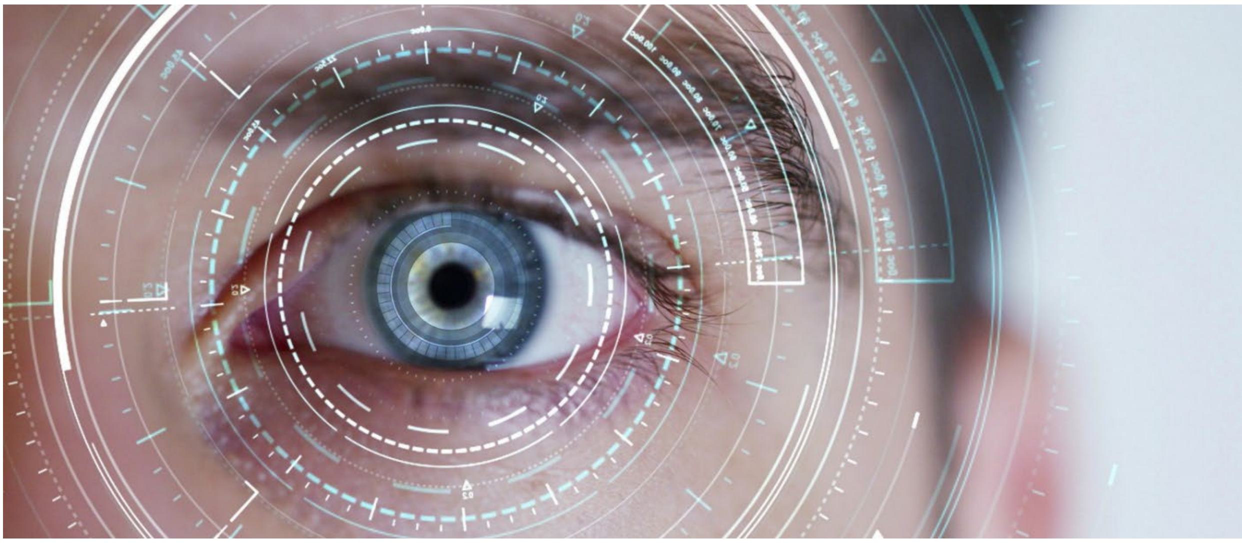

Research Report: Phase 2

FATIGUE/DISTRACTION DETECTION TECHNOLOGY USE IN THE AUSTRALIAN ROAD FREIGHT TRANSPORT SECTOR

NHVR
National Heavy Vehicle Regulator

Andrew Higginson, Professor Drew Dawson, and Dr Madeline Sprajcer

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Executive Summary

In late 2018, the National Heavy Vehicle Regulator (NHVR) initiated a five-phase Fatigue Monitoring Trial to gain a greater understanding of the characteristics, performance and utilisation of a range of fatigue and distraction detection technologies (FDDTs) currently used in the heavy vehicle industry. The overall goal of the Trial was to assess:

1. whether the technology is capable of correctly identifying unsafe driving behaviours attributable to fatigue and/or distraction within the heavy vehicle industry
2. the potential capability of such technologies to help reduce fatigue and distraction related events and thus improve safety outcomes within the heavy vehicle industry regulatory environment
3. if appropriate, how best to encourage industry uptake of such technology.

Phase Two details

This Report provides the findings from Phase Two of the Trial which involved interviewing key stakeholders currently using or providing these technologies. The interviews sought to identify how industry is currently facilitating improved safety outcomes through the successful adoption of FDDTs.

The NHVR commissioned independent consultants from HGH Consulting and CQ University to undertake Phase Two. Expressions of interest to participate were sought from the heavy vehicle industry from which the NHVR ultimately selected 12 road freight and bus companies to participate. Close to 80 transport and bus company participants (including drivers, owners, schedulers, safety staff) were interviewed in person (on site at their depots) between June-August, 2019. In addition, video conference discussions were held with representatives from 8 suppliers involved in developing, manufacturing or selling safety equipment to the industry.

Phase Two findings

The key conclusions from stakeholder interviews in Phase Two are as follows:

1. Amongst participants there was a strong and almost unanimous belief that the effective use of fatigue and distraction detection technology will profoundly reduce the frequency of fatigue and distraction events while driving. If implemented more broadly, they believe this will significantly improve industry safety outcomes.

2. Company representatives all reported that distraction events are far more prevalent and outnumber fatigue events by a factor of four to one.

3. Both company representatives and drivers emphasised the critical importance of developing a genuine partnership between governments and industry to actively encourage and support the widespread adoption of fatigue and distraction detection technologies.

4. Participants argued strongly that FDDTs are a highly positive ‘game changer’ that will enable drivers and operators to better identify and address unsafe driving behaviours prior to accidents. Importantly, this important safety benefit is occurring without:
    a) unnecessarily compromising operational efficiency or

b) producing paradoxical and/or perverse safety outcomes as can sometimes be the case under the current highly prescriptive "one size fits all" approach to manging fatigue under the Heavy Vehicle National Law (HVNL).

5. Implementation and evaluation of FDDTs is still in the early stages with a range of ongoing challenges identified including:
   a) The importance of adopting a collaborative (as opposed to mandated) approach between company management and drivers.
   b) A stated preference by most drivers to encourage the use of FDDTs that identify unsafe fatigue and/or distraction events alerts rather than approaches based on continuous surveillance.
   c) Ensuring the NHVR and industry develop a collective view on the best ways to introduce an effective and workable standard for FDDTs that encourages greater operational flexibility under the HVNL.
   d) The need to develop guidance materials that provides legally defensible policies and procedures on how organisations might reasonably respond to fatigue and/or distraction event alerts.
   e) Ensuring complementary guidance material is available to encourage drivers to use the technology to develop a better understanding of fatigue and to act earlier on their own 'leading indicators' before a high-risk fatigue event occurs.

6. There is increasing industry awareness and focus (through the use of FDDTs) on the centrality of driver fitness for duty (FFD) as a key strategy to help reduce fatigue related accidents. In particular this includes better decision making about whether to drive (or to continue driving). There was widespread support for a stronger emphasis on shared responsibility frameworks. Specifically, participants argued for stronger regulatory guidance around:
   a) developing a legally defensible determination of a driver's fitness-for duty including examining the options for a deemed fatigue impairment measure (similar to BAC) through a minimum sleep/wake guideline
   b) driver control of the decision to stop driving including a legally enshrined, uncontestable "authority to stop" should a driver consider it unsafe to continue driving due to fatigue-related risk
   c) a parallel legal authority requiring and/or authorising a company to direct a driver to stop when it considers a high-risk fatigue event is likely to occur.

7. The widespread industry view that the current complex and highly prescriptive approach to fatigue management under the Heavy Vehicle National Law (HVNL) can inadvertently produce unsafe outcomes rather than encouraging the pursuit of improved safety outcomes through the use of FDDTs and other safety management initiatives. To address these concerns, company representatives and drivers shared a common view that:
   a) the HVNL should provide for increasing operational flexibility (rest break and shift management as examples) to companies who transparently exhibit effective safety management practices that include the effective use of FDDTs
   b) companies and drivers using FDDTs should not be subject to perverse and negative sanctions/outcomes because they use the technology as this would discourage their use
   c) the regulatory culture should encourage and require an increasing focus on targeting high risk operations with less reliance on ad hoc road side enforcement.

8. Phase two participants strongly emphasised a view that the NHVR and other regulators must play a leadership contributing role to support industry reduce fatigue related risks by supporting the delivery of a more flexible regulatory framework and culture (though the HVNL) that provides for:
   a) increased use of FDDTs that meet an agreed standard
   b) the creation of standard operating practices (SOP's), templates or guidance materials for companies using FDDTs
   c) the collaborative collection and exchange of data from FDDTs to accelerate organisational and regulatory learning cycles to assist continuing reduction of fatigue related events.

9. A range of important and associated policy challenges for the HVNL and the NHVR were identified during company and driver interviews. They consistently identified:
   a) the large amount of industry resource currently tied up in back-checking work diaries to identify possible minor administrative non-compliances (such as 15-minute rets break breaches) that might have occurred
   b) the perceived ineffectiveness of the current HVNL driver medical process in assisting companies to identify and assist drivers who are not fit for duty (FFD) and thus pose a safety risk
   c) the lack of a competency (rather than time/age graduated) based driver licensing system to support heavy vehicle driving being seen as a viable professional career option for school leavers rather than one that is perceived to be "last choice" due to the time/age restrictions in the current system.

Recommendations Summary

Recommendation 1

That the National Heavy Vehicle Regulator (NHVR) and the industry identify initiatives on a collaborative and timely basis that will encourage road freight and passenger operators to invest where appropriate in Fatigue and Distraction Detection Device Technology (FDDT) as an integral element of their fatigue risk management system in delivering better road safety outcomes. This should include:

a. *Seeking urgent amendments to the Heavy Vehicle National Law (HVNL) to recognise and support the use of fatigue and distraction detection device technology to provide for greater flexibility and safety in hours of work management.*
b. *Pursuing ongoing work to further enhance guidance material for using this technology including trialling and improving the draft "How to" Manual developed in stage two of the NHVR Fatigue Trial.*
c. *Establishing an industry working group to assist the NHVR identify "best options" to encourage use of this technology including progressing the other recommendations in this Report in particular those regarding data availability to enhance the empirical evidence in pursuing better safety outcomes in the industry.*

Recommendation 2

The Heavy Vehicle National Law (HVNL) should formally allow a flexible framework to encourage the delivery of the potential safety benefits of Fatigue and Distraction Device Technology (FDDT) within a broader Fatigue Risk Management System (FRMS) framework.

Recommendation 3

In order to ensure the effective use of fatigue and detection distraction device technology (FDDT), the NHVR should provide evidence-based guidance materials to assist industry better select, implement, operate, evaluate and improve fatigue (and distraction) detection technologies. Guidance materials should be updated regularly to reflect improvements in the technology and our understanding of how to best use them. (the interested reader is referred to an accompanying report on this topic authored by the NHVR and recent international peer-reviewed publications (see NHVR Research Report: Phase One – Review of Fatigue/Distraction Detection Technology, 2019).

Recommendation 4

Where an operator seeks to use fatigue and distraction device technology (FDDT) to justify increased operational flexibility (vis-a-vis the hours of work requirements in the HVNL) a detailed description of how these technologies would be implemented and evaluated by the operator should be included as part of an application to operate under AFM principles.

Recommendation 5

That the NHVR should propose the establishment of a national database to which individual organisations can contribute fatigue risk data obtained from fatigue and distraction device technology (FDDT). Pooled data will enable the industry and regulators to jointly identify and eliminate high risk fatigue-related activities more rapidly and with greater statistical certainty.

Recommendation 6

That the NHVR consider supporting or developing a research program to assist in identifying evidence to underpin the effective use of fatigue and detection device technology (FDDT) in improving safety outcomes. This would include the collection of data and dissemination of evidence on the how best to use these technologies in order to reduce fatigue-related risk in operational settings.

Recommendation 7

That the appropriate regulatory bodies (being the National Transport Commission (NTC) and the National Heavy Regulator (NHVR)) collaborate to ensure initiatives are pursued to address a range of complementary challenges identified in Phase two of the NHVR Fatigue Trial that are perceived to be associated with delivering better fatigue outcomes.

Contents

1. Overview

In recent years, there has been increased research and development activity focussed on producing fatigue and/or distraction detection technologies (FDDTs) for the transport industry. In the last 5 years, advances in computer technology, video software analyses and artificial intelligence have resulted in wide-spread availability of low-cost detection technologies with a relatively high level of accuracy in detecting unsafe and high risk in-cab behaviours.

Compared with the current prescriptive hours of work laws and regulations, these technologies hold considerable promise in detecting unsafe and high-risk driving behaviours with a high degree of specificity and sensitivity. For many in the industry, these technologies have considerable potential to supplement or even supplant more traditional approaches to fatigue management.

The National Heavy Vehicle Regulator (NHVR) has stated that the current Heavy Vehicle National Law (HVNL) does not yet recognise or provide for the use of FDDTs. In addition, there is limited if any, systematic knowledge or clear guidance on:

1. The relative merits of the different FDDTs and whether they constitute an effective risk control measure and able to deliver the same level of surety as hours of work and rest requirements?
2. The degree of certainty that FDDTs provide in determining whether a driver is fit-for-duty
3. How FDDTs should be integrated within the larger safety management and regulatory systems
4. How an organisation should respond when a driver has been identified through an FDDT as being 'at-risk' while working
5. How individual FDDT data might be aggregated to discriminate between safe and unsafe driving behaviours at the organisational or industry level.

To address this, the NHVR is undertaking a five-phase research project to assess current and emerging fatigue/distraction detection technologies (FDDTs)and the potential capability of such technologies to improve safety performance within the heavy vehicle industry regulatory environment.

This Report covers a brief outline of the findings from Phase One as well as a full Report on Phase Two of this Project.

Phase One involved an in-house desktop review by NHVR staff of the current technologies in the marketplace. In summary, the report noted that there were a broad range of current and emerging technologies noting that there were two broad approaches to fatigue detection. The first was based on 'driver state sensing' and involved direct monitoring of drivers for individual or grouped behavioural indicators of fatigue-related impairment (e.g. eye movements, EEG, posture etc). These were considered the most robust measures of imminent sleep onset and, therefore, fatigue-related risk. The second class of technologies typically inferred fatigue indirectly on the basis of driving performance (e.g. speed, lane position, braking and gear change behaviours) and indicated poor performance as an indirect proxy for fatigue-related behavioural impairment. The authors also noted that several of the driver state sensing technologies also monitored drivers for both fatigue and distraction events as part of their product offering.

The key conclusions of the report echoed the pre-existing scientific literature and suggested that the technologies hold considerable promise to improve our certainty in detecting fatigue-impaired drivers and/or driving. Critically, the report suggested that despite several decades of lab-based research, the technology was still in a very early stage of development with respect to operational deployment and currently lacked a substantive evidence base to validate its use in the field. The report concluded that at this stage, it would appear unlikely that the current suite of technologies would be sufficiently accurate to be relied on as a single or only approach to fatigue risk management but, they could play an important role in in improving our certainty of identifying high risk fatigue events and whether a driver is demonstrably 'fit-for-duty' (FFD).

Phase Two was conducted to:

- understand how organisations currently implement and use fatigue and distraction technologies (FDDTs) based on a sample of Australian road freight and passenger transport operators selected by the NHVR from those that replied to the national Expression of Interest process they undertook
- Determine which FDDTs are currently been trialled or used by the heavy vehicle industry and why
- review how technology providers are promoting and supporting the introduction of these technologies
- consult with industry on how best through the HVNL to support the introduction, use and evaluation of FDDTs in order to improve road safety.

