final report

Project code: B.NBP.0386

Prepared by: Warwick Yates and Associates Pty Ltd

Date published: June 2008

ISBN: 9781741914757

PUBLISHED BY
Meat and Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Development of a driver fatigue management scheme for remote area livestock transport

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Abstract

The Northern Beef industry relies on effective livestock transport systems to move cattle from northern breeding areas to either live export or to southern grow out or feedlots. Recent changes in Federal driver fatigue regulations would impose driving regulations that would add significant costs to the industry by not recognising the distinct differences between livestock and line haul transport.

This study differentiates remote area livestock transport activities and provides a scientific basis for a Remote Area Livestock Transport System (RALTS) that will be the basis of a driver and company accreditation program to effectively manage driver fatigue within the remote area livestock transport sector in Northern Australia

Executive summary

The National Transport Commission (NTC) has issued new regulations (for adoption by States and Territories) limiting hours of work for truck drivers, and imposing a chain of responsibility on management and customers of road freight to ensure enforcement. There are three "optional" regimes of limits on hours, and the options providing greater flexibility are accompanied by requirements for risk based fatigue management systems.

The option providing most flexibility – Advanced Fatigue Management (AFM) – has "outer limits" of 16 hours work per day, and a requirement for 6 hours continuous rest (or two four hour rests) every 24 hours.

However the proposed regulatory arrangements do not meet the needs of remote Australia livestock transport drivers, whose driving regime is set by both the haulage task distances and the welfare of the livestock. These dictate that the cattle must be spelled every 30 hours, and more relevantly, they cannot be left penned in truck during the heat of the day while a driver takes a four hour rest break in the afternoon. These drivers – and this industry – are seeking exemptions to the AFM regime by formulating a fatigue management program to control the inherent risks of the longer working hours.

The purpose of this project was to develop a driver fatigue management scheme for remote area livestock transport operators that will improve safety while preserving cattle industry viability. This scheme will be submitted for approval to the NTC under proposed exemption provisions.

The study involved a number of stages including:

- A scoping and planning project involving key North Australian pastoral companies and the major livestock transport companies operating in the triple bottom road train area
- Independent confidential survey of remote area livestock transport drivers to establish driver requirements and lifestyle profiles
- Monitoring of drivers undertaking remote area livestock transport operations using Actigraph technology to establish work and sleep patterns
- Development of a sleep quality fatigue likelihood assessment, risk analysis and risk mitigation options
- Development of the components that make up the RALTS program package integrating and adding to existing codes of conduct and accreditation procedures
- Review of the proposed RALTS program by pastoral and livestock transport companies
- Review of the proposed RALTS program by the Federal Fatigue Authorities Panel and the National Transport Commission

The study was based on the recognition that remote area livestock transport tasks are different and needs to focus on managing sleep not working hours as such. Fatigue management matrices were built around each type of trip which are either short [say 10 hrs], medium [say over a few days] or long [say up to ten or 12 days] noting the maximum span for animal welfare requirements between loading and spelling is 36 hours that provides a natural break rest and sleep 'book ends'. The project was developed to provide a framework for monitoring and reviewing ongoing performance to the scheme.

The RALTS Management Group met in Brisbane on 11 February 2008 to receive the initial results of the field study from Prof Dawson and to discuss the industry's attitudes and the go forward options. All industry participants were aware of the new driving hours and fatigue laws to be introduced at the end of 2008, and the importance of finding a way to ensure this significant Remote Australia cattle task is performed into the future in a manner that compliments the new package and assists in improving safety outcomes. Following Professor Dawson's presentation, a range of key agreements were reached as follows:

1. The task is unique in many aspects from the normal environment for most freight tasks and associated truck drivers in Australia.
2. It is clear the task is a "lifestyle" rather than a classical work/non work task. It is also seasonal and involves extreme peaks and lows.
3. Drivers are either working or resting/sleeping when performing the task, due to both the remote location and/or the need to keep moving for animal welfare reasons. There is neither opportunity nor conditions for recreational activities or family interaction when undertaking the task.
4. The majority of the task could not be performed within the new standard hours or basic fatigue packages but that an alternative compliance framework could be built within the Advanced Fatigue Management Model. This would see the primary focus achieving the right amount of rest/sleep rather than prescriptive hours of work.
5. A large majority of drivers in the study are balancing their work/rest needs fairly well but there are clear examples of extremes that need to be eradicated; the extent of these extremes during peak season activities also need to be understood. Data integrity was determined as good by UniSA and in line with other studies.
6. Tough challenges have been identified that need to be addressed in managing both driver safety/fatigue and animal welfare issues into the future, particularly at the extremes with some current operations; but these all appear solvable with new practices and better co-operation across the supply chain.
7. Successfully addressing supply chain challenges and attitudes through formal trip planning management and review requirements as well as first and last mile issues particularly with shippers will be a critical part of the transition process to new and safer practices.
8. A strong Code of Practice with an accompanying accreditation scheme are seen as essential to provide a framework on which to achieve positive change and to encourage greater and agreed compliance levels. A continuous review and improvement philosophy incorporating technology and 3rd party/independent Audit requirements are acceptable elements of these schemes to all parties.
9. The Accreditation scheme must fit into a national framework being proposed by the NTC to ensure efficiencies are delivered and past work leveraged in delivering a way forward.
10. Driver fitness for duty will be an important element of the proposed package with mandatory medical checks and drug testing, both at medicals and on a random basis once RALTS has been incorporated.
11. The perception by some that there is not a real problem based on perceived low accident rates in remote Australia livestock transport will need to be addressed and countered in the communication strategy within the project.
12. A transition timetable will be developed in co-operation with governments to move the industry in a proactive way from current practices and beliefs to a new program that embraces both safety and efficiency. It is expected this will be a three year

program with early deliverable being key to build confidence and assist the transition and acceptance of the Scheme.

13. Industry and customers will need to have ownership of the Scheme within agreed parameters including ensuring appropriate funding is available for the Scheme's operation.

The Northern Beef Industry will benefit from this work by having an acceptable set of fatigue management protocols for remote area livestock transport operators that enables continuation of cost effective operation of integrated beef supply chains to southern markets or live export while at the same time facilitating through chain responsibility for both driver fatigue and animal welfare considerations.

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1 Background

1.1 Background to driver fatigue management in the remote area livestock transport industry

1.1.1 Proposed regulatory changes

The National Transport Commission (NTC) has issued new regulations (for adoption by States and Territories) limiting hours of work for truck drivers, and imposing a chain of responsibility on management and customers of road freight to ensure enforcement. There are three “optional” regimes of limits on hours, and the options providing greater flexibility are accompanied by requirements for risk based fatigue management systems.

The option providing most flexibility – Advanced Fatigue Management (AFM) – has “outer limits” of 16 hours work per day, and a requirement for 6 hours continuous rest (or two four hour rests) every 24 hours.

1.1.2 The needs of the remote area livestock industry

However the proposed regulatory arrangements do not meet the needs of remote Australia livestock transport drivers, whose driving regime is set by both the haulage task distances and the welfare of the livestock. These dictate that the cattle must be spelled every 30 hours, and more relevantly, they cannot be left penned in truck during the heat of the day while a driver takes a four hour rest break in the afternoon. These drivers – and this industry – are seeking exemptions to the AFM regime by formulating a fatigue management program to control the inherent risks of the longer working hours.

Two generic trip plans for these drivers – said to be typical of movements in 2006– showed that cattle are loaded into the trucks early in the morning, and are driven to their unloading point (often just for spelling) about 30 hours later. During that time, the truck will stop for an hour (or less) every 3-4 hours to check the condition of the cattle, check the truck tyres, take meals, fuel etc. However while hauling livestock there is only one long rest break of 4-5 hours taken by the driver, usually between midnight and 0500. After unloading the driver will take a longer break (about 12 hours) before reloading or running empty to reposition the rig. Such round trips may take 6-8 days to complete before the driver returns home for a break of usually 24 hours – but it could be less.

As both the remoteness of this part of Australia and animal welfare requirements means that the working hours are relatively inflexible, there was a need to seek ways to better manage the sleep opportunities for the drivers? How much sleep does a driver obtain under these conditions?

1.1.3 The pastoral industry and livestock transport industry cooperate to find a solution

Where is the remote area livestock operating zone

This zone is already promulgated and covers to operating areas for triple bottom road trains across Northern Australia.

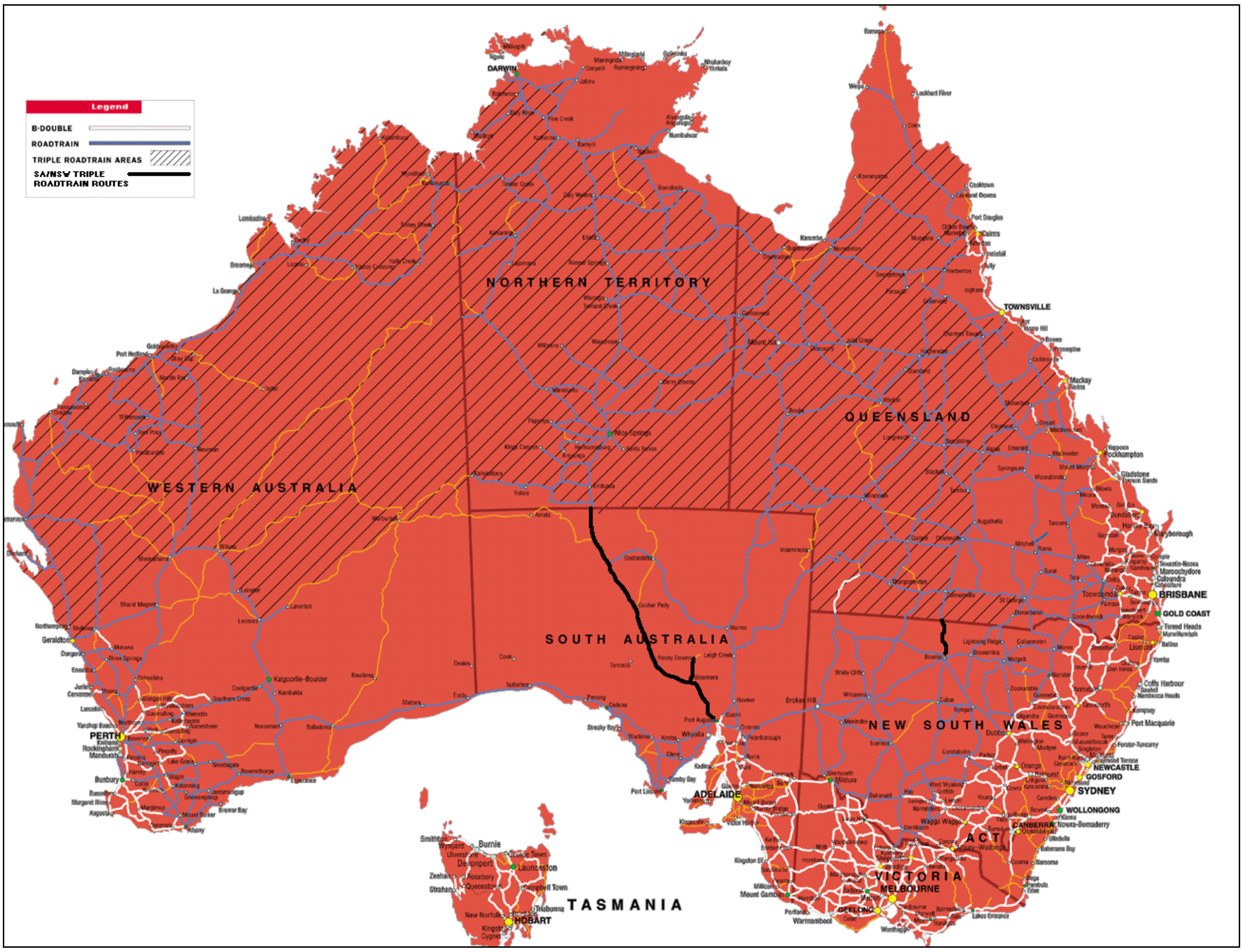


Figure 1 – Remote area livestock operating zone

1.1.4 Proposed project stages

The field fatigue research undertaken as part of the project was been performed by the world renowned UniSA Centre for Sleep Research led by its Director, Professor Drew Dawson.

The RALTS Management Group was also supported by a Working Group on the Livestock Logistics Chain formed by Remote Area Ministers in mid 2007.

The following key project stages were undertaken to provide rigorous scientific evidence that the operating condition for RALTS and management of driver fatigue by improving the quality of sleep could be substantiated for Federal and State jurisdictions.

- Outcome of scoping and planning workshop with industry leaders, pastoralists and fatigue expert
- Documentation of long-distance livestock transport driver requirements

- Driver fatigue management options modelled and risk analysis completed
- Feedback from industry consultation reported
- Review of draft proposal by external fatigue experts

The project secured the involvement of a fatigue management expert (Professor Drew Dawson).

The project was overseen by a management team consisting of Mr Stuart Kenny (NTCA), Mr Ken Warriner, Consolidated Pastoral Company, and Mr Jim Cooper, Gulf RTA.

The project scope was limited to approximately 200 trucks and drivers, and approximately 40 transport companies operating in the existing remote Australia triple bottom zone determined by the regulatory authorities.

The study was based on the recognition that remote area livestock transport tasks are different and needs to focus on managing sleep not working hours as such. Fatigue management matrices were built around each type of trip which are either short [say 10 hrs], medium [say over a few days] or long [say up to ten or 12 days] noting the maximum span for animal welfare requirements between loading and spelling is 36 hours that provides a natural break rest and sleep ‘book ends’. The project was developed to provide a framework for monitoring and reviewing ongoing performance to the scheme.

1.1.5 Project funding support

The current work was being jointly funded by the National Transport Commission (NTC) and the Northern Territory Cattlemen’s Association, the latter having obtained assistance grants from other meat industry sources, including Meat and Livestock Australia (MLA), to help fund the project work.

The importance of NTC support in the following areas is acknowledged:

1. In-principle support to consider this sector as a possible exemption option under the NTC’s current proposals
2. Provide assistance and leadership in obtaining State Minister’s (Qld, NT, WA and SA) recognition and support of the proposed scheme
3. Provide assistance with funding the development, ongoing monitoring and review of the scheme once developed
4. Understand that this will be driven by the pastoralists because of their chain of responsibility obligations; it will be opposed by some trucking operators

MLA support ensured effective integration of research outcomes consistent with chain of responsibility obligations of beef producers, lot feeders and meat processors in WA, NT, Qld and SA and current animal welfare initiatives associated with remote area livestock transport. Allied with these objectives are the obvious benefits to beef and sheep live exports and associated cost competitiveness in domestic and export markets.

2 Project objectives

The purpose of this project was to develop and evaluate a driver fatigue management scheme for remote area livestock transport operators that will improve safety while preserving cattle industry viability. This scheme will be submitted for approval to the National Transport Commission (NTC) under proposed exemption provisions.

The focus of this project was to use expert advice, quantitative evidence and best practice to develop a fatigue management scheme based on management of quality sleep time rather than driving and working hours.

Non-standard and extreme operating conditions faced by livestock transport operators in the triple bottom zone of remote Australia make it impractical to comply with existing NTC proposals. This places livestock operators and drivers at risk. Specific peculiarities which make work and sleep the focus of remote area livestock operators include: large transport distances, limited spelling facilities for livestock, remote work and non-work environment, lack of competing social opportunities and utilisation of natural break points in transport schedule.

