

FIRE NOTE

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SHIFT LENGTH: WHEN LESS IS MORE



▲ Research findings will provide fire managers with new knowledge to help firefighters battle longer bushfire events.

Photo: CFA

SUMMARY

This research is investigating whether shorter, more frequent shifts (referred to as sustained operations shift work) are a better alternative to regular day and night shift rosters that are currently used by fire and land management agencies in Australia. The research team developed a testing procedure that evaluates the fatigue and mental performance implications of shorter, more frequent shifts over a nine-day period. If results support the usefulness of sustained operations shifts, such shifts could be trialled for the duration of a deployment, or periods within the deployment, to reduce the risk of fatigue, incidents and accidents. Data is currently being analysed and findings will be communicated in a future *Fire Note*.

ABOUT THIS PROJECT

The *Firefighter health and safety: beyond endurance sustaining operations* project is conducted under the Bushfire CRC theme *Managing the threat*.

AUTHORS

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CONTEXT

This project has two core aims:

- i) To determine the implications of sustained operations modes of shift work on fatigue, mental performance, and mood.
- ii) To develop biomathematical models to predict the fatigue implications of sustained operations rosters across different operational contexts.

The findings of this research will provide fire managers with initial research on the potential use of sustained operations rosters for firefighters and incident management teams during catastrophic bushfire events.

BACKGROUND

Three factors have been identified as being most associated with reduced mental performance and heightened risk of workplace accidents. These are:

- i) A high number of consecutive days on shift.
- ii) Working at night.
- iii) Working in excess of eight hours per shift.

Multi-day bushfire deployments, with the need for continuous, around-the-clock operations, often expose emergency service workers to all of these factors. In addition to atypical hours of work, these operations frequently occur in remote locations and involve intense physical and/or cognitive workloads, plus isolation from family and social supports (Cater *et al.*, 2007). Working environments that require round-the-clock operations have traditionally used shift work rosters that provide one longer period of work and one primary sleep opportunity per 24-hour period. A common strategy has been to implement 12-hour on/12-hour off schedules, which have the advantage of 24-hour coverage with as little as two teams of workers. However, meta-analyses of the literature around shift work and fatigue risk indicate that time spent on shift greater than eight hours and working at night are both significant contributors to fatigue (Folkard *et al.*, 2005). As such, these longer day and night shift rosters may place individuals – especially

those working at night - at greater risk for fatigue-related accidents and reduced mental performance.

A 'sustained operations mode' of work is proposed to manage those operations that demand high cognitive (e.g. incident management teams) and/or high physical (e.g. front line personnel) workloads. This mode of operation divides the day into multiple work and rest cycles, so that individuals can work multiple short shifts (i.e. two x six-hour shifts) intervened by short rests (i.e. six-hour rests) every 24 hours.

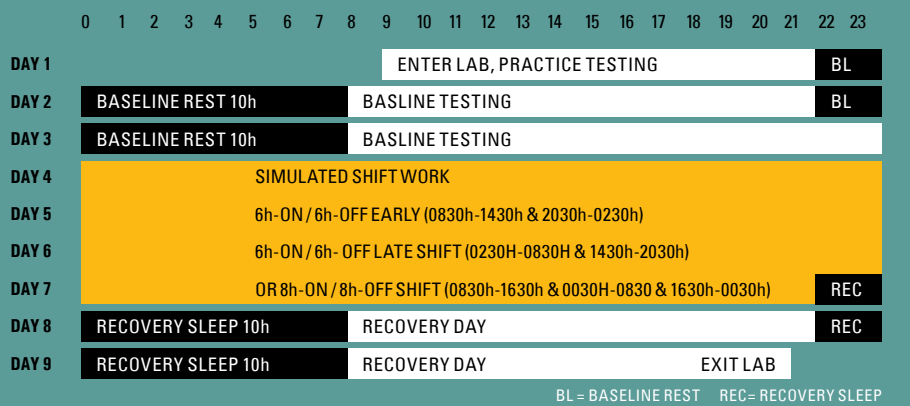
Sustained operations rosters are rosters in which individuals work at least 50% of each work day in frequent, short shifts for two or more consecutive days. These rosters are currently used in different industry contexts, such as six hours on/six hours off ship watch systems or eight hours on/eight hours off shifts of long-haul train drivers (Darwent *et al.*, 2008; Eriksen *et al.*, 2006; Jay *et al.*, 2006; Harma *et al.*, 2008). Despite the use of sustained operations rosters in various industries, the research into the sleep and fatigue effects of these roster systems is limited.

While the challenges of night shift work cannot be eliminated, the potential advantage of sustained operations is that everyone gets at least some sleep opportunities at night and they do not have to sustain alertness for longer than six to eight hours. Thus, these novel rosters may bolster mental performance by substantially reducing time-on-shift fatigue. To date, however, no laboratory-based protocol has been conducted to directly evaluate the effects of sustained operations rosters on individual's sleep, mental performance and fatigue.

