

Shift Work, Sleep, Health, Safety, and Solutions

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Outline

Defining shift work

Shift work, sleep, health, and safety

Shift work and fatigue

Beyond roster management – Fatigue Risk Management Systems (FRMS)

Conclusions



Defining Shift Work

- No agreed description of rosters:
 - shift start times, durations, and end times;
 - **number of shifts before a break \geq 24 hrs;**
 - frequency and duration of breaks during shifts;
 - frequency and duration of breaks between shifts;
 - rotation
 - getting earlier (backward rotation), getting later (forward rotation), speed of rotation
 - **don't rotate (fixed shifts)**

any work pattern that requires an individual to be awake when they would normally be asleep



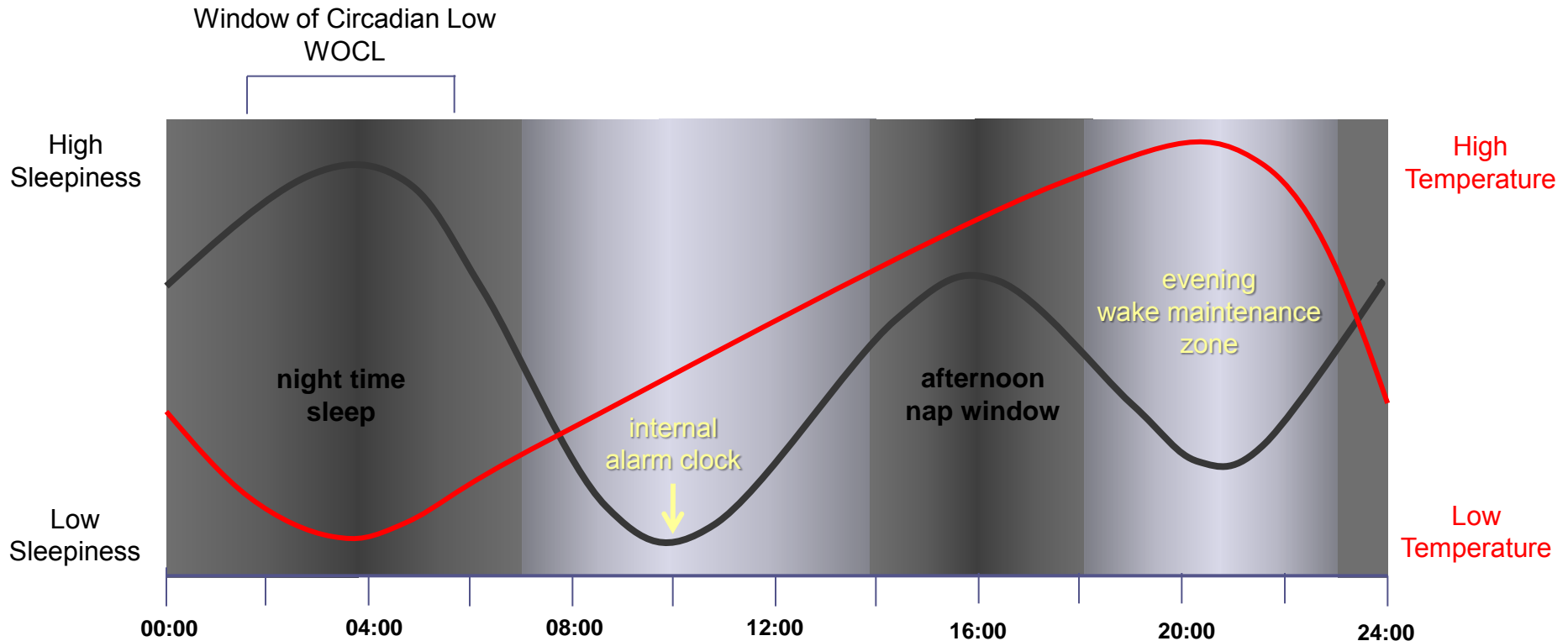


Work and Sleep in Collision

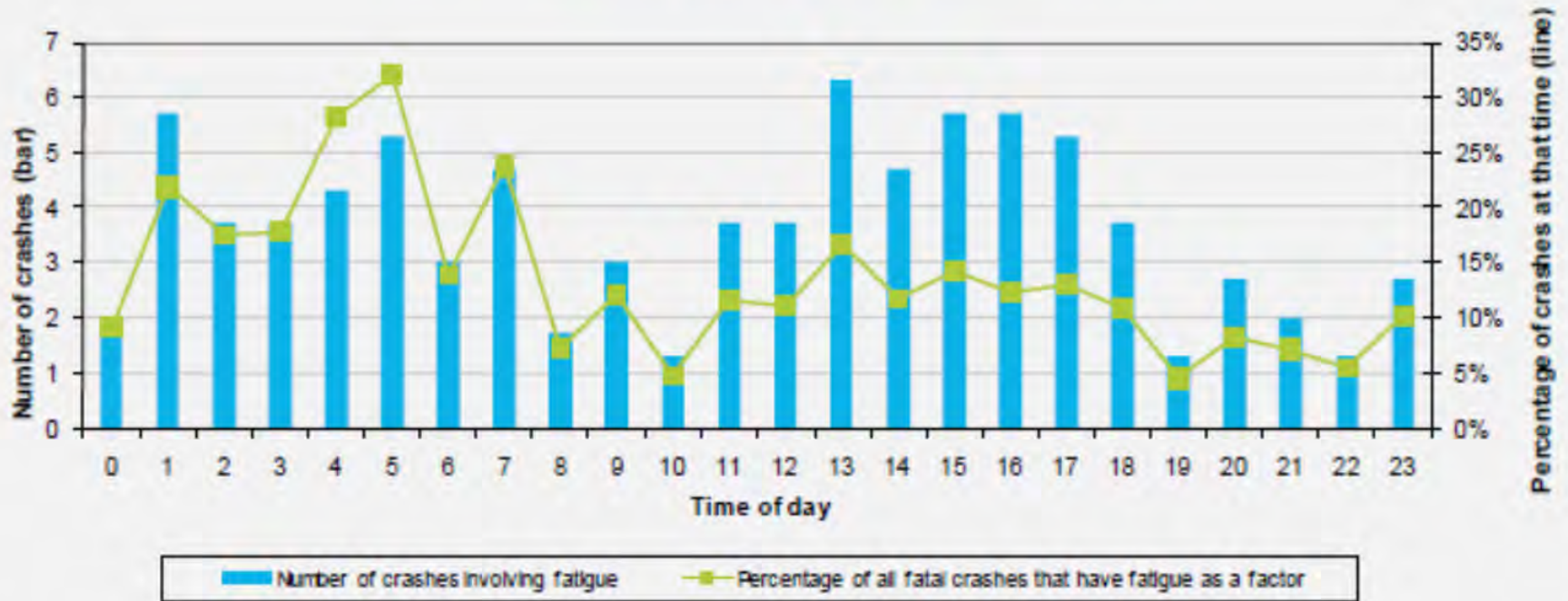
- Circadian body clock
 - Neural pacemaker (hypothalamus)
 - Daily rhythms in sleep propensity, performance, mood, ...
 - Light sensitive (retino-hypothalamic tract)
 - Locks on to day/night cycle
- Shift work
 - Sleeping at sub-optimal times
 - Cumulative sleep debt
 - Working at sub-optimal times
 - Increased risk of error
 - Increased sensitivity to other hazards?



Biological 'Windows' for Sleep



Fatal crashes with driver fatigue as a factor by time of day
