre-flight

- During the day: normal activities, exposure to daylight in the afternoon, avoid coffee and tea after 16h.
- In the evening take a light meal and go bed at your normal time.
- Avoid getting up early. If possible take a nap before leaving followed by coffee or tea. If not take advantage of waiting times during hotel-airport transfers to relax or take a nap, even a very short one.

During flight

- The end of the flight may be difficult because it corresponds to a period favoring sleep.
- Alternate active and passive phases.
- Avoid taking your meals or snacks at the same time as the other crewmember

Layover:

- On arrival: Avoid napping. Moderate coffee or tea is recommended. Have a light meal. If possible, expose yourself to daylight.
- In the evening: have dinner and then go to bed from 22h onwards.
- Upon wake up: breakfast, it is recommended that you drink coffee or tea, avoid morning light
- Have a meal around midday and nap in the early afternoon.
- In the afternoon: expose yourself to daylight and have light physical exercise (walk). Moderate coffee or tea is recommended.
- Same recommendations for the following days.

Retun flight:

Pre-flight

Your body clock is largely on base-time *(score on the LAAQ between 6 and 17)*	***You have adjusted to local-time*** *(score on the LAAQ between 25 and 36)*
During the day: normal activities, exposure to daylight in the afternoon, avoid coffee and tea after 16h. Do not take a nap during the day. - In the evening: take a light meal and go to bed as early as possible.	- During the day: normal activities, exposure to daylight in the afternoon, avoid coffee and tea after 16h. - In the evening, take a light meal and go bed at your normal time. - Avoid getting up early. Take a long nap before leaving followed by coffee or tea. - Take advantage of waiting times during hotel-airport transfers to relax or take a nap, even a very short one.

During flight

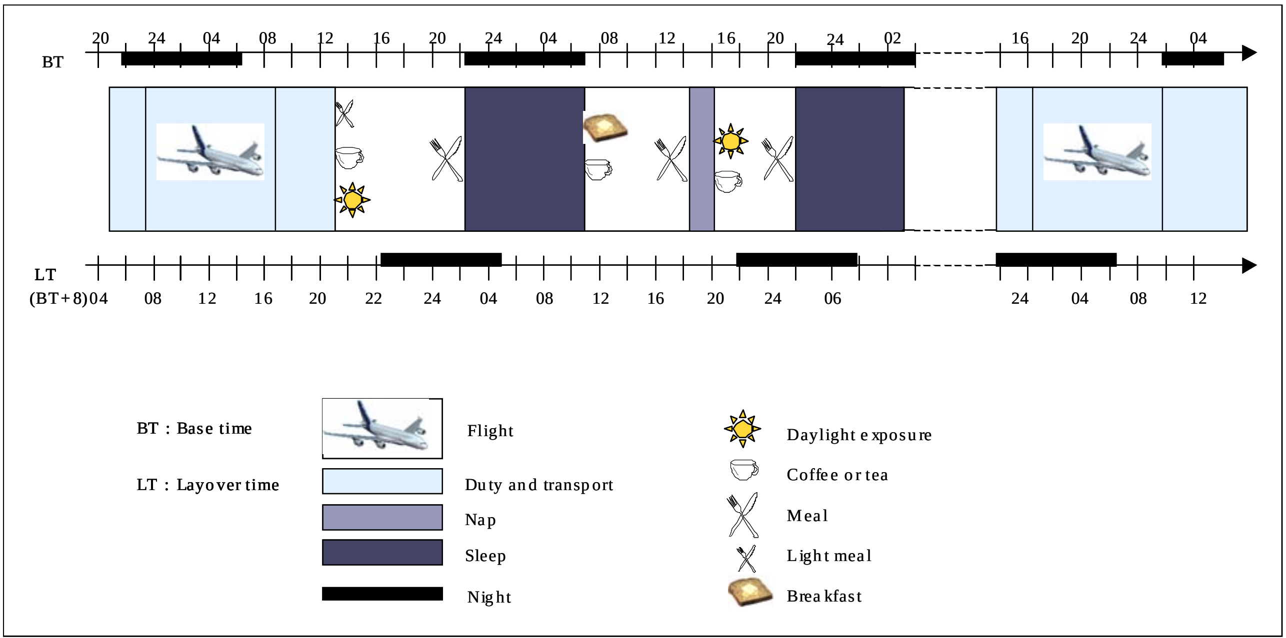
Your body clock is largely on base-time *(score on the LAAQ between 6 and 17)*	***You have adjusted to local-time*** *(score on the LAAQ between 25 and 36)*
- If early wake up, alertness decrement may occur between 13h and 16h.	- Alertness decrements may occur more frequently after midnight if no nap before departure.
- Alternate active and passive phases. - Avoid taking your meals or snacks at the same time as the other crewmember.	

ER / Augmented crew / Shorter layover

Main characteristics of the rotation and recommendation codes:

Outbound Flight	Departure from home: 21h BT Flight departure: 23h30 BT	AC3
Time zone change	Base-time + 8	ER
layover	Arrival at the hotel: 13h BT (21h LT) Duration: 2 local nights	EL6
Return flight	Departure from the hotel: 14h BT (20h LT) Flight departure: 16h30 BT (22h30 LT)	AC2

BT: Base-time, LT: Local-time, AC: Augmented Crew,
E: Eastward, L: layover, R: Rotation



Recommendations

Outbound flight:

Pre-flight

- *Rest during the flight between 18h and 22h.*
  - In the evening: take a light meal and go to bed as early as possible. The following day: normal activity, avoid coffee and tea after 12h, do not take a nap.
- *Rest during the flight after 22h.*
  - In the evening take a light meal and go bed at normal time, avoid coffee and tea after 16h. Avoid getting up early. Take a long nap before leaving followed by coffee or tea.
- *Absence of crew coordination:* Follow the recommendation n°2 above.

During flight

- Alertness decrements may occur more frequently after midnight if no nap before departure.
- Alternate active and passive phases.
- Avoid taking your meals or snacks at the same time as the other crewmember
- *Rest starts between 18h and 21h.* This part of the flight is unfavorable for sleep. You should plan a longer rest period or divide your rest into 2 or 3 periods spread out over the flight.

Layover:

- On arrival: Avoid napping. Moderate coffee or tea is recommended. Have a light meal. If possible, expose yourself to daylight.
- In the evening: have dinner and then go to bed from 22h based time.
- Upon wake up: breakfast, it is recommended that you drink coffee or tea, avoid morning light
- Have a meal around midday and nap in the early afternoon.
- In the afternoon: expose yourself to daylight and have light physical exercise (walk). Moderate coffee or tea is recommended.
- Same recommendations for the following days.

Return flight:

Pre-flight

- *Rest during the first part of the flight.*
  - In the evening take a light meal and go to bed as early as possible. The following day: normal activity, avoid coffee and tea after 12h. Do not take a nap.
- *Rest during the other parts of the flight.*
  - In the evening take a light meal and go bed at your normal time, avoid coffee and tea after 16h. Avoid getting up early. If possible, take a nap before leaving followed by coffee or tea.
- *Absence of crew coordination*: Follow the recommendation n°2 above.

During flight

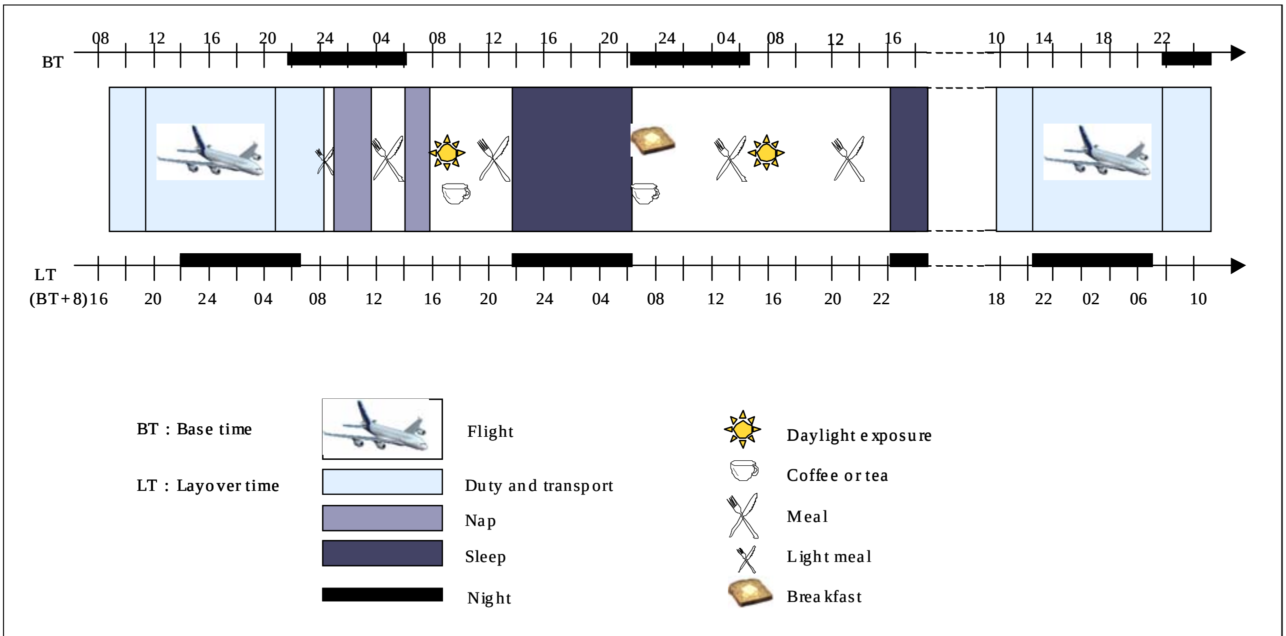
- The end of the flight may be difficult because it corresponds to a period favoring sleep.
- Alternate active and passive phases.
- Avoid taking your meals or snacks at the same time as the other crewmember
- *Rest starts between 16h and 21h:* This part of the flight is unfavorable for sleep. You should plan a longer rest period or divide your rest into 2 or 3 periods spread out over the flight.

ER / Augmented crew / Longer layover

Main characteristics of the rotation and recommendation codes:

Outbound Flight	Departure from home: 8h30 BT Flight departure: 11h BT	AC1
Time zone change	Base-time + 8	ER
layover	Arrival at the hotel: 0h30 BT (8h LT) Duration: 4 local nights	EL5
Return flight	Departure from the hotel: 10 h BT (18h LT) Flight departure: 12h30 BT (20h30 LT)	AC1 or AC3 (depends on your score on the LAAQ)

BT: Base-time, LT: Local-time, AC: Augmented Crew,
E: Eastward, L: layover, R: Rotation



Recommendations

Outbound flight:

Pre-flight

- During the day: normal activities, exposure to daylight in the afternoon, avoid coffee and tea after 16h.
- Do not take a nap during the day.
- In the evening: take a light meal and go to bed as early as possible.
- In the morning: if your rest during the flight is planned in the first part of the flight, you should limit your coffee and tea intake

During flight

- If early wake up, alertness decrement may occur between 13h and 16h.
- Alternate active and passive phases.
- Avoid taking your meals or snacks at the same time as the other crewmember.
- *Rest starts between 9h and 12h*: This part of the flight is unfavorable for sleep. You should plan a longer rest period or divide your rest into 2 or 3 periods spread out over the flight.

Layover:

- On arrival: have a light meal, avoid coffee and tea, and take a long nap as soon as possible.
- Have a meal around midday and nap in the early afternoon.
- In the afternoon: expose yourself to daylight and have light physical exercise (walk). Moderate coffee or tea is recommended.
- In the evening: have dinner and then go to bed from 22h onwards
- Upon wake up: breakfast, it is recommended that you drink coffee or tea, avoid morning daylight.
- Same recommendations for the following days.

Return flight:

Pre-flight

Your body clock is largely on base-time *(score on the LAAQ between 6 and 17)*	***You have adjusted to local-time*** *(score on the LAAQ between 25 and 36)*
- During the day: normal activities, exposure to daylight in the afternoon, avoid coffee and tea after 16h. - Do not take a nap during the day. - In the evening: take a light meal and go to bed as early as possible. - In the morning: if your rest during the flight is planned in the first part of the flight, you should limit your coffee and tea intake	- *Rest during the flight between 18h and 22h*. In the evening: take a light meal and go to bed as early as possible. The following day: normal activity, avoid coffee and tea after 12h, do not take a nap. - *Rest during the flight after 22h.* In the evening take a light meal and go bed at normal time, avoid coffee and tea after 16h. Avoid getting up early. Take a long nap before leaving followed by coffee or tea. - *Absence of crew coordination.*: Follow the recommendation n°2 above.

During flight

Your body clock is largely on base-time *(score on the LAAQ between 6 and 17)*	***You have adjusted to local-time*** *(score on the LAAQ between 25 and 36)*
- If early wake up, alertness decrement may occur between 13h and 16h (LT). - Rest starts between 9h and 12h (LT): This part of the flight is unfavorable for sleep. You should plan a longer rest period or divide your rest into 2 or 3 periods spread out over the flight.	- Alertness decrements may occur more frequently after midnight if no nap before departure. - *Rest starts between 18h and 21h:* This part of the flight is unfavorable for sleep. You should plan a longer rest period or divide your rest into 2 or 3 periods spread out over the flight.
- Alternate active and passive phases. - Avoid taking your meals or snacks at the same time as the other crewmember.	

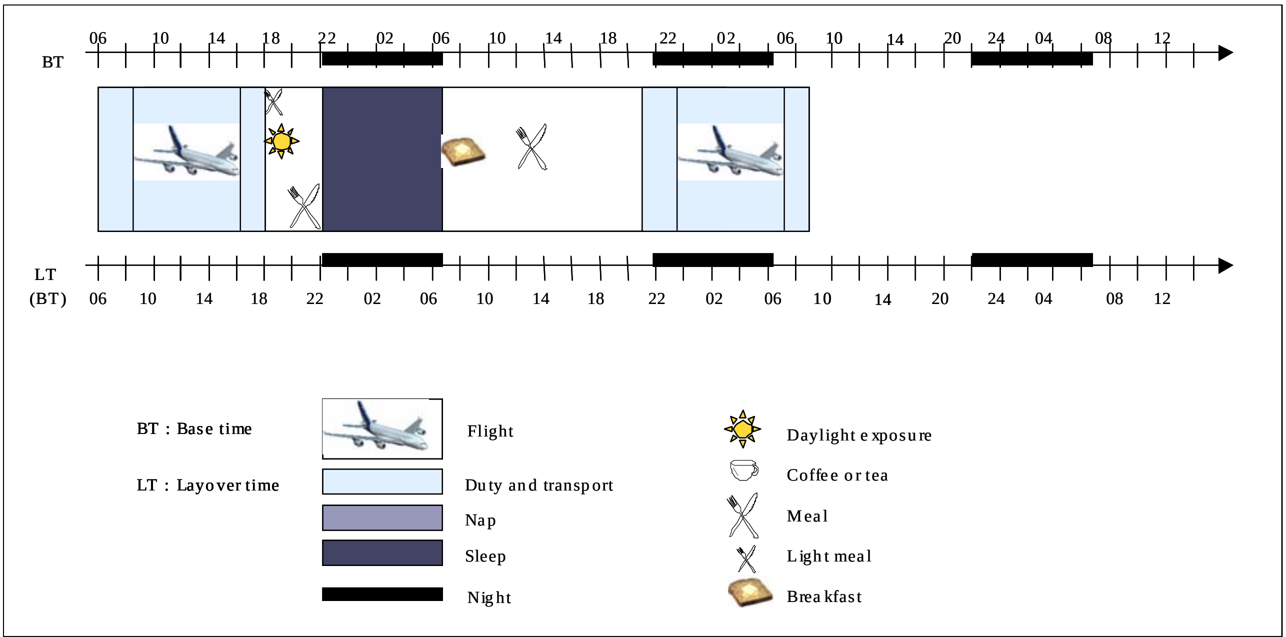
NORTH - SOUTH ROTATIONS (NSR)

NSR / Basic Crew

Main characteristics of the rotation and recommendation codes:

Outbound Flight	Departure from home: 6h BT Flight departure: 8h30 BT	***BC1***
Time zone change	Base-time	NSR
layover	Arrival at the hotel: 18h BT Duration: 1 local night	NS L1
Return flight	Departure from the hotel: 21h BT Flight departure: 23h30 BT	BC3

BT: Base-time, BC: Basic Crew,
NS: North-South, L: layover, R: Rotation



Recommendations

Outbound flight:

Pre-flight

- During the day: normal activities, exposure to daylight in the afternoon, avoid coffee and tea after 16h.
- Do not take a nap during the day.
- In the evening: take a light meal and go to bed as early as possible.

During flight

- If early wake up, alertness decrement may occur between 13h and 16h.
- Alternate active and passive phases.
- Avoid taking your meals or snacks at the same time as the other crewmember.

Layover:

- On arrival: Avoid napping, if possible expose yourself to daylight, take a light meal. Avoid coffee or tea.
- Have dinner at base-time and go to bed at your normal base-time.
- In the morning, take breakfast, possibly drinking coffee and tea.
- Lunch at normal time.
- Avoid coffee and tea after 16h base-time.

Return flight:

Pre-flight

- During the day: normal activities, exposure to daylight in the afternoon, avoid coffee and tea after 16h.
- In the evening, take a light meal and go bed at your normal time.
- Avoid getting up early. Take a long nap before leaving followed by coffee or tea.
- Take advantage of waiting times during hotel-airport transfers to relax or take a nap, even a very short one.

During flight

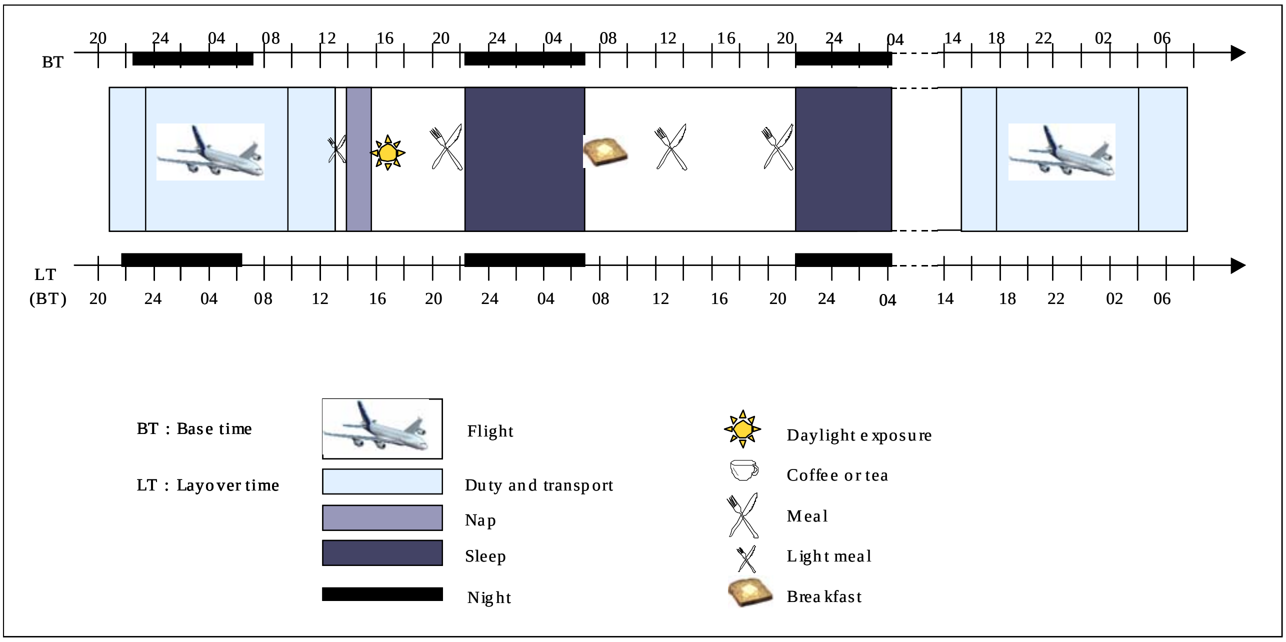
- Alertness decrements may occur more frequently after midnight if no nap before departure.
- Alternate active and passive phases.
- Avoid taking your meals or snacks at the same time as the other crewmember.

