

BEATING FATIGUE: NEW AWARENESS TECHNOLOGY

When a tram derailed at Sandilands in 2016 and it appeared that driver inattention was the cause, it prompted TOL to evaluate the role of fatigue in accidents. Richard Foster looks at two driver awareness systems that have the potential to be game-changers for fatigue management.

Within the space of a mere hundred years, human beings have abandoned their biologically mandated need for adequate sleep – one that evolution spent 3 400 000 years perfecting in service of life-support functions. As a result, the decimation of sleep throughout industrialised nations is having a catastrophic impact on our health.”

Neuroscientist Matthew Walker’s statement is a powerful one for a light rail magazine but bear with us.

The circadian rhythm is the body’s internal clock. It tells you when to go to sleep and it tells you when to wake up. It is coded to work with the rising and setting of the sun.

The development of artificial light has destroyed the natural rhythm. We can now control day and night. Switching on a light to extend the day may now mean we can get more work done but, as Walker explains in his seminal book *Why We Sleep*, this comes at a price. Humanity is not sleeping properly and the problem is compounded by the pressures and stresses of everyday life.

Shift work exacerbates the problem further... and now we get to the crux of the matter.

Driving a tram requires intense concentration but it’s a job built around shift work. There are early morning starts or late night finishes, and drivers can find themselves swapping between the two in

fairly quick succession. That plays havoc with the circadian rhythm, leading to fatigue. Yet there’s a stigma attached to admitting that.

Tiredness could equal laziness; tiredness raises questions about your lifestyle outside work. No one wants to admit to being tired.

Walker says that concentration is one brain function “that buckles under even the smallest dose” of sleep deprivation. Studies have found that ten days of getting six hours of sleep a night resulted in the same performance impairments as going without sleep for 24 hours.

Of the recommendations that the Rail Accident Investigation Branch made in the wake of the Sandilands accident of 9 November 2016, two are relevant here: ▶



▲ ABOVE: A pedestrian makes his way via foot crossings between platforms at Croydon, UK, as a CR400 approaches. The Croydon Sandilands accident in 2016 prompted TOL to research driver awareness systems, such as its since-implemented Guardian system since implemented, and minimise risk due to driver fatigue. Neil Pulling

Driver awareness

- Research and evaluate systems capable of reliably detecting driver attention state
- Minimise risk due to tram driver fatigue associated with both work and out-of-work activities

While those recommendations were specifically aimed at London Trams, fatigue – and the associated loss of concentration and impairment – is an issue faced by tram and light rail operators the world over.

What is 'enough' sleep?

'Chronically sleep restricted' is defined as routinely getting fewer than seven hours sleep a night. One of the common symptoms of the 'chronically sleep restricted' is the 'micro sleep', a momentary lapse in concentration where the eyelids partially or fully close and the brain, Walker says, "becomes blind to... all channels of perception".

A micro sleep while driving – be that a car or tram – can be disastrous. For example, if a driver has a two second micro sleep while travelling at 70kph (43mph), the vehicle will cover 38m with the driver asleep.

That's why UKTram views FOCUS+ as a "breakthrough".

FOCUS+ might look like a wristwatch but it's actually a small biometric device that can warn of fatigue, pre-empting a loss of concentration event, such as a micro sleep.

FOCUS+ owes its origins to Edinburgh Trams' Driver Innovation Safety Challenge (DISC). Backed by Transport Edinburgh and UKTrams, this challenge offered GBP168 000 (EUR196 000) to develop a device or system that would "as close to real time as possible" warn of the early symptoms of some form of loss of concentration or focus.

▼ **BELOW:** TOL has discovered that fatigue events are more common in rural locations, resembling this stretch in Stuttgart. Neil Pulling



▲ **ABOVE:** FOCUS+ is hailed as a 'breakthrough' by UKTram – this small biometric device is worn on the wrist and monitors signs of fatigue and loss of concentration. UKTram

The device's five sensors measure the user's heart rate, the heart's electrical output, blood oxygen saturation, temperature (both of the skin and of the environment) and the skin's electrical response to sweat glands (called the galvanic response). Wearing the device over time allows the FOCUS+ to develop a baseline reading. It will then recognise a change to the baseline that could result in a fatigue or concentration loss event and thus warn both the wearer and the control room.

Developed by Integrated Human Factors of Edinburgh, the first trials took place on the Edinburgh Trams system in 2020. After a year or two of further development, FOCUS+ was trialled across Blackpool, Manchester Metrolink and Sheffield Supertram systems in 2022.

