Predictive Schedule Analysis

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Pilot Fatigue Program

Starting Point

ICAO SAFETY

Scientific principles and knowledge

- The need for adequate sleep
- Sleep loss and recovery
- Circadian effects on sleep and performance;
- The contribution of workload
- The operational and organisational context

The Beginning - What we already have

- Always keeping the science in mind…..
- Must begin with reactive and proactive hazard identification before jumping into predictive analysis:
  - Self-reported fatigue risk from pilot group
  - Incidents/accidents
  - Survey results
  - Schedule analysis – planned vs actual times
  - Safety databases
  - Published scientific studies
  - Internal data collection

- Find <u>your</u> operational “hot spots”

Predictive Hazard Identification

- Operational Experience
- Results of Reactive/Proactive Analysis
- Review of Individual Pairings
- Review Optimization Parameters
- Review of Combinations of Pairings
- Bio-Mathematical Modeling
- Creating Rules to Prevent Increased Risk

Bio-Mathematical Modeling

- Only Half of the Equation

- MUST have a thorough understanding of limitations
- Used as a common tool for predictive fatigue identification
- Current models predict averages, not individual situations
- Does not predict fatigue risk in specific operational environments
- Predictions from modeling must be validated within the operational environment from proactive analysis results
  - Actigraphy, PVT, Sleep Diaries, Operational Data, Surveys
- Use of modeling with other tools available to continuously improve proactive schedule review

Apply Science to the Other Half of the Equation

- **Additional factors must be considered when managing pairings (examples):**
  - Dynamics of sleep loss and recovery – (layover timing)
  - Circadian biological clock – (pilot base or acclimated time)
  - Impact of workload on fatigue – (pairing characteristics -number of segments, flight time, NOTAMS, weather, airport construction)
  - Additional requirements – (training, special airport qualifications)
  - Existing operational requirements - (unaugmented vs. augmented)
  - Availability of additional mitigations (sleep room, crew paired with airplane)

Tritschler 2015

- 2015 Implementation Guide for Operators
- This type of methodology may be used:
  - to identify the causes of fatigue associated with a single duty / type of shift
  - to give a single duty or type of shift a specific and comparable “fatigue value”
  - to identify effective mitigations for a single duty / type of shift (part of the risk mitigation process)
  - to be able to compare the same trip or tasks undertaken at different times
- Categorized into factors associated with increased fatigue:
  1. sleep loss
  2. extended wakefulness
  3. circadian influences
  4. workload

Tritschler, T. (2015) Fatigue Risk Assessment Methodologies.

Type of Shift/Specific Duty: CGN-TFS-CGN: Check in 1600LT, Checkout 0300LT; FDT: 11:00h				
	Fatigue Factor:	Worst Case:	Mitigated	Comments:
Sleep debt	Previous night sleep ** reduced < 4h (night: 22-08LT)	1**	1**	Not relevant if 1st duty day
	Previous night sleep ** reduced > 4h	1**	0	Avoid previous day checkout after midnight
	Reduced night sleep > 4h before previous night ***	1***	0	Avoid any previous day checkout after midnight
	Previous "night duty"** (day sleep only)**	1**	0	Avoid any previous day checkout after midnight
Wakefulness	Time since awake > 2h prior C/I*	1	1	
	Time since awake > 6h prior C/I*	1	(1)	Recommend nap before duty
	Time on task > 10h (FDT)	1	1	FDT > 10h at night (!)
	Time on task > 12h < 14h (FDT)	--	--	
Circadian Factors	Circadian disruption > 4h **	1	0	Previous duties shall be late duties
	Flight after 2300LT or last landing during darkness	1	1	
	Flight time <2h during WOCL	1	1	
	Flight time > 2 h during WOCL	--	--	
Workload	3 or 4 consecutive flights/sectors	--	--	
	5 or 6 flights / or 3 flights during night	--	--	
	Known hassles	--	--	
	Training flights	1	0	Avoid training on this duty
Sum of fatigue factors		11	6	

Assessment of fatigue factors:

- 0-3 relevant factors: accept
- 4-6 relevant factors: check
- 7-9 relevant factors: mitigate
- >10 relevant factors: not acceptable

* Crew member's responsibility

** Depending on preceding duty

*** The night before, 2 consecutive nights are relevant

Note. Factors are not fully weighted! Most important factors are sleep debt, wakefulness, circadian factors then workload, in this order.

Figure 5-4. Example Fatigue Factor Assessment and Mitigation Table

Tritschler, T. (2015) Fatigue Risk Assessment Methodologies.

