Blink and you'll miss it

Paul Moore spoke to all the leading players in both reactive and predictive fatigue management to find out where the industry is in terms of technology and uptake

Today, **Caterpillar** is the global leader in real-time or "reactive" fatigue management systems with its camera-based Driver Safety System (DSS) which monitors eye-closure duration and head pose and it now has over 5,000 units now deployed. *IM* spoke with Todd Dawson, the Cat Senior Fatigue Consultant about how the market has changed and how DSS has changed with it. "Going back a few years, two of the biggest improvements I would mention are both on the technology and on the service and support side of things. Talking technology we have two releases of software upgrades for Cat DSS every year. We own the technology & IP on the mining side but our partner Seeing Machines continues to innovate on the R&D side for both on-highway and mining. The last two releases have focussed on improving the tracking. You can't alert someone for falling asleep if the system can't find the person's face in certain circumstances so we have created what we call suppression zones. In terms of the camera, there are often certain areas of the pit or mining area where there might be tight manoeuvering such as reversing required where before the system may have flagged up a problem and issued an alarm as the operator isn't looking ahead for a period of time. We can now identify those areas and suppress that response – remove the false positives. On the service and support side, there have been big improvements made in reporting and intervention. We have a monitoring centre in Peoria that captures all of the events as they come in as clips and our target is to get back in touch with site within two minutes and we are already at 94% with that. If an operator has a microsleep, the chances of them having more go up very quickly if nothing in their environment changes so speed here is important. Plus as we have added more DSS units so we have had to grow the monitoring centre accordingly."

Clips only appear to the safety advisors when a microsleep has occurred – and even this is typically over 3,000 in a 24 hour period. There are always four safety advisors on shift at any one time. Cat has invested a lot of time in training them and most of them have stayed in the role. Real time of course the operator gets an alarm in the truck – the safety advisor role is to warn the fleet management office locally at the mine that intervention is needed. "It makes more sense this way as opposed to us trying to interact with the drivers directly. And there are of course language issues with mines spread across multiple countries. Even for the contact with the local fleet management staff, while English is OK much of the time, if it isn't workable we have prerecorded translated messages in place for that purpose as part of an automated system, which also works very well."

IM also asked the question if the DSS unit numbers keep going up then surely the next development would be getting the major Cat dealers to set up monitoring centres? Actually this would create as many issues as it would solve said Dawson. "First off it is a major investment for any dealership to set up a high tech monitoring centre like that – but more importantly, the Tier 1 miners have multiple operations in multiple regions that cut across two, three or even more Cat dealers. Newmont have already standardised with DSS across all its sites so it makes sense for it to be handled from the centralised Peoria location. Other global miners like Rio Tinto, Barrick and Newcrest are also already using DSS at multiple sites. It may make sense in the future in key markets such as Finning for Chile or Westrac for WA to get dealers involved, but nothing has been decided on this as yet."

Some miners have also chosen to do their own monitoring. But many mines already have very busy dispatch teams and the management doesn't want them having to deal with the added responsibility. It isn't just intervening, the microsleep events have to be classified and collated. So in some ways it is better to leave it to the experts.

On the market side of things, it has been publicly stated that Newmont is using DSS across the board

WOMBATT successfully completed trials for its technology in minesites in Peru and Guyana in 2019 and now has commercial users in the US. The technology uniquely tracks changes in fatigue through changes in the voice

and discussions are ongoing with other global miners on similar arrangements. That said there are still many mining companies using different FMS strategies and technology at different sites whether for strategic reasons or often just because different local decisions were made for various reasons to go with one technology and as the mine has got used to that system they don't then want to have to change it and make a new investment. Most mines tend to have one "primary" system for real time response whether installed in the truck or the driver using a wearable – so this includes Optalert glasses, Cat DSS, Hexagon MineProtect OAS and SmartCap as an example. But then in tandem with these some mines are also using a secondary Fitbit type more predictive device like the Fatigue Science ReadiBand to look at longer term fatigue trends over hours, days and weeks. Plus there might be some kind of non-fatigue related collision avoidance or proximity detection system installed on the truck.

Then of course there are change management issues – many of the technologies available will work if used and managed correctly but that means getting the training and operator acceptance & buy-in side right and that is an area where Caterpillar feels it has a distinct advantage given its experience in numbers of deployment and longevity of deployments. Dawson did add that the non-wearable aspect of DSS is also an advantage as it doesn't require the operator to remember to wear anything plus they may feel discomfort having to use wearables when tired.

What about the truck brand aspect – are the majority of DSS users running them on Cat fleets just because there was already a close working relationship? "Maybe surprisingly, we have just as many DSS units on non-Cat trucks as we do on Cat. In addition to being used on Cat surface and underground machines DSS has been applied on Komatsu, Hitachi and other brands on surface and even on Sandvik, Volvo and Epiroc trucks underground. If a technology is being rolled out across multiple sites it is inevitable that will involve many mixed fleets plus as open pits go underground, that safety focus often goes with the transition."