Both UKTram and the Light Rail Safety & Standards Board participated in FOCUS+'s development and LRSSB Chief Executive Carl Williams said: "To establish the 98% accuracy of the algorithms used to assess the data is certainly a remarkable achievement.

"It clearly illustrates the potential of the device and the underlying software to effectively detect driver fatigue in real-world situations and to further enhance light rail safety."

James Hammett, Managing Director of UKTram, said: "The independent testing report confirms the potential of FOCUS+. In the future, it could play a key role in fatigue management system guidance, ensuring the well-being and safety of network employees and their passengers."

IHF's CEO Neil Clark added, "FOCUS+ was three years in the making. It represents a significant leap forward in proactive fatigue monitoring and workplace safety. I am excited that we have had the system endorsed by the LRSSB and can now go on and fully commercialise the system. We have already had enquiries from as far away as Australia, with its versatility making it a consideration for many hazardous sectors."





◀ LEFT: The first trials of FOCUS+ took place on the Edinburgh Trams system in 2020, before it was trialled in Blackpool, Manchester and Sheffield in 2022. A 98% algorithm accuracy rate means that the software can reliably detect driver fatigue in real-world situations, such as this pictured on the Edinburgh system in heavy traffic. Neil Pulling

All in the eyes

Using biometric sensors is one way to monitor a person; London Trams has taken a different approach, based on a Percentage of Eye Closure (PERCLOS) and Distraction Monitoring system, delivered using camera-type technology. This system is called the Guardian device.

Guardian monitors the driver's face – in particular, the eyes – and if it thinks attention has wandered for more than two seconds, an alarm will sound in the cab and the driver's seat will vibrate.

Ben Groome is Service Delivery Director at Tram Operations Limited (TOL), which operates the London Trams system on behalf of Transport for London. He described the Guardian system in more depth at the 2023 UK Light Rail Conference (TAUT 1029).

He said, "The drivers are the first people to be aware that they've had a [fatigue] event. They get the sound, they get the vibration and then whether it was a distraction or whether it was a microsleep type event, more often than not, the driver's attention will turn back onto the track and what is in front of them."

When the Guardian system is activated, it sends a message to a data processing centre, which categorises the event; the centre then contacts the TOL control centre and they check if the driver is okay.

Both FOCUS+ and Guardian tick the RAIB's first recommendation of a system that detects driver inattention. They are different from driver aids that prevent collisions or overspeed events.

TOL has made fatigue management a core part of its ongoing operation and is using the five years' data received from Guardian to support decision making and staff wellbeing.

Groome said: "Invariably, we now find that before control receive the information from the data centre, the drivers are already contacting the control room to say that they've had an event."

This is a remarkable turnaround from 2018 when the Guardian was introduced. Drivers

started blaming Guardian for blurry vision and skin blisters and in some cases they reported for duty wearing diving masks as eye protectors. To address this issue TOL took action, by contacting Public Health England to undertake exhaustive research on Guardian. The report concluded that there was more infrared light coming from your [television] remote control than from Guardian.

"The report has done wonders for people in trusting Guardian," Groome said. "I think [since 2018], we've had one report that [Guardian] was affecting their eyes."

Guardian was complemented by a comprehensive training programme that highlighted the risks of fatigue and ways to combat it. Everyone at TOL, from executives to the rostering clerks, have received bespoke fatigue training for their roles. A fun day at its Croydon depot helped make drivers' families aware of how lifestyle can affect fatigue levels.

"I think it was great that the kids saw what the impacts [of fatigue] on their parents were," he said, and joint responsibility can be seen from the individual managing their lifestyle and TOL providing support in the working environment.

Both FOCUS+ and Guardian warn of an impending fatigue event. But how do you prevent that driver from being fatigued in the first place?

Training and fun days can only do so much. This is why Guardian sends a message to a data gathering centre because TOL uses the data to manage fatigue, thus meeting the second RAIB recommendation.

Even an increase in reported cases of fatigue is useful.

"It's one graph we don't mind going up," Groome said. "Where they've done their initial refresher training, we see an initial spike in reports and the drivers feel able to report when they're feeling fatigued, which is something that we want them to."

TOL now has five years' worth of data, which is revealing interesting patterns. For

example, more fatigue events are reported in the last five periods of the fiscal year than at any other time.

