Perspectives on Fatigue Risk Management Systems

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7th August 2018

Requested content…..

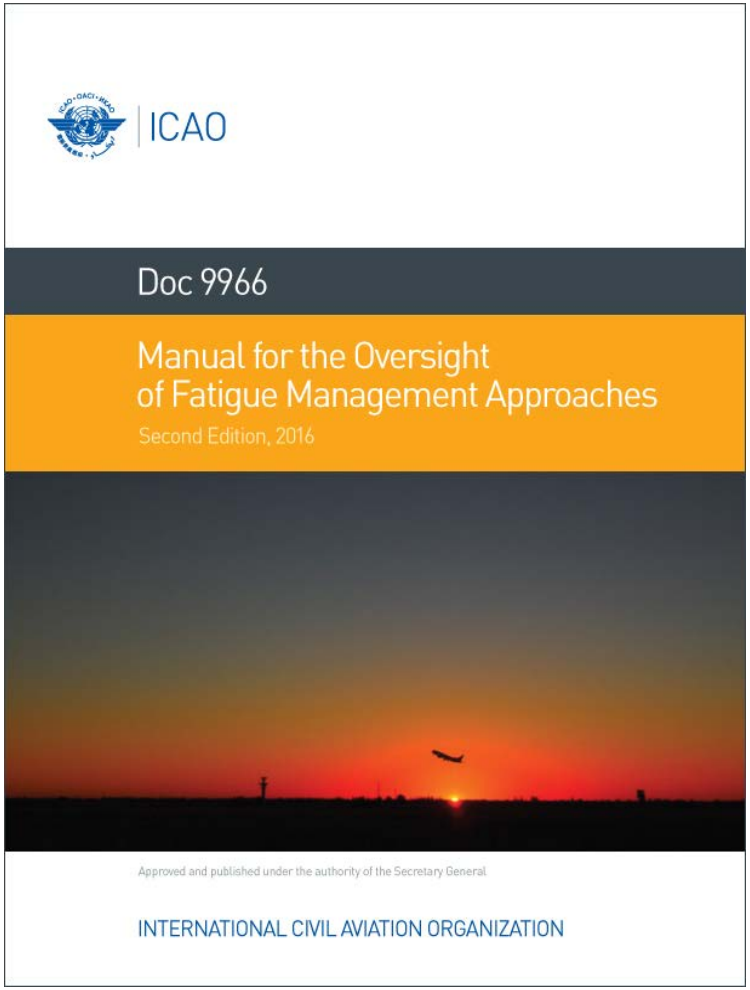
- Prerequisites for implementing an FRMS in place of prescriptive rules
- Examples of FRMS
- Applying bio-mathematical models to FRMS

Agenda

- Avoid presenting the ICAO manual
- Avoid presenting the science
- Present experiences

Proposed topics

- About FRMS: Philosophy of FRMS and FRM
- Some personal experiences
- About Risk and managing it
- Influences of Organisation
- Views from a Regulator
- Prerequisites of an FRMS
- Does FRMS work?
- Examples of an FRMS
- Applying Bio-mathematical Models in FRMS



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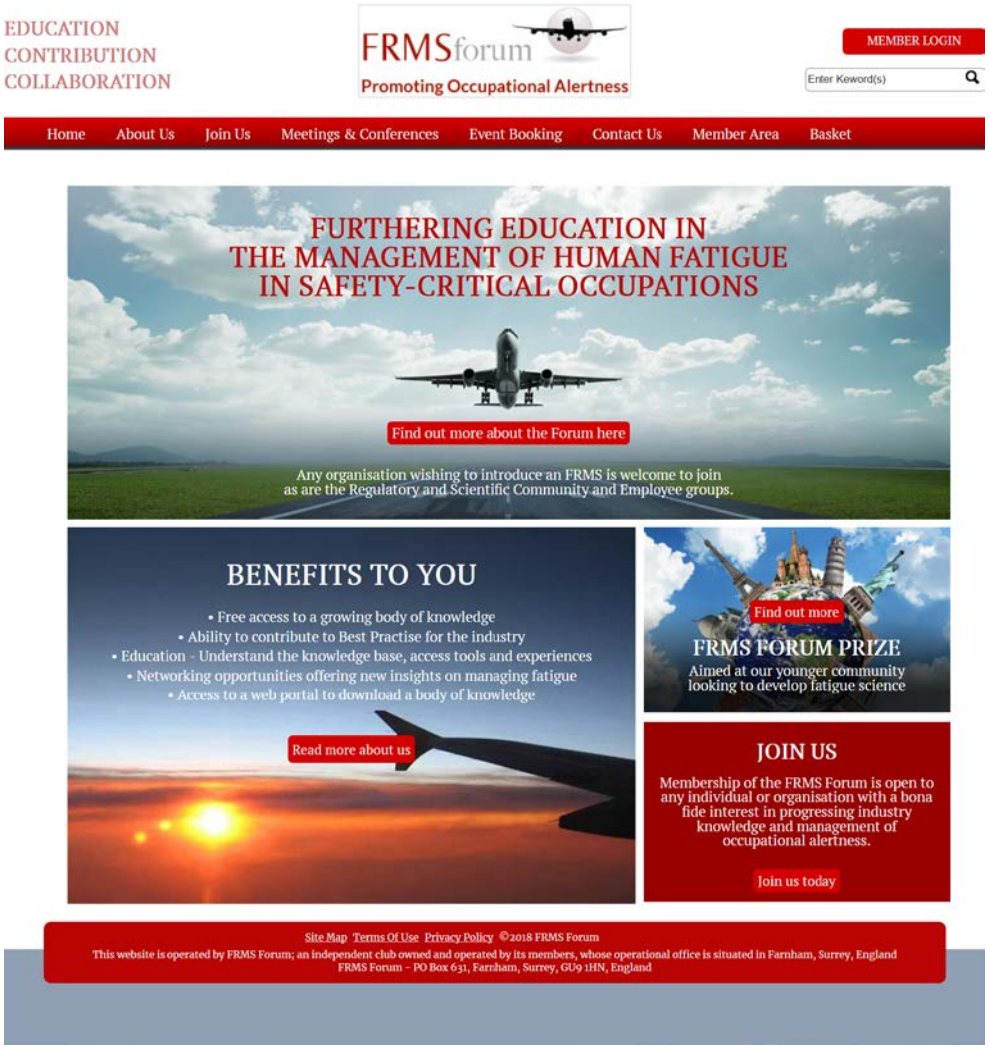
ABOUT THE FRMS FORUM

www.frmsforum.org



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2018 Conference
8th and 9th November 2018

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ICAO Document 9966

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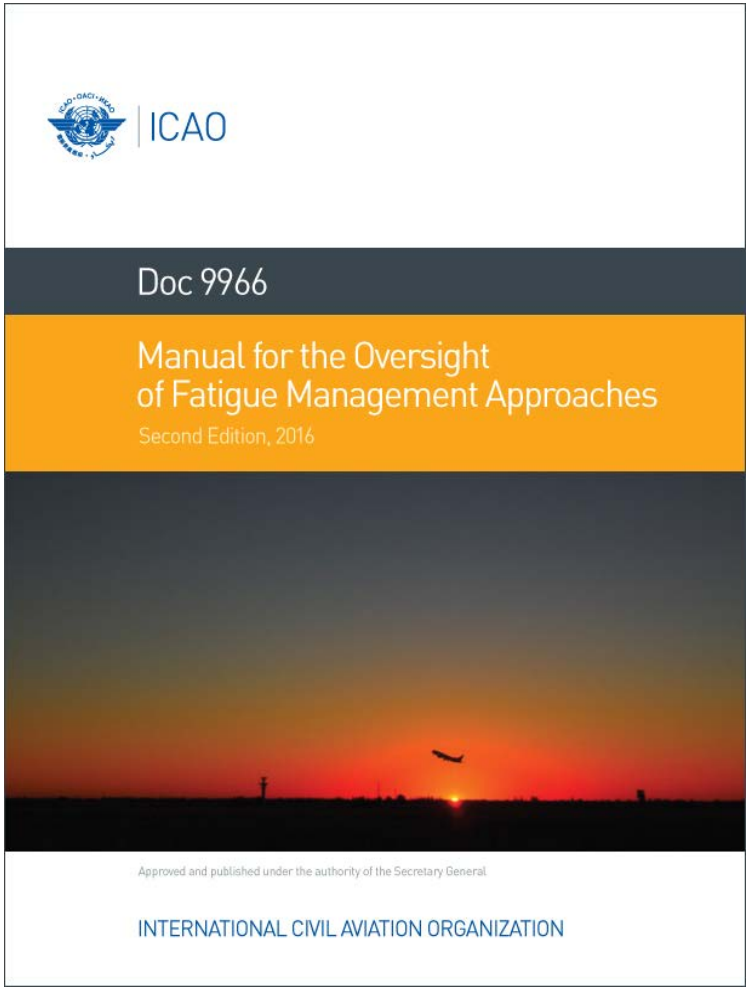

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Definition of Fatigue

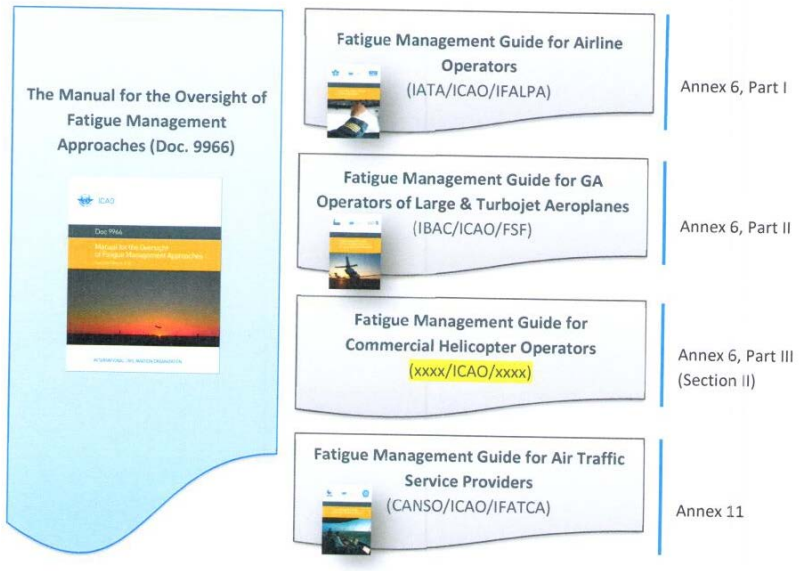
Crewmember fatigue is defined by ICAO as

A physiological ***state of reduced mental or physical performance capability*** *resulting from* ***sleep loss*** *or* ***extended wakefulness, circadian phase*** *or* ***workload*** *(mental and/or physical activity) that can* ***impair a crew members' alertness and ability to safely operate an aircraft or perform safety related duties.***

Definition of Fatigue Risk Management System

A Fatigue Risk Management System is defined by ICAO as

A data-driven means of continuously monitoring and managing fatigue-related safety risks based upon ***scientific principles and knowledge*** *as well as* ***operational experience*** *that aims to ensure relevant personnel are performing at adequate levels of alertness.*



Two approaches supported by ICAO SARPS

1. **Fatigue Management (within the regulations)**

A prescriptive approach that requires the service provider to comply with duty time limits defined by the State, while identifying and managing fatigue hazards through the SMS processes; and

2. Fatigue Risk Management System

A performance-based approach that allows the State to permit its service providers to develop and, once approved, implement a Fatigue Risk Management System (FRMS).

Why Consider Managing Fatigue?

Management requirement for:

- Increase in business performance
  - More flexibility and labour productivity
  - More sales for lower cost base
- Reduce likelihood of fatigue related incidents and higher employee harmony
  - Less costs
  - Employee disharmony: “my pilots tell me they are fatigued but I don’t know if they are”

Cathay Pacific B747F
Ground collision at Stockholm Arlanda

Why Consider Managing Fatigue?

- Discover if there is a hidden fatigue issue
  - Pilot culture, collective agreements, pay structure
  - Hotels, lifestyle, home issues, health
- Operational Excellence leads to revenue improvement
  - Managing occupational alertness makes good business sense
  - Collect data: Data leads to the ability to manage and not just assume.

Cathay Pacific B747F
Ground collision at Stockholm Arlanda

Do Prescriptive Flight Time Limits Handle Fatigue Issues?

- Prescriptive FTLs often create the illusion of ‘safe’ and ‘unsafe’ boundaries
  - May prohibit practices which are safe because they fall outside of the regulations and yet permit a number of factors to be scheduled which are unsafe
  - May ignore factors outside of the regulations e.g. disturbed sleep, commuting time
- Being “Legal” does not always mean being “safe” or “smart”

ASC
AVIATION SAFETY COUNCIL
飛航安全調查委員會

Chronology

- Late 1970s: initial steps taken by IAM (now QinetiQ), DLR, NASA, Univ of Tokyo/JAL etc. to measure fatigue in aviation. Results published 1986.
- CAA asked IAM to develop a fatigue model late 1980s.
- 1990s - Work started on examining fatigue in aviation in Australia and New Zealand.
- 2001/2 Singapore Airlines: First ultra-long haul operations.
- Flight Safety Foundations workshops occurred on managing ULR operations at the same time.

Chronology

- From 2000 – 2005 easyJet and ANZ start being engaged.
- easyJet and DHL in UK gained derogations from CAP371
- 2008 FRMS Forum launched with first meeting in 2009
- 2010 FAA attended FRMS Forum second meeting to learn about FRMS
- ICAO launched guidance on FRMS 2011.
- 2016: EU regulations pass into law
- 2017: UK CAA has 2 approvals; FAA has 3 approvals; Singapore has 1 approval

SOME PERSONAL EXPERIENCES

Some Personal Experiences of Fatigue Issues

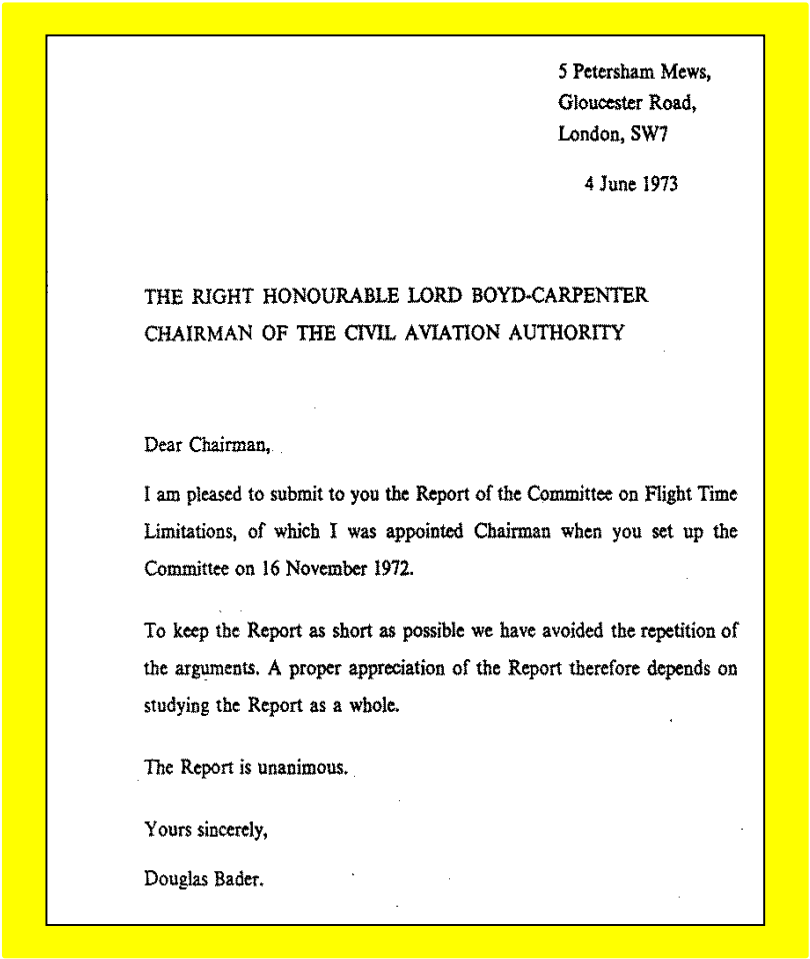
- On average, every 3rd FACT training course delivered, someone confess to have a road accident going home after a duty.
- Fatigue is not only a direct scheduling issue:
  - Poor quality hotels
  - Noisy cabin equipment/bunk near to crying babies
  - Building
  - Health
- Exposure to fatigue can arise out of ignorance or wilfulness
  - Firefighters
  - South American incident
  - “It’s legal”
- Fatigue can be detected by ATC
  - Incorrect read backs
  - Other verbal mistakes

Some Personal Experiences of Fatigue Issues

- Unexpected complaints of fatigue at relatively low predicted SP levels
  - Exposure
- Ground Handling Crew
  - Overtime culture – 120+ hours/week is a badge of honour
  - 8 hour break between activity duty. Enough for 3-hour return home journey to save hotel per diem
  - Want to use fatigue app, any fatigue app …….
- Poor decision making.
  - With a delayed flight and feeling tired, pilots prefer to keep passengers happy (and get home sooner) so make a risky landing instead of going around.

Based on its analysis of US Census data, the odds of dying as a plane passenger is 1 in 205,552. That compares with odds of 1 in 4,050 for dying as a cyclist; 1 in 1,086 for drowning, and 1 in 102 for a car crash.

ABOUT RISK AND MANAGING IT



5 Petersham Mews,
Gloucester Road,
London, SW7

4 June 1973

THE RIGHT HONOURABLE LORD BOYD-CARPENTER
CHAIRMAN OF THE CIVIL AVIATION AUTHORITY

Dear Chairman,

I am pleased to submit to you the Report of the Committee on Flight Time Limitations, of which I was appointed Chairman when you set up the Committee on 16 November 1972.

To keep the Report as short as possible we have avoided the repetition of the arguments. A proper appreciation of the Report therefore depends on studying the Report as a whole.

The Report is unanimous.

Yours sincerely,

Douglas Bader.

Is there a Problem?

Experience suggests:

- Airline industry is a lot safer than other modes of transport
  - 2 pilots check each other's decisions
- Early starts and late finishes are problematic as are long, consecutive duties, multi-sector duties, overnight flights and trans-meridian duties.
- Air Crew tend not to report fatigue until asked
  - Fear of being criticized for declaring fatigue
- Fatigue issues can be hidden
  - Employees of all industries prefer to work additional duties to get a longer time off work
  - Culture and payment systems can mask fatigue issues

Why worry?

Some fatigue related accidents and incidents…..

- 1993 Kalitta International DC-8-61F at Guantanamo Bay
- 1994 Air Algerie737-200F at Coventry, UK
- 1997 Korean Air 747-300 at Guam
- 1999 American Airlines MD-82 at Little Rock, US
- 2001 CrossairBAe146 at Zurich, Switzerland
- 2002 AgcoCorp Challenger 604 at Birmingham, UK
- 2004 MK Airlines 747-200F at Halifax

- 2004 Corporate Airlines BAE Jetstream31 at Kirksville, USA
- 2004 Med Air Learjet35A at San Bernardino, California

Why worry?

Some fatigue related accidents and incidents…..

- 2005 Loganair B-N Islander at Machrihanish, UK
- 2006 Comair CRJ100 at Lexington KY
- 2007 Cathay Pacific 747F ground collision at Stockholm Arlanda
- 2007 Pinnacle Airlines Bombardier CRJ-200 ran off runway at Traverse city, Michigan
- 2008 Go Bombardier CRJ-200 flew past destination airport, Hawaii
- 2009 Colgan Dash 8-Q400 at Buffalo, NY
- 2009 Robinson Helicopter collision in Springvale, Australia

- 2010 Air India Express Flight 812 Mangalore, India
- 2013 British Airways A319 from Heathrow to Oslo – unlatched fan cowl doors.

Lost windscreen on take-off

1990 BA5390 lost its windscreen on take off from LHR.

- The captain, Tim Lancaster, was hanging out of the cockpit window, his head and torso being battered by the extreme cold and wind, while flight attendants clung onto his legs.
- Assuming that Lancaster was dead, the crew discussed letting the body go, but decided not to, reasoning that the body might fly into an engine and cause serious damage.
- Fortunately for Lancaster, the crew didn't let go and the plane landed less than twenty minutes later, with the captain suffering with frostbite, bruising and minor fractures.
- The cause was choice of smaller than specified bolts by tired maintenance engineers

Captain Tim Lancaster
(in the pub later….)