The project involved the collection, analysis and interpretation of interview data drawn from end-users of the technology including drivers, supervisors, managers and owners. In addition, interviews were conducted with technology providers (i.e. manufacturers and distributors).

Interview topics included personal and organisational perceptions of in-vehicle fatigue and distraction technology, particularly with regard to effective implementation and use. Interview data was then collated and analysed to provide the evidence base from which recommendations regarding the appropriate implementation, use and possible future regulation options for this technology were developed.

2. Methodology

Data collection for Phase Two of the Fatigue Monitoring Trial project was undertaken between June and August 2019. Data collection consisted of a series of face-to-face and online interviews with individuals who work in the road freight and passenger transport industry. Ten of the twelve company visits and interviews were conducted by Professor Dawson and Mr Higginson together with the latter undertaking the remaining two interviews on his own.

Expressions of Interest to participate in the Project were sought by the National Heavy Vehicle Regulator (NHVR) in April-May 2019. This was done through a number of its national communication channels (including NHVR website, NHVR regular "On the Road" Publication, NHVR Facebook pages etc.) from which a short list of road freight and passenger transport operators for possible inclusion was prepared. If an organisation was interested in participating, they were then requested to re-confirm their interest having been provided with a summary of the questions that would be asked. Operators were typically those that had implemented either/both driver state detection systems (i.e. driver facing technology designed to detect signs of fatigue and/or distraction) and driver assist systems (i.e. technology designed to respond to detected driving performance indicators, such as lane drift).

The NHVR reviewed the expressions of interest (EOI) and selected the twelve companies for inclusion aiming to include a variety of different freight tasks, size and locations. Nine technology providers who also responded to the EOI were also interviewed by Professor Dawson and Mr Higginson.

The 12-road freight and passenger transport operators that were included in data collection are provided in Appendix B. Interviews were conducted with operators in Victoria, New South Wales, and Queensland, and all operators had fleets with 20+ vehicles. Additional demographic information from these operators (e.g. type of services provided, number of FDDTs fitted) has been excluded to ensure confidentiality.

Face to face interviews were arranged with all twelve transport companies and tele-conference interviews were conducted with the technology providers. Where possible, four drivers, one safety manager, one IT/technology specialist, and one operations manager were interviewed with this varying depending on the size of the company. Union representative were identified as participating in at least two of the interviews at the larger operators. In total, 79 relevant individuals participated in these interviews.

Eight representatives from the relevant technology providers were involved in interviews (see Appendix B for a full list of technology providers). These interviews focused on technology capability, in addition to the provider's views on best-practice approaches to implementation along with any regulatory recommendations considered relevant.

Professor Dawson and Mr Higginson also met with National Transport Commission (NTC) staff involved in the current Heavy Vehicle National Law (HVNL) Review.

Interviews were conducted at mutually agreed times at the company's facilities. Professor Dawson and Mr Higginson travelled extensively throughout Queensland, New South Wales, and Victoria to attend facilities in order to conduct interviews. Individual interviews lasted approximately 30 – 90 minutes with each overall company visit time totalling approximately half a day.

Interviews followed a set of standard questions (see Appendix A) as approved by the NHVR and were used as the 'trigger' for a free-flowing discussion about fatigue and distraction detection technologies. Questions focused on five key areas, with emphasis differing depending on the organisational role of the individual being interviewed. Interview areas included:

1. The organisational decision to invest in fatigue/distraction technology
2. Implementation issues
3. Operation and maintenance of the equipment
4. Governance, policy and recommendations
5. Data utilisation

Ethics approval was sought and provided by the Central Queensland Human Research Ethics Committee (HREC). The application was submitted for approval on 14/06/2019 and approved (identification number: 0000021836).

All interviews were recorded and data was de-identified to ensure confidentiality with regards to intellectual property and competitive advantage. Personal information collected was managed in accordance with the Information Privacy Principles (IPPs) under the *Information Privacy Act 2009 (QLD)*. De-identification was undertaken by the researchers, and also based on the provision of reports (detailed in Appendix C) to each operator.

Operators were provided with a written summary of their individual discussions and asked to amend and provide feedback. The reports were then updated to ensure confidentiality and de-identification. All recordings were deleted following the completion of this Report, to further ensure confidentiality.

The results presented in this report are based on the themes that were identified in these interviews. The interview data was then collated (see Appendix C).

Analyses

A research assistant transcribed each of the interview recordings and produced detailed notes based on content. A table was produced where each interviewee's responses to the identified questions, and any other relevant comments or feedback, were detailed in dot point format. Based on this content, a thematic analysis was used which is a qualitative approach to data collection used to gain a deeper understanding of complex issues than quantitative (statistical) data is able to provide. The thematic analysis undertaken involved identifying common themes between interviews to produce an overall understanding of participant perception of fatigue and distraction detection technologies. In addition, content that did not align with overall themes was identified and included in analysis to provide a more detailed understanding of participant perception and experience.

The following Report contains an overview of the findings and recommendations from Phase Two of the National Heavy Vehicle Regulator (NHVR) Fatigue Monitoring Trial. It was prepared by Mr Andrew Higginson (HGH Consultants) and Professor Drew Dawson and Dr Madeline Sprajcer from Central Queensland University.

3. General Findings

Investment is happening and running costs are realistic

1. Significant investment is already occurring and there is already significant support for the use of fatigue and distraction technology (FDDTs) in the road freight and passenger transport industry in Australia.

2. Current investment to date is typically dominated by larger operators (greater than 30 vehicles) with a publicly stated commitment to 'demonstrable safety' (i.e. safety which can clearly be demonstrated based on systems, safety records, etc.). However, with most companies interviewed, it was still 'early days' in terms of the experience with operation and many were still effectively in the pilot/trial stage of implementation. No fully 'mature' systems were identified as being in place but several companies were able to exhibit that they are continuing to invest in better understanding and utilising FDDTs. Interviews with FDDTs suppliers suggested an increasing number of smaller (1-5) truck companies are now making an investment in FDDTs due to falling costs. However, none sought involvement in Phase Two of the Trial.

3. The technologies have now reached a point where it appears that adoption could be financially viable for most, if not all, operators (installation cost is typically around ~$2000-$2500 per vehicle installation and around $80-100/month for monitoring charges). Both purchase and leasing were identified as financing options. Several participants suggested that the NHVR could make a significant contribution to safety by identifying ways to incentivise and encourage take up – especially for smaller vehicles.

Adopters are in early stages of implementation and system development

4. Despite the absence of any current regulatory requirement (or incentive), companies are voluntarily investing and implementing this technology based on the 'perceived' safety benefits to drivers, companies and customers.

5. The supporting corporate systems, policies and procedures are still embryonic except for the universal understanding that all alerts must be addressed in real time by the driver and company staff. Some weekly reporting from the manufacturer and/or supplier was also evident to assist companies.

Industry view is that FDDTs are a positive game changer for safety (in numerous ways)

6. There is a strong industry belief that the use of the technology will profoundly reduce the likelihood of fatigue and distraction events and significantly improve an organisations ability to demonstrate that their drivers are Fit for Duty (FFD). Importantly, companies and drivers universally reported that distraction events outnumbered fatigue events at approximately 4:1.

7. There is overwhelming support from both companies and drivers for widespread adoption of FDDTs which are regarded by many as a positive 'game changer' as they will enable the industry to more clearly identify drivers who are a high-risk of a fatigue related event and

therefore would not be FFD.

8. An increasing industry awareness from FDDT data of the key challenge in better understanding the importance of FFD in managing fatigue outcomes based on the perception that the majority of fatigue alerts are occurring in the first four hours of a shift rather than at the end.

9. Operators saw the ability to be able to identify possible unsafe driving behaviours as key role for FDDTs. This important benefit would improve safety outcomes without:
    a. unnecessarily restricting operational flexibility as is perceived to be the case with current prescriptive hours of work regulations or
    b. inadvertently compromising demonstrably safer outcomes.

10. Unexpectedly, drivers saw an as yet unidentified role for FDDTs as a ‘biofeedback device’ that:
    a. improved self-awareness of possible fatigue
    b. helped them to assign a greater emphasis on leading indicators of impairment
    c. helped them to make more informed decisions on when to stop driving or declare that they were no longer FFD
    d. provided a more scientifically defensible basis on which hours of work could be managed more flexibly based on individually determined fitness for duty.

The importance of the NHVR and the HVNL framework supporting FDDTs

11. As a whole, the industry saw an important role for the regulator in:
    a. Supporting the broader introduction of FDDTs at the organisational level – especially for smaller operator who may lack the safety infrastructure and maturity to do this effectively.
    b. Providing guidance on how best to implement and use FDDTs at the industry level including working with industry to agree a standard for FDDTs which might deliver greater flexibility.
    c. Pushing for the HVNL to be urgently amended to:
        i. recognise and reward the greater certainty around driver FFD provided by FDDTs
        ii. allow for reduced regulatory reliance on prescriptive and on-road enforcement of hours of work regulations (e.g. work diaries) for companies effectively using FDDTs.
    d. Pursuing a collaborative approach with industry to collect and exchange data from FDDTs to improve understanding and education rather than perversely looking to use such data at the firm level to pursue sanctions.

Other factors identified that are perceived to negatively impact achieving better fatigue management outcomes

12. Interview participants identified a number of perceived problems related to delivering better fatigue management outcomes. These included but were not limited to:
    a. The ready, fire, aim principle i.e. their understandable frustration at the large amount of industry and enforcement effort devoted to ‘after-the-event’ enforcement. That is

in looking backwards rather than forwards in terms of reviewing possible minor and non-safety related administrative work diary errors.

b. The overly-prescriptive nature of the current HVNL and the regulatory approach to enforcement which does not necessarily encourage safer outcomes.
c. Ongoing problems with the perceived failure of the current driver medical system in identifying drivers who may not be fit for duty (FFD).
d. The increasingly aging driver workforce which is perceived to be exacerbated by the inability to target and attract school age drivers who may wish to pursue driving as a professional career mainly based on the restriction of the current graduated licensing system which sees them lost to other careers simply because these options are available earlier.

4. Detailed findings

Why did you buy it?

By and large, the organisational decision to implement the Fatigue and Distraction Device Technology (FDDTs) was based on one of two reasons. Firstly, the organisation had experienced one or more near-miss events and had decided to look at technological solutions rather than continue further with compliance-based solutions based on hours of work. Technological solutions were perceived as providing greater certainty due to the well-established difficulty in reliably predicting fatigue based on hours of work regulation and the well-reported difficulties around subjective estimation of fitness-for-duty (FFD) by drivers and/or supervisors in coercive operational or financial environments.

Second, several companies reported that the decision to deploy a FDDT had been encouraged externally or required by a third party as part of a contractual relationship. Of those who implemented the technology based on third party requirements, chain-of-responsibility legislation was the most commonly cited reason. For one participant, it was not possible to bid for the contract without the technology in place and was regarded by the customer as part of the 'minimum equipment list' for the vehicle.

Which technology did you buy?

The decision on which technology to implement was not typically undertaken in a formal or systematic manner and few organisations said they had developed or articulated explicit written criteria on which to evaluate competing products. This was not limited to the small companies who likely lacked the technical expertise or the resources necessary to access relevant subject matter experts. Even the larger companies were more likely to select a technology based on word-of mouth from respected industry peers or from FDDT sales staff at industry conferences or supplier exhibition events.

It was also clear that most of the participants did not feel they had the expertise to justify their purchasing decision with respect to normal 'due-diligence' requirements. However, they typically rationalised the purchasing decision by arguing that their use of the technology was 'adjunctive' and they did not base the investment on using it as part of an alternate compliance application under AFM or equivalent (although this was acknowledged as the way the future Law should be drafted to ensure safety rather than simply compliance was encouraged). As such companies stated that the investment was made purely on the basis of delivering better safety outcomes (driven by their own or customer's needs) and was effectively 'over and above' traditional compliance requirements under the HVNL. The major concern expressed here was that the regulators would somehow use data from FDDTs to pursue sanctions against drivers and operators.

Importantly in this sense, none of the participants had considered the criminal or civil liability that might flow from using FDDTs in the vehicle. When asked to consider the legal implications of possessing the data and their likely response in the event of a serious accident or injury, most of the participants indicated that they had not considered this in detail. Interestingly, all but one was prepared to provide such data to police in the event of an incident with most saying they would be happy to stand in court if necessary, to justify their investment and approach.

What did participants think of the technologies and how did they use them?

It is important to note that there was very little diversity of specific FDDTs implemented by the participants. Some had both FDDT and other safety related equipment in their vehicles (lane departure, forward facing and side cameras etc) but all saw FDDTs as the key fatigue detection method. Moreover, most of the organisations interviewed were at the early implementation stage and two were still in the early pilot stage for one or more technologies. Only three of the operators had achieved wide-spread FDDT deployment and the longest implementation (at scale) was approximately three years (from trial to full implementation).

It was clear that the Seeing Machines/Guardian system was overwhelmingly the most commonly deployed FDDT used in those interviewed. It is also worth noting that the majority of the systems were designed to detect both fatigue *and* distraction and that for most operators, distraction was by far the more commonly detected 'unsafe behaviour' (approx. 80% of reported alerts) and the majority of the perceived safety benefits were attributable to improved management of distraction behaviours such as mobile phone use, eyes off road etc. Most Seeing Machine and Guardian users had both driver and forward-facing cameras (to assist in better linking the fatigue/distraction event to what was happening outside the vehicle. As an aside, drivers were unanimously supportive of the forward-facing cameras as clear evidence was now available when events occurred where previously they were perceived to be in the wrong.

Overall, there is clear and overwhelming industry support for the benefits of the FDDTs studied in this project. This was partly unexpected because, arguably, it is still too early for there to be clear unequivocal technical evidence that the technology is both valid and reliable as a means of identifying fatigued drivers and reducing risk and accident frequency. This suggests industry support was mainly from the "lived experience" gut feel or intuition based on experience (and usually from sighting video evidence of micro sleep events) that FDDTs for the first time, could assist put drivers and companies in front of a possible fatigue related incident rather than looking at it "post event". it was very clear to us that the "lived experience" of using this technology (at least for drivers, supervisors and customers) was sufficient to persuade operators that the technology would potentially underpin a significant advance in their capacity to manage fatigue-related risk. This sentiment was best articulated by the suggestions of many of those interviewed. That is, that this was the first time they felt well-equipped "*to manage fatigue rather than comply with hours-of-work regulations*".