This project built on preliminary research indicating remote area transport operators can manage fatigue and interstate activities consistent with industry standards. It will build on unique aspects of livestock transport already acknowledged by NTC's new package.

The project recognised the need for a new co-operative approach to increasing driver safety and industry viability. It was envisaged that key fatigue management principles would lead reform hand in hand with animal welfare requirements recognising both have a legislative basis. Post-project ongoing performance-based review to demonstrate compliance is proposed.

3 Methodology

The methodology of this project involved a number of stages that required flexibility as proposed regulatory changes became known and the needs of cross jurisdictional legislators became known. The methodology design was such as to secure national transport Commission and cross State jurisdiction endorsement of a remote area livestock transport accreditation model that distinguished livestock transport from line haul transport operations.

Scoping and planning workshop

Key Pastoralists, transport operators and the NTC Chairman Michael Deegan met in Brisbane on 19 June 2007 to discuss the key issues in considering the introduction of a Remote Australia Livestock Transport Scheme (RALTS). Attendees viewed a presentation covering the main policy drivers underpinning the push for RALTS including:

- The growing impact of the road transport chain of responsibility across the meat and livestock supply chain
- The new road transport legislation on driving hours and fatigue that takes effect in 2008
- The unique aspects of undertaking cattle movements in remote Australia including animal welfare needs and the critical role that road transport plays in this task

- The standards under which the fatigue management aspects of remote Australia road transport operations might operate based on discussions with Dr Drew Dawson, Uni SA

The parties agreed that the above policy drivers are a strong catalyst for the introduction of a Remote Australia Livestock Transport Scheme (RALTS).

Documentation of remote area livestock transport driver requirements

Before the trial started remote area livestock transport drivers were surveyed on confidential basis to establish current operating practices and lifestyle issues. A range of current long haul trip cycles were also reviewed on a confidential basis to establish the extent that current operating practice would sit outside the proposed advanced driver fatigue module. The nature of driving activity, other work activity and driver lifestyle while on the road was also established.

Two generic trip plans for these drivers – said to be typical of movements in 2006– showed that cattle are loaded into the trucks early in the morning, and are driven to their unloading point (often just for spelling) about 30 hours later. During that time, the truck will stop for an hour (or less) every 3-4 hours to check the condition of the cattle, check the truck tyres, take meals, fuel etc. However while hauling livestock there is only one long rest break of 4-5 hours taken by the driver, usually between midnight and 0500. After unloading the driver will take a longer break (about 12 hours) before reloading or running empty to reposition the rig. Such round trips may take 6-8 days to complete before the driver returns home for a break of usually 24 hours – but it could be less.

Driver fatigue management options modelled and risk analysis

Field studies were undertaken by Prof Dawson’s team in September/October 2007 in the Northern Territory and Queensland. This involved 32 drivers normally involved in performing Remote Australia livestock transport tasks participating in a trial to measure the rest/wake behaviour of these drivers. They wore Actiwatches (activity monitoring devices) and maintained a diary (covering their work/rest activities). Importance of finding a way to ensure this significant Remote Australia cattle task is performed into the future in a manner that compliments the new package and assists in improving safety outcomes.

Industry consultation

The RALTS Management Group met in Brisbane on 11 February 2008 to receive the initial results of the field study from Prof Dawson and to discuss the industry’s attitudes and the go forward options. All industry participants were aware of the new driving hours and fatigue laws to be introduced at the end of 2008, and the importance of finding a way to ensure this significant Remote Australia cattle task is performed into the future in a manner that compliments the new package and assists in improving safety outcomes.

Review of draft proposal

The outcomes of the Professor Drew Dawson work have been reviewed by technical staff within the National Transport Commission in conjunction with a consideration of the various components of RALTS. Following that review Professor Dawson’s report was finalised and appropriate recommendations made by the National Transport Commission to the Transport Ministerial Council for the RALTS program to be approved.

3.1 Measurement of sleep quality to manage driver fatigue

There are two ways to measure the amount of sleep obtained – objective and subjective.

3.1.1 Objective measurements

Actigraphy or Actiwatches
As the name suggests these are watch–like devices worn on the wrist. An internal computer monitors, measures and records arm movements across time. From this it can be determined when subjects are asleep, when awake, and how much movement there is during these times. This in turn provides information about activity levels during wake time, as well as sleep quality.

Image 1 – Actiwatch: demonstrating use

An example printout is shown below – the shaded areas are explained:

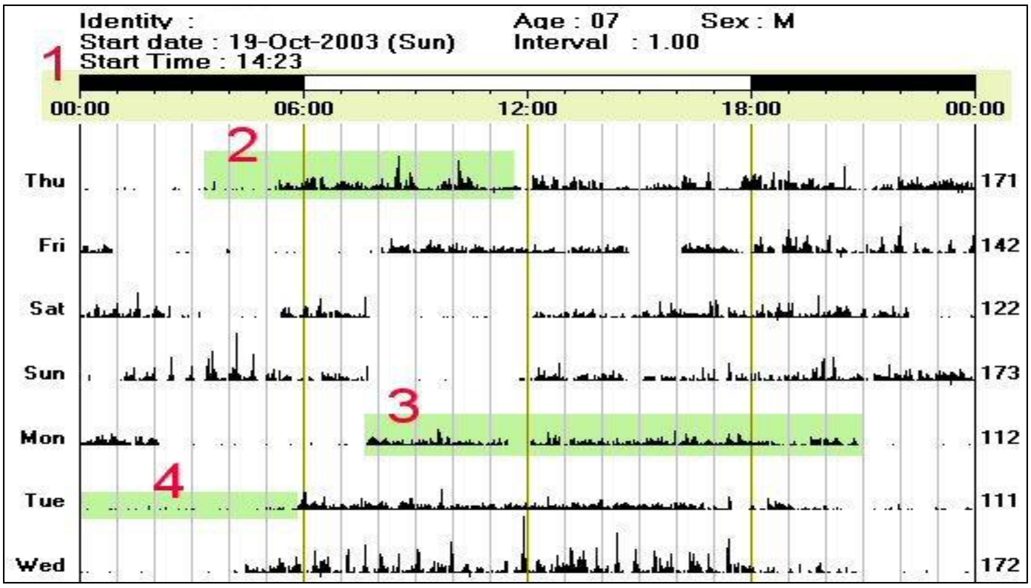


Figure 2 – Output generated from use of the Actiwatch

(1) *Time:* Days are shown horizontally with time starting and ending at 0000hrs from left to right. The grey lines show one-hour blocks across the 24-hour period.

(2) *Activity:* The vertical thin black lines represent the amount of movement logged in a one minute period. The more black lines, the more movement, and the taller the black lines, the more movement there is.

(3) *Wake:* These black lines indicate periods awake, and are generally easy to distinguish from sleep periods.

(4) *Sleep:* Sleep periods are easy to identify since the levels of movement will be much less than during waking periods. These show some small movements (small lines or dots) in patches during the sleep period. This information is an indication of sleep quality. The more movement there is during sleep, the lower the quality.

3.1.2 Subjective measurements

Self-reported sleep length & quality - Subjects were asked to provide detailed information about their sleep for the duration of the study using a sleep diary. For each sleep period (including naps), they recorded the date/time they went to sleep, date/time they woke up, and the number and length of awakenings during the sleep period. Subjects also provide quality ratings for their sleep on the scale: 1 = very good; 2 = good; 3 = average; 4 = poor; 5 = very poor; 6 = did not sleep.

Working time - Subjects will also complete a work diary, providing information about their working day/schedule, its start and end times, as well as the type of work during that time.

Self-reported fatigue - As part of both the sleep and work diaries, subjects rate their level of fatigue before and after each sleep period, and before and after each work period, using a 7-point Fatigue Scale (Samn & Perelli, 1982): 1 = fully alert, wide awake; 2 = very lively, responsive, but not at peak; 3 = okay, somewhat fresh; 4 = a little tired, less than fresh; 5 = moderately tired, let down; 6 = extremely tired, very difficult to concentrate; 7 = completely exhausted, unable to function effectively.

Confidentiality of the data - For analysis purposes there was no requirement to consider individual results. Apart from ensuring an Actigraph was worn by the same person throughout the study, there was no requirement to link the monitor to any individual when downloading the readings. Similarly the sleep/work diary – it did not have a requirement for names – but again it had to be linked to an Actigraph monitor.

To ensure confidentiality the study was conducted under University of SA ethics requirements, which binds the researchers to certain standards of conduct – including the use and storage of data.

This requirement meant that each subject must sign a consent form, which will include an understanding on their part that they are volunteers for this study, and they may withdraw from the study at any time.

Accuracy of the data - The volunteers participating in the study understood that there was a level of discipline required to ensure it provides useful and meaningful data. The Actigraphs HAD TO BE WORN AT ALL TIMES – the only exception was while showering or bathing (they are not waterproof). Similarly the sleep/work diary had to be completed after each sleep (to judge fatigue/recovery levels) and at least every 24 hours.

Number of volunteers - In order to obtain meaningful results the study required at least 40 volunteers from four operators, preferably with varying routes and tasks. Allowing for errors in data capture, (subject make mistakes, faulty Actigraphs, etc) the study aimed to recruit 50 subjects.

Timing of the study - Ideally the study had to cover at least two round trips for each volunteer driver, and the rest/recovery period(s) before, between and after. This meant the study will extend over a three – four week period.

Organising and conducting the study - The study was supervised by a senior research person from the University, assisted in the field by research assistants.

The first step was to select the participating operators and their home bases of Cloncurry and Mt Isa (QLD), Darwin and Adelaide River (NT). They then called for volunteers and provided them with the information necessary.

Once identified, there was a requirement to brief the individual subjects and obtain their consent. The volunteers were then issued with their Actigraph and sleep/work diary, and a number to link the two.

Research assistants monitored progress (by occasional phone calls to the volunteers, and vice-versa should the volunteers have any questions arising during the course of the study) and caught with some volunteers at their between trips break to download some data from the Actigraph (depending on the length of the study).

The subjects were provided with return postage packages so they could forward the Actigraphs and diaries to the University for analysis. At no stage could the Actigraphs or diaries be handled by anyone other than the volunteer or the assigned University research staff.

4 Results and discussion

4.1 Project milestone achievements

4.1.1 Outcome of scoping and planning workshop with industry leaders, pastoralists and fatigue expert

Key Pastoralists, transport operators and the NTC Chairman Michael Deegan met in Brisbane on 19 June 2007 to discuss the key issues in considering the introduction of a Remote Australia Livestock Transport Scheme (RALTS). Attendees viewed a presentation covering the main policy drivers underpinning the push for RALTS including:

- The growing impact of the road transport chain of responsibility across the meat and livestock supply chain
- The new road transport legislation on driving hours and fatigue that takes effect in 2008
- The unique aspects of undertaking cattle movements in remote Australia including animal welfare needs and the critical role that road transport plays in this task
- The standards under which the fatigue management aspects of remote Australia road transport operations might operate based on discussions with Dr Drew Dawson, Uni SA

The parties agreed that the above policy drivers are a strong catalyst for the introduction of a Remote Australia Livestock Transport Scheme (RALTS).

RALTS is aimed at introducing quality road transport standards that deliver confidence to governments and the community that the remote Australia livestock transport task is undertaken professionally and in line with national fatigue and animal welfare legislative requirements.

All parties agreed that a RALT Scheme is essential to support the vitally important cattle production industry in remote Australia and the growing importance of 'paddock to plate' quality assurance to the meat and livestock industry. Commitment was obtained from all parties to participate as appropriate.

It was also agreed that 'logistical efficiency' initiatives must support the specific fatigue/sleep management and training standards that are introduced. This includes such things as ship loading practices, maximum deck lift numbers, emergency drought movements and spelling depots.

4.1.2 Documentation of long-distance livestock transport driver requirements

The needs of remote Australia livestock transport drivers are very different from conventional line haul operations with inert cargoes whose transport routes are most often along Australia's seaboard. Remote area livestock transport drivers, have a driving regime set by both the haulage task distances and the welfare of the livestock. These dictate that the cattle must be spelled every 30 hours, and more relevantly, they cannot be left penned in truck during the heat of the day while a driver takes a four hour rest break in the afternoon. These drivers – and this industry – are seeking exemptions to the AFM regime by formulating a fatigue management program to control the inherent risks of the longer working hours.

Two generic trip plans for these drivers – said to be typical of movements in 2006– showed that cattle are loaded into the trucks early in the morning, and are driven to their unloading point (often just for spelling) about 30 hours later. During that time, the truck will stop for an hour (or less) every 3-4 hours to check the condition of the cattle, check the truck tyres, take meals, fuel etc. However while hauling livestock there is only one long rest break of 4-5 hours taken by the driver, usually between midnight and 0500. After unloading the driver will take a longer break (about 12 hours) before reloading or running empty to reposition the rig. Such round trips may take 6-8 days to complete before the driver returns home for a break of usually 24 hours – but it could be less.

As both the remoteness of this part of Australia and animal welfare requirements means that the working hours are relatively inflexible, there was a need to seek ways to better manage the sleep opportunities for the drivers. How much sleep does a driver obtain under these conditions?

4.1.3 Driver fatigue management options modelled and risk analysis completed

Field studies were undertaken by Prof Dawson's team in September/October 2007 in the Northern Territory and Queensland. This involved 32 drivers normally involved in performing Remote Australia livestock transport tasks participating in a trial to measure the rest/wake behaviour of these drivers. They wore Actiwatches (activity monitoring devices) and maintained a diary (covering their work/rest activities). Importance of finding a way to ensure this significant remote Australia cattle task is performed into the future in a manner that compliments the new package and assists in improving safety outcomes.

The target for this scheme was a specific set of companies involved in the task. This involves approximately 50 transport companies, 200 trucks and 300 drivers.

The risk analysis involves as assessment of the quality and duration of sleep in the preceding 24 and 48 hours before a driving trip commences. Sleep quality is scored to establish the level of risk and the risk management practices that have to be put into place to manage sleep quality and driver fatigue as shown in the following risk management assessment and management diagrams.

The risk assessment and management approach (Fatigue Likelihood Assessment Score-FLA) requires final sign off by the Fatigue Authorities Panel before effective implementation can begin in remote area livestock transport operations. As sleep quality and duration diminish the fatigue likelihood assessment score increases unless there is a sleep break to rebuild the sleep bank. If the FLA score gets into high risk areas (orange and red) then appropriate risk mitigation activities to manage this risk come into play.