(annual average 2005–2010)



Source: <http://www.transport.govt.nz/research/Fatigue/>

Sleep Restriction & Recovery

- Effects of restricted sleep are:
 - cumulative
 - dose-dependent
- Restricted sleep leads to:
 - feeling sleepier, irritability, degraded alertness, slower reaction times, poorer coordination, slower thinking, loss of situation awareness, less creative problem-solving
 - uncontrolled sleep
 - sleepiness → microsleeps → established sleep
- Recovery is not hour-for-hour:
 - deeper, more consolidated sleep on 1st recovery night
 - recovery usually takes at least 2 nights of unrestricted sleep
 - 1st night – recover slow-wave sleep
 - 2nd night – recover REM
 - **≥ 2 full nights of sleep to recover waking function**



Shiftwork and Health

- Compared to day workers, shift workers have more
 - general health complaints
 - sleep problems
 - gastro-intestinal problems (peptic ulcer)
 - cardiovascular disease
 - mental health problems in some industries
 - menstrual cycle irregularities, miscarriages, pre-term births, low birth weight babies
 - increased risk of breast cancer and possibly colon cancer in women
- What causes this?
 - Circadian disruption and sleep loss?
 - Other stresses (domestic, social life, etc)

*Can these effects be avoided or reduced?
short term → long term*

Shift Work a Carcinogen?

