Human elements of system safety:

Fatigue risk management

Introduction

- Safety improvement project
- Human elements of system safety:
  - **Human factors integration**
  - **Fatigue risk management**
- Practically oriented
- Share common issues
- Successes
- This visit not part of compliance program

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Topics

- **Importance of managing fatigue-related risk**
  - Fatigue, safety and productivity
- **Fatigue risk management in practice**
- **Achieving compliance**

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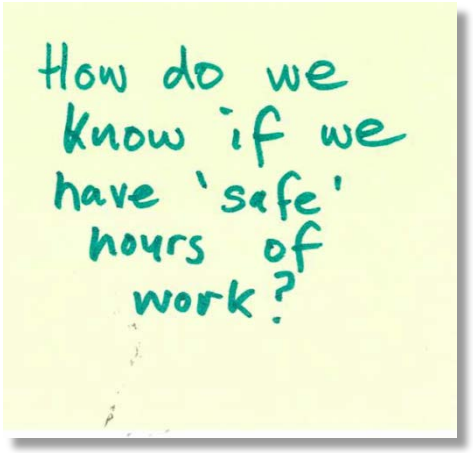
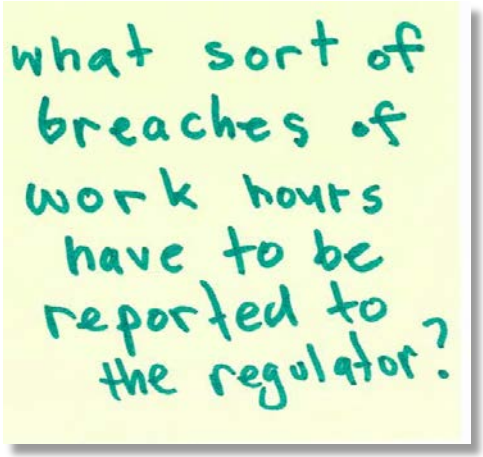
Your needs and expectations?





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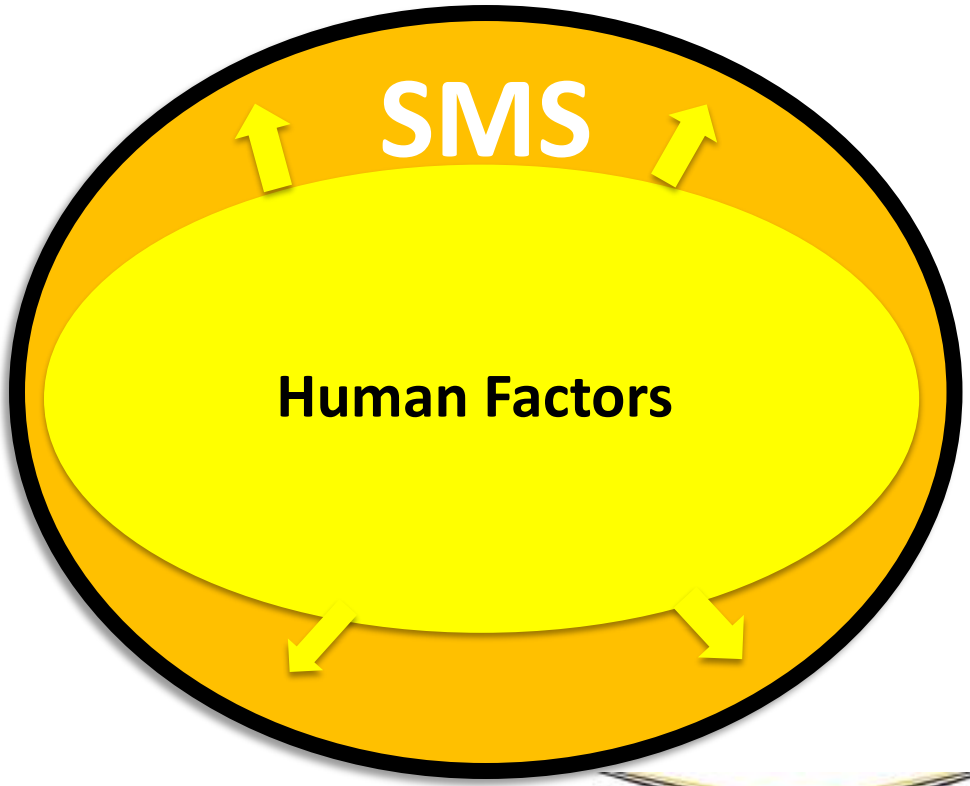
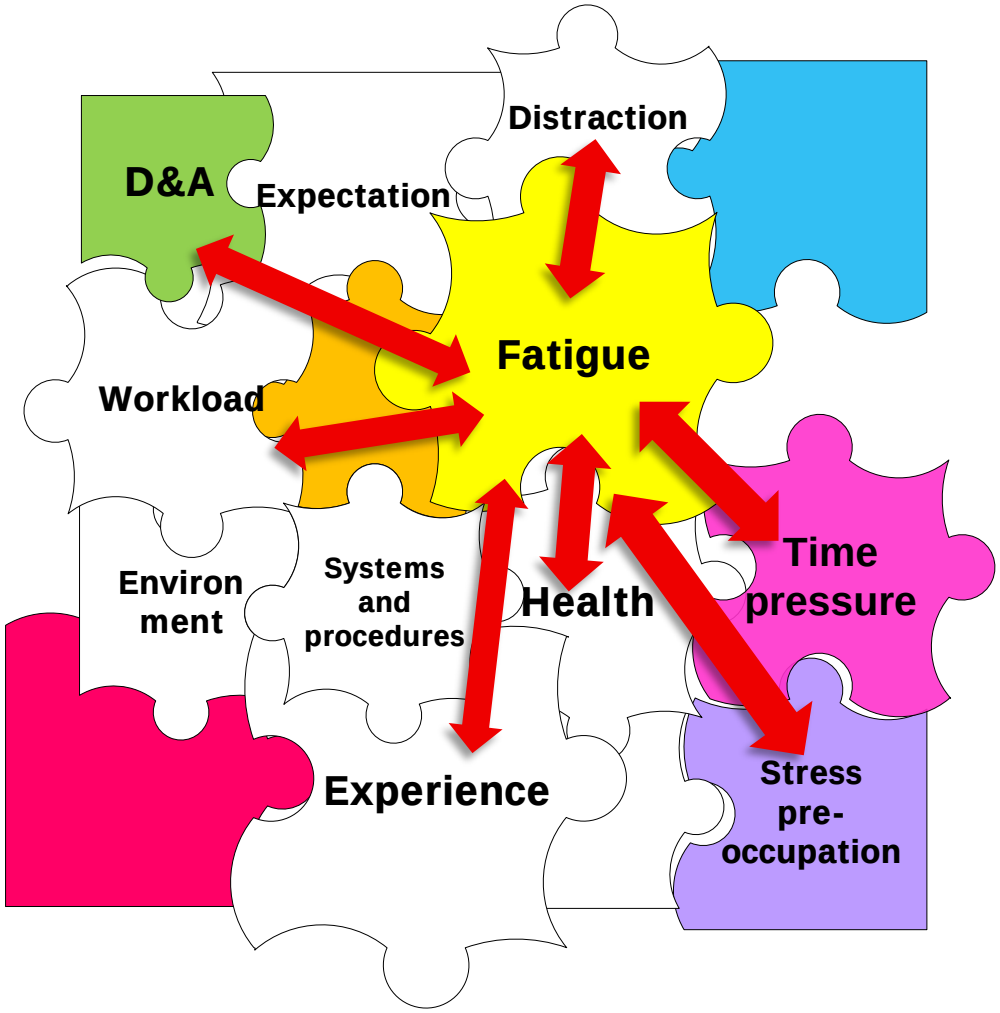
The regulatory context

- Human factors taken into account in
  - SMS development,
  - SMS operation
  - SMS maintenance
- Human factors principles/knowledge integrated into operational and business systems



National Regulations Schedule 1 Cl 17

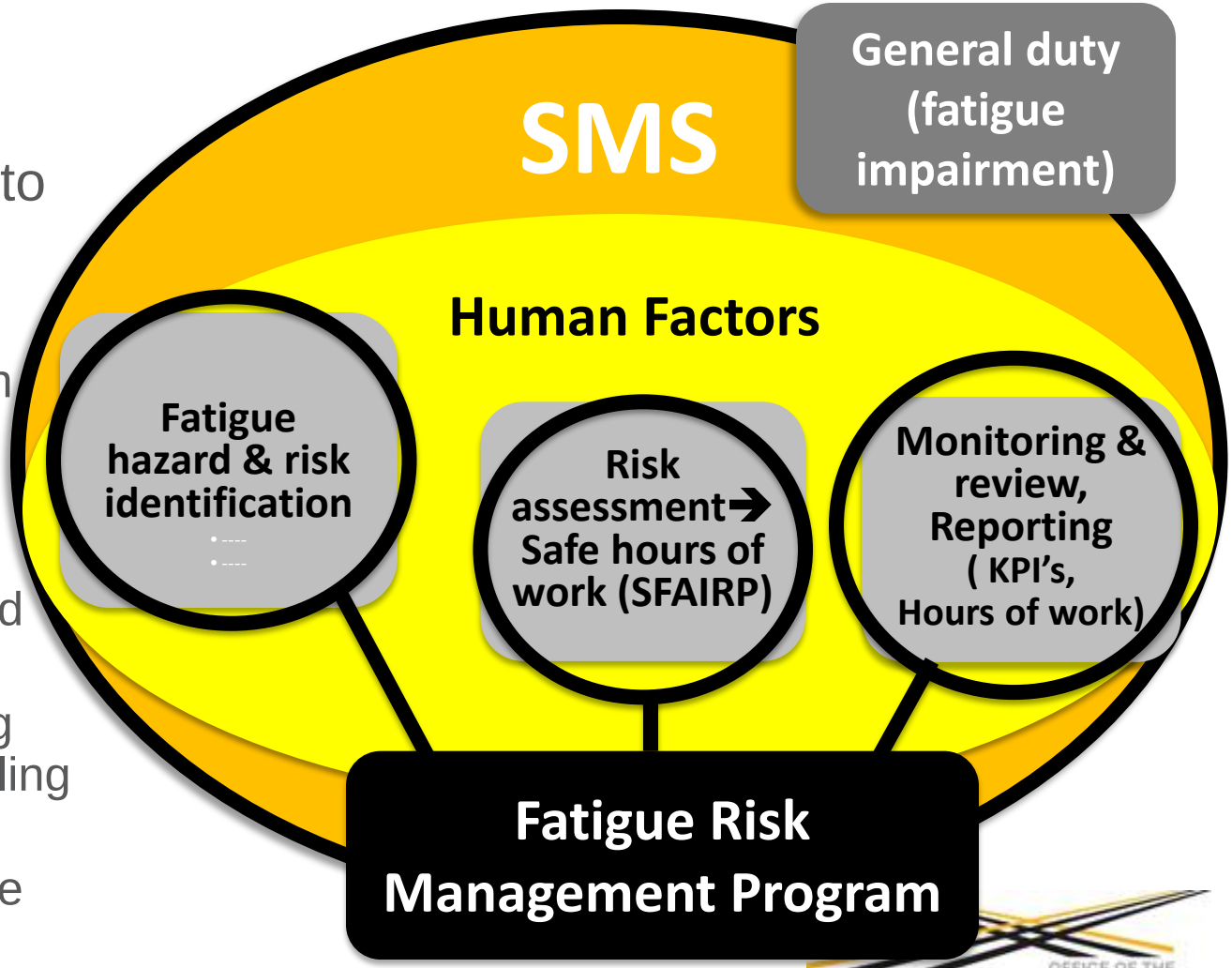
Fatigue is one of many performance influencing factors



Fatigue interacts with and amplifies other performance influencing factors

The regulatory framework

- General duty
  - RSW not fatigue 'impaired'
- FRMP integrated into SMS
- Regulations:
  - Risk based approach
  - Specified fatigue hazards to be considered
  - Monitoring of planned vs. actual hours
  - Occurrence reporting (breaches of scheduling practices)
  - Notification of change (work scheduling practices)



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The regulatory framework

RISSB Fatigue Risk Management Guidance

- Information on research and technologies
- Case studies

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Importance of managing fatigue related risk

Fatigue, safety and productivity

The context of rail operations

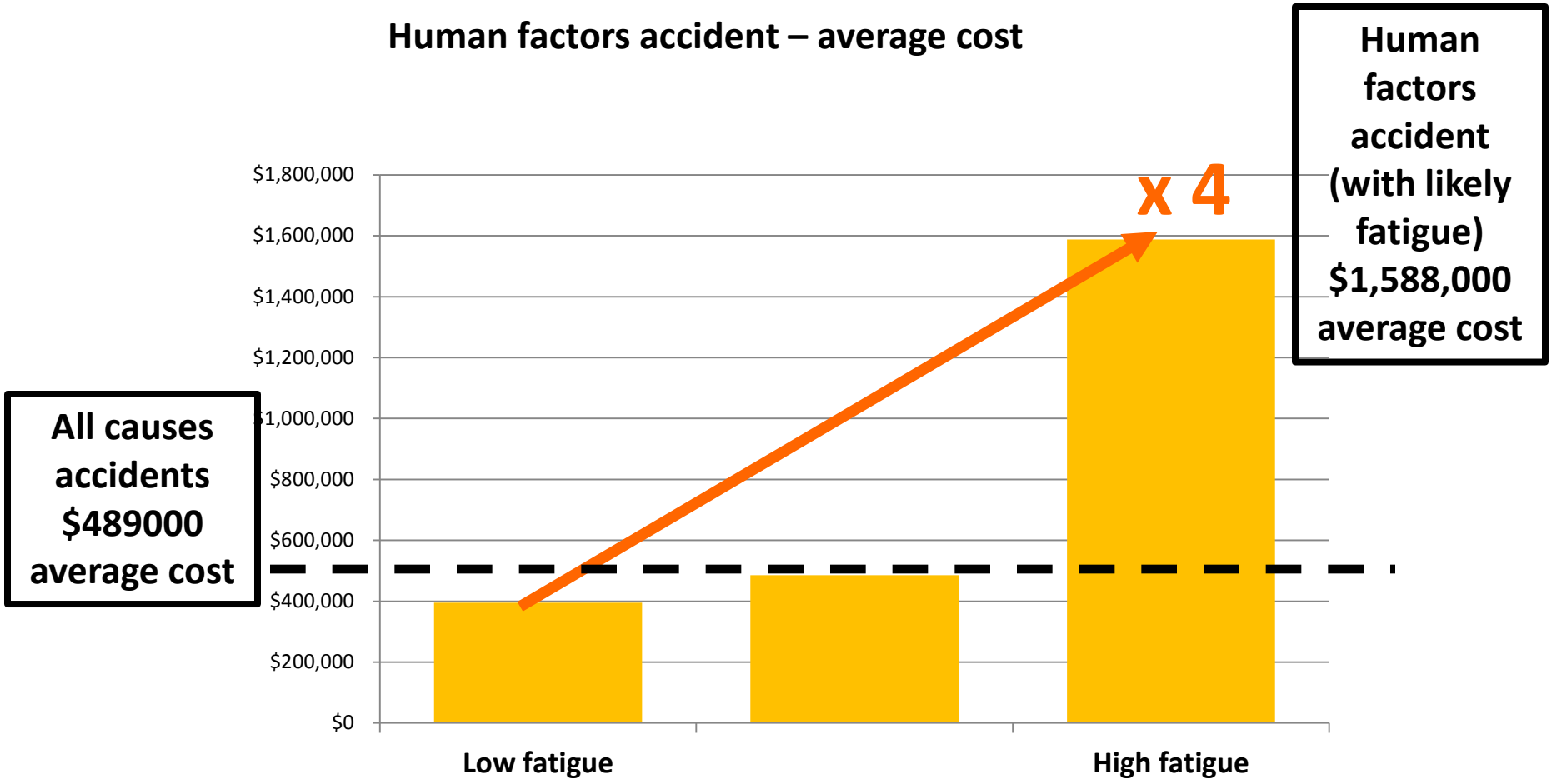
- 24/7 operations
- Sustained attention tasks
- Busy one hour, monotonous the next
- Systems depend on human performance

Fatigue

- Largest identifiable and preventable cause of accidents in commercial transport modes
- 15-20% of all accidents
- More than drug/alcohol incidents
- Often underestimated

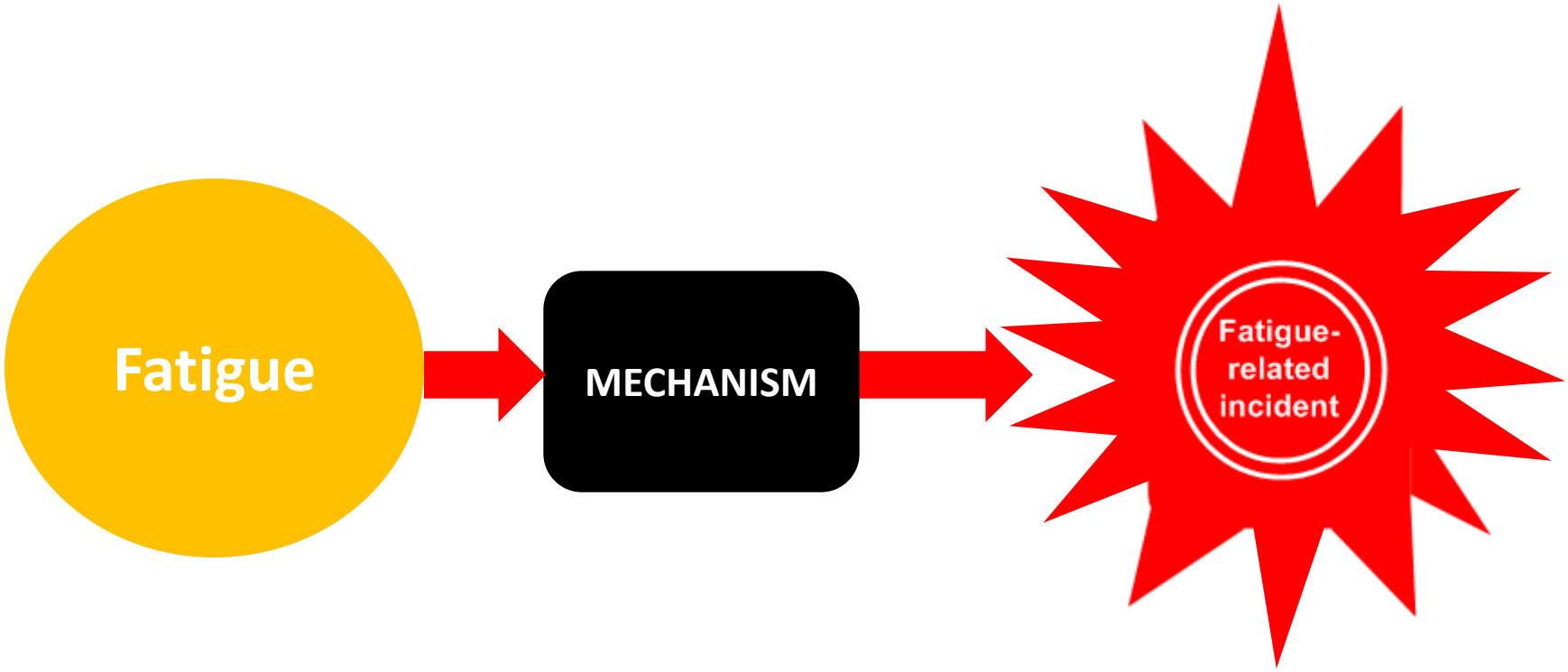
Akerstedt 2000

Incident cost – US rail data



Source: US Department of Transportation Federal Railroad Administration 2011

Fatigue and risk



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Sources of fatigue

Work environment

Task dimensions

Social/psychological factors

Rest environment

Human physiology

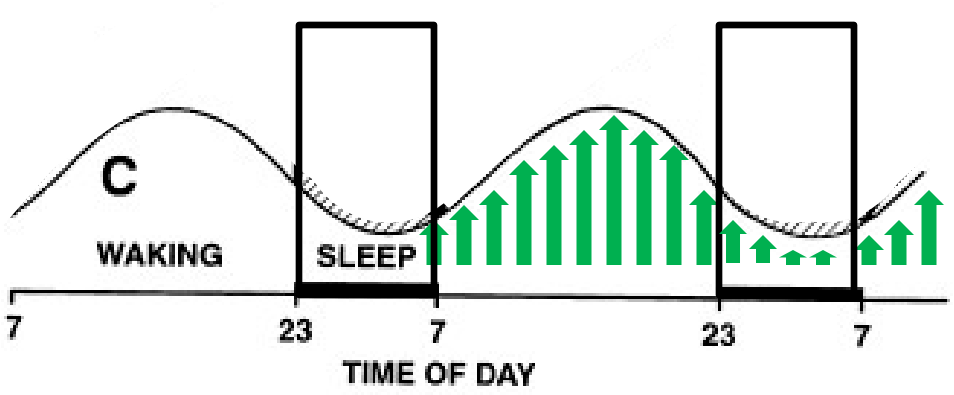
Blocks image credit: www.freeimages.co.u