FATIGUE ASSESSMENT

STEP 1: Sleep in prior 24 hours

Sleep	≤ 2h	3h	4h	5+h	
Points	12	8	4	0	

STEP 2: Sleep in prior 48 hours

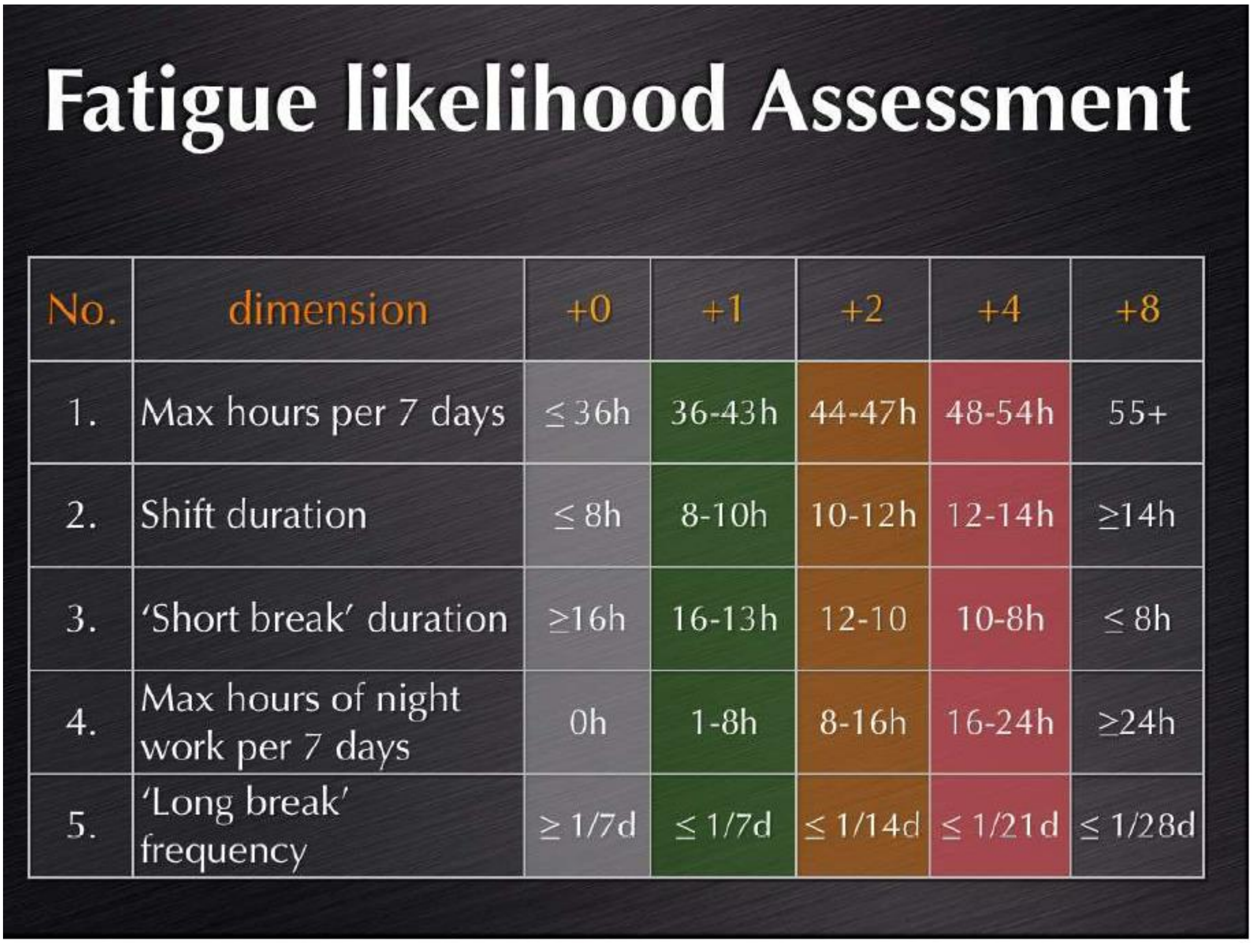
Sleep	≤ 8h	9h	10h	11h	12h
Points	8	6	4	2	0

STEP 3: Hours awake since last sleep

If sleep in Step 2 is greater than hours awake, points = 0.
If less, add 1 point per hour awake greater than sleep in Step 2.

SUM ALL POINTS TO DETERMINE YOUR FATIGUE LIKELIHOOD ASSESSMENT SCORE

Figure 3 – Fatigue assessment



Fatigue likelihood Assessment

No.	dimension	+0	+1	+2	+4	+8
1.	Max hours per 7 days	≤ 36h	36-43h	44-47h	48-54h	55+
2.	Shift duration	≤ 8h	8-10h	10-12h	12-14h	≥14h
3.	'Short break' duration	≥16h	16-13h	12-10	10-8h	≤ 8h
4.	Max hours of night work per 7 days	0h	1-8h	8-16h	16-24h	≥24h
5.	'Long break' frequency	≥ 1/7d	≤ 1/7d	≤ 1/14d	≤ 1/21d	≤ 1/28d

Figure 4 – Fatigue likelihood assessment

SCORE	RESPONSE LEVEL	WHAT ACTION TO TAKE
0	Individual	• Nil – unless behavioural indicators are evident (e.g. feeling tired) • Self-monitor for symptoms of fatigue
	Management	• Nil – unless reports of behavioural indicators are made (by either the employee or others)
1-6	Individual	• Inform management • Undertake standard personal fatigue countermeasures (e.g. use of caffeine, napping, self-monitoring of behaviour)
	Management	• Document incidence of non-zero FLA score • Ask employee to follow a standard risk mitigation plan (e.g. planned naps, reduced work hours)
7-12	Individual	• Inform management • Undertake standard personal fatigue countermeasures (e.g. use of caffeine, napping, self-monitoring of behaviour) • Agree to a formal risk mitigation plan with management and countersign
	Management	• Document incidence of non-zero FLA score • Ask employee to follow a standard risk mitigation plan (e.g. planned naps, reduced work hours) • Agree to a formal risk mitigation plan with employee and countersign • Supervise employee
13+	Individual	• Inform management • Get some sleep
	Management	• Document incidence of non-zero FLA score, *if caused by employee's working time arrangements* • Employee to stay at home or taxi home if at work

Figure 5 – Fatigue likelihood assessment score

The above approach would be subject to independent third party audit as with the TruckSafe program as outlined in the following diagram.

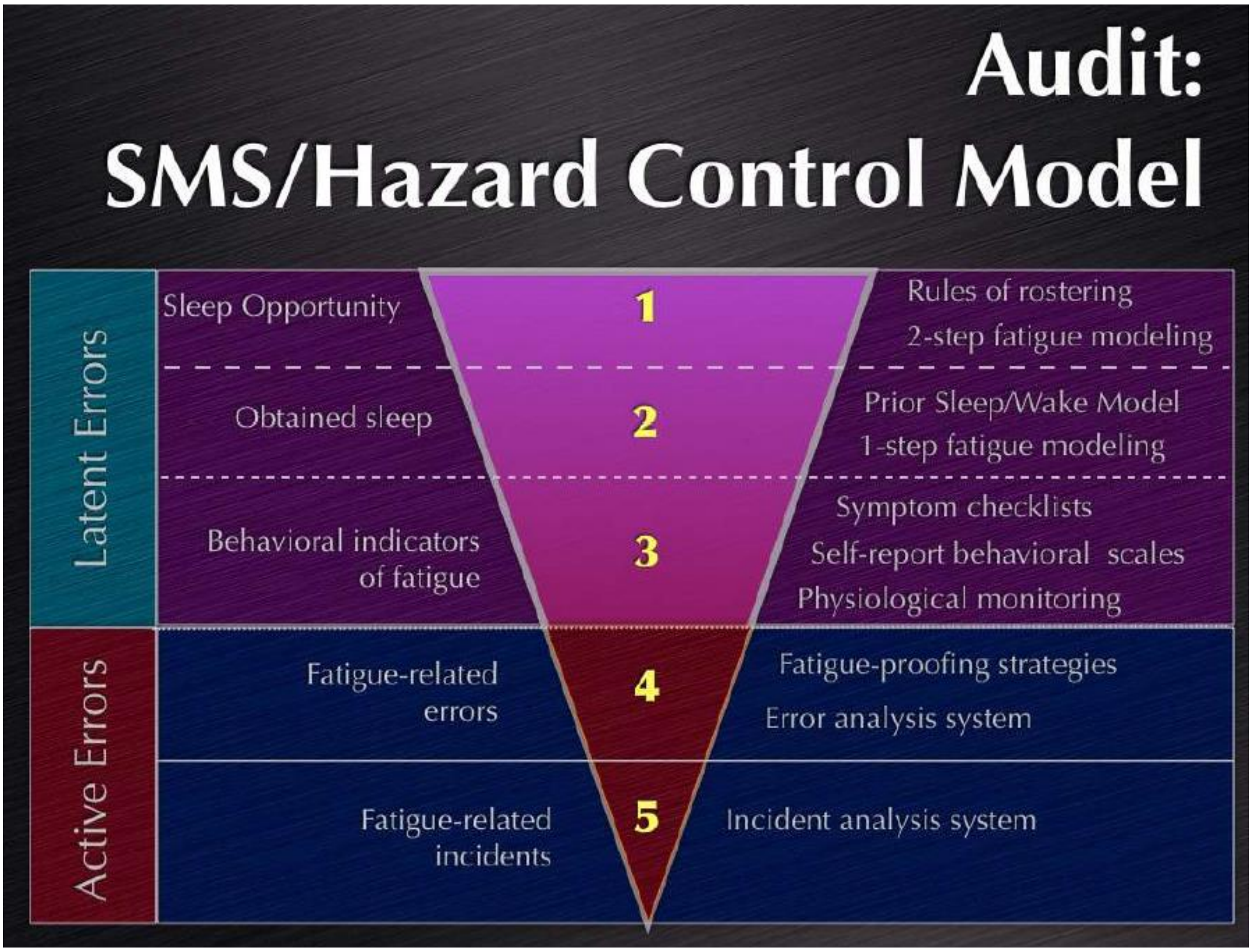


Figure 6 – SMS/Hazard Control Model

4.1.4 Feedback from industry consultation reported

The RALTS Management Group met in Brisbane on 11 February 2008 to receive the initial results of the field study from Professor Dawson and to discuss the industry's attitudes and the go forward options. All industry participants were aware of the new driving hours and fatigue laws to be introduced at the end of 2008, and the importance of finding a way to ensure this significant Remote Australia cattle task is performed into the future in a manner that compliments the new package and assists in improving safety outcomes.

Following Professor Dawson's presentation, a range of key agreements were reached as follows:

1. The task is unique in many aspects from the normal environment for most freight tasks and associated truck drivers in Australia.
2. It is clear the task is a "lifestyle" rather than a classical work/non work task. It is also seasonal and involves extreme peaks and lows.
3. Drivers are either working or resting/sleeping when performing the task, due to both the remote location and/or the need to keep moving for animal welfare reasons. There is no opportunity or conditions for recreational activities or family interaction when undertaking the task.
4. The majority of the task could not be performed within the new standard hours or basic fatigue packages but that an alternative compliance framework could be built within the Advanced Fatigue Management Model. This would see the primary focus achieving the right amount of rest/sleep rather than prescriptive hours of work.

5. A large majority of drivers in the study are balancing their work/rest needs fairly well but there are clear examples of extremes that need to be eradicated; the extent of these extremes during peak season activities also need to be understood.

6. Data integrity has been determined as good by UniSA and in line with other studies.

7. Tough challenges have been identified that need to be addressed in managing both driver safety/fatigue and animal welfare issues into the future, particularly at the extremes with some current operations; but these all appear solvable with new practices and better co-operation across the supply chain.

8. Successfully addressing supply chain challenges and attitudes through formal trip planning management and review requirements as well as first and last mile issues particularly with shippers will be a critical part of the transition process to new and safer practices.
9. A strong Code of Practice with an accompanying accreditation scheme are seen as essential to provide a framework on which to achieve positive change and to encourage greater and agreed compliance levels. A continuous review and improvement philosophy incorporating technology and 3rd party/independent Audit requirements are acceptable elements of these Schemes to all parties.
10. The Accreditation scheme must fit into a national framework being proposed by the NTC to ensure efficiencies are delivered and past work leveraged in delivering a way forward.
11. Driver fitness for duty will be an important element of the proposed package with mandatory medical checks and drug testing, both at medicals and on a random has been incorporated.
12. The perception by some that there is not a real problem based on perceived low accident rates in remote Australia livestock transport will need to be addressed and countered in the communication strategy within the project.
13. A transition timetable will be developed in co-operation with governments to move the industry in a proactive way from current practices and beliefs to a new program that embraces both safety and efficiency. It is expected this will be a three year program with early deliverable being key to build confidence and assist the transition and acceptance of the Scheme.
14. Industry and customers will need to have ownership of the Scheme within agreed parameters including ensuring appropriate funding is available for the Scheme's operation.

4.1.5 Quantitative evaluation of driver fatigue management scheme with pastoralists and livestock transport operators reported

The analysis was based on 669 days of objectively assessed sleep/wake times and self-reported work/driving times collected from 32 RALT drivers (comprising ~13% of the driver population).The767 sleep periods and1,319 driving shifts sampled during the study were deemed to be sufficient to assess the fatigue-related safety risks arising in the industry.

Initial screening of the data sets revealed inconsistencies in conceptions of 'work' across the sample. Some drivers regarded work as anytime spent away from home during operations, while others reported more traditional work/rest type sequences. This was taken to suggest that the distinction between 'work' and 'non-work' times had little significance for this population of drivers – consistent with industry descriptions of the 'working- lifestyle' culture that exists within the industry. This 'working- lifestyle' culture was further confirmed by an analysis of drivers' sleep locations, wherein approximately 85% of the total sleep obtained by sample occurred in a workplace setting (~75% in trucks and ~10% depots).

Drivers generally maintained appropriately timed sleep/wake cycles in phase with the biological timekeeping system. They obtained an average daily sleep amount of only about six hours–between one or two hours less than ideal. The quality of sleep obtained was moderate to good and was consistent across sleep locations. The drivers were able to sleep just as well in truck cabins and depots as they did when resting at home in between trips.Cross-industry comparison with the Australian rail and aviation industries revealed that RALT drivers' sleep quality was approximately the same as that obtained by train drivers and aviation pilots respectively.

Only about one-third of driving hours would have been in complete compliance with the proposed RALTS, but another one-third would have been permitted if supplementary fatigue risk countermeasures were deployed. The remaining one- third of driving hours could not have been operated at all; instead the drivers would have been required to obtain more sleep before attending to driving duties. There were considerable inter-individual differences in the fatigue risks incurred by drivers. The majority of driving times for the majority of drivers would have been allowed under the RALT safety case. However, more than 50% of driving hours for approximately 20% of the sample would have fallen into a very high fatigue risk category and outside of the proposed compliance standards.

4.1.6 Review of draft proposal by external fatigue experts

The outcomes of the Professor Drew Dawson work have been reviewed by technical staff within the National Transport Commission in conjunction with a consideration of the various components of RALTS. Following that review Professor Dawson's report was finalised and appropriate recommendations made by the National Transport Commission to the Transport Ministerial Council for the RALTS program to be approved.

4.1.7 Fatigue management scheme for long-distance livestock transport drivers

What is RALTS?