NSR / Augmented crew

Main characteristics of the rotation and recommendation codes:

Outbound Flight	Departure from home: 21h BT Flight departure: 23h30 BT	***AC3***
Time zone change	Base-time	NSR
layover	Arrival at the hotel: 13h BT Duration: 2 local nights	NSL3
Return flight	Departure from the hotel: 15h BT Flight departure: 17h30 BT	AC2

BT: Base-time, AC: Augmented Crew,
NS: North- South, L: layover, R: Rotation



Recommendations

Outbound flight:

Pre-flight

- *Rest during the flight between 18h and 22h.*
  - In the evening: take a light meal and go to bed as early as possible. The following day: normal activity, avoid coffee and tea after 12h, do not take a nap.
- *Rest during the flight after 22h.*
  - In the evening take a light meal and go bed at normal time, avoid coffee and tea after 16h. Avoid getting up early. Take a long nap before leaving followed by coffee or tea.
- *Absence of crew coordination:* Follow the recommendation n°2 above.

During flight

- Alertness decrements may occur more frequently after midnight if no nap before departure.
- Alternate active and passive phases.
- Avoid taking your meals or snacks at the same time as the other crewmember
- *Rest starts between 18h and 21h.* This part of the flight is unfavorable for sleep. You should plan a longer rest period or divide your rest into 2 or 3 periods spread out over the flight.

Layover:

- On arrival: have a light meal, avoid coffee and tea, and take a nap as soon as possible. In the afternoon: expose yourself to daylight, have light physical exercise (walk).
- Avoid coffee and tea after 16h, base-time.
- Have dinner at base-time and go to bed at your normal base-time.
- In the morning take breakfast, possibly drinking coffee and tea.
- Lunch at normal time.

Return flight:

Pre-flight

- *Rest during the first part of the flight.*
  - In the evening take a light meal and go to bed as early as possible. The following day: normal activity, avoid coffee and tea after 12h. Do not take a nap.
- *Rest during the other parts of the flight.*
  - In the evening take a light meal and go bed at your normal time, avoid coffee and tea after 16h. Avoid getting up early. If possible, take a nap before leaving followed by coffee or tea.
- *Absence of crew coordination*: Follow the recommendation n°2 above.

During flight

- The end of the flight may be difficult because it corresponds to a period favoring sleep.
- Alternate active and passive phases.
- Avoid taking your meals or snacks at the same time as the other crewmember
- *Rest starts between 16h and 21h:* This part of the flight is unfavorable for sleep. You should plan a longer rest period or divide your rest into 2 or 3 periods spread out over the flight.

5. PRACTICAL RECOMMENDATIONS FOR ULTRA LONG RANGE FLIGHTS

With the arrival in service of new aircraft, such as the A340-500, a new set of recommendations was drawn up to cover those specific operations that are called Ultra Long Range flights (ULR). This has been undertaken in response to the request of Singapore Airlines (SIA) but since then other operators are seeking support in this matter.

For SIA this corresponds to an adaptation of the long-range flights recommendations presented in this issue to the very first ULR flights launched by SIA between Singapore and Los Angeles (SIN-LAX) in February 2004 as well as to the Singapore- New York route (SIN-JFK) being launched in June 2004. These recommendations are provisional and were drawn with the best state of knowledge available in the absence of prior experience with these types of ULR flights. In due time we will therefore develop proper operational evaluations and validations.

5.1. CHARACTERISTICS OF THE ROSTERS & RECOMMENDATIONS CONSTRAINTS

The schedules of these ULR flights are shown in the table here below (layover time):

	SIN – LAX – SIN (+8)		**SIN-NY-SIN (+12)**	
	departure	arrival	departure	arrival
Outbound flight	**16h** (0h)	**8h** (16h)	**12h10** (23h50)	**5h** (17h)
Return flight	12h (**20h**)	6h (14h)	12h30 (**23h30**)	6h40 (18h40)

The common characteristics to these rosters are obviously the long flight duration (between 16 and 18 hours) and the crew composition (double crew instead of augmented crew for long haul flight). Therefore, there are new possibilities of in-flight rest management for each crew in terms of the amount of opportunities and duration. The landing crew may have the choice between these different possibilities according to their feeling.

The timing of the outbound flights and the amount of time zones are the main differences between SIN-LAX and SIN-JFK routes. Consequently there slight differences in the recommendation for the outbound flight and layover rest management.

The recommendations are based on the following criteria :

- all crews are based in SIN
- the crews are fully adapted to SIN time before departure
- the crews at the controls for take off and landing are the same and are known beforehand (before the flights)
- the crew at the controls for landing may have the choice of in-flight rest period (in terms of timing and amount of rest periods) according to :
- the duration and the quality of their sleep before flight
- the time since sleep or nap

5.2. DETAILED REVIEW OF RECOMMENDATIONS

5.2.1. SIN-LAX-SIN

5.2.1.1. THE DAY BEFORE THE OUTWARD FLIGHT

Recommendations depend on the timing of in-flight rest period:

– first part or second part of the flight.

If your main rest period is planned in :

- the first part of the flight :

- take light meal in the evening
- go to bed as early as possible
- the following day, normal activity
- avoid coffee or tea after 12h
- do not take a nap

- the second part of the flight:

- take a light meal in the evening
- avoid coffee and tea after 16h
- go to bed at your normal time
- avoid getting up early
- if possible, take a nap before leaving for the airport
- appropriate time for coffee or tea if needed
- if not, relax and take a nap during home/hotel airport transfers, even a very short one

5.2.1.2. DURING THE OUTWARD FLIGHT

The second part of flight is more favorable to sleep because it corresponds to the normal home time for sleep. The landing crew should have its main sleep period in the second part of the flight. If there are 4 equal rest periods of 4 hours each, nobody will have enough sleep: The “excitement” of departure may prevent sleep in the first part of the flight therefore sleep inertia will probably be high after the second rest period. On the contrary, if there is a long rest period in the second part of the flight, the probability to sleep 4 to 5 hours is high and the level of alertness of landing crew will be appropriate.

Consequently there are 2 possible rest management periods in terms of the amount and of the timing of rest periods:

- 2 rest periods of 2 and 5 hours duration for each crew:
  - Crew A: 5 hours after take off and 2 hours before landing of the flight in the second part of the flight
  - Crew B: 2 hours in the first part of the flight and 5 hours in the second
  - Landing crew should be B rather than A
- Unequal number of rest periods between crews A and B:
  - Crew A: 7 hours in the second part of the flight
  - Crew B: of 5 and of 2 hours duration
  - Landing crew should be A rather than B

5.2.1.3. DURING THE LAYOVER

5.2.1.3.1. Upon arrival to the hotel

There is a period of about 12 hours before base time sleeping period so crews will need to choose between cases A , B or C according to their feelings of fatigue.

- Case A: You got a long sleep in the second part of the flight and you don't feel too tired:
    - have a light meal.
    - appropriate time for coffee or tea if needed
    - avoid napping or limit the duration of the nap.
    - dinner late in the evening (LT)
    - go bed from 18h (SIN time)

- Case B or C: your in-flight sleep was poor and you feel very tired :

- Case B: your main sleep during layover night
    - avoid coffee and tea
    - take light meal
    - go to bed as soon as possible.

- Case C : Split your sleep in 2 periods of 4 to 5 hours each
    - avoid coffee and tea
    - take light meal
    - go to bed around 14h and 2h (SIN time)

5.2.1.3.2. THE FOLLOWING DAYS

There are different sleep patterns during layover :

- main sleep on Base Time night (BT) :

- advantages : good sleep, no troubles with the biological clock, last sleep period is close to the return flight departure, rapid recovery after the rotation
- drawbacks : unsociable

- main sleep on Layover Time night (LT) :

- advantages : convenient for social life
- drawbacks : poor sleep, biological clock disturbances, it takes long to recover after the rotation

- split sleep of 2 periods in either night : Layover and Base Time (LBT) :

- advantages : by getting some of the sleep during base time night you stabilize the biological clock, rapid recovery after the rotation
- drawbacks : slightly restrictive for social life

The following recommendations are probably a good compromise :

- Expose yourself to daylight
- Perform light exercise (walk)
- Have a meal at midday layover time
- Take a nap
- Have a light meal in the evening layover time
- Go to bed around 22h layover time
- Take long nap the day of the return flight

5.2.1.3.3. BEFORE RETURN FLIGHT

The choice of In-flight rest periods depends on your sleep and nap management during layover and in particularly for the last day. You should use the LAAQ (Layover Adjustment Assessment Questionnaire) below to assess your level of adjustment:

	At normal base-time	A lot closer to base-time	A bit closer to base-time	A bit closer to local-time	A lot closer to local-time	At normal local-time
When did you take your main sleep?	1	2	3	4	5	6
When did you start to feel tired?	1	2	3	4	5	6
When did you feel like taking a nap?	1	2	3	4	5	6
When did you have your bowel movement?	1	2	3	4	5	6
When did you have your meals?	1	2	3	4	5	6
When did you feel most alert?	1	2	3	4	5	6

Now please calculate your overall score by adding up the numbers that you have circled.

- If you scored between 6 and 17, your body clock is largely on base-time. During the return flight you should have your main in-flight rest period during home base sleeping hours (second part of the flight)

- If you scored between 18 and 24, your body clock has started to adjust to local time, but has not fully done so. During the return flight you should have 2 rest periods during layover sleeping hours.

- If you scored between 25 and 36, your body clock is largely on local time. During the return flight you should have your main in-flight rest during layover night (first part of the flight).

5.2.1.4. DURING THE RETURN FLIGHT

The landing crew has to choose the optimal solution for in-flight management according to their feeling and sleep management during the layover. The LAAQ questionnaire may help you to make your choice between the 3 following possibilities :

- 2 equal rest periods of 4 hours for each crew (score between 18 and 24)
- 2 rest periods of duration 2 and 6 hours for each crew. The timing of the longer period depends of the LAAQ score : between 6 and 17, the main sleep period in the second part of the flight and between 25 and 36 in the first part of the flight.
- 1 rest period of 8 hours for each crew. The timing of this rest period depends of the LAAQ score : between 6 and 17, the sleep period in the second part of the flight and between 25 and 36 in the first part of the flight.

5.2.2. SIN-NYC-SIN

5.2.2.1. THE DAY BEFORE THE OUTWARD FLIGHT

As the flight is scheduled at 12h10, the day before the flight, the crews have to

- avoid to nap
- take a light meal in the evening
- go to bed as early as possible
- avoid getting up early

5.2.2.2. DURING THE OUTWARD FLIGHT

The timing of the flight covers the 2 sleep gates. The departure scheduled at 12h offers the possibility to get a sleep period in the first part of the flight which corresponds to the secondary sleep gate. The landing at 5h may limit “nocturnal” sleep duration in the second part of the flight. Therefore, the appropriate rest management should include 2 rest periods of 2 and 6 hours:

- Crew A: 6 hours after take off and 2 hours before landing of the flight in the second part of the flight
- Crew B: 2 hours in the first part of the flight and 6 hours in the second part
- Landing crew should be B rather than A

5.2.2.3. DURING THE LAYOVER

Due to the high number of crossed time zones (12), it is difficult to maintain base time sleeping habits during the layover. Therefore, try to sleep during the layover night and take a nap after midday meal or try to split your sleep over 2 periods in either night, layover and base time.

5.2.2.3.1. UPON ARRIVAL TO THE HOTEL

- have a light meal (or breakfast if possible)
- Avoid coffee and tea
- Go to bed as soon as possible

5.2.2.3.2. THE FOLLOWING DAYS

There are 2 sleep patterns during layover :

- Main sleep on Layover Time night
  - advantages : convenient for social life
  - drawbacks : poor sleep, biological clock disturbances, it takes long to recover after rotation

- Split sleep over 2 periods in either night : Layover and Base Time :
  - advantages : by getting some of the sleep during base time night you stabilize the biological clock, rapid recovery after rotation
  - drawbacks : slightly restrictive for social life

The following recommendations are probably a good compromise :

- Expose yourself to daylight
- Perform light exercise (walk)
- Have a meal at midday layover Time
- Take a nap
- Have a light meal in the evening layover Time
- Go to bed around 22h layover Time
- Take long nap the day of the return flight

5.2.2.3.3. BEFORE THE RETURN FLIGHT

The choice of in-flight rest periods depends on your sleep and nap management during layover and in particular the last day. You should use the LAAQ questionnaire below to assess your level of adjustment:

	At normal base-time	A lot closer to base-time	A bit closer to base-time	A bit closer to local-time	A lot closer to local-time	At normal local-time
When did you take your main sleep?	1	2	3	4	5	6
When did you start to feel tired?	1	2	3	4	5	6
When did you feel like taking a nap?	1	2	3	4	5	6
When did you have your bowel movement?	1	2	3	4	5	6
When did you have your meals?	1	2	3	4	5	6
When did you feel most alert?	1	2	3	4	5	6

Now please calculate your overall score by adding up the numbers that you have circled.

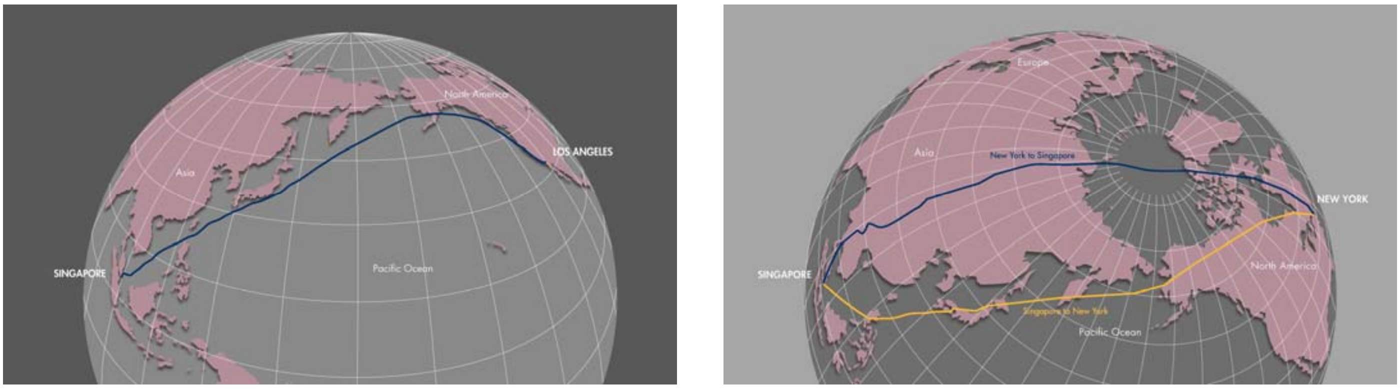
- If you scored between 6 and 17, your body clock is largely on base-time. During the return flight you should have your main in-flight rest period during home base sleeping hours (second part of the flight)
- If you scored between 18 and 24, your body clock has started to adjust to local time, but has not fully done so. During the return flight you should have 2 rest periods during layover sleeping hours.
- If you scored between 25 and 36, your body clock is largely on local time. During the return flight you should have your main in-flight rest during layover night (first part of the flight).

5.2.2.4. DURING THE RETURN FLIGHT

The landing crew has to choose the optimal solution of in-flight management according to their feeling and sleep management during the layover. The LAAQ questionnaire may help you to make your choice between the 3 following possibilities :

- 2 equal rest periods of 4 hours for each crew (score between 18 and 24)
- 2 rest periods of duration 2 and 6 hours for each crew. The timing of the longer period depending of LAAQ score: between 6 and 17, the main sleep period in the second part of the flight and between 25 and 36 in the first part of the flight.
- 1 rest period of 8 hours for each crew. The timing of this rest period depending of LAAQ score: between 6 and 17, the sleep period in the second part of the flight and between 25 and 36 in the first part of the flight.

Preparing for A340- 500 ULR Operations at Entry Into Service in SIA



A340-500 ULR Route Patterns at SIA: SIN - LAX and SIN - NYC

Forward Crew Rest Area and Cabin Crew Rest Area of the A340-500

Capt. H.K. Leong on the ULR Operational Issues during the A340 Fleet Meeting held in January 2004

6. SHORT SUMMARIES

Recording wrist activity throughout the flight with actometry

Early daylight with UTA to Singapore on B747-400 in 1990

Night flight with UTA to Singapore on B747-400 in 1990.

Caffeine Intake on night flight with UTA to Singapore on B747-400 in 1990.

Assessing crew performance through double task test at Air France in 1994.

Validating recommendations on crew rest and alertness at Air France in 1994.

6.1. ALERTNESS LEVELS & DECREMENT

Behavioral continuum	Vigilance or attention levels	Efficiency
Strong emotion	Dispersed and diffused attention	Poor, loss of control, disorganized behavior
Attentive alertness (active wakefulness)	Selective attention prone to variations, concentration, anticipation	Good: efficient, selective and quick reactions. Behavior suitable for serial responses
Relaxation or alertness decrement (diffused alertness)	Attention wavering, not concentrated	Good for routine reactions and creative thought. Bad for monitoring tasks
Drowsiness	Limit condition, mental pictures, dreaming	Poor, uncoordinated behavior, unstable, loss of time references
Light sleep	Considerably reduced awareness	None
Deep sleep	Total disappearance of vigilance	None

Taken from Defayolle et al., 1971

DEFINITIONS

Alertness levels also called wakefulness or level of arousal, or central nervous system activation, represent a continuum from hyperexcitation to deep sleep. In other words, there is no difference in the nature of these levels, they only differ by their magnitude of activation. The notion of alertness level must be distinguished from that of performance level. The alertness level is only a component of the performance level. It constitutes a necessary but insufficient condition. The other condition being the voluntary investment by the operator, i.e. the maintenance of a certain attention or vigilance.

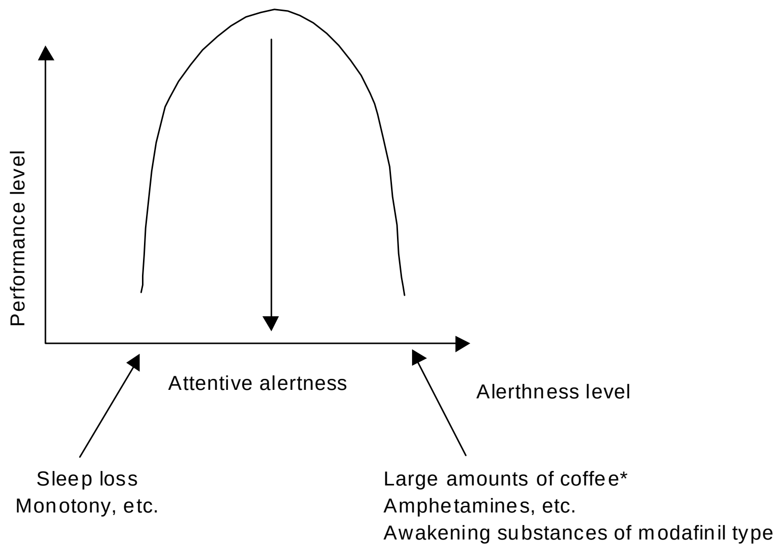
Each alertness level is associated with a probability of reaching a certain efficiency level. This means that being awake does not necessarily ensure an optimum efficiency level: too high a level (strong emotion) disorganizes attention, too low a level (drowsiness) does not allow attention to be fixed on any pertinent information.

An optimum efficiency level can be reached from wakefulness level called "attentive alertness".

Relaxation, dispersed alertness or **alertness decrement**, are not consciously perceived. Change of state is reversible: return to attentive alertness is possible following a modification in activity or environment. This alertness decrement state can be facilitated through monotony. In case of sleep pressure, this condition rapidly turns into drowsiness. In alertness decrement situations, the ability to detect rare or unexpected signals is impaired.

A nonlinear relation exists between wakefulness level and performance. This relation is shown on the following figure:

Alertness level and performance



* Formally not recommended for crews

Taken from Schimiatke, 1976

6.2. FATIGUE

The notion of fatigue must be distinguished from alertness decrement and from the need for sleep. In fact, fatigue may appear with a high alertness level.

It can be defined as "a set of manifestations generated by intense and prolonged work extending beyond a certain limit". These manifestations are accompanied by a "feeling of fatigue", and a less favorable relation between efficiency and the effort required to accomplish it. In other words, to maintain equivalent performance, the tired subject must make greater efforts. Pushed to the extreme, a very high workload performed during prolonged periods, interrupted by very short rests, may lead to the development of an exhaustion phenomenon. This phenomenon causes asthenic type pathological reactions.