Sources of fatigue – human physiology

- Circadian (body clock) rhythm effects
- Time awake
- Sleep inertia
- Sleep loss over days (chronic sleep loss)

Sources of fatigue – sleep physiology

- Circadian(body clock) rhythm effects

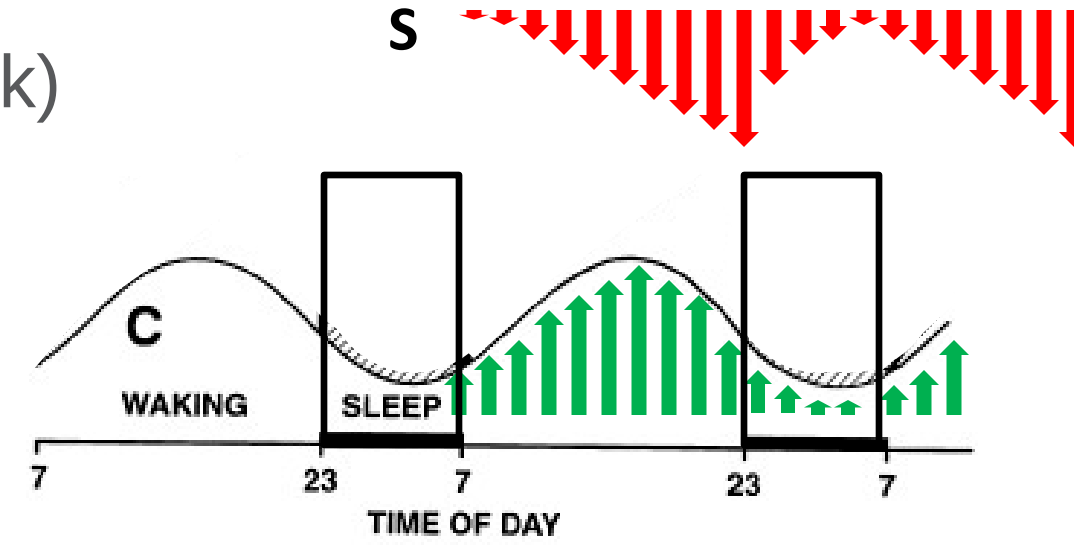


MODEL OF SLEEP

(circadian) cyclical alerting process

Sources of fatigue – sleep physiology

- Circadian(body clock) rhythm effects
- **Time awake**



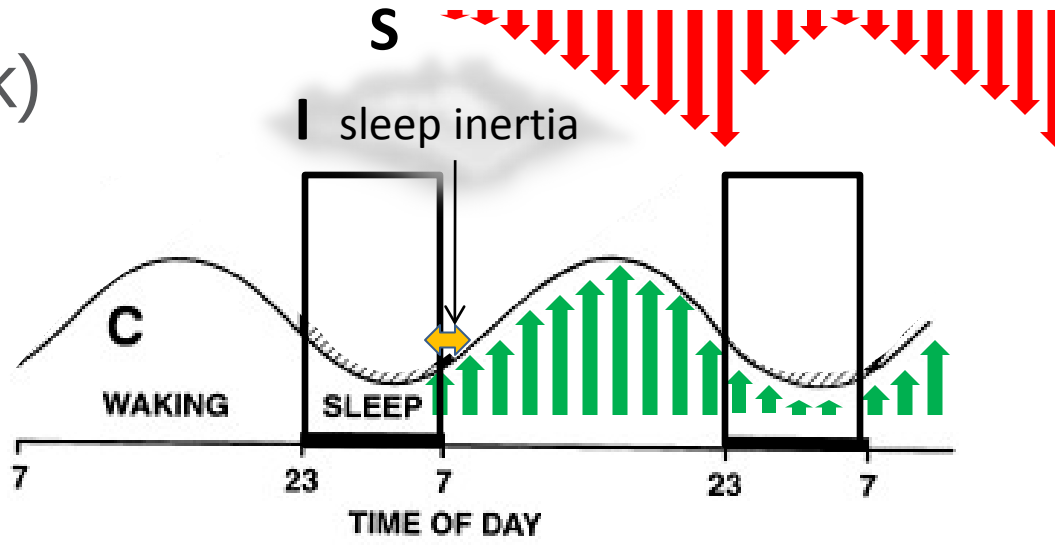
MODEL OF SLEEP

Sleep process = drive to sleep with time awake

C (circadian) cyclical alerting process

Sources of fatigue – sleep physiology

- Circadian(body clock) rhythm effects
- Time awake
- **Sleep inertia** (grogginess)



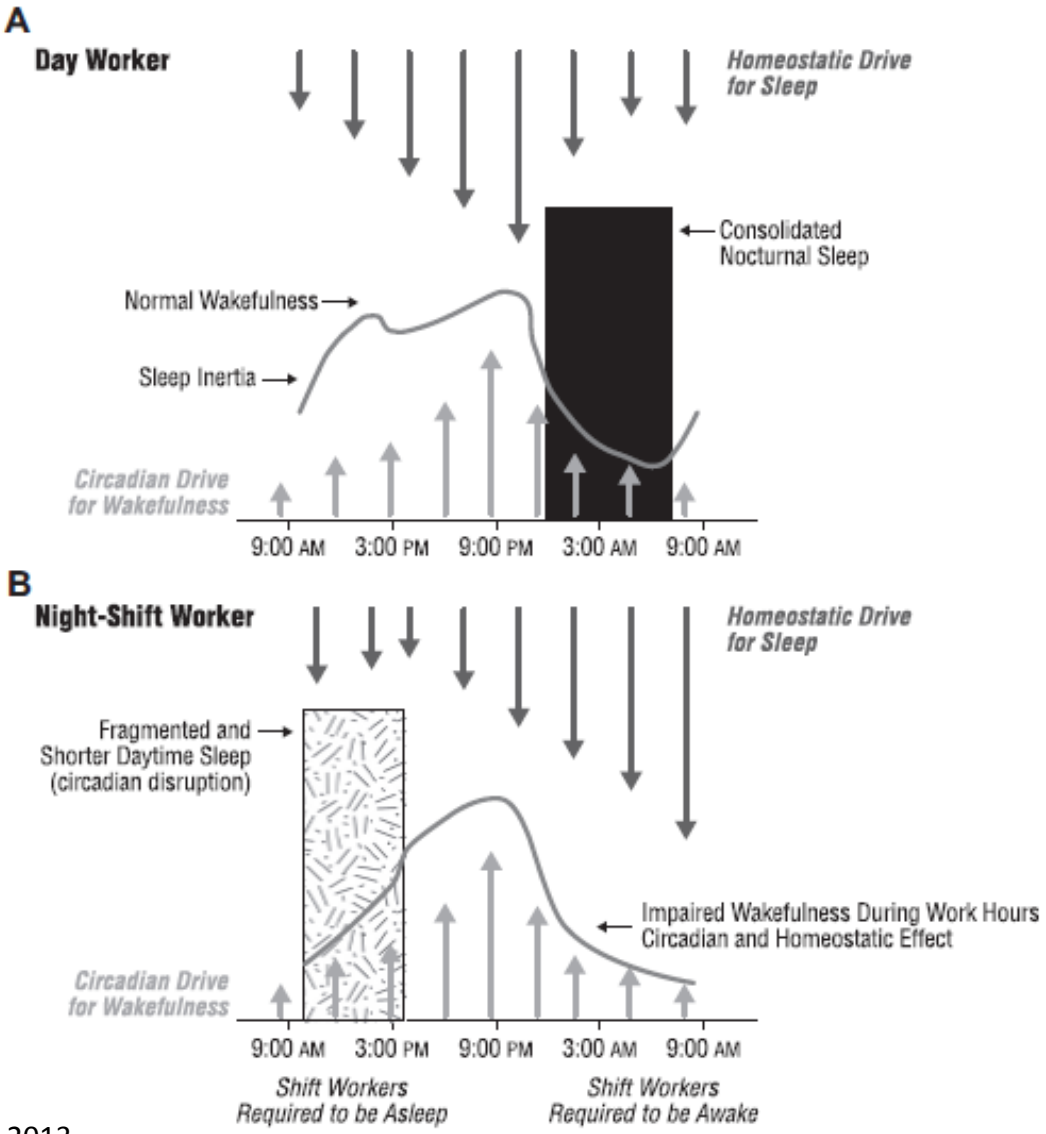
MODEL OF SLEEP

Sleep process = drive to sleep with time awake

C (circadian) cyclical alerting process

I Sleep Inertia = transient grogginess

Sources of fatigue – sleep physiology



Source: Wright et al 2013

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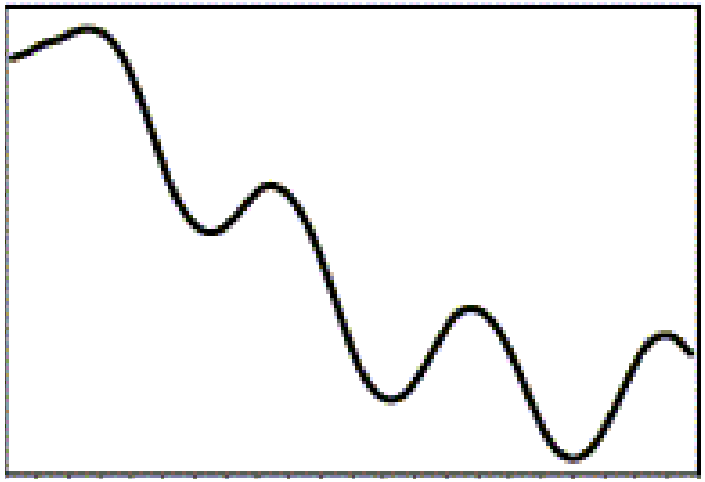
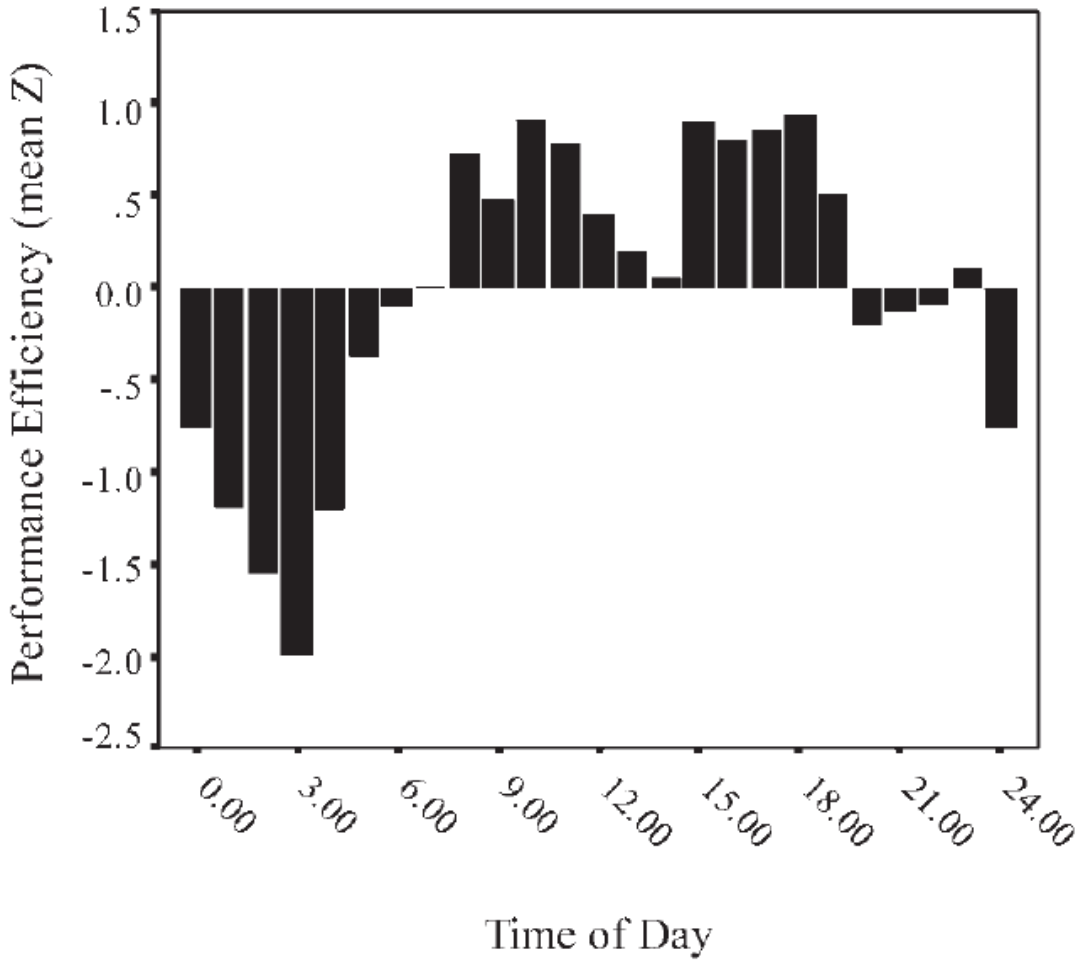
Sources of fatigue – sleep physiology

Combined effect of
- circadian rhythm and extended wakefulness



Circadian effects on performance



Source: Folkard and Tucker 2003

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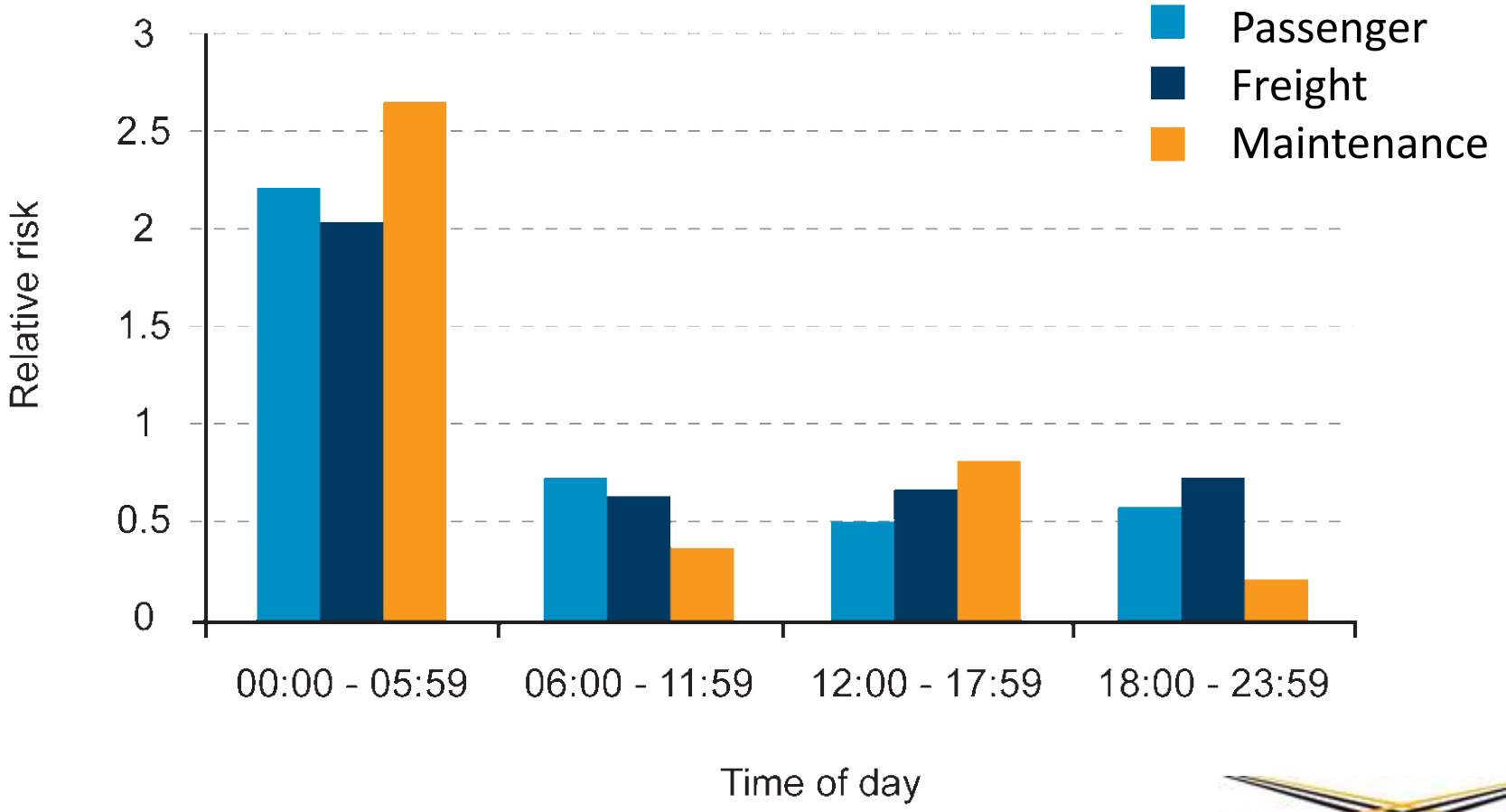
Circadian effects on incident risk: UK SPADs