- International Agency for Research on Cancer (IARC) (2007) conclusion, based on:
 - Limited evidence in humans for the carcinogenicity of shift-work that involves night work
 - Sufficient evidence in experimental animals for the carcinogenicity of light during the daily dark period (“biological night”)

Shift work that involves circadian disruption is probably carcinogenic to humans (Group 2A)

Shift Work Prevalence

- USA
 - Night work (regular start times 18:00 - 04:00), 4.25%
 - Early morning (regular start times 04:00 - 07:00), 12.4%
 - Afternoon/evening (regular start times 14:00 - 18:00), 4.3%
 - Rotating, 2.7%
 - Drake and Wright, 2011
- New Zealand
 - **Blood Donors' Health Study (rotating with/without nights, permanent nights, n=3,119/15,365) 21.2%**
 - Injury risk
 - rotating with nights - adjusted RR=1.9 (1.5-2.4)
 - rotating without nights - adjusted RR=1.8 (1.2-2.6)
 - **excessive sleepiness (ESS ≥ 10)** - adjusted RR= 1.34 (1.07–1.67)
 - Fransen et al., 2006

Shift Work and Fatigue

- Department of Labour (DOL) guidance:
 - does not define shift work
 - shift work causes fatigue which is a hazard that must be managed
- International Civil Aviation Organisation - fatigue is:
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 member's alertness and ability to safely operate an aircraft or perform safety related duties.

Manage the hazard

Fatigue in aviation accidents

Airline	Date	Probable Cause	Outcome
American International 808	1993	Impaired judgment, decision making and flying abilities due to fatigue	3 serious injuries
Korean Air 801	1997	Crew failure to prepare for/execute non-precision approach	228 fatalities 26 serious injuries
American Airlines 1420	1999	Flight crew failure to discontinue approach and ensure that spoilers had extended after touchdown. Contributing factor was the flight crew's impaired performance due to fatigue	11 fatalities 45 serious injuries
Federal Express 1478	2002	Crew failure to establish and maintain proper glide path at night. Fatigue was contributing factor	3 serious injuries
Corporate Airline	2004	Combination of fatigue related factors producing pilot error	13 fatalities 2 serious injuries
Shuttle America	2007	Fatigue contributing factor affecting ability to plan and monitor approach leading to runway overrun	No fatalities

Source: FAA Advisory Circular 120-100 Basics of Aviation Fatigue

CAUSE OF FATIGUE HAZARD	DOMESTIC SHORT HAUL	DOMESTIC NIGHT CARGO	LONG HAUL
Restricted sleep due to short rest breaks	X		
Restricted sleep due to early duty report times	X		
Multiple high workload periods across the duty day	X		
Multiple sectors	X	X	
High density airspace	X		
Long duty days	X		X
Extended wakefulness on duty days			X
High workload during circadian low		X	X
Shorter sleep periods at wrong phase in the circadian cycle		X	X
Circadian disruption (due to night work)		X	X
Split sleep patterns and short sleep episodes on layovers		X	X
Circadian disruption (due to crossing multiple time zones)			X
Circadian drift away from home time zone following extended trip patterns			X

Gander PH, Rosekind MR, Gregory KB (1998). Flight crew fatigue IV: a synthesis. *Aviation, Space and Environmental Medicine* 69 (9): B49-B60.