Table 5-5. Example Categories for Assessment of Fatigue Factor Scores under Existing Conditions (Step 1)

Assessment of Fatigue Factors under Existing Conditions (Step 1):		
Relevant factors	Acceptability	Action
0-3	Accept	No mitigation required
4-6	Check	Identify mitigations to reduce relevant fatigue factors
7-9	Mitigate	Identify mitigations to reduce the remaining fatigue factors to the minimum
> 9	Not Acceptable	Identify mitigations to reduce the remaining fatigue factors to an acceptable minimum. If not possible this duty is not permissible

Table 5-6. Example Categories for Acceptability of Fatigue Factor Scores after Mitigating Actions (Step 2)

Acceptability of Fatigue Factors after Mitigating Actions (Step 2):		
Relevant factors	Fatigue Impairment	Acceptability
0-3	Low	Acceptable, no further mitigation required
4-6	Increased	Acceptable, but keep remaining fatigue factors as low as reasonably practicable. Monitor operation
7-9	Significant	Acceptable if remaining fatigue factors are kept at the minimum (all avoidable fatigue factors are avoided). The number of times this duty can be scheduled is limited per crew member per time-period. Monitoring of this work period required
> 9	High	Not acceptable

Table 5-7. Example Risk Assessment Matrix for Cumulative Fatigue

Frequency of Exposure per Crew Member per Working Period (week)				
Relevant fatigue factors	May be scheduled every day	May be scheduled twice per week	May be scheduled once per week	Unexpected circumstances
0-3	low	low	low	low
4-6	moderate	moderate	low	low
7-9	high	moderate	moderate	moderate
> 9	high	high	high	high

Tritschler, T. (2015) Fatigue Risk Assessment Methodologies.

Operational SPIs

- Create your own Safety Performance Indicators
- Derived from data that you already routinely collect
- Reflective of the specific causes of fatigue risk in different operations
- Supported by scientific knowledge and fundamentals

- Creation of “the Mangie list”

Science Behind SPIs

Pairing Risk Name	Scientific Intent
Special Airports	Additional workload associated with these airports may increase fatigue. Pilots need to be fully rested for best performance through additional challenges
Multiple Time Zone Crossing	Sleep may be disrupted if the circadian master clock is not fully synchronized to local time. Pilots often split sleep - some during local night and some during biological night.
Late Release Time	Duty overlaps biological night and therefore restricts sleep opportunity. Later landings can occur during the WOCL.
Early Start Time	Duty overlaps biological night and therefore restricts sleep opportunity. Earlier take-offs may occur during the WOCL.
Domestic Rotation Limits	This limits the risk of greater sleep debt accruing over longer rotations.
Multiple Ocean Crossing	Long sequences of back-to-back transmeridian flights can cause circadian drift (circadian master clock cannot synchronise to any time zone and adopts a period longer than 24 h). This contributes to sleep disruption and cumulative sleep debt.
Execute Table B C Limits	Scheduling to within 1 h of the FDP limits gives limited room for unforeseen delays that can lead to schedule changes and/or reduced rest breaks.
Execute Table B Limits Consecutive Days	This limits the likelihood of sequential schedule disruptions and break reductions.
Degrees Crossing Direction	Eastward flights across at least 4 time zones can result in major circadian desynchrony as some rhythms adapt by shifting eastward and others by doing the inverse adaptation westward (e.g., 4 h west versus 16 h east). In general, adaptation is slower after eastward than westward flights crossing the same number of time zones.

Science Behind SPIs

Pairing Risk Name	Scientific Intent
Execute Table B Limits Last Rotation	At the beginning of the last FDP, pilots will be affected by any fatigue already accumulated across the rotation.
Execute Table B Limits Min Layover Both Ends	A short layover (less than 10h 30min) increases the likelihood of sleep restriction (the amount of sleep obtained will depend how much the short layover overlaps with biological night). A long FDP adds additional risk of fatigue, so this combination should not be followed by a second short layover.
Late Arrivals To Early Report	The late release time restricts sleep opportunity and so should not be followed by a duty period that further restricts sleep opportunity and requires working though the WOCL.
Minimum Rest	Limiting minimum rest helps ensure an adequate opportunity for recovery sleep (the amount of sleep obtained will depend how much the layover overlaps with biological night).
Day Layover Encompass	More time is required to obtain adequate sleep during a daytime layover (assuming that the pilot's circadian master clock is on local time).
Excessive Sit Time In FDP	Long sit times contribute to long FDPs and are reported by some pilots to add to fatigue.
Max Sectors In FDP	The workload associated with each take-off and landing adds to cumulative fatigue across an FDP.
WOCL Intrusion	The 4-hour window allows for differences between morning-types and evening-types in the precise timing of the WOCL. It also takes into account the finding from lab studies that poorest performance tends to be just after the WOCL.
Red Eye Check	Flights meeting this definition of red eye will entail considerable sleep restriction before and/or after the FDP and continue through the WOCL.

Creation of Mitigations

- Adjust optimizer rules or create new rules
- Pairing construction
- Hotel location/facility adjustments
- Creation of new policies and procedures
- Improvement of crew rest facilities on aircraft or in crew base
- Augmentation when not required under regulation
- Review and adjust regulatory and labor requirements

Thank you for your attention