Source: RSSB 2010 Research Programme T699 Appendix F

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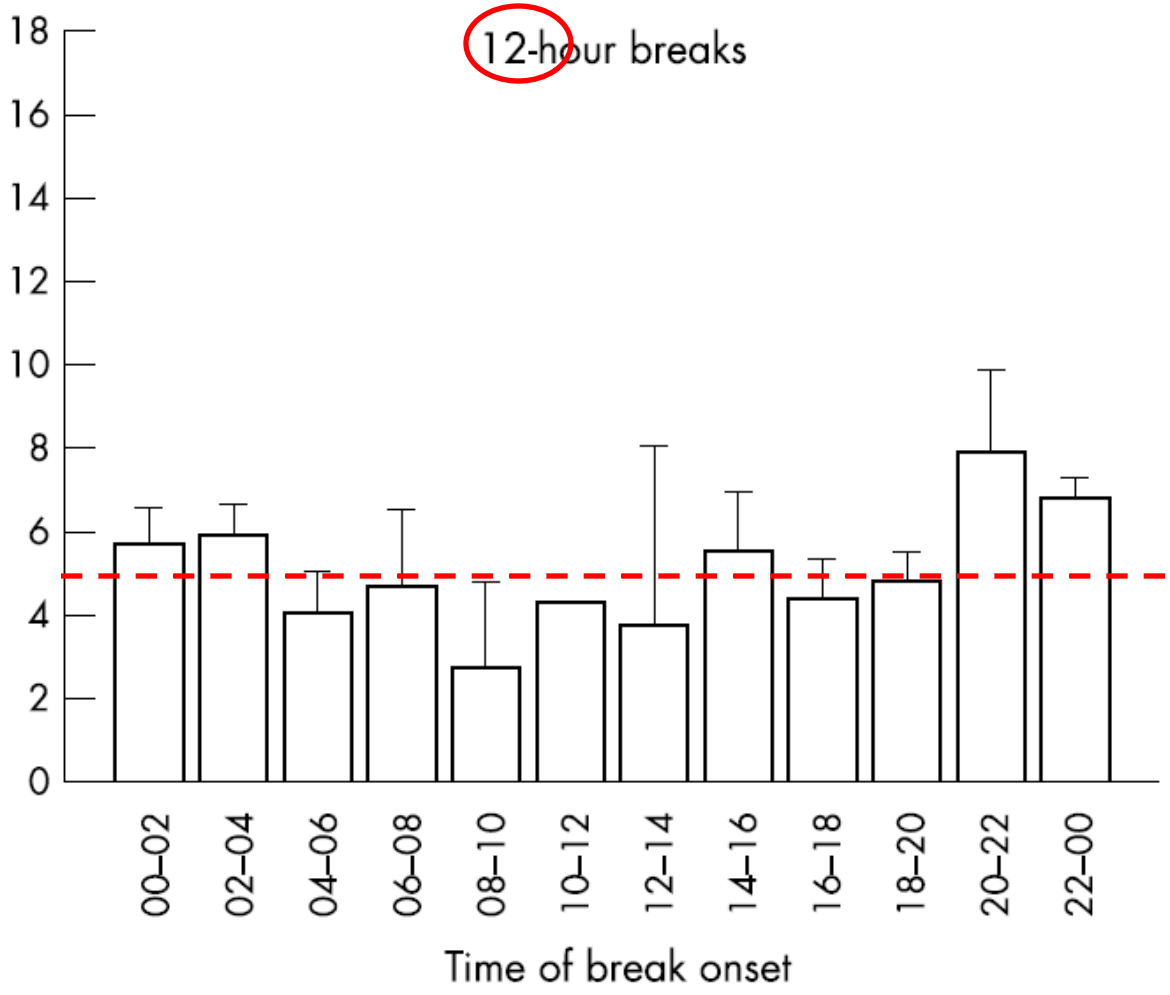
Circadian effects on train driver sleep



Arbitrary line at 5 hours for comparison purposes

Source: Roach et al 2003

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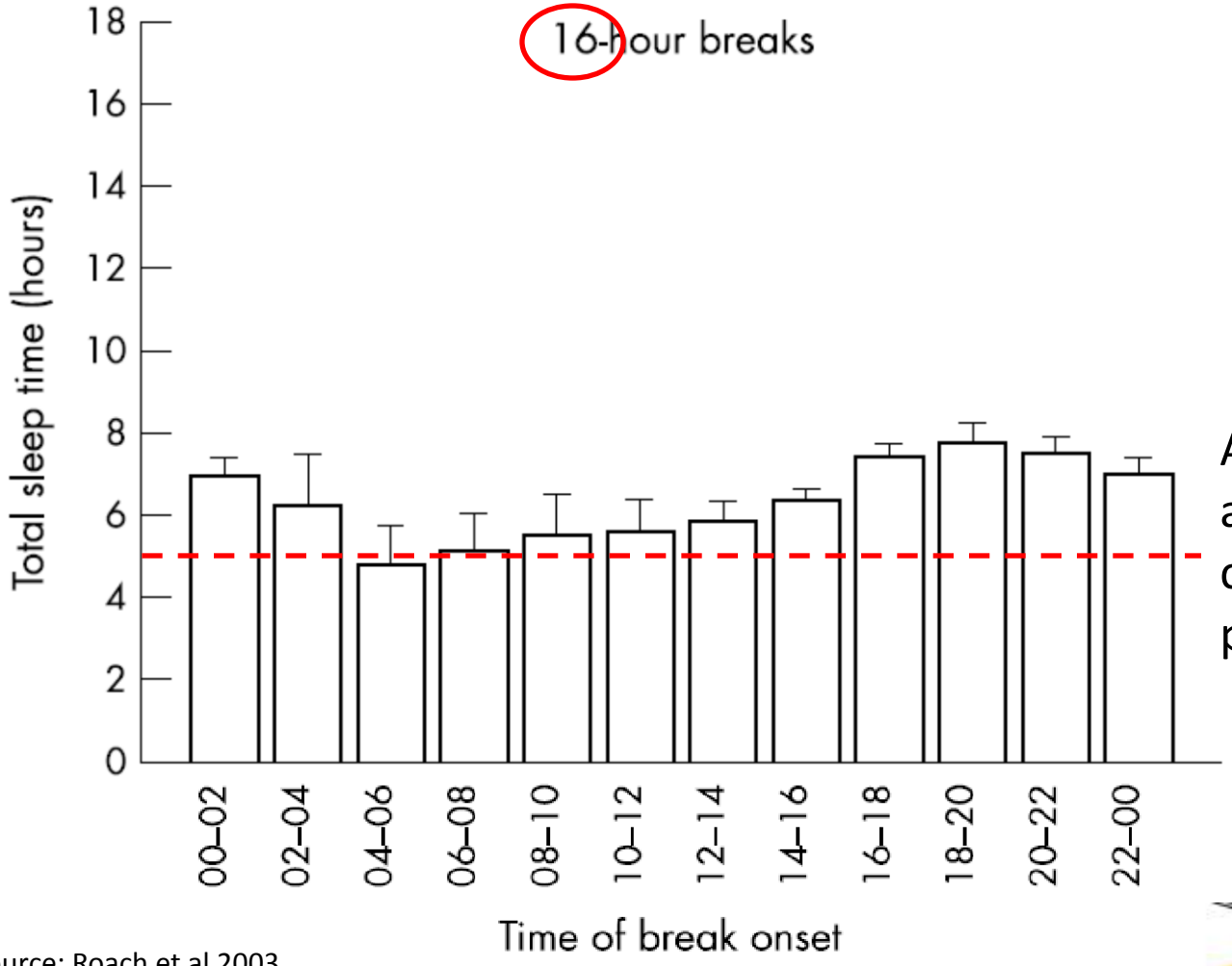
Effect of longer break = more sleep



Arbitrary line at 5 hours for comparison purposes

Source: Roach et al 2003

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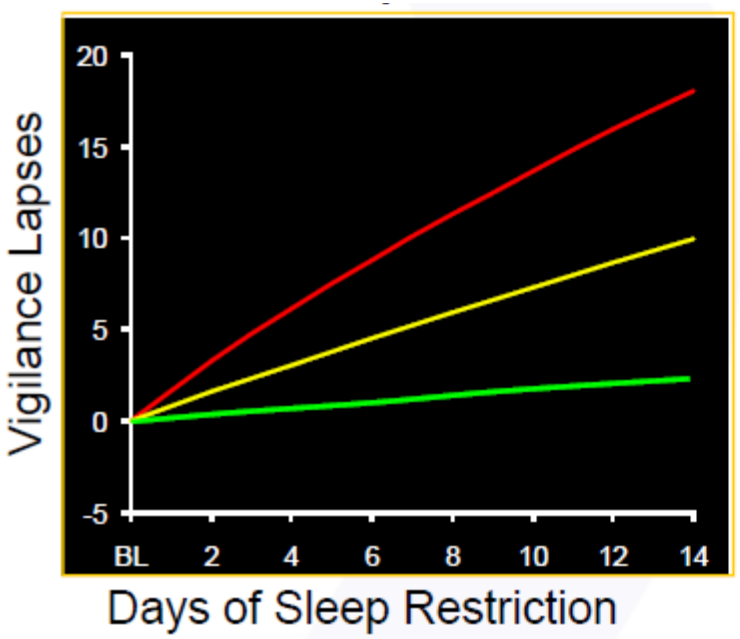
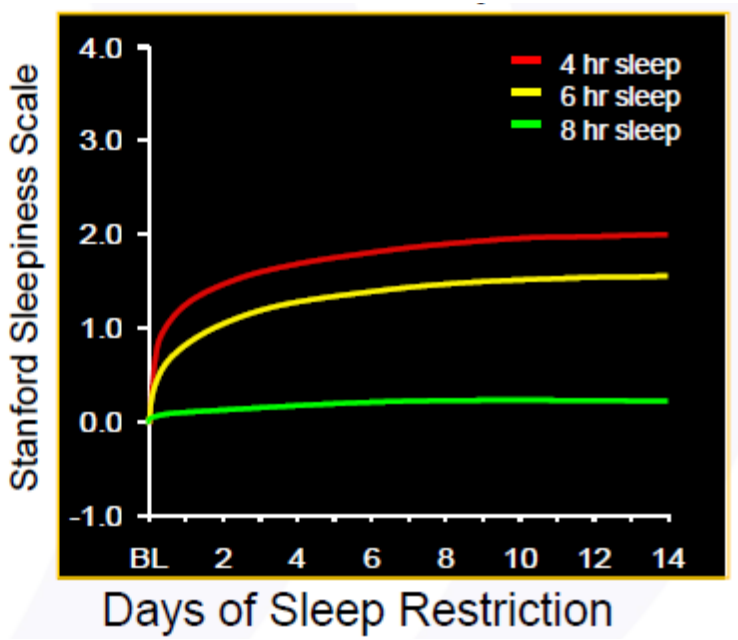
Sources of fatigue – physiology
Chronic sleep loss effects

Performance deterioration



Self rated sleepiness



Van Dongen et al 2003 (Figures from Hursh 2010)

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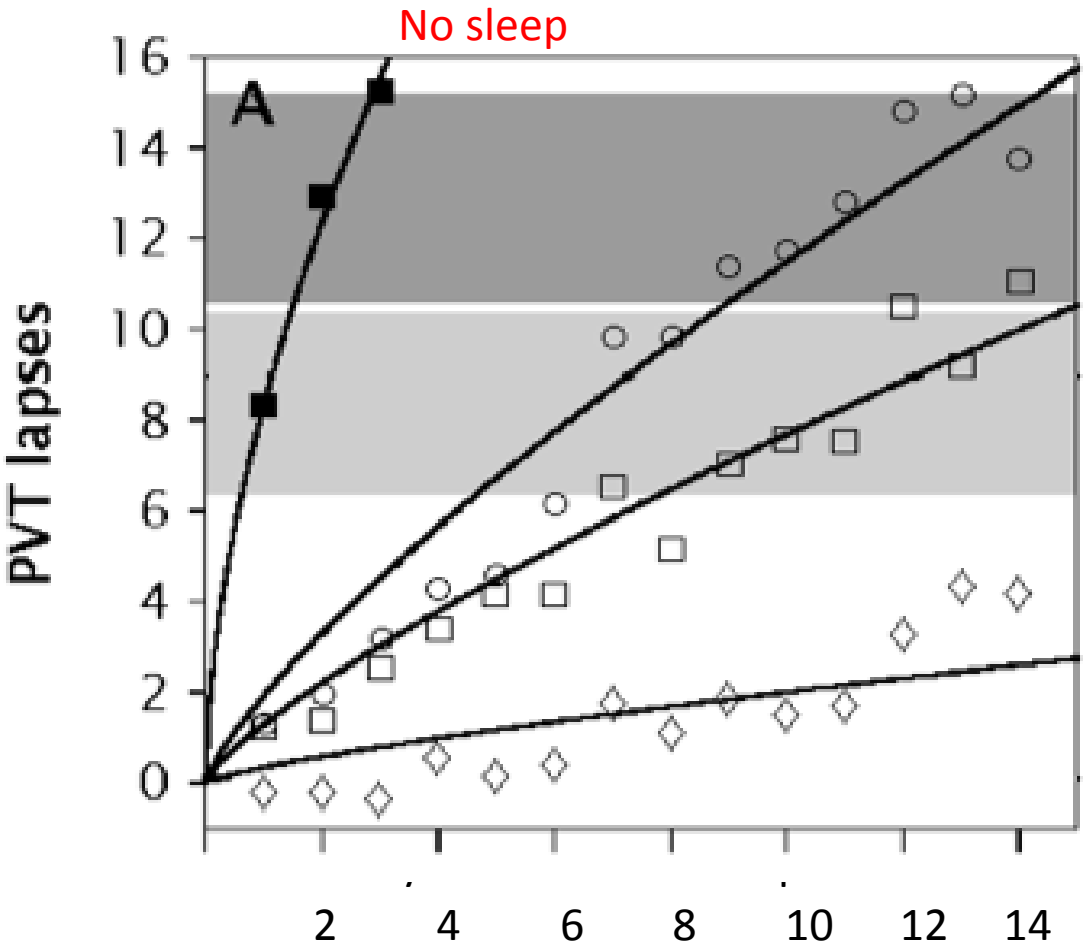
Sources of fatigue – physiology
Chronic sleep loss effects



4 hours time in bed

6 hours time in bed

8 hours time in bed

Source: Van Dongen et al 2003

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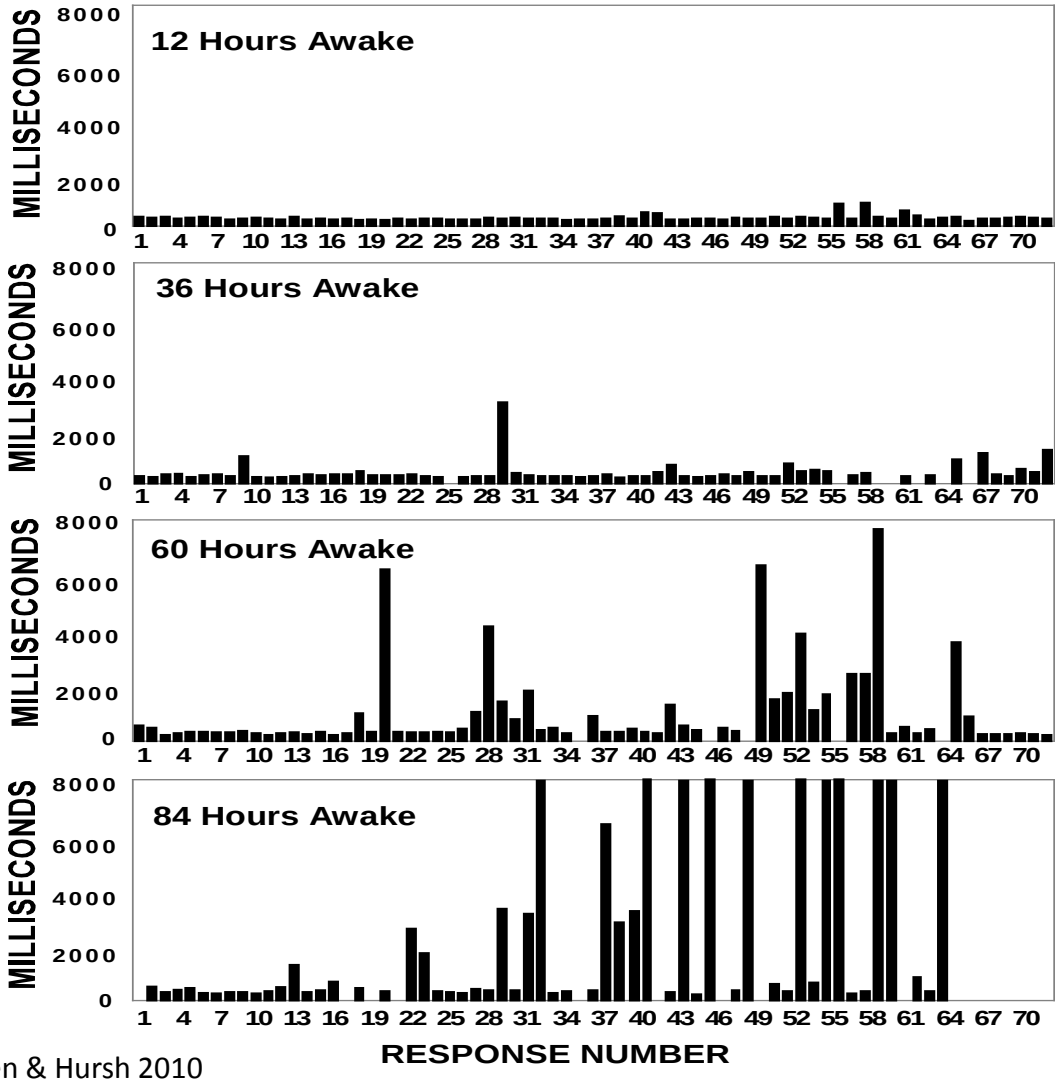
Sources of fatigue – physiology
Sleep loss and performance