So what about underground – why did surface FMS come first and is underground now catching up? And on surface is it pretty much still all haul trucks – what about shovel operators not to mention light vehicles for personnel, wheel loaders, wheeled dozers, graders, water bowsers and other units?

"In a way underground is easier as the machines are making shorter trips, the shifts tend to be eight not 12 hours plus the environment is very fixed and defined. The only issue underground is lack of GPS as that is used on the surface system for equipment

location, speed calculation etc. Instead DSS taps into the machine data for those parameters. And of course the underground network needs to be good enough to allow the sleep event clips to be sent in real time. If not then there will be a delay until the machine passes a relay point. The underground FMS market really began around 2017 and has still ramped up fairly slowly since then. Cat DSS started underground in Australia and has expanded to other mining regions since then, particularly through the 100% site deployment agreement with Newmont such as at Porcupine Gold Mines near Timmins, Ontario which includes the Hoyle Pond underground mine"

Looking at non haul trucks – Cat has an agreement with Seeing Machines Pty Ltd to deliver and support light vehicle and on-highway driver fatigue and distraction monitoring Cat® dealers. Seeing Machines'Guardian 2 system replaces the Cat DSS-H and is "an advanced, non-intrusive system that senses operator movements and analyses them for symptoms of fatigue or distraction in light vehicle applications." Similar to the off-highway DSS system, seat vibration and audio alarms alert operators when a microsleep or distraction event is detected to effectively reduce dangerous and costly incidents. Guardian 2 joins DSS in the Cat MineStar™ Detect portfolio of safety technologies and services.

Light vehicles work as they are being driven from A to B like a large haul truck such as in and out of the pit. But most other heavy equipment types in the pit have their own peculiarities in terms of how the operator is working. Water bowsers aren't being used continuously so there aren't the same fatigue issues but again as they are a form of truck FMS is now being applied. Shovel and dragline operators are in a roomy aircon cab and the machine is not that mobile beyond the swing when operating. And the operator on the biggest units are often looking down through a floor panel window. Dozer operators are generally doing specialised tasks on stockpiles or wastepiles. Some of these roles may be more suited to wearables but there still isn't much of a market where it doesn't involve a truck of some kind.

"Looking at graders as an example, the operator given the nature of the machine task is looking obliquely most of the time. The tech would work but maybe only 25% of the time when they happened to be looking in the right place. Seeing Machines is looking at a system with multiple inputs based on multiple cameras for these types of applications but of course that means a higher cost."

Of course, one reason why the big trucks came first was that this was deemed to be the area most in need of FMS for relative risk reasons. But also the relative cost of fitting out a whole fleet of high cost machines was minor. But as technology has evolved customer awareness of fatigue has increased so the interest has moved beyond just haul trucks to the light systems so lower cost, less physically robust systems have been developed for those vehicles and many customers are now installed light systems at

sites where the haul trucks already have DSS. The same applies to coming back and putting it on non-primary fleets such as 100 t class trucks used for earthmoving tasks or even ADTs. And putting DSS on contractor operated trucks is becoming more widespread.

Finally, to what extent is FMS being required via regulation. "Taking the US and Canada as an example, we see most regulators wanting mines to do something about fatigue but haven't reached the point yet of requiring it. The most common situation today is a mine being required to have a fatigue management plan but there not being many specifics about what has to be in that plan from a technology point of view. In a way it is good that is isn't a legal requirement because the mines are doing it to be safer not because they have to tick a regulator's box."

Fatigue Science goes to the enterprise level

Fatigue Science is based in Vancouver, BC, Canada and describes itself as "a leading provider of predictive human performance data in heavy industry, building software that leverages scientifically-validated biomathematical models in order to quantify and predict the cumulative effects of sleep disruption on human reaction time and cognitive effectiveness." Most recently, it launched 14-Day Fatigue Forecasting which it says is a breakthrough advancement in fatigue management technology is a powerful new addition to the company's Readi™ Enterprise Suite software platform. "Readi Enterprise Suite, the Fatigue Management Information System from Fatigue Science, is widely relied upon for its ability to provide objective historical and real-time visibility into workforce fatigue. Now, the release of 14-Day Fatigue Forecasting expands this visibility, providing the world's first 360 degree view of fatigue – past, present, and future." With this advancement, FS says proactive planning measures and proactive safety critical actions that were previously impossible are now achievable.