Distinction should be made between three sorts of fatigue:

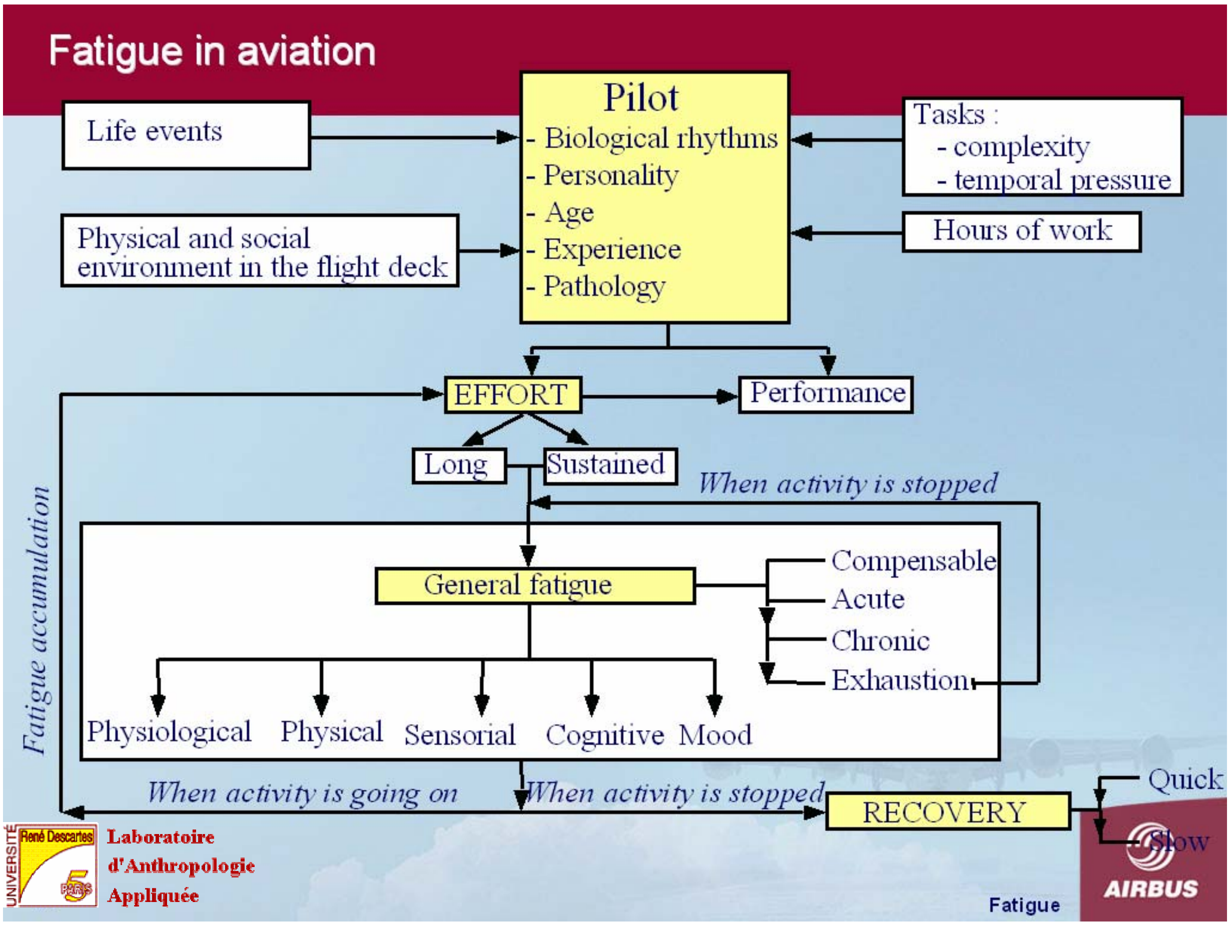
- sensorial fatigue: auditive, visual,
- muscular fatigue,
- mental fatigue.

Sensorial fatigue and **muscular fatigue** are relatively well defined. These can be objectified and measured. **Mental fatigue** however is more difficult to characterize and to assess. It must be attributed to the highly subjective character of fatigue: one feels "tired", but it is sometimes difficult to translate this sensation into objective manifestations. Indicators therefore remain essentially subjective. Performance tests can however show degradation in those mental functions (memory, attention, etc.) that are related to fatigue.

One of the main characteristics of fatigue lies in the fact that it is a phenomenon that progressively builds up with time (fatigue accumulation). Fatigue is not necessarily related to an excessive workload, to rest, which is too short, or even to disturbed sleep.

A given task may generate feelings of fatigue for certain subjects and lead to no particular fatigue whatsoever in others. This refers us back to the psychological aspects of motivation and satisfaction in the task to be accomplished. For these aspects, great inter-individual differences are observed.

Recovery from fatigue, i.e. return to a rested condition, is also poorly known and is associated with inter- and intra-individual differences.
Thus, in certain cases and for certain subjects, recovery seems to be very long in spite of sufficient sleep of satisfactory quality.
These aspects must therefore be subject to in-depth research in order to determine all factors influencing level of fatigue and its manifestations and consequences.
In particular, the accumulation of fatigue remains unexplored even if it is of capital importance in aviation. Moreover, there is a lack of documented studies on the consequences of successive jet lags when operating in opposite directions over long periods of time.



In spite of the fatigue aspects which are still poorly known, certain manifestations (i.e. ↓ lowering, decrement or decrease, ↑ rising, increment or increase) have been identified in the physiological and psychomotor fields.

In the physiological field	In the psychomotor field
↓ in body temperature	↓ in memory
↓ in muscular force or strength	↓ in communications skill
↓ in binocular vision	↓ in ocular tracking (following objects with eyes)
↓ in volume of circulating blood	↓ in attention span
↓ in muscular glycogen (energy stores)	↓ in personal care
↑ in blood sugar (glucose)	↓ in activity
↑ in pupil response time to light (in natural reflex of the eye to light)	↓ in muscular control and coordination
↑ in visual accommodation time	↓ in cooperativeness
↑ in eye fatigue	↓ in acceptance of criticism
↑ in heart rate	↑ in reaction time
	↑ in irritability, anxiety, depression
	↑ in errors and omissions
	↑ in decision making

Taken from J. MARKLE, 1984

Plotting North Atlantic navigation track at UTA on DC-10 in 1990.

Checking navigation performance on ETOPS flight with Air France B767 in 1994

Observing crew activity alternation modes at UTA on DC-10 in 1990.

Validating Active / Passive crew alternation at Air France on A340 in 1994

Evaluating the effects of sleep inertia at Sabena on 340 in 2002

6.3. MONOTONY

6.3.1. DEFINITIONS

The alertness level can be greatly influenced both by the environment and by the activity of the subject himself.

The environment and the type of task determine the degree of monotony of the situation as it can be defined as "the characteristics of a task in which the sensorial stimulations remain almost constant and extremely repetitive". In fact, there are two concepts in the notion of monotony:

- the state of monotony,
- the monotonous nature of the task.

The state of monotony corresponds both to a subjective feeling and to physiological and psychological manifestations.

The subjective feeling manifests itself as boredom, as disinterest in the work to be done and as a feeling of drowsiness.

From a physiological point of view, a reduction in the activation of the central nervous system is observed. During a monotonous task, the electro-encephalogram (EEG) shows a marked increase in the alpha and theta rhythms typical of a reduction in wakefulness level. A reduction in the heart rate of about 30% and a reduction in blood pressure are also observed.

Taken to the extreme, monotony can lead to psychological disorders causing stress and acute fatigue. The stress would be related to the constant effort required to maintain a sufficient level of arousal to execute the task.

6.3.2. FACTORS INCREASING THE DEGREE OF MONOTONY

6.3.2.1. ENVIRONMENT

Generally speaking, all situations lacking sensorial stimulations or with stimulations which largely remain constant, lead to a state of monotony favorable to a reduction in wakefulness level irrespective of the time of day and this, even when there is no sleep loss.

Several environmental factors can reduce alertness levels
• Repetitive or low-intensity sensorial simulations • Reduced visual field • Restriction in the liberty of movement (no change in postures) • Rare social interactions • High temperature • Low lighting intensity

6.3.2.2. MONOTONOUS TASKS

Distinctions should be made between two types of monotonous tasks:

- repetitive activities,
- monitoring continuous processes.

Repetitive activities are associated with work mechanization and especially its fragmentation into simplified operations. The degree of monotony of these tasks can be influenced by different factors:

- low number of actions to be repeated per time unit,
- simplicity of the actions,
- imposed rhythm.

The development of supervisory activities is to be seen in relation to the development of automation. The degree of monotony of these tasks is mainly influenced by:

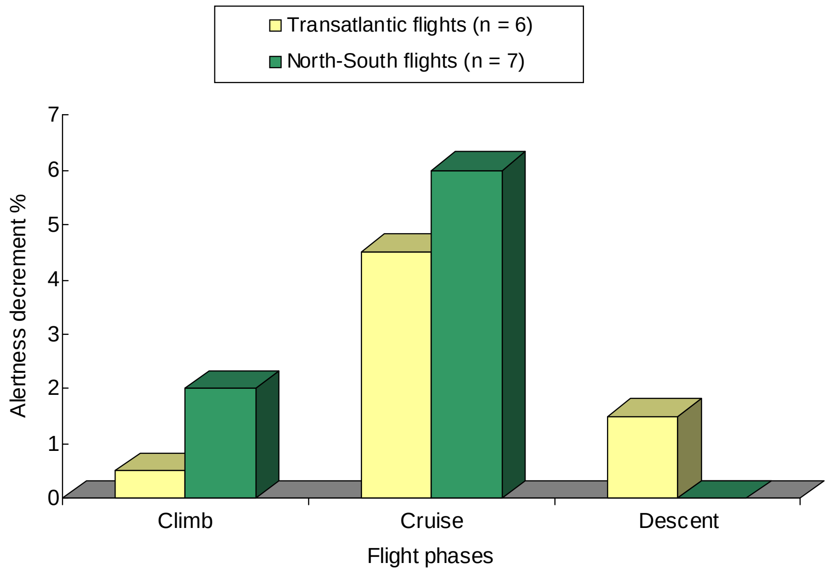
- a reduced visual field (night flying, observing cathode ray tubes),
- the small amount of useful information received per unit of time.

6.3.3. MONOTONY & LONG-HAUL FLIGHT

Monotony is one of the most important constraints in aviation, primarily during long-haul flights. This constraint might be accentuated when these flights are made on new-generation glass cockpit aircraft.

This was studied from experiments conducted by LAA and Airbus in real flight situations with voluntary crews from several participating airlines. Variations in alertness levels in flight were assessed from electro-encephalograms (EEG) and electro-oculograms (EOG). Crewmember activities and behaviors were simultaneously observed by means of an Aircrew Data Logging System. Sleep duration and quality before the rotation, during layover and after the rotation were also determined from recordings made with wrist actometers and from sleep logs (see chapter 6-2).

Long-haul flights



Taken from DOC AA 302/93

Results indicate that alertness decrement occurrences may be very frequent, even during daytime flights, without previous sleep loss.

Results also show that alertness decrement rates are higher during north-south flights than during transatlantic flights, especially for the cruise phase. This difference may be due to the very high monotony of cruise phases during north-south flights for which radio contacts are rare. However, for Asiatic rotations, the high number of ATC communications contributes towards limiting reductions in the alertness level.

These alertness decrements may occur simultaneously for both pilots. This can be attributed to potentially highly synchronized activities between the two pilots. Observing activities and behaviors shows that certain actions, such as reading technical documents or passively supervising systems, favor these reductions in alertness. Inversely, motoric tasks associated with a cognitive activity, such as interacting with the FMS (Flight Management System), reactivate the pilots' alertness level. Also, the mutual knowledge that pilots have of themselves, the aircraft and the route may have a negative influence on alertness.

These results reflect the effect of monotony towards reducing the alertness level.

6.3.4. REDUCING THE EFFECT OF MONOTONY

Some laboratory and field research is available to document developed solutions for alleviating the effects of monotony on an operator's alertness. The following methods were deemed efficient:

- introducing short breaks during the task (10 minutes every 30 minutes),
- introducing a different task,
- task execution rate set by the operator.

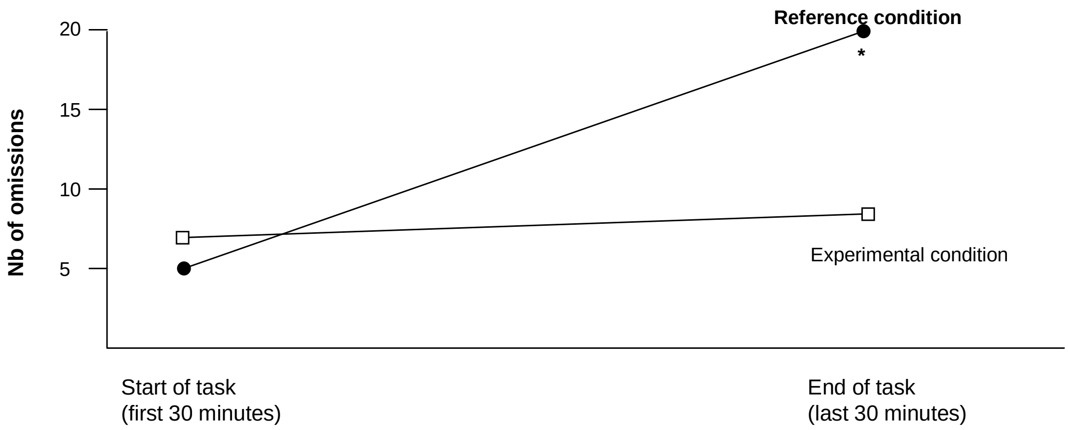
Another method consists of altering the task execution process without modifying its nature. This solution was shown to be well founded by experimental laboratory research (Cabon, 1992). The task used in this experiment was a critical signal supervision and detection task requiring the use of "automatic" processes. Its duration lasted 4 hours.

In order to break the monotony of the task, subjects were forced to use "controlled" processes during short periods. These processes required greater attention than the "automatic" processes. This situation (experimental condition) was compared with a condition in which the subjects only used the automatic processes (reference condition). As a result of this daytime experiment, the following results were observed between start and end:

- similar performance (number of omitted signals) **under experimental conditions**,
- significant decrease in performance **under reference conditions**.

When the experiment was held at night, significant reductions were observed irrespective of the conditions.

Reducing the effect of monotony



* Significant difference at p<0.001

Taken from Cabon, 1992

These experimental results show that modifying the nature of the task, its duration, its execution rhythm and also the response execution process can attenuate the effects of monotony.

The principle for breaking monotony by alternating "automatic" and "controlled" cognitive processes was transposed to real situations involving military air surveillance operators (Cabon, 1992).

Field research carried out with nuclear power plant control room operators confirmed possibilities for practical uses of this solution when monitoring automated processes (Cabon, 1992).

This method was transposed to real long-haul flight situations within the context of validating recommendations. In these recommendations, it is specified that pilots should alternate passive and active vigilance phases.

Active vigilance periods are characterized by:

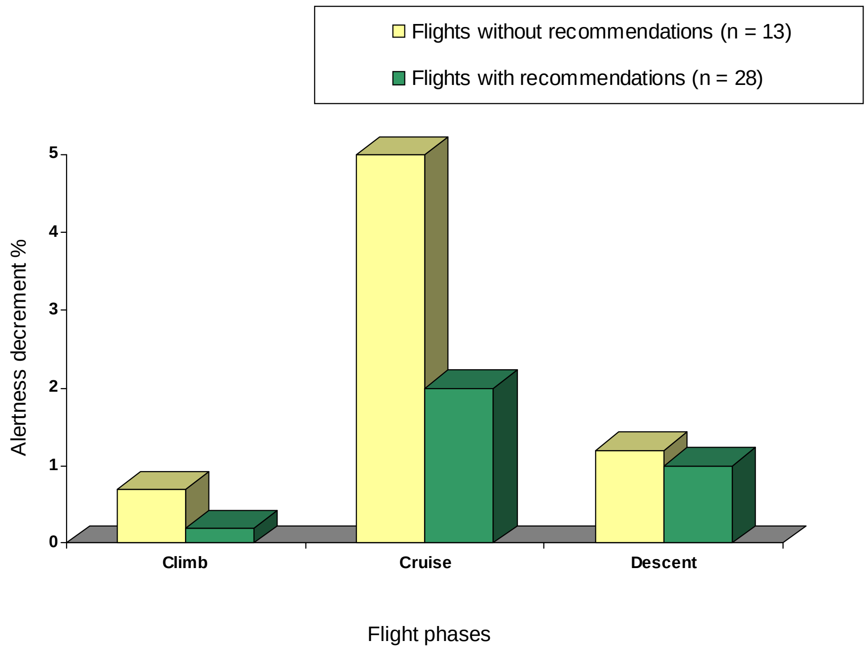
- tasks and verbal exchanges related to flight management,
- varied motor actions associated with mental tasks involving electronic interfaces (FMC, ECAM/EICAS for example),
- no meals during this period.

During the passive vigilance periods, we suggest favoring:

- activities not related to the flight (reading of papers for instance),
- more dispersed supervision of the flight,
- meals or snacks,
- napping.

It is proposed that pilots alternate these periods at a frequency between 20 to 40 minutes according to flight context. This alternation is mainly justified during calm cruise periods with no strategic changes in flight plan. Also, pilots are asked to verbally express the end of each phase in order to inform the other crewmember.

Long-haul flights



Taken from DOC AA 302/93

Results demonstrate that alertness decrement rates are lower for flights with recommendations, irrespective of the flight phase. Observing crews' activities shows that this reduction can be attributed to crew activity management conducive to reduced flight monotony.

6.4. CIRCADIAN RHYTHMS

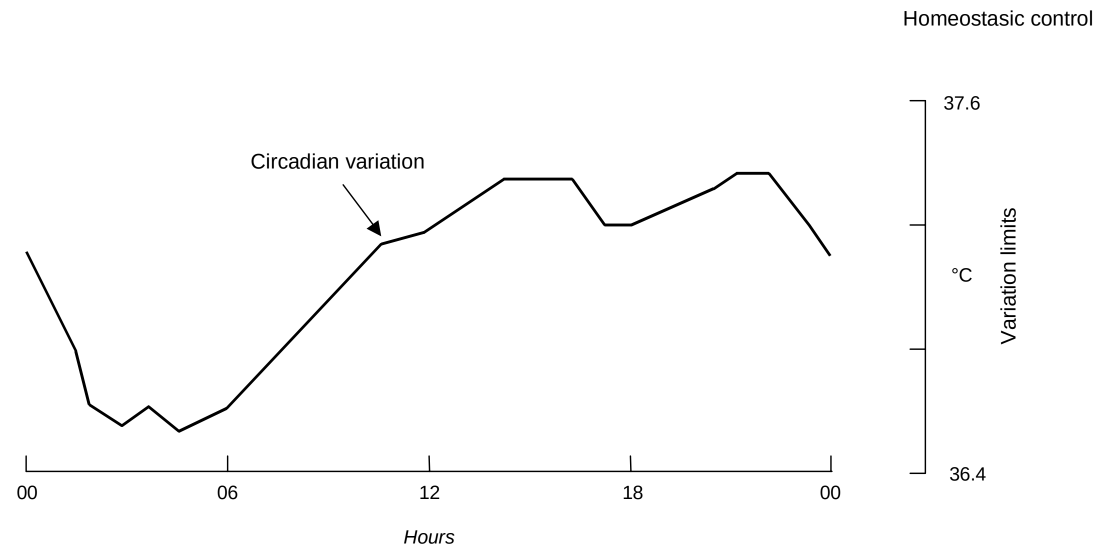
6.4.1. CONSTANCY & RHYTHMICITY

6.4.1.1. DEFINITIONS

Human functioning has two main regulatory modes: circadian (circa: about, dies: day) and homeostasic (homeo: constant, stasis: level).

Vital functions pass through a maximum and a minimum during a period of 24 hours (circadian variation). These variations are within limits beyond which the organism would be in danger (homeostatic regulation).

Stability and variation



Example of circadian and homeostasic control of body temperature (°C)

6.4.1.2. MANIFESTATIONS

The homeostasic process manifests itself in individual life through sensations such as hunger, thirst, fatigue, drowsiness, etc. Satisfying these needs restores the internal balance needed to maintain physical and mental integrity.

Circadian regulation is reflected by a diurnal increase and a nocturnal decrease in the individual's functional capabilities. It is at the origin of sleep disorders, disturbances in the biological rhythms and mental performance when the rest-activity cycle is modified or after rapidly crossing many time zones.