Source: Van Dongen & Hursh 2010

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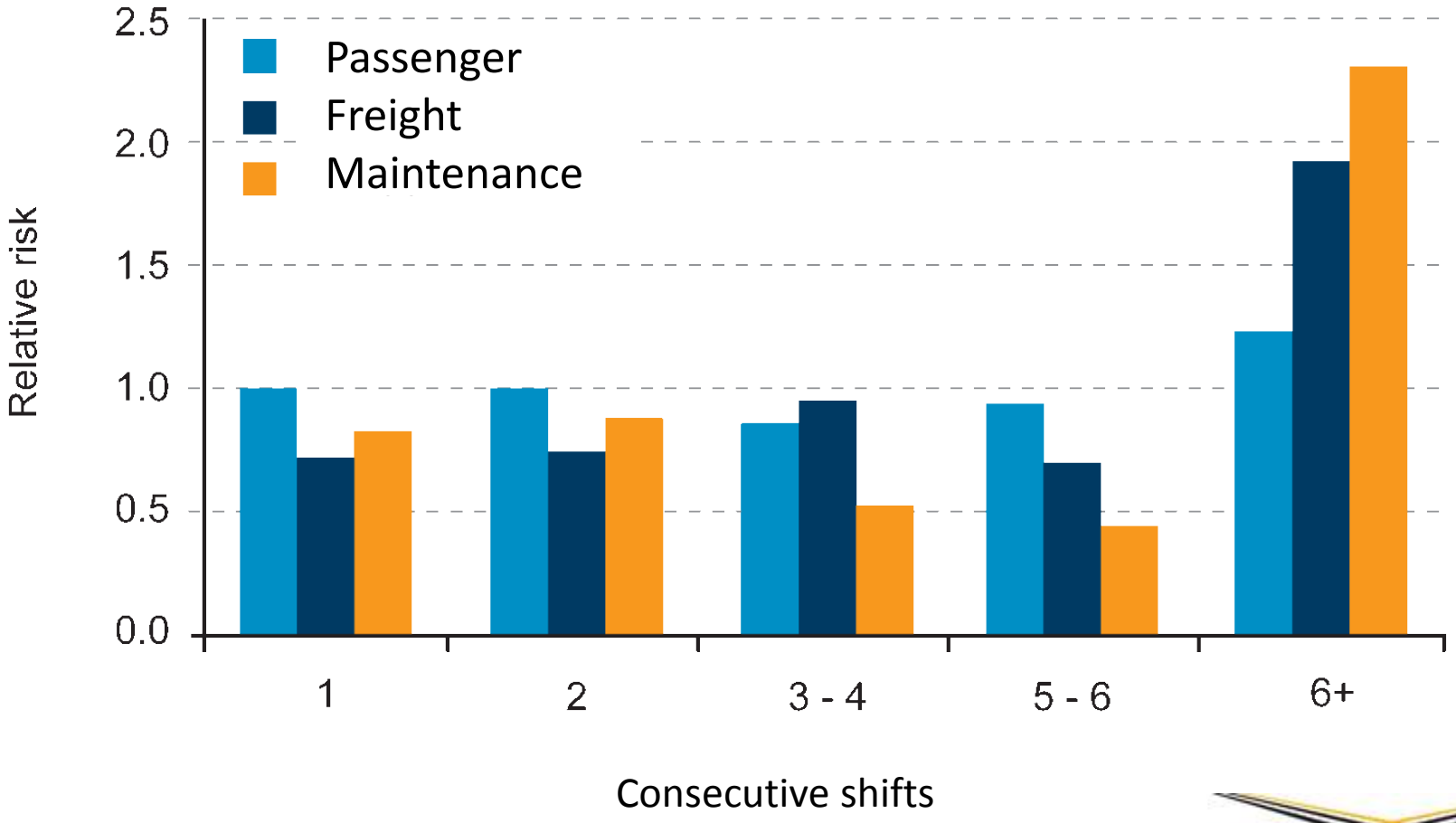
Number of consecutive shifts and incident risk: UK SPADs



Data source: RSSB 2010 Research Programme T699 Appendix F

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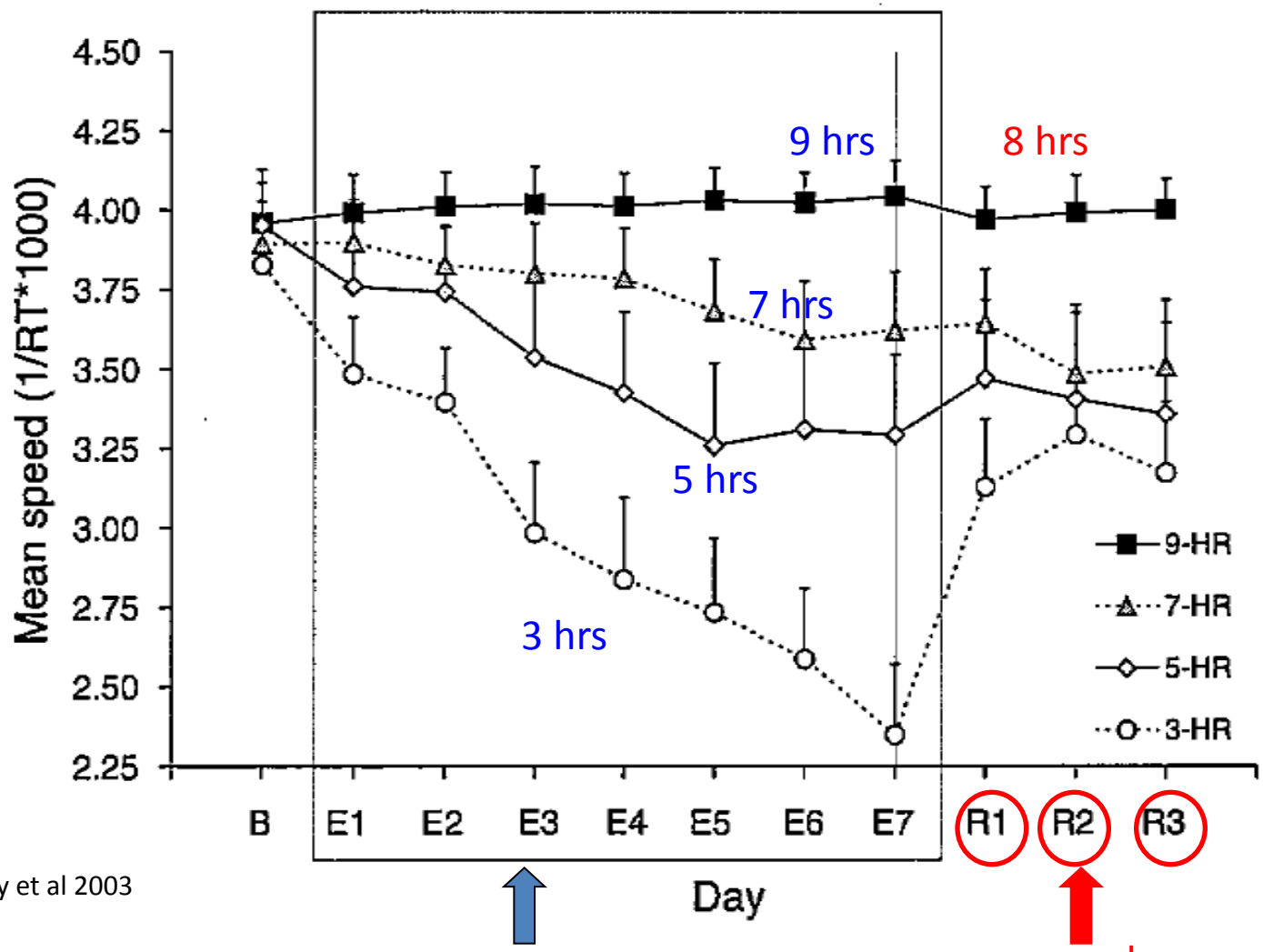
Sources of fatigue – physiology
Recovery from sleep loss



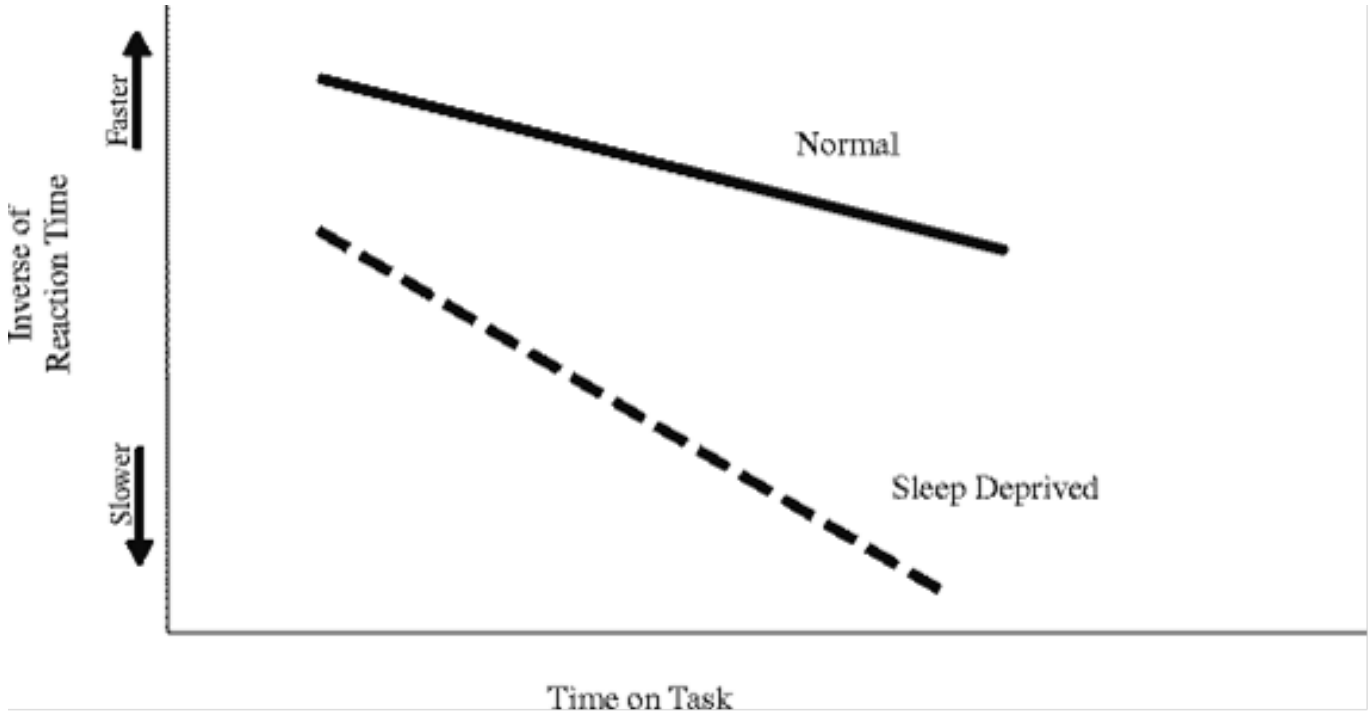
Belenky et al 2003

7 days of restricted sleep

recovery sleeps restricted to
8 hours time in bed

Sources of fatigue – task effects

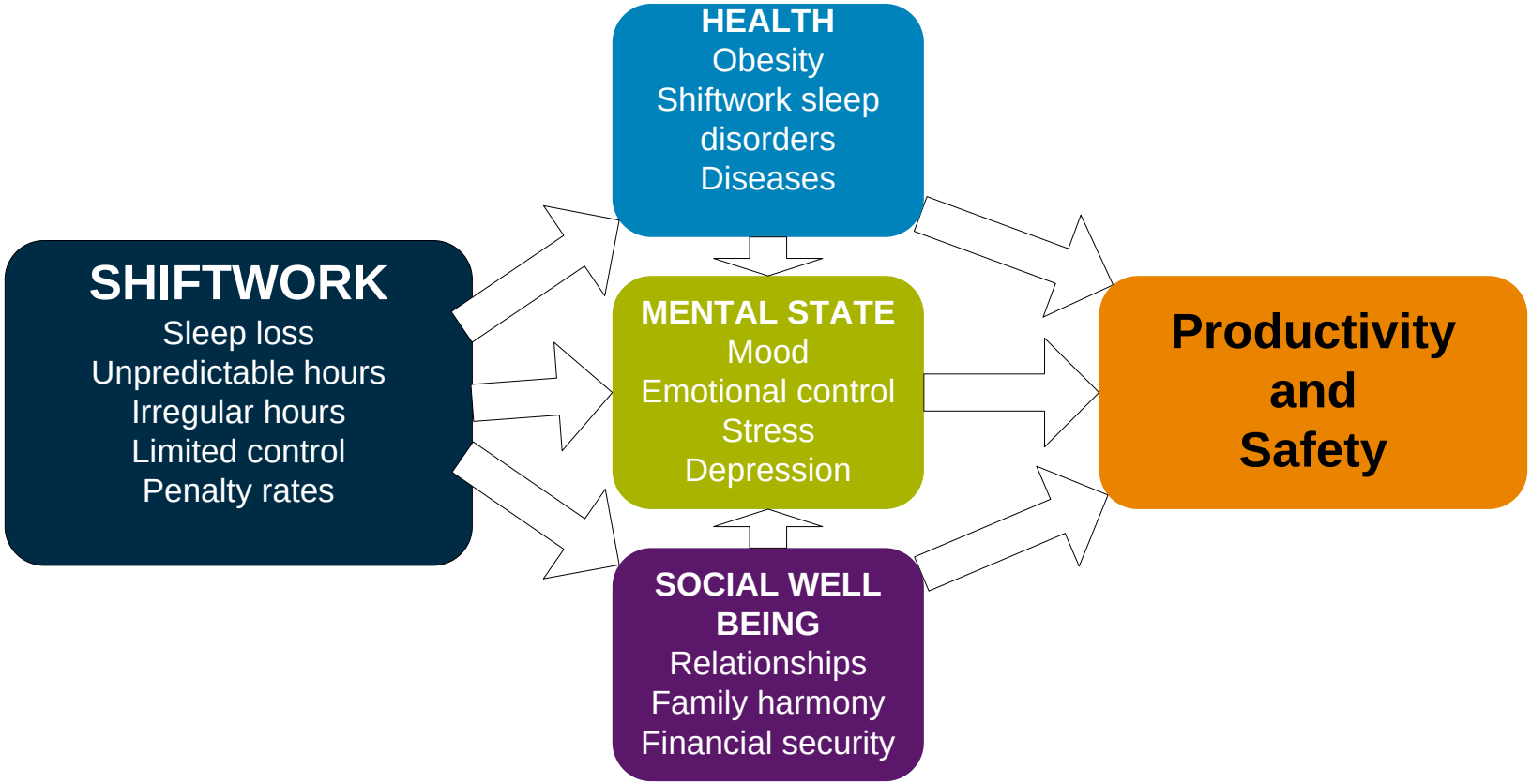
- Time on task



Continuous hours worked and incidents - UK SPAD data

Data source: RSSB 2010 Research Programme T699 Appendix F

Sources of fatigue – social/psychological factors



Recap – sources of fatigue

- Physiological factors
  - Circadian
  - Time awake
  - Sleep inertia
  - Sleep loss over days
- Task and workload
- Social/psychological

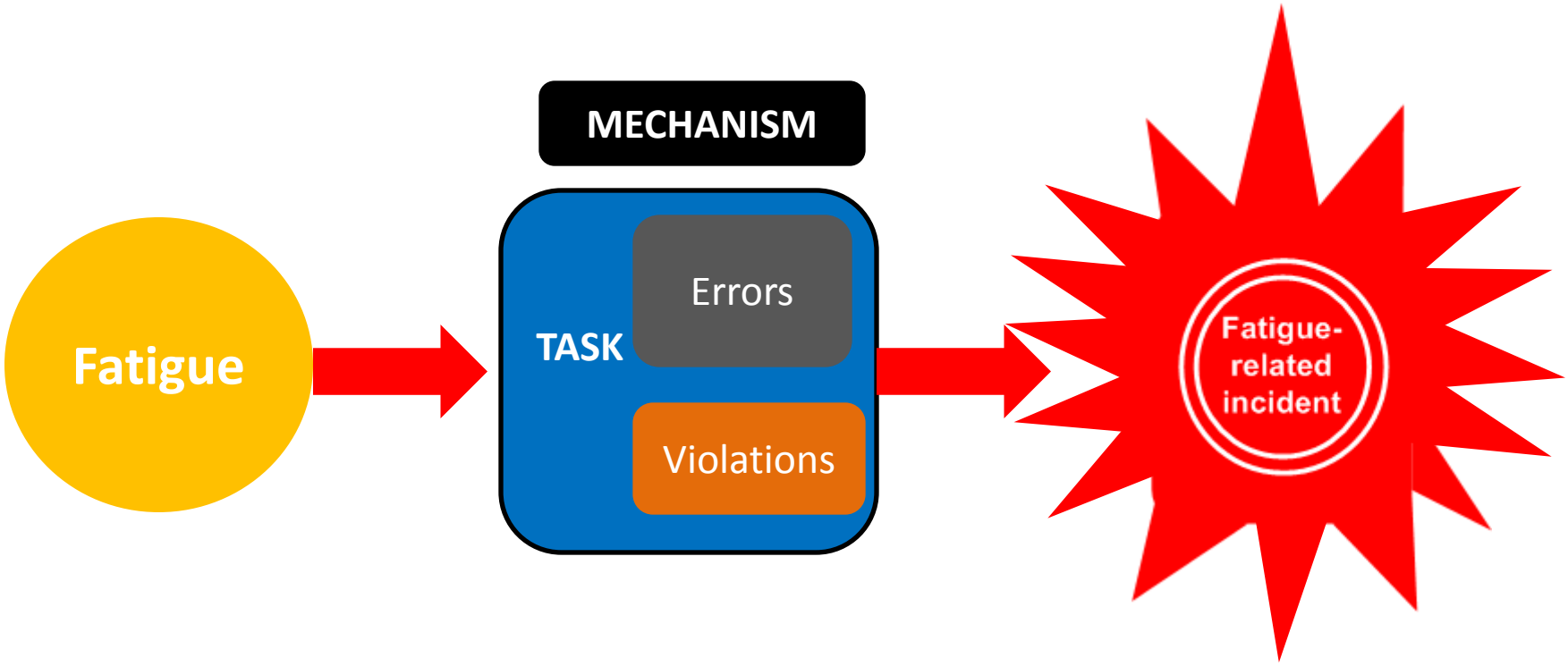
Others:

- Work environment
- Rest environment
- Commuting
- …

What controls are in place for these hazards?