RALTS is an independently audited Australian quality assurance system for managing the road transport of livestock in remote Australia. It will seek to introduce standards and helpful management tools that embrace the latest scientific and regulatory standards that assist in successfully managing driver and equipment 'fitness for work' and safety along with animal welfare in the road transport of stock. RALTS will be:

- Restricted to Remote Australia triple bottom road train access areas;
- Restricted to remote area livestock transport only;
- Restricted to operators that comply with agreed RALTS standards;
- A complete safety and animal welfare package covering all safety issues;
- Built on the principles agreed under the NTC's Advanced Fatigue Management Module;
- A Quality Standards Package that will be audited and regularly monitored and improved and revolve on systems and management;
- Underpinned by four key principles based on a fitness for the task philosophy shown in the following diagram covering:
  - Fitness for duty of the driver
  - Fitness of the equipment for the task
  - Welfare of the stock
  - Efficiency of the supply chain

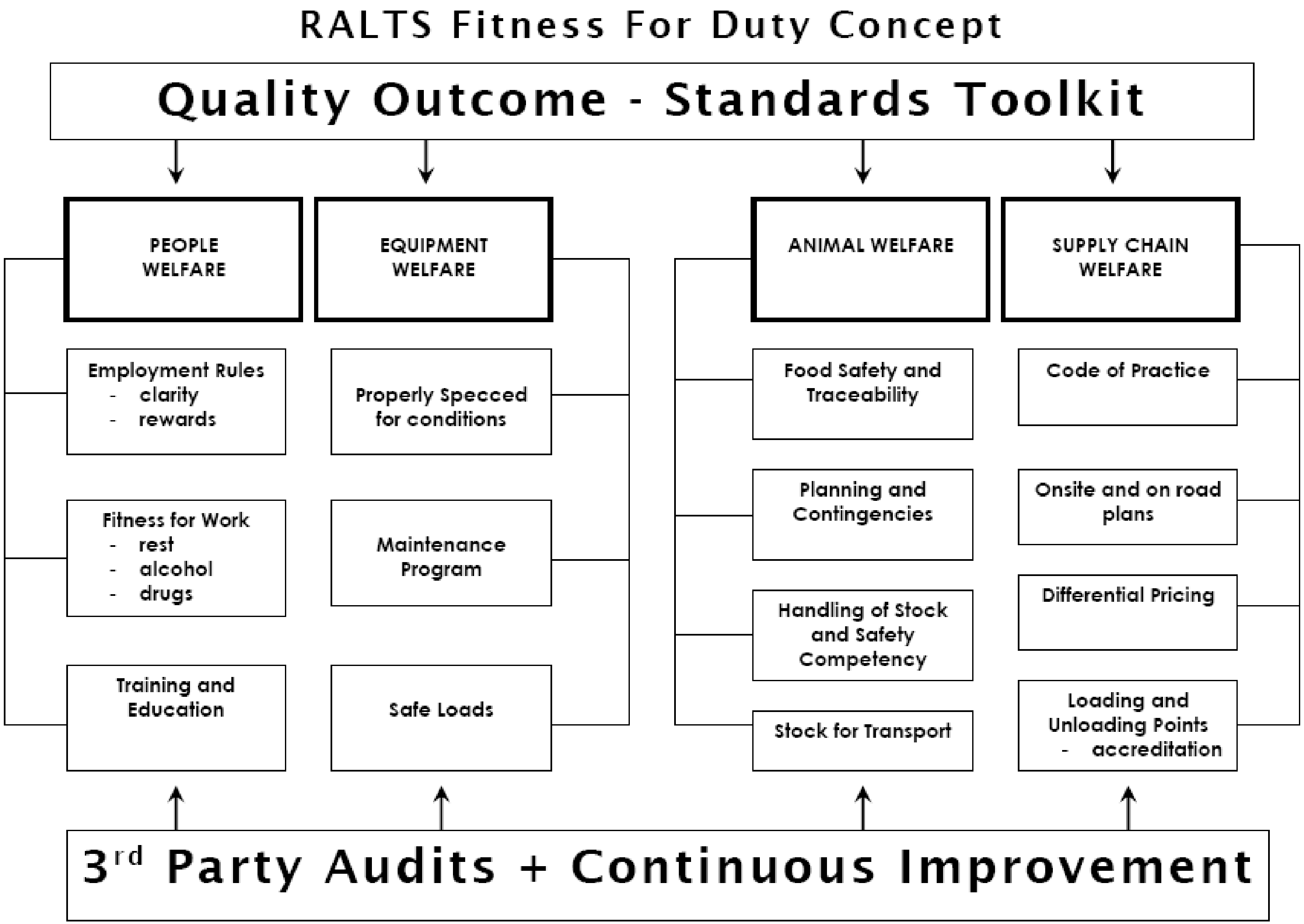


Figure 7 - RALTS fitness for duty concept

This scheme has been proposed to the National Transport Commission underpinned by the scientific work undertaken in this study. The outcomes are in the process of being reported to the National Transport Ministers Ministerial Council with recommendations from the National Transport Commission that the RALTS scheme be approved for effective sleep quality management of drivers in the remote area livestock transport operating area.

4.1.8 The strategy going forward

Remote Australia livestock transport task is unique, needs alternative compliance type approach

- The research work undertaken to date shows Remote Australia livestock transport is not a one size fits all application both in terms of the nationally agreed approach and also from operation to operation;
- The uniqueness of the task means that alternative compliance options need to be considered with the AFM initiative being the base;
- Due to the unique characteristics of the task, we are picking up the AFM type principles in our work but in a setting where we look to manage rest rather than hours work; this is mainly due to the drivers being either at work or resting in most remote Australia operations.

Recognise changes will need to be made

- The RALTS Group acknowledges the sector has a range of issues that need to be addressed and it is not defensible to say nothing needs to change
- RALTS needs to ensure future operations are secure and a safety case is properly made. This includes better collaboration along the whole supply chain to:
    - a) Review and analyse current industry practices and challenges
    - b) Document and build on examples of good practice already being used in the industry
    - c) Amend practices where possible to reduce risk
    - d) Eliminate where necessary identified high or unacceptable risk activities
- Dr Dawson and UniSA work done to date shows that:
    - o we have some good and safe operations that are analogous with airline and rail operations in terms of quality of sleep etc
    - o we also have activities that fall into both the “need to amend and/or eliminate” categories
- the complexity of delivering change within this environment is complex but there is a genuine whole of remote area beef industry sector commitment to do this, led by the customers

Building of safety case analysis about to commence

- Dr Dawson and the Group are about to start work on the next stage of the project. This involves building safety cases based on actual tasks being undertaken in remote Australia;
- This will involve all players in the supply chain participating to better understand the fatigue hot spots and current constraints and activities that are not safe;

- Out of all this the RALTS Group is looking to build an accreditation scheme that has fatigue management as its central theme but also build in animal welfare and vehicle and company management requirements

Current activities

1. RALTS was signed off by the RALTS group and agreed to release of the Uni SA Research report on current operations in Remote Australia Livestock Transport;
2. The RALTS Group agreed to commence work with UniSA to prepare whole of supply chain safety case examples;
3. The RALTS Group agreed to appointment of consultants (Michelle Edge) to commence work on draft standards for RALTS – including a Fatigue Management Plan (FMP) and other elements to cover off company, driver, vehicle and animal welfare “health” (with health being an all encompassing goal). This will enable effective integration of RALTS with TruckSafe and the animal welfare codes of practice;
4. The RALTS Group agreed to commence interactions with Fatigue Authorities Panel (FAP) comprising the Federal Government, National Transport Commission and key state governments to pursue a win/win showcase type outcome that everyone can see is workable and achievable

The presentation on RALTS was made to the Fatigue Authorities Panel on August 1, 2008. The FAP is charged with working out how to implement the new fatigue management legislation and is comprised of members from each jurisdiction and the Federal Government. It is chaired by Tim Eaton from NTC who is supportive of the RALTS approach. FAP see the RALTS approach as being possibly the highest level of accreditation for drivers and livestock transport companies supported by third party audit;

At that meeting the Drew Dawson report was presented to FAP. At the end of the day FAP will take advice from experts such as Drew Dawson who is at the forefront of looking at fatigue in terms of quality of sleep rather than driving hours.

NTC has approached the RALTS group to ask if an abstract be prepared on the RALTS approach to be presented at an International driver fatigue conference in Boston. That abstract is being prepared by both NTC and members of Drew Dawson’s team from UniSA.

At a state level Queensland Livestock Transporters Accreditation Working Group has been formed to work out implementation strategies for remote area livestock transport. A member of the RALTS Executive Group has been appointed to this group with the first meeting scheduled on 12 September2008.

MLA in conjunction with the NTC needs to continue to financially support the adoption and implementation of report outcomes to realise benefits for the northern beef industry. Those steps involve the following components and would be realistically completed over the next 18 months to 2 years:-

Further work to be progressed on the supply challenges with the support from the Remote Ministers Working Group on the Livestock Logistics Chain. Some of the proposed work would involve:

- Identification of practical solutions to better manage out limit trips caused by crisis movements of cattle such as in drought or heavy activity periods such as first and second musters;

- Identification of and purchase of pilot trial appropriate technological solutions to better manage the outer limit trips such as GPS data loggers;
- Communications program to all northern beef industry supply chain players (livestock transport companies, pastoral companies, government and the community) to improve/increase adoption and implementation rates;
- Development of realistic operational plans that will see the recommendations of the Professor Drew Dawson report implemented;
- Project management to ensure effective delivery of an improved remote area livestock transport driver fatigue management system,
- Visits/discussions by RALTS Management Group representatives with Minister’s/jurisdictions involved in the proposed RALTS (QLD, NT, WA, SA)
- Fatigue Authorities Panel (FAP) to undertake a dry run review with UniSA/RALTS Management Group representatives of proposed approach; will include review of the scientific base that underpins the approach and proposed approach
- Undertake any review work required from dry run with FAP then submit proposal for final review
- Broader elements of proposed Code of Practice and Accreditation scheme to be developed including standards writing and audit matrix preparation covering all standards

Estimated future funding required

We estimate a future funding extension in the range of $250,000-300,000 will be required to complete the suggested additional scope of work.

4.1.9 Final report

This document is the final report for this project. The full technical report is contained in Appendix 1.

5 Success in achieving objectives

The key objective of this project was as follows:

By 28 February 2008 the project will have developed and tested a fatigue management scheme for long-distance livestock transport drivers for submission to the NTC and relevant Government departments.

That objective has been achieved with the finalisation of the Drew Dawson sleep quality study, consideration of the findings and the proposed RALTS scheme by the National Transport Commission and submission made by the National Transport Commission to the Transport Ministers Ministerial Council for endorsement across jurisdictions.

6 Impact on the meat and livestock industry – now and in five years time

The Australian beef industry has developed along an integrated supply chain system especially in Northern Australia. That system has allowed country to be specialised for breeding growing or finishing stock to various market specifications. These changes have also facilitated to development of the live export industry and appropriate movement of livestock in severe drought events. The remote area livestock transport industry is the mechanism whereby cattle can be effectively transported to the next stage in the supply chain. The mooted regulatory changes would have significantly added to livestock transport cost, increased the time cattle were on trucks, multiple livestock off loads in a journey and inappropriate for the operating environment of the remote area beef industry.

This report provides the scientific evidence that will enable advanced driver fatigue management modules to be developed with particular regard to the needs of the Northern Beef industry and accommodate the provisions of the cross chain of responsibility from breeding property to abattoir.

The report dismantles commonly held perceptions and conclusively provides evidence of:

- the differences between line haul transport operators on coastal routes around Australia and remote area livestock transport operators;
- experienced operators have sleep quality similar to the airline and rail transport operators;
- that long haul trips can be effectively managed by managing the quality of sleep

The outcomes of the report will be the basis of an effective code of practice for remote area livestock transport companies and drivers that will enhance the professionalism of the sector and dovetail with the extensive work that has been done on animal welfare management for livestock transport

7 Conclusions and recommendations

7.1 Conclusions

The most important findings of the study, alongside their major implications in respect to the management of fatigue in the RALTS industry include:

(1) Drivers exhibited relatively normal sleep/wake cycles and obtained an average daily sleep amount of approximately 6 hours (1to 2 hours less than ideal), suggesting that policies encouraging drivers to get more sleep are likely to convey the most significant safety benefits to the industry,

(2) The great majority (85%) of sleep was obtained in workplace settings and the quality of this sleep was moderate to good, suggesting that: (a)managing sleep during transport operations is critical to the safety of those operations; and (b) potential for reduced quality of sleep in truck cabins and depots is not a major safety concern, and

(3) Approximately one third of driving hours would be compliant with the proposed RALTS, one third would require additional fatigue risk countermeasures to be allowed, while the final one third would not have been permitted at all, suggesting that an appropriately implemented RALTS would result in a substantially improved fatigue risk profile for the industry.

The remote location and distances involved in RALT operations, as well as the relative absence of family responsibilities, promotes a working lifestyle culture that is not entirely congruent with the traditional work/life distinction implicit to most prescriptive hours of work rules. This lifestyle factor, when combined with the requirement to balance animal welfare and driver fatigue priorities, underpins the rationale for the focus on the amount of sleep obtained by drivers, rather than the amount of work performed. Discussions with industry members suggest that the potential for beneficial safety outcomes stemming from the RALTS safety case are achievable, in part via improvements in the management of supply and demand issues across the supply chain. This is because the RALTS safety case is partly predicated on the requirement for customer pickup and delivery expectations to be reasonable vis à vis fatigue.

7.2 Recommendations

(1) There is a need to maintain the document as commercial in confidence while the complex negotiations are undertaken by the industry, State and Federal jurisdiction to have the RALTS approved across all jurisdictions where the remote area livestock transport industry operates;

(2) This report is the start of the development of appropriate codes of practice that should be co-jointly developed by the northern livestock and transport industries. There is a valid role for MLA to support this activity given the importance of effective livestock transport systems to the North Australia beef industry; and

(3) MLA in conjunction with the NTC should provide financial support for the implementation of the report findings by way of the proposed next steps outlined in this report.

8 Appendices

8.1 Appendix 1

Report: - The sleep of remote Australia livestock transport drivers

THE SLEEP OF REMOTE AUSTRALIA LIVESTOCK TRANSPORT DRIVERS

Remote Australia Livestock Transport Scheme (RALTS)

June 2008

Centre for Sleep Research
University of South Australia

Quality System™ Quality Endorsed Company ISO 9001 QEC6382

Professor Drew Dawson
Mr Frank J. Hussey
Dr David Darwent
Dr Greg Roach

Centre for Sleep Research
University of South Australia
GPO Box 2471, Adelaide SA 5001
AUSTRALIA

Ph: +61 8 8302 6624
Fax: +61 8 8302 6623
http://www.unisa.edu.au/sleep

University of South Australia

EXECUTIVE SUMMARY

Regulatory setting

The Australian National Transport Commission (NTC) has issued new fatigue management regulations for heavy vehicle operators that will come into force later this year. The regulation consists of three tiers or levels. An operator must choose which of these levels they will use to manage fatigue-related risk. At the base level, operators are required to comply with a system consisting of prescribed hours-of-work regulations and log-books along with basic training and education on personal strategies to minimise fatigue-related risk.

For operators in need of greater flexibility, there are two additional levels of fatigue-risk management. These levels permit longer working hours but mitigate the elevated level of risk by introducing additional control measures and increased accountability and compliance requirements. This approach is consistent with recent developments in Safety Management theory [e.g. AS 4801] and conforms to the generally accepted principle of permitting greater operational flexibility on the proviso that increased risk is offset by a demonstrable and proportionate risk mitigation program [e.g. AS 4362].

Within the third tier of the new system [Advanced Fatigue Management (AFM)], there is a provision for operators to apply for an exemption to the standard guidelines. An exemption may be granted where an applicant can demonstrate that the increased risk associated with the increased hours-of-work has been reasonably offset through risk mitigation measures that reduce the net risk to a comparable level to that allowed under AFM.