Changing Regulatory Approach

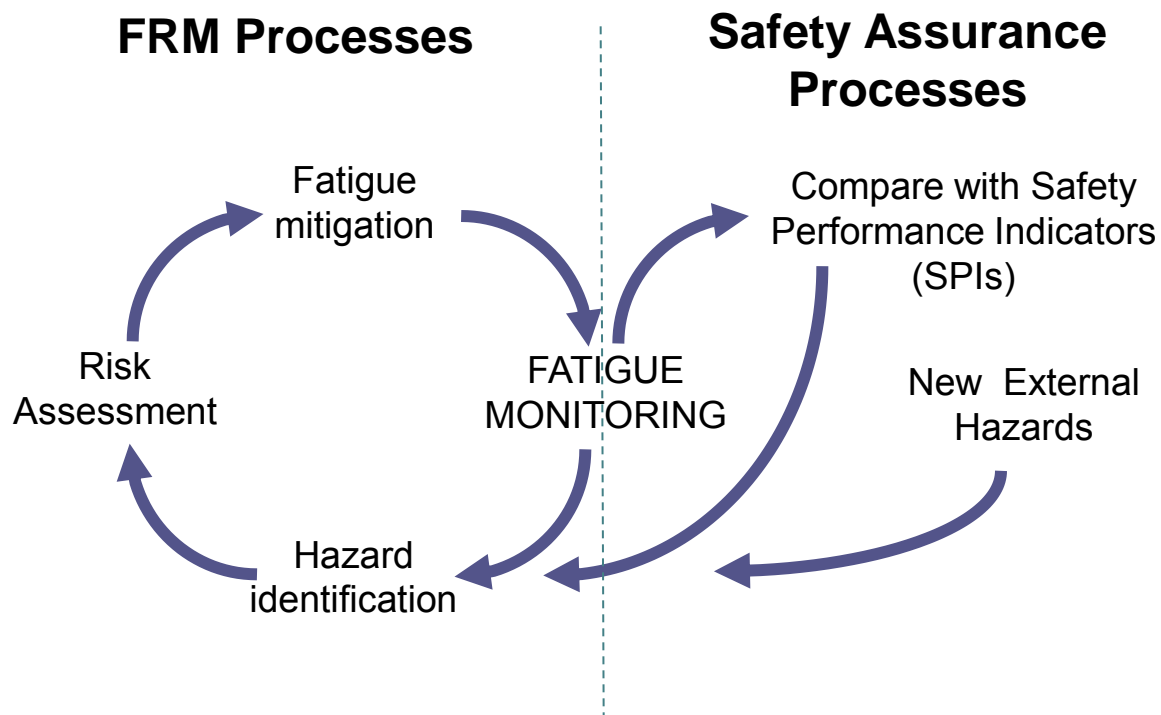


- Traditional regulatory approach - Flight and Duty Time Limits
 - Causes of fatigue – long hours, high or low workload
- New Regulatory Approach - Fatigue Risk Management Systems (FRMS)
 - New science (last 60 years)
 - Recovery = sleep (not just rest)
 - Circadian rhythms in work capacity, sleep propensity
 - Circadian clock locks onto the day/night cycle, hard to shift
 - Safety Management Systems
 - Ultra-long range (ULR) flight

Fatigue Risk Management Systems

- ICAO definition
 - *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.*
- Required components
 1. Policy and safety objectives
 2. Documentation
 3. Fatigue risk management processes
 4. Safety assurance processes
 5. Promotion processes

Data Driven FRMS



Operational SPIs: Examples

- Track data on number of:
 - exceedances of planned crew duty day (e.g. > 14 hrs)
 - flight duty periods ending > 30 mins later than scheduled
 - flight duty periods starting / ending within window of circadian low (WOCL)
 - reserve crew call-outs (on particular flights, at a particular crew base, etc)
- Crew fatigue reports

Monitoring for FRM processes

Monitoring for safety assurance processes



Crew Fatigue SPLs: Examples

- Fatigue status at start of duty
 - sleep in last 24 hrs
 - time awake
 - subjective sleepiness, fatigue ratings
 - performance on standard test(s)
- Fatigue status at top of descent (TOD)
 - in-flight sleep
 - time awake
 - subjective sleepiness, fatigue ratings
 - performance on standard test(s)