1. ……
2. …….
3. ……

Fatigue and risk



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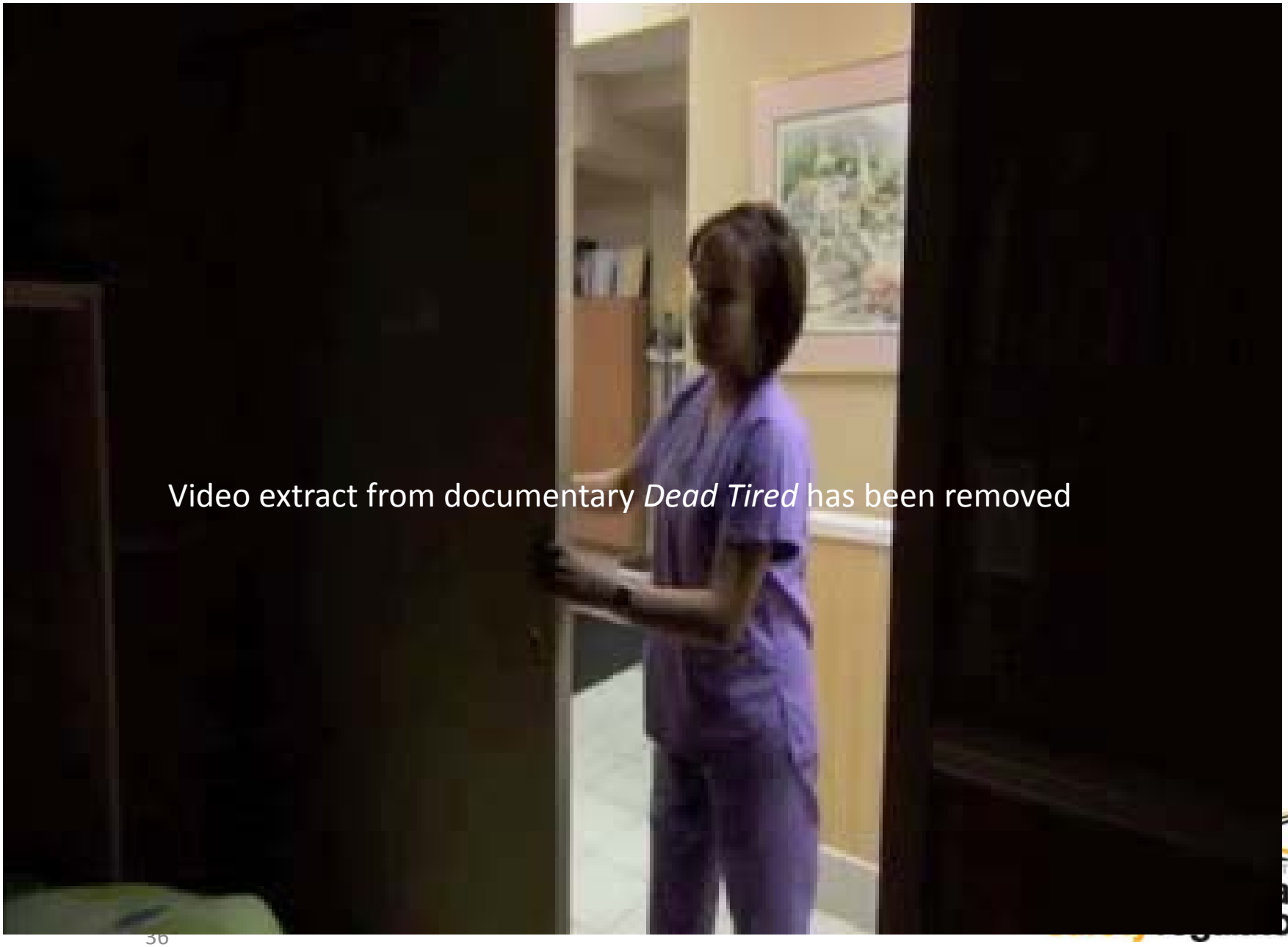
Attention

- Decreased attention span
- Lapses on attention rich tasks (eg monitoring, driving)
- Tunnelling – narrowing of field of attention
- Micro-sleeps
- Sleep incapacitation


Video extract from documentary *Dead Tired* has been removed

Cognition (thinking)

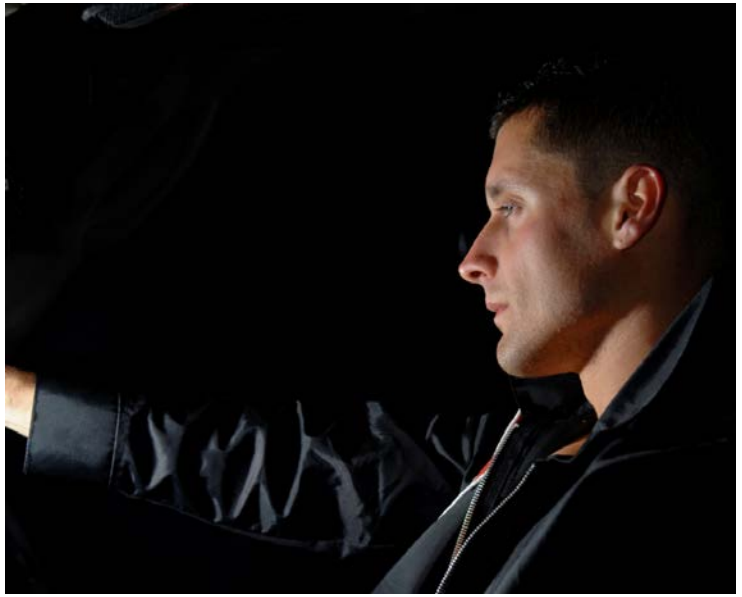
- Slower to interpret and integrate information
- Short term recall, working memory
- Reduced ability to learn
- Decision making
  - ➔ Difficulty weighing up options
  - ➔ Persist with ineffective responses

Motivation and insight

- Compensatory effort to maintain performance
- Initiate tasks ok but then deteriorates
- Divert attention to interesting tasks
- Neglect tasks judged to be non essential
- Less interested in outcomes
- Less likely to pick up someone else's errors
- End goal seduction

Emotional control

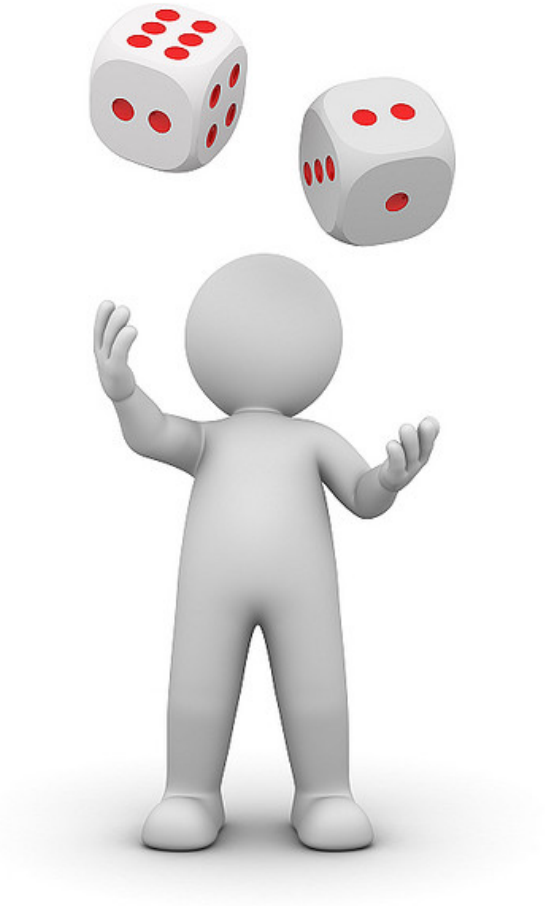
- Feeling low and irritable
- Inability to suppress responses
- Terse communications



Source: Walker 2009

Summary: fatigue effects on performance

Increased error probability



Decreased error detection and recovery

Summary: fatigue effects on performance

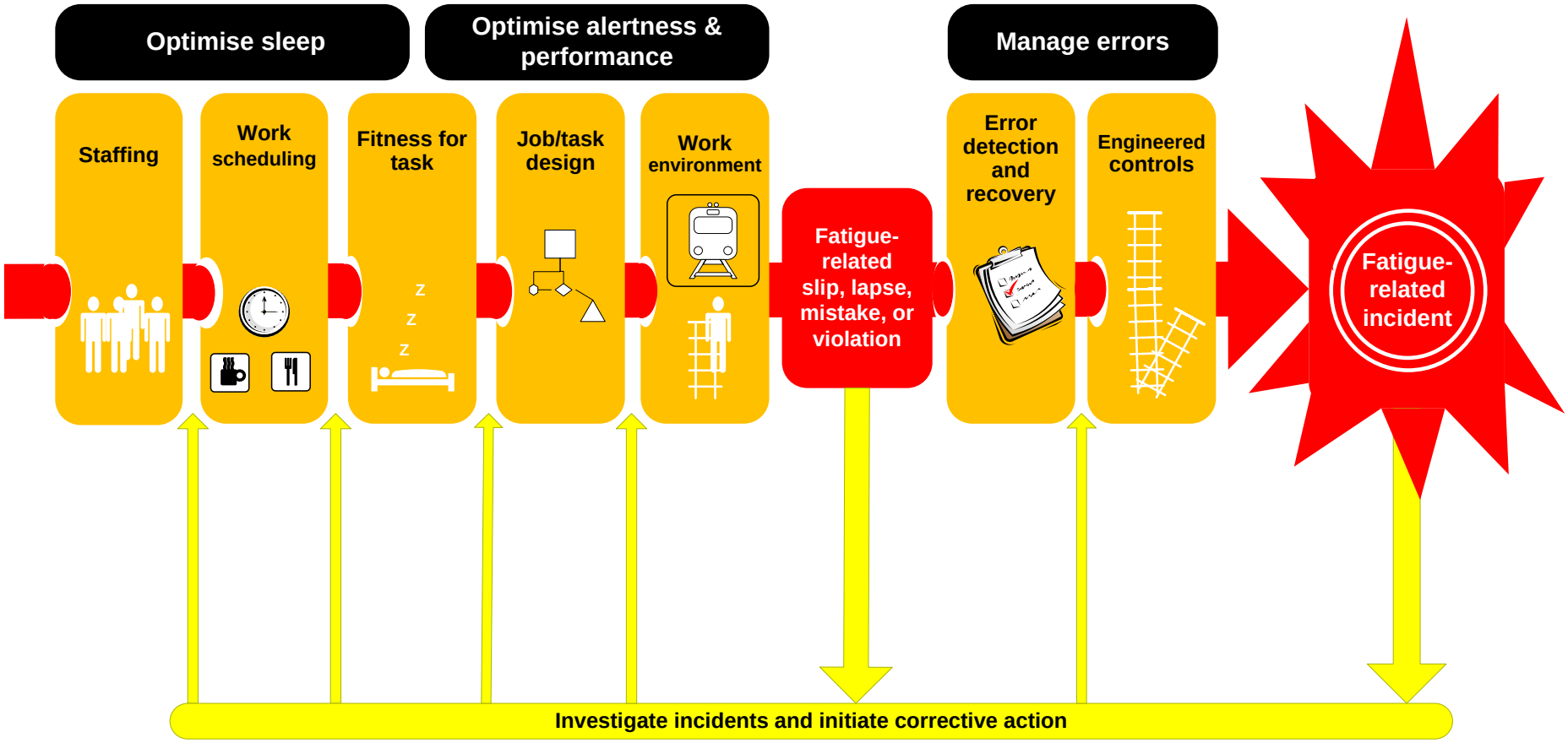
Short cuts & violations more likely

Decreased likelihood of detecting problems

Fatigue risk management in practice:

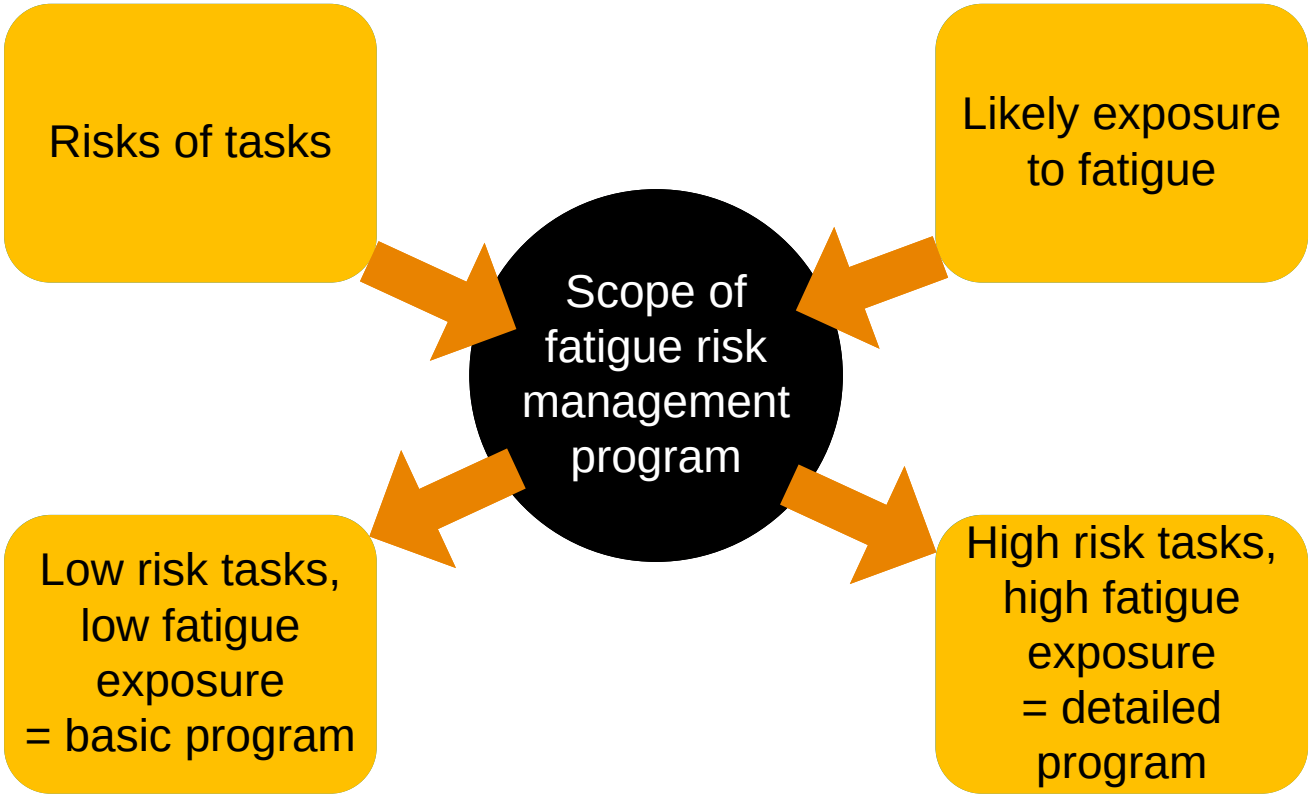
Developing and reviewing the FRMP

Multiple layers of defence

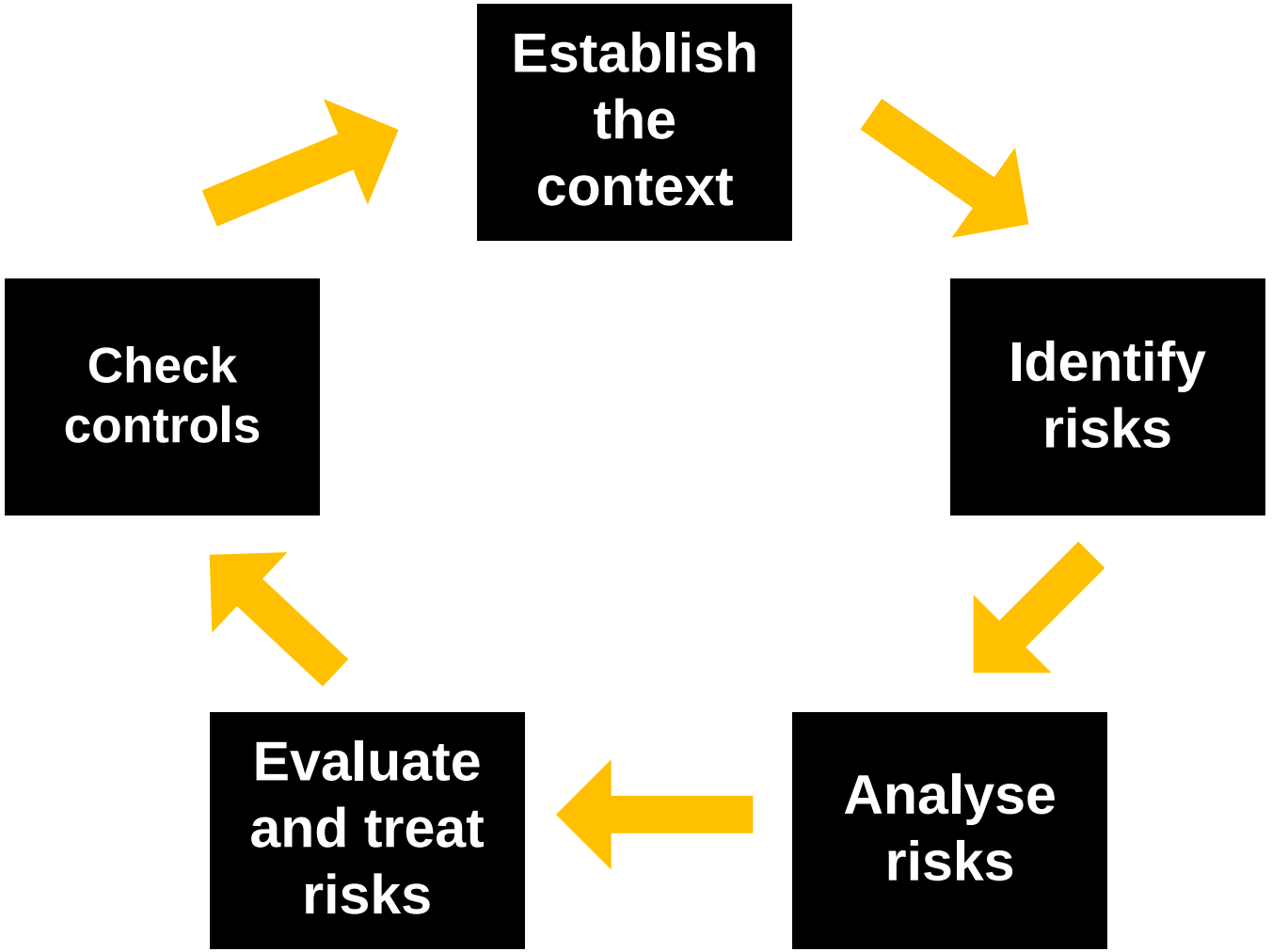


*Layers of defence and accident trajectory concepts based on Reason, J 1997. Managing the risks of organizational accidents, Ashgate, Aldershot