Moreover, this strong support for FDDT was also somewhat surprising given that the purchase, installation and monitoring costs cannot yet be offset against increased operational flexibility or reduced costs associated with insurance or accidents[1].

Overall, without exception, the drivers and operators were convinced that FDDT systems were a better way to manage fatigue and justified the purchase solely on perceived improvement in safety.

Why did they embrace the technology so enthusiastically?

As indicated above, the industry's enthusiastic support, even in the absence of formal evaluative data, was unexpected. In general, the perception of some is that industry has not always embraced regulatory change enthusiastically, even when it is perceived as having a clear safety dividend. In this case, we think the enthusiasm for the fatigue detection technology reflect a combination of technical and industry safety cultural factors that have coincided to encourage adoption and deployment.

[1] *Note: NTI and Seeing Machines are publicising that Australian fleets who have Guardian installed in their vehicles can now access a range of Insurance Policy benefits and Financial incentives in recognition of their proactive approach to the culture of safety within their fleet, bringing a stronger link between risk management activities and insurance*

Firstly, drivers and management all believe the use of these technologies has a very significant potential to reliably identify fatigued and thus high-risk behaviour drivers while operating a vehicle. They further believe the technology will significantly increase the likelihood of organisations and drivers detecting and thereby reduce the likelihood of distraction and fatigue-related errors and accidents.

In our discussions, it was very clear that while drivers and operators were aware of the limitations of the technology (i.e. the non-zero false positive and false negative rates), their 'benchmark' was the improvement in discriminability over current hours of work rules. While not perfect in discriminating between safe and unsafe driving, they intuitively recognised that the flaws were far outweighed by the benefits. That is, that 'perfect is the enemy of better'.

Drivers and operators consistently indicated that (a) current hours of work laws (e.g. Standard Hours/BFM) did not enable operators to discriminate between safe and unsafe driving with any degree of certainty and (b) that the fatigue detection technologies provided better and more appropriate information in order to help them differentiate between safe and unsafe driving and, critically, with a much higher degree of certainty.

Second, operators reported that the technology shifted the locus of control back onto their staff and provided a greater sense of operational efficacy. While not stated in these terms, operators typically reported that the technology permitted them to manage fatigue-related risk internally rather than through external actors (such as the hours of work regulations). Drivers and operators frequently cited the compliance-culture of regulators and police as counterproductive – especially the perceived targeting of good operators because they have the records to pursue administrative sanctions. In their opinion, the FDDTs provided a relatively objective and verifiable way to identify and manage fatigue related risk without the need for counterproductive third-party oversight.

It is worth noting that the operators interviewed did not suggest that the outer hours of work regulations should be eliminated for those using FDDTs but rather that where a FDDT is demonstrably more reliable in determining whether a driver is fatigued (or not), operators might reasonably assign primacy to the more reliable predictor of fatigue and to use this information to inform and justify fatigue-related decision making. Flowing from this increased confidence, they also believe that operational decisions based on reliable FDDTs should be considered legally defensible with respect to fatigue risk management and should be attributed more weight than mere compliance with prescriptive hours of work limits.

How did they introduce the technology and make it work for the company and drivers?

While clearly supportive of the technology, drivers and operators acknowledged the importance of cultural and organisational climate factors in influencing the success (or otherwise) of implementation at the firm level. All clearly identified the need for sensitive implementation of these technologies within the workplace and then ensuring their use was promoted, supported and encouraged in day to day operations. Drivers in particular were highly sensitive to the potential surveillance and privacy issues associated with these technologies. Companies also advised that perceived health issues relating to infra-red lights and electrodes in head bands also initially had to be addressed. A general resistance to devices that required drivers to wear anything was also identified. Drivers were distinctly uncomfortable with any FDDT that involved continuous recording although these devices are allegedly increasingly used particularly in the bus and coach sector to monitor all onboard vehicle behaviour. Most drivers felt continuous surveillance approaches were an unacceptable invasion of privacy and expressed significant resistance often based on the misunderstanding that in fact, only specific events were recorded[2].

Importantly, the identification and/or recording of safety critical events (due either to distraction or fatigue) was considered acceptable by all those interviewed in Phase two but for a very small minority of drivers. With devices involving cameras, 'event recording' identified at risk behaviours and then recorded 4-8 seconds before and after the event. This event was then scrutinised by the FDT provider remotely and/or sent directly to the employer. This safety critical event recording was used by the organisation to verify the incident and also for instructional purposes within most. The verification of events was considered critical by drivers and managers in establishing that safety critical events had occurred and were then used in real time to inform subsequent decision making on whether to continue driving or not.

In general, managers and supervisors adopted the technology because it provided relatively objective data on whether a driver was perceived to be fatigued or distracted. Many reported that this data increased their 'sense of certainty' as to whether a driver was tired or not at the time of the discussion around an alert. Critically, they reported this made the decision to request a driver to have a rest break easier for supervisors in the context of high tempo operations. Drivers liked the relatively objective nature of the data because they considered it was able to identify fatigue when they were not necessarily aware of it or might be reluctant to admit to it to themselves or others. It was often likened to "*having a mate or your partner tapping you on the shoulder to say have a break*".

Despite the lack of extensive formal training in some companies, drivers, supervisors and operators demonstrated a high degree of sophistication in their understanding of both the strengths and limitations of the technology. All of the drivers and most of the managers and supervisors clearly understood that the technology was not perfect at discriminating – especially with respect to fatigue. Most participants were aware of the possible false positive rates for the technology – this was significant especially in the implementation phase but also acknowledged that once the 'teething problems' were sorted the equipment worked very well and the false positive rate was acceptable. What was less certain was the thinking around false negatives. Most of the participants were not really aware of the issue (for the obvious reasons) and had not implemented the technology for long enough for this to become a visible problem. Indeed, we would argue, given the relatively low frequency of severe fatigue-related events, very few of the organisations had sufficient experience of false negatives to become aware of this issue. In addition, it was reported that the technology providers adopted a conservative approach and reported 50/50 type cases on the basis of being "*wrong rather than sorry*".

Importantly, both drivers and managers intuitively grasped the idea that the technology should be benchmarked against the low predictive utility of the current hours of work regulation rather than perfect discriminability. Indeed, several drivers commented that while the technology was not '*perfect'* it was clearly '*better'* than whether you were compliant or non-compliant with the current hours of work regulations and the associated work diary.

It is worth noting that drivers were particularly attracted to the Seeing Machines technology which involves third party "human" oversight of potential safety events by "specialists" at a 24/7 monitoring centre before notifying management at the local level. They felt that human oversight

[2] *Note: a recent Fair Work Australia hearing resulted in a decision that allows the use of FDDTs based on the safety benefits.*

significantly increased the sensitivity and specificity of this device and that it reduced the high rate of false positives perceived to be associated with earlier implementations of the Seeing Machines.

A second important factor was the way in which all of the organisations had addressed the issue of false negatives. That is, when the FDDT might fail to identify a driver impaired by fatigue. We were surprised to note that all of the organisations had an incontestable and absolute 'authority to stop' for drivers. This was unexpected as there has been much written in the literature about the potential for unintended behavioural consequences associated with the introduction of FDDT.

One of the perceived concerns was that companies would try to 'push' drivers who had not yet been identified as fatigued. Despite the undoubted appeal of this prediction vis-a-vis the road transport industry, we observed the direct opposite. Drivers in all of the companies interviewed both publicly and in private reported that an absolute authority to stop irrespective of their fatigue (as determined by the FDDT in place) or operational status. Importantly, all drivers, supervisors, managers and owners reinforced the importance of this principle in ensuring that the FDDT was effective. They all expressed clearly their concern over the risks associated with false negatives and the importance of the 'absolute authority to stop' as part of the safety management system supporting their use of FDDT's.

What did they do when the alert went off?

The last aspect of implementation raised by the interviewees was related to how an organisation responds to an alert indicating that a driver is possibly distracted or fatigued. This was discussed using two broad time scales. First, we explored how individual organisations responded to the real time risk associated with a driver alert. We then explored how drivers and organisations were responding iteratively to better understand how they might use the data on fatigue. That is, how drivers perceived the technology to alter their behaviour over time and how were organisations responding to aggregate data generated by these technologies?

Real-*term response to an alert*: Unlike the issues raised above, there was no clear consensus and considerable diversity on how the organisations should and did respond to a fatigued driver alert. Firstly, receiving an immediate in cab alerts (sound and/or seat vibration) were identified as critically important to the driver. Secondly the "what next" responses varied from stop driving at the next safe spot after the first alert to stop driving after the third alert. Most used a tiered approach whereby the first alert resulted in a supervisor (or proxy) calling the driver to discuss their fitness-for-duty with the driver ultimately determining his/her fitness to continue, with or without a rest. None of the companies currently permits a driver to continue driving after the third alert without an extended sleep opportunity. Organisations varied considerably in terms of intermediate steps with some simply mandating a 15-30 minutes break before continuing. Others made the decision based on a collegial discussion between driver and supervisor on how best to manage the risk in the context of the immediate driving task.

A second issue was the specific 'line of reporting' following an incident. In the larger organisations with 24/7 operations coverage, the alerts typically went through to a line manager to respond. There was then a discussion to further assess the risk and then a decision as to whether to continue driving or not or alternatively, what mitigations would be put in place if a driver did continue for whatever reason, to drive. In the smaller organisations or those without direct 24/7 supervisory support, notification was usually dealt with by a third-party organisation such as a 24-hour security service or at worst, the next day. Where there was an external referral process, the third party usually had a relatively formal and scripted interaction and decision process to follow. Participants frequently noted the trade-offs and possible prescriptive nature of third party non-expert responders but also acknowledged the difficulty and reality of providing 24/7 coverage in some small operations.

Based on these conversations it was clear that participants were still learning and experimenting with how to effectively operationally manage fatigue alerts both for safety outcomes and in a legally defensible manner. When we asked operators to explain specifically how they interacted with the drivers to determine whether (or not) to continue driving, most companies reported a relatively informal process whereby drivers were asked to self-assess their capacity to continue driving. Based on this discussion, the supervisor and driver would determine the most appropriate risk mitigation strategy in the circumstances.

Some of the organisations had semi-formal and formal documented approaches based on a series of risk assessment questions that were used to inform the decision. Most of these involved an assessment of prior sleep wake behaviour along with a range of less directly related issues that they considered relevant to making a decision about the fatigue risk. These were typically 'scored' and used to make this decision. It is worth noting that the informal decisions were often well-informed, and the more formal decisions were perhaps ill-informed mainly due to the lack of driver input (you will do this irrespective of how you feel) and the poor legal defensibility of the decision rules used.

The participants frequently indicated that there was no clear guidance from the FDDT provider or regulator on how best to make a decision whether to stop/continue driving and what constituted an appropriate risk mitigation strategy to continue or for how long they should stop driving/have a rest break before recommencing their journey. Critically, when pressed on this matter, the lack of clarity concerned participants and the wide variety of responses suggests guidance material and advice would be extremely useful in this area. They also indicated that in the absence of clear guidance, they had often sought advice informally from other operators or the FDDT provider on how best to manage alerts with the latter reported as naturally being cautious with advice in this area.

The other issue that emerged from this conversation was the choice of risk mitigation. For most of the operators, the only mitigation used prior to a third alert sleep-break was a 15-30-minute break from driving either roadside or at a truck stop. When asked why this was selected and if there was an evidence base for its use, none of the operators could defend the decision except to say it was based on the perception that these breaks have some standing based on the HVNL. While not stated, it would appear that this was the only mitigation they were aware of and used. Following a third alert, operators who permitted a third alert indicated that the subsequent break must involve sleep rather than rest. There was no clear consensus however on how much sleep was sufficient with responses varying between a 'power nap' to a 7-hour rest (again, perceived as appropriate in line with the HVNL).

How did the driver's behaviour change over time in response to the technology?

This was an interesting aspect of the research. Our initial view had been that drivers would have some reservations that the technology might potentially be used coercively. That is, "if the machine says you're not tired, keep going". Nothing could have been further from the truth. As indicated above, all of the companies incorporated an 'absolute authority to stop' as part of the policy architecture around fatigue. As a consequence, driver's self-assessment (as unsafe to continue) was always assigned primacy at all times over fitness-for-duty predictions based on either the working time arrangement, prior sleep-wake, self-report or the FDDT.

What was also interesting was how the driver's used the FDDT feedback over time to learn and improve their understanding about the fatigued state at a personal level. That is, most had a heightened awareness and desire to identify leading indicators of fatigue more reliably (e.g. inattention, reduced situational awareness, intermittent performance monitoring of speed or lane position.). This was perceived as being a matter of pride as well as fulfilling the basic requirements to be considered as a professional driver.

In a sense, many of the drivers felt that an alert was a good thing because it helped avoid a possible accident but also that it indicated a personal and professional failure to identify impairment. Many of the drivers indicated that they were using the technology to better understand their personal 'tells' with respect to fatigued driving (examples being head scratching, rubbing eyes, jiggling foot). While not stated by the drivers, it was clear to the authors that they were using the technology as a biofeedback device to identify when they were fatigued and to learn to better recognise the fatigued state. As 'operant conditioning' theory would suggest, drivers were using the technology to improve the accuracy of self-assessment based on identifying and learning the key antecedent behaviours predicting a micro-sleep. The FDDTs enabled them to 'get ahead of the game' by increasing their self-awareness of an imminent micro-sleep event. Critically, some of the drivers interpreted the occurrence of a fatigue alert as *prima facie* evidence that they had not been sufficiently 'professional' to identify the impairment before the technology did.

How did the organisations learn from aggregate data?

The simplest answer to this question is that by and large in the formal sense, they have not - yet. Most of the organisations had only developed a 'response' methodology at the individual alert level. How to respond to repeated alerts based on time variables (e.g. time-of-day, time-of-shift etc) or individual differences (e.g. repeated reports from a specific individual) were at best *ad hoc.* Some of the organisations had developed reporting templates and graphs to illustrate aggregate data. However, while these data provided more information than was previously available, they were of limited statistical validity in supporting safer decision-making.

It is worth noting that most of the organisations indicated that fatigue alerts were usually in the first 2-3 hours of a driving task and that they found this counter-intuitive. They expected fatigue to predominate at the end rather than the start of the driving task. While the explanation of some of this is quite straightforward (the fatigue was often associated with early starts coinciding with the circadian nadir between 3-6am) it does illustrate the relatively simplistic (and incorrect) beliefs reinforced by the current hours of work regulations (i.e. that fatigue events are more likely to occur towards the end of the shift This is unsurprising given the relatively singular focus on the duration rather than time-of-day at which the driving task occurs. One of the longer-term and bigger users said that "*the fatigue alerts are occurring anytime during the shift and at any time of the day rather than what we anecdotally thought was towards the back end of the shift which is counter intuitive to what we thought would be the case*".