6.4.2. BIOLOGICAL RHYTHMS

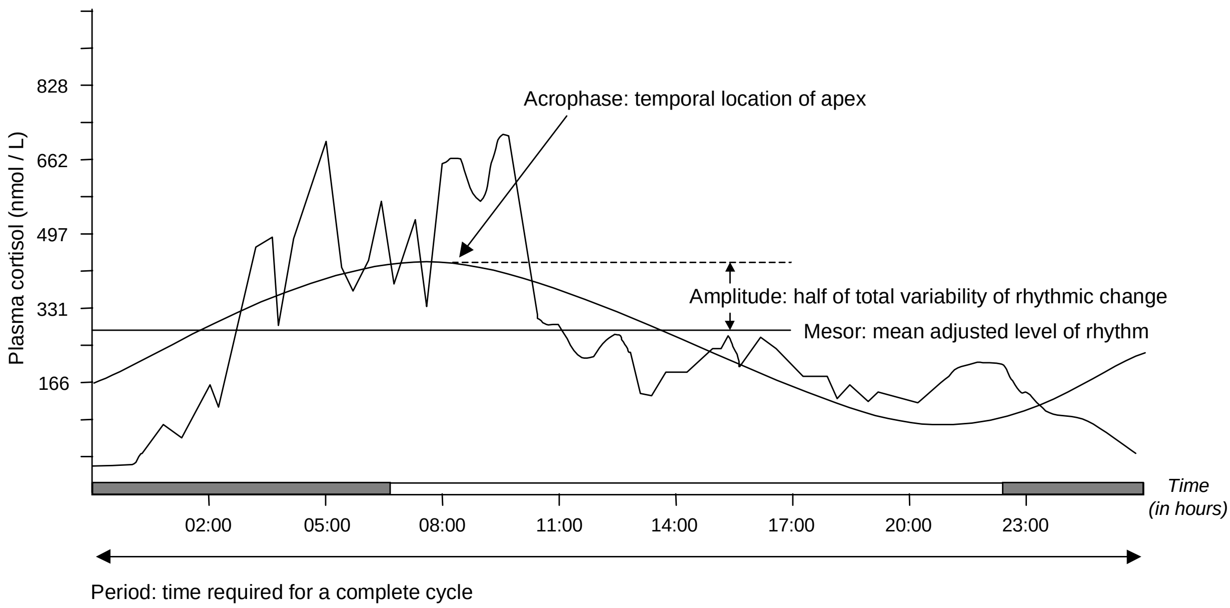
6.4.2.1. DEFINITIONS*

Vital activities which characterize cells, tissues, organs, individuals and even populations, do not occur evenly or randomly in time, but have a daily maximum and minimum.

A rhythm can be defined as being the periodic recurrence of a sequence of events occurring in the same order during the same time interval.

Four parameters characterize a biological rhythm: period, mesor, amplitude, acrophase.

Biological rhythms



Characteristics of circadian fluctuations of plasma cortisol
over a period of 24 hours (taken from Nelson, 1979)

A rhythm is called ultradian, circadian or infradian when the period is lower than, equal to or greater than 24 hours respectively.

6.4.2.2. TEMPORAL STRUCTURE

Peaks of the different variables are not randomly distributed. On the contrary, a time-related or "temporal structure" organization exists for the distribution of the acrophases over 24-hour periods.

The Various vital functions have strong phase relations between the ascending and descending parts of their rhythms.

The alteration of these phase relations is at the origin of the disorders related to jet lag and shift work.

Chronobiology is defined as being "the study of the temporal structure of each living being and that of its alterations".

6.4.2.3. ORIGIN

Circadian rhythm periods are close to those of the earth's rotation.

One is therefore led to think that these rhythms strictly and rigorously depend on environmental variation, i.e. day-night alternation, darkness-daylight, heat-cold, rest-activity, etc.

Under constant environmental and behavioral conditions (experiment called "constant routine") biological rhythms do persist.

We are therefore left to conclude that an internal mechanism regulates body function. This mechanism is simply known as the biological clock.

6.4.2.4. IMPLICATIONS

In certain cases, choosing the best time to administer a drug allows its therapeutical effects to be optimized and its secondary effects reduced. For example, as the acrophase of cortisol secretion is located around 8am, administering corticoids (drugs chemically similar to cortisol) in phase with its peak secretion reinforces their actions. Another example is the time duration over which an antihistamine drug will act; the effective time is doubled if the drug is administered at 7am rather than 7pm.

The effects of various toxic agents (heavy metals, organic solvents, carbon oxides) vary considerably over a period of 24 hours. At certain times, a toxic agent can cause substantial lesions, whereas the same dose received at another time in the 24-hour cycle would be much less harmful. These temporal differences in the intensity of toxic effects are most often correlated with the capacity of the liver and the kidneys to "detoxicate" blood of these harmful substances.

6.4.3. CIRCADIAN RHYTHMS OF PERFORMANCE

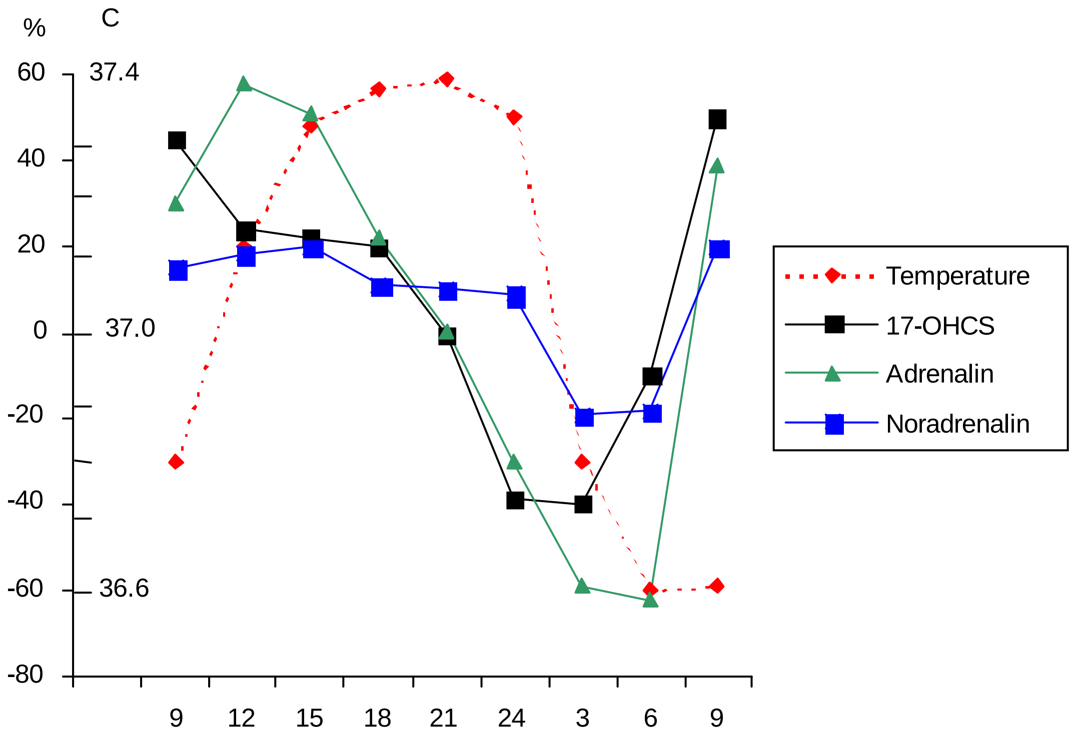
6.4.3.1. DESCRIPTION

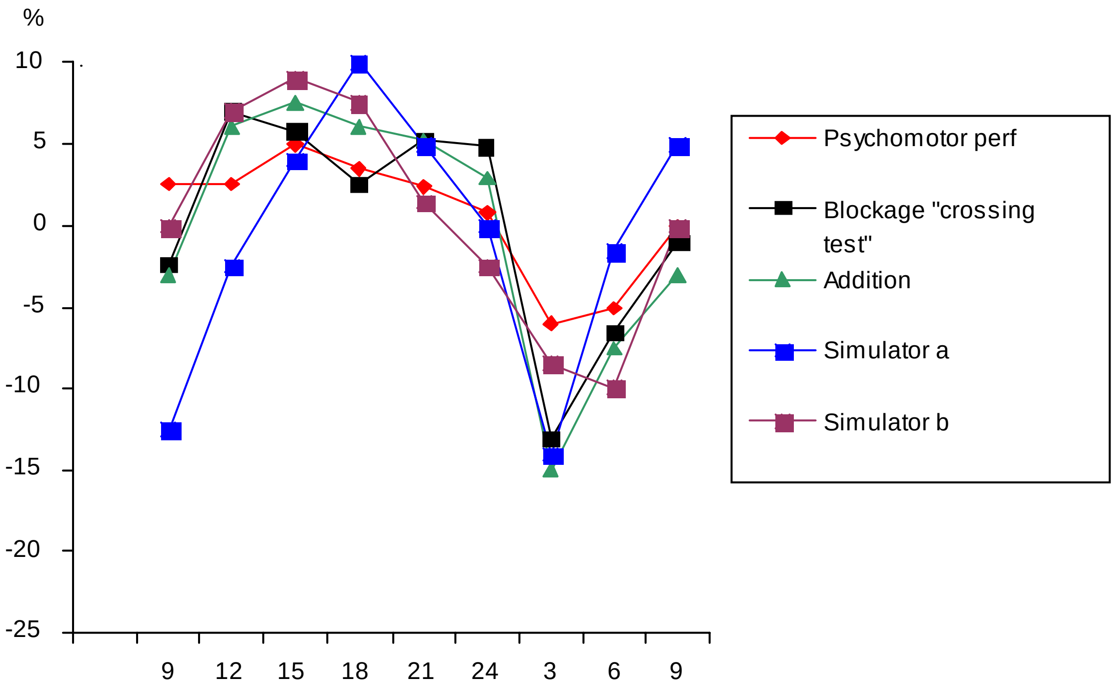
Operators engaged in any given tasks do not always react in the same way at different times of day and night. Similar to biological functions, perceptual and mental functions are subject to rhythmic variations over a 24-hour span.

Performance in trials demanding sustained attention improves during the morning to reach a maximum in the middle of the afternoon then starts to decline towards the evening to reach a minimum during the night.

Degradation in performance is sometimes observed early in the afternoon. This phenomenon, called the "post lunch dip" effect, occurs even when meals are not eaten.

Circadian variations in efficiency are, in most cases, highly correlated with variations in body temperature except in the early afternoon where this is paradoxically not paralleled by a similar decrease in temperature.





Examples of the circadian rhythms of physiological and psychological functions
(taken from Klein and Wegmann , 1988)

6.4.3.2. MODULATION OF CIRCADIAN VARIATIONS

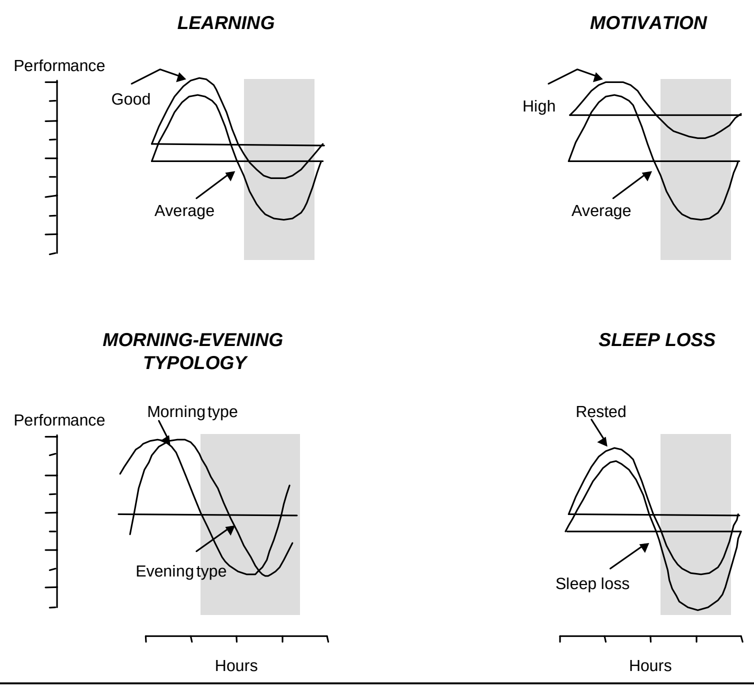
Exerting a greater effort can compensate for circadian rhythmicity: the reduction in performance controlled by circadian rhythmicity can be compensated for if the operator is able to mobilize more of his resources.

The ability for mobilizing resources varies according to:

- the type of task,
- the individual
- motivation,
- learning,
- knowledge of performance results.

Increasing the mobilization of the operator's capabilities, operational adaptation, change from a low activity state to an active mobilization state, when foreseeable or random events occur, causes physiological problems and has long-term medical consequences for the operator.

Modulation of circadian variations



Schematic representation of the factors modulating performance circadian rhythm (taken from Klein, 1976)

6.4.4. SLEEP LOSS & PERFORMANCE

6.4.4.1. DEFINITION

Partial sleep loss can be either attributed to a reduction in sleep time amounting to several hours (going to bed late, getting up early) or to a fragmentation of the sleep period.

Deterioration in performance related to sleep loss is generally indicated by omissions in test or in supervisory monitoring processes, i.e. periods of non-response to a critical signal. These periods correspond to episodes of drowsiness or reduced alertness levels.

Monotonous supervisory tasks are those that are the most affected by sleep loss. They present a low sensorial stimulation level, constant or repetitive, but requiring constant alertness.

6.4.4.2. MANISFESTATIONS

Signal detection: the capability to detect rare and low-level signals drops as sleep debt increases.

Rational critical analysis of situations: individuals with a sleep debt will have a tendency to accept raw sensorial impressions without critical analysis. During situations favoring the appearance of sensory illusions, or even visual and auditive hallucinations, a subject, even well-trained, will loose all ability to rationally criticize a situation and will act in an inappropriate manner. Sleep debt reduces the possibilities for critical analyses of increased sensory impressions.

Psychomotor learning: sleep loss can represent an important stress factor capable of inhibiting recently acquired automatisms and of archaic reactions which had disappeared under the recent learning effect.

The table below summarizes the main effects of sleep loss on mental processes and mood as well as on tasks most altered by sleep debt.

Effects on mental processes:

- lack of concentration,
- periods of inattention,
- reduction in alertness level,
- slow actions,
- alteration in short-term memory,
- loss of critical analysis and advocacy,
- interpretation errors,
- visual illusions,
- disorientation.

Effects on mood:

- sensation of fatigue,
- depressive state,
- irritability,
- loss of interest in people and events,
- increasing and irresistible longing for sleep.

Most altered tasks:

- sustained tasks,
- tasks without stimuli,
- routine work,
- supervisory monitoring tasks,
- insufficiently learnt tasks,
- tasks with high workload,
- tasks requiring complex decision-making.

(after British Army Personnel Research Center, 1986).
Cited in Lagarde, 1990

6.4.4.3. MODULATIONS OF THE EFFECTS OF SLEEP LOSS

Noise: in normal situations, noise has too high an activation effect leading to a reduction in efficiency, but it facilitates efficiency when associated with sleep loss (Wilkinson, 1963). Sleep loss reduces the cerebral activation level, noise moves this level towards the optimum.

Alcohol: associated with a sleep deprivation, reduces the wakefulness level and, in parallel, degrades mental performance.

Moderate physical exercise: increases cerebral activation.

Validating Active/Passive crew alternation at Air France on A340 in 1994

Validating Crew Rest on board with dedicated sleep bunks on A340 in the early 90's

6.5. SLEEP & NAPPING

6.5.1. SLEEP

6.5.1.1. DESCRIPTION–NORMAL SLEEP

Sleep onset is a periodic phenomenon that occurs every day at almost the same time.

Sleep generally starts at the end of the day, when the body temperature begins to drop and it continues so for 6 to 8 hours.

Spontaneous awakening occurs during the ascending part of the thermal cycle, that is 2 to 3 hours after the thermal minimum which, on average, takes place around 5am.

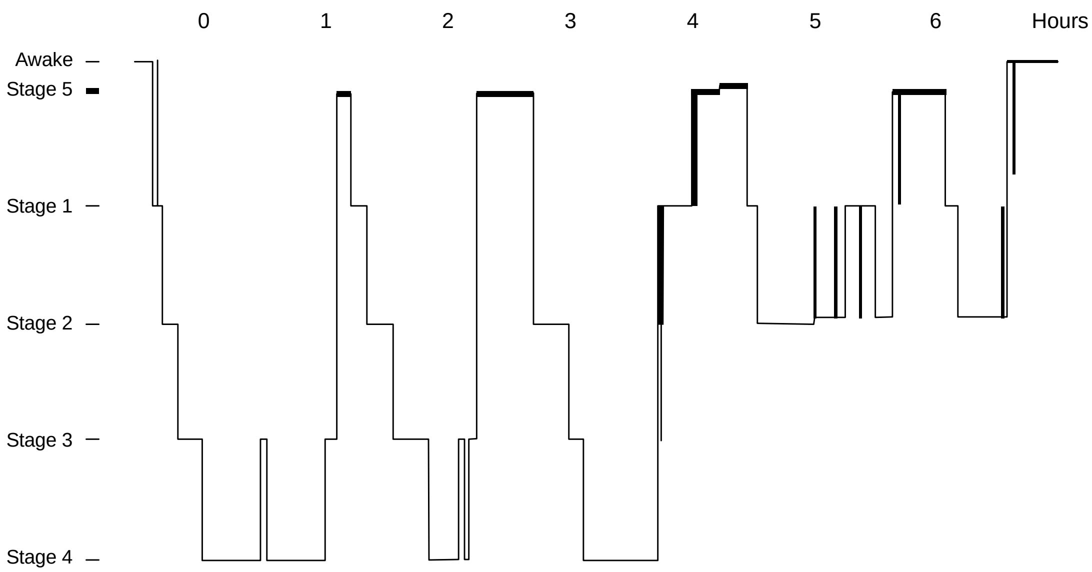
The polygraphic study of sleep, recording of cerebral activity, muscular tone and eye movements, allows the various increasing depth stages to be separated:

- Stage 1: sleep onset,
- Stage 2: light sleep,
- Stages 3 and 4: deep slow-wave sleep,
- Stage 5, Rapid Eye Movement (REM) sleep.

	Minutes	Percentage
Wake time	12	3%
Stage 1	48	12%
Stage 2	159	39%
Stages 3 and 4	117	28%
Stage 5	76	18%
Total	412	100%

Sleep composition and organization (Benoit, 1984)

Sleep



Example : hypnogram of a normal night (taken from O. Benoit, 1984)

After sleep onset, the subject progresses through Stages 2, 3 and 4. He remains for a certain time at Stage 4, whereafter sleep becomes lighter with a return to Stage 2 which leads to the first REM phase. This terminates the first sleep cycle.

A normal night's sleep includes 4 to 5 cycles depending on total sleep time. The REM stage occurs every 90 to 120 minutes.

Deep slow-wave sleep (Stages 3 and 4) occurs mainly in the first half of the night.

The REM sleep episodes are longer during the second half of the night.

6.5.1.2. SPONTANEOUS VARIATIONS BETWEEN INDIVIDUALS

6.5.1.2.1. Sleep time: short & long sleepers

Average sleep time is between 7 and 8 hours.

It is accepted that the minimum and maximum sleep time limits are 4 hours and 11 hours respectively.

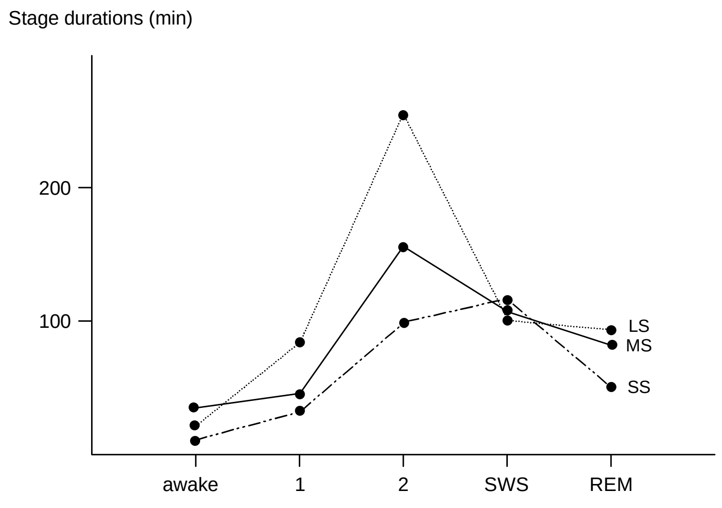
Sleep times of less than 5 ½ hours are recorded with short sleepers. Long sleepers sleep for more than 9 ½ hours.