LITERATURE REVIEW

The factors described previously are detailed in a bushfire instance in a report by Cater *et al.*, (2007). The report describes the experience of Victorian Department of Primary Industries staff (now the Department of Environment and Primary Industries) during the Great Divide bushfires in 2006/2007, highlighting the numerous factors negatively impacting on firefighters sleep, thus increasing fatigue. The report detailed the very long hours of work, often in excess of 12 to 14 hours per day, and due to the need for 24-hour fire suppression, a high proportion of firefighters were required to work consecutive night shifts. Most firefighters reported beginning the deployment with a significant sleep debt and fatigue, and ongoing chronic sleep loss across the deployment, resulting in high levels of fatigue. This was particularly the case for firefighters working night shift who were attempting to sleep during the day against their usual sleep pattern. Night

FIGURE 1: SCHEMATIC OF THE SUSTAINED OPERATIONS SIMULATION



HOW SLEEP AND SLEEP QUALITY IS MEASURED

Sleep is measured objectively using polysomnography, or PSG. This involves recording brain, eye and muscle activity using small electrodes that sit on the surface of the skin. PSG allows researchers to determine the length of sleep, stages of sleep, and aspects of sleep quality, such as how long it takes someone to fall asleep, and how often and for how long they are awake during the sleep period. PSG is the most reliable method of measuring sleep, particular when compared to subjective reports of sleep, which are prone to a number of biases.

workers frequently reported accommodation that was too noisy, too light and too hot to allow for quality sleep.

Similar studies have been undertaken in other fields that involve working for long periods where a high level of concentration is required.

Studies of Australian train drivers working eight hours on/eight hours off shifts found that while total sleep was reduced on these schedules when compared to sleep at home, sleep quality was not diminished. Most importantly, performance was not impaired (Darwent *et al.*, 2008; Jay *et al.*, 2006). One study of bridge officers on ships found that those schedules where the proportion of time spent working per work/rest period was lower (i.e. more time was spent resting on shift, rather than working), tended to allow more sleep to be obtained per 24 hours (Harma *et al.*, 2008). However, this varied substantially between studies, and even among those with identical shift timing and duration. It is likely additional factors, such as the appropriateness of the sleeping environment, the observation of shift finish times, and whether shifts are fixed or rotating, may account for some of this variability.

While literature exists around sustained operations shift work, this work has predominantly described the effects of a particular sustained operation schedule. To effectively evaluate the comparative benefits or implications of different schedules, the use of comparison groups or conditions, or comparison to baseline performance, is required. In addition, few studies have included performance measures. Previous research has shown that sleep-restricted individuals experience plateaus in subjective sleepiness and fatigue, while performance deficits continue to increase. As such, the inclusion of metrics in addition to sleep and subjective sleepiness is warranted, especially measures of objective performance and polysomnography (PSG, see breakout box, left) to objectively measure sleep.

BUSHFIRE CRC RESEARCH

The present program of research uses a rigorous protocol, designed in collaboration with project lead end user Robyn Pearce from the Tasmania Fire Service, to evaluate the fatigue and performance implications of shorter, more frequent shifts. Three shift work rosters were simulated at the University of South Australia Centre for Sleep Research laboratory: a six-hour on/six-hour off early shift, a six-hour on/six-hour off late shift, and an eight-hour on/eight-hour off shift. Research participants were healthy adults who volunteered to take part in the study. Each shift roster spanned nine days and eight nights. The first two days and nights were for adaptation to testing protocols and obtaining baseline measurements, while the following four days and nights were spent working one of the three shift work rosters. The final three days and two nights assessed recovery following the shift work.

WHAT IS BEING TESTED?

As the applied focus of this research is for potential use by incident management teams, the primary outcomes of interest are cognitive (mental) or performance-based. Further information on how cognitive performance

is measured is outlined below, as is subjective fatigue (how tired an individual perceives themselves to be). Additional tests measure sustained attention, reaction speed, risk-taking, cognitive processing speed, memory and mood. Most of these measures are tested every two hours when participants are awake. These measures tap into those attributes and capabilities central to the effective functioning of incident management teams. Due to the established link between sleep, fatigue and performance, all sleep periods are measured using PSG, which is the gold standard for the objective measurement of sleep (see breakout box, page 2).

COGNITIVE PERFORMANCE - PSYCHOMOTOR VIGILANCE TASK

The Psychomotor Vigilance Task (PVT) is a sustained attention reaction time task. Participants fixate on a computer screen and are required to press a button when a stimulus appears. Inter-stimulus intervals range from two to 10 seconds. Each test lasts for 10 minutes, from which PVT lapses (reaction times greater than 500 milliseconds), and speed (fastest 10% of reaction times, abbreviated to FS10%RT) were calculated. PVT speed provides an indication of how quickly an individual is able to respond to a stimulus, while PVT lapses offer an indication of an individual's ability to sustain attention. Both PVT speed and lapses are sensitive to sleep loss and amenable to multiple tests. The ability to sustain attention and respond to stimuli in a timely fashion is important to a variety of higher-order cognitive functions. These measures have excellent reliability and validity.