"We ask what's happening in those last five periods towards the end of the (calendar) year?" Groome said. "What you see is that the clocks go back, the clocks go forwards, you have the festive period. With information like this, it has enabled managers to be more on the 'front foot' when approaching seasonal patterns."

He said that TOL has discovered that fatigue events were more common on Mondays, Tuesdays and Wednesdays, particularly after a long weekend or a period of absence. They are more common in more low workload areas (out of town) and least likely in high workload (urban) settings, where drivers are on high alert for hazards. Stretches of tramway in out of town locations are more likely to trigger an event.

While the period when the clocks change is problematic, hot summer temperatures can also be disruptive to drivers' sleep behaviours, as the data has now revealed: "The Stadler [Variobahns] have air-conditioning in the cab ▶



▲ ABOVE: While TOL's Guardian helps to monitor for signs of driver fatigue, it's been complemented by a comprehensive training programme that highlighted the risks of fatigue and ways to combat it. TOL

▼ BELOW: Artificial light can play havoc with the body's circadian rhythms, and the period when the clocks change over can prove particularly problematic. Here at Amsterdam Centraal, night has fallen but the station remains busy. Drivers working changing shift patterns, particularly night-time shifts, can be prone to fatigue, and spotting these patterns raises questions that can help to improve driver wellbeing. Neil Pulling



► RIGHT: Data collected by TOL suggests that temperature can also play a role in fatigue events. The Costa Blanca seafront section north of Alicante is one such system where temperatures can reach 40 degrees C, but air conditioning in the cab can help to keep drivers alert. Neil Pulling

but the old Bombardier [CR4000s] don't, they have an air-cooling system," Groome said. "We started looking to see if we're getting a higher trend of activations within the fleet in the summer months. Most parts of the year is a 50/50 split."

Spotting patterns in the data raises questions that can often improve driver wellbeing. For example, a pattern of Guardian activations early in a shift, Groome said, provokes the question: "How is the wellbeing of the drivers when signing on, and timeliness of when they are signing on?"

A spate of fatigue events or time of day in relation to a particular duty enables TOL to study the positioning of breaks within that duty.

"The allocation team... have a critical role in making sure that they're allocating the right jobs to people," Groome said, "to ensure that we are doing our best to maintain fatigue-free allocation."

Having so much data to hand also enables complaints to be handled effectively. "When I am informed that a specific duty is potentially the cause of fatigue, I can point out that that duty hasn't had a Guardian activation on it in the last five years.

"I ask, 'does this say to us that the drivers are preparing themselves better for that duty, knowing that it's a harder duty?'"

An area for consideration is where a longer or harder duty is placed within a roster and the duties either side, and the data helps show where improvements could be made.

TOL is using the data it holds to build profiles of its drivers. Groome explained: "Within the last 12 months we have started using the data to build a dashboard. An example we identified was a driver with five activations within the last 12 months,



which have all been in the first half of the duty, and always before a break.

This level of insight helps to give our management team the opportunity to ask that driver if they're preparing themselves for work at the right time, doing things the correct way, following all the training. It enables our management teams to have a different type of conversation than perhaps they would have previously had."

Having a camera monitor your face while data about you is being collected might feel as though George Orwell's dystopian vision of Big Brother has become reality.

But, Groome emphasised: "There is no discipline associated with anyone being fatigued. It's never been and will never be used as a disciplinary tool."

What it is used for is to help remove barriers between managers and drivers. It's enabling managers to have honest conversations in order to help drivers cope better with the rigours of shift working and managing their wellbeing.

For example, Groome cited one case of a driver who reported fatigue after three days' leave.

"I wouldn't expect a driver to report being fatigued on duty having just had

three days off, so it's allowing us to have a conversation," he said. "You have to ask: are you preparing yourself in the right way prior to coming in? It's not just about having an early night's sleep the day before, it's perhaps about having an early night's sleep two days before."

The data we have from Guardian has had a positive side effect, in identifying untreated health conditions. "We have had a number of people that have been diagnosed with sleep apnoea, hyperactive thyroids and Type 2 diabetes, all as a result of triggering the Guardian many times," Groome said.

The success of TOL's Fatigue Management System, including the data received from Guardian, means that TOL is involved and supporting the RSSB in a project - including trials on Britain's national railway network where Guardian-like monitoring devices are being fitted in the cabs of freight locomotives and heavy rail vehicles. He is proud of TOL's involvement.

"Light rail," he said, "for the first time is trying to sway the future of something that's happening in heavy rail. I think that's something that we should all be proud of."

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