On the market for fatigue monitoring in mining, CEO Andrew Morden told **IM**: "Mines see complex tasks being carried out on long shifts in remote locations with significant safety risk so fatigue monitoring is being seen more and more as a must have in safety and operator health and wellness assessment. Also, there is a revenue aspect as better productivity of operators at mine sites can make a huge difference in the bottom line over a relatively

Fatigue Science's Readi™ technology is most commonly now applied on Fitbits

short time period when you talk about an extra truckload per shift for example. Mines are also used to dealing with data. We are at a point now where we are even correlating things like spot times and dig rates with fatigue which has been really powerful for our clients plus gives a quantifiable ROI for them in investing in our technology. So it is no longer just about safety – its about production efficiency as well."

He adds: "It does seem that fatigue management and the use of fatigue data is most advanced in the oil and gas industry but mining is not far behind. We have some traction now with two global Tier 1 mining houses, both of whom have rolled out major Readi deployments. Of the top 25 mining companies we have or have had projects with upwards of 10 of them which could include a pilot or risk analysis of their fatigue data using our software."

That said, the company due to NDAs hasn't said much publicly since it announced the rollout of 1,000 ReadiBand devices at the Peñasquito gold mine in Mexico in 2019 (now Newmont but then Goldcorp). But FS says this is also as it has transformed itself from focussing on the physical Readiband product to the Readi enterprise platform approach – an IIoT solution – providing predictive analytics and forecasting future fatigue risk profiles for operators.

Morden says: "Our mining customers tell us they want to be proactive as well as reactive. We complement the likes of a DSS by giving the mines insight into when their operators are likely to fatigued in the near future – up to 14 days in the future." Some FS customers are now monitoring fatigue hotspots over time so they are able to do things like alter rosters and schedules slightly where necessary. Equally as mentioned elsewhere in this article, primary reactive systems have been dominated by large haul trucks for cost and strategic focus reasons – FS has allowed mines to get an overview of fatigue across the whole workforce, very useful for health and safety managers and senior management while at an individual level the operators can monitor their own sleep and be alerted to imminent fatigue via their wrists.

This transformation to an enterprise approach also means the focus is no longer just on its own Readiband proprietary wearable – Readi technology is most commonly now applied on Fitbits and to some extent Garmins. Up to a point FS says it is ready to integrate with whatever preferred wearable to mine chooses to work with.

VP, Product & Corporate Development Robert Higdon talked through some details on ongoing product development at FS: "The system starts with a wearable device that is set up for validated sleep data capture and uses SAFTE, our biomathematical fatigue model. At an individual level it is looking back at a person's up to two weeks of sleep data and from that it is looking specifically for the qualities of the sleep that have been statistically correlated as good predictors of fatigue – that includes sleep quality, level of interruptions, timing including circadian rhythms, as well as things like seasonal light

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exposure and accumulated sleep debt. The operator fatigue level is plotted on a scale of zero to 100 over a time curve. This value, known as the ReadiScore indicates predicted fatigue in terms of mental effectiveness, reaction time and lapse index – ie when you don't respond to a stimulus. We have been able to correlate this data with machine telematics data. If you are 85 or above – in the green – on the fatigue scale we have found operators to be performing 3.2-3.3% more efficiently for a given task such as moving a haul truck into position to be loaded, ie spotting. Then correlating our data with an in-cab reactive system, we find that operators with a score of 70 or below are 14 times more likely to have a microsleep event. Aside from all these analytics, we have built out our enterprise analytics suite to make the data more meaningful and in the right context for mining customers. While our product has long been predictive for an 18 hour period, we have now been able to extend this forecast out to 14 days."

FS performed a telematics analysis with an American mining company's major gold mine site and found that haul truck and shovel operators performed over 3% more efficiently in terms of dig rate and spot time when operating with a ReadiScore in the 'green zone' of 85-100 (low fatigue level) as compared to the 'red zone' of 70 or lower (fatigue impaired). "Our mining clients have used these findings to support investments in fatigue reduction programs that result in workers spending more of their time on duty in the state of high performance." Elsewhere in a typical pilot of Readi at a US copper mine owned by a major Australian mining company, 100 participants were eligible to receive wrist-worn Fatigue Alerts informing them of upcoming fatigue risk later in their shift. Over 550 such alerts were sent in a three month period, increasing operator awareness of fatigue. The group also identified that the most fatigued 20% of operators accounted for nearly 50% of all on-duty fatigue risk, helping the team provide targeted sleep support to those in greatest need, all whilst preserving the privacy of individual worker sleep data. This mine is now transitioning to a site wide deployment.

Additionally, mining clients use FS "shift pattern heatmaps" to determine fatigue hotspots – times of day, and days in a shift pattern, when performance is projected to be lowest and microsleep risk is likely to be highest. With this, they can match the right worker to the right task at the right time, as well as avoid planning the most critical tasks for the times of lowest output and greatest risk. An analysis conducted with a major mining customer over a one year period revealed a 20% reduction in time spent fatigued on duty among Readi participants as compared to a baseline period. Additionally, 80% of a set of workers who were identified as "chronically fatigued" in the baseline period sustained a significant improvement in personal fatigue levels between periods.