The three-tier system, alongside the new chain of responsibility legislation, represents a significant advance in safety for the vast majority of the road transport industry. While the advances are likely to incur significant upfront and greater direct running costs, these are likely to be outweighed by the indirect cost reductions associated with improved road safety. On the other hand, what is good for the majority is not universally good for each segment of the industry. The unique operational requirements of the remote Australia livestock transport industry, along with the distinctive environmental and cultural context within which it works, have significant potential to produce the opposite and perverse outcome. That is, an operational impact and cost consequence for which the reduction in operational flexibility is not offset by the countervailing improvements in road safety.

This scenario has been anticipated within the new regulatory landscape. Concerns raised by industry over the last 5 years have prompted the NTC to include provision for an operator to apply to the relevant jurisdiction for an exemption from the three-tier system. While the basis for an approved exemption has not yet been formalised, the remote Australia livestock transport industry is of the view that the general principles of risk- and safety- management as articulated through Australian Standards 4801 and 4362 provide a reasonable basis for assessing the acceptability of an application for an exemption. That is, *where an applicant can demonstrate that the increased risk associated with increased hours of work has been reasonably offset through risk mitigation measures that reduce the net risk to a comparable level to that permitted under AFM.*

Remote Australia Livestock Transport Scheme

The remote Australia livestock transport industry is proposing to adopt an alternative compliance scheme under the AFM option. The scheme, called the Remote Australia Livestock Transport Scheme (RALTS), is a quality standards package designed to complement the safety management principles embodied in AFM, while still ensuring the future of the industry. RALTS is envisaged as a comprehensive accreditation approach that would provide a complete occupational health and safety and animal welfare package covering all safety issues, including fitness for duty of the driver, fitness of the equipment for the task, welfare of the stock, and efficiency of the supply chain. Provision for regular auditing and ongoing monitoring and calibration of agreed standards are included to ensure that safety goals are realised.

An alternative compliance approach is considered necessary for the industry to effectively comply with both animal welfare and driver fatigue legislation. The complexity of this undertaking resides in having to comply with two sets of rules simultaneously, both of which purport to govern how long drivers may operate their trucks. This complexity is compounded by the remote location, the distances involved in operations, and the availability of facilities for spelling livestock. Industry members also point out that the remote Australia livestock transport task is more akin to a lifestyle, rather than a mere employment arrangement. Whereas domestic location and family responsibilities mark the distinction between 'work' and 'life' for most Australian employees, this distinction is obfuscated for many truck drivers working in remote Australia because of the relative absence of family and social responsibilities and opportunities while on the road.

The extent of distance and geographical and social isolation necessitated by remote Australia livestock transport operations may be discerned from the map overleaf. This shows Australia divided according to the geographical remoteness categories defined in the *Australian Standard Geographical Classification (ASGC), 2001* (*Australian Bureau of Statistics, cat. no. 1216.0*). These categories include *Major City*, *Inner Regional*, *Outer Regional*, *Remote*, and *Very Remote* areas. The categories represent a relative index of the remoteness of locations from goods, services and opportunities for social interaction.[1] The number and percent of Australia's population living within these geographic areas is also reported. While the vast majority of Australia's land mass falls into either the *Remote* or *Very Remote* categories, only a combined 2.34% of the population actually live in these areas.

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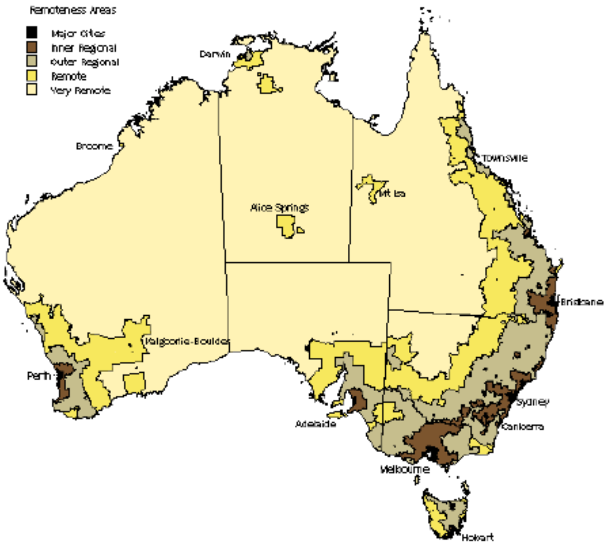

REMOTENESS	POPULATION (*N*)	POPULATION (%)
Major Cities	14,167,674	68.44
Inner Regional	4,084,217	19.73
Outer Regional	1,965,681	9.50
Remote	314,842	1.52
Very Remote	169,074	0.82
Total	**20,701,488**	**100%**

Source – *3218.0 - Regional Population Growth, Australia, 2006-07, ABS*

[1] The method of calculation is complex. A description can be found in the Australian Bureau of Statistics report, *1244.0 Information Paper: ABS Views of Remoteness 2001*.

The RALT industry has developed a safety case framework to support an exemption to AFM that they believe will provide the community, via the jurisdiction, with sufficient evidence to legitimise the application and to ensure that the net risk is not significantly increased. The scheme would be restricted to livestock transport operations in triple bottom road train access areas of remote Australia. The key idea behind the RALT industry's case for an exemption is based on the ideas that:

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(1) operational and risk environments of the remote Australia livestock transport industry are sufficiently unique that the three-tier AFM system, while suitable for the vast majority of operators, is not well-suited to this industry. In particular, it does not account for the unique impact and safety implications of the competing priorities for animal and employee health and welfare

(2) geographical and social isolation in remote Australia: (a) reduces the net risk posed to Australia's road users; (b) has fostered a working-lifestyle culture that is not consistent with the traditional work/life distinction underlying hours-of-work rules; and (c) promotes sleep during non-driving periods in the absence of competing social events, and

(3) fatigue-related risk arising in connection with longer working and driving hours is caused by longer wake times and reduced sleep time, not longer working and driving hours *per se*. If it is possible to demonstrate directly that a driver is obtaining sufficient sleep in order to drive safely then greater driving hours *per se* may not increase risk unacceptably.

Hence, the basis of the RALT industry safety case is to assess the hours of sleep obtained by RALT drivers and to determine systematically, the extent to which they obtain sufficient sleep to operate a vehicle safely.

This report is a first step in that process and provides a detailed analysis of the relationship between driving hours and the sleep-wake behaviour of truck drivers operating in the RALT industry.

Study findings

The specific purpose of the study was to assess the compliance of current operating practices with the proposed RALTS. The analysis was based on 669 days of objectively assessed sleep/wake times and self-reported work/driving times collected from 32 RALT drivers (comprising ~13% of the driver population). The 767 sleep periods and 1,319 driving shifts sampled during the study were deemed to be sufficient to assess the fatigue-related safety risks arising in the industry.

Initial screening of the data sets revealed inconsistencies in conceptions of 'work' across the sample. Some drivers regarded work as anytime spent away from home during operations, while others reported more traditional work/rest type sequences. This was taken to suggest that the distinction between 'work' and 'non-work' times had little significance for this population of drivers – consistent with industry descriptions of the 'working-lifestyle' culture that exists within the industry. This 'working-lifestyle' culture was further confirmed by an analysis of drivers' sleep locations, wherein approximately 85% of the total sleep obtained by sample occurred in a workplace setting (~75% in trucks and ~10% depots).

Drivers generally maintained appropriately timed sleep/wake cycles in phase with the biological timekeeping system. They obtained an average daily sleep amount of only about six hours – between one or two hours less than ideal. The quality of sleep obtained was moderate-to-good and was consistent across sleep locations. The drivers were able to sleep just as well in truck cabins and depots as they did when resting at home in between trips. Cross-industry comparison with the

Australian rail and aviation industries revealed that RALT drivers' sleep quality was approximately the same as that obtained by train drivers and aviation pilots respectively.

Only about one-third of driving hours would have been in complete compliance with the proposed RALTS, but another one-third would have been permitted if supplementary fatigue-risk countermeasures were deployed. The remaining one-third of driving hours could not have been operated at all; instead the drivers would have been required to obtain more sleep before attending to driving duties. There were considerable inter-individual differences in the fatigue risks incurred by drivers. The majority of driving times for the majority of drivers would have been allowed under the RALT safety case. However, more than 50% of driving hours for approximately 20% of the sample would have fallen into a very high fatigue-risk category and outside of the proposed compliance standards.

Conclusions

The most important findings of the study, alongside their major implications in respect to the management of fatigue in the RALTS industry include:

(1) drivers exhibited relatively normal sleep/wake cycles and obtained an average daily sleep amount of approximately 6 hours (1 to 2 hours less than ideal), suggesting that policies encouraging drivers to get more sleep are likely to convey the most significant safety benefits to the industry,

(2) the great majority (85%) of sleep was obtained in workplace settings and the quality of this sleep was moderate-to-good, suggesting that: (a) managing sleep during transport operations is critical to the safety of those operations; and (b) potential for

reduced quality of sleep in truck cabins and depots is not a major safety concern, and

(3) approximately one-third of driving hours would be compliant with the proposed RALTS, one-third would require additional fatigue-risk countermeasures to be allowed, while the final one-third would not have been permitted at all, suggesting that an appropriately implemented RALTS would result in a substantially improved fatigue-risk profile for the industry.

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The remote location and distances involved in RALT operations, as well as the relative absence of family responsibilities, promotes a working-lifestyle culture that is not entirely congruent with the traditional work/life distinction implicit to most prescriptive hours-of-work rules. This lifestyle factor, when combined with the requirement to balance animal welfare and driver fatigue priorities, underpins the rationale for the focus on the amount of sleep obtained by drivers, rather than the amount of work performed. Discussions with industry members suggest that the potential for beneficial safety outcomes stemming from the RALTS safety case are achievable, in part via improvements in the management of supply and demand issues across the supply chain. This is because the RALTS safety case is partly predicated on the requirement for customer pickup and delivery expectations to be reasonable *vis-à-vis* fatigue.

1 INTRODUCTION

The National Transport Commission (NTC) has issued new regulations to help combat heavy vehicle driver fatigue on Australian roads. To comply, trucking operators would have to select one of three regimes of limits on the working hours of truck drivers. The regimes providing greater flexibility are accompanied by mandatory risk-based fatigue management systems. The option providing the most flexibility – Advanced Fatigue Management (AFM) – has 'outer limits' of sixteen hours of work *per* day, and a requirement for six hours continuous rest (or two four hour rests) every twenty-four hours.

Livestock transport industry participants point to the need to accommodate the unique requirements of the remote Australia livestock transport task within the AFM alternative compliance option. The working hours of this population of drivers is already constrained by legislation governing the welfare of livestock. The *Australian Animal Welfare Standards and Guidelines – Land Transport and the Model Code of Practice for the Transport of Livestock* specify maximum water deprivation times, minimum rest requirements, and maximum travel times that must be observed in order to protect the welfare of livestock. Industry participants wish to ensure that concurrent compliance with both animal welfare and driver fatigue legislation is achievable in the unique remote Australia livestock transport environment.

The livestock transport industry is seeking to adopt an alternative compliance scheme under the AFM option. The scheme is designed to complement the principles agreed to under the NTC reforms, while ensuring that the remote Australia livestock transport task can be performed into the future. This scheme has been called the Remote

Australia Livestock Transport Scheme (RALTS). RALTS is aimed at delivering significant on road safety improvements, good animal welfare outcomes in line with legislative requirements, and sustainability in meeting driver occupational health and safety and animal welfare needs. The most important distinction between the current AFM regime and the proposed RALTS resides in the strategies used to evaluate fatigue-risk. Whereas the former attempts to manage fatigue-risks by prescribing explicit limits on work hours, the latter attempts to ensure that drivers obtain adequate sleep.

To assess 'fitness for duty' in respect to fatigue-risk, RALTS proposes to make use of a heuristic prior sleep/wake model (PSWM) developed by the Centre for Sleep Research (see Appendix A). The model is based on scientific principles and enables individuals to evaluate whether they have obtained sufficient sleep before starting work. The evaluation is based on a comparison of the sleep obtained by a given individual with a set of general threshold values. These thresholds specify how much sleep ought to have been obtained in the previous 24 and 48 hours, and how long he/she can remain awake before fatigue-risks become too high. Thus, rather than inferring 'fitness for duty' via a restriction on work hours, the PSWM provides a direct indication of how fatigued an individual is likely to be.

Study aims

This purpose of this study was to conduct a fatigue-likelihood assessment of current work practices in the remote Australia livestock transport sector. The specific objectives were to: (1) assess the basic characteristics of truck drivers' sleep-wake behaviour (i.e. sleep timing, duration, quality, and location); and (2) evaluate the fatigue-related risk occurring in connection with observed sleep/wake and driving/work times in remote Australia settings.

2 METHODOLOGY

Ethics

The research protocols complied with the Australian *National Statement on Ethical Conduct in Human Research* (National Health and Medical Research Council, 2007). Ethical approval for conducting the study was granted by the Human Research Ethics Committee (HREC) of the University of South Australia (UniSA).

Collaborators

The study was conducted by the Centre for Sleep Research (CFSR) at UniSA in collaboration with the Australian Livestock Transport Association, the Northern Territory Cattleman's Association, and the National Transport Commission. Access to professional, livestock transport drivers was granted by three commercial companies. These included Road Trains of Australia, Curley Cattle Transport and Fawcett Cattle Company[2].

Recruitment

Participants were recruited from the Mount Isa, Noonamah and Quilpie depots operated by Road Trains of Australia, and the Cloncurry depot operated by Curley Cattle Transport. Potential recruits were identified by on-site managers, and their names provided to CFSR research staff. A satchel enclosing research materials was delivered to each of these drivers via the on-site manager. Each package enclosed an Information Sheet, a Consent Form, a Study Diary, and a General Health Questionnaire.

[2] Volunteers from Fawcett's Cattle Company were not given the opportunity to participate because the equipment required to assess sleep-wake behaviour was not available in sufficient quantities to cover all sites.

The drivers indicated their willingness to participate in the study by signing the Consent Form provided. All potential recruits were informed that participation was voluntary, that any information collected would be de-identified and confidential, and that non-participation or withdrawal from the study would not influence future employment conditions. The name and contact details of an informed HREC representative was given on the Information Sheet in case drivers had any ethical queries about the study.

Participants

A provisional sample of 39 professional hire and reward drivers collected sleep/wake and driving/work information. Data sets from 32 (82%) of these participants were deemed suitable for analysis. The remainder were excluded from consideration because of missing and/or incomplete records and/or non-compliance with the study protocol[3]. There is substantial seasonal variation in the numbers of drivers undertaking the remote Australia livestock transport task. Industry participants estimate that the sample comprised approximately 13% of the driver population (N ≈ 250) undertaking the task at the time of the study.

The adjusted, all-male sample had worked as truck drivers for a mean (± standard deviation) of 13.83 (±9.11)[4] years. They had a mean (± standard deviation) age of 35.41 (±9.78)[5] years and a body mass index (BMI) score of 28.65 (±4.34)[6] kg/m^2. Approximately 26% of participants were in the 'Normal' BMI range, 33% were in the

[3] Failure to follow the study protocol was not necessarily the fault of individual drivers. Data sets were excluded for variety of reasons, including but not limited to: Actiwatch devices not being worn, equipment breakages, and holidays from work, etc.
[4] Values based on 26 of 32 (81%) data points – 6 missing data points.
[5] Values based on 29 of 32 (91%) data points – 3 missing data points.
[6] Values based on 27 of 32 (84%) data points – 5 missing data points.