Effects of fatigue

Fatigue is an inevitable consequence of disrupted sleep schedules and circadian rhythm disruption. For pilots it can mean

- Inaccurate flying and Missed radio calls
- System warnings missed or slow to pick up
- Routine tasks performed inaccurately or forgotten
- Loss of situational awareness
- Micro sleeps and Task fixation
- Poor communication between crewmembers

- But fatigue is not exclusive to pilots…….any member of the team can be affected - cabin crew, managers, maintenance staff, ATCs
- Estimated that fatigue **contributes** to approx. 15-20% of commercial aviation accidents

Avoiding hazards

ABOUT SWERVING

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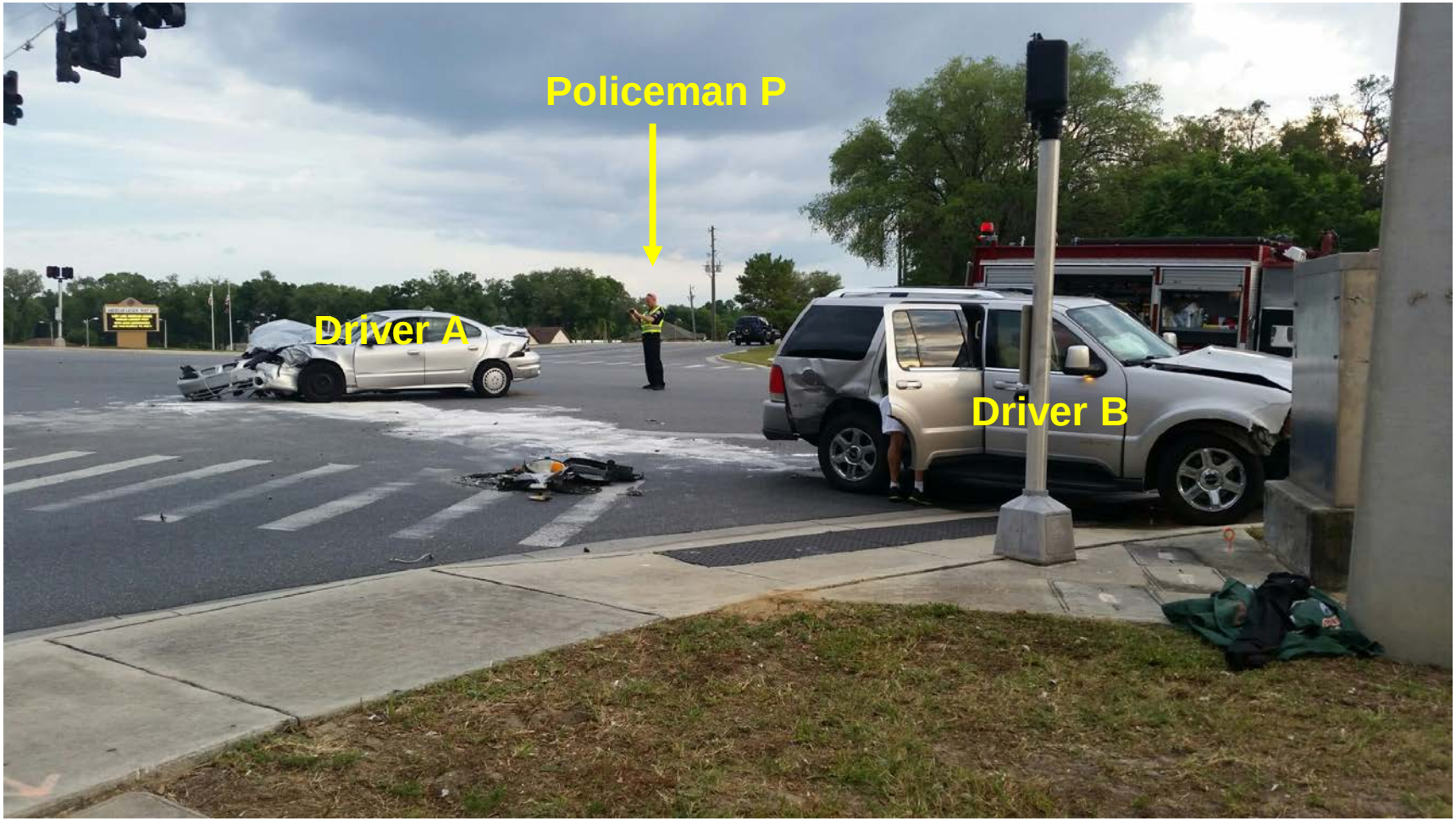
Joining the highway from a side road

Driver B does not stop.

Result: an Accident



Driver A

Driver B

Aftermath of the Incident

What happened

- Accident assessed as being caused by driver B not stopping before joining main highway
- Driver A in hospital
- Driver B apprehended, admits guilt and is in jail
- **Satisfactory conclusion**
  - ✓Cause identified
  - ✓Culprit arrested
  - ✓Culprit jailed
  - ✓Driver A makes full recovery.

What could have happened

- Hazard caused by driver B not stopping before joining main highway
- Driver A not fatigued and can see driver B is not stopping
- Driver A swerves to avoid collision
- Very satisfactory conclusion
  - No accident

… but nothing is reported

Fatigue could be a component of many hazards

FLIGHT SAFETY INFORMATION
FSINFO.ORG
YOUR SOURCE FOR AVIATION NEWS
Flight Safety Information

Flight Safety Information — July 6, 2018 - No. 136

In This Issue

ARGUS 2018 TRAINING COURSES

Incident: Delta MD88 at Atlanta on Jul 3rd 2018, engine failure on departure

Incident: British Airways A320 over Switzerland on Jul 5th 2018, loss of communication

Incident: THY A321 at Istanbul on Jul 4th 2018, engine shut down in flight

Incident: Dolomiti E195 at Oslo on Jul 4th 2018, hydraulic failure

Incident: India B788 near Hong Kong on Jul 5th 2018, cracked windshield

MiG-29 Fatal Accident (Poland)

LIBIK Fire Suppression Kits for the Cabin and Flight Deck.

FAA Alleges Illegal Charters by Hincojet

Tightening Chest and Tingling Fingers: Why Are the Military's Fighter Pilots Getting Sick?

Air Traffic Controllers Overcome Complexities, Challenges

FAA Challenged to Prove Runway Incursion Plans Work

World's First Flying Car Production Model Makes Its Aviation Debut at Farnborough Airshow

Women In Aviation Accepting Scholarship Applications

Looking at a future where aircraft de-icing is a thing of the past

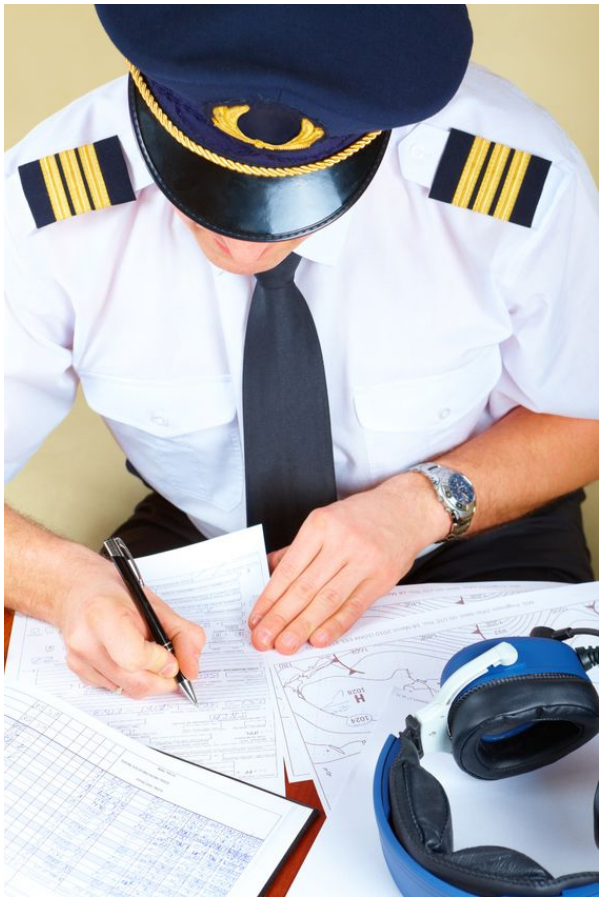
Airbus To Develop Nanocomposite Materials For Aircraft Application In China

ABOUT RISK FACTORS AND RISK APPETITE

Risk Factors For Fatigue in Aviation

There are many factors associated with design of duty rosters that can contribute to the development of fatigue:

- Extended duty hours
- Reduced rest
- Long commuting times
- Split duties
- Standby duties
- Irregular duty start and end times
- Disrupted sleep pattern
- Time zone transitions
- Consecutive duties
- High workload
- Multiple legs
- Early starts and late finishes



Mitigations needed for these according to Risk Appetite

On Risk Appetite

Risk appetite is dynamic

- With many spare pilots, risk appetite can be low
- With no spare pilots, risk appetite rises ……. or the flight is cancelled.
- Higher than normal risk appetite may be acceptable with mitigations in place
- Risk appetite has to be higher than normal with new routes and new operations
- Consequently, risk is balanced with commercial imperatives.
  - Operational challenges are dynamic
  - Risk appetite is dynamic

This means humans should set the final risk level

Humans make Decisions

- Humans are the last link in the chain; the final back stop for decision making.
- Relying on a computer to make a decision in this domain is not acceptable.
  - Managers make decisions: machines are tools to help decision making
  - Over-familiarity and **over-reliance on computers** in our daily lives de-skills competence and decision making within the human performance domain.
- The FSAG is responsible for considering duties with high fatigue scores and deciding
  - Accept them
  - Mitigate them
  - Reject them

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SETTINGS LEVELS OF RISK APPETITE

Fatigue Measurement Scale

Samn Perelli Subjective Fatigue Scale

1. Fully Alert, wide awake
2. Very lively, responsive, but not at peak
3. OK somewhat fresh
4. A little tired, less than fresh
5. Moderately tired, let down
6. Extremely tired, very difficult to concentrate
7. Completely exhausted, unable to function

Other Scales

- Karolinska sleepiness scale
- Karolinska Probability
- Missed responses
- Vigilance degradation
- Complex vigilance degradation test
- 100 point alertness scale
- Etc.

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What level of fatigue is safe?

The envelope of concern

THRESHOLD SETTINGS

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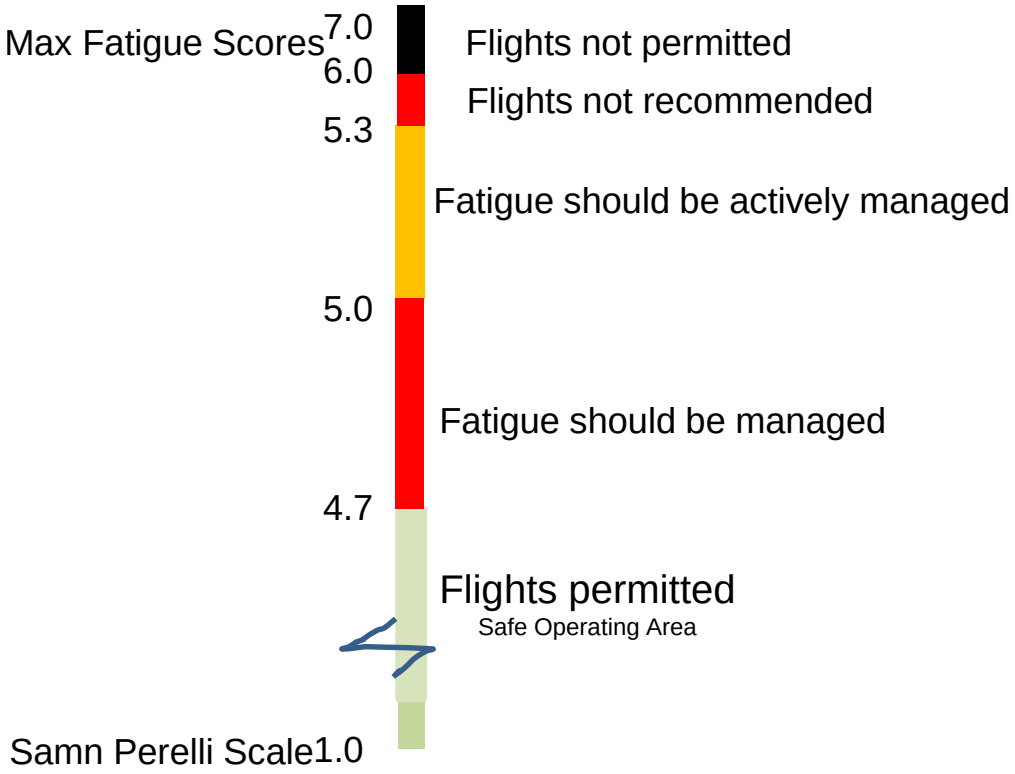
Managing the envelope of concern



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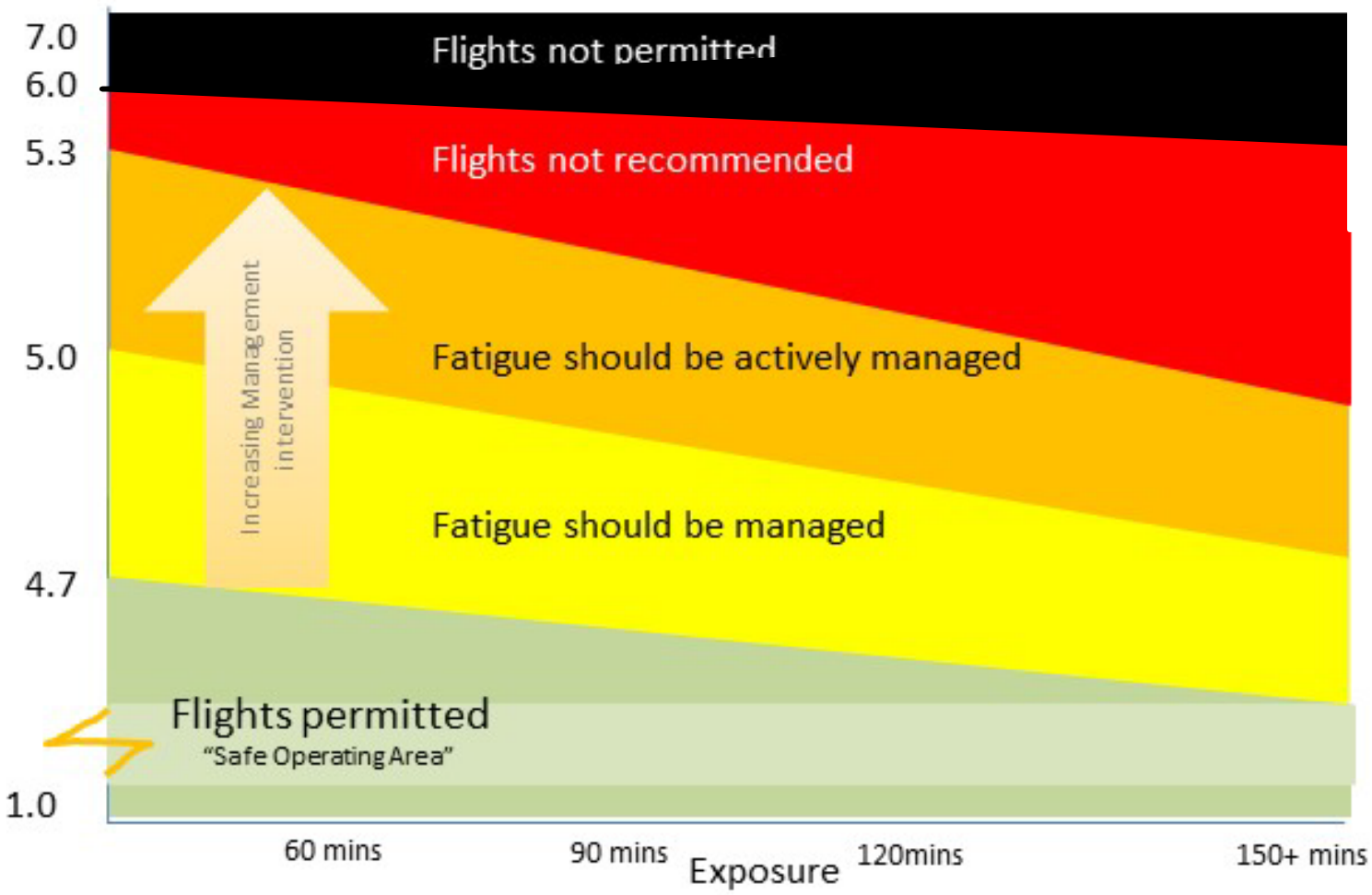
Managing the envelope of concern



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Power in Organisations

ORGANISATIONAL INFLUENCE

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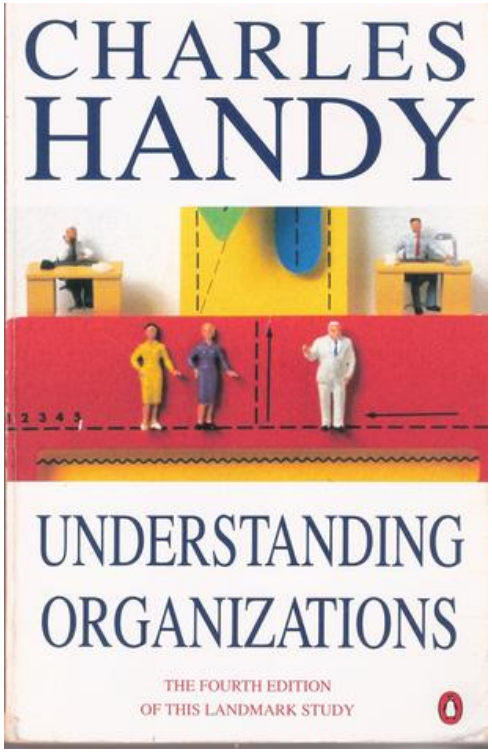
Power in Organisations

(can work against adoption of new standards)

- Power in organisations* derives from:
  - Positional Power
  - Expert Power
  - Information/Resource Power
  - Machiavellian Power

  (*Understanding Organisations.
  Prof Charles Handy. London Business School)
- Front line staff have up to date technical skills and day to day focus
- Senior managers have strategic focus and leave day to day decision making to front line staff
- The “Just Culture” is essential to challenge organisational/CEO direction.



Power in Organisations

(can work against adoption of new standards)

- Staff want to please boss
- Boss wants low costs and status quo
- Staff will compromise standards to please boss, if required to do so
- The board of an organisation must be educated and committed to FRMS else it becomes just a compliance issue with a focus on “being legal”.
- Lack of management support is the biggest reason why many project fail

Australian Government

Civil Aviation Safety Authority

VIEWS FROM REGULATORS

What Regulators look for in an FRMS

- Regulators are looking for an understanding of the risks involved and a thoughtful, comprehensive approach to mitigation within the operational context.
- Regulators define the generic situation whilst Operators must consider the operational context
  - Regulators look for consideration of operational context
- Need to demonstrate a holistic approach to hazard identification
  - This should cover all areas where humans are involved.
  - Must cover all risks and mitigations, using data collected from the aircrew.
  - Must demonstrate an understanding of the principles of FRMS and apply it.

What Regulators look for in an FRMS

- Relying on “but it is legal” is not good enough.

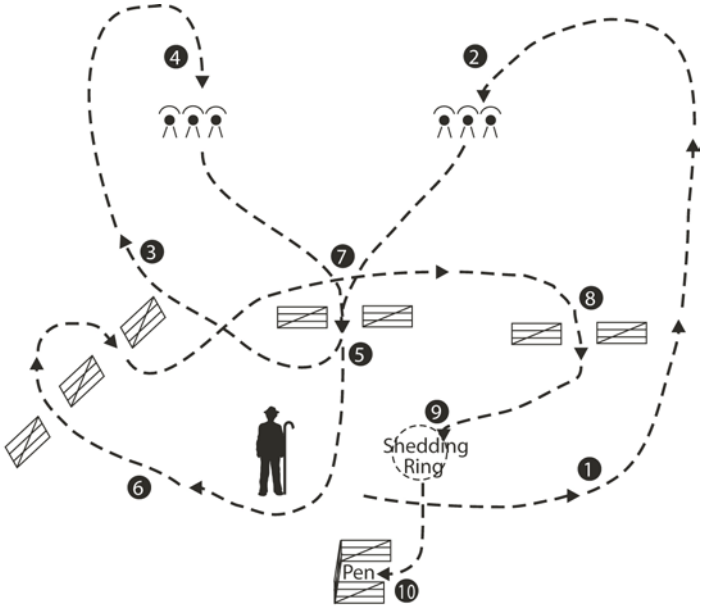
- Must demonstrate a thorough understanding of the principles and operational context
  - Airline X submitted an FRMS application to use economy seats for in-flight rest citing the research others had published using Business Class seats. Application rejected.