In our discussions, it was very clear that the organisations currently lacked the expertise and guidance necessary to inform good policy and decision-making with respect to aggregate data. Those reports that existed were typically developed in an *ad hoc* manner by operations managers or safety staff without necessarily the support of relevant knowledge or experience. This could carry a significant risk of (a) failing to identify patterns that were clearly present or (b) over-reacting to alerts that were to a certain extent unpreventable (e.g. between 3-6am).

How could the regulator help most?

It was very clear from the participants that the NHVR has a key role to play in supporting the introduction and use of FDDTs if this can be facilitated through the HVNL (which it currently isn't). In saying this, most participants had little understanding of the fact the NHVR works within the constraints of the HVNL and cannot in its own right, amend the Law.

Participants expressed significant concern that the traditional Law makers (state jurisdictions) might struggle to find the right balance between prescriptive and risk-based approaches to regulating FDDTs. Given their enthusiasm for the FDDTs they have implemented, participants saw the key role of the regulator as an enabler (standard setter) rather than an arbitrator of what technology to adopt. That is, to provide industry with the necessary support and advice to ensure the scientific and legal defensibility of decisions made around FFD using the different FDDTs.

However, participants were also very clear that these technologies, in and of themselves, were not a viable alternative to the current HVNL nor were they a 'silver bullet' solution to managing fatigue-related risk. They clearly saw an important role for these technologies but as an ***additional*** element within the broader fatigue risk management system. They saw these technologies as a very important way to ensure that their employees were FFD irrespective of their hours or work and/or their self-reported FFD. That is, the FDDTs provided a very good way to 'triangulate' objectively between hours of work, and driver self-report indicators of FFD safety.

Critically, they saw FDDTs as significantly better predictors of safe driving than compliance with the current prescriptive hours of work regulations or self-reported FFD. Importantly, they typically suggested that FDDTs enabled them to determine if a 'compliant' driver was fatigued on a given day at a given time and to use that information to intervene safely. Not surprisingly, they also saw the opportunity for FDDTs to be used to justify flexibility in the decision to modify the operational envelope safely if and when required.

When asked how best to incorporate FDDTs into the regulatory framework most operators indicated their current use or preference for a multi-layered 'defences-in-depth' approach to safety whereby hours of work, prior sleep-wake and in-vehicle behaviour are used conjunctively to determine the certainty that a driver is FFD. For many of the operators, FDDTs provide a higher degree of certainty around FFD and therefore could enable an operator to demonstrate safe operations but with less emphasis on hours of work with prior sleep-wake as the primary determinants of FFD.

Participants also saw an important role for the regulator in ensuring the adoption of FDDTs does not inadvertently disadvantage companies that adopt it. Drivers and operators frequently expressed concerns over the potential uses of this technology – especially with respect to accident litigation and minor sanction enforcement. For example, in the event of an accident, where a driver and operator had received an alert and had made a reasonable decision to continue to drive, it is possible that this could be used as evidence against the organisation. Alternatively, a similar organisation without the FDDT in place, would clearly not be exposed to the same liability as there would not be any evidence that the driver may have exhibited symptoms of fatigue. In the absence of legally defensible code of practice or guidance materials from the regulator, adopting FDDTs might prove inadvertently counterproductive. This would likely slow the adoption of this technology, particularly for companies at the smaller end of the market who are typically not self-insured.

The study participants also saw an important role for the regulator in creating incentives for operators who adopted the technology in a way that promoted and demonstrably improved risk and safety management. When asked how best this could be achieved, they identified two key areas. First, they saw significant potential for the technology to be used to provide evidence of safe operations independent of the working time arrangements. In their view, an operator who was identifying and managing risk using these technologies may not need to place the same level of emphasis on compliance with the full prescription of 'hours of work' regulations. In their view, FDDTs provided much stronger and transparent evidence of safe operations than compliance with hours of work regulations. They saw considerable opportunity for greater flexibility in hours of work since fatigued drivers could be identified and risk mitigated directly rather than indirectly via compliance.

Second, they saw considerable potential for reduced compliance monitoring via third party enforcement agencies (e.g. police). In their view, a well implemented FDDT would provide greater certainty of safe operations than is currently achieved through roadside enforcement. Several operators suggested that companies using a demonstrably effective FDDT might reasonable be exempted from roadside inspections. In their view this would provide a significant incentive for adoption and to reduce the resources currently devoted to work diary inspections and prosecution.

Finally, participants indicated that they had struggled with how best to aggregate and analyse FDDT 'alert' data and their responses. While some of the companies had developed *ad-hoc* aggregate data and reports, they were not confident that they were doing this appropriately and were unsure how to use such data in monitoring and review processes. Smaller companies did not typically aggregate data in a formal manner. There were two reasons for this. One, the actual volume of alert data could be quite low (1-2 reports per months) and the operators typically lacked the analytical skills to make sense of the information in a meaningful way. Similarly, they were unclear on how such data should be reported. For the larger companies, while the data volumes were higher, they also struggled with analysis and reporting. Having said this, most participants could clearly articulate how they identified a driver who was consistently receiving alerts and usually linking this to the need for a more focused medical intervention to be undertaken.

Participants saw a key role for the regulator in supporting operators in how best to aggregate, analyse and report their data and where possible, collaborate with others to deliver a bigger and faster picture of challenges. Smaller operators recognised that low data volumes would make it very hard for them to develop statistically reliable databases to inform decision-making around best-practice over the short-term and even the larger operators were not confident in their capacity to undertake scientifically defensible analyses. When asked on their willingness to contribute alert data to a national database, all of the operators indicated that they thought this was a good idea. Participants also suggested an important role for the regulator, (supported by appropriate subject matter experts) to use this data to inform best-practice and to provide whole-of-industry guidance on how to manage fatigue-related risk based on FDT data.

Is the equipment reliable?

Most companies reported that they had a low rate of maintenance issues with the technology with the majority of issues perceived to be related to early "teething" challenges requiring minor adjustments. Interestingly, the main issue here appeared to be the timeliness of repairs when equipment did need attention and what counter measure they should take when a FDDT was not operating correctly. Some out of operation issues also related to early driver suspicions about the equipment including cameras being inadvertently covered by caps. An issue raised with the head band technology was drivers removing it when out of the vehicle or leaving it in the car at the start of a shift.

Overall, the study participants reported the FDDTs seemed highly resilient and operated consistently even under tough conditions (excessive heat, rough terrain, building sites etc). They also reported that they received timely reports when equipment wasn't functioning and were able to take corrective action, either with the driver or where maintenance/adjustment was required.

What did the Suppliers say?

Suppliers naturally saw an important role for this technology going forward and indicated that they believed the technology would play an important role in reducing fatigue-related risk and improving safety in the trucking industry. That being said, they also understood that these are not 'mature' technologies and that providers and end-users still lack good empirical data on which to assess the 'validity' and level of risk mitigation afforded by these technologies both 'in theory' and 'in practice'.

Based on our discussions with technology providers, it was clear that the installed base for these technologies was relatively low and experience in implementing, using and evaluating these technologies was, at best, nascent. Furthermore, the providers reported that when purchasing, operators did not typically undertake a critical evaluation of the technologies that would meet normal 'due diligence' requirements. It is worth noting that most of the technology providers did not have strong validation data for their products nor did they typically point out that limitation to potential purchasers. The technology providers reiterated the conversations with operators in that most referrals were driven by 'word-of-mouth' (typically from key opinion leaders in the industry) or from conversations started at trade show exhibitions

At this stage this lack of validation data may not be a critical issue, since operators are typically using these technologies for improving the certainty of FFD while remaining *within* the hours of work regulations. On that basis, provided the predictive value is greater than random, it could be justified. However, in the event that these technologies would be used to underpin an application for proposed flexibility operations outside the hours of work regulations, the lack of good validation data could potentially prove problematic. This is a critical 'emerging' issue since the technologies investigated are quite different in their approaches and what constitutes 'validation' will vary between technologies *and* the context within which they are implemented and used by different organisations. It is possible that some Technology providers may be persuaded to share some of their aggregate data if encouraged by the opportunity of greater sales.

Based on our discussions and the Phase One Report, currently available technologies fell into two broad categories. That is, driver state sensing (DSS) and embedded performance measures (EPM). Since DSS technologies monitor the driver, validation data would always be referenced to 'gold standard' measures of fatigue such as EEG. This is typically done in laboratory or field-based settings and requires expertise not typically available in the company. As a consequence, operators have to rely on third party expertise to establish the 'validity' of the technology in identifying a fatigued driver. This is typically done by commissioning research groups to undertake and publish validation studies to justify the use of the technology.

On the other hand, EPM technologies are not necessarily concerned about 'why' a driver is driving unsafely. They typically identify that unsafe driving has occurred and report it either immediately or later to another party within the organisation. Poor driving is then used as a trigger for a performance management process to improve subsequent driving safety.

Determining whether a driving behaviour is unsafe or not based on EPM's is generally considered something the operator's staff can reasonably judge and thus does not require the same level of independent external validation. Determining the root cause of the impaired driving does not benefit directly from third party expertise and is typically left to a post-alert discussion between driver and supervisor. These differences in the validation requirements of the different technologies are important to understand from a regulatory perspective since different technologies will need different criteria to determine their likely certainty in determining FFD.

It was clear from discussions with suppliers that the larger companies with bigger installed bases of DSS technologies could often afford to employ staff with demonstrable expertise in principles and practice of Human Factors and Safety Management. These employees were able to provide considerable post-marketing support to customers on how best to implement these technologies and had, in some cases, developed standardised procedures on how best to respond to alerts in a defensible manner. On the other hand, where a FDDT was part of a distributor's broader product suite, there was perhaps less expertise available to support the customer.

Only one of the suppliers was able to supply even basic validation data that met reasonable criteria for lab, field-based and longer-term use. However, even for the most advanced technology provider, this had not been systematically collected, analysed or published in the peer-reviewed international literature. It would be reasonable to conclude that the lack of systematic validation data especially for DSS technologies was an acknowledged limitation of the technology. Companies providing DSS technology understood the need for such data but also argued (reasonably) that it was still very early days for in-field and long-term evaluations and that these would likely become available as the installed base for the technologies increased. They also indicated that they felt that there was a role for government in funding or co-funding such research given the relatively small capital base of technology providers and the perceived bias associated with in-house studies.

In addition, the technology providers were concerned that where this technology might be used to underpin a safety or more flexibility case, poorly validated 'copy-cat' technologies might become available. their specific concern is that an unregulated market for these technologies could potentially compromise safety if companies invested in cheap, poorly-validated technology. They felt that if the technology was to become 'essential' then cost pressures would, as always, drive adoption of cheaper less well-validated technology by the less profitable operators. They indicated that there were already a significant number of inexpensive, well-marketed but poorly validated technologies available. Along with the operators, they saw the 'validation' issue for technology providers as a very significant threat to effective adoption of the technology.

When asked on how best to address this issue, the technology providers saw an important role for the regulator in establishing an 'accreditation process' for approved technology. However, when pressed on this issue, they also recognised that this might be beyond the remit and expertise of the regulator also noting operators talk about setting a standard rather than approving specific technology. They also acknowledged that this might create barriers to entry for innovative new products. Most of the technology providers agreed with the suggestion that where an operator intended to use these technologies as a part of an application for greater flexibility, the regulator might if appropriate (say with a new device), require the applicant to provide an assessment of the validation data for a specific technology and context as part of the approval process.

The technology providers also indicated a potential role for the technology in helping insurance companies better target individual insurance premiums and/or excess payments. While some of the operators interviewed in this study were self-insured and gained an immediate benefit from any safety improvements, this was not always the case for companies that bought insurance commercially at 'whole-of-industry' rates.

They also felt that companies who adopted the technology even within the current regulatory envelopes might reasonably be rewarded individually for improved safety. They indicated that it was difficult for an individual operator to provide data justifying this as it could take 5-10 years to show measurable reductions in claims. They did, however, suggest a role for the regulator in using pooled or aggregated data to determine the safety benefits of the technology so that the insurance providers could make and ensure quicker, more accurate assessment of an individual operators' risk profile. As mentioned above, the possibility of suppliers providing aggregate data to help improve understanding was raised during the interviews and whilst there wasn't a strong commitment to do so (on commercial grounds), there was acknowledgment that this could be helpful to further encouraging adoption and regulatory acceptance.

Some providers also highlighted the perception that there is strong resistance and apparent acceptance in the Australian market (as opposed to others) to technology that required the driver to wear equipment to measure fatigue. It was suggested that this hasn't been an issue in some other countries where the drivers perhaps do not have as much say in operational issues. One supplier suggested this type of equipment should be mandated to help the market mature and assist their supply chain.

5. Recommendations in full

Recommendation 1

That the National Heavy Vehicle Regulator (NHVR) and the industry identify initiatives on a collaborative and timely basis that will encourage road freight and passenger operators to invest where appropriate in Fatigue and Distraction Detection Device Technology (FDDT) as an integral element of their fatigue risk management system in delivering better road safety outcomes. This should include:

a. *Seeking urgent amendments to the Heavy Vehicle National Law (HVNL) to recognise and support the use of fatigue and distraction detection device technology to provide for greater flexibility and safety in hours of work management.*
b. *Pursuing ongoing work to further enhance guidance material for using this technology including trialling and improving the draft "How to" Manual developed in stage two of the NHVR Fatigue Trial.*
c. *Establishing an industry working group to assist the NHVR identify "best options" to encourage use of this technology including progressing the other recommendations in this Report in particular those regarding data availability to enhance the empirical evidence in pursuing better safety outcomes in the industry.*

Stage two of the NHVR's Fatigue Trial clearly showed that both small and larger businesses in the freight and passenger transport sectors are increasingly investing in improving fatigue risk safety outcomes through the growing use of fatigue and distraction detection device technology. The operator and driver interviews alike provided almost unanimous support for these devices and highlighted their belief that their use leads to fewer near misses and crashes which is in turn keeping drivers and other road users safer. The writers also recognised that to date, that this investment in safety is being made without any regulatory support or benefit which highlights the importance of pursuing cooperative and timely industry/government initiatives to leverage and continue to encourage rather than hinder the greater use of this safety technology.

