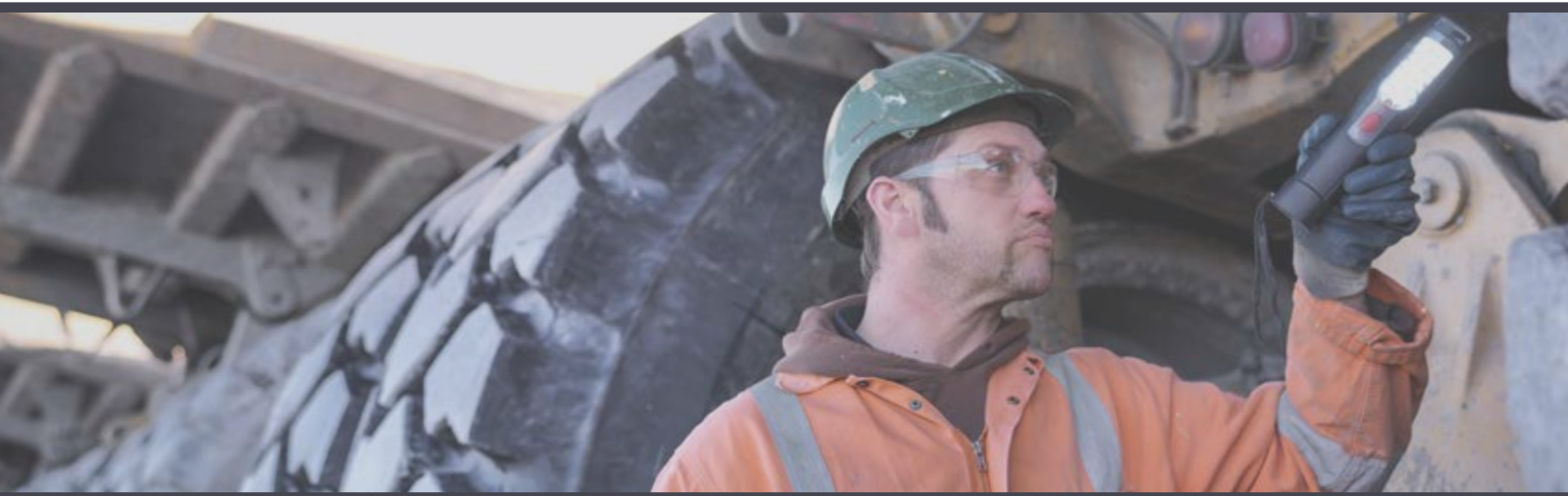
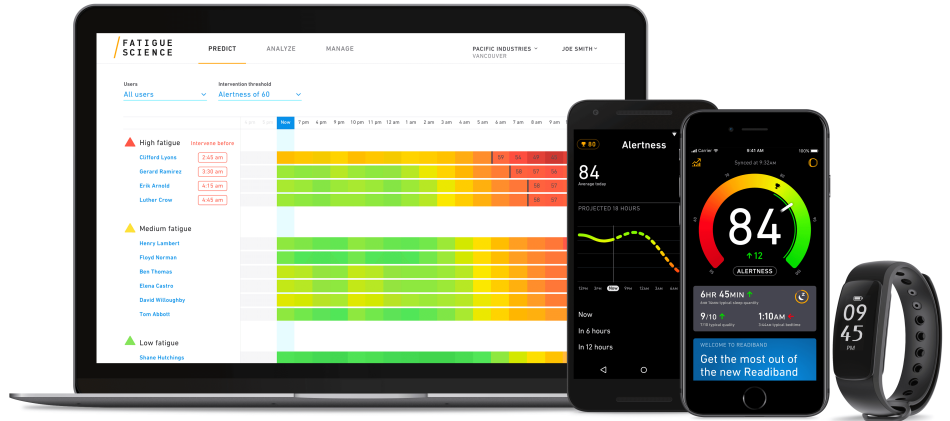


# Predictive fatigue risk management for mining

Scientifically-validated  
technology to predict  
and prevent fatigue-  
related accidents



# The mining industry is awakening to the true cost of worker fatigue

As data continues to advance every aspect of heavy industry, leading firms are beginning to recognize the quantifiable effects of worker fatigue on safety and productivity. Nowhere are these risks more pronounced than in mining, where the demands of production challenge your workforce every day.

Fortunately, new developments in connected technology now make it possible to mitigate fatigue risks like never before, creating unprecedented opportunities for improved safety and performance.

## Finally, you can predict worker fatigue hours in advance

Since 2006, mining firms have relied on analysis from Fatigue Science to optimize their shift schedules around worker fatigue.

