SUSTAINED OPERATIONS MODE: A NOVEL STRATEGY FOR MANAGING FATIGUE DURING EXTENDED FIREFIGHTING OPERATIONS

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CONTEXTUAL BACKGROUND

Future demand characteristics

• Climate change fueled by global warming is expected to increase the frequency, duration and severity of extreme weather events, including bushfires.


• As a consequence, the frequency and length of firefighting campaigns, and the demands placed on personnel are likely to increase.

• In turn, increased demand on personnel poses a greater likelihood of incidents and accidents caused by fatigue.
The broad aim of the ‘sustained operation mode’ project is to:

1. propose an alternative rostering strategy for managing fatigue within the context of increasing demands, and

2. to compare the fatigue implications of these novel strategies with that of existing practices

Ultimately, we hope to evaluate whether the existing rostering strategy is still the best option to manage fatigue given added demands or if there any alternative or complimentary strategies that might be beneficial.
Fatigue. Diminished capability to perform mental and/or physical work due to inadequate rest, and in particular lack of sleep.

- The current rostering strategy usually employs two teams who work either continuous 12-hour day shifts or continuous 12-hour night shifts.

- This rostering strategy ensures that operations can be staffed round-the-clock, but is potentially problematic because it requires some personnel to work continuous night shifts.
Industry reports submitted to the 2009 Royal Commission cited fatigue due to inadequate rest as a threat to safety on the fireground and during commute.


- **Results:** Personnel working the 12-night shift:

1. were frequently **awake in excess of 24 hours** during the initial deployment:
   - time awake prior to the call for deployment
   - commute time to the fireground
   - the first 12-hour night shift

2. some reported obtaining an **average of only 3-4 hours of sleep** on subsequent days of deployment.
• Sleep loss of this magnitude is not sustainable for longer than a few days, and is generally associated with:
  • High levels of subjective fatigue
  • Poor performance on basic neurobehavioural and cognitive tasks
  • Poor safety outcomes

• Recovery from the effects of fatigue requires a minimum of two full-nights of sleep, where roughly 7-8 hours of sleep is obtained on each night

• In the absence of recovery sleep, the extent of performance deficits depends on the extent of ongoing sleep loss
  • if daily sleep is reduced but > 5-6 hours, then performance efficacy will be diminished but remain relatively stable across days
  • if daily sleep loss < 5 hours, then performance efficacy will continue to degrade across days until profound exhaustion is reached
# SUSTAINED OPERATIONS ROSTERS

## Split-shift systems

### STANDARD 12-HOUR SCHEDULE

<table>
<thead>
<tr>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team 1</td>
<td>work</td>
<td>rest</td>
<td>work</td>
</tr>
<tr>
<td>Team 2</td>
<td>rest</td>
<td>work</td>
<td>rest</td>
</tr>
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<td>rest</td>
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### SUSTAINED OPERATIONS MODE

6-hour ON, 6-hour OFF

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<td>work</td>
<td>work</td>
</tr>
<tr>
<td>Team 2</td>
<td>rest</td>
<td>rest</td>
<td>rest</td>
</tr>
</tbody>
</table>

8-hour ON, 8-hour OFF

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SUSTAINED OPERATIONS ROSTERS

Split-shift systems

**Examples**
- naval setting (6-hour watch systems)
- rail industry (8-hour ON, 8-hour OFF)
- military operations (varied)

**Under investigation...**
- space operations (National Aeronautics and Space Administration)
- truck drivers (Federal Motor Carrier Safety Administration)
SUSTAINED OPERATIONS ROSTERS

Split-shift systems

• Instead of standard operations, i.e. replacing 12-hour shift system with a 6-hour or 8-hour shift system for specific groups (e.g. incident management teams)

• In conjunction with the standard operations to manage acute fatigue-risks, such as:
  
  • the start-up phase of deployments, i.e. getting personnel from home to the fireground and onto a standard shift rotation in a fit state