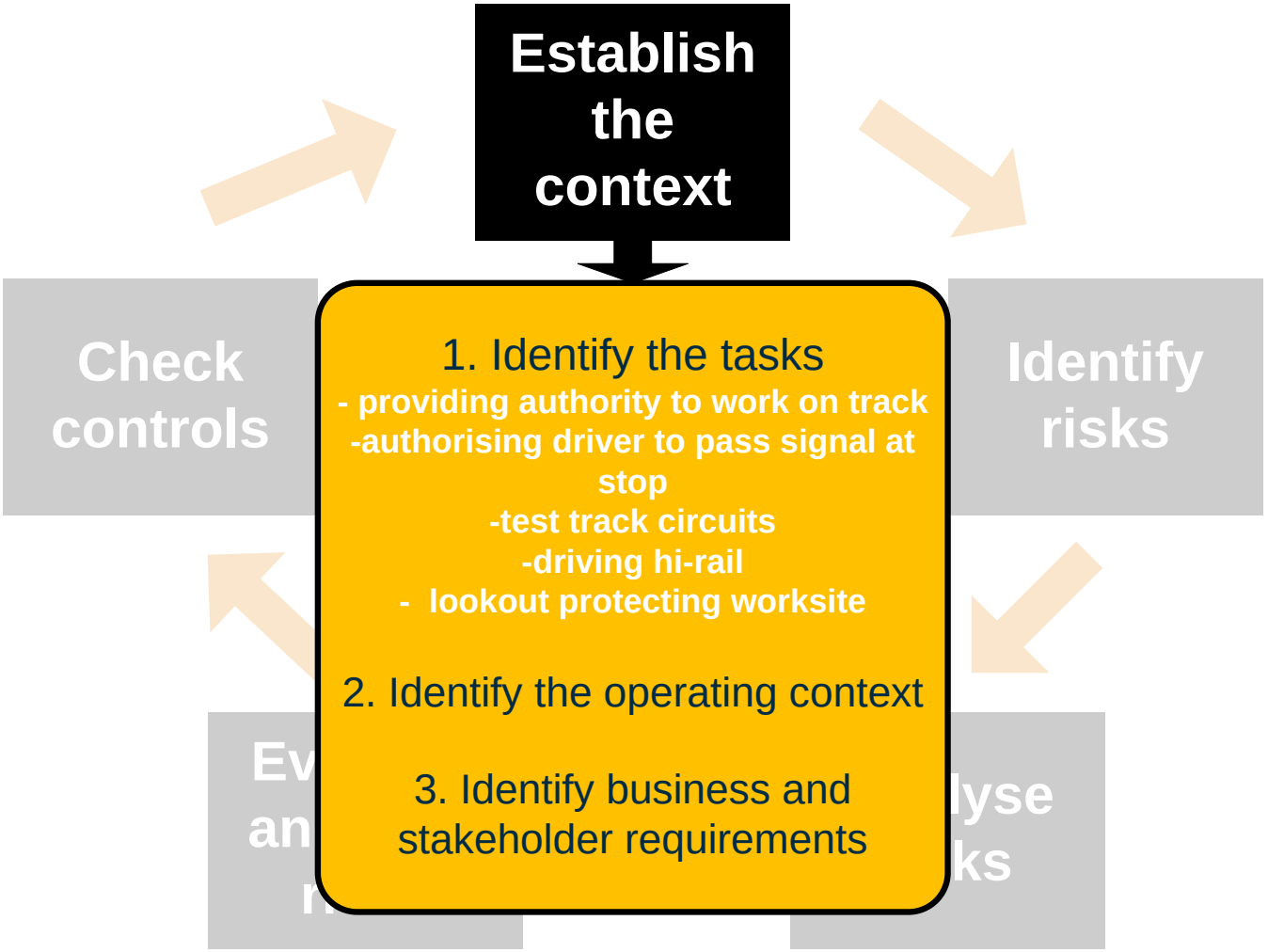
Scoping the fatigue management program



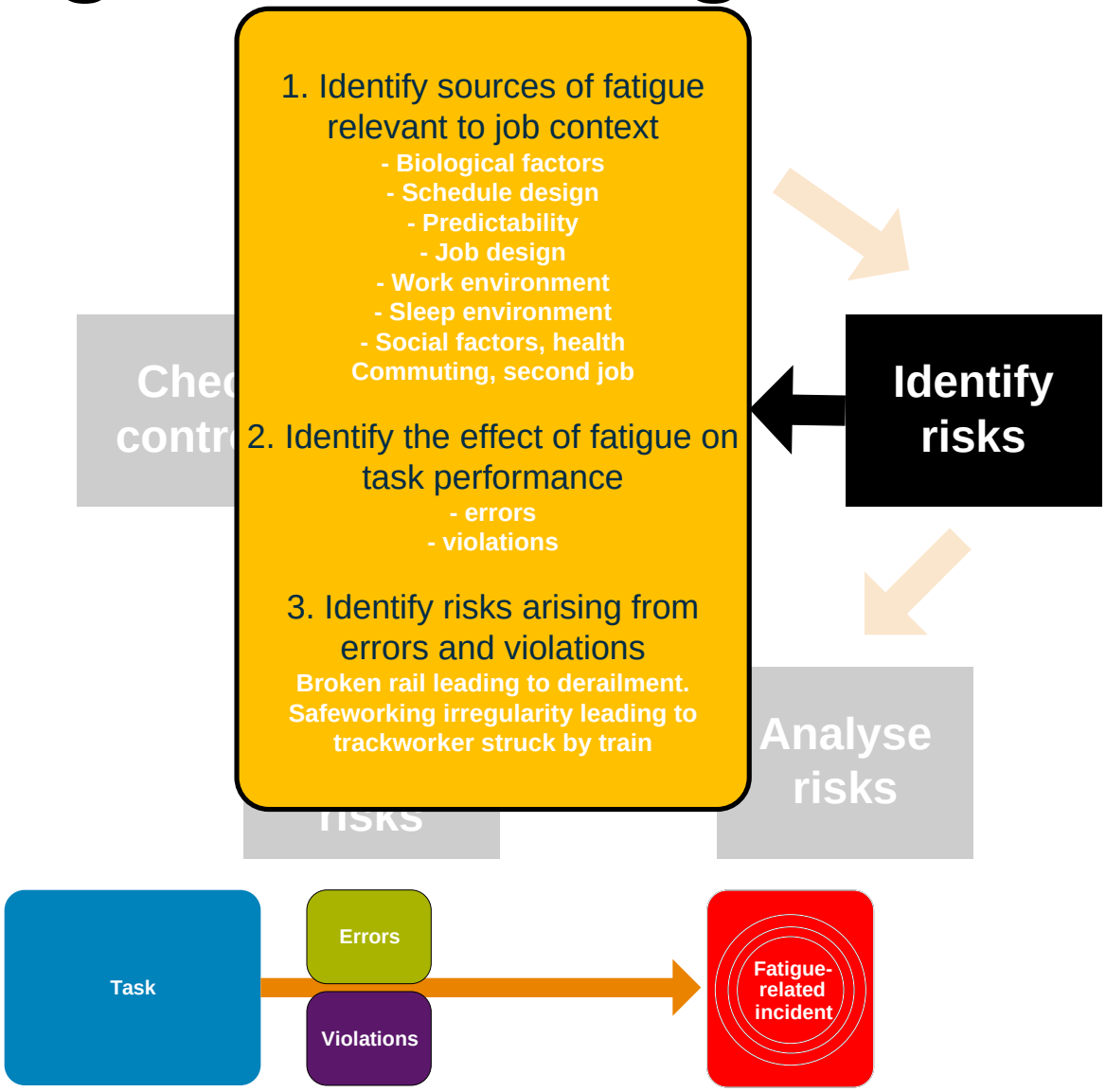
The fatigue risk management cycle

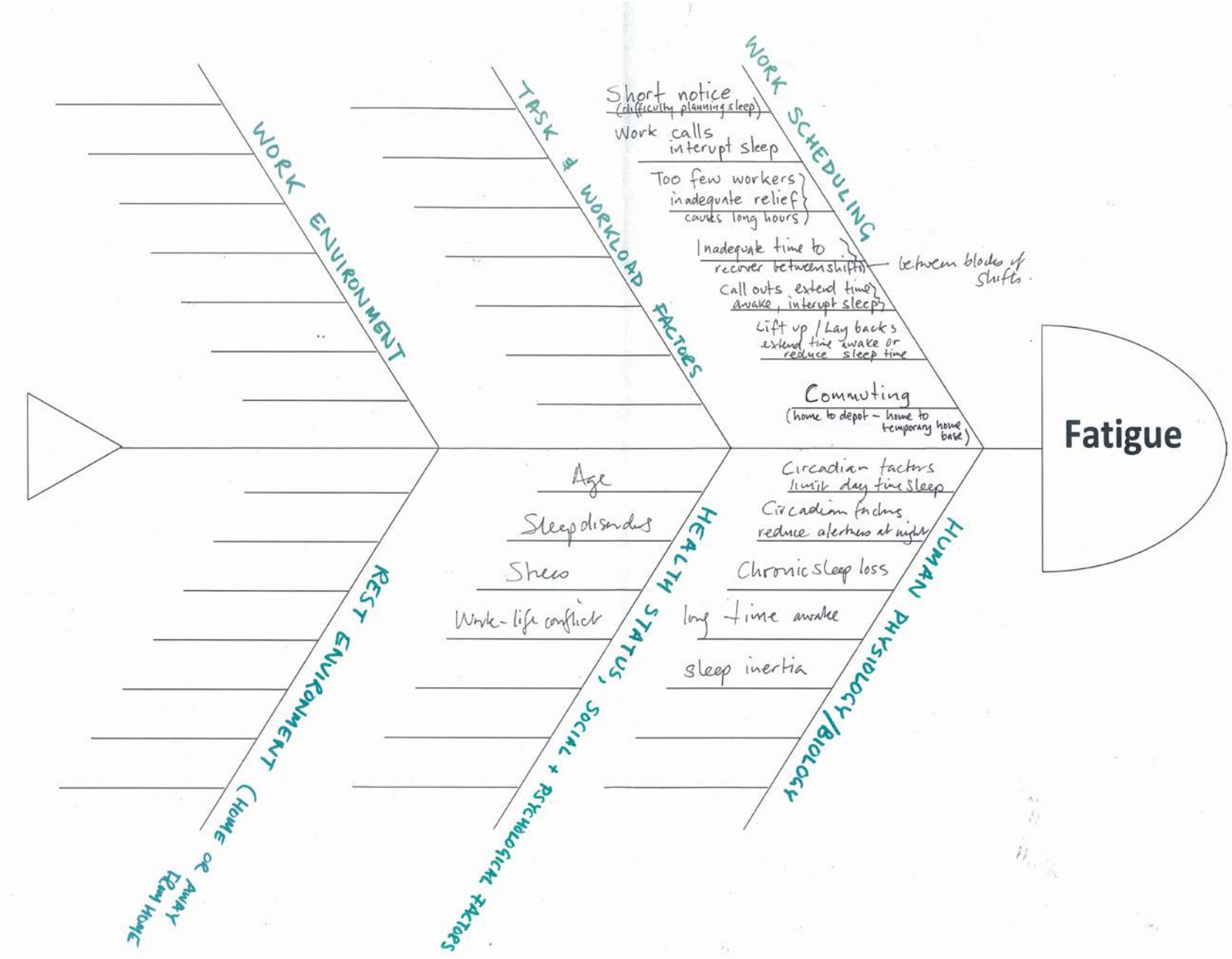


Fatigue risk management cycle

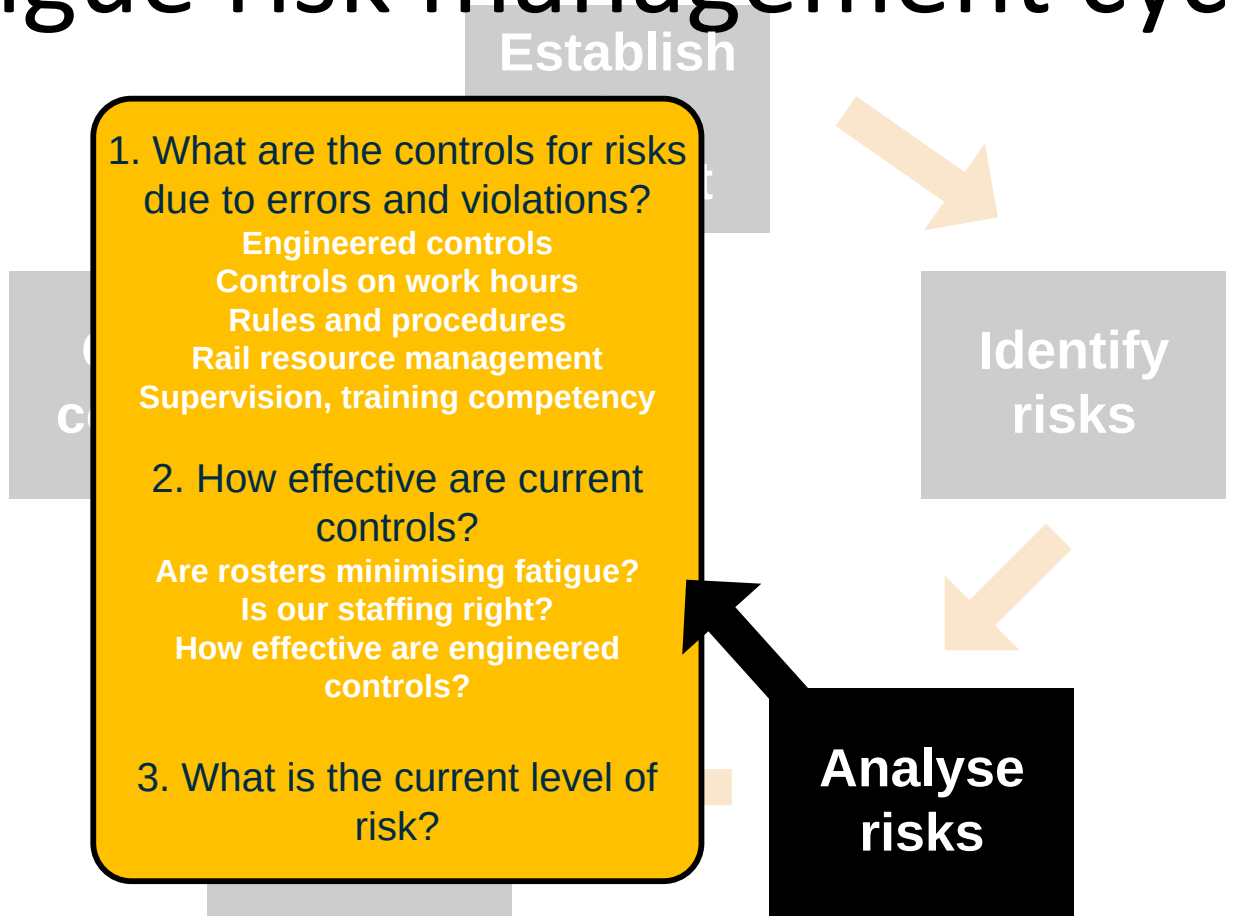


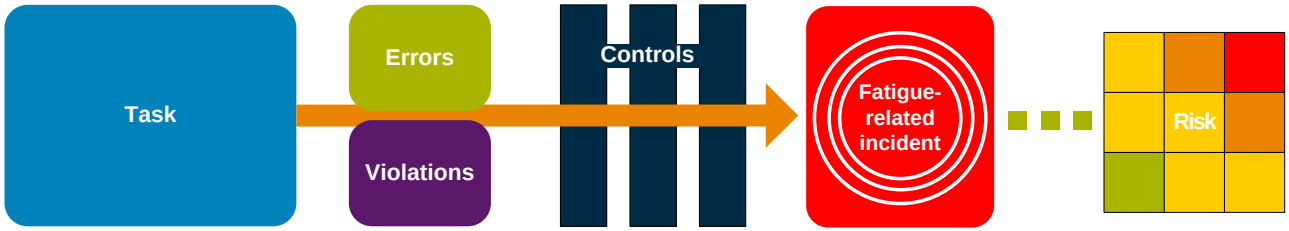
Fatigue risk management cycle



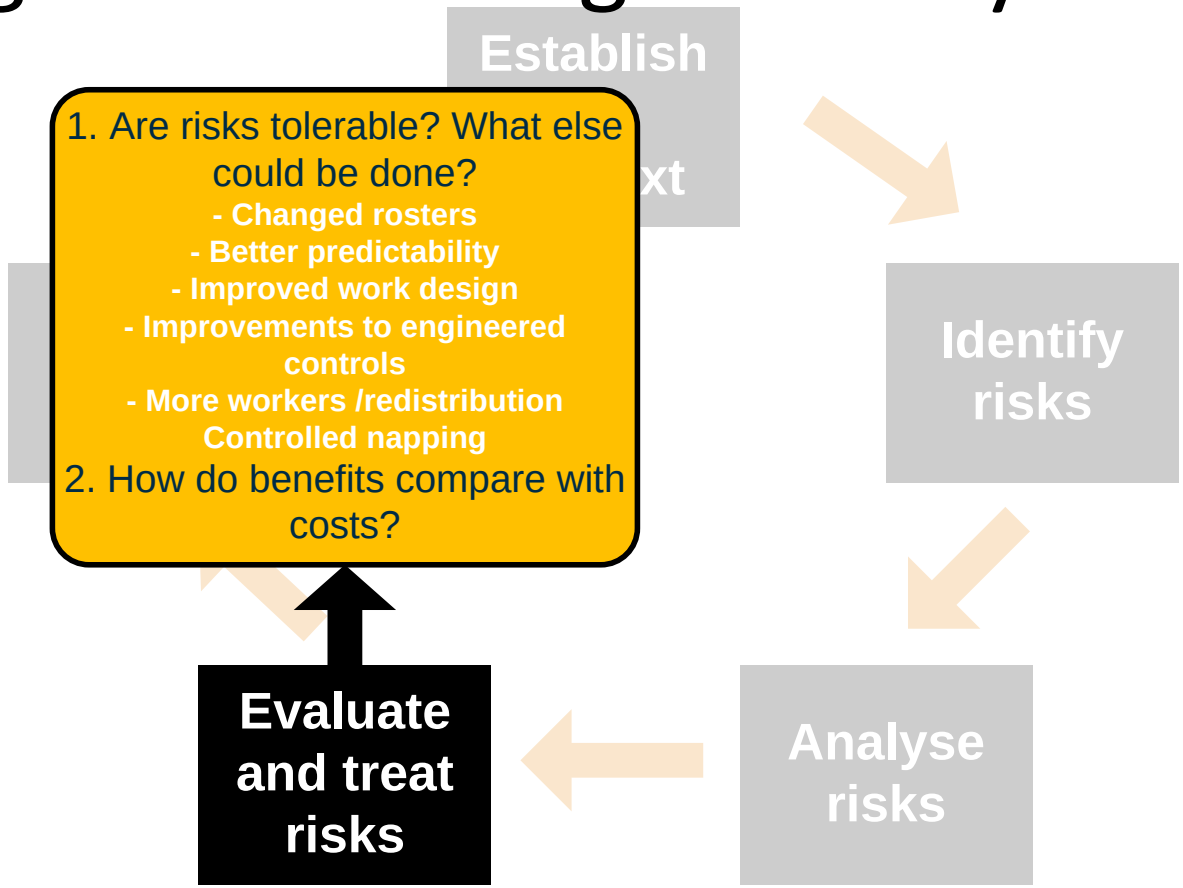

WORK ENVIRONMENT
TASK & WORKLOAD FACTORS
WORK SCHEDULING
Short notice (difficulty planning sleep)
Work calls interupt sleep
Too few workers inadequate relief causes long hours
Inadequate time to recover between shifts
between blocks of shifts
Call outs extend time awake, interupt sleep
Lift up / Lay backs extend time awake or reduce sleep time
Commuting (home to depot – home to temporary home base)
Fatigue
REST ENVIRONMENT (HOME or AWAY FROM HOME)
HEALTH STATUS, SOCIAL + PSYCHOLOGICAL FACTORS
HUMAN PHYSIOLOGY/BIOLOGY
Age
Sleep disorders
Stress
Work-life conflict
Circadian factors limit day time sleep
Circadian factors reduce alertness at night
Chronic sleep loss
long time awake
sleep inertia