Dave Trotter, Senior Vice President, Sales & Marketing comments: "Even though our 14-Day Fatigue Forecasting is relatively new, most of our major mining customers are now using it. They are looking at those 14 days to work out where the risk points for fatigue are in their schedules such as a particular set of nightshifts for a particular group of operators and how they can proactively address this. Clients pay FS a site license for the whole operation with the hardware cost then just added on to that. ReadiAnalytics enables them to do a lot of the analysis themselves with extra help from FS available if needed." In terms of getting operators to wear the band whether a ReadiBand or Fitbit or Garmin (or Cat Smartband as these are powered by FS technology), Morden says that this isn't really an issue as they are treated like PPE, especially when they are sleeping on site. Another big plus is that FS technology doesn't require the band to be worn 24/7 – workers can wear it for enough time to make a sleep profile then extrapolations can be made from that but of course the more they wear it the better the data and analysis. And the operators are getting the Fitbit for free that they can also use for their own fitness and activity monitoring.

Highlighting the fact that reactive and predictive systems are viewed differently in the industry today – FS is actively partnering with Cat on its Smartband while Cat is also marketing FS Readi as a complementary technology to its own DSS to mining customers in certain markets via its dealer network. FS is also complementary to other reactive technologies and has collaborated with its customers and these suppliers at a number of sites.

WOMBATT VOZ goes commercial

WOMBATT recently finalised the commercial release of its predictive fatigue management system, WOMBATT VOZ, where technology is deployed before work commences that assesses an individual's level of fatigue based on an analysis of the voice. "WOMBATT VOZ uses artificial intelligence to analyse multiple characteristics of the voice, and accuracy at detecting a fatigued speaker is up to 90% once the algorithm learns the individual's personal vocal characteristics, allowing management to proactively predict fatigue levels of individuals before they commence work, or even before they drive to and from work."

The company says that as WOMBATT VOZ operates in the background and uses off the shelf hardware plus is non-intrusive, it has proven popular with operators and supervisors. It adds that it can be fully integrated with any mining dispatch or collision avoidance system.

The technology and the algorithms behind WOMBATT VOZ were developed by UK scientists for the European Space Agency to predict and manage the fatigue of astronauts on long duration space missions. Following a series of successful field trials with Lima-based mining contractor Stracon in gold and copper mines in Guyana and Peru, and with the assistance of ESA's Business Applications Programme, WOMBATT is now commercialising the technology.

The AI-based program analyses a short voice audio recording made by the operator and transmitted to the cloud or a local server by any Android, IOS or Windows 10 mobile phone, tablet or computer. Once the algorithm learns the individual's voice characteristics the system takes approximately five seconds to predict the level of fatigue of the user and return the result to the user. A green result means a person is fit to work for the next four to five hours. Orange means the person is at a higher risk of having a fatigue event during that time period, perhaps continuing work but with worker and management both aware of the elevated risk. Red means the risk of a fatigue event occurring during the next few hours has reached a point where action, such as a power nap or similar intervention, needs to be taken. In the event of an alert, a notification by email and/or SMS is sent to the supervisor, dispatch and other management as required, allowing the appropriate protocols to be applied.

The system only requires a minimum of three recordings per day, usually taken at the start, middle and end of shift. The program cannot be circumvented or cheated because every voice recording is like a fingerprint and each recording is individually unique to the person and the moment. Pre-recordings are immediately detected.

WOMBATT's original iVOICE system involved staff monitoring and reporting fatigue data from a central control centre. However, WOMBATT VOZ acts as an on-the-ground predictive, fully automatic process with continuously updated online reporting and no longer requires offsite human intervention. Combined with standard mobile phones, tablets or computers this makes it a low-cost yet effective option and it is generating a lot of interest with mid-tier and smaller mining companies. Jean Verhardt, CEO of WOMBATT adds: "The big miners also want predictive 'fitness for work' systems to run alongside their reactive in-cab systems and WOMBATT VOZ is entirely capable of integrating with existing dispatch and other systems to fill that need."

He adds: "After successful field trials, we now have full deployment customers in North and South America. As with other fatigue monitoring technologies the initial focus has been haul truck drivers, however, WOMBATT VOZ applications in mining also include Enaex explosives engineers in Peru driving MMU trucks and it is a viable and effective solution for ancillary mining machine operators."

Hexagon combines CAS and OAS

Hexagon Mining's HxGN MineProtect Operator Alertness System (OAS) is an integrated fatigue and distraction-detection, alerting, and reporting solution that helps operators to maintain the level of attention necessary for long hours and monotonous tasks. Most recently the company also rolled out its OAS-LV version for light vehicle operators.

HxGN MineProtect Portfolio Manager, Marcos Bayuelo told *IM*: "Integrated with HxGN MineProtect