'Overweight' range, and 41% were in the 'Obese' range. No relevant diagnosed medical and/or sleep disorders were reported.

Assessment of sleep

Sleep was assessed using Respironics Actiwatch devices in conjunction with sleep diaries. The Actiwatch (depicted in Figure 1 below) is an unobtrusive device weighing 17gm and having dimensions 27×26×9mm. Worn like a wrist watch, the device measures wrist activity movements using an accelerometer with a sensitivity of .01g. An analogue sensor is used to count the number of wrist movements made by the individual wearing the device. Activity information is collected in variable length epochs (1-minute epochs were used in this study) and stored in a 64-kilobyte non-volatile memory.

The device comes bundled with Actiware-Sleep software (Cambridge Neurotechnology Ltd) that enables downloading of the raw activity counts. It also includes an interface to derive estimates of sleep based on user-inputted bed-times (collected via the Study Diary) and a pre-defined set of algorithms. Estimates of sleep derived using this family of devices and algorithms have been validated in the laboratory and in medical and shiftwork settings.

Figure 1—An Actiwatch activity monitoring device.

The principle underlying 'wrist actigraphy' is that high activity levels indicate wake, while low activity levels (or inactivity) indicate sleep. In field settings, there is a potential for error where periods of sedentary wakefulness (e.g. watching TV, reading, meditating) cannot be distinguished from sleep. This possibility was minimized in the present study by cross-validating activity data with drivers' self-reported bed times and sleep locations (either: Home, Truck [unloaded], Truck [loaded], Depot, or Other). This was achieved using an activity plot (see Figure 2 below) in conjunction with a set of validation rules. Visual inspection of the plot permits users to assess the consistency of information and, where appropriate, amend or exclude records accordingly.

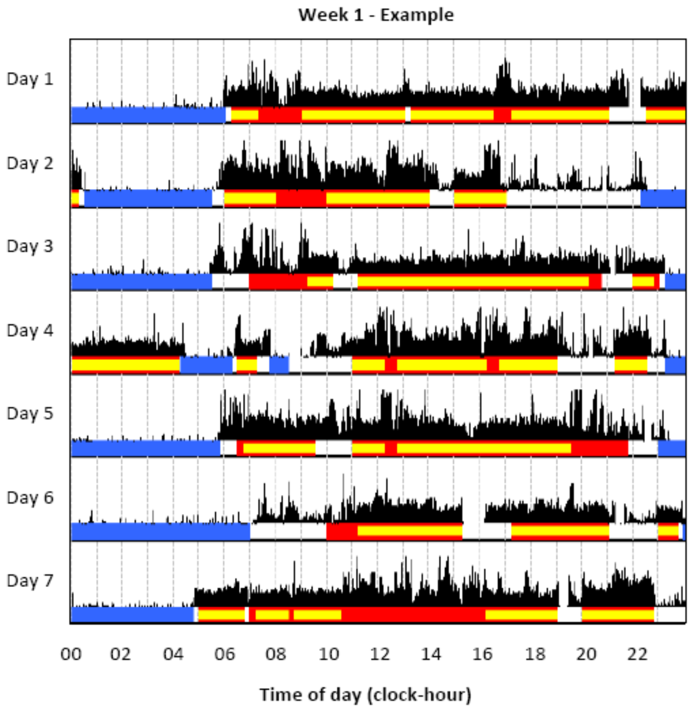

Figure 2—An example activity plot showing activity counts and sleeping, working, and driving times for a 1-week (24 hour × 7 days) period. Week day is shown on the vertical axis (Day 1 to Day 7); time-of-day is reported on the horizontal axis (00-h to 24-h). Activity data is usually sampled using a wrist activity monitor fastened to the non-dominant wrist. Visual inspection of the plot enables cross-validation of sleeping and working/driving periods and activity levels.

Assessment of fatigue

Fatigue-related risks were evaluated in terms of compliance with an heuristic, prior sleep/wake model (PSWM). Compliance with the PSWM is evaluated on the basis on three simple rules (see Figure 3 below), where:

X and Y rules – Prior to commencing duty, it was determined whether each driver obtained:

- [X] hours sleep in the prior 24 hours
- [Y] hours sleep in the prior 48 hours

Where, [X] and [Y] are threshold values set according to the safety-risks associated with work tasks.

Z rule – Prior to commencing duty, it was determined whether the period from wake-up to the end of the duty period (i.e. the time awake by the end of the duty period) exceeded the sleep obtained by drivers in the 48 hours prior to commencing duty.

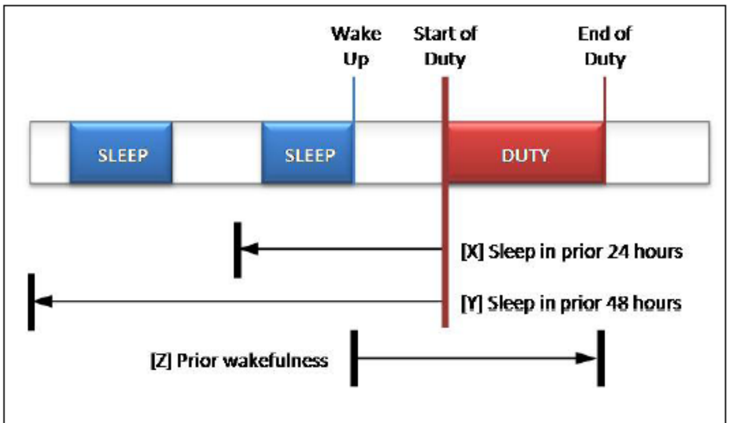

Figure 3—Prior sleep/wake model, where [X] and [Y] indicate the amount of sleep obtained in the 24 and 48 hours prior to work start respectively, and [Z] the length of wakefulness from awakening to the end time of work.

The [X] and [Y] threshold values ought to be set according to the safety-risks of work. These risks can be assessed via an analysis of the fatigue-related errors, incidents, and accidents arising in the work setting. A stepwise calibration process is required to determine acceptable threshold values. These steps include:

Step 1 initial [X] and [Y] thresholds values are set according to some theoretical basis

Step 2 subsequent safety-outcomes are measured and assessed against target safety-outcomes

Step 3 [X] and [Y] threshold values are reset in view of differences between the measured and the target safety-outcomes

Steps 2 and 3 of the calibration process are repeated at regular intervals to ensure that the target safety-outcomes continue to be achieved.

PSWM compliance rates for drivers in this study were assessed using [X] and [Y] threshold values of 5 and 12 hours respectively. These initial values were selected on the basis of a review of the scientific literature relating to the fatigue implications of recent sleep/wake history (see Appendix A). Frequency distributions of prior sleep and wake, and the percentage of work hours in compliance with a range of threshold values (0-10 hours for [X] and 0-20 hours for [Y]) have also been calculated.

A fatigue likelihood assessment (FLA) was undertaken to identify the fatigue-risks incurred by individual drivers. The FLA is an algorithm that assigns points to work hours according to the extent of PSWM rule violations. Points are summed to derive a ‘fatigue likelihood score’ representing fatigue-risk. A FLA was calculated for each hour of each driving shift for all drivers. Table 1 (pg. 10) presents the point system that was used in the determination of fatigue likelihood scores. A working illustration of the algorithms is provided in Example 1 (pg. 10).

Driving hours were grouped into fatigue-risk levels by comparing fatigue likelihood scores with pre-defined threshold categories, including: (1) Low [score range = 0, colour code = green]; (2) Moderate [score range = 1-6, colour code = yellow]; (3) High [score range = 7-12, colour code = orange]; and (4) Very high [score range = 13+, colour code = red]. The percentage of driving hours spent in each fatigue-risk category was then calculated for each driver.

Protocol

Data collection was undertaken in the 45 days between the 10th of September and the 25th of October in 2007. Each driver was asked to follow the protocol for a period of 3 weeks during normal commercial operations. There was no experimental manipulation of driving/work schedules or drivers' sleep/wake behaviour.

Drivers who agreed to participate in the study were given an Actiwatch device by the on-site manager[7]. The protocol required the drivers to wear the device at all times, except when underwater. The drivers were instructed to record all sleep, work, and driving periods in the Study Diary. Once a 3-week period had elapsed, the Actiwatch device and the completed Study Diary were given back to the on-site manager in a sealed envelope. The on-site manager then returned each envelope to the CFSR via a replied-paid satchel.

[7] The Actiwatch devices were provided to on-site managers by the Centre for Sleep Research. Each device was calibrated to ensure accurate data collection beforehand.

Table 1—A fatigue likelihood assessment showing the points assigned to work hours depending on the extent to which an employees' prior sleep/wake history violates the X, Y and Z rules of the Prior Sleep/Wake Model[1].

FATIGUE LIKELIHOOD ASSESSMENT					
STEP 1—Sleep in the prior 24 hours					
Sleep (hrs)	≤2	3	4	5+	
Points	12	8	4	0	
STEP 2—Sleep in the prior 48 hours					
Sleep (hrs)	**≤8**	**9**	**10**	**11**	**12**
Points	8	6	4	2	0
STEP 3—Hours awake since last sleep					
If sleep in Step 2 is greater than hours awake, points = 0. If less, add 1 point per hour awake greater than sleep in Step 2.					

[1]Values reported reflect prior sleep threshold values for [X] and [Y] of 5 and 12 hours respectively.

PRIOR SLEEP RULES

Rule	**Sleep**	**Action**	**FLA points**
X	4 hours	Lookup FLA points in Step 1 of FLA table	4
Y	11 hours	Lookup FLA points in Step 2 of FLA table	2

PRIOR WAKE RULE

Rule	**Awake**	**Action**	**FLA points**
Z	13 hours	Calculate FLA points *as per* Step 3 of FLA table (i.e. 13 -11 = 2)	2
		FLA SCORE	8

Example 1—A working illustration of the procedures for calculating fatigue likelihood scores for a 'hypothetical employee'. The employee had obtained 4 hours of sleep in the prior 24 hours, 11 hours of sleep in the prior 48 hours, and had been awake for 13 hours.

Data integrity

The drivers were generally diligent in wearing the Actiwatch devices and in completing the Study Diary. The level of driver engagement was similar to that experienced by the CFSR in analogous studies conducted with the Australian rail and aviation industries.

Throughout the data validation process it became evident that drivers' notions of 'work' were not consistent across the sample. Some considered work as any time spent away from home (or the resident depot), and thus reported especially long periods of work in line with trip lengths (i.e. an entire two or three day trip was regarded as a single period of 'work'). Others adhered to a more stringent definition – reporting frequent periods of rest (i.e. non-work periods) intervening frequent periods of work across trips. In comparison, there appeared to be no corresponding inconsistencies in reports of driving and sleeping times.

In view of the poor reliability of the work variable, it was not possible to distinguish between work (other than driving) and non-work times. This should not be construed as a weakness of the study methodology, or as a sign that drivers failed to complete the Study Diary properly. The distinction between 'work' and 'non-work' simply appears to have little significance for this population of drivers. Indeed, talks with industry participants suggest that drivers undertake the job as part of a lifestyle rather than a mere employment arrangement. Irrespectively, the potential for accident and the subsequent severity of injury is likely to be much greater when fatigue-related errors are committed while driving as opposed to while performing other work tasks (i.e. loading cattle). Given these disparities, all PSWM and FLA analyses have been conducted only for driving times.

3 RESULTS

A total of 669 days/nights of sleep and driving information was available for analysis. This included 767 sleep periods and 1319 driving shifts.

Time spent sleeping and driving

Figure 4 (below) shows the percent of drivers who were sleeping and driving in 1-minute intervals of the day (i.e. clock-times). The plot shows, for instance, that at 00h (00:00:00 AM) approximately 60% of drivers were sleeping (see blue area ranging from 0-60% on the vertical axis), 20% were driving (see yellow area ranging from 80-100% on the vertical axis), while the remaining 20% were engaged in other activities (see white area ranging from 60-80% on the vertical axis).

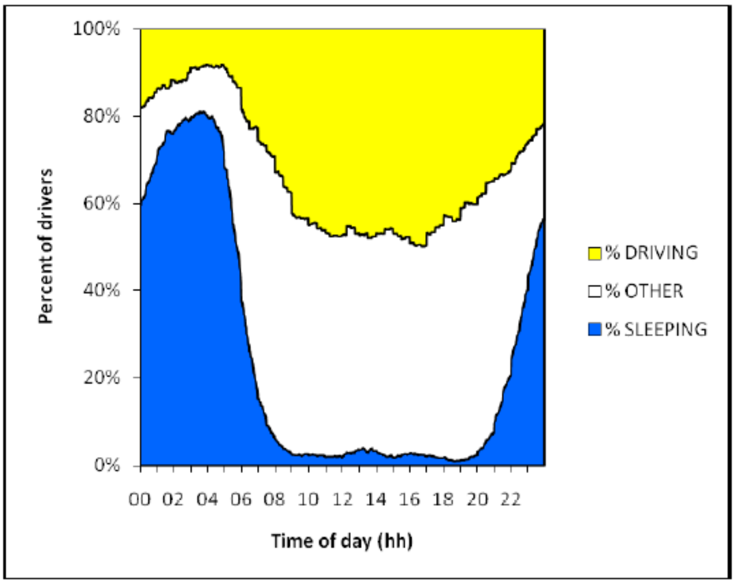

Figure 4—Probability distribution showing the percent of drivers (vertical axis) who were sleeping and driving in 1-minute intervals of the day (horizontal axis).

Drivers were most likely to be asleep at night. Approximately 95% of all the sleep obtained by drivers occurred within the 20-07h time window. Analogously, drivers were most likely to be driving during the day, from about 08-20h.

The timing and length of sleep attempts

A 'sleep attempt' refers to any occasion when an individual goes to bed with the intention of falling asleep. These include sleep attempts in which sleep onset (the act falling asleep) is not achieved (sleep length = 0 hours). A 'sleep period' refers to a successful sleep attempt; it is defined by: (a) the initial sleep onset after going to bed; and (b) the final sleep offset (the act of waking up) before getting out of bed (sleep length = time interval between initial sleep onset and final sleep offset).

The percent of sleep attempts made by drivers across two-hour intervals of the day is depicted in Figure 5 (pg. 14). The mean length of these sleeps is plotted for the same 2-hour intervals in Figure 6 (pg. 14). The majority of sleep attempts clustered into the night period between dusk and sunrise, from about 20-06h. Sleeps periods initiated during this time interval were typically longer than at any other time of the day. The only exception was for sleep attempts initiated in the early evening, from 18-20h. These however were infrequent. A linear trend was evident in the length of night-time sleeps – drivers slept for longer the earlier they went to bed. A smaller, secondary cluster of sleep attempts occurred in the mid-afternoon period, from 12-16h. On average, these sleeps (or naps) had relatively short durations of between 1 and 3 hours.