**Press this if you
are left-handed**

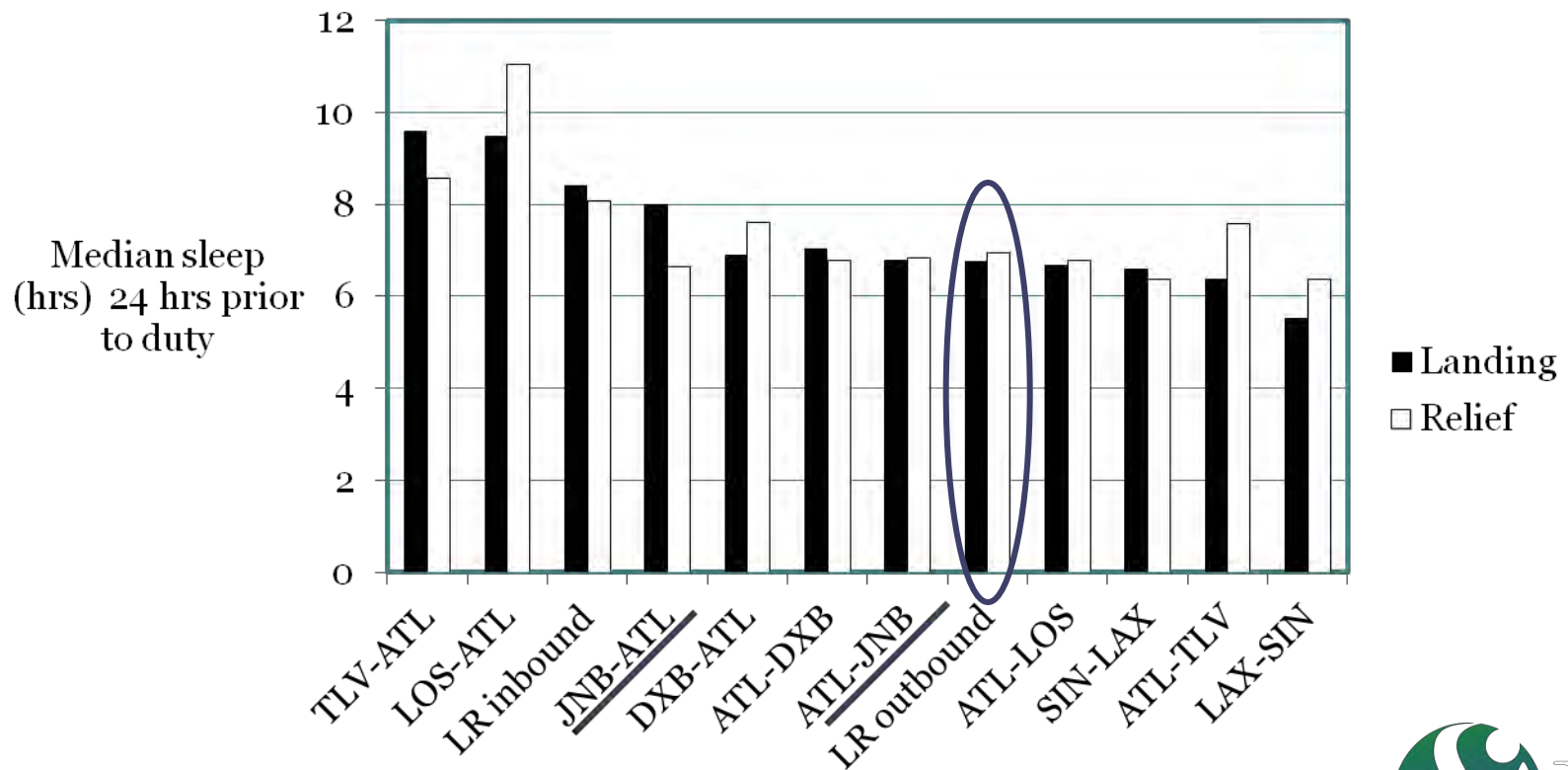
**Press this if you
are right-handed**



SLEEP~WAKE research centre
MOE TIKA~MOE PAI

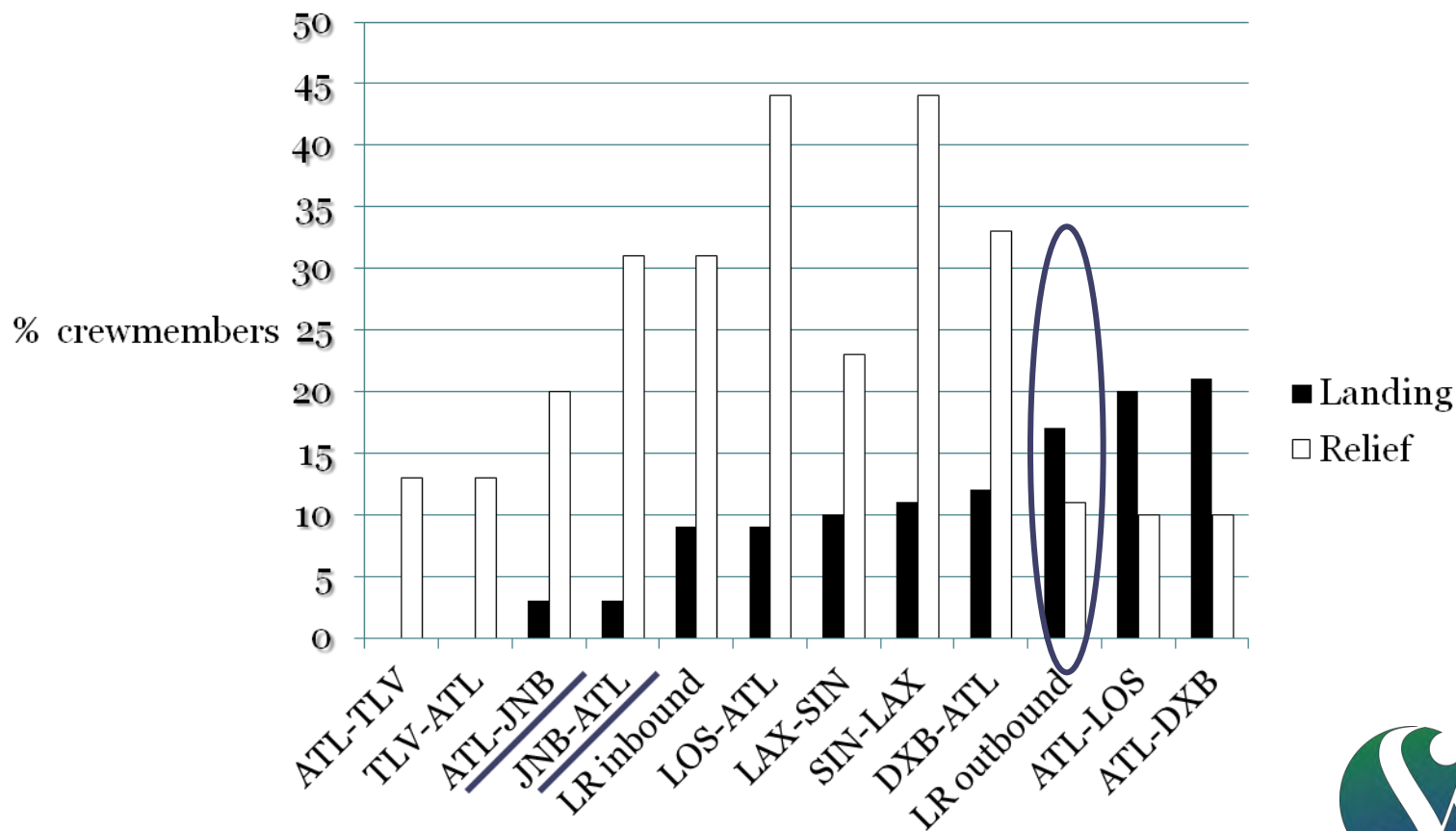
Fatigue Status at Start of Duty

SPI - sleep in the last 24 hrs



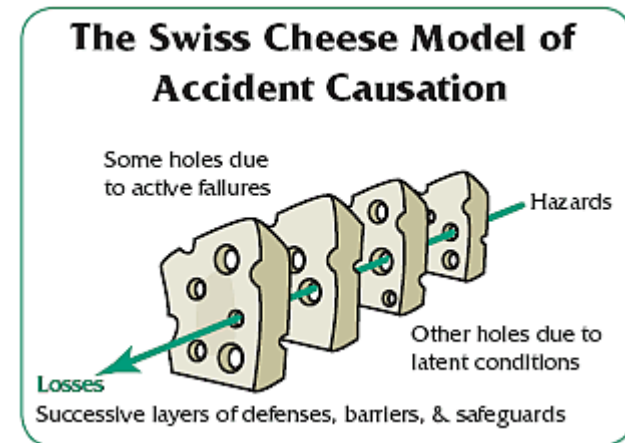
Fatigue Status at Top of Descent

SPI - % crew with KSS ≥ 7



What About Rostering?