- Don’t “cut, paste and adapt” a risk matrix.
  - Show understanding in the approach

What Regulators look for in an FRMS

- **Set the pilot up for success each day.**
  - Don't try to show FRMS as window dressing to keep status quo
  - Share the load across all aircrew
- FRMS is continuous improvement – demonstrate it.
  - Get feedback from crew constantly on every fatigue hazard
- **A bio-mathematical model is not an FRMS**

aled_owen_and_roy.jpg



PREREQUISITES FOR AN FRMS

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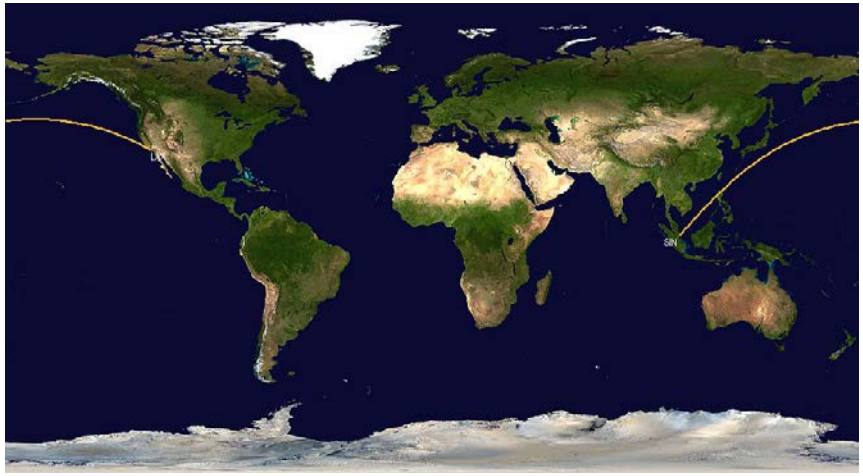
Prerequisites to move from FRM to FRMS

1. Must have a logical need to go outside the prescriptive regulations
    - FRMS is onerous and relatively expensive

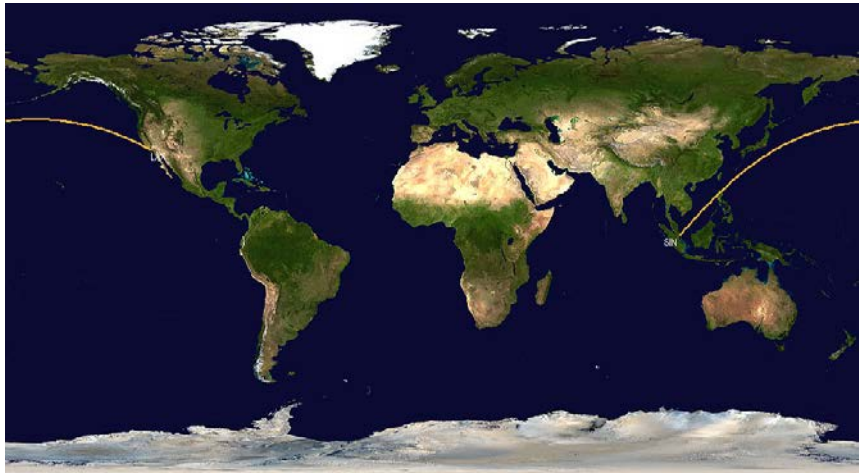
2. Must have already demonstrated that the SMS is robust and that fatigue is being well managed within the prescriptive regulations.
    - If you cannot show this, why do you expect to succeed with FRMS?



Prerequisites to move from FRM to FRMS

3. Must have a plan approved by your Regulator

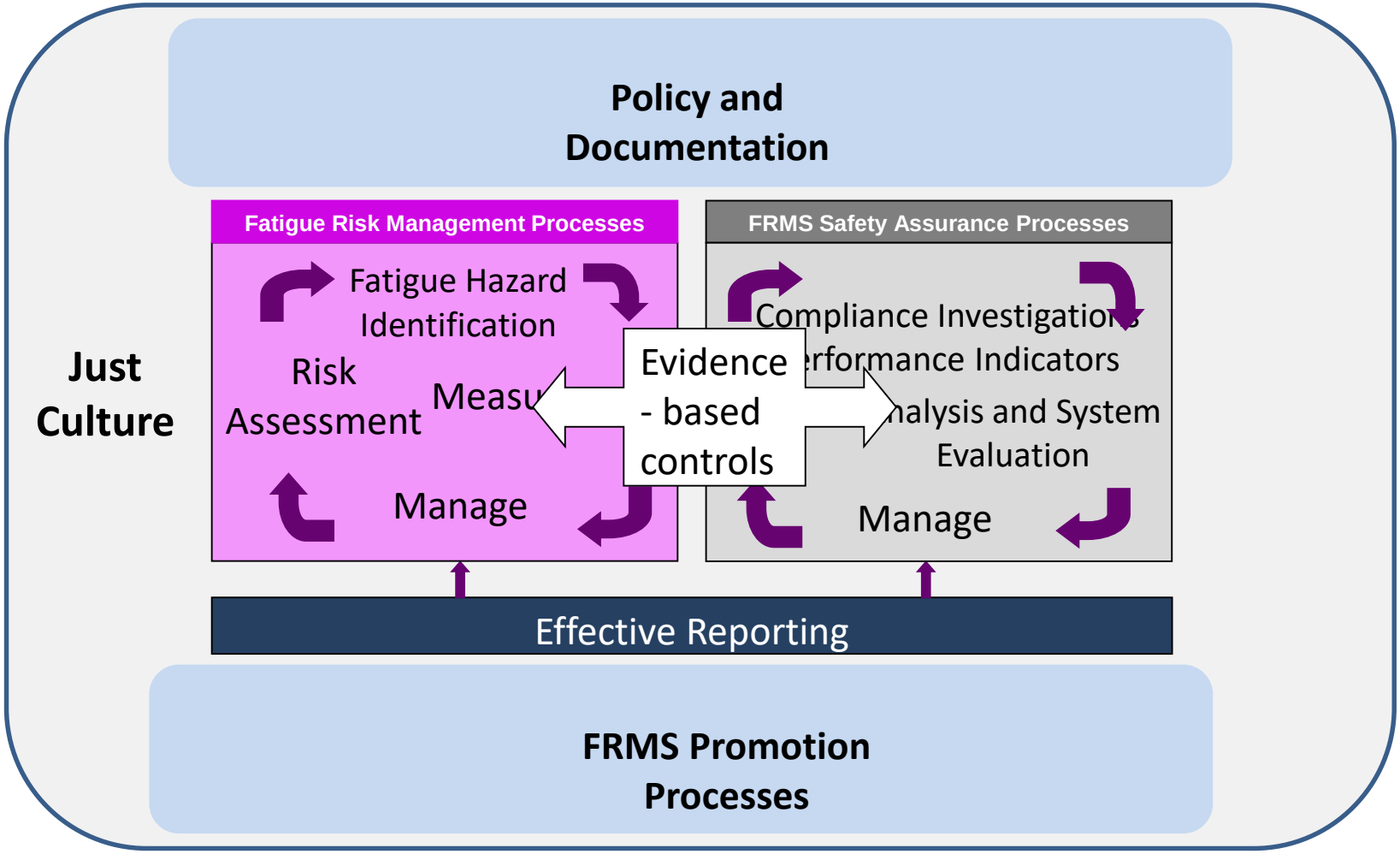
- CEO and board committed to it
- FSAG in place
- Acceptable tools and processes
- Acceptable data collected for every part of operations included in proposed FRMS to prove safety is not compromised



Nobel Explosives, Ardeer, Scotland

SOME EXAMPLES OF FRMS

An outline of FRMS



Courtesy of easyJet

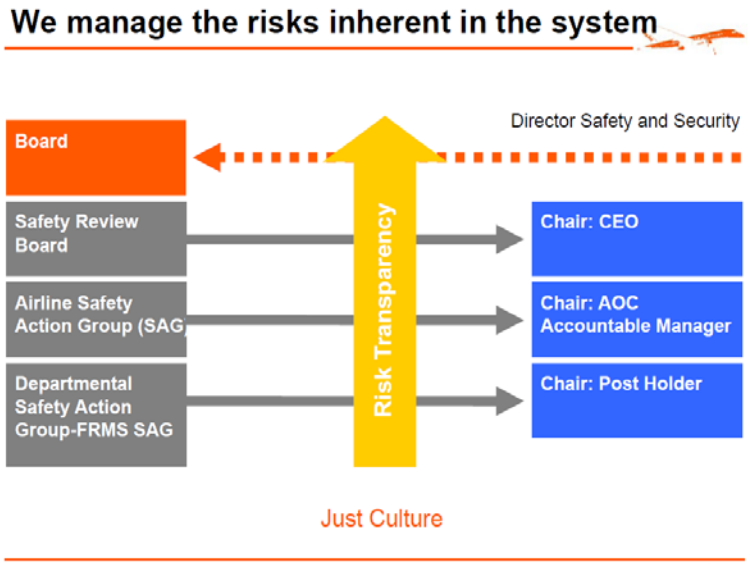
Initial Approaches to Managing Fatigue

- easyJet UK
  - Requirement to work consecutive early and late duties
  - Demonstrated to the UK CAA that the approach they proposed was safe
  - Continue to use objective data to influence design of schedules
- Air New Zealand
  - Review fatigue-related issues on an annual basis
  - Set up a scientific advisory committee to provide an independent review
  - Carry out in-flight investigations of specific routes

Benefits from FRMS

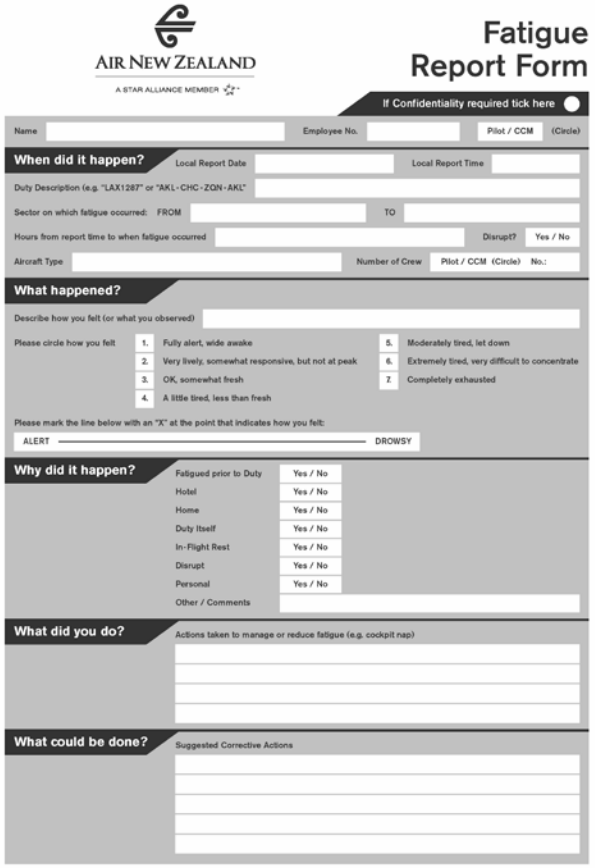
As determined by easyJet

- Reasons for investing in an FRMS include:
  - FRMS provides a measure of the exposure to fatigue risk
  - Provides some protection to the brand image by maintaining the safety record
  - Facilitates increased rostering flexibility and workload balance
  - Improved allocation of work time and time off
  - Company insurance premiums are linked to risk
  - Reduction in frequency of medium and high risk events
  - Reduction in oversight from the regulating authority
  - Greater retention of staff; easyJet roster pattern is a recruitment incentive
  - Reduction in fatigue lost duty days and in sickness due to fatigue-related factors



Air New Zealand Experience

- Air New Zealand has almost 20 years experience of reviewing their operations
  - Identified a methodology for assessing fatigue
    - Included a multiparty group
    - Involved the unions
    - External review body
  - Regular surveys of pilots and cabin crews
  - Developed a fatigue reporting form (held on all aircraft)
  - Review of flight and crew data
  - Use of SAFE model to assess fatigue risk
  - Use of objective data to inform changes to schedules
    - For both pilots and cabin crews



AIR NEW ZEALAND
A STAR ALLIANCE MEMBER

Fatigue Report Form

If Confidentiality required tick here

Name | Employee No. | Pilot / CCM (Circle)

When did it happen?

Local Report Date | Local Report Time

Duty Description (e.g. "LAX1287" or "AKL-CHC-ZQN-AKL")

Sector on which fatigue occurred: FROM | TO

Hours from report time to when fatigue occurred | Disrupt? Yes / No

Aircraft Type | Number of Crew | Pilot / CCM (Circle) No.:

What happened?

Describe how you felt (or what you observed)

Please circle how you felt

1. Fully alert, wide awake
2. Very lively, somewhat responsive, but not at peak
3. OK, somewhat fresh
4. A little tired, less than fresh
5. Moderately tired, let down
6. Extremely tired, very difficult to concentrate
7. Completely exhausted

Please mark the line below with an "X" at the point that indicates how you felt:

ALERT ——— DROWSY

Why did it happen?

Fatigued prior to Duty	Yes / No
Hotel	Yes / No
Home	Yes / No
Duty Itself	Yes / No
In-Flight Rest	Yes / No
Disrupt	Yes / No
Personal	Yes / No
Other / Comments	

What did you do?

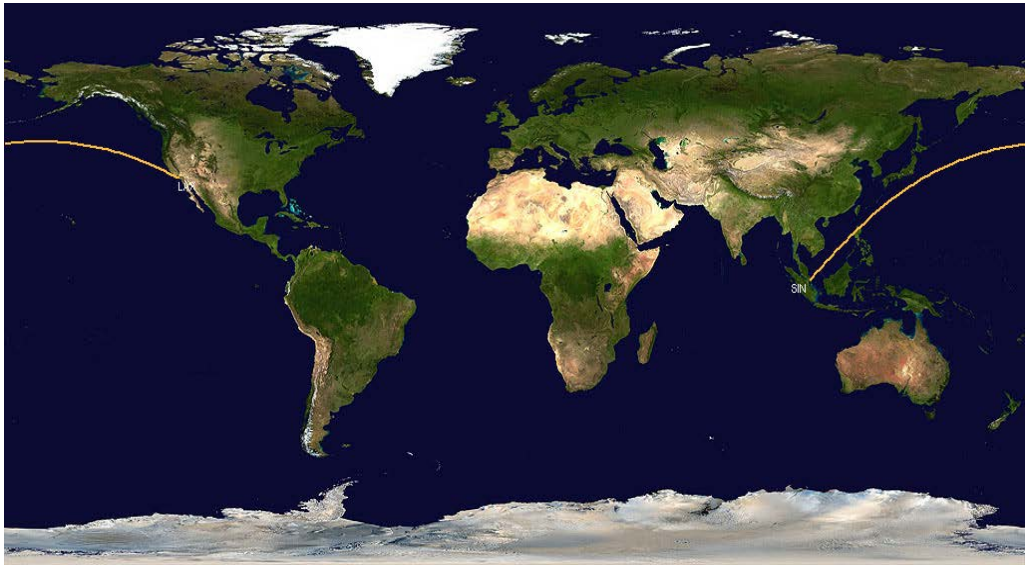
Actions taken to manage or reduce fatigue (e.g. cockpit nap)

What could be done?

Suggested Corrective Actions

With hindsight ……

THE FIRST FRMS



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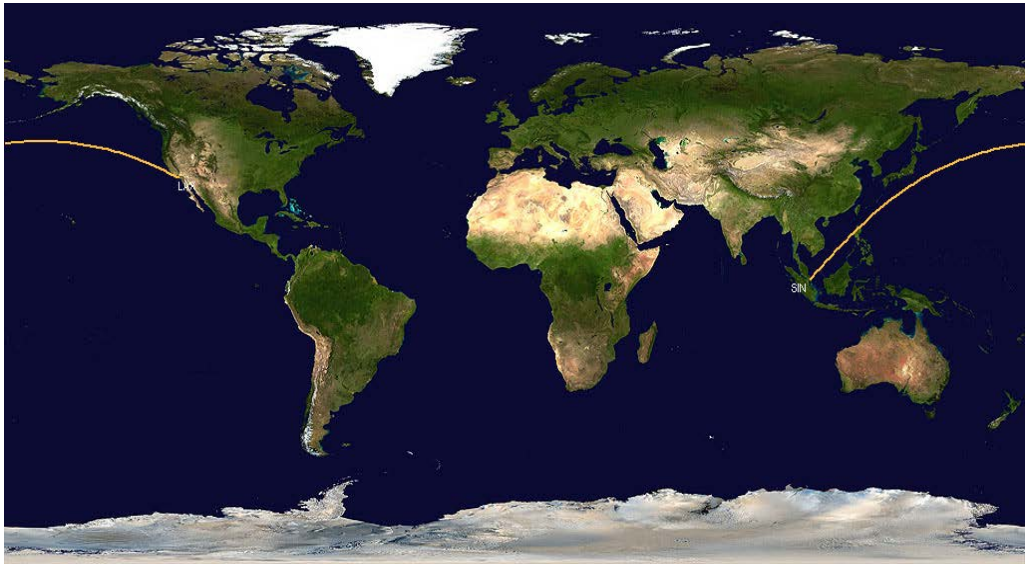
First Ultra-long-range (ULR) operations

SIN-LAX(2002). Singapore Airlines A340-500

Planning stage

- Phase 0 – Hazards identified and measured. Mitigation strategy agreed between aircrew representatives, Singapore Airline management and CAA Singapore.

Singapore Airlines A340-500



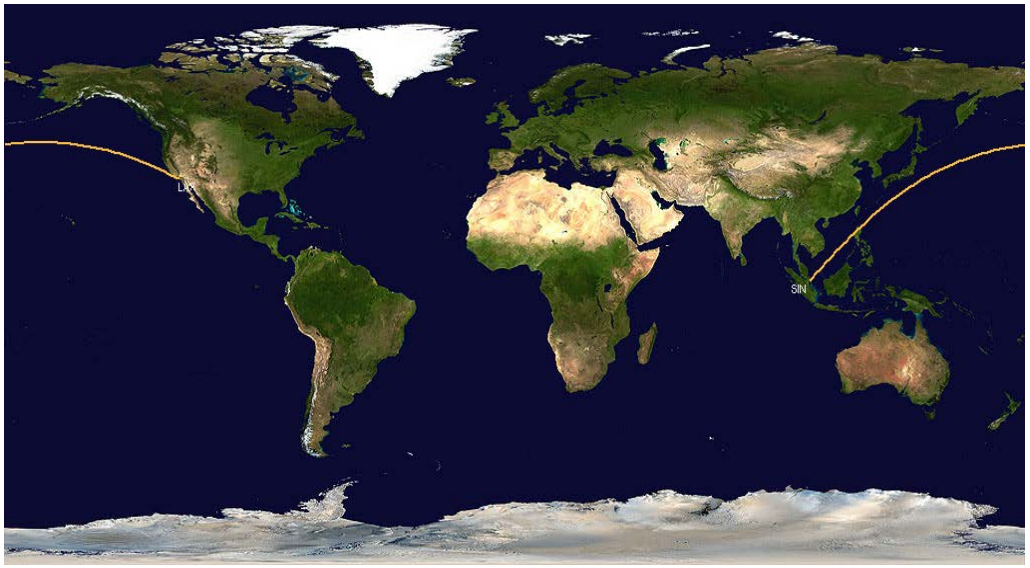
First Ultra-long-range (ULR) operations

SIN-LAX(2002). Singapore Airlines A340-500

Implementation

- **Phase I –** SAFE bio-mathematical used to model potential scenarios; the output informed discussions between regulator & operator
- **Phase II –** validation of the model estimates with respect to existing long-haul schedules being operated by the same airline
- **Phase III –** monitoring fatigue in-flight during first 6 months of first ULR operations

Singapore Airlines A340-500



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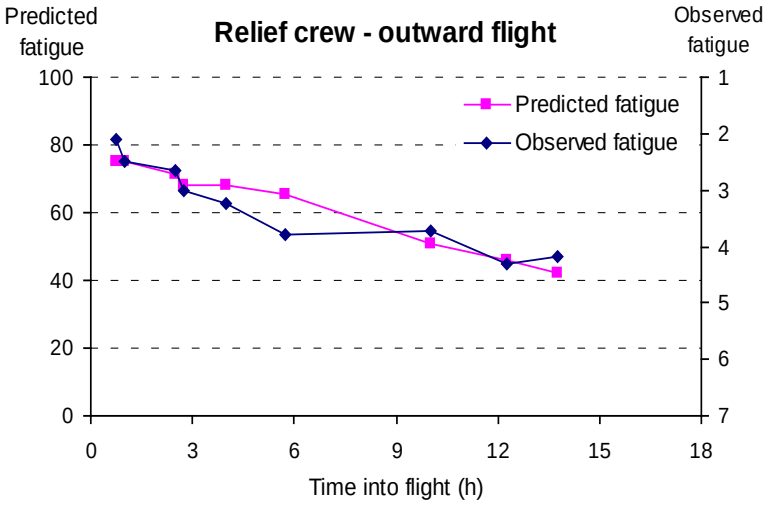
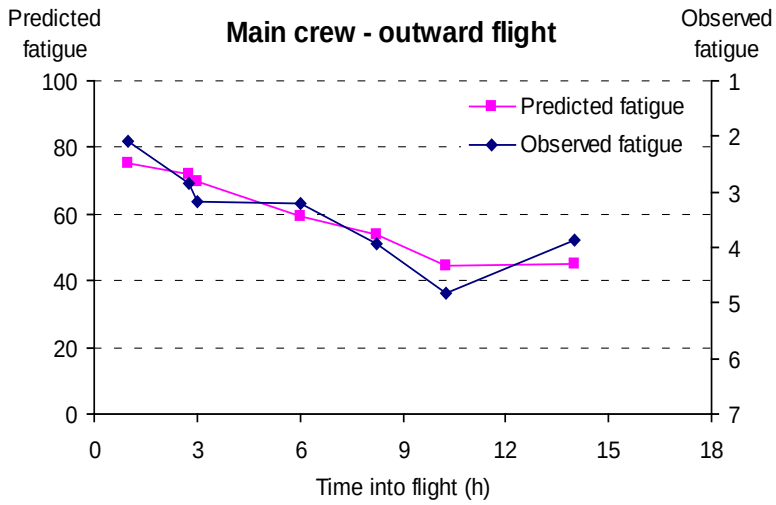
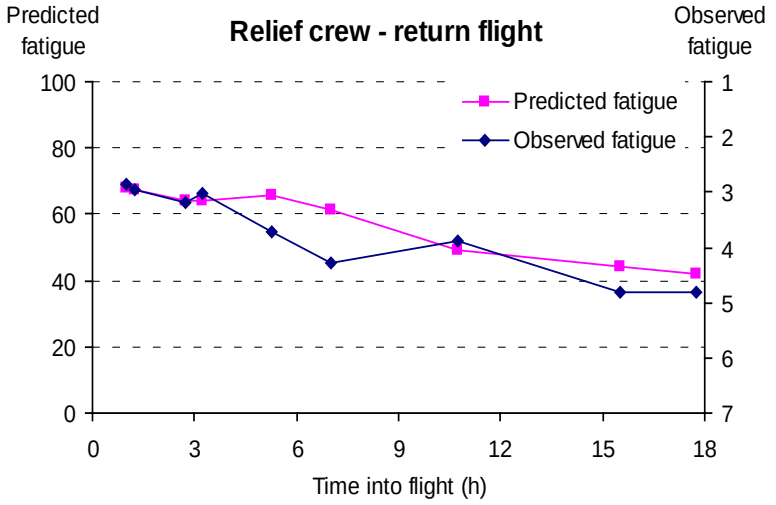
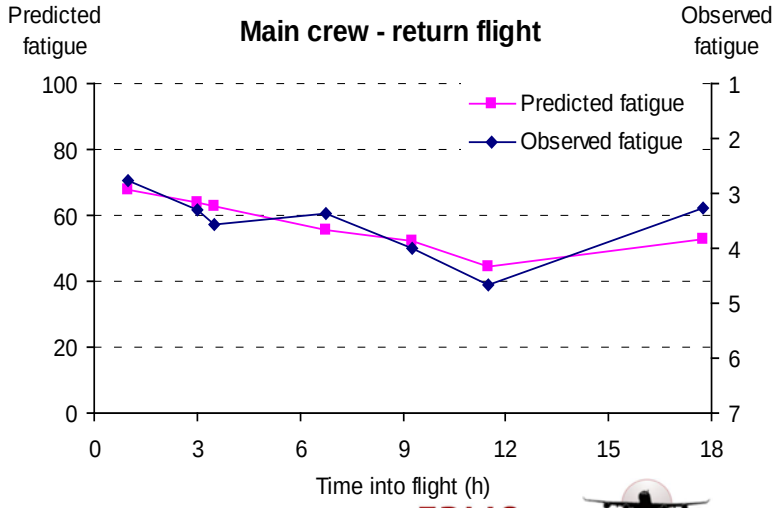
Phase III: observed v predicted









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MOVING AIRCRAFT AT THE END OF THE DUTY.