Recommendation 2

The Heavy Vehicle National Law (HVNL) should formally allow a flexible framework to encourage the delivery of the potential safety benefits of Fatigue and Distraction Device Technology (FDDT) within a broader Fatigue Risk Management System (FRMS) framework.

In our opinion, it would be highly useful for the HVNL to conceptualise fatigue risk mitigation strategies along a continuum proving increasing flexibility as appropriate contingency measures are in place. The decision to drive (or not) should be shaped by the organisational certainty that a driver is (or is not) Fit for Duty (FFD). In a sense the controls constitute a 'hierarchy of certainty'.

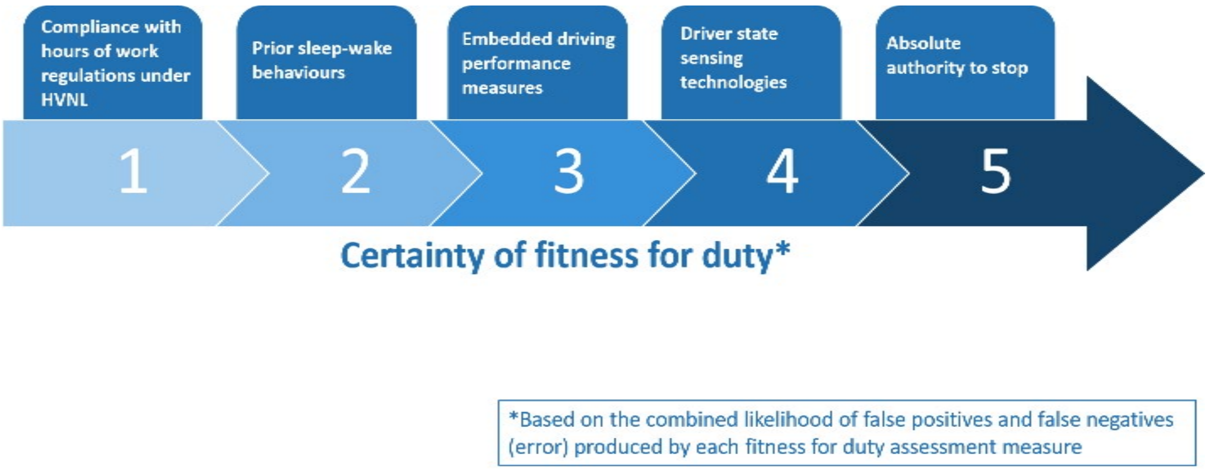
At the top of this hierarchy the driver has an 'absolute authority to stop' if fatigued. Given the dual duty of care provisions under WHS and NHV legislation, the driver plays the primary role in determining FFD and, therefore, fatigue-related risk. In our view (and those of all the participants), the driver is the best-placed person to decide FFD.

If a driver indicates they are not fit to drive that decision should be considered absolute and incontestable. No organisation should have the ability to over-rule a driver's decision at the point at which a driver self-identifies as not FFD. At the point a driver indicated no longer being FFD, the operator should immediately be legally obliged to take all reasonable steps to enable the driver to eliminate the risk to as low as reasonably practicable (ALARP). Clearly, if this becomes a habitual or chronic behaviour then it would be subject to performance management in the same way as absenteeism or other performance management issues.

In our view, there is a shared responsibility that the drivers and operators immediate focus of responsibility should be on ensuring that the driver can stop safely without unacceptable additional risk to themselves or the community. We do, however, acknowledge that a driver may elect to continue to drive (for whatever reason) knowing that they are not FFD or are unaware that they are not FFD.

To avoid this situation, we might additionally over-ride a decision to continue driving based on data drawn from other predictive or proxy indicators of the likelihood of fatigue. For example, if there were multiple alerts reported by a fatigue detection device, clear evidence of insufficient sleep or demonstrable impairment. Based on the criteria of 'certainty of FFD', that is, the predictive utility of the technology for determining FFD, we could reasonably assign a hierarchy as such:

1. Compliance with hours or work regulations under HVNL
2. Prior sleep-wake behaviours
3. Embedded driving performance measures
4. Driver state sensing technologies
5. Absolute authority to stop



Based on our discussions with industry (and the existing scientific literature), along with the 'absolute authority to stop' all of the technologies assessed in this report, along with prior sleep-wake controls, typically provide greater certainty vis-à-vis FFD than compliance with the current hours of work regulations. Moreover, based on the report in Phase One and the broader scientific literature, it is likely that driver state sensing technologies have higher predictive utility than those based on embedded measures of driving performance.

We would suggest that the HVNL provide for the regulator to use this continuum to determine the measures company's use to ascertain the certainty that a driver is FFD and to assign primacy and greater flexibility to those levels that provide the greater certainty. From a safety management perspective, mitigation systems based on higher levels of certainty could be assigned primacy over lower levels. A well implemented system that provides a high level of certainty that a driver is FFD will likely reduce the value attributed to controls at a lower level of certainty.

Recommendation 3

In order to ensure the effective use of fatigue and detection distraction device technology (FDDT), the NHVR should provide evidence-based guidance materials to assist industry better select, implement, operate, evaluate and improve fatigue (and distraction) detection technologies. Guidance materials should be updated regularly to reflect improvements in the technology and our understanding of how to best use them. (the interested reader is referred to an accompanying report on this topic authored by the NHVR and recent international peer-reviewed publications (see NHVR Research Report: Phase One – Review of Fatigue/Distraction Detection Technology, 2019). In particular, operators indicated a very strong interest in guidance materials on how best to respond to alerts in a legally and scientifically defensible manner.

In addition to specific guidance on how to use the technology, it was very clear in the interviews that operators would benefit from more guidance with how to effectively integrate fatigue detection technologies into their broader safety management system framework. This likely reflects their unfamiliarity with such approaches and a century long reliance on highly prescriptive hours of work regulation. We would suggest that the NHVR work with appropriate specialists to develop guidance materials with a specific focus on:

- selecting technology
- implementing the technology within the workplace
- strategies for creating the right safety culture to support its use
- developing clear standardised procedures for responding to alerts in both the short and longer term
- developing reporting templates for organisations to evaluate the efficacy of the technology and its reliability in identifying risky operational practices
- analysing the data from the technology to enable it to be used as part of a continuous improvement process.

Recommendation 4

Where an operator seeks to use fatigue and distraction device technology (FDDT) to justify increased operational flexibility (vis-a-vis the hours of work requirements in the HVNL) a detailed description of how these technologies would be implemented and evaluated by the operator should be included as part of an application to operate under BFM of AFM principles.

Most of the participants had adopted the technology within their pre-existing fatigue management policy/program. For most of them it was too early to consider how this technology might be used to support or supplant current driving hours regulations. However, many had started to think carefully about how this might be done in the future. There was a general consensus from the operators that the technology could not be regulated independent of the context in which it was used. They felt that where an organisation was interested in using the technology to increase operational flexibility it would be reasonable to use a mechanism like the current BFM/AFM processes and conceptualise the use of the technology as a more sophisticated and continuous form of FFD testing after driving had commenced. In effect, the FDDTs could be used to increase the certainty that a driver was FFD when operating both inside and outside agreed base regulatory envelopes.

Recommendation 5

That the NHVR should propose the establishment of a national database to which individual organisations can contribute fatigue risk data obtained from fatigue and distraction device technology (FDDT). Pooled data will enable the industry and regulators to jointly identify and eliminate high risk fatigue-related activities more rapidly and with greater statistical certainty.

Given the highly diverse nature of the heavy vehicle industry in Australia (most operators with less than 5 trucks), it is clear that the 'alert' and incident rates for an individual organisation will be quite low. For the study participants, fatigue alerts were relatively rare with 5-8 fatigue alerts per week in the operators with the largest installed base. In small companies, analysis of the data from these systems will have low statistical reliability for many years until there are sufficient reports to build a reliable statistical model. In the many small companies, 1-5 alerts per month would be typical. While each of those alerts identifies a very high-risk situation and requires a significant short-term response to mitigate the risk, root cause analysis will require hundreds to thousands of alerts before the possible causes can be clearly identified with any degree of statistical certainty.

The complexities and costs associated with undertaking such an initiative could be considerable but the road safety benefits, if successful, would likely be greater. It would require a new cooperative approach to data sharing from government and industry particularly to ensure that information collected was properly de-identified to avoid possible sanction action. Such an initiative would rely on data from the transport companies and data supplied to them by their providers noting the sensitive issues relating to protection of commerciality for suppliers and the importance of evolving a solution to gain their cooperation. It is worth noting that such data bases are common in the aviation sector as a direct result of their shift toward a more risk-based approach to managing fatigue-related hazard.

A national database that enables data to be pooled across hundreds or even thousands of operators would enable the NHVR to create 'big data' sets that could be made available to researchers and policy analysts. Such data sets could be used to understand the extent to which individual features of the working time arrangement (e.g. timing and duration of shifts and breaks, cumulative hours and countermeasures) influence fatigue-related accident risk.

Recommendation 6

That the NHVR consider supporting or developing a research program to assist in identifying evidence to underpin the effective use of fatigue and detection device technology (FDDT) in improving safety outcomes. This would include the collection of data and dissemination of evidence on the how best to use these technologies in order to reduce fatigue-related risk in operational settings.

Given the novelty of these technologies, it is likely that product development and best-practice use will evolve rapidly over the next decade. During this decade or so, it will be critical to observe and record the ways in which many different operators implement and use a very diverse range of emerging technologies. Monitoring this period of change will be critical if we are to rapidly identify best-practice approaches and avoid unnecessary mistakes or duplication of effort.

Recommendation 7

That the appropriate regulatory bodies (being the National Transport Commission (NTC) and the National Heavy Regulator (NHVR)) collaborate to ensure initiatives are pursued to address a range of *complementary challenges identified in Phase two of the NHVR Fatigue Trial that are perceived to be associated with delivering better fatigue outcomes.*

These complimentary challenges listed below were consistently raised by operators and drivers and include:

a. Developing a better understanding of the fitness for work challenges in the heavy vehicle industry including:
    a. the development of a deemed fatigue impairment measure similar to BAC based on a minimum sleep – wake guide
    b. investigating identified concerns re the usefulness of the current driver medical process to assist in better identifying and managing drivers who are not fit for duty.
b. Reviewing the current driver licensing system to place a higher value on competency and development of a career path rather than the current restrictive age and time graduated approach.

6. Appendices

Appendix A – Semi-structured interview questions

Section 1: Decision to Invest

1. What was the main reason your company decided to invest in fatigue/distraction detection technologies?
2. How did you go about choosing the fatigue/distraction detection technology?
3. How were options with different technologies evaluated and what was the nature of the procurement process?
4. Have you implemented driver state awareness systems (those that monitor drivers for symptoms of distraction or drowsiness) or driver assist technologies (those that monitor and correct driving performance such as lane-drift), or both?
5. If both, how do these technologies complement each other?
6. What system(s) were not selected, and why?
7. What system(s) was/were selected, and why?
8. What regulatory incentives might companies seek for using the technology?

Section 2: Implementation

9. Who was responsible for implementing the systems?
10. Do you use multiple systems in combination? If so, how are they integrated?
11. How long have you had the technology, and is it in all your vehicles?
12. What training was necessary for drivers / managers / maintainers?
13. What was difficult in the implementation process?
14. What was easy in the implementation process?
15. Did you undertake a consultation process?
16. Did any drivers leave the company as a result of implementing the technology?
17. Are there any options / extended uses of the technology that you opted not to implement?

Section 3: Operation and Maintenance

18. How are the systems maintained?
19. What resources and costs are involved in monitoring and reviewing the data?
20. Have there been any issues in operation?
21. What is the feedback like from the drivers?
22. Do you sleep better and night having made this investment?
23. Have you seen an actual reduction in incidents / accidents or improvements in safety?
24. Have you seen any actual behavioural change in drivers as a result of the technology?
25. Is it possible to identify any behavioural differences/outcomes between drivers where some vehicles are using detection devices and others aren't?

Section 4: Policy and Governance

26. Is there a formal policy for the use of such technologies?
27. Are there formal procedures for use by drivers / operational managers / safety managers?

28. Are the systems used in disciplinary / performance management processes?
29. How are any potential issues with driver privacy managed?
30. What interaction have you had with the regulator in relation to the implementation and operation of your systems?
31. Have you received benefits from your insurer through implementing and operating these systems?

Section 5: Data Utilisation

Access to data available to selected companies is likely to vary on a case by case basis and will also be dependent on the assurances the project team can provide with respect to it being deidentified and also not subject to any sanction action. Data availability will also be framed by what information is provided to the companies from the technology provider.

Based on the above, the following questions will be asked:

32. How is the data from your system used in the organisation?
    a. Individual day-of-operations?
    b. Individual feedback on performance?
    c. Performance management / disciplinary procedures?
    d. Trend analysis across a fleet / route / network?
    e. How does this data get used within your Safety Management System (SMS)?
33. Are you happy to discuss frequency of incident alerts from the systems?
    a. How frequently do your drivers receive alerts from the system?
    b. Do you have a “baseline” alert rate?
    c. Are there KPIs anywhere within the organisation in relation to alerts?
    d. Do you know the rate of “false positives” (alerts when the driver is not fatigued / distracted)?
    e. Have you had any false negatives (no alert when the driver has been fatigued / distracted)?

Appendix B – Interviewees

Road freight and passenger transport operators

Company	Location
Daryl Dickenson Transport	Brisbane, QLD
Greyhound	Mackay and Moranbah, QLD
Hanson Construction Materials	South Eastern QLD
Jim Pearson Transport	Port Macquarie, NSW
MultiQuip Transport	Austral, NSW
Origin Energy	Brisbane, QLD
Rocky's Own	Helidon, QLD
Ron Finemore Transport Services	Wodonga, VIC
Tasco Petroleum	Bendigo, VIC
Toll Group	Melbourne, VIC
Visa Global Logistics	Brisbane, QLD
Wettenhalls	Melbourne, VIC

Technology providers

Company
Augmented Intelligence
Directed Australia
DriverRisk
Connect Source
Mobileye
Optalert
Seeing Machines
SmartCap

Appendix C – Aggregate Interview Reponses

Section 1: Decision to Invest

Q1. What was the main reason your company decided to invest in fatigue/distraction detection technologies?

There were several key themes that were raised among interviewees during data collection with regards to the reason behind the implantation of Fatigue and Distraction Device Technology (FDDT). Broadly, these themes can be categorised into safety, industry trends, and customer requirements.