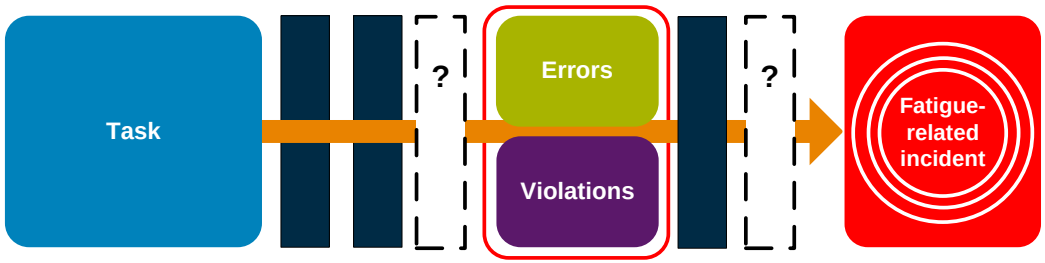
Fatigue risk management cycle



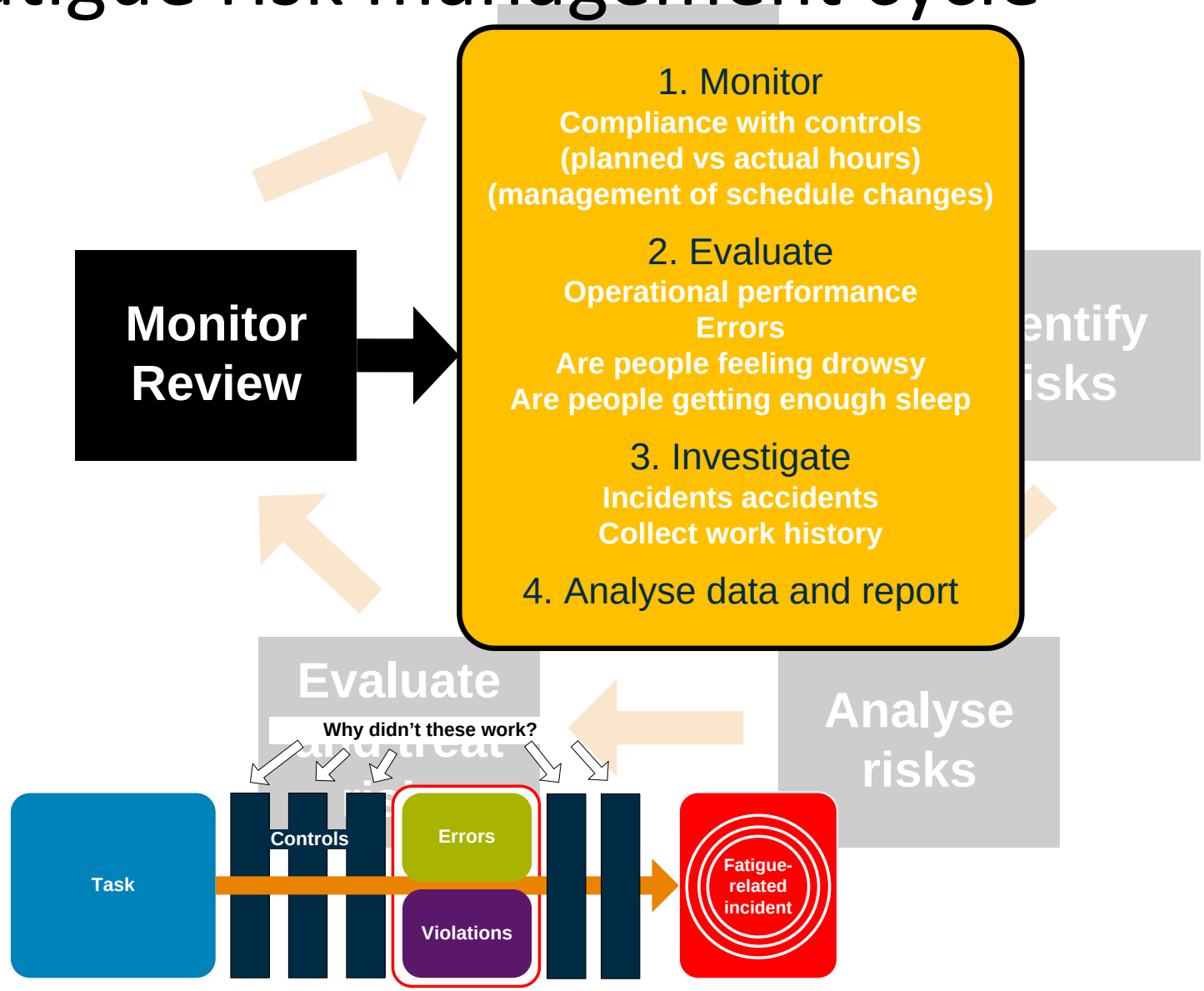


Fatigue risk management cycle

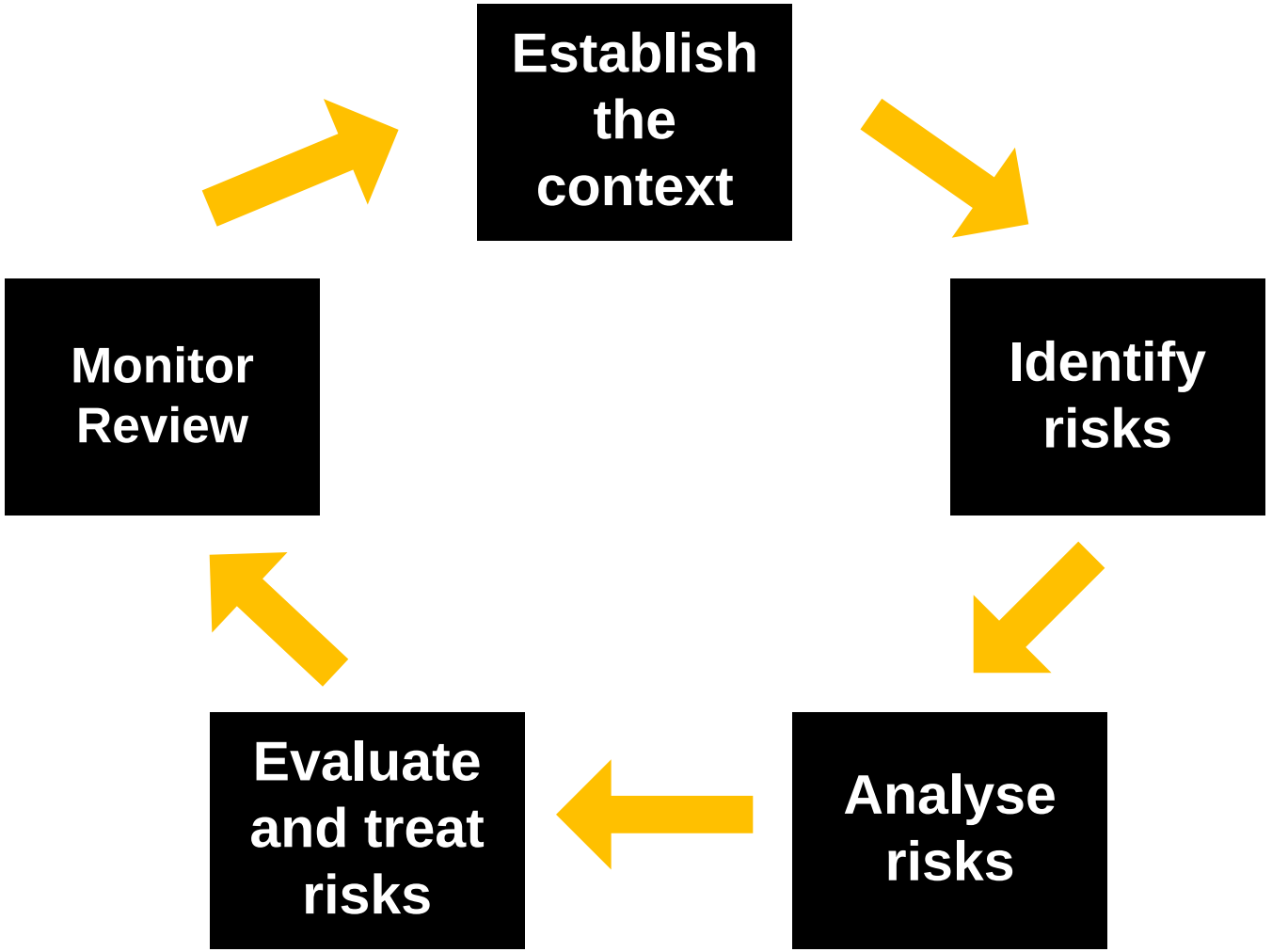




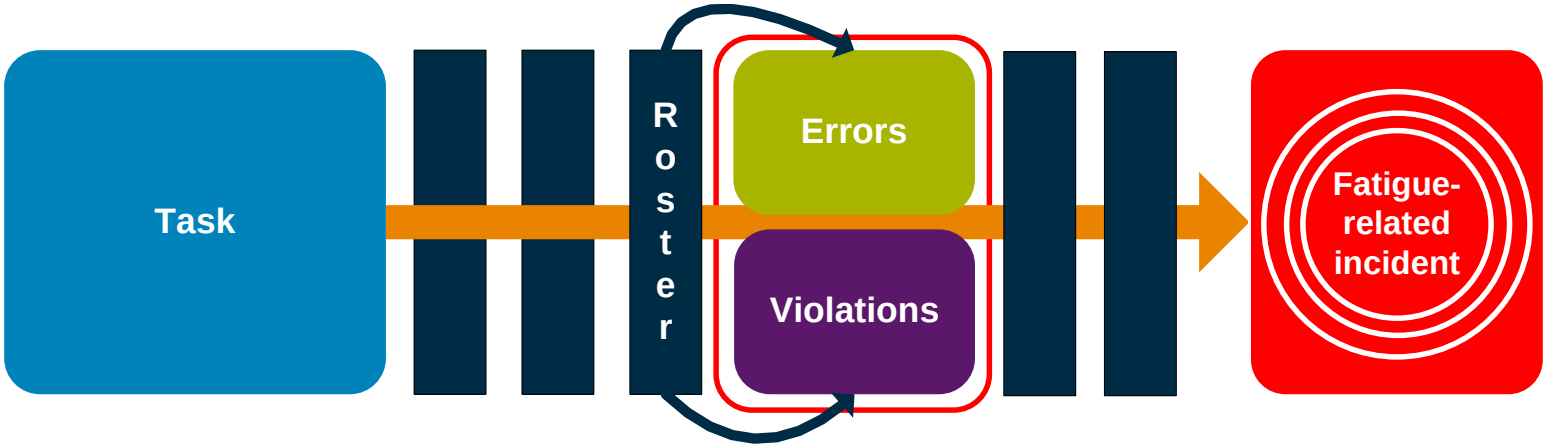
Fatigue risk management cycle



Same approach as for other risks



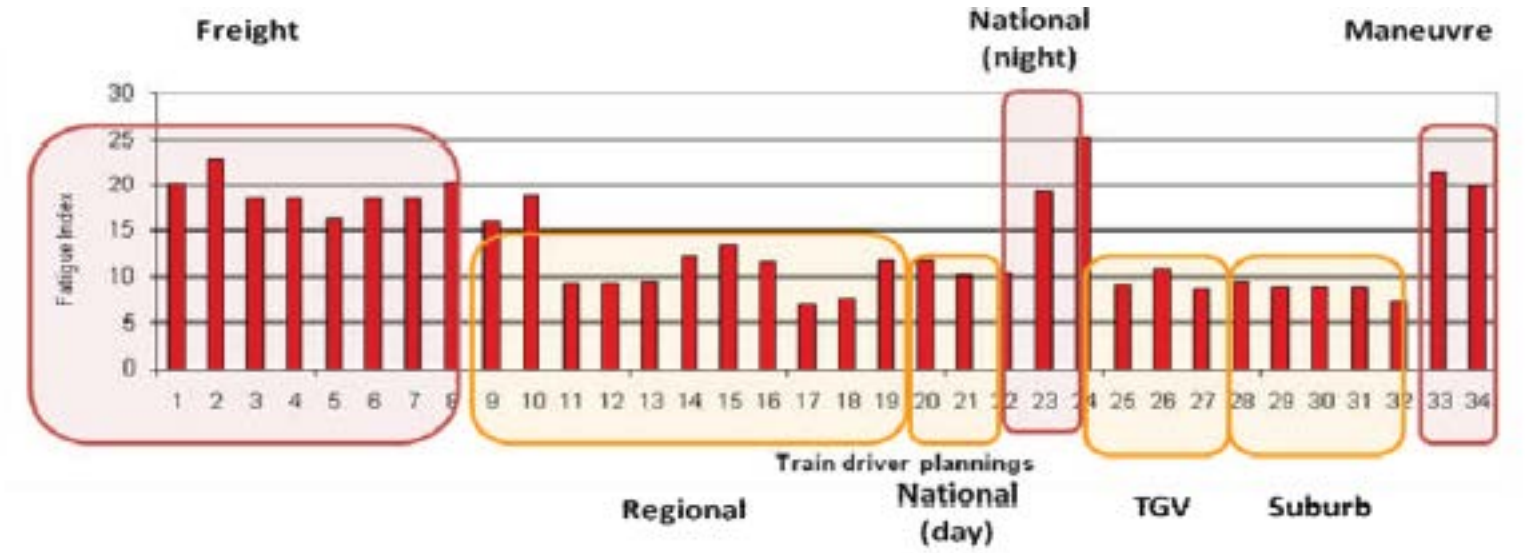
Fatigue models in risk management



- Not valid for individuals
- Different models predict different things
  - Fatigue (sleepiness),
  - Performance,
  - Incident risk
- Generally less predictive if continued sleep loss
- Rostering principles are essential

Use of fatigue models

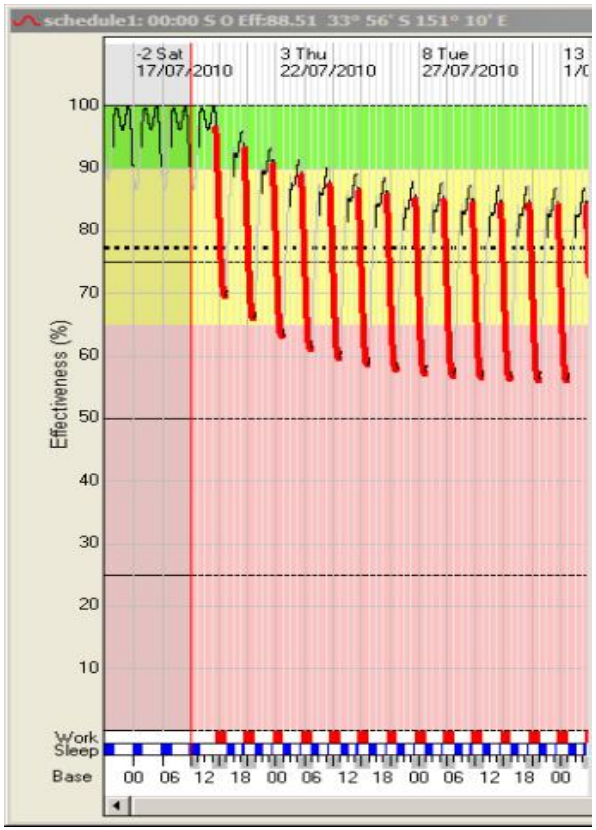
- Distribution of fatigue across business units
- Check staffing levels
- Analyse roster options

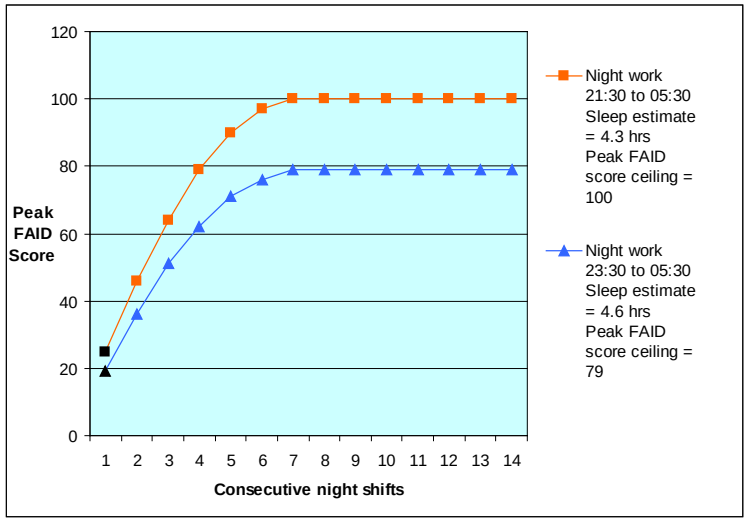


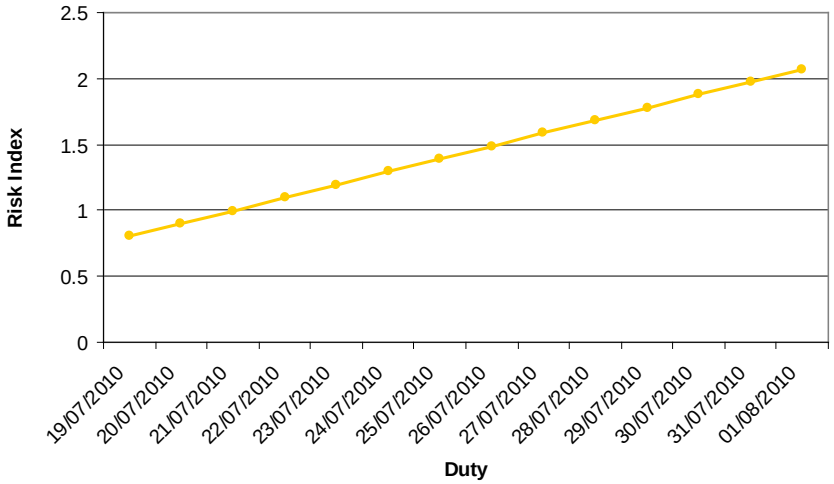
Source: Cabon, Lancelle and Mollard 2009