Repositioning aircraft at the end of the day

- Positioning an aircraft at the end of the day even if the crew are tired is extremely beneficial to an airline.
- To get permission to do that, airlines must apply for special permission from CAA to extend the normal duty day. This requires a risk analysis with measurements of fatigue and mitigations etc.
- With an FRMS in place, Regulators will be content to delegate responsibility for the decision making to the airline
- **RESULT:** with a **single** aircraft movement per annum, easyJet lowered their cost of operations by an equivalent of the cost of the 5 staff working in their FRMS department.

FAA RULE: THE PILOT LANDING THE AIRCRAFT MUST HAVE THEIR IN-FLIGHT REST IN THE SECOND HALF OF THE FLIGHT.

Sleep between services is better

- Current experience is that the landing pilot prefers to take the middle rest position between cabin services
- New FAA rule is for landing pilot to take rest in last half of flight
- Fatigue study required **from every airline** to demonstrate that the pilot is no more fatigued by taking the middle rest period than if they had taken the rest wholly in the last half of the flight.

Risk appetite is variable.

TRANSPORTING IMPORTANT PEOPLE

Transporting Queen Elizabeth II from Sydney

Her Majesty The Queen visited Australia on an official visit in the 1990s

The Court of Queen Elizabeth invited British Airways to ensure her safe return to Windsor Castle.

Issues

- What risk appetite should be adopted?
- What is the best time to operate the flight?
- How will the flight be managed in terms of pilot rest?
- How to demonstrate the risks are managed before and during the flight?
- The trip is 19 hours duty time

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BENEFITS ACCRUED FROM MANAGING FATIGUE IN AVIATION

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Benefits of FRMS

Collecting data, creating leading indicators

- Benefits to Air Crew
  - Feel better, perform better, fly safer
  - The company's recognition of our fatigue indicates we're a team!
- Benefits to safety manager
  - Higher safety perimeter, another risk managed
  - Regulatory compliance.
- Benefits for CEO
  - A high performance workforce
  - Lower risk of On the Job Injuries
  - Increase flexibility and productivity
  - Lower operational risk = lower insurance costs.

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Return on CEO's investment (ROI)

- Protects the Brand (company values)
  - Particularly with cabin crew
- ROI in production
  - Maximize crew utilisation safely
- Risk Reduction and tracking
  - Covers hidden fatigue due to pay incentives etc.
- Reduction in costs
  - operational efficiencies
  - Reduced Insurance Premia
  - fatigue absence, attrition, sickness
- Improved compliance effectiveness (performance based)
  - robust defences against fatigue related risk

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OTHER POINTS TO NOTE….

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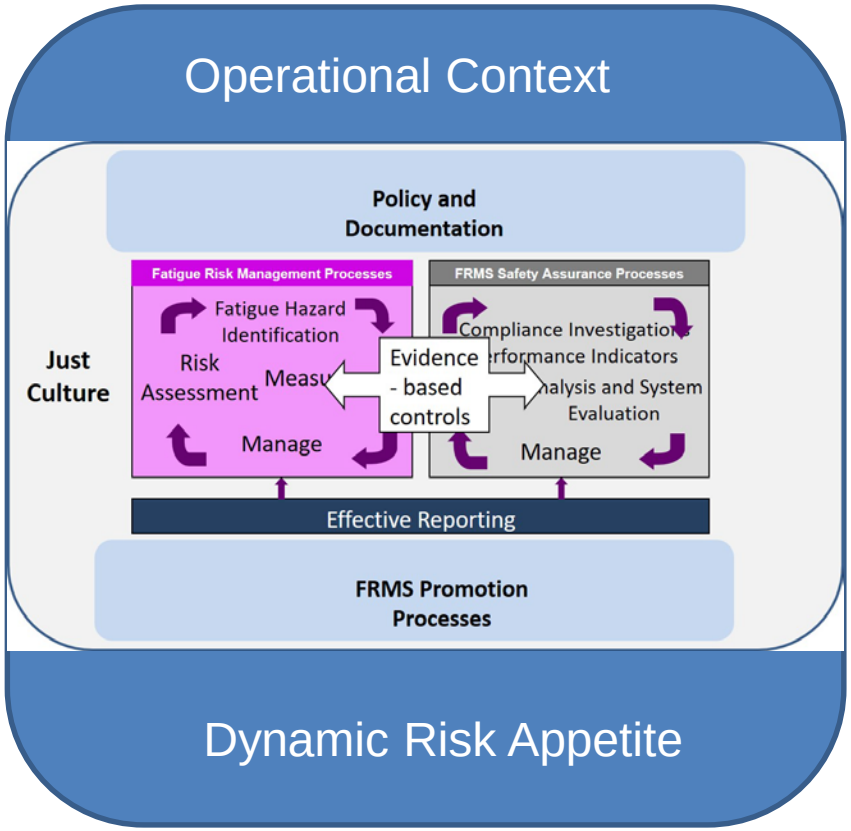
Is Using a Bio-mathematical Model the Same as an FRMS?

- **The human makes the decision** NOT the computer/model
- Regulators look for airlines considering ALL risks and will not accept an FRMS application if only a computer model is used.
- Airlines must understand why they use a model and its capabilities.
- Regulators insist that airlines must demonstrate they are fully conversant with all hazards, have measure them and made good judgements when proposing mitigations.
- Bio-mathematical models are **tools** – not a decision making system.



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Caveat Emptor

- Beware models with great IT/GUI and no data on which to base their predictions.
- Consultants claiming to be an FRMS expert
  - Having some knowledge of rostering and/or SMS;
  - Using charts from the ICAO document 9966, other scientists research and none of their own.
  - with no background in science.

Are the benefits of FRMS being secured?

DOES FRMS WORK?

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Is FRMS Working?

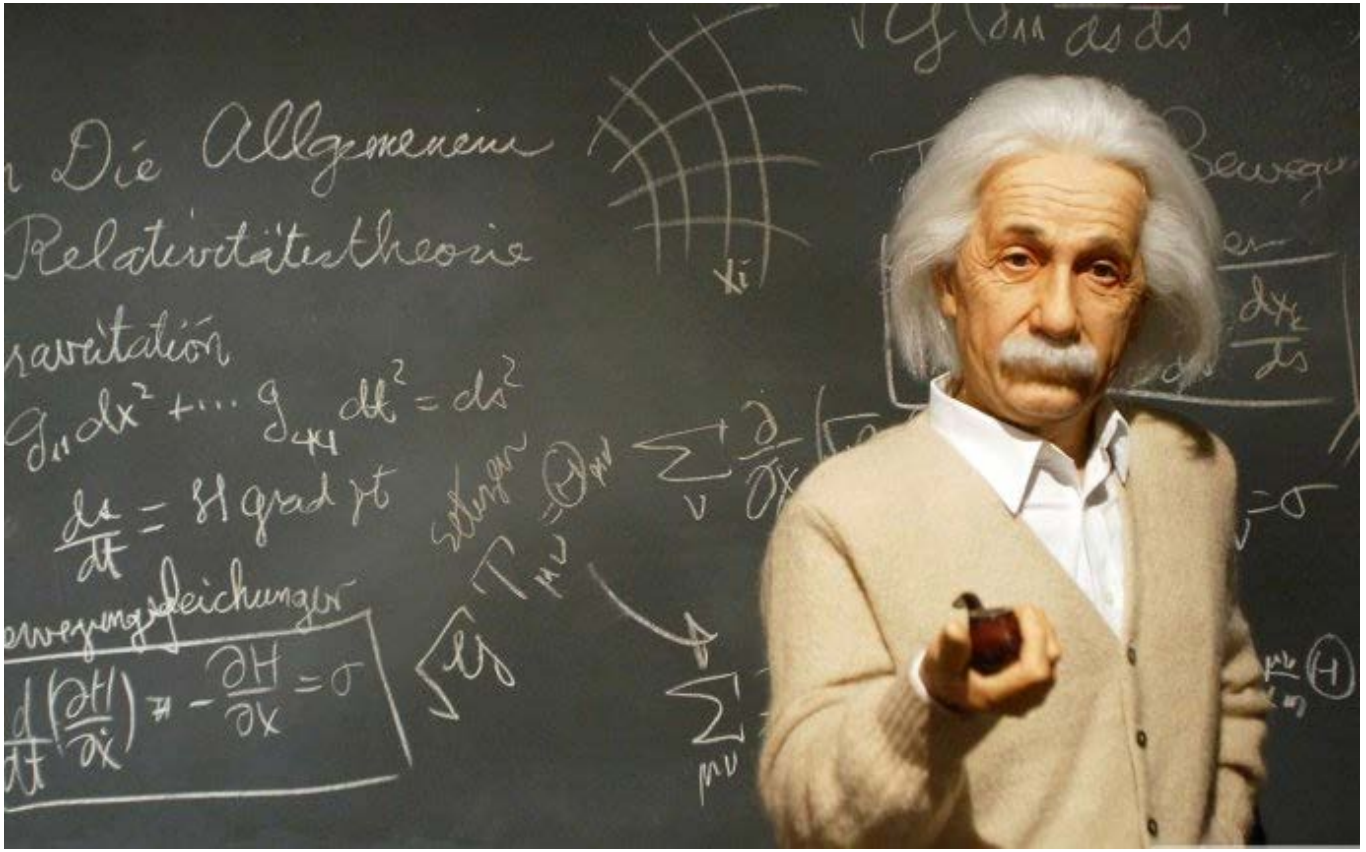
- Most NAAs are not engaged with FRMS
- In UK only 2 airlines have succeeded with gaining an FRMS accreditation
- In USA only 3 airlines have accreditations
- EU says 70% of NAAs in Europe unable to inspect for Fatigue Management.
- Are the benefits being enjoyed by all stakeholders?
  - Another hazard managed
  - Happier aircrew
  - Reduced insurance premiums
  - More flexibility and competitive advantage
  - Less accidents and incidents

Accidents and Incidents

- List of accidents and incidents to show them to be very low - but more are being reported of late
- 2014 reg EU376/14 now exist on how you report any incident; and copies held centrally. Useful for exploring reported incidents.
- BUT fatigue was previously often ignored in such reports so need to look say, 2 years before 2014, and see what the change looks like since (if any)…..
- Statistician's advice needed on when will we know if there is a change? How many year's data do we need? Other elements of aviation change e.g. automation increases. The environment is not a steady state
- So are there less occasions where the pilots feel less fatigued?
- Ongoing EU and CASA studies……

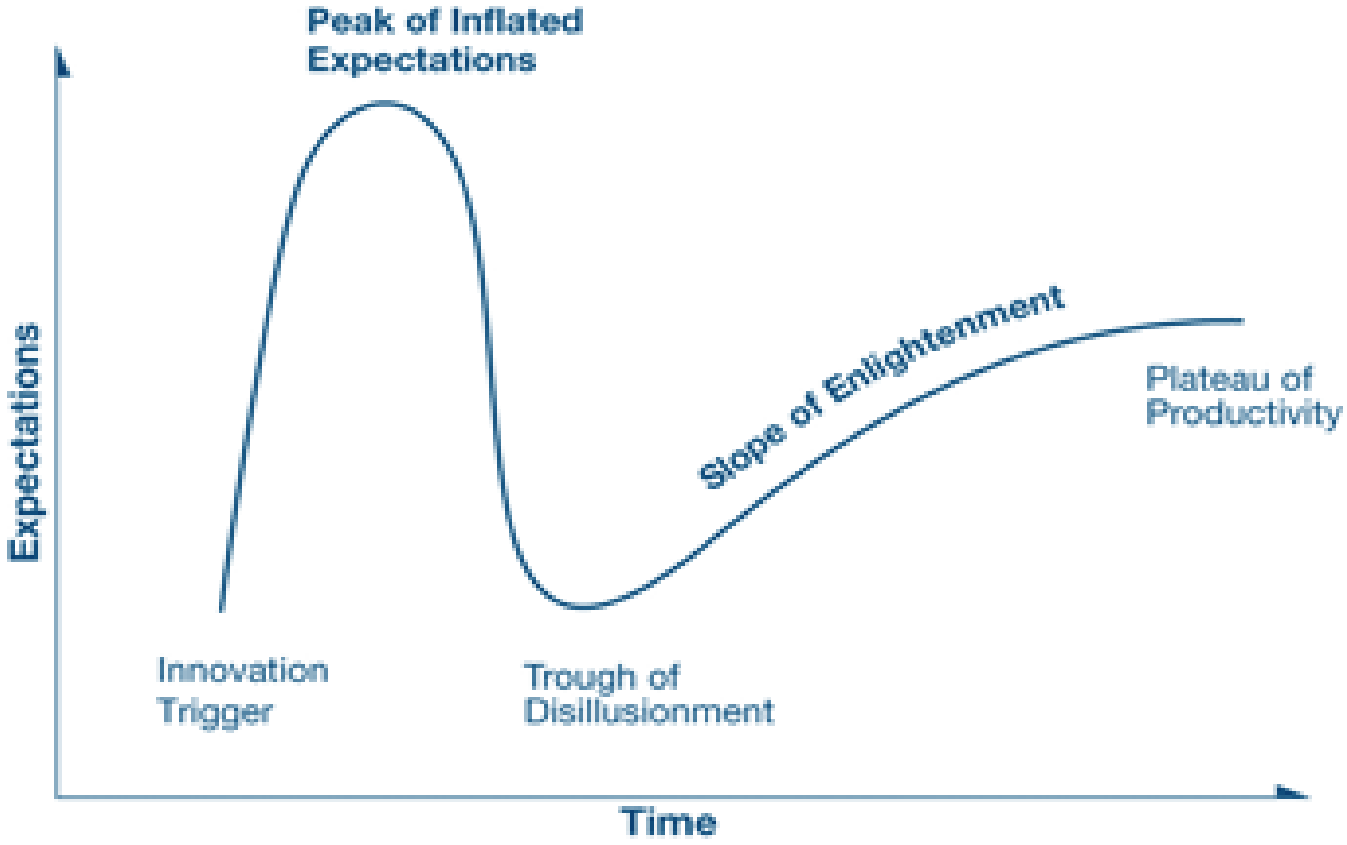
Who benefits?

Scientists and Training Providers



On Maturity

The Hype Curve: Gartner 2001



Conclusions - 1

- It's too early to say whether it is working or not
  - **Not enough data collected** (except EU376/14) so only anecdotal "evidence" exists though some work started with EU and CASA to evaluate safety aspects
  - **Low fatigue incidents** so need a lot more time to collect data (several years) before we can see a trend
  - Cannot see "Near Misses" so incident data could be hidden and will be important to capture to see trends. Fatigue incidents used to be suppressed and not reported.
  - Moving towards the trough of disillusionment of the **hype curve**

Conclusions - 2

- However, it is evident that
  - Change is difficult in large organisations. Many airlines are adopting Fatigue Management and are struggling to come to terms with the **need to invest** in it before expecting a return for their investment.
  - Many airlines trying to **fit the new requirements** to existing processes to maintain status quo. “If it’s legal, it’s safe”
  - **Instant results required**. Some airlines have tried Fatigue Management and found it an unrewarding experience (given up too early)
  - Some airlines **do not need it** – not enough of an inherent fatigue issue to worry about it.
  - Many airlines and other parts of the aviation industry **remain unaware**……

Conclusions - 3

It is also evident that:

- Regulators need to start **regulating**
- The FRMS consultancy market is booming:
  - **Caveat Emptor**
- Reports of fatigued pilots are **still evident**
- Some airlines are resisting the investment
  - More **compliance** than internalisation
  - Changing the concept to fit **current prejudices**
  - Setting fatigue thresholds **too high**
  - **Low levels** of experience and expertise exists

Conclusions – 4

- The **granularity** of our measurement techniques maybe not so good. Do aircraft type and time of year need consideration.
- Need to plan for an **acceptable work pattern** without pushing pilot up the limit frequently
- Issue of **contract pilots vs permanent pilots**. Contractors less likely to report fatigue. Does each group submit the same proportion of reports?
- Is the rest of **life getting too hard** – debts to pay off; worries about buying houses, moving bases from time to time. Pilot marriage-survival rate creates pressures. Is lifestyle becoming more of an issue than schedule design?

Some thoughts …..

on helping managing fatigue to be more successful

- Create level playing field with all **regulations equal** in each country..
  - FTL rules are all different around the world. Why is this? Why can't NAAs agree some general set of rules to cover everyone.
  - Cockpit napping Guidance should be universally agreed. Pilots in those countries that forbid it still "put head back and examine the ceiling for a few minutes"
  - Fatigue threshold limits vary enormously with airline risk appetite.
- Regulators must **regulate for safety** else progress only driven by anticipated business advantages identified.
- Tools should **work** and be **appropriate**.

Questions and Comments?

Thanks for listening

Douglas Mellor

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USING BIO-MATHEMATICAL MODELS IN AN FRM OR AN FRMS

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Uses of Bio-Mathematical Models

- **Bio-mathematical models can be used to**
  - Identify hazards
    - How many, where, how big
  - Compare planned with actual schedules
  - Estimate fatigue for new routes
  - Assess fatigue reports
  - Assess fatigue at point of incident
  - Work out possible mitigation strategies
  - Set regulations, or internal limits

- Connected to a rostering programme can provide scores for building non-fatiguing schedules or even optimising for minimum fatigue.

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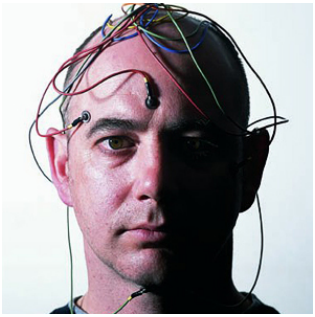
About Bio-mathematical models

- **Models are built from datasets, mostly.**
  - Ensure the research conducted to gather the data is built on **robust scientific principles**
  - Ensure that the data collected comes from the correct occupation
  - Ensure that **enough data** is collected by focussed research identifying hazards and measuring the fatigue
  - Ensure that **both** subjective (diary data) and objective (actiwatches and EEG) data is collected



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About Bio-mathematical models

- Avoid just considering the usability/ IT /graphi design of the interface.
- Beware of low significant elements being overstated. (caffeine, light, chronotype)
- One model will generally not fit all occupation
- A model is often seen as a rostering tool, not as a hazard reduction or safety tool

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Fatigue Models vs Sleepiness models

- Several models exist but of varying quality

- Fatigue is caused by
  - sleep disturbance and changes in circadian rhythm
  - Cognitive workload (high concentration)

- Sleep disturbance caused by
  - Shift working (early starts, late finishes, overnight duties)
  - Time zone transitions
  - Sleep disorders
  - Consumption of alcohol, caffeine and other pharmaceuticals

A fatigue model has to cover both sleep disturbance and cognitive workload.