Short and long sleepers represent less than 5% of the total population.

The difference between short and long sleepers is mainly explained by the differences in Stage 2 and REM sleep.

Long sleepers have more awakenings, more light sleep and more REM sleep stages but almost the same amount of deep slow-wave sleep (Stages 3 and 4) as short sleepers.

Spontaneous variations between individuals



Quantities of various sleep stages in short (SS), medium (MS) and long (LS) sleepers.

REM/ Rapid Eye Movement sleep ; SWS : Slow Wave Sleep (according to O. Benoit, 1984)

6.5.1.2.2. Spontaneous sleep times: morningness –eveningness

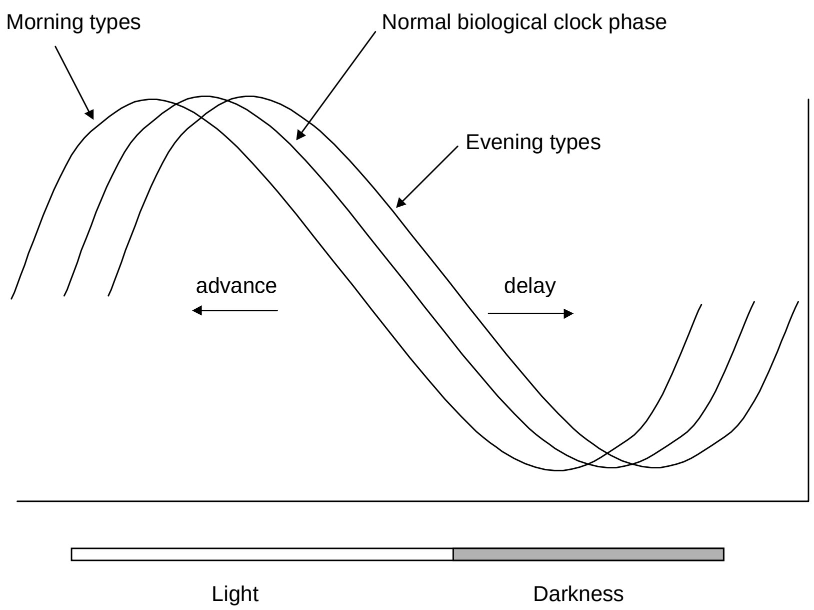
The body temperature cycle is an excellent biological clock phase marker. It is said to be normal when the thermal minimum is around 5am, in advance when it occurs before, and delayed when it occurs after 5am.

Evening types have a biological clock phase, which is delayed with regard to the environmental synchronizers, and morning types have a biological clock phase, which is in advance of the environmental synchronizers.

Spontaneous sleep onset and wake onset are related to the biological clock phase. Advance in phase leads to early bedtimes and early rising. A delay in the biological clock leads to the opposite phenomenon.

Sleep onset times correspond, on average, to 10pm and 1am for morning types and evening types respectively.

Spontaneous sleep time: ***morningness - eveningness***



These differences are less obvious during working days but become more marked during holidays and days-off: evening types delay their bedtimes considerably and extend rising times when social and professional constraints have less predominance than private ones.

6.5.1.3. FUNCTIONS

REM sleep is said to be involved in the restoration of attention, learning, memory, emotional balance and mood mechanisms.

Deep slow-wave sleep apparently allows reconstruction or maintenance of physical integrity: nocturnal increase in protein synthesis and cell division.

6.5.1.4. ORIGIN

It is sometimes implicitly assumed that nocturnal sleep onset is simply related to habit. However, when there are no "direct time givers (watch, radio, newspapers, etc.) or "indirect time givers" (lighting, noise, temperature, vibrations, etc.), an isolated subject maintains his wake-sleep cycle rhythmicity but with a period of around 25 hours instead of 24 hours. This shift leads to increasingly later rising times and bedtimes.

The persistence of the sleep-wake periodicity reflects the existence of an internal system, or biological clock, which functions autonomously and has its own frequency.

Under normal conditions, the circadian clock is driven or synchronized to a period equal to 24 hours by periodic variations called environmental synchronizers.

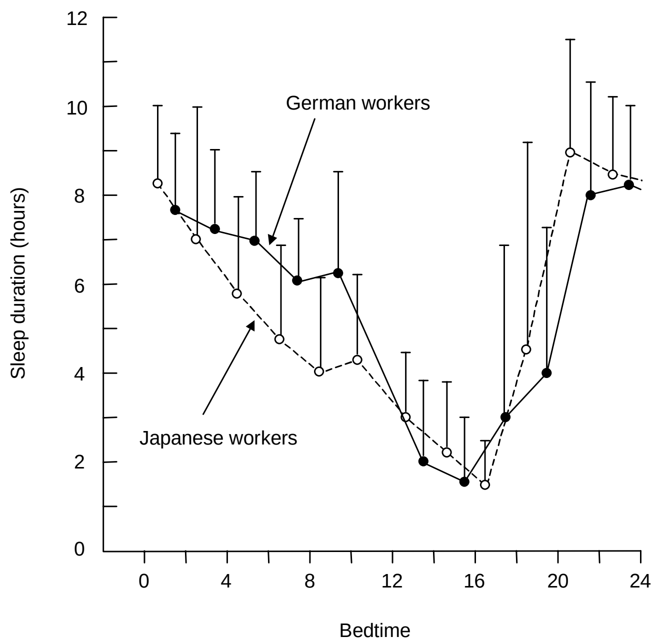
The 25-hour cycle suggests that when they are no constraints, human beings have a natural tendency to lag behind the environmental synchronizers.

Because of this spontaneous tendency, it is easier for a traveler to delay both his bedtimes and rising times after a westward flight than to advance them for an eastward flight.

6.5.1.5. RELATIONS BETWEEN SLEEP & BIOLOGICAL CLOCK PHASE

Sleep latency, duration and composition depend on body temperature cycle where sleep onset is located.

Relation between sleep and biological clock phase



Variation in sleep durations as a function of bedtime for shift workers
(cited in Kogi, 1985)

6.5.1.5.1. If sleep starts a little after maximum temperature, i.e. around 11pm

- sleep duration is long and awakening occurs during the ascending part of the thermal cycle,
- sleep architecture is normal:

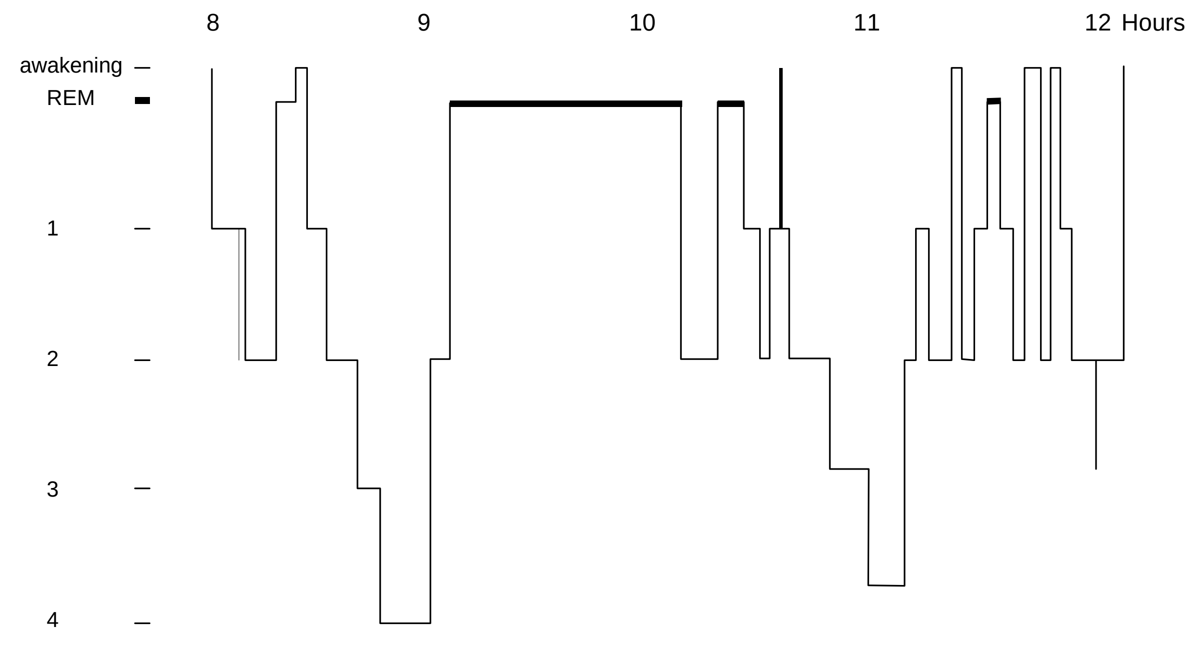
– REM stage occurs every 90 to 120 minutes,

– REM sleep episode duration is higher in the second half of the night,

– deep slow-wave sleep (Stages 3 and 4) is concentrated within the first half of the night.

6.5.1.5.2. If sleep starts around the thermal minimum, i.e. around 5am

- drowsiness is extreme with low sleep latency,
- REM sleep is facilitated (reduction in latency of first episode and increase in its duration),
- sleep will be relatively short as wake-up occurs as soon as body temperature starts rising.



Morning sleep hypnogram
REM : Rapid Eye Movement sleep (taken form O. Benoit, 1984)

These data allow us to understand the shortness of a morning sleep (4 to 5 hours) observed after a sleepless night. In fact, morning sleep generally starts between 7am and 8am and ends when body central temperature becomes high, generally around 12am.

This situation is found in the case of a westward flight when sleep time is delayed towards physical local night. Sleep duration during the first night can sometimes be longer, as all the environmental factors lend themselves to this, but the sleep will have an abnormal architecture and will be punctuated by awakenings.

6.5.2. NAPPING

6.5.2.1. DEFINITION

A nap corresponds to a period of sleep lasting between 20 minutes and 2 hours.

It plays a fundamental role in reducing sleep dept. It can act as a compensating phenomenon in case of sleep loss and allows fatigue to be overcome.

6.5.2.2. TIME ZONES FAVORABLE FOR NAPS

After a normal night's sleep, drowsiness presents a clear bimodal distribution with a peak in the middle of the afternoon as well as a nocturnal peak.

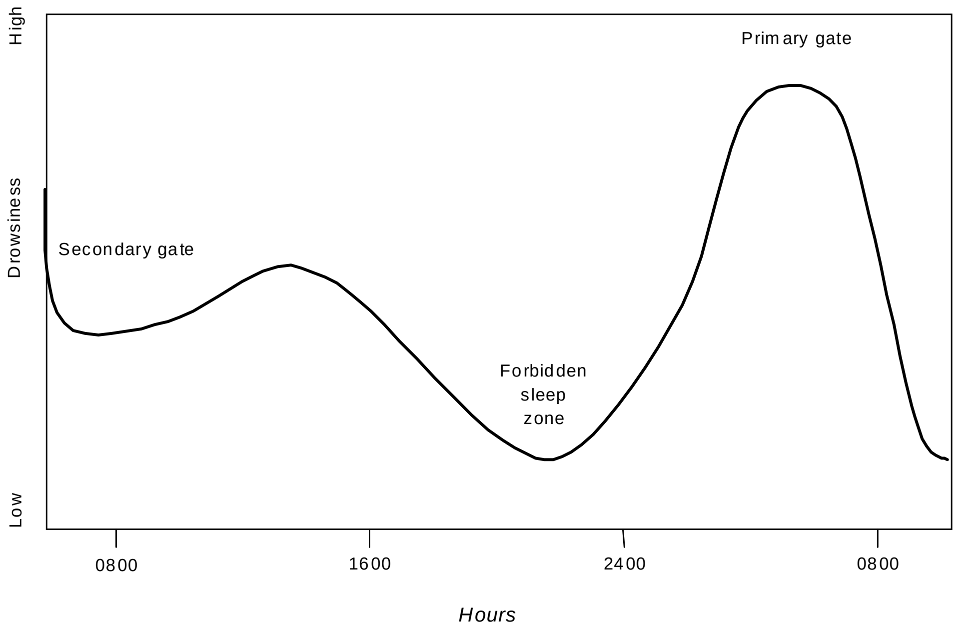
The nocturnal peak is called the "primary sleep gate" and the one in the middle of the afternoon the "secondary sleep gate".

The zone of least drowsiness located between the secondary and the primary sleep gate is called the forbidden sleep zone.

Napping early in the afternoon is not simply related to a cultural phenomenon, climate or to a good meal. It is a manifestation of the spontaneous two-phase character of sleep inherent to all individuals.

The forbidden sleep zone explains the difficulties that a person can encounter when trying to go to sleep earlier as a preliminary measure for very early rising.
After sleep loss, the bimodal drowsiness structure remains very evident with, however, more marked morning drowsiness related to an immediate shortage phenomenon.

Napping



Schematic representation of time periods favouring sleep onset
Taken from Stampi, 1989

The wakefulness time preceding a nap seems to influence the amplitude of the peaks (higher drowsiness) but not their time of occurrence.

6.5.2.3. ARCHITECTURE

The composition and organization of the various sleep stages during napping both depend on the time of day in which it is located and on its duration for subjects who slept normally during the previous night:

- The morning nap located between 8am and midday has a similar architecture to that of the second half of a nocturnal sleep. It is richer in REM sleep than the afternoon or evening nap (between midday and midnight). REM sleep onset during the morning nap will appear sooner than for normal sleep.

- The architecture of the afternoon or evening nap does not resemble either the first or the second half of nocturnal sleep. It depends more on the length of the nap:
  - a nap of thirty minutes does not include REM sleep,
  - a nap of one hour can include a REM sleep period (small amount),
  - if length of naps is two hours or more, REM sleep occurs, at the earliest 50 minutes after nap onset and its duration is higher than that of the deep slow-wave sleep.

After a prolonged period of activity (e.g.: 30 hours) deep slow-wave sleep is predominant irrespective of the time of day in which the nap is taken.

6.5.2.4. EFFECTS OF NAPPING

6.5.2.4.1. Nocturnal sleep following a nap

- Diurnal nap:
  - The time slot in which the nap takes place determines the repercussions that will occur during the following night's sleep;
  - A nap at the start of the afternoon delays sleep onset and reduces the duration of the deep slow-wave sleep during the subsequent night;
  - The REM sleep predominant in the morning nap (8am to 10am) will neither influence the composition nor the duration of the subsequent night's sleep.
- Nocturnal nap:
  - A nocturnal nap implicitly supposes sleep loss,
  - The wakefulness period between the nocturnal nap and next night's sleep is increased,
  - Sleep latency is low on the subsequent night,
  - Sleep architecture is maintained (90-minute cycle),
  - Increase (rebound effect) in the duration of the various sleep stages:
- The first nocturnal sleep will be very rich in deep slow-wave sleep without change or even with a reduction in REM sleep,
- The REM sleep rebound occurs during the second night or even during subsequent ones.

It seems, therefore, that the need for deep slow-wave sleep takes precedence over the need for other types of sleep.

6.5.2.4.2. Sleep inertia: immediate effect of taking a nap

6.5.2.4.2.1 Definition

Sleep inertia leads to a transient state of disorientation or mental confusion upon waking up. It occurs irrespective of the time of day and even in subjects not suffering from sleep loss.

Temporary symptoms are degradation in mental performance and an alteration in mood.

While its length normally varies from 5 to 15 minutes it can reach up to several hours in case of high sleep debts.

6.5.2.4.2.2 Factors increasing sleep inertia

- Sleep stage in which wake-up occurs: sleep inertia is very high when awakening suddenly occurs during a deep slow-wave sleep phase.
- Length of deep slow-wave sleeps: the longer the deep slow-wave sleeps period, the higher the inertia.
- Length of previous wakefulness period: high sleep loss leads to an increase in the duration of the deep slow-wave sleep and, as a result, sleep inertia increases from 25 minutes to several hours.
- Nap time: in case of sleep loss (45 hours), an early morning nap (4am – 6am) leads to very high inertia which can last for several hours. However, inertia is attenuated to a great extent when the nap is taken in the afternoon (12pm – 2pm), even if sleep loss is higher (53 hours).

6.5.2.4.3. Performance & mood: long-term effects

6.5.2.4.3.1 Night time naps

After 17 hours awake, a nap of one or two hours, from 9pm onwards, prevents physiological nocturnal reduction in mental performance.

This effect lasts for several hours after the end of the nap.

After sleep loss of two or three nights, the nap leads to an immediate and long-term negative effect on performance. This nap is very rich in deep slow-wave sleep.

6.5.2.4.3.2 Daytime naps

A nap improves performance in memory and reaction time tasks requiring sustained attention.

It has a positive effect on subjective feeling: the subject is more relaxed and less anxious.

A nap of 30 minutes or 2 hours has the same positive effects.

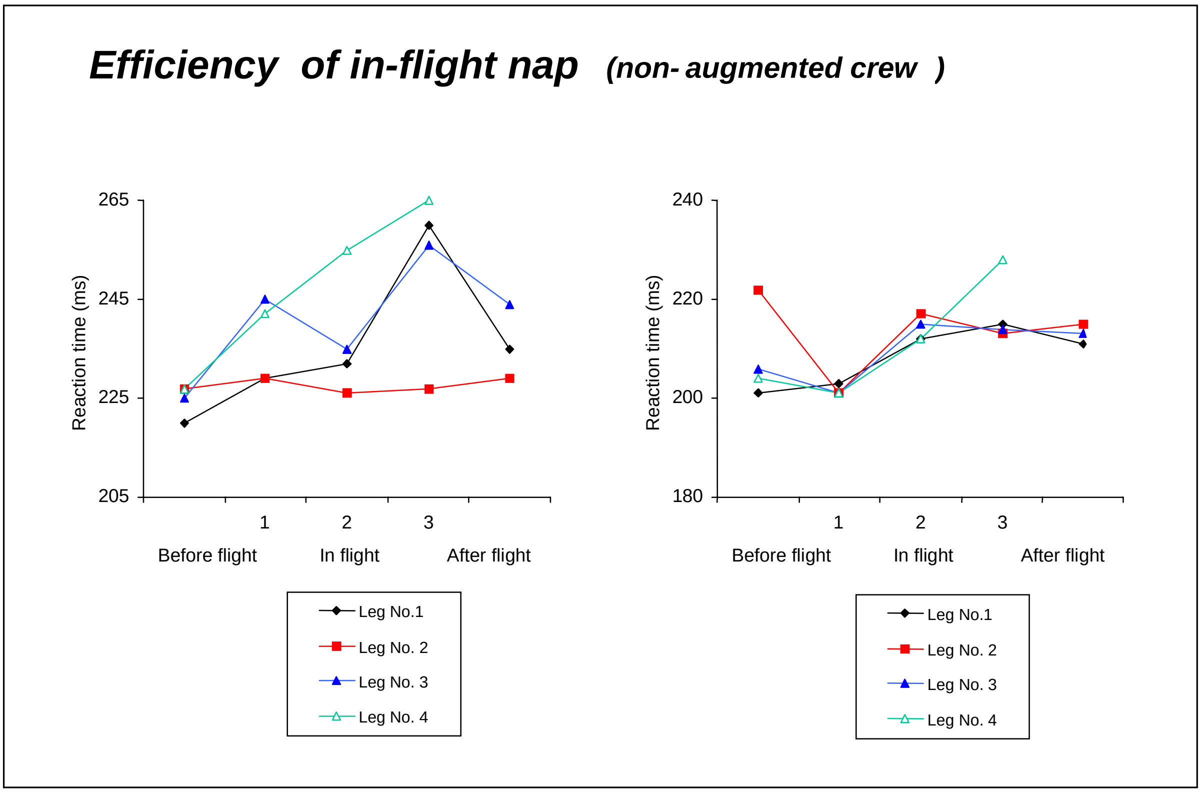
Some will maintain that the improvement in performance is not related to the nap but rather to the circadian increase in performance during the day.