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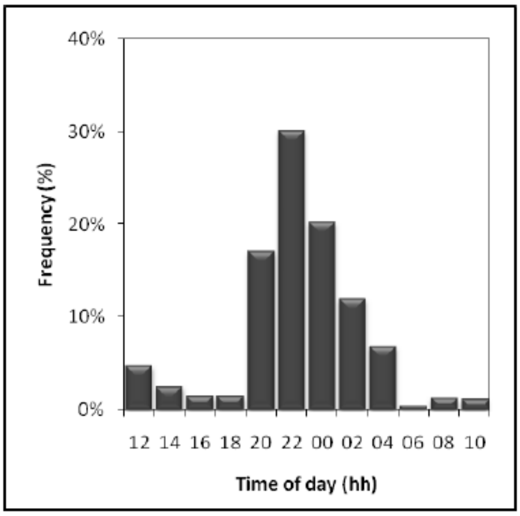

Figure 5—Frequency of sleep attempts (vertical axis) that occurred in each 2-hour increment of the day (horizontal axis).

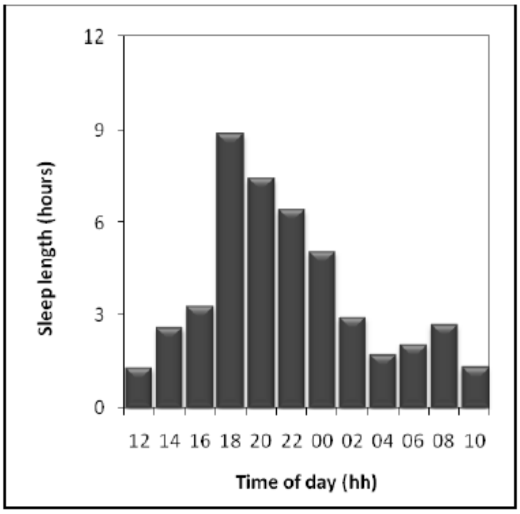

Figure 6—Mean length of sleeps (vertical axis) initiated in each 2-hour increment of the day (horizontal axis).

The location of sleep attempts

Figure 7 (pg. 16) shows the percent of sleep attempts made in various locations (either: Home, Truck [unloaded], Truck [loaded], Depot, or Other). The plot reflects a weighted adjustment of the sleep locations reported by drivers. This was necessary because location was not recorded in 31% of reported sleep attempts. Figure 8 (pg. 16) shows the mean length of sleeps organised by sleep location (sleeps with missing location data were excluded from consideration). The majority of sleeps were initiated in sleeping berths onboard the trucks (77% in total). The length of these sleeps depended on the load status of the trailer. Drivers slept for longer when the trailer was unloaded as opposed to when laden with cattle. The remainder of sleep attempts were otherwise split near-evenly between the home and depot locations. On average, sleeps initiated at home or in depots were longer than those obtained in the truck.

Sleep per 24-hour period

Sleep per 24-hour period was calculated for each driver using the formula: *(sum of all sleeps ÷ data collection period) × 24.* By this method, drivers sleep equated to an average of 6.07 (±1.18) hours of sleep per day (minimum = 3.91 hours, maximum = 8.91 hours). This was estimated to comprise of 0.98 hours of home-based sleep, 4.29 hours of truck-based sleep, and 0.80 hours of depot-based sleep. Figure 9 (pg. 17), which shows the percent of drivers who obtained certain amounts of sleep per 24-hour period of data collection (i.e. 2-3 hours, 3-4 hours..., ..., 8-9 hours of sleep). There was considerable inter-individual variation across the sample. However, the great majority (84%) of drivers obtained more than 5 hours of sleep per day (green shaded bars). Only a minority (16%) obtained less than 5 hours of sleep per day (red shaded bars).

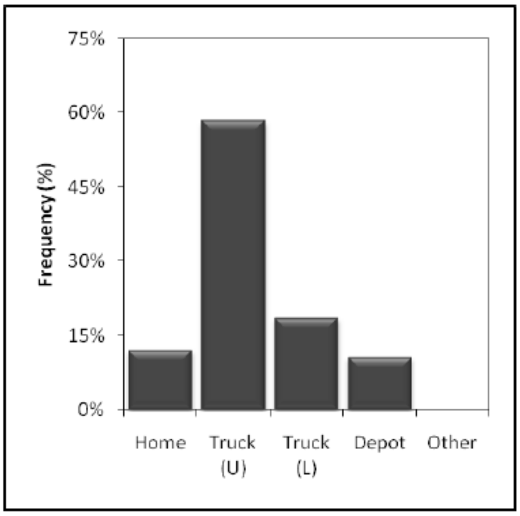

Figure 7—Frequency of sleeps (vertical axis) initiated in each sleep location (horizontal axis), where U = unloaded truck and L = loaded truck.

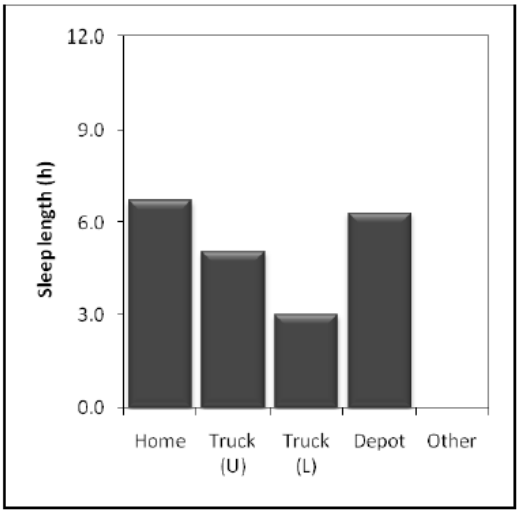

Figure 8—Mean length of sleeps (vertical axis) initiated in each sleep location (horizontal axis), where U = unloaded truck and L = loaded truck.

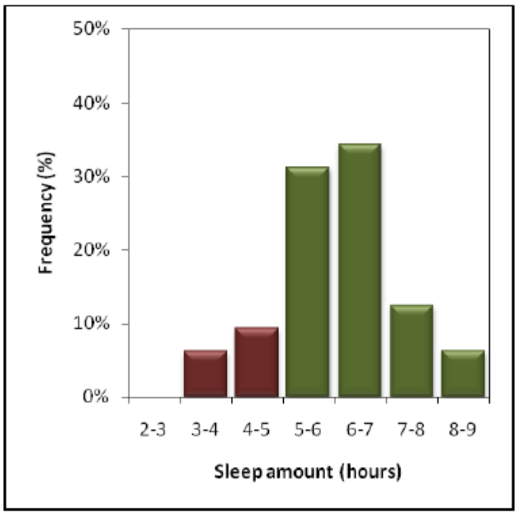

Figure 9—Frequency of drivers (vertical axis) who obtained specified amounts of sleep (horizontal axis) per 24-hour period of data collection. Red-shaded bars indicate drivers who obtained less than 5 hours sleep per 24-hour period. Green-shaded bars indicate drivers who obtained 5 or more hours sleep per 24-hour period.

Sleep quality

The occurrence of short bouts of wakefulness within sleep periods is considered a normal part of the way people sleep. 'Sleep efficiency' is the term used to describe the proportion of a sleep period that is actually spent asleep (i.e. sleep period – any time awake). For instance, a sleep efficiency value of 75% indicates that an individual was asleep for 75% of the sleep period and awake for the other 25%. Sleep efficiency is regarded as an indicator of sleep quality. Higher sleep efficiency values indicate better sleep quality, while lower values indicate poorer sleep quality.

Figure 10 (pg. 18) depicts the sleep efficiency values arranged by sleep location (either: home, in-vehicle, or layover/depot) and occupation (either: aviation pilot, livestock truck driver, or train driver). Data for the aviation pilots and train drivers were collected during analogous studies using equivalent methods for assessing sleep (i.e. wrist activity monitors). Sleep efficiency values were all in the moderate-to-good range (mean values ranged from 81% to 91%), indicating that sleep quality was moderate-to-good irrespective of sleep location or occupation. Overall, the differences between all 'sleep location × occupation' combinations were marginal.

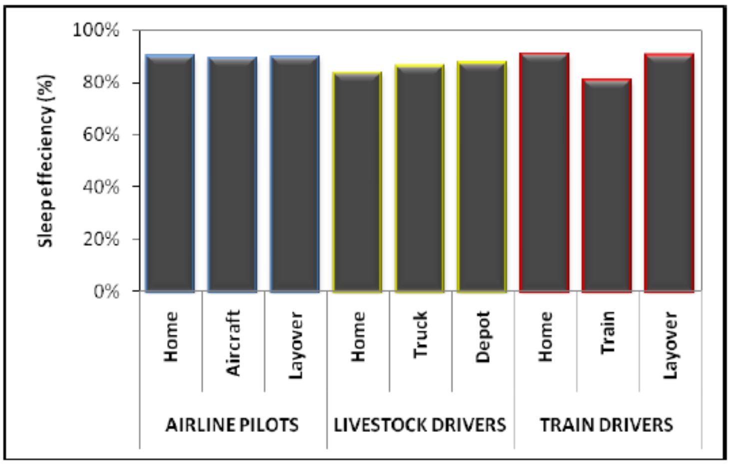

Figure 10—Sleep for three samples of transport occupations (airline pilots, livestock truck drivers, and train drivers). Mean sleep efficiency values (vertical axis) are shown for sleeps initiated: (1) at home; (2) in vehicles (aircraft, truck, or train); and (3) in hotel layover/depot locations.

Prior Sleep/Wake Model

Of the 1319 driving shifts, 1067 (81%) had sufficient historical information (i.e. a minimum 48 hours of observed sleep/wake history) to evaluate compliance with the PSWM. The average driving shift was short, mean = 3.91 (± 3.20) hours. On average, drivers obtained 5.54 (± 2.76) hours of sleep in the 24 hours prior to the start of driving shifts, and 11.43 (± 4.08) hours of sleep in the prior 48 hours. Drivers had been awake for a mean of 7.18 (± 6.10) hours at the beginning of driving shifts, and for a mean of 11.10 (± 6.42) hours by the end of driving shifts.

Analysis of compliance with the PSWM rules indicated that: (1) 55.95% of driving shifts were compliant with the 'X rule' (i.e. drivers obtained 5 or more hours of sleep before ~55% of driving shifts); (2) 40.67% of driving shifts were compliant with the Y rule (i.e. drivers obtained 12 or more hours of sleep before ~40% of driving shifts); and (3) 64.70% of driving hours were compliant with the Z rule (i.e. drivers had been awake for less than the time spent asleep in the previous 48 hours for ~65% of driving hours). Complete compliance with all X, Y and Z rules of the PSWM was achieved for only 33.58% of driving hours.

Cumulative frequency distributions for sleep in the 24 and 48 hours prior to driving shifts are depicted in Figure 11 (pg. 21) and Figure 12 (pg. 21) respectively (see yellow line). The plots enable readers to examine the percent of driving shifts (the vertical axis) for which drivers obtained specified amounts of sleep (the horizontal axis). The dot-points, highlighted by the bold arrows, depict compliance rates for the initial [X] and [Y] threshold values of 5 and 12 hours respectively (i.e. as reported in the above paragraph). The steep slopes of the distributions indicate that compliance rates would be highly sensitive to changes in the [X] and [Y] threshold values. Thus, only about 45% of shifts would be compliant with the X rule if [X] was set to 6 hours, and only about 25% would be compliant with the Y rule if [Y] was set to 14 hours.

The two figures also depict analogous distributions for studies conducted in the Australian rail (see red line) and aviation (see blue line) industries. Cross-industry comparison reveals that livestock truck drivers obtained less sleep in the 24 and 48 hours prior to driving shifts than either aviation pilots or train drivers. Compliance rates with the X and Y rules of the PSWM for these industries would be around 90-to-95% if equivalent [X] and [Y] threshold values of 5 and 12 hours respectively were used. Importantly, compliance rates should be interpreted in respect to the inherent safety-risks of work

Fatigue likelihood scores

Figure 13 (pg. 22) shows, for each driver, the percent of driving hours spent in each fatigue-risk category. Fatigue-risk categories are designated by the colour scheme represented in Table 2 (below). The upper and lower plots represent the same information, but in a re-ordered format to emphasise: (a) drivers with a high level of PSWM compliance (upper plot); and (b) drivers with a high level of PSWM violations (lower plot). Of the 66.42% of driving hours not compliant with the PSWM, 19.84% are represented by the yellow shaded areas, 15.27% are represented by the orange shaded areas, and 31.31% are represented by the red shaded areas.

Table 2—Colour codes and categories of fatigue-risk for individual fatigue likelihood scores.

Colour code	Score range	Risk-level
(green)	0	Low
(yellow)	1-6	Moderate
(orange)	7-12	High
(red)	13+	Very high

The plots also indicate a considerable inter-individual variation in levels of compliance with the PSWM. Thus, >50% of driving hours were in the 'low' fatigue-risk category (green shaded areas) for 25% of drivers. Conversely, >50% of driving hours were in the 'very high' fatigue-risk category (red-shaded areas) for 19% of drivers.

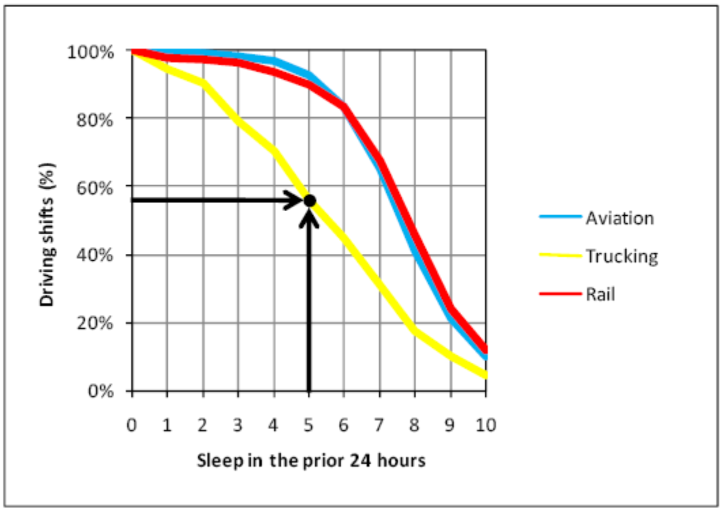

Figure 11—Cumulative frequency histogram showing the percent of shifts (vertical axis) in which participants obtained various amounts of sleep (horizontal axis) in the 24 hours before shift start. The dot-point, highlighted by the bold arrows, indicates compliance with the prior sleep/wake model when the [X] threshold equals 5 hours.

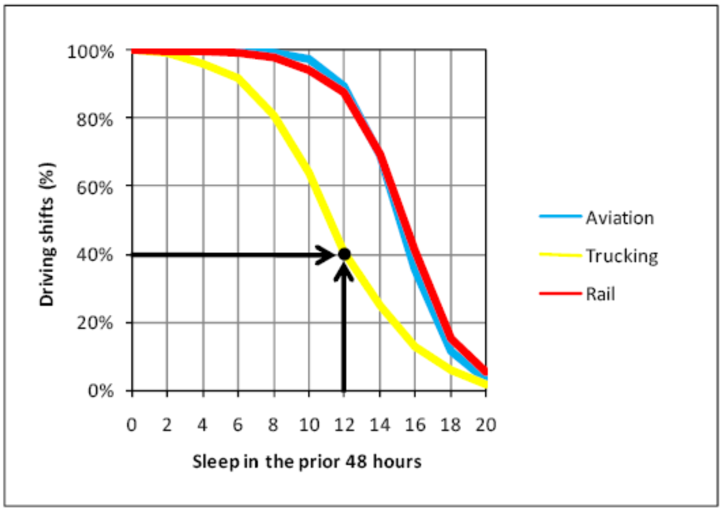

Figure 12—Cumulative frequency histogram showing the percent of shifts (vertical axis) in which participants obtained various amounts of sleep (horizontal axis) in the 48 hours before shift start. The dot-point, highlighted by the bold arrows, indicates compliance with the prior sleep/wake model when the [Y] threshold equals 12 hours.