The System for Aircrew Fatigue Evaluation (SAFE)

Est. 1980

Hosting platform contains the Cabin crew (CARE) model and the FRI model for Ground Crew and Maintenance Engineers

EXAMPLES OF USING A BIO-MATHEMATICAL MODEL

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Data requirements

Reference	On duty date	On duty time	Start airport	Off duty date	Off duty time	End airport	Sectors	Crew composition	Sleep count	Sleep order	Sleep class	Home base
Pilot	01/05/2010	18:35:00	JFK	02/05/2010	06:40:00	SVO	1	3	1	1	1	JFK
Pilot	03/05/2010	06:35:00	SVO	03/05/2010	18:55:00	JFK	1	3	1	1	1	JFK
Pilot	07/05/2010	21:50:00	JFK	08/05/2010	09:20:00	BUD	1	3	1	1	1	JFK
Pilot	10/05/2010	09:15:00	BUD	10/05/2010	21:25:00	JFK	1	3	1	1	1	JFK
Pilot	11/05/2010	21:25:00	JFK	12/05/2010	08:10:00	TXL	1	3	1	0	1	JFK

Timezone	On partial augment date	On partial augment time	Off partial augment date	Off partial augment time	First rest start date	First rest start time	First rest end date	First rest end time	Second rest start date	Second rest start time	Second rest end date	Second rest end time	Split Shift
1													
1													
1													
1													
1					12/05/2010	00:00	12/05/2010	04:00					

Roster view Report

Reference	On duty date	On duty time	Start airport	Off duty date	Off duty time	End airport
Pilot	01/05/201	22:35	KJFK / JFK /	02/05/201	10:40	UUEE / SV(
Pilot	03/05/201	10:35	UUEE / SV(	03/05/201	22:55	KJFK / JFK /
Pilot	08/05/201	01:50	KJFK / JFK /	08/05/201	13:20	LHBP / BUI
Pilot	10/05/201	13:15	LHBP / BUI	11/05/201	01:25	KJFK / JFK /
Pilot	12/05/201	01:25	KJFK / JFK /	12/05/201	12:10	EDDT / TXL
Pilot	14/05/201	11:55	EDDT / TXL	14/05/201	22:55	KJFK / JFK /
Pilot	16/05/201	03:10	KJFK / JFK /	16/05/201	14:10	LIRP / PSA
Pilot	18/05/201	13:55	LIRP / PSA	19/05/201	01:45	KJFK / JFK /
Pilot	20/05/201	00:00	KJFK / JFK /	20/05/201	08:28	KSFO / SFO
Pilot	20/05/201	22:30	KSFO / SFO	21/05/201	10:34	KLAS / LAS
Pilot	22/05/201	07:59	KLAS / LAS	22/05/201	14:30	KJFK / JFK /
Cabin crew	01/05/201	22:35	KJFK / JFK /	02/05/201	10:40	UUEE / SV(
Cabin crew	03/05/201	10:35	UUEE / SV(	03/05/201	22:55	KJFK / JFK /
Cabin crew	08/05/201	01:50	KJFK / JFK /	08/05/201	13:20	LHBP / BUI
Cabin crew	10/05/201	13:15	LHBP / BUI	11/05/201	01:25	KJFK / JFK /
Cabin crew	12/05/201	01:25	KJFK / JFK /	12/05/201	12:10	EDDT / TXL
Cabin crew	14/05/201	11:55	EDDT / TXL	14/05/201	22:55	KJFK / JFK /
Cabin crew	16/05/201	03:10	KJFK / JFK /	16/05/201	14:10	LIRP / PSA
Cabin crew	18/05/201	13:55	LIRP / PSA	19/05/201	01:45	KJFK / JFK /
Cabin crew	20/05/201	00:00	KJFK / JFK /	20/05/201	08:28	KSFO / SFO
Cabin crew	20/05/201	22:30	KSFO / SFO	21/05/201	10:34	KLAS / LAS
Cabin crew	22/05/201	07:59	KLAS / LAS	22/05/201	14:30	KJFK / JFK /

Alertness (SP)	Alertness (KSS)	Alertness (AS)	Alertness (KP)	Alertness (VD)	Alertness (CRD)	Alertness (PMR)	Alert Time
4.65	6.08	24.45	0.18	12.52	108.35	40.6	06:36
4.48	5.84	27.67	0.15	11.71	96.03	37.33	11:36
4.12	5.32	34.52	0.09	10.02	74.15	30.8	09:06
4.33	5.62	30.55	0.12	10.99	86.2	34.51	21:16
4.8	6.29	21.63	0.22	13.24	120.48	43.53	00:41
4.24	5.48	32.38	0.11	10.54	80.44	32.77	18:41
4.74	6.21	22.71	0.21	12.96	115.67	42.4	03:55
5.22	6.89	13.64	0.36	15.33	164.04	52	21:40
5.88	7.84	1.1	0.66	18.77	282.67	64.89	04:15
5.82	7.75	2.22	0.63	18.45	267.88	63.8	06:30
5.83	7.77	1.99	0.64	18.51	270.81	64.02	09:29
4.89	6.42	19.92	0.25	13.68	128.57	45.33	06:36
4.89	6.42	19.95	0.25	13.67	128.4	45.29	18:51
4.54	5.91	26.67	0.16	11.96	99.72	38.34	03:51
4.77	6.25	22.24	0.21	13.08	117.75	42.89	21:16
4.91	6.45	19.49	0.26	13.79	130.67	45.78	00:41
4.63	6.05	24.89	0.18	12.41	106.58	40.15	18:41
5.13	6.77	15.33	0.33	14.88	153.42	50.2	03:10
5.63	7.48	5.87	0.54	17.43	226.8	60.13	21:40
6.21	8.32	0	0.82	20.6	396.25	70.82	04:15
6.12	8.18	0	0.77	20.08	358.24	69.22	06:30
5.97	7.98	0	0.71	19.29	309.59	66.65	10:29

Identifying the Hazards

sort roster view report by max fatigue score

Reference	On duty date	On duty time	Start airport	Off duty date	Off duty time	End airport	Alertness (SP)	Alertness (KSS)	Alertness (AS)	Alertness (KP)	Alertness (VD)	Alertness (CRD)	Alertness (PMR)	Alert Time
Cabin crew	20/05/201	00:00	KJFK / JFK /	20/05/201	08:28	KSFO / SFO	6.21	8.32	0	0.82	20.6	396.25	70.82	04:15
Cabin crew	20/05/201	22:30	KSFO / SFO	21/05/201	10:34	KLAS / LAS	6.12	8.18	0	0.77	20.08	358.24	69.22	06:30
Cabin crew	22/05/201	07:59	KLAS / LAS	22/05/201	14:30	KJFK / JFK /	5.97	7.98	0	0.71	19.29	309.59	66.65	10:29
Pilot	20/05/201	00:00	KJFK / JFK /	20/05/201	08:28	KSFO / SFO	5.88	7.84	1.1	0.66	18.77	282.67	64.89	04:15
Pilot	22/05/201	07:59	KLAS / LAS	22/05/201	14:30	KJFK / JFK /	5.83	7.77	1.99	0.64	18.51	270.81	64.02	09:29
Pilot	20/05/201	22:30	KSFO / SFO	21/05/201	10:34	KLAS / LAS	5.82	7.75	2.22	0.63	18.45	267.88	63.8	06:30
Cabin crew	18/05/201	13:55	LIRP / PSA	19/05/201	01:45	KJFK / JFK /	5.63	7.48	5.87	0.54	17.43	226.8	60.13	21:40
Pilot	18/05/201	13:55	LIRP / PSA	19/05/201	01:45	KJFK / JFK /	5.22	6.89	13.64	0.36	15.33	164.04	52	21:40
Cabin crew	16/05/201	03:10	KJFK / JFK /	16/05/201	14:10	LIRP / PSA	5.13	6.77	15.33	0.33	14.88	153.42	50.2	03:10
Cabin crew	12/05/201	01:25	KJFK / JFK /	12/05/201	12:10	EDDT / TXL	4.91	6.45	19.49	0.26	13.79	130.67	45.78	00:41
Cabin crew	01/05/201	22:35	KJFK / JFK /	02/05/201	10:40	UUEE / SVO	4.89	6.42	19.92	0.25	13.68	128.57	45.33	06:36
Cabin crew	03/05/201	10:35	UUEE / SVO	03/05/201	22:55	KJFK / JFK /	4.89	6.42	19.95	0.25	13.67	128.4	45.29	18:51
Pilot	12/05/201	01:25	KJFK / JFK /	12/05/201	12:10	EDDT / TXL	4.8	6.29	21.63	0.22	13.24	120.48	43.53	00:41
Cabin crew	10/05/201	13:15	LHBP / BUD	11/05/201	01:25	KJFK / JFK /	4.77	6.25	22.24	0.21	13.08	117.75	42.89	21:16
Pilot	16/05/201	03:10	KJFK / JFK /	16/05/201	14:10	LIRP / PSA	4.74	6.21	22.71	0.21	12.96	115.67	42.4	03:55
Pilot	01/05/201	22:35	KJFK / JFK /	02/05/201	10:40	UUEE / SVO	4.65	6.08	24.45	0.18	12.52	108.35	40.6	06:36
Cabin crew	14/05/201	11:55	EDDT / TXL	14/05/201	22:55	KJFK / JFK /	4.63	6.05	24.89	0.18	12.41	106.58	40.15	18:41
Cabin crew	08/05/201	01:50	KJFK / JFK /	08/05/201	13:20	LHBP / BUD	4.54	5.91	26.67	0.16	11.96	99.72	38.34	03:51
Pilot	03/05/201	10:35	UUEE / SVO	03/05/201	22:55	KJFK / JFK /	4.48	5.84	27.67	0.15	11.71	96.03	37.33	11:36
Pilot	10/05/201	13:15	LHBP / BUD	11/05/201	01:25	KJFK / JFK /	4.33	5.62	30.55	0.12	10.99	86.2	34.51	21:16
Pilot	14/05/201	11:55	EDDT / TXL	14/05/201	22:55	KJFK / JFK /	4.24	5.48	32.38	0.11	10.54	80.44	32.77	18:41
Pilot	08/05/201	01:50	KJFK / JFK /	08/05/201	13:20	LHBP / BUD	4.12	5.32	34.52	0.09	10.02	74.15	30.8	09:06

10 Hazards

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Contemplating new routes or new schedules

1. ASSESSING CITY PAIRINGS

Alert Air: New schedule to CDG-HKG-SYD

Reference	On Duty Date	On Duty time	Start Airport	Off Duty Date	Off Duty Time	End Airport	Sectors	Crew Composition	Sleep Count	Sleep Order	Sleep Class	Home Base	Timezone
Jean-Pierre Brun	06/06/2012	08:45:00	CDG	06/06/2012	14:45:00	CDG	0	2	0	0	0	CDG	2
Jean-Pierre Brun	07/06/2012	04:30:00	CDG	07/06/2012	10:30:00	CDG	0	2	0	0	0	CDG	2
Jean-Pierre Brun	08/06/2012	18:30:00	CDG	09/06/2012	08:30:00	NBO	1	2	0	0	0	CDG	2
Jean-Pierre Brun	10/06/2012	08:30:00	NBO	10/06/2012	16:10:00	CDG	1	2	0	0	0	CDG	2
Jean-Pierre Brun	11/06/2012	15:40:00	CDG	11/06/2012	18:40:00	MAN	0	2	0	0	0	CDG	2
Jean-Pierre Brun	12/06/2012	09:25:00	MAN	12/06/2012	15:01:00	MCO	1	2	0	0	0	CDG	2
Jean-Pierre Brun	14/06/2012	17:40:00	MCO	15/06/2012	11:15:00	CDG	1	2	0	0	0	CDG	2
Jean-Pierre Brun	16/06/2012	18:30:00	CDG	17/06/2012	08:17:00	NBO	1	2	0	0	0	CDG	2
Jean-Pierre Brun	21/06/2012	08:30:00	NBO	21/06/2012	16:12:00	CDG	1	2	0	0	0	CDG	2
Jean-Pierre Brun	26/06/2012	20:00:00	CDG	27/06/2012	18:11:00	HKG	1	3	1	3	1	CDG	2
Jean-Pierre Brun	29/06/2012	18:00:00	HKG	30/06/2012	07:20:00	SYD	1	3	1	3	1	CDG	2
Jean-Pierre Brun	01/07/2012	13:05:00	SYD	01/07/2012	22:23:00	HKG	1	3	1	3	1	CDG	2
Jean-Pierre Brun	03/07/2012	22:05:00	HKG	04/07/2012	04:49:00	CDG	1	3	1	3	1	CDG	2
Jean-Pierre Brun	08/07/2012	07:00:00	CDG	08/07/2012	12:32:00	JFK	1	2	0	0	0	CDG	2
Jean-Pierre Brun	09/07/2012	16:55:00	JFK	10/07/2012	05:42:00	CDG	1	2	0	0	0	CDG	2
Jean-Pierre Brun	14/07/2012	07:00:00	CDG	14/07/2012	12:47:00	JFK	1	2	0	0	0	CDG	2
Jean-Pierre Brun	15/07/2012	16:55:00	JFK	16/07/2012	06:23:00	CDG	1	2	0	0	0	CDG	2
Jean-Pierre Brun	16/07/2012	19:30:00	CDG	17/07/2012	11:13:00	DEL	1	3	1	3	1	CDG	2
Jean-Pierre Brun	18/07/2012	11:35:00	DEL	18/07/2012	17:23:00	CDG	1	3	1	3	1	CDG	2

Alert Air: CDG-HKG-SYD

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2. MITIGATING HIGH FATIGUE

Alert Air Cargo schedule

JNB – LUN - HRE - LUN - LNB

- Alert Air in Johannesburg has a contract cargo operation which is fatiguing so Management run two teams of pilots to execute the operation
- Team 1 flies the schedule whilst team 2 rest and vice versa.
- This is unsatisfactory as pilots complain they are still very tired.
- What can be done to alleviate fatigue without costing more to run the operation?

Cargo schedule

JNB - LUN-HRE - LUN - LNB

Reference	On Duty Date	On Duty Time	Start Airport	off duty date	Off Duty Time	End Airport	Sectors	Crew Composition	Sleep Count	Sleep Order	Sleep Class	Home Base	TimeZone
Pilot 0	10/04/2018	22:40:00	JNB	11/04/2018	03:20:00	LUN	2	2				JNB	0
Pilot 0	11/04/2018	16:25:00	LUN	12/04/2018	03:35:00	LUN	3	2				JNB	0
Pilot 0	12/04/2018	16:25:00	LUN	13/04/2018	03:35:00	LUN	3	2				JNB	0
Pilot 0	13/04/2018	16:25:00	LUN	14/04/2018	03:35:00	LUN	3	2				JNB	0
Pilot 0	14/04/2018	16:25:00	LUN	15/04/2018	03:35:00	LUN	3	2				JNB	0
Pilot 0	15/04/2018	16:25:00	LUN	15/04/2018	19:40:00	JNB	1	2				JNB	0

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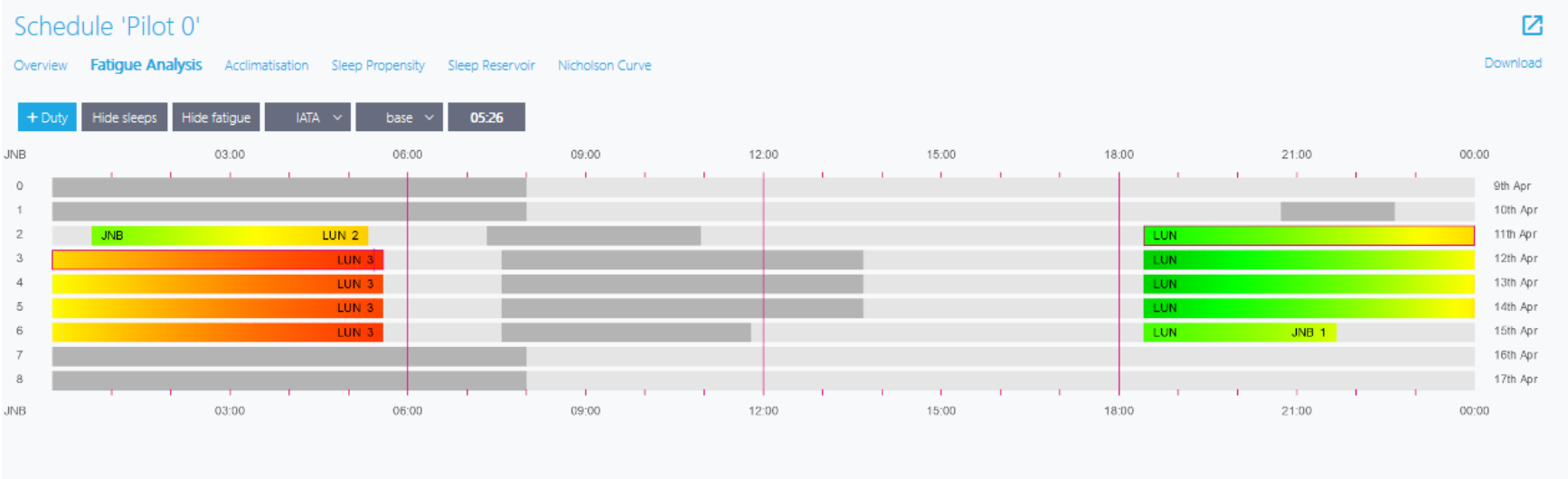
SAFE display



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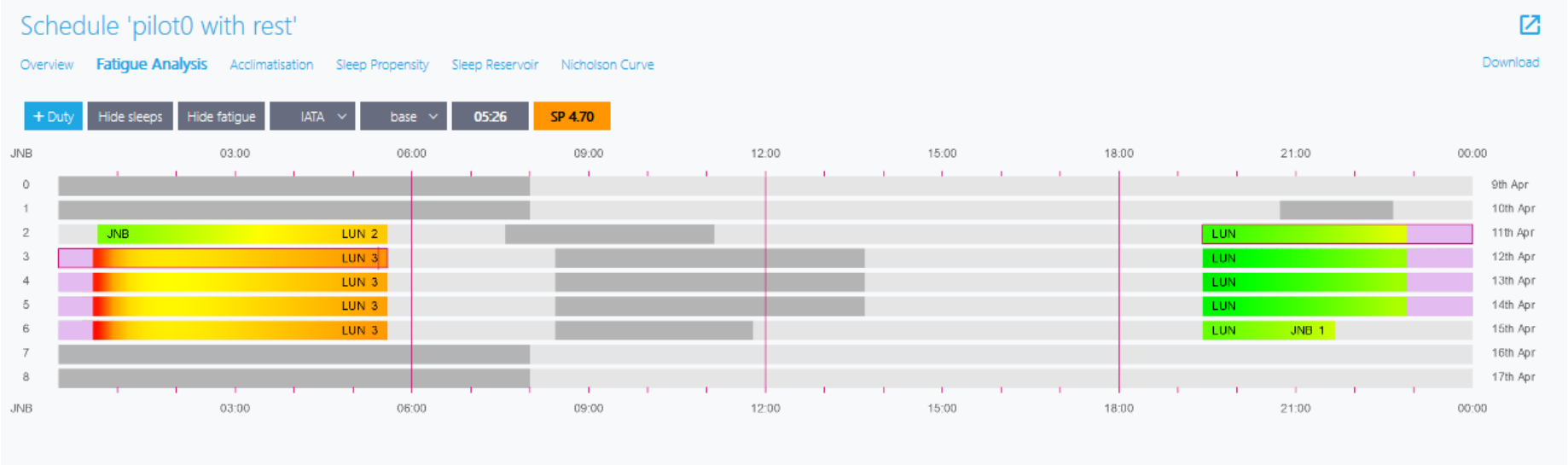
Mitigate by adding in-duty rest