Use of fatigue models

Use for roster scenario testing





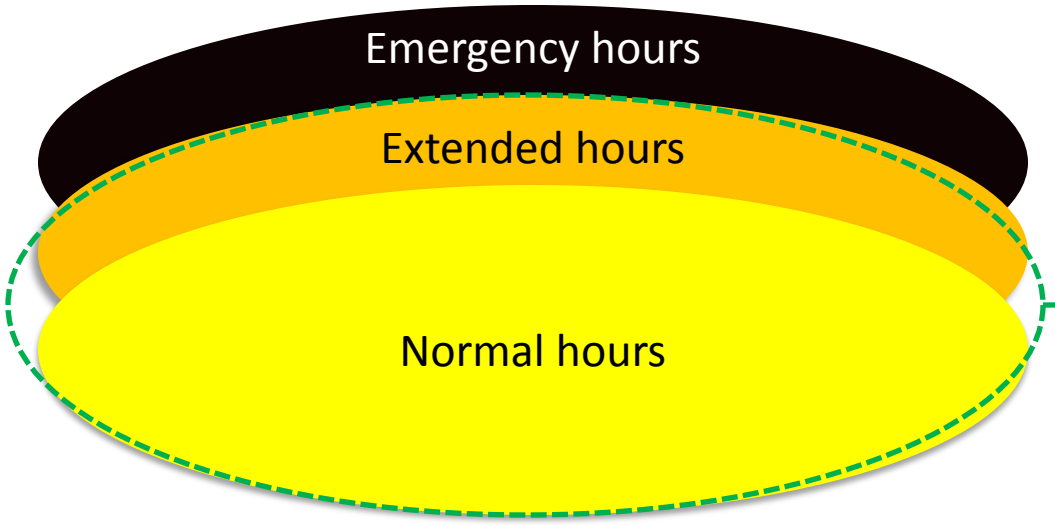


Establishing tolerable boundaries for hours of work (safe hours of work)

Regulation 29: *FRMP must specify work scheduling practices that provide for safe* hours of work*

**….hours are work taken to be safe if the effect of implementing those hours is sufficient to manage risks arising from fatigue SFAIRP*

Example scheme:



Tolerable boundary for *safe hours of work*

Example scheme:

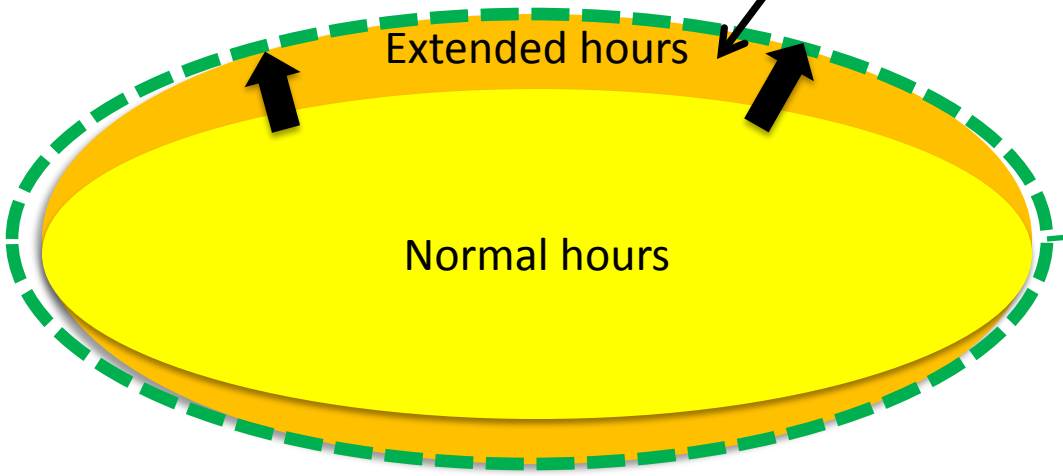
Normal hours

- Based on risk of tasks and foreseeable range of operating conditions
- Caters for leave, attrition, common delays and equipment failures
- Planned to cover majority of the work

Example scheme:

Extended hours
- Defined infrequent events
- Not foreseeable and no practical alternate

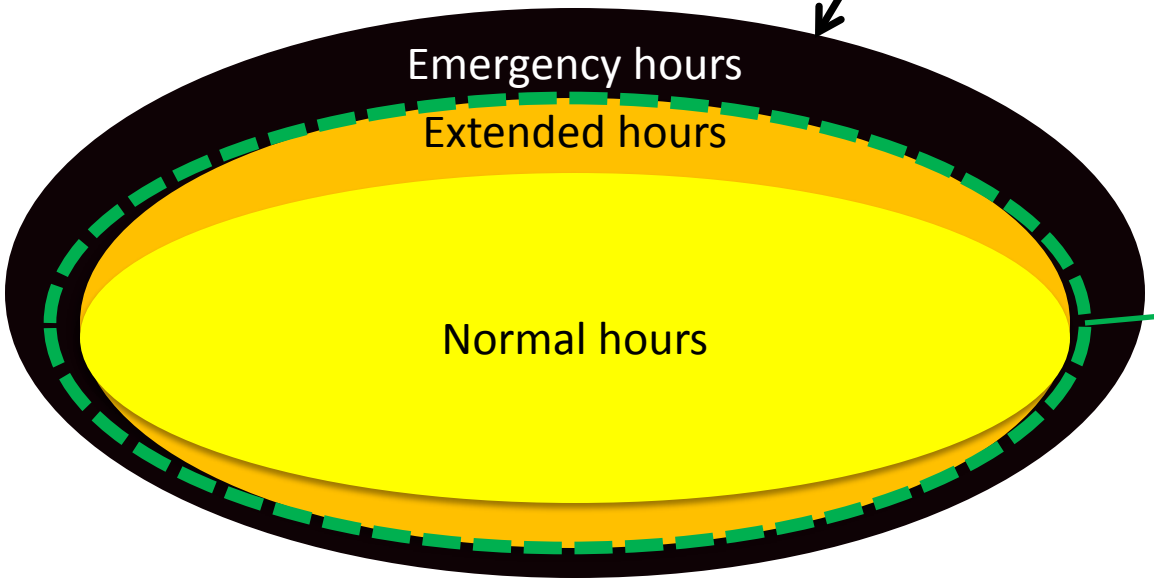
(eg major equipment/ infrastructure failure, breakdown, or unplanned leave & no reliever available)
- Undesirable but risk tolerable if exposure limited and additional risk controls



Tolerable boundary for *safe hours of work*

Example scheme:

Emergency hours
- Extraordinary events (accident or natural disaster or unusual event that affects network and multiple trains).
- Life threatening or extreme loss implications
- High risk due to combination of degraded human performance and technical systems
- Outside risk tolerance



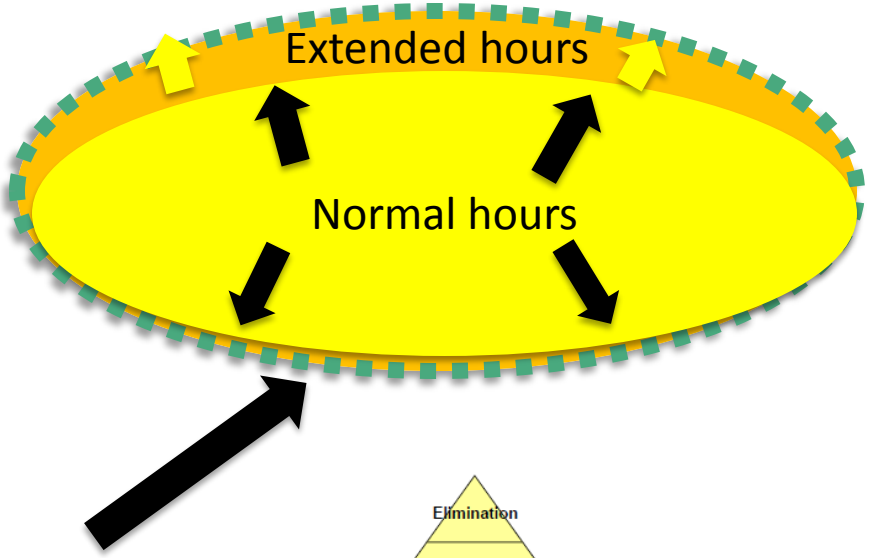
Tolerable boundary for *safe hours of work*

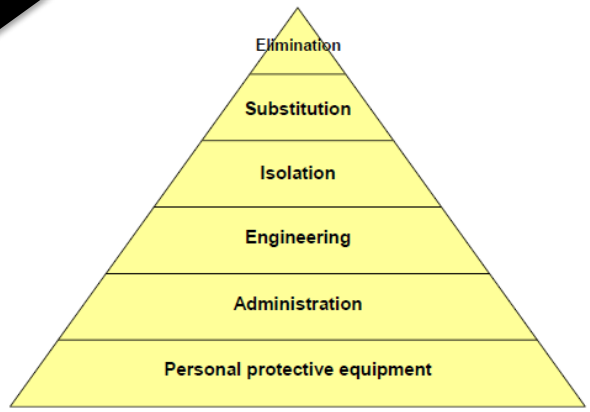
Boundaries determined by risk

Risk assessment has determined:

- High task related fatigue
- Unpredictable hours
- Unfavourable work environment
- Unfavourable rest environment
- Commuting long distances
- Systems not error tolerant
- Consequences of error are high
- …….
- ……

Decision: narrow envelope for tolerable hours



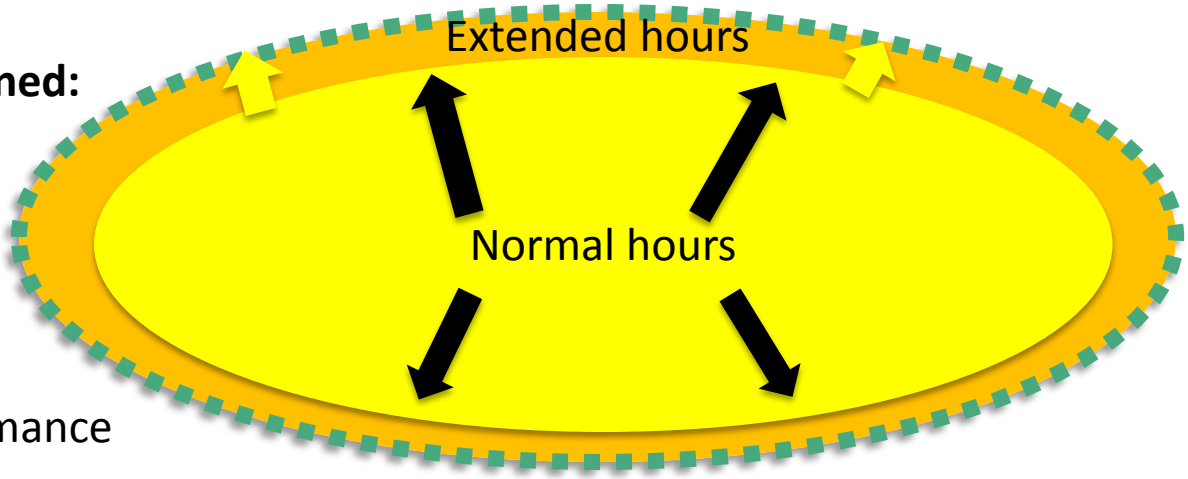


Boundaries determined by risk:

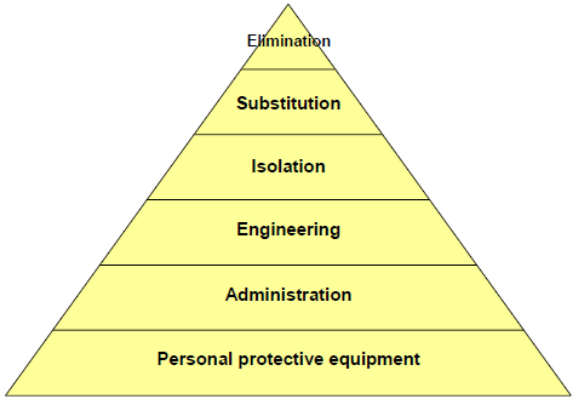
Risk assessment has determined:

- Lower risk tasks
- High number of rest breaks
- Opportunity for naps
- Error tolerant systems
- Safety assurance processes

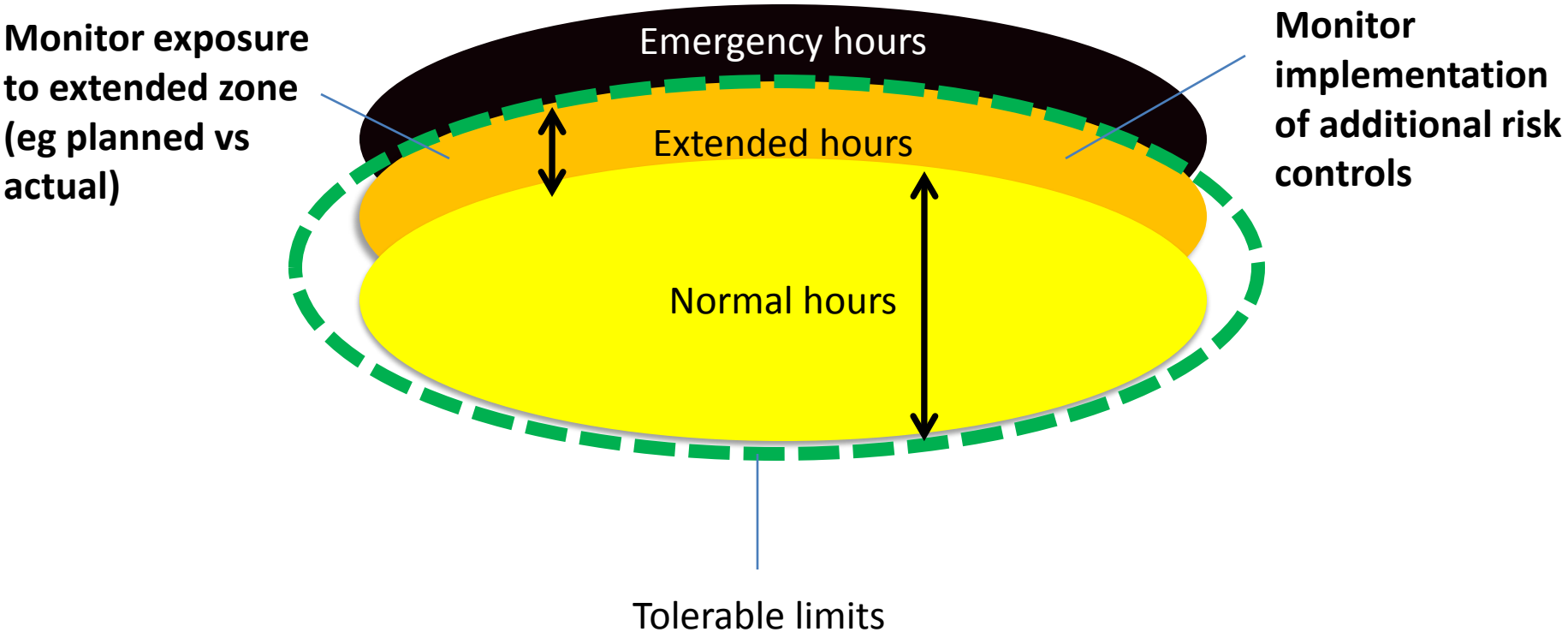
monitoring sleep and performance



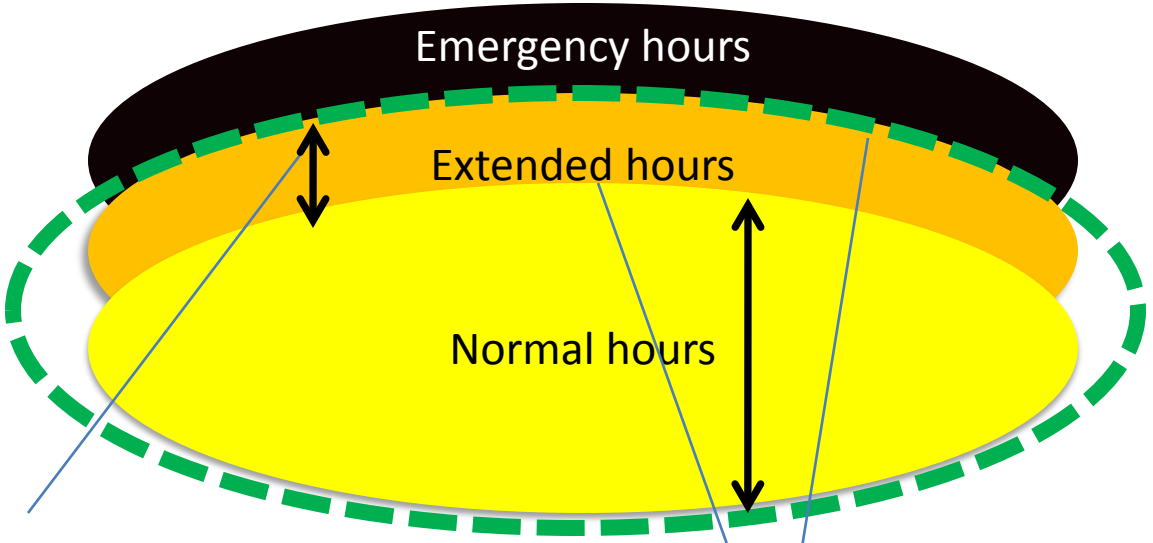
= wider envelope for tolerable hours



Monitoring (example)



Reporting (example)



Report breaches of tolerable limits as Cat B occurrences

Notify changes in boundaries of normal or extended

Achieving compliance: future ONRSR work

Future ONRSR Checklist (draft)

- RTO consults with workers in development/review of FRMP
- Identifies and assesses unique sources of fatigue:
  - Timing of work and breaks
  - Circadian and time awake factors
  - Time on task and workload
  - Call outs and on call
  - Commuting
  - Changes such as lift up and lay back
  - Staffing levels and relief
  - Work environment
  - Rest environment

Compliance checklist (draft)

- ❑ Assesses risk under normal/abnormal /degraded &emergency conditions
- ❑ Analyses tasks to identify main errors and violations and associated risks
- ❑ Identifies current controls for fatigue related hazards and risks
- ❑ Evaluates effectiveness of controls
- ❑ Identifies options for improved or new controls
- ❑ Rejects or adopts controls according to risk criteria

Compliance checklist (draft)

- Identifies tolerable boundaries of work scheduling practices
- Provides adequate staffing/relief
- Provides education/training to RSW
- Monitors compliance with risk controls
  - Planned vs actual hours
  - Changes due to overtime, shift swapping
- System to report scheduling breaches to ONRSR as Cat B
- System to report change boundaries of work scheduling practices

Resource: www.railroadersleep.org

Summary and conclusions

- **Theory of sleep**
  - Fatigue, safety and productivity
- **Fatigue risk management in practice**
- **Achieving compliance**
- **Next steps**
- **Have we met your needs and expectations?**
- **Any questions??**

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