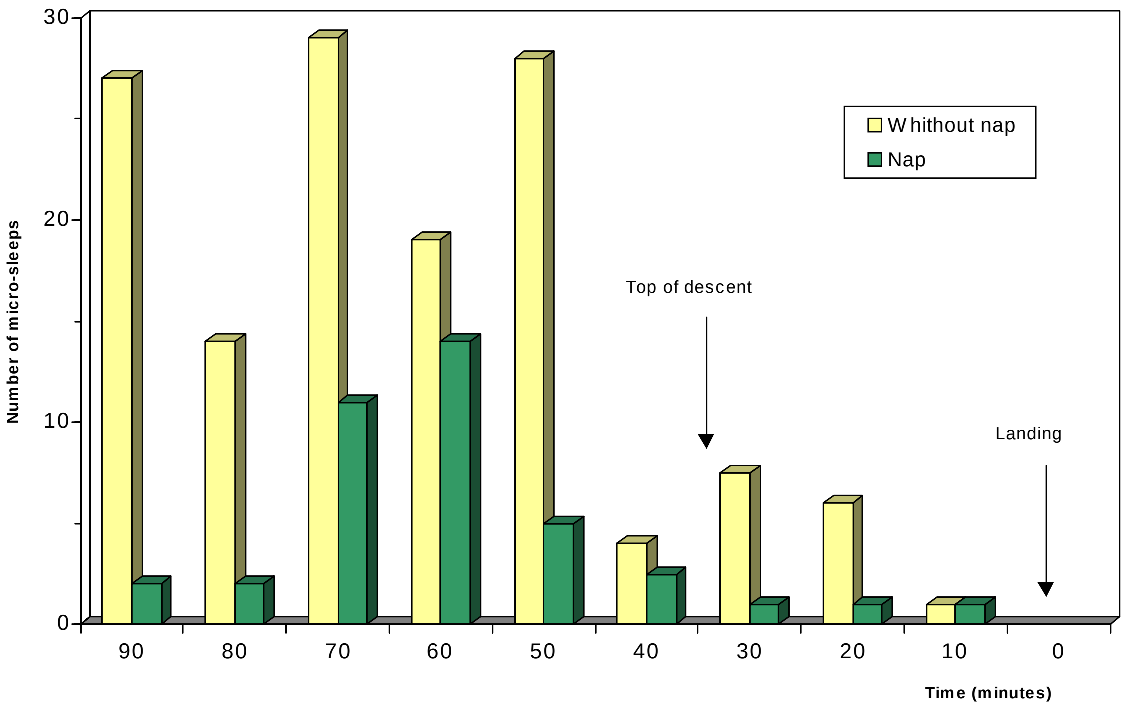
6.5.2.5. EFFICIENCY OF IN-FLIGHT NAPPING (NON-AUGMENTED CREW)

One of the main recommendations promoted in these guidelines is based on the alternation of crew rest and activities, including cockpit napping. In fact, results obtained have shown that most 2-pilot crew tend to synchronize their activities along the flight. This was graphically highlighted by means of the ebb and flow fluctuations evidenced through the task analyses of flight logs performed by ET Systems (Speyer et al, 1999). That means they tend to be active at the same moment and consequently to be tired at the same moment. Therefore, it was suggested to desynchronize pilot activities through alternating passive and active flight monitoring to avoid simultaneous decreases of their alertness. In the case of extreme sleepiness, an appropriate napping strategy should be adopted by each of them. The efficiency of cockpit napping was first emphasized by Graeber et al (1990). Naps of around 20 minutes were taken during flight and planned in order not to hinder correct flight progress: they had to be taken until one hour before descent at the latest.

Main conclusions drawn from this study can be summarized as follows:

- pilots, while resting at their seats, can quickly obtain short sleep periods of good quality;
- naps increased performance as assessed by reaction time tests;
- pilots of the "nap" group had 5 times less drowsiness episodes than the control group, indicating the efficiency of these naps in maintaining alertness during flight, in particular during those phases that require high involvement.

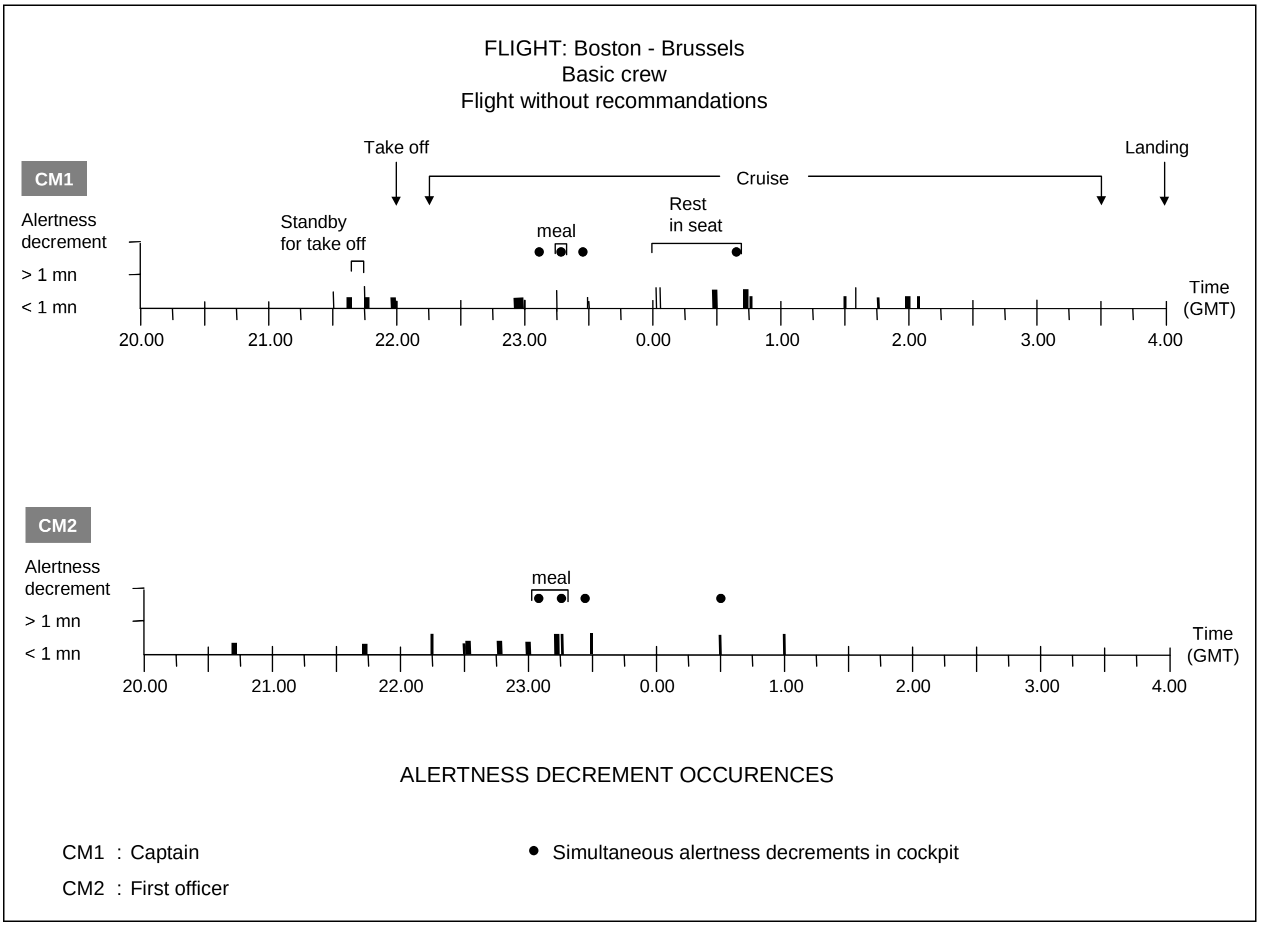




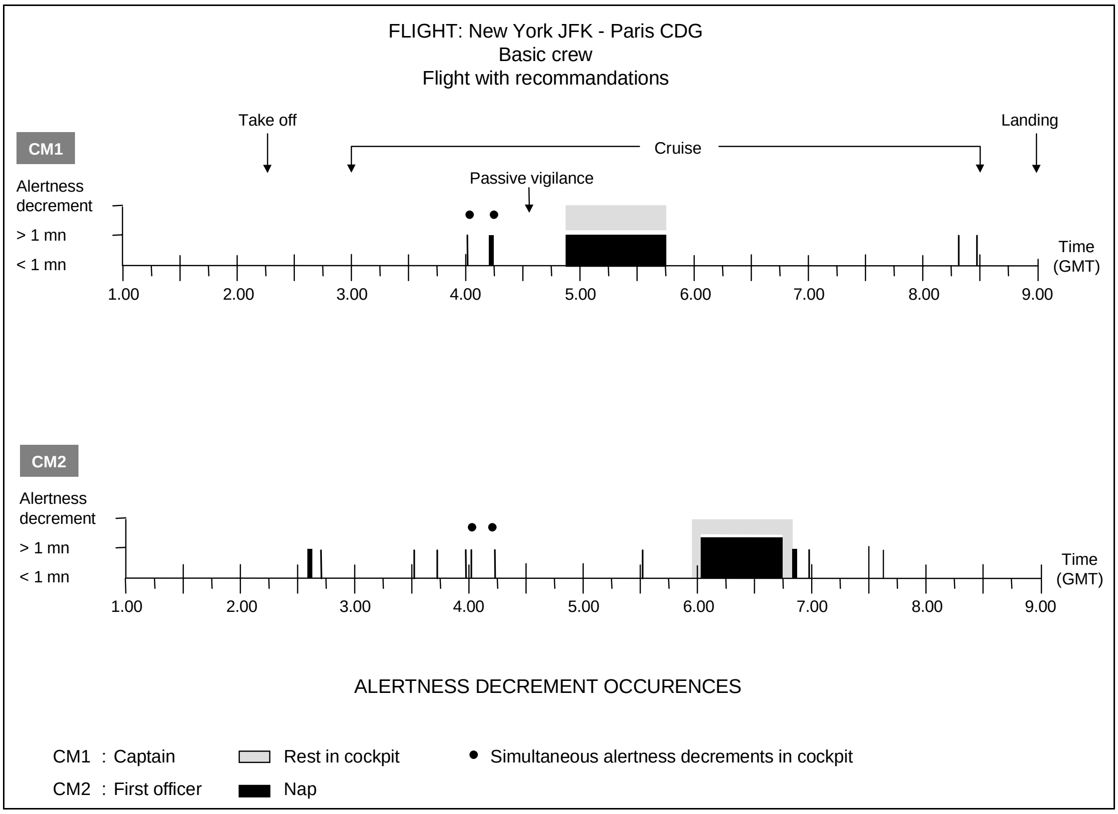
Comparison in number of micro-sleeps in “nap” group and “without nap” group at the end of a night flight (taken from Graeber et al., 1990)

Nap efficiencies were also documented by LAA during the validation phase of its practical recommendations for alleviating in-flight alertness decrements. One of these recommendations consisted of proposing alternation of passive vigilance-active vigilance phases (refer to "monotony"). It was suggested that pilots take a short nap in their seats while in the passive vigilance stage, having formally informed the other active crewmember of their temporarily remote status. The active/passive alternation scheme stems from earlier work that clearly documents alertness decrements to sometimes occur for both pilots simultaneously. This appears to be mainly related to high sleep pressure, particularly during night flights.

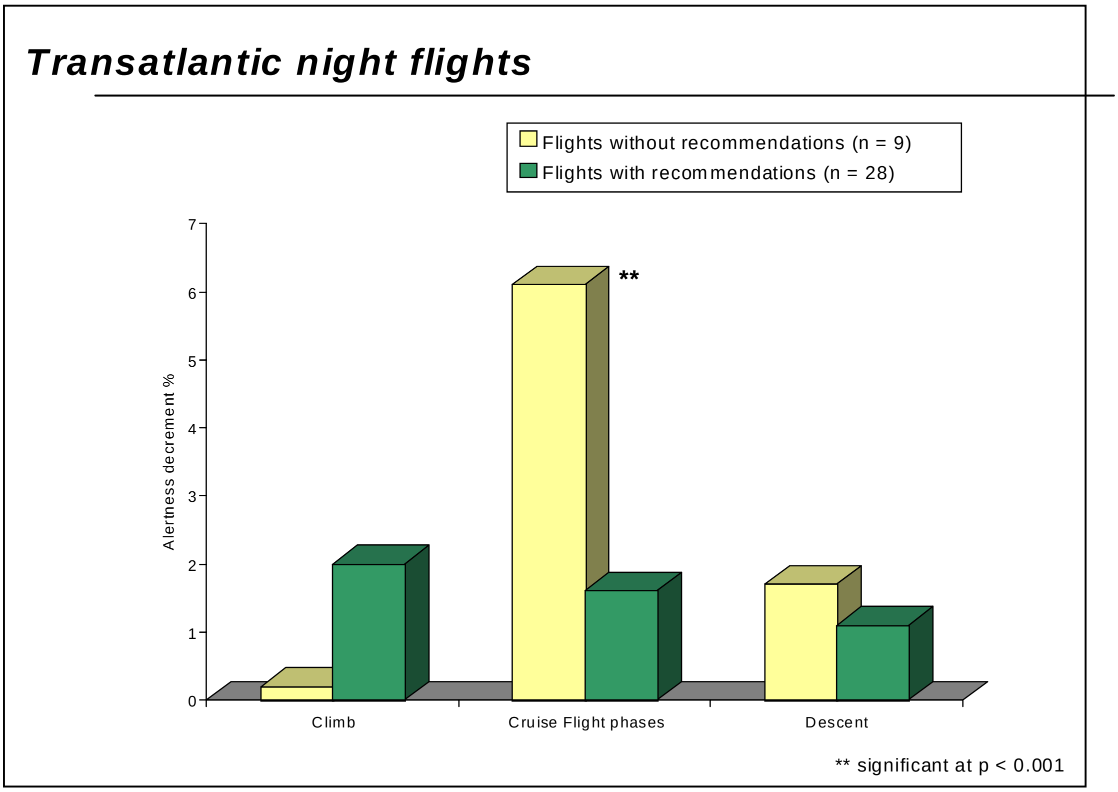
The results shown below concern transatlantic return flights, following short layovers of 24 to 48 hours.



During flights with recommendations, fairly frequent naps were taken. Naps lasted between 20 minutes and 90 minutes and significantly reduced the number of alertness decrements.



This leads to a global reduction in the alertness decrement rates, especially during cruise phases. We can also see that these naps have a beneficial effect on the alertness level during descent.



6.5.3. DEVELOPMENTS IN FATIGUE & ALERTNESS MODELING

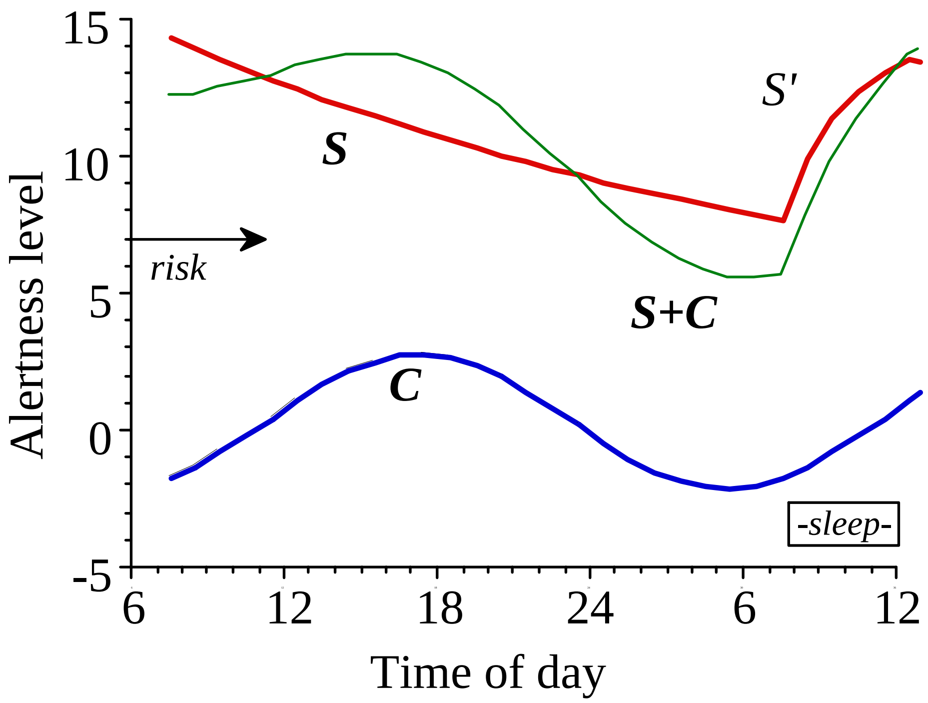
The syntheses included in this brochure are the same as those included in the first issue. There has, however, been some progress (and quite notably so) in the development of various models designed to "predict" fatigue and/or alertness on abnormal sleep/wake schedules such as those involved in long haul operations. A detailed review of these models is beyond the scope of the present brochure. Rather the intention here is simply to summarize their development and to give some idea as to how they operate. Interested readers are referred to a meeting that was held in Seattle in June 2002 at which seven of the models were presented and evaluated. The edited proceedings of this meeting will shortly (2003) be published as a special supplement to the journal "Aviation Space and Environmental Medicine". (see http://fatigue.anteon.com/announce.htm for further details).

Most of the models that have been developed have been based on data obtained from individuals on abnormal sleep/wake schedules. They rely on the fact that under these conditions it is sometimes possible to make separate estimates of the endogenous and exogenous (or homeostatic) components of alertness or fatigue. The former component reflects on the influence of the "body clock" while the latter reflects primarily on the timing of sleep and wakefulness, but may also include factors such as the timing of meals and length of time spent at work. The two original models in this area were developed independently and were first published in 1987 (Folkard & Akerstedt 1987, Spencer 1987). Both were based on the results from experiments in which subjects lived on an abnormal sleep/wake schedule in a temporal isolation unit. The results allowed estimates to be made of the body clock and homeostatic components.

These two models showed a substantial agreement with one another, estimating the body clock component of alertness to be sinusoidal in nature, with a peak at about 17:00, and the homeostatic component to result in a decrease over most of the time spent awake. The only exception to this monotonic decrease in alertness over time awake due to the homeostatic component occurred during the first two to three hours after awakening when alertness was rather lower than might be expected. This was thought to reflect on a "wake up" or "sleep inertia" effect and was modeled by Folkard and Åkerstedt (1987) as a short-lived exponential decrease in alertness. The two main components of the Folkard and Åkerstedt (1987) model are illustrated in the following figure. This shows the overall trend in alertness for someone taking a "day-sleep" between two successive night duties, together with the estimated body clock and homeostatic components of this trend.

Note that alertness is modeled as decreasing exponentially over time awake and recovering exponentially during sleep. The overall trend in alertness is simply the sum of the underlying components.

As shown in the following figure, the overall trend in alertness for someone on a night duty (green line) together with the estimated body clock (blue line) and homeostatic (red line) components of this trend.



As indicated above, these original two models spawned a number of new models, some of which include additional functions and features. They have undoubtedly increased our understanding in this area and have resulted in a number of more applied versions aimed at, for example, predicting the fatigue levels of long-haul pilots. However, as one of the organizers of the Seattle meeting concluded, the predictions from the various models agree with one another rather better than they do with the raw data! Further, it is notable that the models cannot currently account for the well-established trends in the risk of accidents and injuries associated with various features of shift systems (Folkard & Åkerstedt 2003). Thus, although the development of models has increased our knowledge in this important field, we are still some way from being able to use them with any certainty in applied situations.