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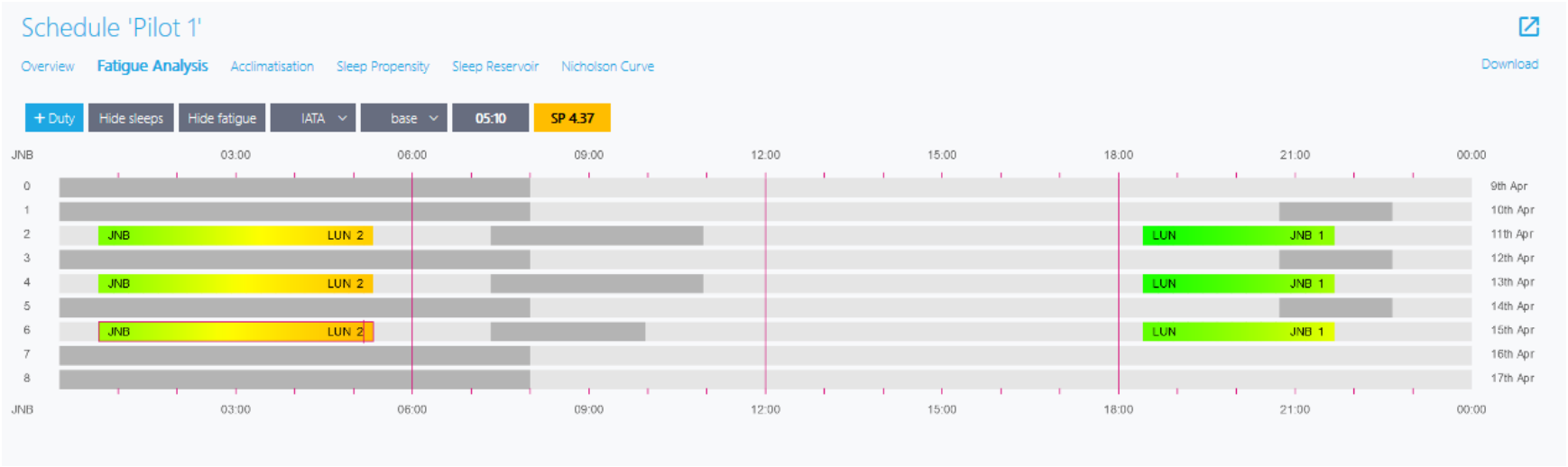
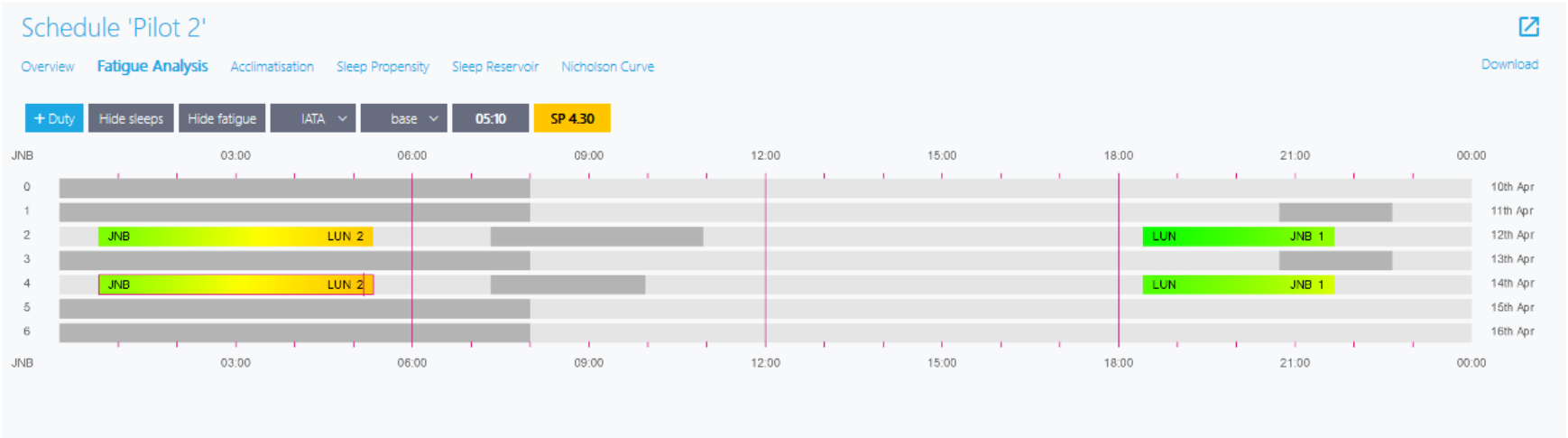
Mitigate more with sharing alternate duties





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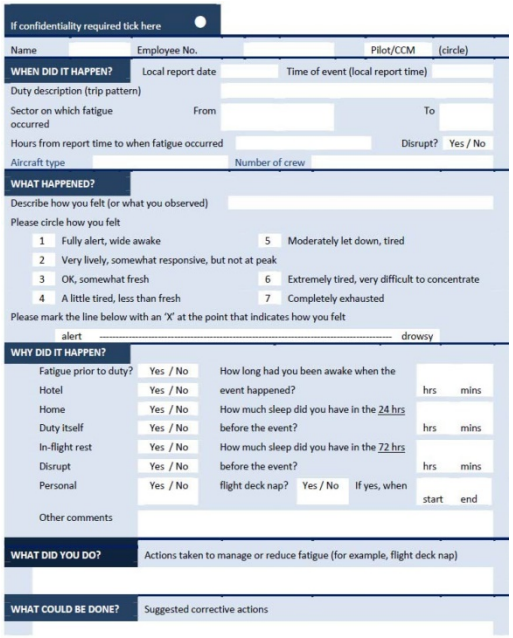

If confidentiality required tick here

Name | Employee No. | Pilot/CCM (circle)

WHEN DID IT HAPPEN? Local report date | Time of event (local report time)

Duty description (trip pattern)

Sector on which fatigue occurred From To

Hours from report time to when fatigue occurred | Disrupt? Yes / No

Aircraft type | Number of crew

WHAT HAPPENED?

Describe how you felt (or what you observed)

Please circle how you felt

1 Fully alert, wide awake
2 Very lively, somewhat responsive, but not at peak
3 OK, somewhat fresh
4 A little tired, less than fresh
5 Moderately let down, tired
6 Extremely tired, very difficult to concentrate
7 Completely exhausted

Please mark the line below with an 'X' at the point that indicates how you felt

alert ——— drowsy

WHY DID IT HAPPEN?

Fatigue prior to duty? Yes / No
Hotel Yes / No
Home Yes / No
Duty itself Yes / No
In-flight rest Yes / No
Disrupt Yes / No
Personal Yes / No

How long had you been awake when the event happened? hrs mins

How much sleep did you have in the 24 hrs before the event? hrs mins

How much sleep did you have in the 72 hrs before the event? hrs mins

flight deck nap? Yes / No If yes, when start end

Other comments

WHAT DID YOU DO? Actions taken to manage or reduce fatigue (for example, flight deck nap)

WHAT COULD BE DONE? Suggested corrective actions

3. ASSESSING FATIGUE REPORTS

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Flight Attendant Sophie White

Fatigue report

- Flight Attendant White reported that she was unable to work due to fatigue on the 29th October due to a fatiguing duty on the 28th On that day, there were reported to be delays all day, no time to eat or use the toilet, a medical emergency and abuse from customers. Her commute time is 1hour 30 minutes both ways.

Flight Attendant Sophie White

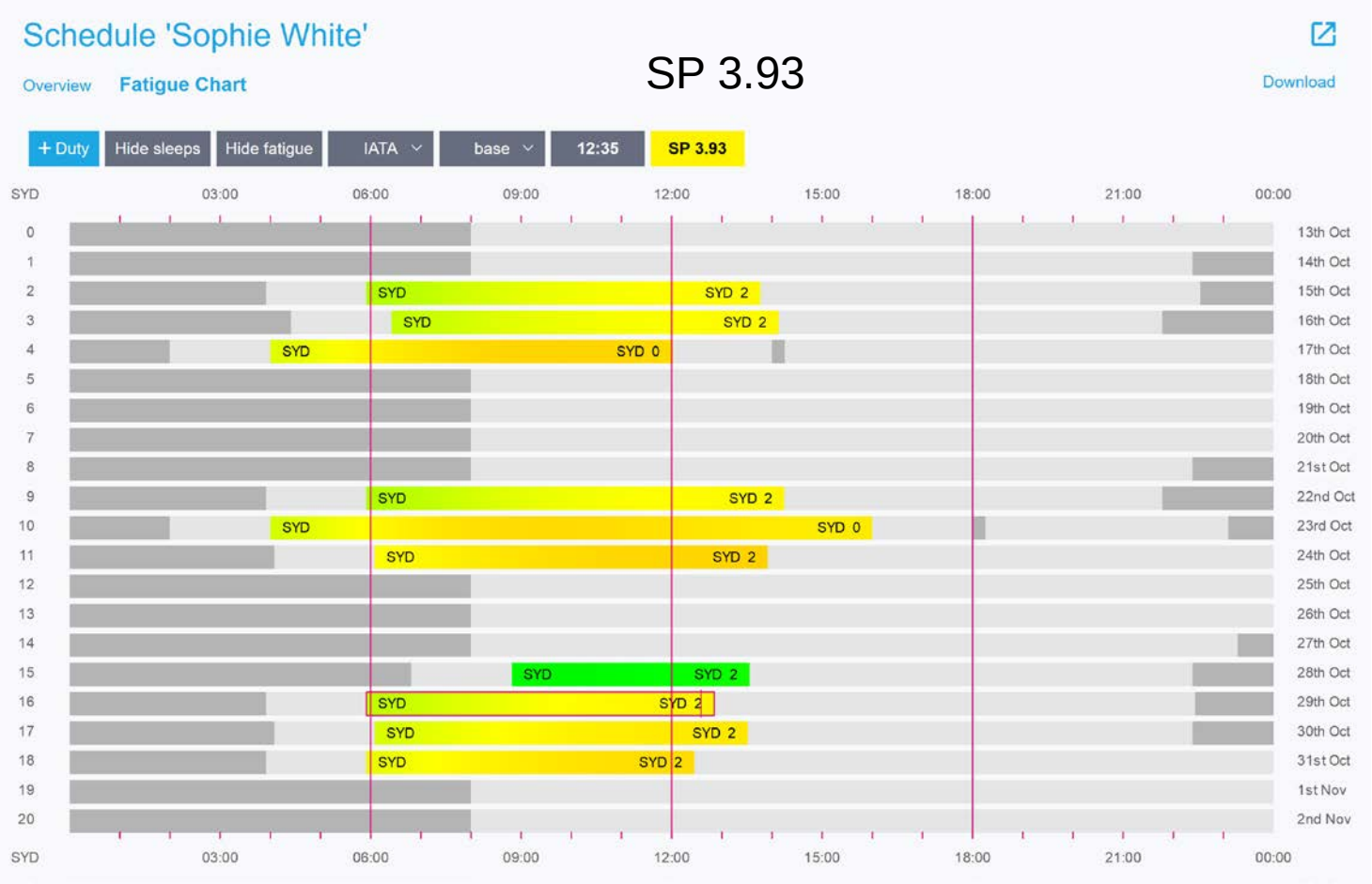
schedule

Reference	On Duty Date	On Duty Time	Start Airport	Off Duty Date	Off Duty Time	End Airport	Sectors	Crew Composition	Sleep Count	Sleep Order	Sleep Class	Home Base	Timezone
Sophie White	14/10/2013	18:55	SYD/YSSY	15/10/2013	02:46	SYD/YSSY	2	9	0	0	0	SYD/YSSY	0
Sophie White	15/10/2013	19:25	SYD/YSSY	16/10/2013	03:08	SYD/YSSY	2	9	0	0	0	SYD/YSSY	0
Sophie White	16/10/2013	17:00	SYD/YSSY	17/10/2013	01:00	SYD/YSSY	0	9	0	0	0	SYD/YSSY	0
Sophie White	21/10/2013	18:55	SYD/YSSY	22/10/2013	03:15	SYD/YSSY	2	9	0	0	0	SYD/YSSY	0
Sophie White	22/10/2013	17:00	SYD/YSSY	23/10/2013	05:00	SYD/YSSY	0	9	0	0	0	SYD/YSSY	0
Sophie White	23/10/2013	19:05	SYD/YSSY	24/10/2013	02:55	SYD/YSSY	2	9	0	0	0	SYD/YSSY	0
Sophie White	27/10/2013	21:49	SYD/YSSY	28/10/2013	02:33	SYD/YSSY	2	9	0	0	0	SYD/YSSY	0
Sophie White	28/10/2013	18:55	SYD/YSSY	29/10/2013	01:51	SYD/YSSY	2	9	0	0	0	SYD/YSSY	0
Sophie White	29/10/2013	19:05	SYD/YSSY	30/10/2013	02:31	SYD/YSSY	2	9	0	0	0	SYD/YSSY	0
Sophie White	30/10/2013	18:55	SYD/YSSY	31/10/2013	01:27	SYD/YSSY	2	9	0	0	0	SYD/YSSY	0

Flight Attendant Sophie White

analysis

Planned schedule
For 29 October



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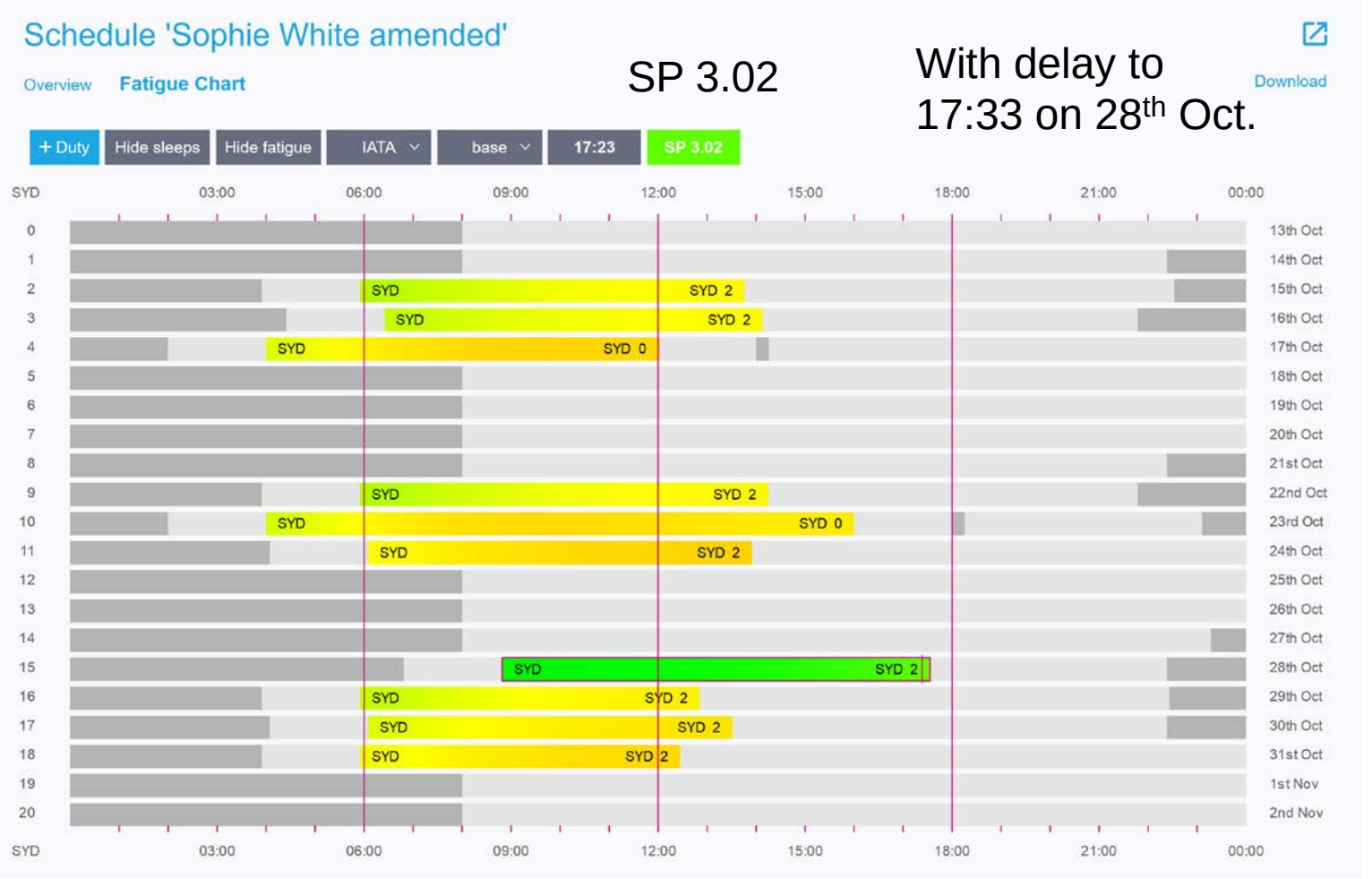
Flight Attendant Sophie White

analysis



SP 3.02

With delay to 17:33 on 28th Oct.

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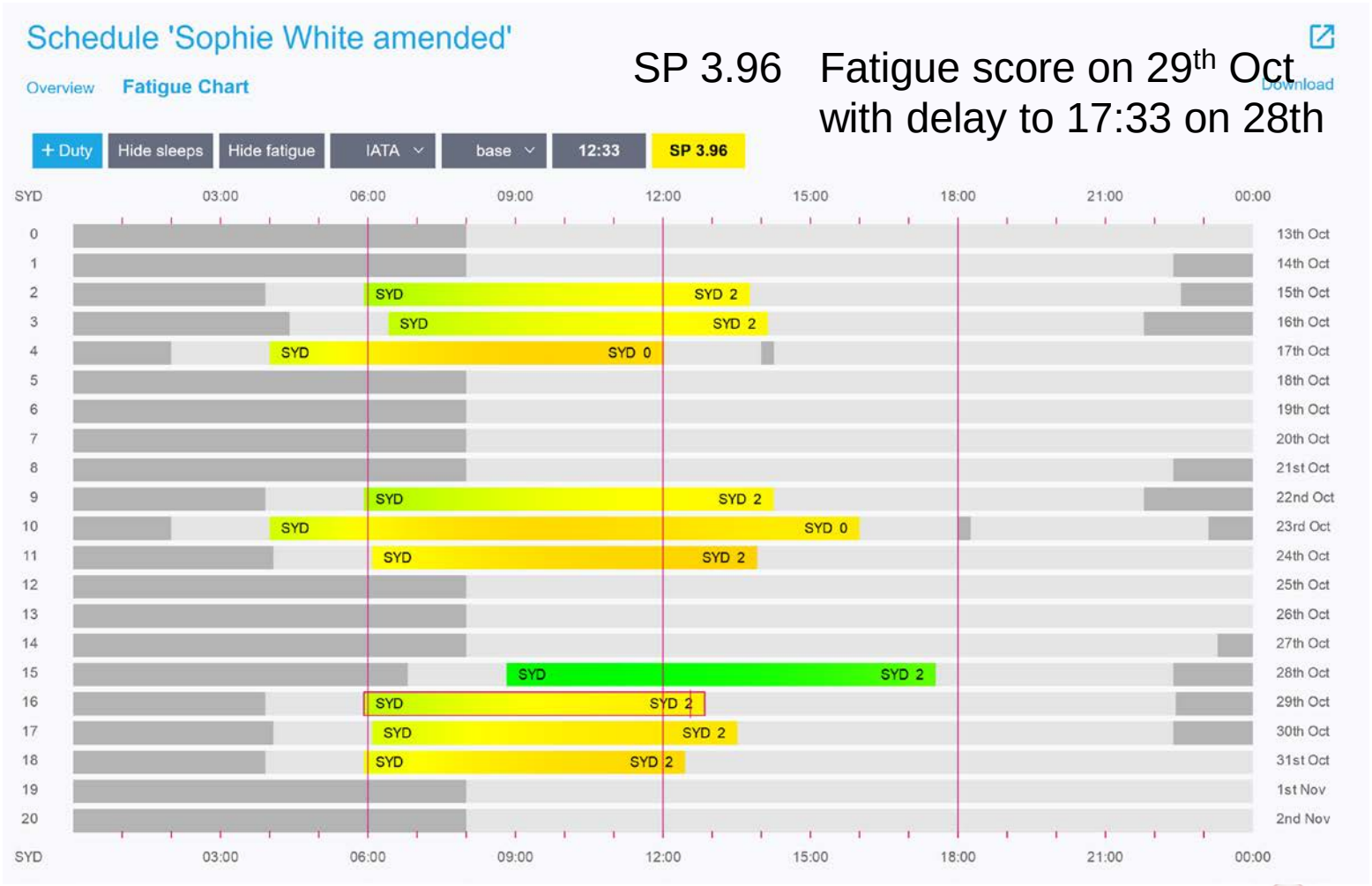
Flight Attendant Sophie White

analysis



SP 3.96 Fatigue score on 29th Oct with delay to 17:33 on 28th

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4. SETTING REGULATIONS/INTERNAL LIMITS

Examining the impact of changes to the regulations for *Ruritania CAA*

- *Ruritania CAA* proposes 10h FDP at night beginning at 23.00h with up to 3 sectors
- *Alert Air* proposes 11h FDP beginning at 23.00h with up to 8 sectors