1. FRMS policy and safety objectives
2. Documentation
3. FRMS processes
 - Identification of fatigue hazards
 - Predictive hazard identification
 - Evidence-based **rostering**
 - Proactive hazard identification
 - Reactive hazard identification
 - Risk assessment
 - Risk mitigation strategies
 - **Rostering**
 - Crew complement
 - On-board crew rest
 - Quality of layover hotels
 - Route-specific advice on sleep planning
 - **Education on personal coping strategies**
4. FRMS safety assurance processes
5. FRMS promotion processes



Conclusions

- Sleep is the ‘missing link’ for managing shift work and fatigue risk
- Shift work and fatigue management requires:
 - shared responsibility
 - involves factors at work and factors outside of work
 - fatigue is inevitable in 24-hr operations (no-blame)
 - a shared knowledge base
 - education/training on causes of fatigue, management strategies
 - workforce/management collaboration (ERA)
 - pooling expertise
 - clear communication, policies, and procedures
 - regulators with adequate knowledge and resources
 - collaborative partnership with companies



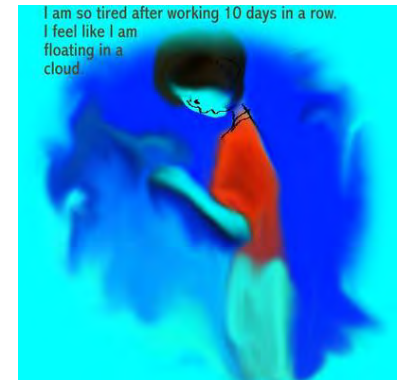
Questions?



Roster Design Principles

the perfect roster is permanent day work

- Managing sleep opportunities
 - how fast is sleep debt building up?
 - how long 2 full nights of sleep in a row?
- Managing risks at work
 - how tired are staff going to be on this shift?
 - how difficult are the work demands/conditions?
 - how long should they keep going?
- Getting people home safely
- Managing work/life balance
 - each person reacts differently
 - regular, predictable work patterns help time management
 - fair distribution of weekends off
 - staff input in roster design, management



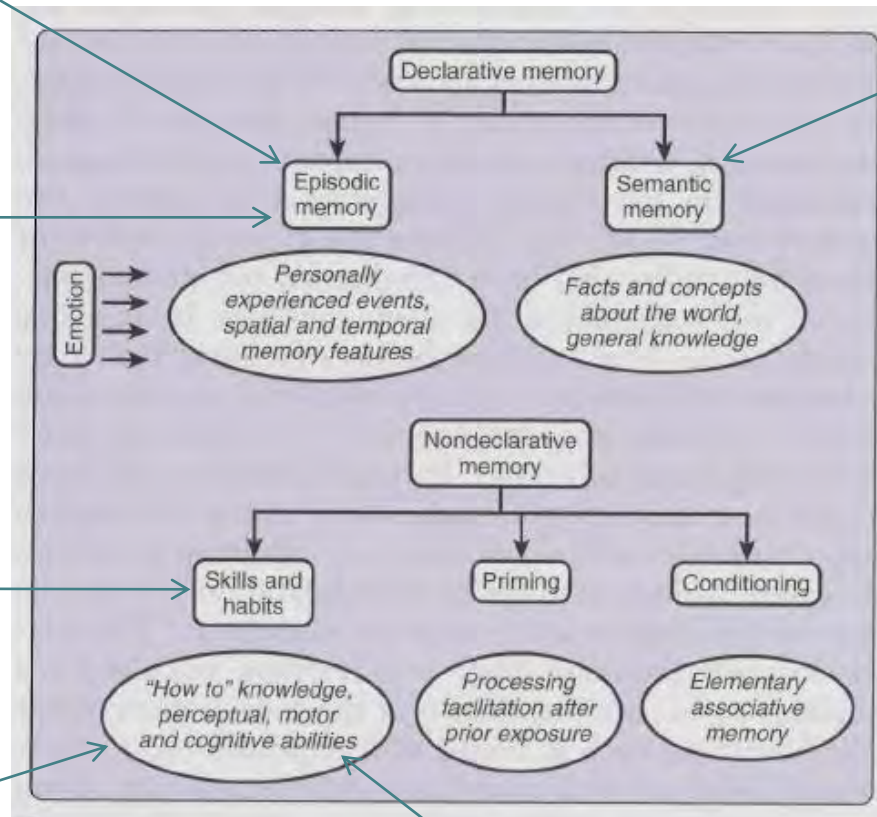
*family and social support are important
for coping with shift work*

Sleep and Memory Processing

Declarative learning associated with increased SWS, increased non-REM stage 2 (sleep spindles)

1 night's sleep deprivation inhibits long-term memory for verbal material

Emotional recall better after REM sleep



Learning improved by post-training sleep

Peigneux & Smith, Principles and Practice of Sleep Medicine, 2011

For visual learning, SWS prompts memory formation with further consolidation during REM

REM sleep supports consolidation of implicitly acquired complex relationships