With regards to safety, a number of the organisations that were interviewed were aware prior to the implementation of the technology that fatigue and distraction were significant safety issues within their driver population. For some, FDDT was implemented in response to workplace incidents. One organisation described a fatigue-related incident involving a truck rollover and fatality as an instigating factor. Another commented "*I looked after the company line haul component and we were having incidents that were attributed to fatigue*". Other organisations described an understanding that while they had not had a significant fatigue-related accident, "*it wasn't a case of if, but a case of when - sooner or later you're going to have one*". Several interviewees also mentioned significant organisational culture change that had taken place in recent years, expressing that there was an increased focus on safety, and less pressure on drivers to "*toughen up*" rather than admitting to being fatigued. One manager remarked that "*we want to be able to show that we're proactive in our thinking...we have our driver's safety and the public's safety as a top priority*". Another remarked "*Customers having a focus on fatigue and fit for work, particularly after a few fatigue-related incidents. These were recorded by in vehicle cameras (not fatigue detection technology)".*

Industry trends and customer requirements were also mentioned by several organisations. Several managers remarked that it was "*just a matter of moving forward*", and that there is an "*obligation to follow industry trends*". This was also reflected by the understanding that other operators had implemented FDDT, and to be a leader in the industry this is an important safety technology to implement. Several operators also indicated that the technology had been implemented in response to customer requirements, including tender prerequisites. One manager simply stated that the technology had been implemented because "*the customers wanted it*".

Many companies interviewed had or were currently running trials or pilots of FDDTs in a relatively small percentage of their fleet. Some had undertaken full implementation following successful completion of trials and/or after seeing their first images of drivers having micro sleeps. One said "*what we detected on the 10 trucks during trial was enough reason to put it into all trucks, thought shifts were well controlled but quickly learned that this was incorrect, learned fatigue can happen anywhere in the shift, anytime of day, always believed fatigue to be in back half of shift and/or at night, worst times were 6, 7 & 8 am and 3 and 4 pm, didn't understand why*".

Growing customer awareness of Chain of Responsibility requirements was also mentioned in some interviews, a typical comment being "*When you work for companies...they want to see what sort of processes you have in place for fatigue".*

Q2. How did you go about choosing the fatigue/distraction detection technology?

There was not a great deal of variation between operators in terms of the FDDT that was currently operational. For the overwhelming majority of operators, the Seeing Machines Guardian system had been implemented with limited comparisons undertaken with other technology options. One operator indicated that they had selected the Guardian system because there was a desire to align with industry leaders. One manager indicated that they had received a proposal regarding the Guardian system, which was validated by industry colleagues. Another stated "*we were also looking to see who the competitors were for the Guardian system but we couldn't find any*". Yet another said "*we looked at other technologies, we were looking to see who the competitors were for the DSS but we couldn't find any*".

For several operators, trials had been conducted on one or two other (not specific FDDT) technology options, often with limited success. FDDT options were, in some instances, discounted because there was no option to include a driver alert. Instead, some technology options provided delayed notification to management rather than a real time alert. These technology options were typically not rolled out widely following trials.

An important factor in the choice of FDDTs raised by most companies related to whether they provided an in-cab alert (noise and/or seat vibration). This was seen by both drivers and management as an important real time intervention to assist in avoiding a possible incident, "*Seeing Machines was chosen for its real time capabilities*".

Some participants also pointed to the perceived strong resistance of some drivers to use of any FDDTs that required them to wear equipment. One driver said "*I don't see myself wearing anything around my forehead, some drivers like it and some don't*".

Some companies explained that they used FDDTs with other technologies such as DriveCam; they feel the latter gives them a broader view of any incidents which is valuable in post event analysis; also used for seat belt usage and other forms of compliance detection.

Q3. How were options with different technologies evaluated and what was the nature of the procurement process?

For one operator, the procurement process for FDDT was limited, due to being provided the system at no cost for a trial which is still underway. Cost was also a factor for several other operators, and was key in the procurement process. One manager also indicated that it was a combination of the lower cost, and the fact that their chosen FDDT was Australian-made that resulted in implementation.

Few interviewees indicated that a scientific evaluation of the technology options was made. One individual mentioned that the "*general literature*" was evaluated as part of the procurement process. However, this was described as a "*generalist assessment*".

A comment made by a few companies was something like "*trialled other technology which didn't work very well, was too expensive, settled on Seeing Machine Guardians instead*". Another said "*We looked at "smart glasses" and sensor caps but weren't impressed with the concepts*". Yet another stated "*Some comparative data was investigated, but thought the statistics from the Guardian system were backed up by other companies we spoke to who were already using the tech*".

Q4. Have you implemented driver state awareness systems (those that monitor drivers for symptoms of distraction or drowsiness) or driver assist technologies (those that monitor and correct driving performance such as lane-drift), or both?

The FDDT options that were selected by most operators were those that monitored signs of fatigue in drivers, rather than driving behaviours. The Seeing Machines Guardian technology was most frequently used. This technology is based on the recognition of driver facial expressions (i.e. whether eyes are open and looking at the road ahead). Two operators had implemented a trial of SmartCap. This technology utilises electroencephalographic assessment of brain activity to provide an indication of fatigue. As with the Guardian technology, SmartCap provides an assessment of driver states.

Several operators indicated that telematics systems were also in vehicles. Telematics systems include monitoring of driving activity, including harsh braking, acceleration, and seat belt use. One operator noted that this was due to a legacy issue, stating that there were "*five different telematics systems in the trucks*". Further, other operators indicated that additional camera systems were in place in vehicles, though these were largely for monitoring the road, rather than driver-facing.

Many of the operators that were included in this project indicated that they had additional in-vehicle monitoring technologies in place. However, most of these technologies were implemented to monitor driver hours, speed, and crash detection, rather than driver assistance. For example, several operators used MT Data fatigue checker software, which is based around hours of work and route tracking. Organisation-specific technology was also mentioned, though this was again based on route tracking and hours of work monitoring. One said "*the forward-facing camera has been important for providing evidence of fatigue happening on the road*" (e.g. truck drifting over white line), could have been a roll over in previous times. Telematics is also used for monitoring speed and driver actions at the time of an event e.g. harsh breaking (monitoring for fatigue and alerting driver in real time), distraction being monitored and reported (in real time). Another company said "*the majority of our fleet are Volvo trucks which have been fitted with the "Safety Pack" which includes: adaptive cruise with forward collision warning, lane control, EPS etc*.".

Some drivers commented that it is difficult to keep up with the increasing focus on in cab technology and what each piece of equipment does.

Q5. If both, how do these technologies complement each other?

Few operators provided specific feedback regarding the interaction between FDDT and additional technology options. It appeared that there was little crossover and interaction between the two although one operator said "*we use Drive Cam and Seeing Machines together to get a broader view into the cab*". The lack of perceived formal interaction may be due to the differing factors that are addressed by the technologies. One operator noted that, similarly to FDDT, managers would receive notifications if speeding occurred. Another commented "*it would be beneficial if Seeing Machines and Drive Cam could work together and combine their technology*".

Q6. What system(s) were not selected, and why?

Few operators had trialled alternative FDDT options prior to implementing their current option. Also see responses to Questions 2, 3 and 4 above.

However, a common theme between operators who had used more than one FDDT was that the technology options that did not include real time driver alerts were not suitable. One manager said "*lane departure systems (not selected) due to inaccuracy of line markings on roads*".

The other reasons that operators stated they had not selected a specific technology were due to privacy issues associated with continually recorded driver-facing cameras and costs. One operator trialled a five-camera system they declined to name. With this technology, managers were able to log in to the system and view a video of the drivers in real time. The manager who was interviewed stated that drivers had not been receptive to its use due to the "*big brother*" effect. Another interviewee indicated that "*it's the live footage [the drivers] are worried about*".

Several operators also indicated that technology designed to be 'reactive', rather than 'proactive' was determined to be unsuitable for fatigue purposes. Specifically, technology options that did not provided alerts when drivers were distracted or could be micro-sleeping were deemed by several operators to be less useful, as the alerts came "*too late*" to prevent a fatigue- or distraction-related incident. For example, one operator noted that they had done a trial of a full camera technology option, but it was not selected due to the perceived lack of real time information or alerts on fatigue.

Q7. What system(s) was/were selected, and why?

The FDDT system that was in use with the overwhelming majority of operators was the Seeing Machines Guardian technology. This was for several key reasons. The first was that this technology appears to have a reputation as somewhat of an "*industry standard"*. Managers indicated that they were aware that other Australian transport companies had this technology in use, and were therefore more likely to also implement it (industry standard). Other operators indicated that this technology had been selected based on the combination of front- and driver-facing cameras, in addition to the provision of real-time alerts. These real time alerts were described as a "*safety net*" by several interviewees.

Two organisations were also currently undergoing a trial of SmartCap technology, and reported strong support from both managers and drivers. Based on the provision of auditable fatigue alerts prior to fatigue-related events (e.g. microsleeps), one manager in principle supported the potential future full implementation of this technology stating that "*I think it's got more benefits than any other system I've personally used*".

Other "safety" technologies that were not solely focussed on fatigue and distraction technology were also in use in most companies. These were usually used in an ad hoc way to support information obtained from FDDT. One safety manager said "*section 228 (of the HVNL) the driver must not drive whilst impaired by fatigue', so I think when you look at it through that lens, DSS was quite clearly one of the best options on the market*".

Q8. What regulatory incentives might companies seek for using the technology?

The overwhelming feedback from all operators who were included in this research project was that this technology could, and indeed should, be used to increase the flexibility associated with current HVNL hours of work regulations. This was also seen as a good way to encourage take up of FDDT "*it would be easier for industry to get the technology into the vehicles and get acceptance from the drivers if there's something in it for them*". The majority of operators suggested that the implementation of FDDT should be incentivised by less prescriptive hours of work regulations being monitored by the regulator. The option of regulating maximum weekly hours of work rather than specific hours of work guidelines (e.g. break times, shift length) was suggested by several interviewees. One manager suggested that an overall limit on daily driving hours (e.g. 14 hours plus loading time) would be a potential option. Operators overwhelmingly indicated that the use of FDDT to monitor fatigue on an individual basis, rather than basing fatigue assessment on hours of work, would be preferable. One manager stated that "*giving drivers greater flexibility with their management of their fatigue as a reward for having technology in the truck is the way. How you structure that is up to the regulator*." There was also a significant sentiment that the current hours of work are not tailored for individuals and expect a "*one size fits all*" approach. It was suggested that increased flexibility would be preferable to avoid "*tarring everyone with the same brush*".

Operators also indicated that the current hours of work guidelines may have safety limitations. Specifically, this was due to the inability of the guidelines to truly identify whether a driver was fatigued, and the focus on work diary errors and compliance rather than fatigue detection. One manager noted that "*to be compliant, we're potentially not doing safety properly*". Another stated that "*...the technology should skip electronic log books…really it's not going to have any safety improvement for us. If we want safety improvements we have to go to [fatigue detection technology*]".

These interviews also produced an overwhelming indication that the current hours of work regulations are problematic. It was generally acknowledged that the current system isn't good at identifying fatigue (counts hours), and that there is a preference for more flexible system. The current regulations were also described as being impractical at best (e.g. "*if you run out of hours at 10am....you've got to sleep in the middle of the day whether you're tired or not*"), and unsafe at worst (e.g. "*the work diaries have a lot of explaining to do with fatigue-related crashes*").

Problems were also described with the enforcement of the current regulations. There was a sentiment that the hours of work regulations are currently used as a 'punishment' tool, where drivers and operators may be fined for administrative errors (e.g. poor spelling, missed administrative errors). It was suggested by several interviewees that a system based on education around the management of fatigue would be preferable. Another manager noted, with regards to the current regulations: "*We're trying to massage the HVNL [hours of work regulations] ...to neatly fit a circle in a square hole in our operation. It just doesn't fit*".

The vast majority of interviewees also indicated that there is a need for a simpler system than the current hours of work regulations. It was suggested that a regulatory framework in which fatigue detection technologies could be used in place of the complex work diary system would be preferable. In reference to the current system, one driver noted that "*you've got to be a mathematician [to complete the work diaries]*". Another said "*I defy anyone to get everything right in a work diary day after day*". Moreover, while operators were aware that BFM and AFM application options are available, that there was "*a reluctance to go down the AFM path because it's time consuming and you need to present a lot of evidence*". One manager simply requested, with regards to the potential implementation of a system based on fatigue detection technology: *"can you [the NHVR] tell me the ins and outs of it in a really easy way?*". Yet another said "*it would be attractive if this company could operate under another system (like AFM) where there are no restrictions (i.e. 30-minute breaks) and not conform to prescriptive hours but attempting to get AFM remains uncertain, slow and expensive (but this might have improved)".*

Several companies also suggested they used standard hours as BFM was too complex. One stated "*if NHVR suggested installing seeing eye machines and then offer you BFM accreditation without all the processes that go with it then they'd be happy to go ahead*", another said "*reward for effort: if you can prove as a company that you can show that you are monitoring the fatigue and not counting the hours by the technology, then get rid of BFM and AFM and let the driver manage fatigue*".

Most companies also favoured the formation of a group using the technology to swap ideas, "*we'd be interested to see what policies other companies (similar in size to us) have in place, when we talk to other industries we find that there are lots of good ideas, it would be great to be part of a group where we come together and share information, implementation of something new can be very daunting. If they want people to come on board with AFM for example, a lot more ground work is needed*".

Section 2: Implementation

Q9. Who was responsible for implementing the systems?

FDDT implementation was typically initiated by individuals at the managerial level, including the managing directors of several operators, or senior management groups. One FDDT trial was funded by a combination of regulatory organisations, and as such was initiated by these external bodies.

Q10. Do you use multiple systems in combination? If so, how are they integrated?

See Q4 and Q5.

Q11. How long have you had the technology, and is it in all your vehicles?

FDDT was typically a fairly recent addition to operator vehicles. Most operators indicated that the technology had been implemented within the last two years. Several operators were currently in the trial phase, or had only recently initiated implementation (within the last few months) using a limited number of vehicles. All suggested they thought the trials would deliver a positive outcome and lead to implementation across their fleet.

Q12. What training was necessary for drivers / managers / maintainers?

Some training was described by a few of the operators who were interviewed. A number of operators indicated that fatigue was included as a toolbox topic, or as a dedicated training session prior to implementation. However, this was typically with regards to fatigue management more generally, rather than use of the technology. One operator described their chosen FDDT as being "*idiot-proof*", and as such not requiring formal training.