Ruritania CAA:
10h FDP 3 sectors beginning 23:00h

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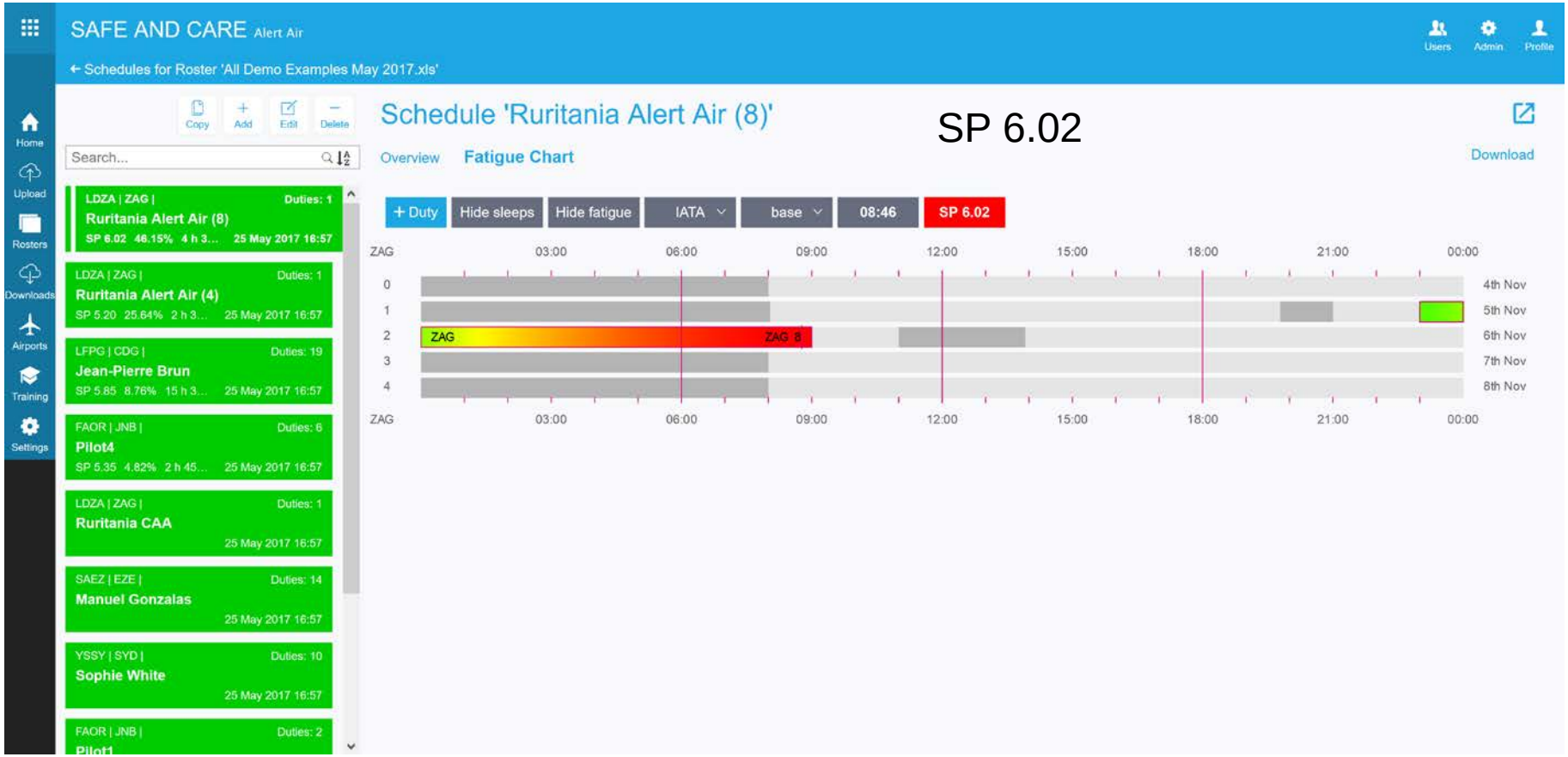
Alert Air:
11h FDP 8 sectors beginning at 23:00



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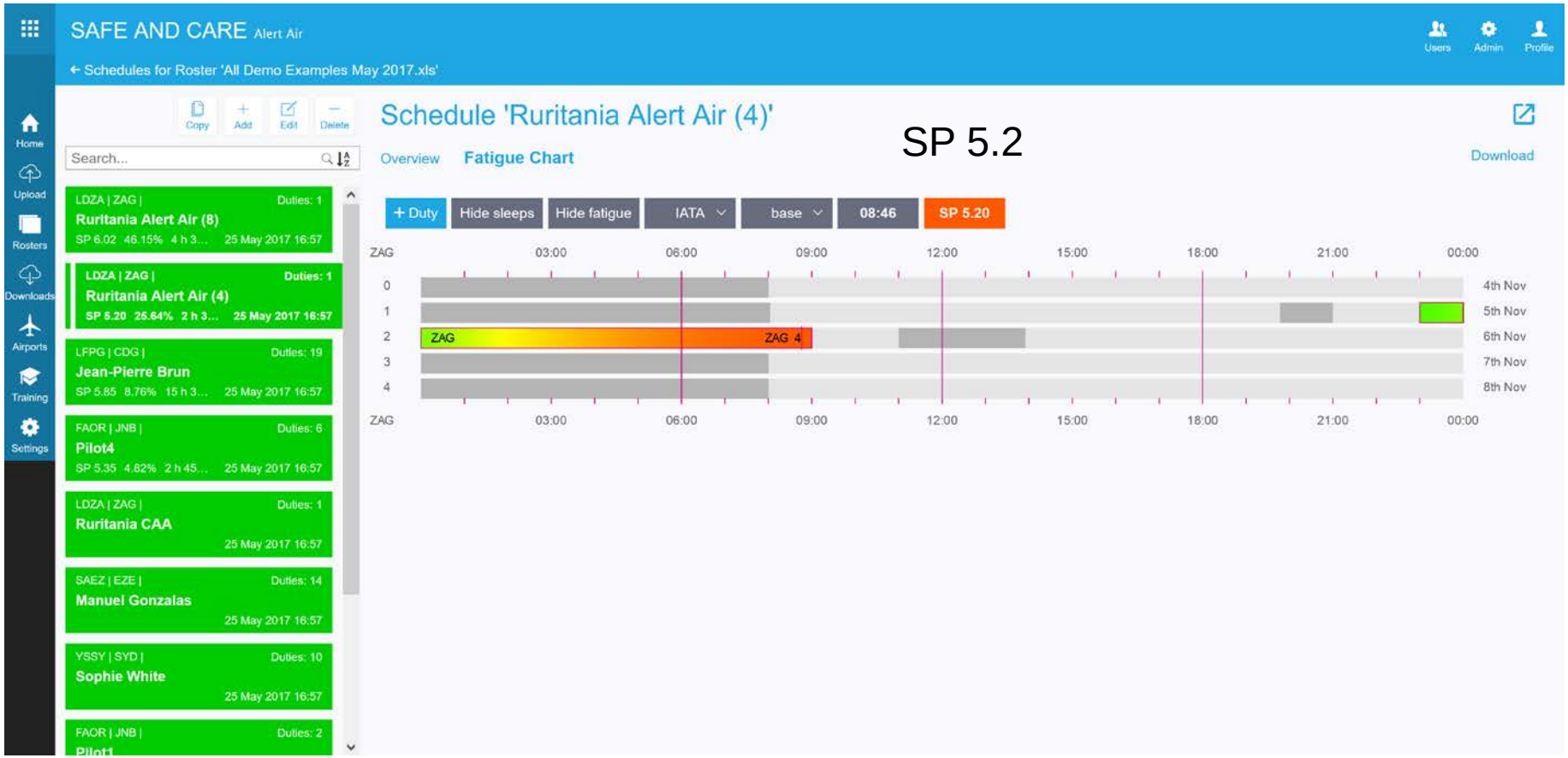
Alert Air:
11h FDP 4 sectors beginning at 23:00



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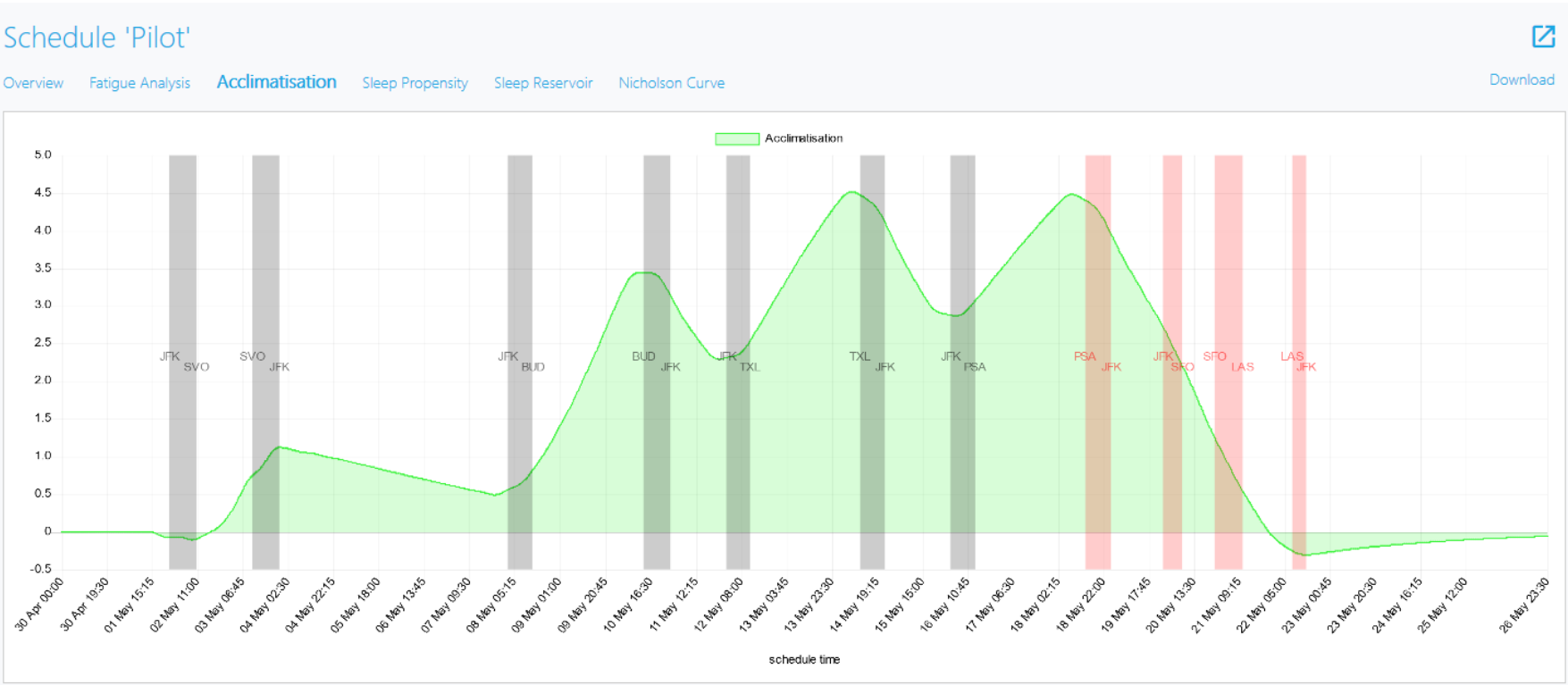
Acclimatisation Curve



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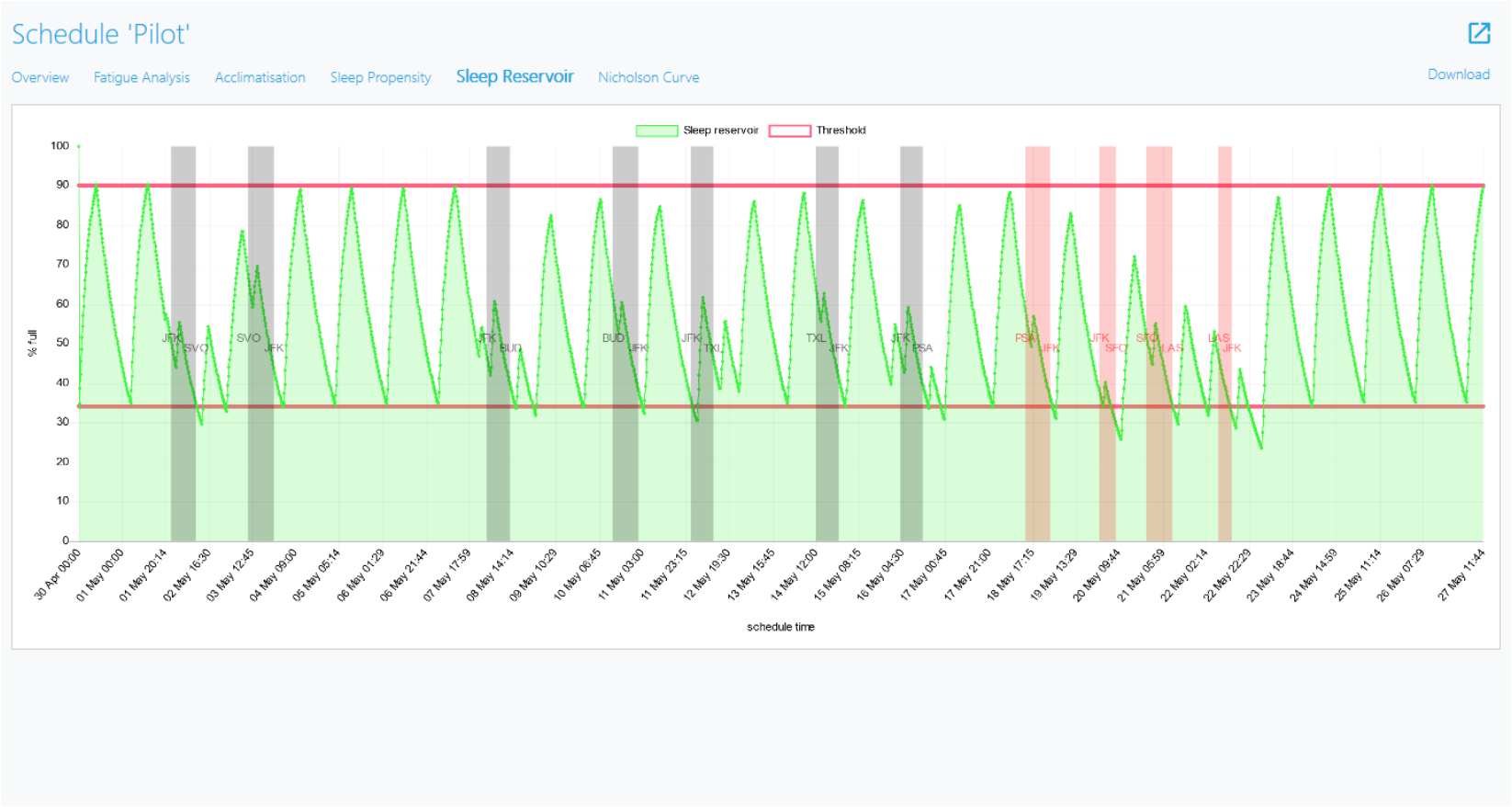
Sleep Reservoir Curve



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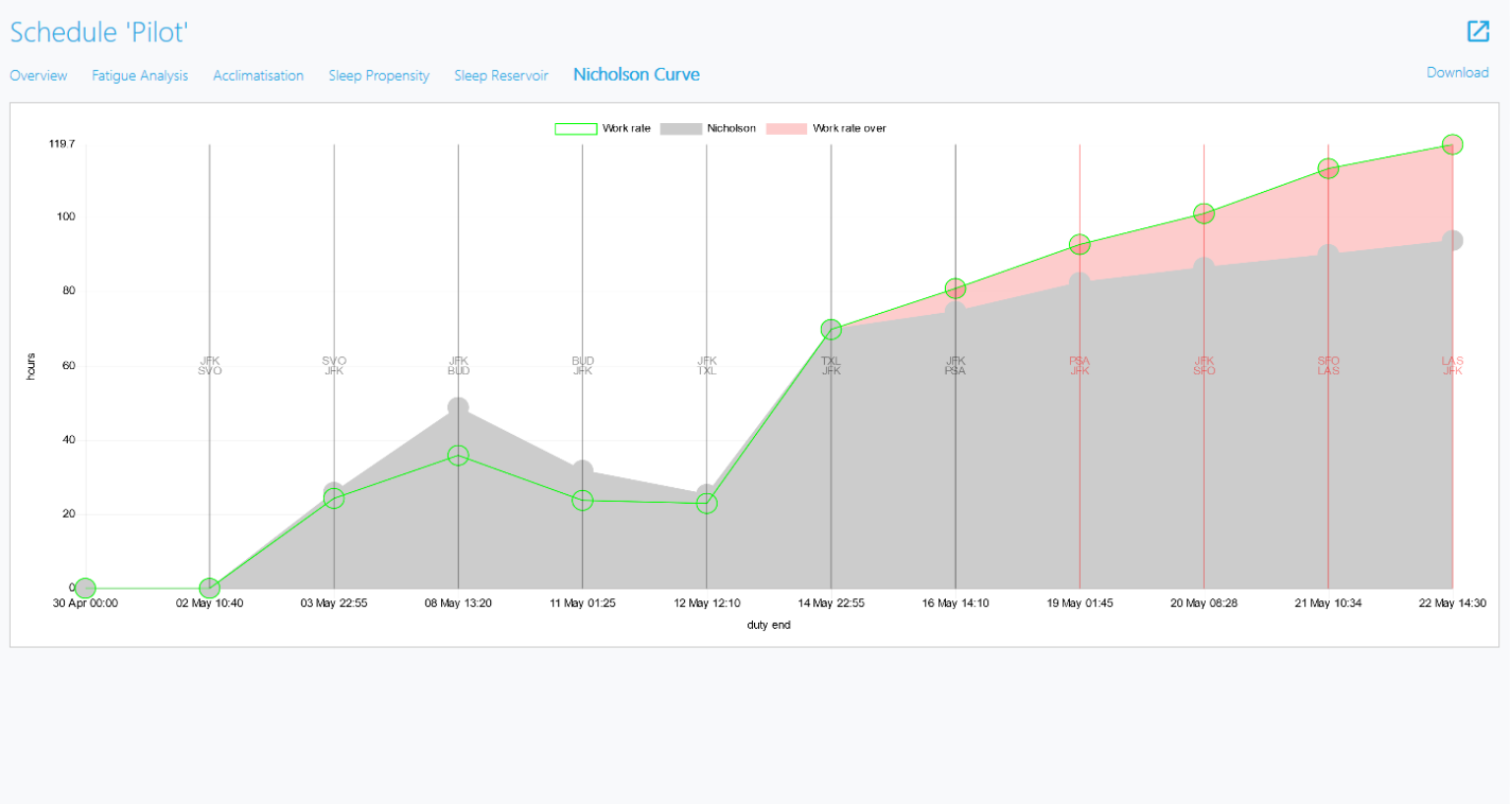
Nicholson Curve



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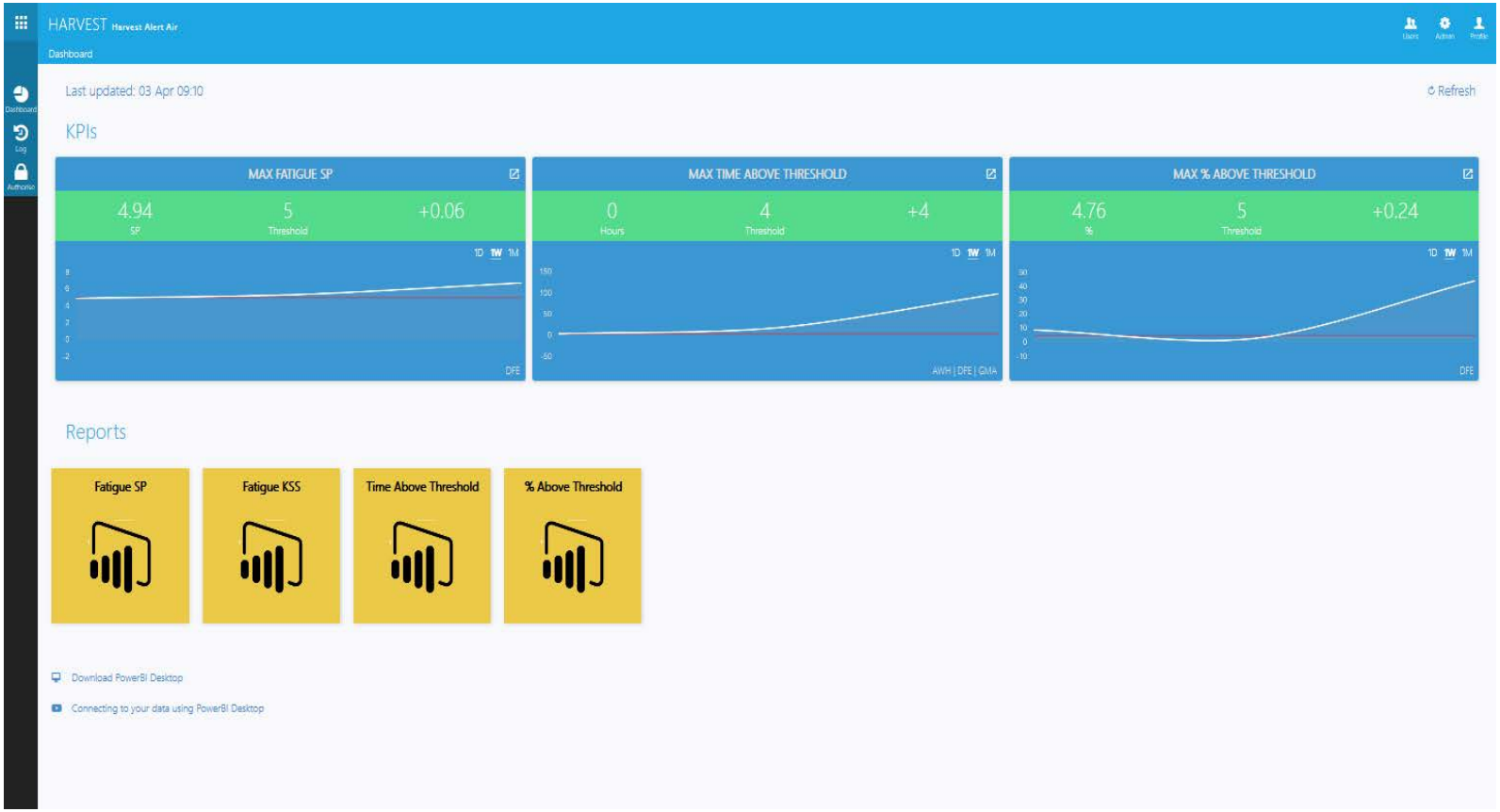
HARVEST – an analytics dashboard