SUBJECTIVE FATIGUE

The Samn-Perelli 7-point scale of fatigue was used to assess levels of fatigue. This scale consists of seven numbered descriptors, ranging from 1 ('fully alert, wide awake') to 7 ('completely exhausted, unable to function'). Participants are asked to select the descriptors that most closely reflect their fatigue at that time.

The nature of sustained operations deployments is highly variable. Between deployments, there are substantial variations to the length of deployment, as well as travel times between accommodation and the fireground or work location. To account for these variations, biomathematical modelling is applied to provide information regarding how sustained operations shift work may apply in different operational settings.

HOW COULD THIS RESEARCH BE USED?

If results support the usefulness of short, frequent shifts, there are a number of ways that this research could potentially be used.

Sustained operations shifts may be of use in



▲ The study is investigating if shorter, more frequent shifts will help reduce fatigue on the fire ground.

Photo: CFA

END USER STATEMENT

Emergency service agencies face significant challenges resourcing long campaign incidents – whose duration ranges from several days through to many weeks. Agencies need resource strategies for long duration bushfire seasons that allow firefighters and incident management teams to achieve high level performance safely. We need to understand the impact of differing shift lengths on our people as it could offer different options to agencies on how they deal with resource challenges while keeping both our people and the community as safe as possible. This type of research is new to the emergency services industry and will encourage consideration of alternative models of working hours for our people.

– Robyn Pearce, Director Human Services, Tasmania Fire Service

situations where long deployments indicate heightened fatigue risk. As such, this type of shift system could be used for the duration of such a deployment. Alternatively, sustained operations shifts could be implemented at the beginning of a deployment, as this is a time when it is recognised that long periods of wakefulness are often combined with long travel times. Sustained operations shifts may help to minimise further time-on-shift fatigue and prompt opportunity for recuperative sleep.

Sustained operations shifts could also be implemented towards the end of a deployment. This could help provide adequate opportunities for all workers to obtain adequate sleep prior to the drive home. Finally, sustained operations shifts could also be used in the middle of traditional 12-hour on/12-hour off shift. One six hours on/six hours off shift in the middle of a traditional 12-hour day and night shift roster effectively rotates the day and night shift teams without extending waking hours or reducing the sleep opportunity of either team. Rotating the roster may help to reduce the chronicity and severity of fatigue associated with consecutive night shifts.

EXTENDING THIS RESEARCH

Additional work is being conducted by doctoral and honours students at the University of South Australia, some of whom are affiliated with the Bushfire CRC. This will support and extend the core work into sustained operations shift work.

This research is investigating:

How long does it take to regain cognitive functioning after being woken from sleep?

Sleep inertia is the term used to describe the brief period of grogginess, disorientation and impaired cognitive performance after waking from sleep. This period of impaired performance and low subjective alertness typically dissipates within 30 minutes to pre-sleep levels, although some studies have observed asymptotic recovery lasting two to four hours. Bushfire CRC associate PhD



▲ Research involved simulated shift work over nine days.

student Cassie Hilditch is evaluating the time course and severity of impairments immediately following wakening.

How long does it take to recover from a period of sustained operations shift work?

Performance deficits may remain for several days following a period of shift work. This is a particular concern given that driving while fatigued (i.e. from the fire ground home after a deployment) has been identified as one of the largest risk factors to which firefighting personnel are routinely exposed (Cater *et al.*, 2007). Bushfire CRC associate PhD student Stephanie Centofanti is evaluating how long it takes for individuals' performance and mood to return to baseline levels after sustained operations shift work.

What are the physiological implications of sustained operations shift work?

As well as the detriments to sleep and performance associated with shift work, researchers are becoming aware of similar

negative effects to aspects of physiological functioning. This study measures the stress hormone, cortisol, together with glucose metabolism and blood pressure at baseline and following simulated shift work to determine potential physiological implications.

What factors predict an individual's adjustment to sustained operations shift work?

There are marked individual differences in individual's abilities to deal with work undertaken at different hours. Some people manage shift work very well, while others fall ill or cannot cope with the fatigue after only a short amount of shift work. Honours student Alex Agostini is examining whether age, personality factors, or being a 'morning-type' or 'evening-type' can predict how well an individual tolerates sustained operations shift work.

All of these have applied ramifications for industry practice and will broaden the understanding of the implications of sustained operations modes of work.

REFERENCES /FURTHER READING

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FUTURE DIRECTIONS

This is the first study of its kind to evaluate the use of these different shift work systems in a rigorous, controlled environment, using measures relevant to the cognitive demands of incident management and firefighting. Data collection is completed and data analysis is well underway, with findings to be reported in a future *Fire Note*. If supported, this research could provide incident managers with an evidence base to support sustained operations shift work as an alternative to the traditional 12 hours on/12 hours off shift model to manage the fatigue-related risks associated with long deployments.

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