Several other operators indicated that educational sessions were conducted in order to "*sell it*" to the drivers. This was not described as training, but instead was an overview of what the technology could and could not do (e.g. surveillance versus alerting). One manager said "*here's a lot of things you can't learn in a book, you've got to learn it on the job*". In support of this, a former driver said "*I used Seeing Machines when I was a driver at another company and thought it was great, it would beep as a warning to focus and then the seat would go off, it wasn't used as a punishment, I sat down and watched the footage, I didn't realise how you reacted at times, it opened my eyes (literally) to what had happened*".

Another company said "*from 2014 we started 'Myth Busting' a short Q&A around myths and realities around fatigue. We were trying to unpack a lot of these notions that drive people to continue even when know they are not fit for duty. we looked at fatigue as being a biological imperative and not a weakness in character, also looked at the impact that stress and trauma have on road safety. We were trying to create a space where drivers felt they could disclose, was something happening in their personal life that was perhaps impacting their performance*". Another said "*A roadshow was taken around to all the drivers with a booklet that breaks down what Guardian was all about and what it* *would/wouldn't be used for. The way I sell it is 'this is your wife in the passenger seat, looking over, giving you a nudge'*".

Q13. What was difficult in the implementation process?

The main difficulty that was indicated by most operators was getting the support of drivers for FDDT implementation. Though there was overwhelming support from drivers, as one operator described "*there's probably resistance from a couple of the dinosaurs that were here, that didn't embrace the technology*". This resistance was described by several operators as occurring due to drivers not understanding that they would not be under surveillance at all times. Typically, once drivers were made aware that they would only be recorded if a fatigue or distraction event occurred, support increased.

One operator described getting "*negative pushback*" from drivers, but stated that "*that's a smaller price to pay compared to the bigger [safety] gains potentially*". This manager indicated that next time with the full roll out, in order to gain driver support, he would explain "*…the worst-case scenario, which is probably not the worst case, is that you've run off the road and into a tree and now you're not here. Ok, that's pretty bad. But hang on, you've run off the road and you've run into a car with Joe, his wife, and his kids. You're here, they're not. That, I think, needs to be pushed a little bit*". Another said "*we trod very lightly in the beginning, we introduced the system by implementing a voting process at the end of the 12 months to vote the technology in or out. Of course, this never happened as once the drivers saw the videos, their support was immediate*".

In some cases, managers were also not supportive of FDDT implementation initially. However, this was typically short lived. One senior manager described "*a few branch managers [who] thought it was rubbish, but after being shown the first videos they became instant supporters*".

Physical implementation of the system (i.e. installation in vehicles) was not described as problematic by any operators.

Q14. What was easy in the implementation process?

Physical implementation was described as being easy by all operators. One operator indicated that in order to speed up the installation process, they hired an independent contractor to fit the machines as quickly as possible. Another noted that their organisation had paid for two employees to become accredited installers, to keep the process in-house.

A trial period was undertaken by most operators, to ensure that the technology both functioned effectively and had organisational support. This was seen by most operators as an effective step in the implementation process. One operator noted that they began a trial period without alerts (just data tracking), and "*in the first two weeks…some of the things we saw...the boss said no, bugger that, we're turning them on right now*".

Typically, feedback from drivers during the implementation period was positive. See Q21.

Q15. Did you undertake a consultation process?

A consultative process was described by a few operators. One indicated that an initial consultative process was undertaken with health and safety representatives, who were also able to engage with drivers regarding potential implementation. Another operator described a consultative process where driver concerns were heard and responded to, but that managers and drivers ultimately had to "*agree to disagree*".

One operator indicated that no consultation was undertaken because of the assumption that drivers would not be supportive of the idea in theory. However, this organisation noted that once the technology was implemented, it was supported by drivers. Another said "*Initiatives such as this fall into the category of major change. So, you need constant and consistent communication, respond to issues and concerns promptly and have management oversight and ownership to overcome initial and any ongoing resistance (compromise is not an option in this instance)".*

An overview of the process taken by one company is "*informed union about what they were doing, there was immediate engagement with those in the trial, provided information to whole driver fleet to let them know about what was coming, we engaged with key people to start driving the conversation differently, had a dedicated resource day-to-day to manage issues (false positives), we were listening to the feedback we were getting then and there and acting upon it resulting in drivers wanting to take this further. Selection was made by whether an individual had a good driver training background, tech savvy and able to listen and articulate what drivers are saying into tech speak on a help desk*".

Q16. Did any drivers leave the company as a result of implementing the technology?

Approximately a third of the operators had at least one driver who had left as a result of FDDT implementation. One manager described having lost a driver who "*said he felt that there was a big stick and that it was too much for him to handle*". For several operators however, several drivers had been terminated due to interfering with the FDDT (e.g. covering the camera). One operator described having "*arguments with drivers threatening to leave. You install it in the truck, and I say to them, you might be a perfect driver, then that sits on the dash and its obsolete*." The majority of operators indicated that while drivers were initially resistant to the technology, once it was installed, they were far more accepting. One company also reported "*one left and returned as he felt safer with the systems in place*".

Q17. Are there any options / extended uses of the technology that you opted not to implement?

This was not the case for most operators. One manager noted that the technology they implemented had the option for more cameras to be installed (e.g. front-facing), but they had only installed the driver-facing camera. There was anecdotal comment that some operators only "*turned on*" the in-vehicle alerts and did not want to receive messages back to base. This has not been verified or mentioned by others. One reported that they "*requested additional features to be included*".

Section 3: Operation and Maintenance

Q18. How are the systems maintained?

Typically, for the Seeing Machines Guardian system, which was used by the majority of operators, a limited amount of maintenance was required. This system was described as performing its own diagnostics, which can be checked online or via daily diagnostic reports. Where the system needed to be repaired, the technology company could be contacted to perform maintenance. However, this was identified as being potentially problematic given the location of trucks (i.e. travelling Australia-wide). No maintenance was described by operators who use other FDDT systems.

Q19. What resources and costs are involved in monitoring and reviewing the data?

The two installation options described by operators were either leasing or purchasing the technology. For operators who leased the technology, the cost was approximately $100/month per truck for both the technology and monitoring. For other operators, who purchased the systems outright, the first year was described as being "*quite expensive*" due to the installation costs, but that there were limited ongoing monitoring and maintenance costs. One operator indicated that the initial set up cost was approximately $2500 per truck, with ongoing maintenance and monitoring costing approximately $40/month. Another operator indicated that the upfront cost was approximately "*$1240 for the hardware and installation*", with ongoing costs of $89/month per device[3].

In terms of resourcing requirements, operators appeared to differ significantly. One operator indicated that 2 h per day, plus sporadic phone calls overnight, was spent managing and monitoring the FDDT. This resulted in an estimated 0.5 FTE required. Another operator noted that maintenance was taking up too much managerial time, so the organisation had decided to engage an external provider to perform monitoring. A third operator indicated that one FTE was required to manage and monitor their chosen FDDT. However, other interviewees noted that a limited time investment was required, with one operations manager stating that it takes "*about an hour a week*". These differences in time investment are likely due to the size of the organisation and therefore the number of devices that need to be monitored and maintained. One manager noted that "*you can't put a price on safety, can you?*", another said "*quite significant human component to post event analysis, not relying entirely on technology to know what is going on*".

Q20. Have there been any issues in operation?

Very few issues were noted regarding operation of FDDT.

The Seeing Machines Guardian system was described as being "*very reliable*" by several managers. A few issues with false positives were noted by both managers and drivers with regards to "*first generation*" Seeing Machines technology that had been installed previously. However, several interviewees noted that this was less of a problem for the second generation of devices, and that software updates had resulted in improved performance. One operator noted that in one specific brand of truck there were issues with installation, due to the "*amount of metal in the trucks*" which appeared to interfere with performance to a small degree.

Several interviewees also noted that due to driver height or face shape, that there were occasional difficulties with either false positives, or the camera not picking up facial features appropriately. However, these issues were described as being fairly minor.

One operator who was trialling SmartCap technology noted that there were some slight issues with connectivity if the driver got out of the truck. However, the manager noted that SmartCap had been notified of the issue and it had been resolved quickly.

Q21. What is the feedback like from the drivers?

Driver feedback was in most cases overwhelmingly positive from all operators.

[3] Note: varying costs depend on whether both a forward-facing camera and a driver facing one are installed

Drivers indicated that they felt the technology was for their own safety, and as such were supportive of its use. For example, one driver noted that "*I totally agree with it...I like it. I've been driving for quite a few years...when you start getting doughy and that machine is set up with the vibration, it'll bring you back to life pretty quick*". Another noted that "*they're good to know...that if you do fall asleep, which is quite possible for anyone to do, that that thing [the technology] will wake you up*". Other drivers stated that "*it should be compulsory*" and that "*they're a must*", in terms of safety.

Several drivers noted that the installation of FDDT within their organisation made them feel as though their employer had their safety in mind. One driver stated that "*I'm going to go to [work at] a company that has safety features...they're worried about you".*

Several drivers expressed that had this technology been available in the past, that a number of accidents could have been avoided. One driver stated that "*a lot of my mates would still be here who were killed in the way we used to do it*". Another stated that "*I've changed my tune a bit...I actually think it's a good thing...last Thursday an old 2-up partner of mine would have been killed in a double fatality. He was in the bunk asleep, and the driver fell asleep, and if it wasn't for the Seeing Eye... there would have been a funeral this week*".

Drivers also reported that while there was some initial scepticism with regards to driver-facing cameras, they found the technology to be unobtrusive. One described there being "*nothing invasive about it".*

Most operators noted that there was some level of resistance from drivers, particularly initially. During trial periods, some drivers refused to wear or use the technology, and some reported that drivers believed that they were better at determining their own fatigue than the technology. One reportedly told his manager that "*I've been driving a truck for 10 years, and no one knows my fatigue better than me*". However, for all operators, the initial resistance decreased significantly after implementation.

A common theme for nearly all operators was that the main concern from drivers was that the technology would be used as a surveillance tool. Drivers reportedly did not like the idea of being watched all the time. One manager noted that "*it's that live footage they're worried about*". However, for most operators, when drivers were educated regarding the use of the footage (i.e. that it is only recorded if an event occurs), support increased significantly. Other issues raised by drivers included questions about the health aspects of infra-red lights in some devices and also the perceived reluctance of drivers to wear any equipment.

Q22. Do you sleep better and night having made this investment?

The majority of managers who were interviewed indicated that they slept better at night having installed FDDT in their organisation. One managed stated that "*it's $100/month for peace of mind…I wouldn't be sleeping until I had it in there*". Another noted that while he did not believe so prior to installation, after seeing the number of fatigue events, he now does sleep better. One interviewee noted that "*maybe I need to tell my daughter about it so she sleeps better at night*". Another said "*you can see the person falling asleep and then waking up at that last second, knowing that gives me peace of mind even if for some reason we can't get hold of the driver, I still know that if I can't get hold of them the seat will wake them up, the vibration prevents the incident right there, right then*".

Operators also noted that from an organisational and reputational perspective, they feel that it is important to have FDDT in place. One manager stated that from his perspective "*just knowing that we as a company are doing everything in our power to keep our people safe, plus the passengers* *obviously... we start talking consequence of a serious accident, you know that's [our organisation's] reputation*". Another said "*in regards to the risk of the business, it's good to get ahead of the events. Approximately 15-20 events that we've seen in 18 months would have been a truck off the road, guaranteed".*

Q23. Have you seen an actual reduction in incidents / accidents or improvements in safety?

Most operators reported that there were safety improvements and a reduction in incidents following FDDT implementation. One manager described a "*significantly improved year on year downward trend of accidents and breaches*" occurring following implementation. Another manager stated that single vehicle incidents on open roadways had dropped significantly, though they had not been eliminated.

Some interviewees noted that it was difficult to say whether fatigue events had decreased following implementation, as they were not aware of these events prior. It was noted by several managers that many fatigue events that were recorded looked as though they would have led to accidents had the driver not been alerted. Another manager stated that there had not been a reduction in small accidents, as these were not usually fatigue- or distraction-related (e.g. backing up the truck). However, it was noted that the likelihood of more significant accidents had been reduced (e.g. trucks veering off road due to the driver falling asleep).

Several companies indicated that distraction alerts outnumbered fatigue ones by 4:1.

One operator was very specific about his views in this area saying "*I've asked people in our industry of how much this technology could reduce incidents if it was across the board? The lowest response I've had is 25% and the highest is 50%. We have strong evidence which shows that we've seen a reduction in incidents. our claims history and premiums have reduced in the last 5 years*". Another said "*single vehicle incidents on open roadways have dropped significantly but not eliminated, previously for vehicles running off the road (e.g. getting bogged) there were 8-10 occurrences a year*". Yet another said "*intuitively, yes, we've seen a reduction in fatigue incidents but we know that not all of them are going to go pear shaped. How much does the accident you don't have cost you, that's the reconciliation, if we haven't written a truck off, we're not up for the insurance, or we haven't got someone on Workcover or a driver having flashbacks to rolling over".*

Q24. Have you seen any actual behavioural change in drivers as a result of the technology?

Most operators indicated that they had seen behavioural changes in their drivers as a result of FDDT implementation. One major behaviour change that was identified was a decrease in 'distracted' behaviour. This includes mobile phone use, and other behaviours where drivers are not looking at the road for more than a few consecutive seconds. One manager noted that drivers no longer look at their paperwork while driving as a result of the technology.

Virtually all operators indicated that there was improved driving performance from drivers as a result of the technology. This was described as being because having the technology in the vehicle operates as though there is a "*driving instructor next to you*". Drivers also noted that over the longer term, the technology was able to ensure they did not slip into bad driving habits. One driver stated:

> *"When you first start driving, you might get distracted for a couple of seconds, and two years later you might [be distracted for] three seconds - pretty relaxed, then five years down the track you might be looking away for 4 or 5 seconds at a time, because nothing's telling you 'hang on, you're pushing this out'. Whereas this*

> *[technology] is holding you to that. You get in the habit of only looking away for 2 or 3 seconds."*

Interviewees also reported improved personal fatigue management by drivers as a result of FDDT. This appeared to be in an effort to avoid producing fatigue alerts. Drivers reportedly were having breaks more frequently and earlier, because they want to be thought of as professionals who are skilled in managing their own fatigue prior to alerts being triggered. One driver stated that "*you can let it go until, you know, it'll tell you, or you can get in early*". One Manager said "*by explaining what occurs in footage (for a distraction event for example) the driver's behaviours have changed*".