6.6. JET LAG

6.6.1. JET LAG SYNDROME

6.6.1.1. MANIFESTATIONS

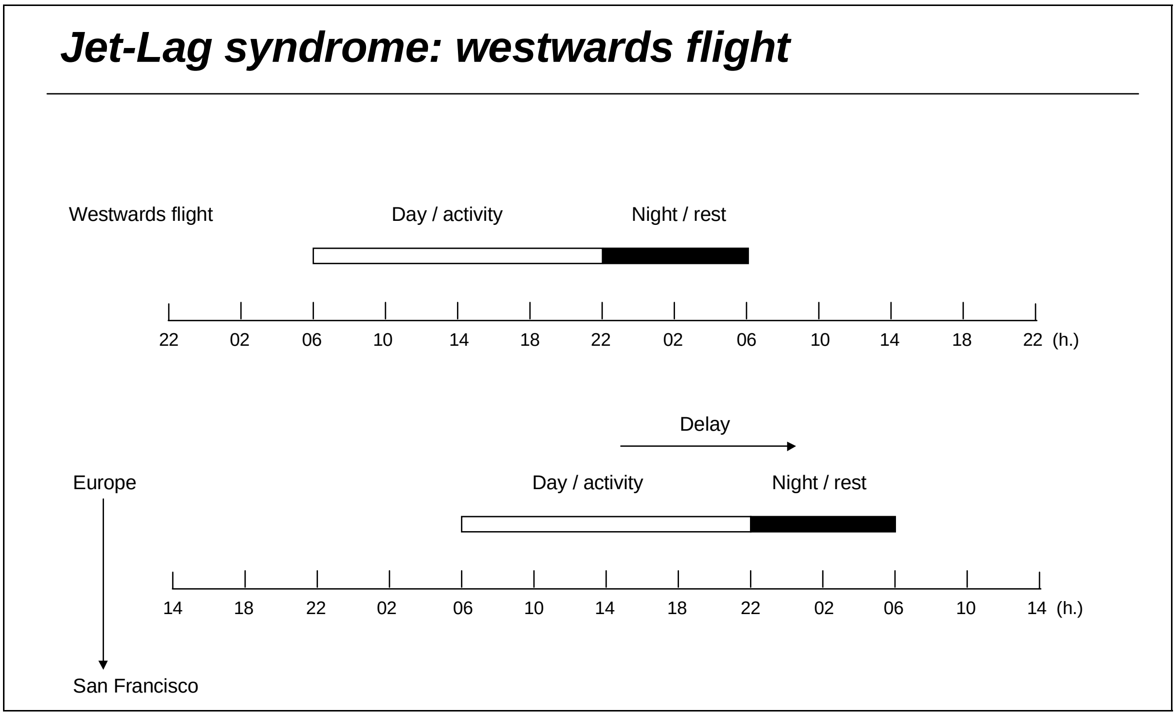
- High fatigue.
- Alertness, mood and performance disorders.
- Disturbed sleep.

6.6.1.2. SHIFTING ENVIRONMENTAL SYNCHRONIZERS

Free running is the natural tendency for 24-hour cycles to extend in the absence of external time-givers. This is why it is easier to delay bedtimes and rising times than to advance them.

6.6.1.2.1. Westward flights

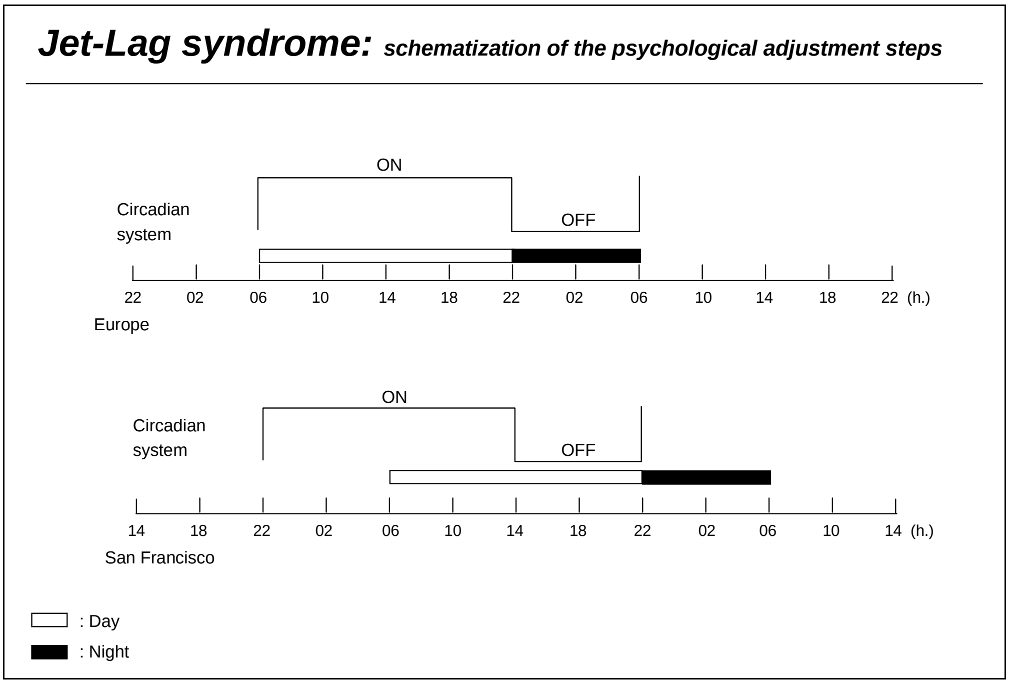
Delay of environmental synchronizers phase: dark-light alternation, rest-activity cycles, social rhythms, etc.
Synchronization to the new time requires going to bed and getting up at increasingly later times.



6.6.1.3. SCHEMATIZATION OF PSYCHO-PHYSIOLOGICAL ADJUSTMENT STEPS

6.6.1.3.1. Example: Westward flights

At 1 to 2 days after the flight, the circadian system and environmental synchronizers are out of phase.
Under normal conditions, the biological clock is in phase with the environmental synchronizers: the period of least efficiency (OFF) coincides with the nocturnal period, the period of maximum efficiency (ON) with the diurnal period.
Due to its inertia, the biological clock does not immediately adjust to the new time zone after having crossed several ones. The result is a sudden shift between local time in the country of arrival and the biological body clock, which is still synchronized with home time.



At 3 to 4 days after flight: internal dissociation.

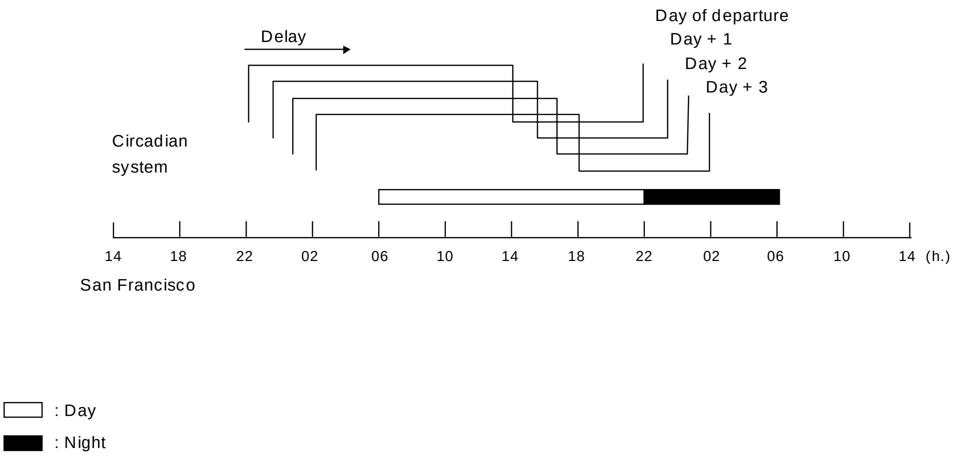
Progressive adjustment (by phase delay) of bedtimes and rising times and of psycho-physiological functions.

Adjustment rate: 1 to 1.5 hours per day.

The psycho-physiological functions adjust at various speeds: 1 week for temperature, 3 weeks for endocrine rhythms.

The result is a loss of harmony in the circadian system called "internal dissociation" and responsible for the jet-lag syndrome.

3 to 4 days after flight: internal dissociation

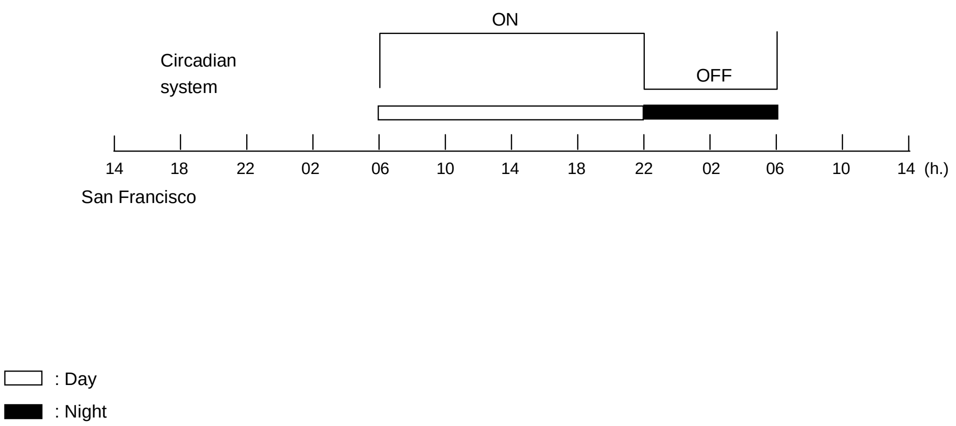


At 8 to 9 days after the flight: adjustment of the circadian system.

Synchronization between local time and biological time.

Synchronization between most parts of the psycho-physiological functions.

8 to 9 days after flight: adjustment of the circadian system



6.6.1.4. LAYOVER & RETURN TO BASE

If layover time is short (< 48 hours), it is preferable not to adjust but to continue living according to home or base time.

The longer the layover, the more the body will adjust to the new time zone and the more difficult it will be to synchronize with home or base time after the return flight.

The rest period after the return flight to home or base must be at least equal to the previous layover period to allow for resynchronization.

6.6.2. SLEEP DISORDERS

6.6.2.1. JET-LAG

Changes in sleep-wake cycle times related to phase modifications in environmental synchronizers.

6.6.2.1.1. Westward flights

- Bed time is delayed so that sleep period coincides with local physical night.
- The first night after arrival depicts several modifications with regard to normal sleep. There is more REM sleep in the first part than normal and this tends to be interrupted by awakening episodes in the second half. The result is diurnal sleepiness.
- Normal sleep is generally recovered itself after three nights.
- When layover is short (< 48 hours), it is preferable to keep normal bedtimes and rising times in order to avoid disturbances related to the first night.
- When the layover is long (> 48 hours), it is preferable to synchronize with local time by going to bed as late as possible as from the first night.

6.6.2.1.2. Eastward flights

- The first night's sleep is sometimes better than normal, provided that the subject did not sleep during the flight and did not take a nap upon arrival. He or she will have accumulated a sufficient sleep debt to compensate for the jet-lag effects.
- These effects show themselves during the following nights by more unstable sleep with more interruptions.
- An improvement in the quality of sleep will occur after a period of around seven days.
- In Eastward rotations a short layover (< 48 hours) is therefore preferable in order to stay synchronized with home time.

6.6.2.2. NIGHT WORK & ALTERNATING WORK SCHEDULES

Changes in sleep-wake cycle times are related to work schedules.

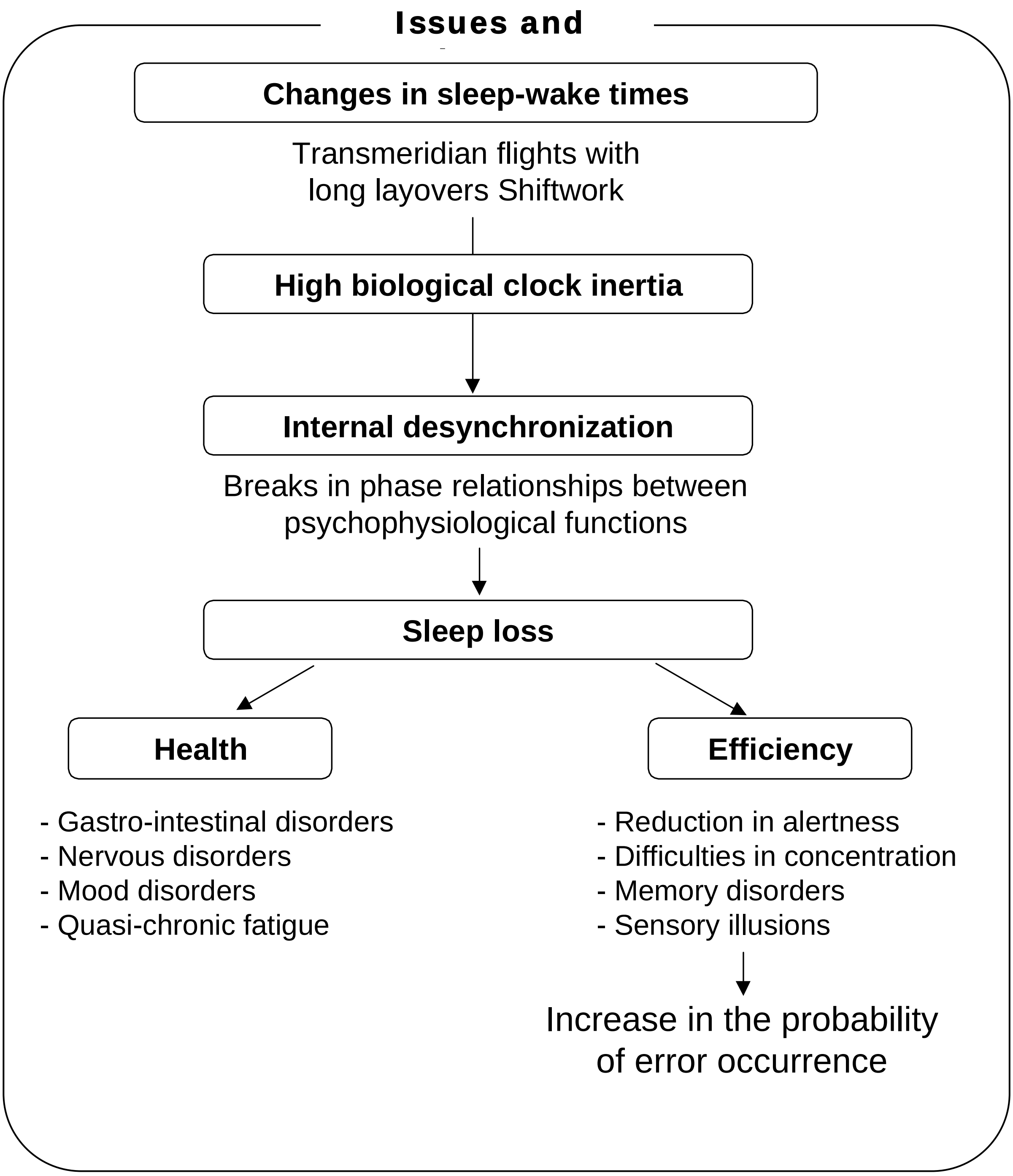
Coping with disturbances in sleep related to shift work is often more difficult than with those related to jet-lag. In fact, the environmental synchronizers, as stated earlier, tend to keep the circadian system on a par with standard time.

The result is a perpetual conflict between biological clock phase and the sleep period imposed by working hours.

Both quality and quantity of sleep taken during the day after a night shift are insufficient. Sleep occurs during a period of the day that is unfavorable to sleep both from a biological (ascending body temperature phase) and from an environmental point of view (light, noise, and social rhythms).

Night sleep before a morning shift is shorter due to early wake-up. The zones of least drowsiness located at the start of the evening, as well as social pressures do not lend themselves for sleep time to be advanced. Going to bed earlier serves no purpose, as the onset of sleep will not be much earlier than usual.

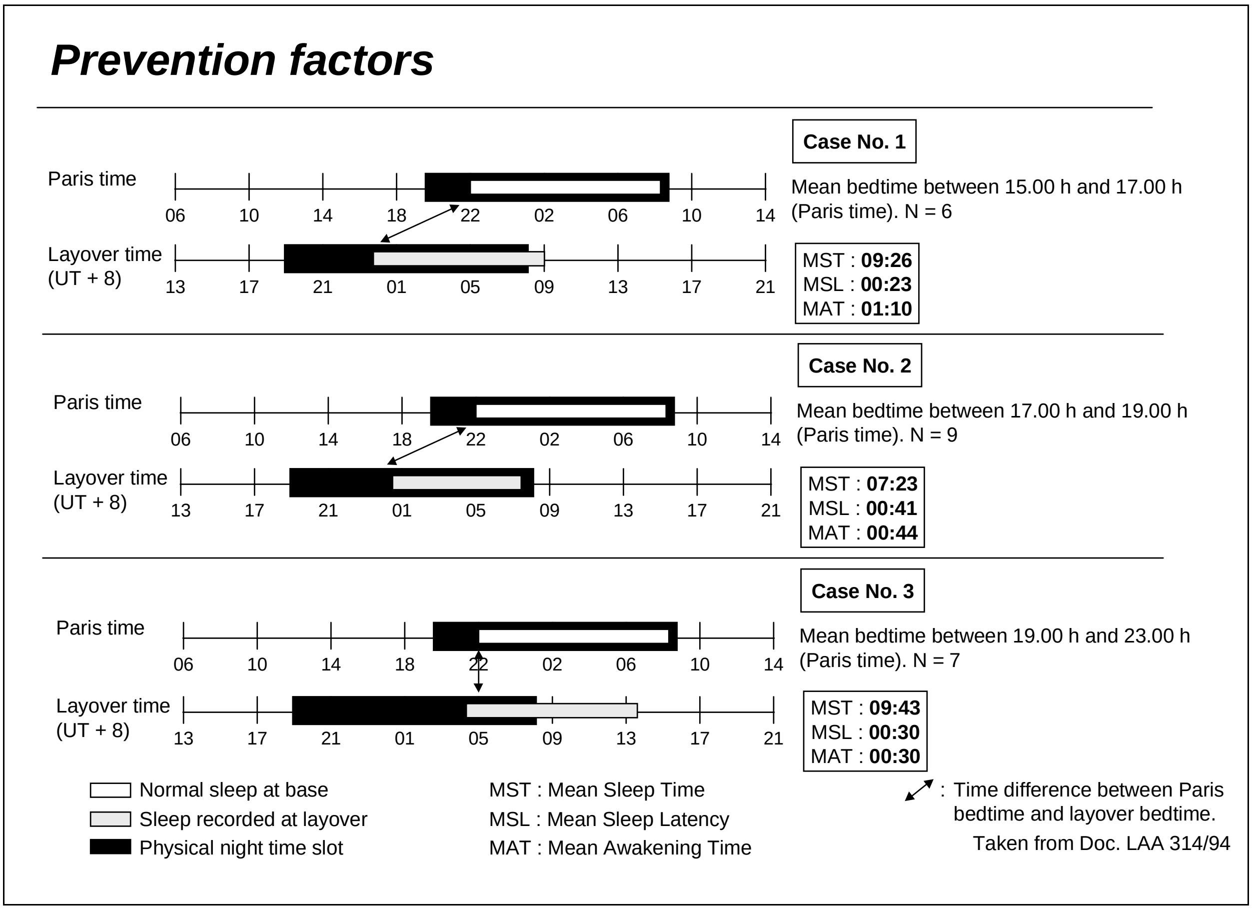
6.6.3. NATURAL PREVENTION OF DISORDERS RELATED TO CHANGES IN SLEEP-WAKE TIMES



6.6.3.1. PREVENTION FACTORS

6.6.3.1.1. Short layovers

During short layovers, biological rhythms do not have time to adjust to the new time zone. This type of layover requires specific management of rest-activity rhythms. One has to force one's self to keep bedtimes and meal times synchronized with home or base times, even if in opposition to local social rhythms.
Results obtained from our work with long-haul aircraft pilots show that those who attempted to synchronize with local time were either affected by a degradation in sleep quality (Case N° 1) characterized by high sleep latency and frequent awakenings, or by a reduction in sleep time (Case N° 2).



In Case N° 3, pilots maintained bedtimes synchronized with home or base times as put forward in the recommendations. It can be seen that sleep is indeed longer and of better quality.

6.6.3.1.2. Long Layovers

Biological clock inertia is the primary cause of disorders related to changing sleep-wake cycle times.

To prevent disorders of this type, the biological clock must be adjusted to the new sleep-wake cycle times. You must therefore harmonize the biological clock phase with that of the sleep period in as short a time as possible.

Natural factors should be used to favor this adjustment:

- exposure to light,
- social contacts (meals, leisure activities, etc.),
- moderate physical exercise.

Exposure to light represents, as will be seen, the most powerful factor in adjusting the biological clock to new time zones.

6.6.3.2. EFFECTS OF LIGHT

6.6.3.2.1. Basic information

Daily and seasonal changes in the length of day (photoperiod) are transmitted to the biological clock by means of melatonin, a hormone secreted by the pineal gland.

This hormone has a clearly marked circadian rhythm with total absence of secretion during daylight hours, production occurring during night-time only.

The longer are the nights, the longer the secretion of melatonin and vice versa.

The period of least efficiency (OFF) coincides with maximum melatonin secretion.

Whenever going through a time zone change, the aim should be to induce a shift in the biological clock phase that is of the same amplitude and in the same direction as the normal sleep period.