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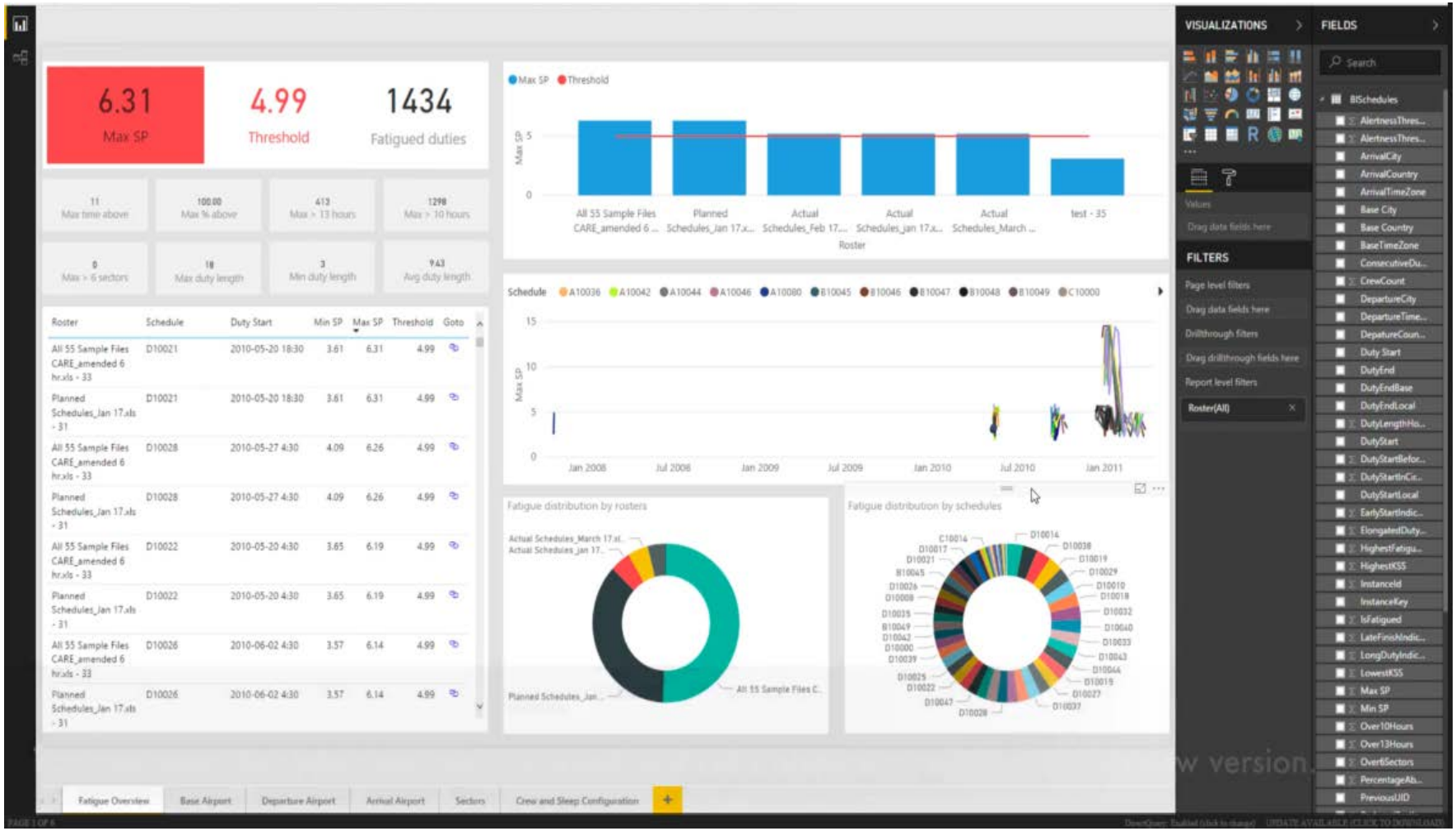
Max fatigue score report

Overview



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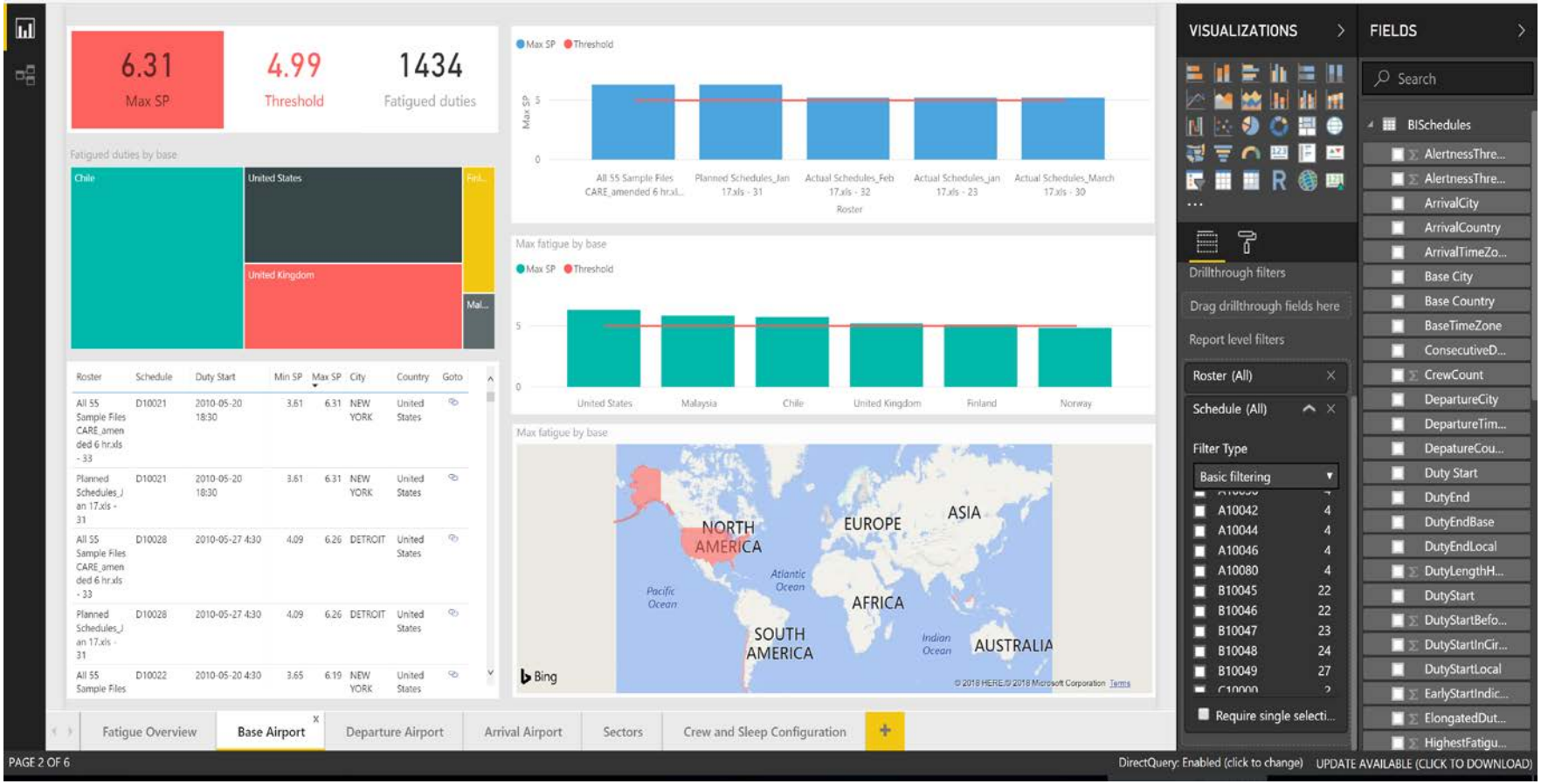
Max fatigue score report

Base Airport



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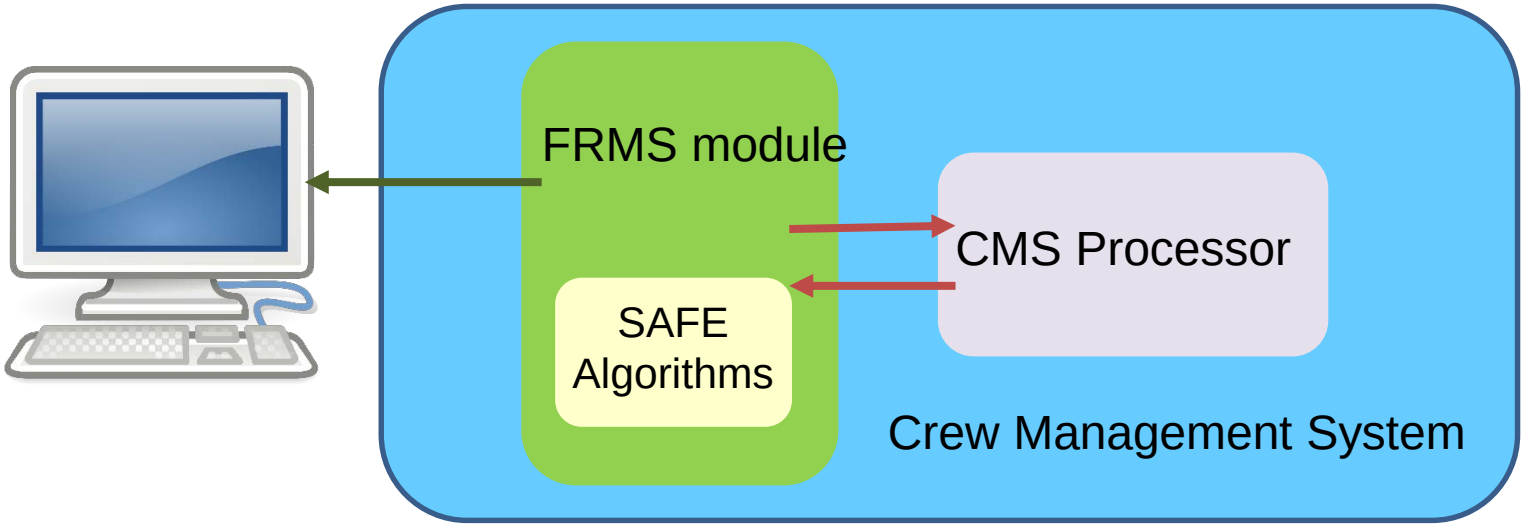
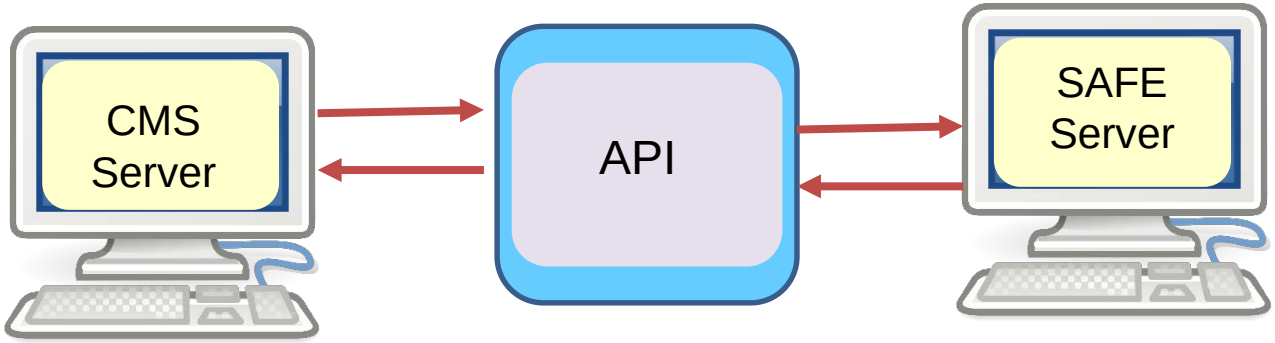
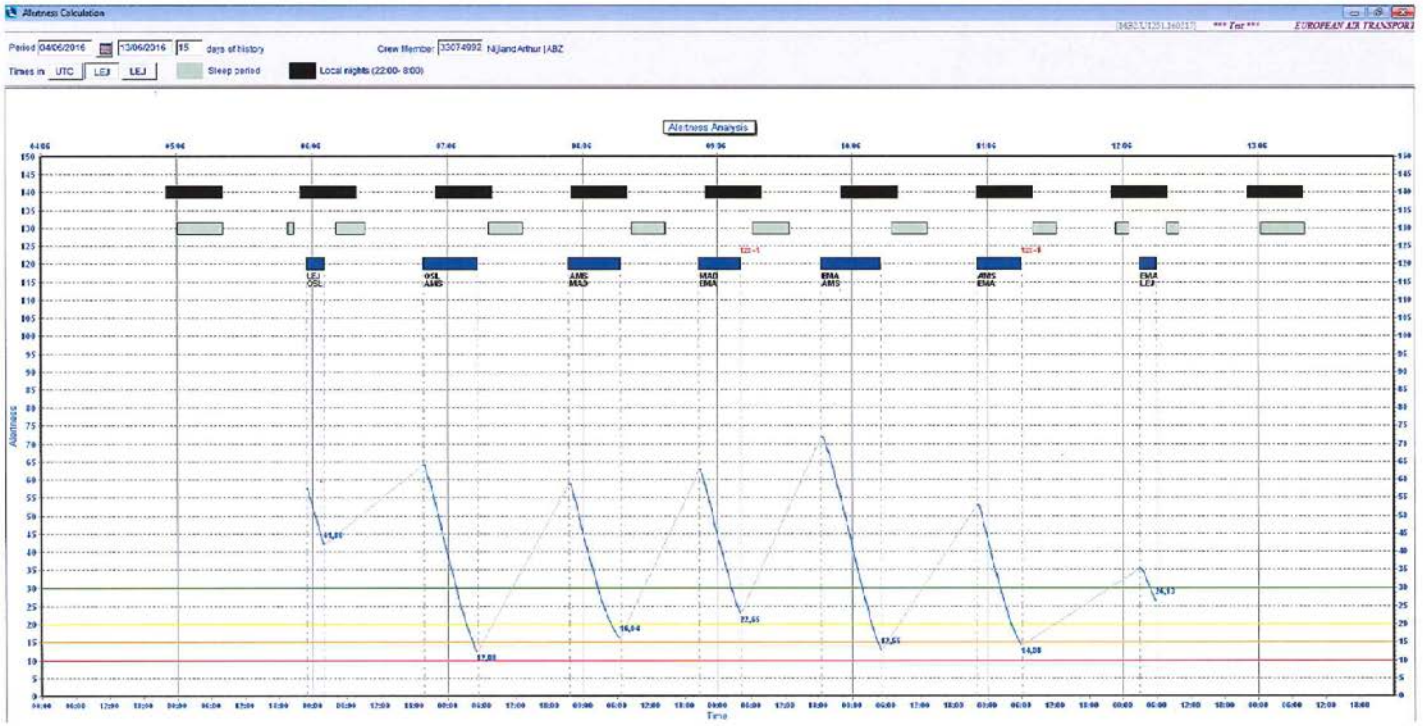
API and Embedding the Algorithm Library in Crew Management Systems





Typical display from a rostering suite



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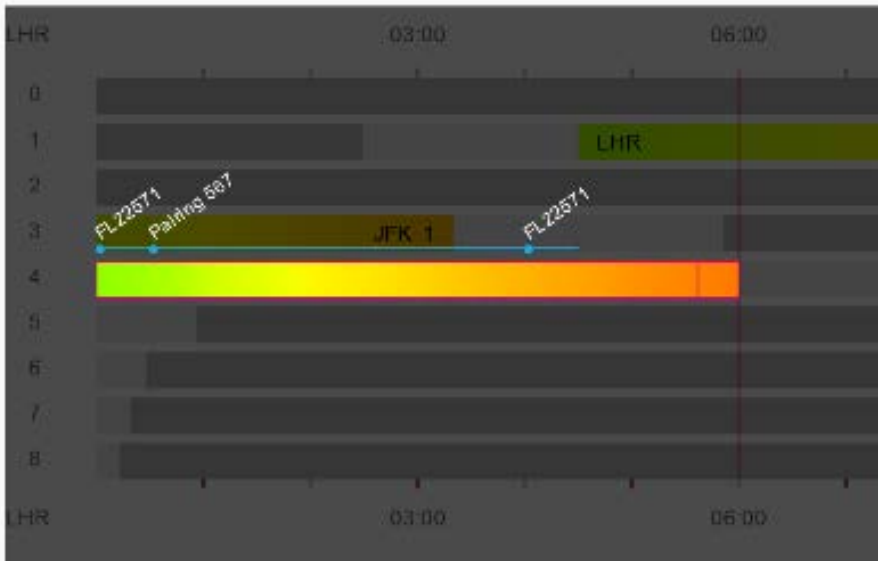
Future developments

New Features

- Choice of method of acclimatisation
- Variability of workload
- Variability of sleep assumptions
- Increased granularity of duty activities



New models

- App for on-demand operations (fit to fly?)
- Business Jet/ Air Taxi/ EMS/Corporate Jet model
- Air Traffic Control Model
- Ground crew/ Maintenance Engineers model
- Rotary wing model

Typical client reactions when first using a bio-mathematical model

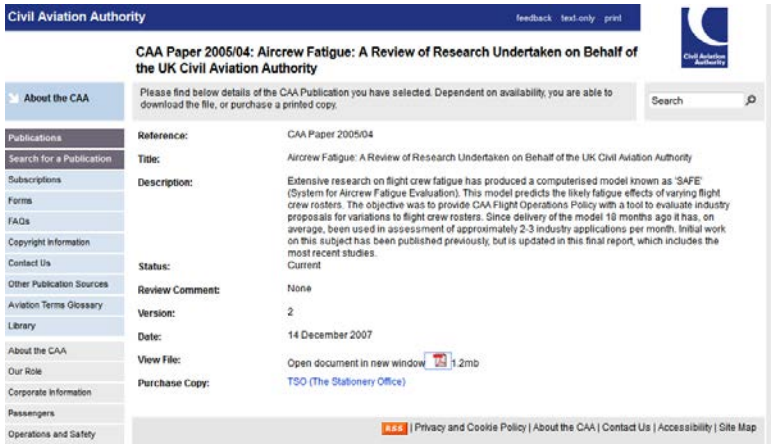
- “Can you change the algorithms to fit our operation?”
- “Your software does not work. It shows too many high scores”
- “I need to have the fatigue scores at the beginning and end of every flight in every duty”
- “We plan for duties longer than 16 hours - up to 43 hours – but we allow for sleep periods. Can your model handle 43 hour duties?”
- “We want to analyse fatigue in terms of each flight and have minute by minute fatigue scores.”
- I need to consider the effects of light, caffeine, gender, chronotype…..

Summary

- Bio-mathematical models can be helpful to
  - identify and scope hazards on new or existing routes for the **AVERAGE** employee
  - Explore strategies for mitigation
  - Analyse fatigue reports
  - Assess likely fatigue with accidents and incidents
  - Interrogate the roster analytical dBase with add-ons such as HARVEST

Summary

- Ensure the model you choose
  - Is appropriate for the occupation
  - Is based on robust scientific research with objective datasets as well as subjective.
  - Is based on an adequate number of schedules
  - Covers cognitive fatigue as well as sleepiness



http://publicapps.caa.co.uk/docs/33/CAAPaper2005_04.pdf

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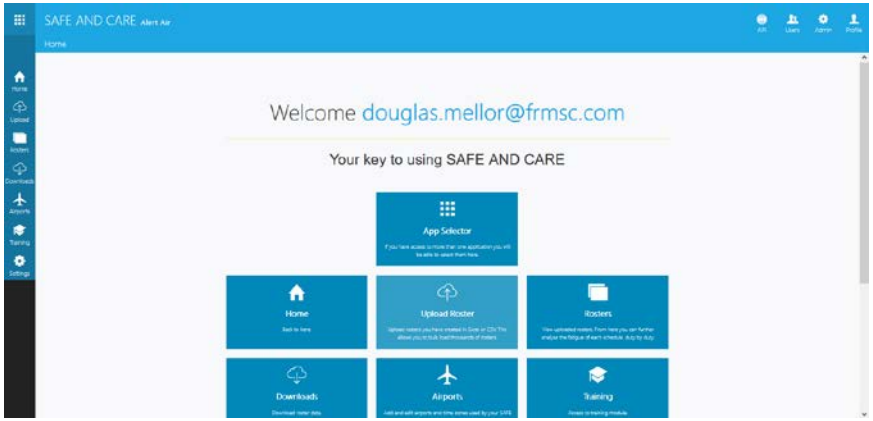
Summary

- **Bio-mathematical models are tools;** not decision making systems or an FRMS in itself

- Asking for maximum granularity in data or wanting to operate unrealistically long duties/short times between duties is not realistic.

- Using inappropriate, unvalidated scales or risk metrics and relying on insignificant mitigations will not help with any FRMS application



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Summary

- Biomathematical models can be very productive when connected to rostering suites for automatic creation of rosters with optimum fatigue levels

- In assessing an airline's schedules, they are indispensable as they are quick and inexpensive when relative to alternative methods of fatigue assessment.

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Thank You for Listening

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Managing Occupational Alertness Makes Good Business Sense

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