Several companies reported shift and/or driver changes based on FDDT information. "*We had a driver transfer from night to day and consistently was getting level 4s – we sat down with the driver, identified points where he was tired, and amended his start time to 2 hours later (0600h instead of 0400h)"*. One Manager said "*I'm not sure that we've coached drivers to become more self-aware or trialled the system long enough. When it came (FDDT) it had some level of influence on everybody that was exposed to it (e.g. I didn't realise that I took 10 second looking at my left-hand mirror to change lanes)".*

One said "*old school drivers' who said the system was rubbish and would never work changed their mind when seeing footage of how lives could be put in danger. They completely changed their perspective on the system after that, went from non-supporter to supporter, they are seeing people they know, their teammates in dangerous situations, actual driver footage is critical for use in training environments*". Also said "*there has been a change in culture, drivers no longer 'push through', system legitimises fatigue and allows drivers to openly discuss issues, sometimes drivers are still embarrassed about being fatigued".*

Overall, from a company perspective, most were frustrated that through necessity, more resource goes into work diary compliance than actual fatigue management, one saying '*we don't manage fatigue, we count hours".*

Q25. Is it possible to identify any behavioural differences/outcomes between drivers where some vehicles are using detection devices and others aren't?

No operator indicated that they were actively comparing behaviour differences and outcomes between drivers in vehicles with and without FDDT. One operator said "*yes, it's slowly modifying behaviour, there's only one driver's whose face I've never seen on a Drive Cam, behaviour is individual and depends on the person".*

Section 4: Policy and Governance

Q26. Is there a formal policy for the use of such technologies?

Most but not all operators described a formal policy for the use of FDDT. At least three operators indicated that there was a formal policy and flowchart of actions to be taken in the event of a fatigue alert. This policy was very similar to the procedures described by other operators in Q27. There was an overall understanding that a policy may be required in future, but that the use of FDDT was new and was still "*being worked out*" by some operators.

Q27. Are there formal procedures for use by drivers / operational managers / safety managers?

Most operators described a similar procedure occurring in the event of fatigue or distraction event detection. Typically, and depending on the number of vehicles involved, this procedure was either outlined in organisational documentation, or occurred based on informal organisational practices. All companies were strong on the point of access to video footage being strictly limited to a few senior staff or depot managers (mainly for privacy issues but also to ensure footage wasn't used incorrectly or for non-safety related actions).

When a fatigue alert occurred, drivers would be immediately notified, to ensure they were awake (e.g. by the seat vibrating, or an auditory alert). For most technology, the driver's manager would be alerted also, in near-real time. For some organisations, the first alert would trigger a call from the manger, to "*check in*" on the driver. For all organisations, when a second alert occurred within a relatively short period of time, a call would definitely be triggered. This would then result in some combination of a conversation with the driver, the driver pulling over for a break, or other fatigue management strategies.

When asked about the use of post-alert fatigue management strategies further, however, all operators reported that they had not based their implementation on any specific advice, but instead were intuitively implementing strategies based on their own experience and how fatigued they believed the driver was. There was also an understanding from most interviewees that this procedure had been or still is being developed in-house, with little input from either regulatory bodies or FDDT manufacturers. There was a frequently expressed feeling that it would be beneficial for the regulator to provide guidance around legally defensible organisational responses to FDDT alerts. One company response was "*Ops person has authority as to whether driver stops or keeps going depending on questions on checklist. Checklist questions must be answered in a certain way or driver will be made to have mandatory break, email then comes back from ops manager on the back on this event and measured, approx. a third of the drivers having incidents would be recommended to pull up for a break, if a second fatigue event occurs in a shift you have a non-negotiable break*".

A few companies specifically mentioned raising incident reports for significant fatigue alerts or maintenance failures, "*any maintenance failures become an incident too and a report is required*".

It is important to note that for all operators, managers and drivers highlighted that drivers have an absolute authority to stop if they believe they are impaired by fatigue.

Q28. Are the systems used in disciplinary / performance management processes?

No disciplinary procedures specifically relating to fatigue events were described by operators who were interviewed. The primary cause of disciplinary procedures in relation to FDDT use was distraction related based on non-compliance in other areas. One operator described terminating several drivers who intentionally covered the FDDT camera. Additionally, disciplinary measures have been taken in response to mobile phone use that was captured by FDDT video, "*we classify this as 'tampering with a safety device"*.

One operator described the footage of fatigue events being used primarily for "*conversation and assessment*", rather than discipline. FDDT is also reportedly used as an educational tool for drivers. One manager stated that "*we've had drivers who will absolutely deny that they've had a fatigue event and when we show the footage and they say 'oh my God'*". Others reported that FDDT is part of their systems and "*getting to know drivers and see what's best and most suitable for them and* *what works and what doesn't. if drivers aren't suitable for long haul drives then discussions take place*".

No drivers reported disciplinary measures in response to fatigue events.

Q29. How are any potential issues with driver privacy managed?

Privacy was identified as being a key factor for drivers with regards to their acceptance of FDDT. Operators all acknowledged that it was fundamental to ensure that video recordings of drivers having fatigue or distraction events were not made publicly available. One manager noted that "*one of the big things about the technology about the footage that we get is privacy…the way we destroy the trust of our drivers is if one of these shows up on YouTube".*

Operators also indicated that they believed privacy issues were largely addressed by the fact that video recordings were only made when a fatigue or distraction event occurred, rather than at all times. Several operators stated that they had many discussions with drivers around privacy, to ensure they were aware of the limited recordings that were made (i.e. managers cannot log in and view the driver at any time). One operator mentioned it is important to ensure "*the camera is outside of curtains (bunk area) in the cabin of the truck*", another said "*the way we'll lose our drivers is if one of these things shows up on YouTube, we have a responsibility to make sure it doesn't show up on social media*".

Q30. What interaction have you had with the regulator in relation to the implementation and operation of your systems?

Few operators reported having had interaction with the regulator with regards to the implementation and operation of FDDT. One operator indicated that they had discussed AFM with the NHVR, and had asked for advice regarding FDDT implementation. However, they indicated that the NHVR had not provided many instructions or specific rules regarding implementation. As a result, the organisation "*did what we thought was right*". This operator also expressed that it would have been helpful to have examples from other transport operators to ensure standardised implementation and use of FDDT. Another said "*if what you have to do becomes too prescriptive, it's going to hinder the uptake*".

Q31. Have you received benefits from your insurer through implementing and operating these systems?

At least two operators described having reduced insurance premiums as a result of implementing FDDT, "*Yes, we have seen a reduction in our premiums when we took our insurance to market - based on our equipment, technology and how we use it*". However, other operators currently undergoing trial periods have reportedly heard from the technology providers that there may be future insurance benefits. Additionally, one interviewee reported that there may be differences in insurance benefits for smaller operators, who are independently insured, versus larger operators, who may be self-insured[4].

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[4] *Note: NTI and Seeing Machines are now publicising that Australian fleets who have 'Guardian' installed in their vehicles can now access a range of Insurance Policy benefits and Financial incentives*

Section 5: Data Utilisation

Q32. How is the data from your system used in the organisation?

a) Individual day-of-operations?

On the day procedures are outlined in responses to Q27. As stated in that section, real time alerts are presented to the driver (e.g. seat vibration, alert tone). For most operators, just one alert will trigger a phone call from their manager, usually described as a "*welfare check*". For other operators, two alerts, or several 'high' fatigue scores in a short period of time will trigger this manager contact.

Operators have differing strategies as to the management of fatigue events during this contact. The majority of operators have a simple conversation-style check-in, where drivers are permitted to decide on self-management strategies. Other operators require drivers to stop at the next available and safe opportunity for a short break. Napping was also supported by many operators in response to a fatigue event. One driver stated that "*if you need to have it, they don't care. The boss-man would prefer you to pull up than destroy a truck*".

Two operators indicated that they had formalised heuristics, checklists, or matrices in use to determine the appropriate course of action in response to a fatigue alert. However, these at-the-time response systems have all been developed in-house, and are not based on manufacturer or regulatory requirements or recommendations. One operator said "*every event is a conversation*".

b) Individual feedback on performance?

All operators reported using FDDT to provide individualised feedback on performance for their drivers. This was specifically in relation to fatigue events, where drivers did not believe they had fallen asleep. It was common for organisations to use video recordings from the technology to show drivers that they had fallen asleep behind the wheel.

Trend analyses were also performed informally based on driver history. This was done to identify drivers who set off fatigue alerts with high frequency. These drivers were often sent for sleep apnoea testing. Drivers who had frequent fatigue events were also spoken with, and asked for any information that may explain their heightened fatigue. This information was used by several operators to alter driver schedules. For example, one driver who had frequent fatigue events in the early morning hours was scheduled onto shift starting slightly later to minimise the likelihood of fatigue. Another operator described rescheduling some drivers who had a high frequency of alerts overnight to work only days, outside of the "*bad hours*" (i.e. midnight – dawn).

This approach also appeared to be supported in most companies by a strong and informal social awareness of their drivers, statements like "*if outside factors influence the ability for drivers to do their job (i.e. new baby) they are spoken to proactively at every shift*".

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in recognition of their proactive approach to the culture of safety within their fleet, bringing a stronger link between risk management activities and insurance.

c) Performance management / disciplinary procedures?

Performance management and disciplinary procedures are discussed in Q28.

d) Trend analysis across a fleet / route / network?

A high proportion of operators reported using trend analyses of FDDT data within their organisation. Some operators used formalised methods, including computer generated reports or dashboards, whereas other operators reported having a staff member manually creating spreadsheets for analysis.

The kind of analyses undertaken also ranged from formalised to an informal overview. One operator reported performing strategic analyses on FDDT data, in order to determine specific times where high levels of fatigue events were identified. This information was then used to change allocations (e.g. longer breaks between shifts, fewer start time changes). One operator reported that they did not do any kind of "*pattern analysis*" because there were too many variables. However, this operator also reported that "*we keep a list of the events the guys are having...we've got a list and the dates...so obviously somethings not working here, what are we going to do about it*".

Other operators expressed an interest in performing trend and root cause analyses, but indicated that they would need either more devices installed or a longer time period in order to perform meaningful analyses.

e) How does this data get used within your Safety Management System (SMS)?

Few operators included FDDT as a formalised part of their SMS. In general, it appeared that due to the newness of FDDT in vehicles, organisations were yet to determine where this information sits with regards to the SMS as a whole.

One operator indicated that logging fatigue and distraction events was included within their SMS, but that their current system was not set up to provide in depth information regarding these events. However, a new safety management system is currently under development for this operator, which will include drill down capabilities regarding these events. One other operator indicated that fatigue and event detection forms part of weekly safety meetings. Another said "*we get a monthly report and trending graphs from Seeing Machines which we review to see what our current trends are*". Another mentioned they are now looking through the data to see if they can identify any earlier warning signs that suggest an alert might be triggered.

Q33. Are you happy to discuss frequency of incident alerts from the systems?

All companies were happy to discuss this aspect of the Project.

f) How frequently do your drivers receive alerts from the system?

The frequency of alerts for most operators appeared to have decreased in the time since FDDT implementation. One manager stated that "*fatigue events have seemingly dropped off a bit in number, partially I think because there's been a growing awareness*". Another operator stated that they had zero events in the previous month, down from 5-6 per month during implementation. This operator noted that during the first six months, the FDDT system had recorded 8 events, and in the second twelve months just seven were recorded, indicating a 50% decrease.

The number of events recorded was obviously also based on the size of the operator and the type of driving that occurred (i.e. fewer events recorded for operators that performed only short trips). For an operator with around 300 trucks, it was reported that approximately 5-6 fatigue or distraction events are detected per day.

Most companies advised they were surprised that there was "*no real pattern or consistency*" to alerts noting at the same time that when they did happen, it was usually in the first 3-4 hours of a shift. One safety manager said "*our data overwhelmingly indicates that our fatigue events are at the start of a shift or the start of a leg. We typically see a cumulative effect on a Wednesday when people have been on a 5-day roster, in the early part of that shift, you'll see a spike. Thursday is starts to lower and is lower again on Friday and very low on the weekend*". Another said "*all of our events have been at different times, places and runs".*

For an organisation that was trialling SmartCap (which identifies fatigue likelihood based on brain activity), rather than camera-based technology (identifying microsleeps and distraction), it appeared that fewer 'serious' events were recorded. This technology provides real time information to drivers about which 'level' of fatigue they are at (e.g. level 2 is alert, level 3 is getting fatigued, level 4 is at risk of a microsleep). Drivers are therefore able to self-manage fatigue when they are at, for example, level 2, prior to reaching the 'notification level' (level 4, at which managers are notified). A manager noted that it was common for drivers to receive one level 4 notification towards the end of a shift, but that it was usually quickly self-managed back to a 2 or 3 quickly by the driver. On just one occasion during the four-month trial did a driver receive continual level 4 notifications over an extended period.

g) Do you have a "baseline" alert rate?

Few organisations had a specific "baseline" alert rate. Several operators indicated that alerts occur on a fairly sporadic basis with "*no real pattern or consistency*". Another noted that alerts occur "*some days frequently and some days not*". One manager stated that while they did not have a baseline level for alerts, that they would ideally have no alerts, and to that end perform investigations on all alerts to determine cause. Another said "*if a driver has a rest and then alerts again, we don't have a system - we're making it up as we go along, everyone is individual as are the roads they're on and the conditions, there are so many variables, you have to take it case-by-case*".

h) Are there KPIs anywhere within the organisation in relation to alerts?

Few KPIs were reported by any interviewed operators. One company said "*yes, incidents are recorded and reported within safety management packs for management review - no KPI's in terms of reduction or target number*". Another said "*KPIs target is ZERO events. The outcomes of each event category are set out in the "Consequence Matrix" for the three categories of fatigue, distraction and mobile phone use. Weekly updated reports provide graphic and numeric insight into performance and trends".*

i) Do you know the rate of "false positives" (alerts when the driver is not fatigued / distracted)?

All operators using camera-based technology reported some degree of false positives. These reports typically were based on drivers with specific face shapes, or drivers who were particularly tall or short comparative to camera placement. Drivers also reported setting off the alarm if they sat too far back in their seat.

Operators using EEG-based technology did not report false positives, but as this technology is based on pre-event detection, it would be difficult to identify these incorrect alerts outside of a laboratory environment.

No operators were able to provide a specific rate of false positives, but were able to say with certainty that there was some small amount of these alerts.

j) Have you had any false negatives (no alert when the driver has been fatigued / distracted)?

All but one operator did not report any instances of false negatives. There was the sense, however, that drivers were sometimes able to tell that they were experiencing fatigue prior to an alert sounding. One operator suggested that because some microsleeps occur with eyes being open, these would not be detected by most FDDT.