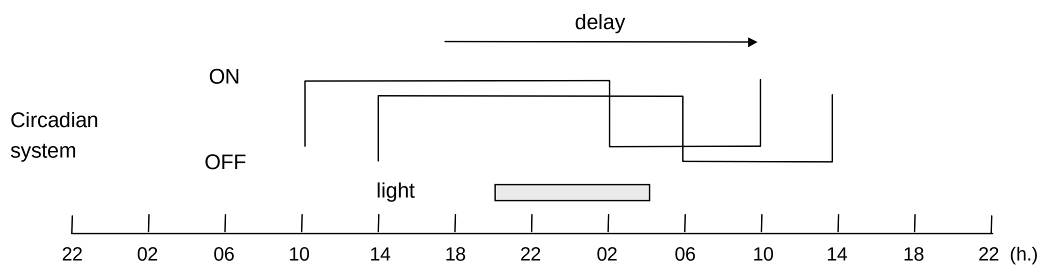
This would be accomplished by means of light, the result of its action on the biological clock being the movement of melatonin production towards the new sleep period.

This shift is accompanied by a similar shift in OFF period.

Shift direction is determined by the choice of light exposure range:

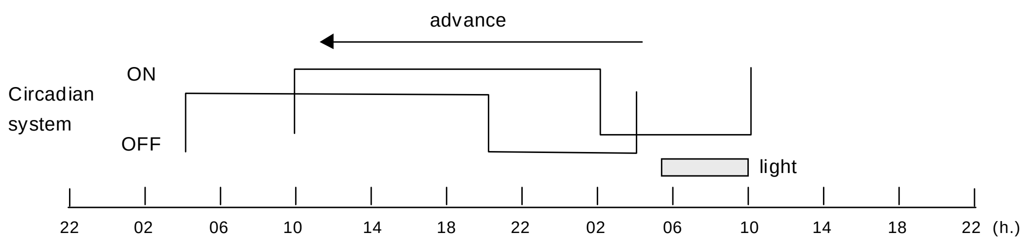
- Exposure to light in the evening or during the first part of the night (before 5am) delays the melatonin secretion phase.

Effects of light



- Exposure to light in the second part of the night (after 5am) advances the melatonin secretion phase.

Effects of light



- These shifts in the biological clock (delay and advance) can be attained using a light intensity of around 2500 lux.

- The sun's intensity at midday reaches around 100000 lux.

- Light intensity of a bedside lamp varies between 50 and 200 lux.

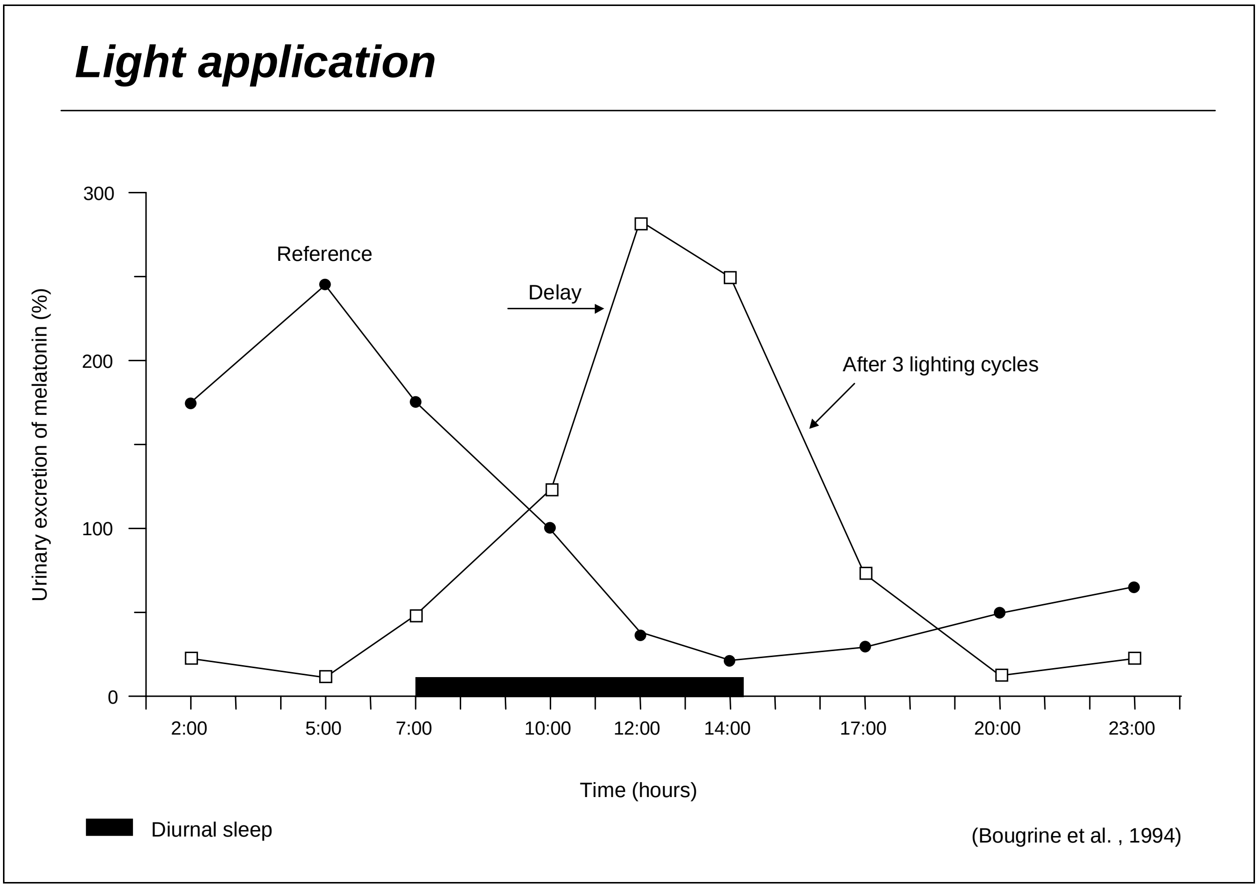
6.6.3.2.2. Light application

Example 1: westward flight or night work

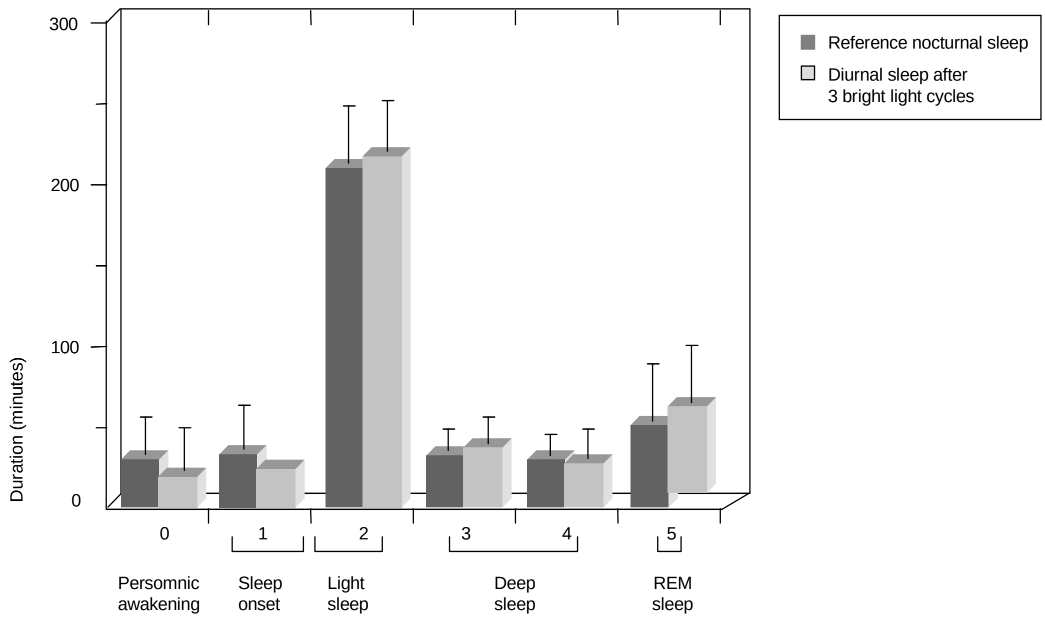
Bedtime delayed 7 hours with regard to biological clock phase

Results show the following after three lighting cycles between 2am and 5am at 2500-3000 lux:

- The biological clock adjusts completely to the new sleep times: melatonin secretion peak is moved from 5am to 12am.

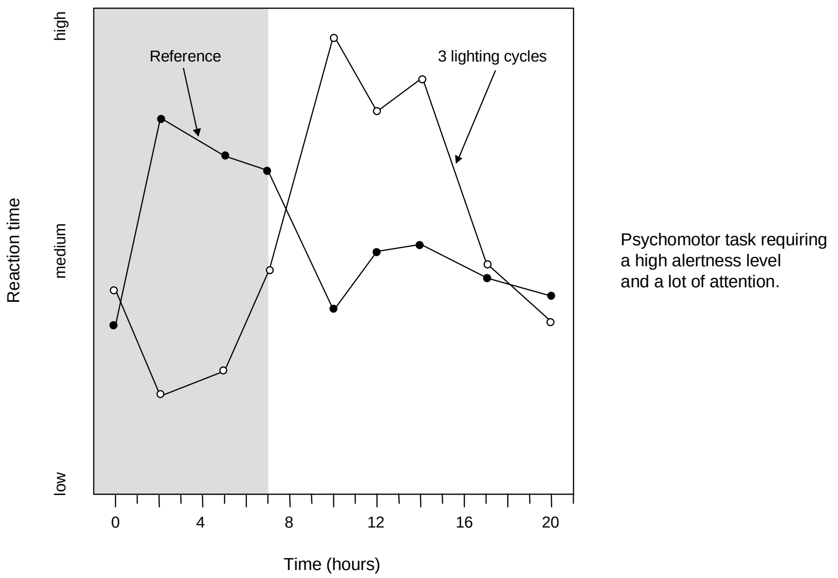


- Daytime sleep under these conditions is of the same quantity and quality as reference nocturnal sleep with perfect adequacy for each sleep stage.



(Bougrine et al. , 1994)

- Cognitive performance improves during the night. A complete inversion of the performance rhythm is observed with regard to the reference normally observed at night.



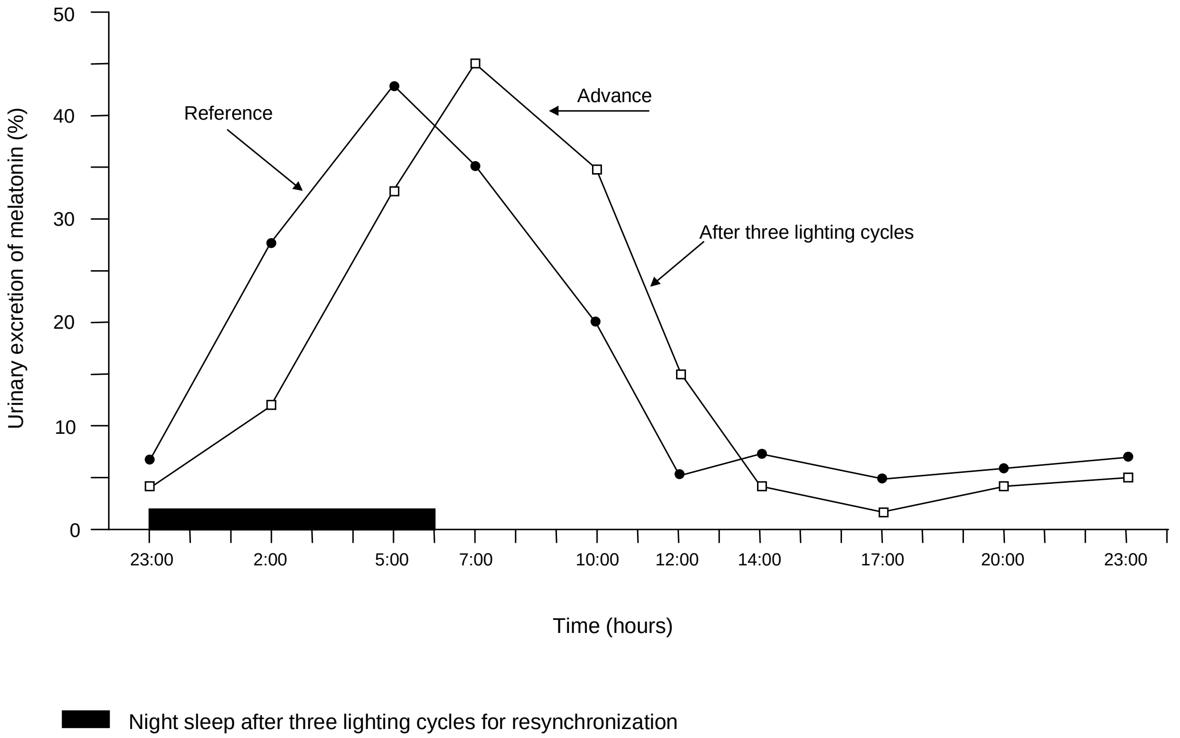
(Bougrine et al. , 1994)

Example 2: return to Europe from the US after a long layover or after a long series of night shifts

Bedtime is advanced by 7 hours with regard to biological clock phase

Three lighting cycles between 10am and 1am are able to advance the biological clock by some 5 hours. The remaining shift (2 hours) is related to the intrinsic difficulty of moving the biological clock phase forward.

Upon return to Europe from the US, it is good practice to schedule rest periods at least equal to those of the layovers and not set off again immediately eastwards.



(Bougrine et al. , 1994)

Time periods favouring exposure to light during and after a long layover

Time slots are given in base time.

Exposure to light for three hours either continuously or discontinuously (e.g. by periods of 30 minutes) shows similar beneficial effects.

During layover following a westward flight (for example towards the US), exposure to light between 8pm and 5am.

During layover after an eastward flight (for example towards Asia), exposure to light between 5am and 10am.

Upon return to Europe after a long stay in the US, exposure to light between 10am and 3pm.

Upon return to Europe after a long stay in Asia, exposure to light between 1pm and 12pm.

Exposure to light during A340 Sabena flight in 1999

End of Blue Skies coinciding with project's end

Life hygiene

6.6.4. FOOD HYGIENE

- A gain or a loss in weight indicates inappropriate or wrong food habits.
- Lipid metabolism disorders are one of the most important factors in vascular risks.
- Irregular meal times can cause digestive disorders linked with the circadian rhythms of the digestive enzymes' activities.
- During night work, meals very rich in fats must be avoided as the stomach is accustomed to working less during night than in daytime.
- Food rich in carbohydrates contributes towards reducing arousal level during the second half of the night.
- Extra proteins can help in limiting the reduction in arousal level during night.
- A good meal taken just before bedtime may disturb sleep.
- When you sleep during the day (e.g. after a night flight or crossing several time zones), you may be awakened by hunger before having had sufficient amounts of sleep.
- A meal of more than 600 kilocalories can cause drowsiness when taken during the night.
- It is preferable to eat snacks of fruit or dairy produce.
- Milk and dairy produce are rich in proteins that are found in all the tissues of the human body.
- Fresh fruit and fruit juice are good sources of natural elements which rapidly provide energy.

- During short layovers after transmeridian flights, it is preferable to eat meals at normal times. Example: if you are on a short layover (< 48 hours) in New York, eat a good meal at local breakfast time as, for your organism, breakfast time corresponds to your normal lunch time.

- However, during long layovers, eating meals at local times facilitates adjustment to local time in country of arrival.

- To facilitate adaptation after a transmeridian flight, breakfast and lunches should be rich in proteins (e.g.: meat, eggs, cheese, yogurt…) to stimulate arousal, evening meals rich in carbohydrates (e.g.: potatoes, pasta, rice,…) to facilitate sleep.

6.6.5. PHYSICAL EXERCISE

- To better combat stress, and for the sake of a better state of mind, you are recommended to raise your heartbeat to an "athletic rate" for twenty minutes three times a week.

- The minimum athletic rate corresponds to 180 heartbeats per minute less your age: 140 if you are 40, 130 if you are 50. Maximum rate is 220 beats per minute less your age.

- Using your leg muscles by cycling, swimming, jogging or walking quickly increases heart rate.

- The time at which physical exercise is taken affects the quality of the awakening and the sleep during the following night.

- It is essential not to tire yourself out by intense physical exercise before a flight, especially for evening or night flights.

- During night flight, light or moderate physical exercise (walking, various movements) attenuates the negative effects of sleep loss by increasing wakefulness level and reducing fatigue.

- Abnormally intense physical exercise during the afternoon leads to stress which reduces deep slow-wave sleep during the following night in sedentary subjects and increases it in sportsmen.

- When physical effort is moderate and exerted not too late in the day, fatigue and drowsiness are higher in the evening and sleep is of good quality.

- In order to facilitate adaptation during long layovers, take advantage of daylight exposure periods to undertake light (walking) or moderate physical exercise.

6.6.6. PHARMACOLOGICAL MEASURES

6.6.6.1. SOPORIFIC DRUGS

Soporific drugs come mainly from two classes of psychotropes: benzodiazepines and barbiturates.

Effects

- Sedative
- Hypnotic
- Anxiolytic
- Muscle-relaxant

Effects on sleep

- Increase in Stages 1 and 2
- Reduction in Stages 3 and 4
- Reduction in REM sleep

Secondary effects

- Memory disorders
- Reduction in attention
- Increase in nightmares
- Residual sedation upon awakening leading to a reduction in intellectual and psychomotor efficiency
- Feeling of weariness
- Empty-headedness
- Increase in reaction time
- Motor in-coordination
- Confusion
- Sickness
- Dizziness
- Headaches
- Withdrawal symptoms at the end of long treatment or after high hypnotic doses: insomnia, irritability, anxiety, fits of panic, trembling, and palpitations.

6.6.6.2. PSYCHOSTIMULATING DRUGS

Distinctions can be made between three families of psycho-stimulating drugs: amphetamine substances, xanthine derivatives (caffeine, theophylline, theobromine), synthetic psycho-stimulating drugs.

Aims

- Prolonged wakefulness
- Without behavioural modifications
- Without performance deficiencies

Amphetamines: primary effects

- Increase in general arousal tonicity
- Euphoria
- Increase in psychomotor performance

Secondary effects

- Signs of anxiety
- Tendency to social isolation
- Aggravation of paranoiac signs
- Trouble with visual perception
- Anorexia
- Increase in heart rate

Xanthine: primary effects

Only small doses of caffeine are attractive as a psychostimulating drug.

- Stimulates level of arousal
- Reduces the sensation of fatigue
- Favours cognitive activities
- Increases respiratory capacities

Secondary effects

- Cardiac arrhythmia
- Increased diuresis
- Reduction in cerebral circulation
- Trembling
- Trouble in visual perception

The synthetic psychostimulating drug Modafinil, a recent formulation, seems to favor a good level of wakefulness with a minimum of immediate secondary effects. At present, Modafinil is used only for pathological cases and over-the-counter sales by drugstores are not authorized. The long-term consequences on health remain unknown. We absolutely advise against the use of this drug.

Self-medication

Self-mediation is a secular tradition in all civilizations. Unfortunately, times have changed for the followers of these practices. Indeed, up until the Second World War, pharmacopoeia, i.e. the drugs and medicinal products that physicians could prescribe, included only a few active ingredients or, more exactly, these were generally highly diluted. This was the great era of herbalists and medicinal products. We can regret their fading away as, evidently, they still would have their place besides the synthetic drugs available today. The action of these drugs is, most of the time, remarkably strong. Misuse comprises a real danger. Moreover, these powerful synthetic products are quite often incompatible with others also on the market. These drugs possess ingredients whose coexistence within the body may lead to real disorders or even death.

Our generation is the first one to be confronted with this risk and we underline the need to accurately inform your physician of the medication you take. This means that the more or less licit procurement of a drug, the use of a product prescribed for someone else or dipping into the medicine cabinet to find a product prescribed some time ago, exposes you to real risks. If you regularly take a drug, do consult your doctor or pharmacist before using any other product obtained or in your possession that would seen to be suitable for a new illness or for even an temporary symptom.

We should also add a few words on hypnotic products, tranquillizers, sleeping pills, amphetamine substances and other psychotropes. In all cases, avoid using them before speaking to your physician and inform him of your profession. Each of these products has very precise effects and some must be considered as incompatible with a professional activity such as ours. Beware of these products, they may be extremely harmful and some are similar to narcotics because of the dependency they may entail. As for awakening substances, we suggest, as our knowledge stands at present, that you avoid them.

Modern-day drugs are extraordinarily efficient but they have toxicity, which is just as real. Beware! Do not take anything unnecessarily. It would be stupid to make yourself ill by trying to cure yourself.

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