  • transition personnel between day and night shifts, i.e. managing staff transition due to mental and/or physical fatigue or physical injury

  • the closing phase of deployments, i.e. to ensure personnel are in a fit state prior to leaving for home
CAUSES OF FATIGUE
Basic physiological processes

- **Internal body-clock**
  - generates a 24h rhythm in fatigue
  - anchored to the external day/night cycle

- **Sleep/wake cycle**
  - time spent awake
**CAUSES OF FATIGUE**

Basic physiological processes

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CAUSES OF FATIGUE
Basic physiological processes

Team 1
Team 2

DAY 1       DAY 2       DAY 3       DAY 4

07 15 23 07 15 23 07 15 23

FATIGUE

Team 1
Team 2

2 hrs

7 am

Fatigue level

Fatigue level

Time spent awake

Time of day

CAUSES OF FATIGUE
Basic physiological processes

Fatigue level

Time spent awake

Fatigue level

Time of day

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CAUSES OF FATIGUE
Basic physiological processes

Team 1
Team 2

DAY 1  DAY 2  DAY 3  DAY 4

07 15 23 07 15 23 07 15 23

FATIGUE

07 15 23 07 15 23 07 15 23

Time spent awake

Fatigue level

Time of day

Fatigue level

8h
6h
4h

4h
8h
6h

Fatigue level

Time of day

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THEORETICAL ADVANTAGE

6-hour split-shift system

Fatigue level vs. Time of day

Team 1
Team 2

DAYS

D1 D2 D3 D4

07 15 23 07 15 23 07 15 23 07 15 23

Time spent awake

Fatigue level vs. Time of day
SPECIFIC OBJECTIVES
Investigations of short-shift routines

- Any wholesale adoption of short-shift sustained operations mode would require substantial redesign of operation practices.
- This would have implications for fireground logistics and increase the number of staff handovers.
- The specific purpose of this project, therefore, is to establish the basic sleep and fatigue implications of sustained operations rosters.
EMPRICAL INVESTIGATIONS

Study protocols

- **Experimental protocol**

A. Investigate the basic sleep and performance outcomes when working in sustained operations mode
   - healthy young adults
   - performance measures that assess basic neurobehavioural and cognitive functions

B. Compare sleep and performance during a standard 12-hour and a sustained operations roster
   - firefighters
   - performance measures that are relevant to firefighting
Research objective A

Determine the sleep and performance outcomes for healthy young adults working sustained operations rosters

Laboratory protocol

Imposed sleep during sustained operations

Sleep measured via brain waves

Performance measured via 1-hour test batteries

- Vigilance
- Cognition
- Mood
- Sleepiness
- Balance

Repeat ×7
Research objective A

Determine the sleep and performance outcomes for healthy young adults working sustained operations rosters

Laboratory protocol

Imposed sleep during sustained operations

Levels of imposed sleep restriction

Data already collected in a separate study
**Research objective A**

Determine the sleep and performance outcomes for healthy young adults working sustained operations rosters

**Laboratory protocol**

Imposed sleep during sustained operations

- **4-hour**
- **4-hour**

Levels of imposed sleep restriction

- **8-hour**
- **6-hour**
- **4-hour**
Research objective B

Compare sleep and performance for firefighters during a standard 12-hour and a sustained operations roster

Laboratory protocol

Sustained operations

- Sleep measured via brain waves
- Performance measured via industry relevant tests

Repeat x4
Research objective B

Compare sleep and performance for firefighters during a standard 12-hour and a sustained operations roster

Laboratory protocol

Sustained operations

12-hour ‘day shift’

12-hour ‘night shift’
1. Collect the basic scientific evidence and peer-reviewed publications to support any future safety case for the use, or trial of, a sustained operations mode in firefighting.

2. Develop a general mathematical model for predicting the fatigue implications of sustained operations rosters.