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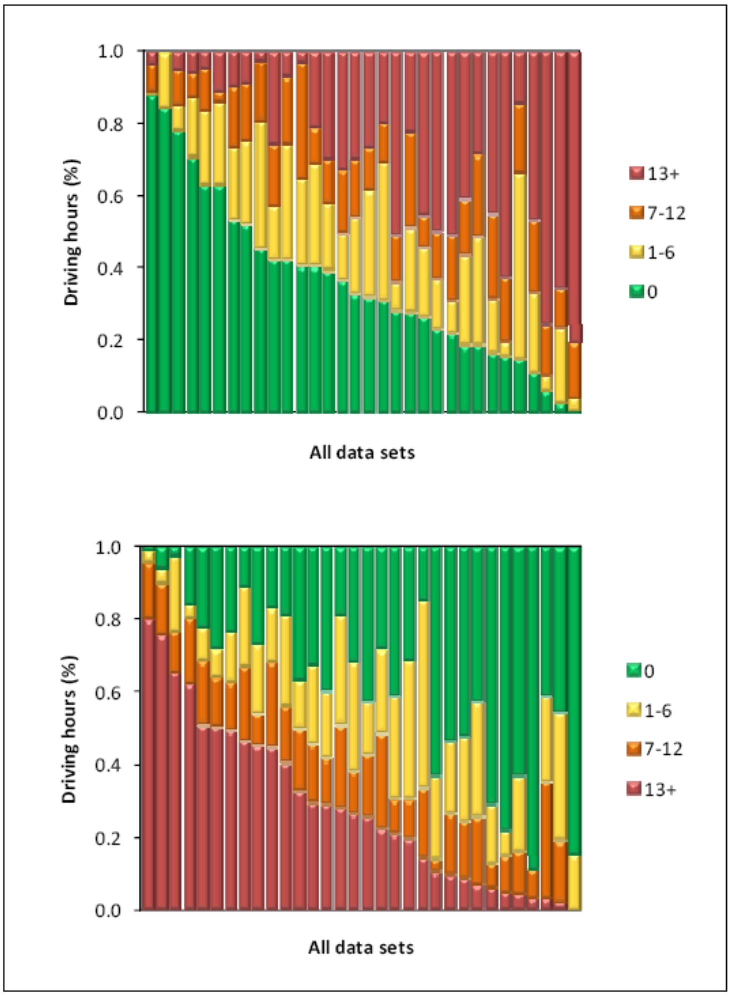

Figure 13—Cumulative column graphs representing the percent of driving hours (vertical axis) having specified fatigue likelihood scores (categories = 0, 1-6, 7-12, and 13+) for each individual driver (1 column = 1 driver). The top panel is ordered such that drivers having greatest percent of driving hours compliant with the PSWM (green shaded area) are plotted from left (i.e. most compliant) to right (i.e. least compliant). The lower panel represents exactly the same data, but the data has been re-ordered such that drivers having the greatest percent of driving hours compliant with the most extreme category of PSWM violation (red shaded area) are presented from left (i.e. most violations) to right (i.e. least violations).

4 DISCUSSION

The purpose of the foregoing analysis was to evaluate the fatigue-risk implications of current driving-time practices in the remote Australia livestock transport industry. The specific objectives were to assess: (1) the basic characteristics of drivers' sleep-wake behaviour; and (2) the subsequent fatigue-risks arising in connection with driving-times. To this end, a sample of professional hire and reward drivers collected sleep/wake and driving-time information during the course of normal operations. The Centre for Sleep Research (CFSR) is satisfied that the information collected was sufficient in quantity and quality to undertake these evaluations.

Drivers' sleep

Fatigue-risks arising in connection with industrial operations are proportional to the amount of sleep obtained by employees during non-work periods. This is because the risk of committing a fatigue-related error is directly related to an individual's historical sleep/wake profile, not the amount of work performed *per se*. In industrial settings, the major threats to alertness are operations that require employees to sleep at inappropriate phases of the day/night cycle; to be awake for extended periods and/or restrict the amount of sleep obtained; or to sleep in conditions that reduce the quality of sleep that can be achieved. These disturbances cause disruptions to the biological systems governing sleep, and ultimately increase the risk of fatigue-related incidents and accidents.

In the Remote Australia livestock transport industry, drivers most often maintained a monophasic sleep/wake cycle (one sleep *per* day) characterised by a main, night-time sleep. Main sleep attempts were most frequent in the late evening period, but were longest for bed-times occurring in the early evening. As a general rule, sleep times became progressively shorter as bed-times became progressively later. On some occasions, drivers exhibited polyphasic sleep/wake cycles (multiple sleeps *per* day) wherein the main sleep was supplemented with one or more day-time naps. These naps were most frequent in the mid-afternoon period, coincident with the so-called 'post-lunch dip'. These results indicate that the sleep behaviour of remote Australia livestock transport drivers is not exceptional, but consistent with that expected on the basis of normal sleep physiology.

On average, drivers obtained about 6.0 hours of sleep *per* day, subject to inter-individual variation. This is less than the widely cited ideal of getting between 7.0 and 8.0 hours of sleep *per* day. These results probably reflect a tendency for drivers to forgo longer sleep opportunities in view of driving/working commitments. The absence of a reliable working time measure (as opposed to driving time, see pg. 11) prevented a definitive analysis of available sleep opportunities. But irrespectively, drivers only appeared willing to engage in work/sleep and safety trade-offs up to a certain extent. This is evidenced by the fact that only a small minority of drivers obtained an average of less than 5.0 hours of sleep *per* day (i.e. the minimum recommended in the 24 hours preceding a driving shift).

The great majority of sleep was obtained in trucks and depots. In aggregate, truck-based sleeps accounted for about 4.0 hours (67%) of sleep *per* day, and depot-based sleeps for about 1.0 hour (17%) of sleep *per* day. By comparison, home-based sleeps accounted for only about 1.0 hour (17%) of daily sleep. Of particular note, there was no evidence to suggest that the quality of sleep obtained by drivers while resting in trucks or depots was inferior to that obtained at home. Drivers enjoyed moderately good sleep efficiency, irrespective of whether sleeps were initiated at home or elsewhere. The observed sleep efficiency values were *on par* that measured in commercial aviation pilots and freight train drivers using an equivalent methodology.

The foregoing analysis has revealed that sleep obtained in trucks and depots is critical to the safety of remote Australia livestock transport operations. In general, drivers were able to maintain appropriately timed sleep/wake cycles while engaged in the task; and the quality of this sleep (as indexed by sleep efficiency) was moderately good across all sleep locations. The relative absence of social and/or domestic responsibilities during transport operations probably contributed to these positive outcomes. Of particular note, the traditional distinction between work and non-work times appears to have little significance for this population of drivers. Thus, rather than attempting to regulate work times *per se*, the results of this study suggest that policies encouraging drivers to obtain an agreed amount of sleep would likely convey the greatest benefits in terms of reducing fatigue-risks.

Driving hours and fatigue-risk

Fatigue-risks occurring in connection with reported driving times were assessed using the prior sleep/wake model (PSWM) and a fatigue likelihood assessment. The analysis revealed that only about 35% of driving hours were compliant with the PSWM. Thus, approximately 65% of driving hours violated one or more of the X, Y, and Z rules of the model. The extent of violations was dependent on the [X] and [Y] threshold values of the PSWM. Modifying these threshold values upwards would produce poorer compliance outcomes.

Cross-comparison with the Australian rail and aviation sectors provides an upper benchmark with which to grade remote Australia livestock transport drivers. The extent of X and Y rule violations were greater than that observed for a sample of Australian rail and aviation operations. This difference was not unexpected given the disparity in risk profiles (i.e. the consequences of a fatigue-related accident are likely to be greater in trains and aircraft than in truck-based transport operations) and the correspondingly tighter regulatory controls exercised in rail and aviation. Nonetheless, these results demonstrate that there is considerable scope for improvement in the remote Australia livestock transport industry.

In operational contexts, PSWM rule violations would not necessarily signify that the offending shift(s) should not be worked. The fatigue likelihood assessment (FLA) revealed that approximately 35% of driving hours (yellow and orange designated hours) would require fatigue-risk mitigation strategies to offset elevated fatigue-risk levels. This would likely require some reduction (or minor re-scheduling) in the hours that individuals would be expected to drive. About 30% of driving hours (red designated hours) were associated with fatigue-risks that could not be offset by means other than drivers' obtaining more sleep. These driving hours would thus not be permitted under the type of fatigue-risk management system being sought by industry participants. The required re-distribution of driving hours would likely necessitate the employment of additional drivers to maintain equivalent level of services.

There was considerable inter-individual variation in the fatigue-risks incurred by individual drivers. A minority (25%) operated driving schedules that were more than 50% in complete compliance with the PSWM. Conversely, another minority (19%) operated schedules that were more than 50% non-compliant with the PSWM. The CFSR notes significant concern in respect to the driving schedules operated by these latter individuals. In between these extremes, there was a linear decrease in the compliance/non-compliance ratio. These findings indicate that elevated fatigue-risk levels are not limited to just a few select individuals, but are likely to be distributed across the driver population.

5 CONCLUSIONS AND RECOMMENDATIONS

The Remote Australia Livestock Transport Scheme (RALTS) seeks to implement fatigue-risk management strategies within a more general safety management system (SMS). The SMS covers a wide range of factors that may impact on driver fatigue and the safety of the livestock transport task more generally. These factors include, but are not limited to, driver health and fitness, education programs, supply chain logistics and customer awareness, vehicle roadworthiness, and animal welfare. The Centre for Sleep Research (CFSR) generally advocates the SMS approach to managing fatigue-risks, but further acknowledges a strong *prima facie* case supporting the introduction of the proposed RALTS for managing fatigue-risks in this particular industry.

RALTS was developed in response to National Transport Commission (NTC) reforms to heavy vehicle driver fatigue legislation. The Advanced Fatigue Management (AFM) provision of these reforms provides for outer compliance limits of sixteen hours of work *per* day, and a requirement for six hours continuous rest (or two four hour rests) every twenty-four hours. RALTS has been proposed as an alternative compliance model to be operated under the safety management principles exemplified in the AFM provisions. The fatigue-risk management component of RALTS is based on that developed and advocated by the CFSR (see Appendix A). Thus, whereas the current AFM model evaluates compliance based on the number of hours worked, RALTS proposes to assess compliance based on the amount of sleep obtained.

RALTS is envisaged as a comprehensive accreditation approach applicable only to remote Australia triple bottom road train routes. Industry members consider that an alternative compliance approach is necessary for the industry to effectively comply with both animal welfare and driver fatigue legislation. The complexity of this undertaking resides in having to manage two sets of rules simultaneously, both of which purport to govern how long drivers may be engaged in driving their trucks. This complexity is compounded by the remote location, the distances involved, and the availability of facilities for spelling livestock. Industry members also highlight that drivers are just as much engaged in a 'lifestyle' as in a working-time arrangement. This feature of industry culture was reflected in the inconsistent conceptions of 'work' discovered in the data validation stage of this study (see pg. 11). This lifestyle factor, when combined with a need to balance animal welfare and driver fatigue issues, underpins the rationale for the focus on the amount of sleep obtained by drivers, rather than the amount of driving performed.

The purpose of this study was to evaluate the fatigue-risk implications stemming from current operational practices in the remote Australia livestock transport industry. The sleep/wake and driving information collected from drivers was deemed to be sufficient in both quantity and quality to evaluate these risks. Fatigue-risks occurring in connection with driving hours were evaluated using a prior sleep/wake model (PSWM). The PSWM is comprised of three rules against which drivers' sleep times were assessed (see pages 7-9 for details). Within the proposed RALTS approach, violations of the PSWM rules would require the company, individual drivers, and other members of the supply chain to undertake fatigue-risk mitigation strategies or, in extreme cases, for the driver to be rested until an adequate sleep amount were obtained.

The results of the study revealed that drivers generally maintained a normal sleep/wake cycle, in phase the biological timekeeping system. Sleep quality was moderately good, irrespective of the fact that most sleep was obtained in depots or in truck cabins rather than at home. These positive outcomes may in part be attributed to the relative absence of family and social responsibilities while drivers are 'on-the-road'. Given the amount of sleep obtained in trucks and depots, the CFSR advocates the establishment of industry standards relating to the sleeping facilities available to drivers. Provisions for developing these standards already form part of the proposed RALTS.

The amount of sleep obtained by drivers (around 6.0 hours *per* day) was less than ideal. This was reflected in the fact that a significant proportion of driving shifts violated the PSWM rules to some extent. In total, approximately one-third of all driving shifts were entirely compliant with the PSWM. Another one-third would have been permitted in the proposed RALTS, but only if specific fatigue-risk mitigation strategies were actioned. The remaining one-third of driving shifts would not have been permitted under the proposed RALTS. Discussions with industry members suggest that operating practices falling outside of the proposed RALTS could be addressed through better trip planning and management of supply and demand issues across the supply chain. Of particular relevance are so-called 'first-mile' and 'last-mile' bottlenecks, where long delays in loading and unloading livestock could be better managed.

Anecdotal reports of illicit amphetamine use have raised concerns about the quality of sleep obtained by this population of drivers. Disruptive effects of amphetamines on sleep quality have been observed in polysomnographic (PSG)[8] measures of sleep efficiency collected in laboratory settings. Analogous deficits in sleep efficiency would therefore be expected in wrist actigraphic measures of sleep, although this has not been investigated directly. Evidence of drug-induced deficits in sleep quality were not manifest in this study. Indeed, the sleep efficiency values found for this sample of drivers was *on par* with that found in samples of Australian train drivers and aviation pilots using an equivalent methodology. The proposed RALTS intends to address concerns about illicit amphetamine use through 'fitness for driving' provisions that would include medical checks (including screening for medical sleep disorders) and an agreed random drug testing regime.

The CFSR is satisfied that the livestock transport industry has the potential to amend current operational practices in line with the *general principles* of the RALTS proposal. Both the industry and the CFSR agree that a continuous improvement and monitoring process should be part of the proposed RALTS. This would include calibration of PSWM threshold values via post-implementation surveillance of fatigue-related incidents and accidents. Thus, the initial 5 and 12 hour threshold values used in this study would serve only an initial platform, to be adjusted as part of a stage-wise introduction and calibration of compliance targets determined on the basis of actual incident and accident data. This would be required to ensure that steps taken to address fatigue-risks do in fact translate into drivers getting more sleep and improved safety outcomes generally.

[8] PSG is generally regarded as the 'gold-standard' for measuring sleep.

APPENDIX A

Dawson, D. and McCulloch, K. (2005). Managing fatigue: It's about sleep. *Sleep Medicine Reviews*, *9*(5): 365-80.