Now, we're combining our decades of validated scientific research with a first-of-its-kind connected platform that can predict individual worker fatigue onset — hours before other technologies make possible.

For the first time, it's now possible to ensure all workers on-duty are fit for the day's challenges ahead.

# The high cost of workforce fatigue in heavy industry

Worker fatigue is now recognized as the single greatest cause of mining accidents, causing more damage than alcohol and drug use combined.

## Safety incidents and accidents

A 2011 study by Caterpillar Global Mining found that up to 65% of all surface mining haul truck accidents were fatigue-related.

**65%**  
truck accidents

A broad US industry study last year concluded that fatigue results in a 13% increased risk of death and the loss of 1.2 million workdays per year. Another study found that workers who slept less than 5 hrs. per day were 3.5x as likely to be injured than those sleeping 7+ hrs.

## Lost productivity

It's estimated that up to 20% of the general population suffers from sleep disorders, such as sleep apnea and other conditions. Organizations that invest in employee well-being programs typically find that absenteeism decreases by 40%, turnover by 25%, and accidents by about 50%.

**20%**  
sleep disorders

## Communication failures and on-site errors

Even when fatigue-related accidents don't occur, worker fatigue often poses significant challenges to smooth operation, including an uptick in errors for process-oriented tasks and collaboration efforts.

## Assets and maintenance

A US Dept. of Transportation study of railroad operators found that the average cost of accidents caused by a fatigued worker was 5x greater than a non-fatigued worker. Moreover, fatigued operation of vehicles often has a significant impact on "wear and tear" and maintenance costs, especially drivetrain and braking components.

**5x**  
accident cost

## Insurance and liability

Legal precedents that have made headlines in the transportation sector are now appearing in mining (see "Australian..." opposite). Technology has made fatigue impairment measurable and detectable, and it's placed the onus on employers to either face increased liability and insurance costs, or control costs with effective fatigue management practices.

## Reputation

Mining operates under intense public scrutiny, and preventable accidents raise red flags with employees, investors and the larger community. Proactive leadership in fatigue-related safety is now more of a priority than ever for global mining companies.

## Microsleeps: accidents waiting to happen

Microsleeps are momentary lapses in consciousness due to fatigue. In the span of as little as three or four seconds, a fatigued driver experiencing a microsleep can travel over 20 meters with their eyes closed, entirely unaware of what is happening. Microsleeps are particularly threatening because they can arise before a worker feels sleepy or shows any other outward signs of fatigue.



## Australian coal miner awarded almost US\$1m in damages

In December of 2016, the Queensland Supreme Court awarded a coal miner AU\$1.25m in damages after being injured in a car crash driving home from work. The court found the mining company didn't do enough to reduce the risk of fatigue.

Beginning in the late 1990s, Australia began introducing fatigue risk management legislation to combat fatigue in the transportation sector. Legislation now covers all sectors, including mining.



# Reactive vs. Predictive: A key difference in fatigue risk management approaches

## REACTIVE

Reactive technologies detect fatigue once physical symptoms appear. While valuable as part of a broader toolkit, they don't address the root cause of fatigue, and used alone, leave less time for intervention.

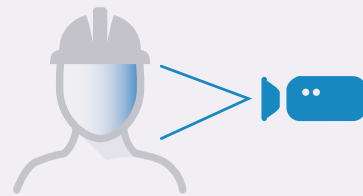
### EEG monitoring

Headwear embedded sensors, which capture brain wave (EEG) data, can alert managers to on-duty drowsiness. As with all reactive systems, interventions are limited to reacting with little notice, instead of planning in advance.



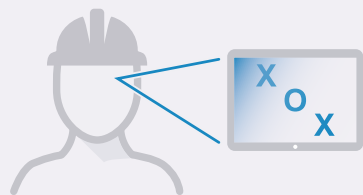
### In-cab driver monitoring

In-cab devices detect fatigue from changes in facial, eye, and body movement, such as head-nodding. They can identify fatigue once these symptoms of severe fatigue have begun to occur.



### PVT alertness testing

Psychomotor vigilance tests can give a fatigue snapshot at the time of testing, but they're unable to predict fatigue while a worker is in the middle of a shift—a more common scenario than fatigue at the day's beginning.



### Telematics analysis

Telematics systems can try to detect erratic steering and braking, often due to fatigue. However, these systems only work with certain vehicles and roadway conditions. Moreover, by the time fatigue is detected, dangerous driving is already underway.



## PREDICTIVE

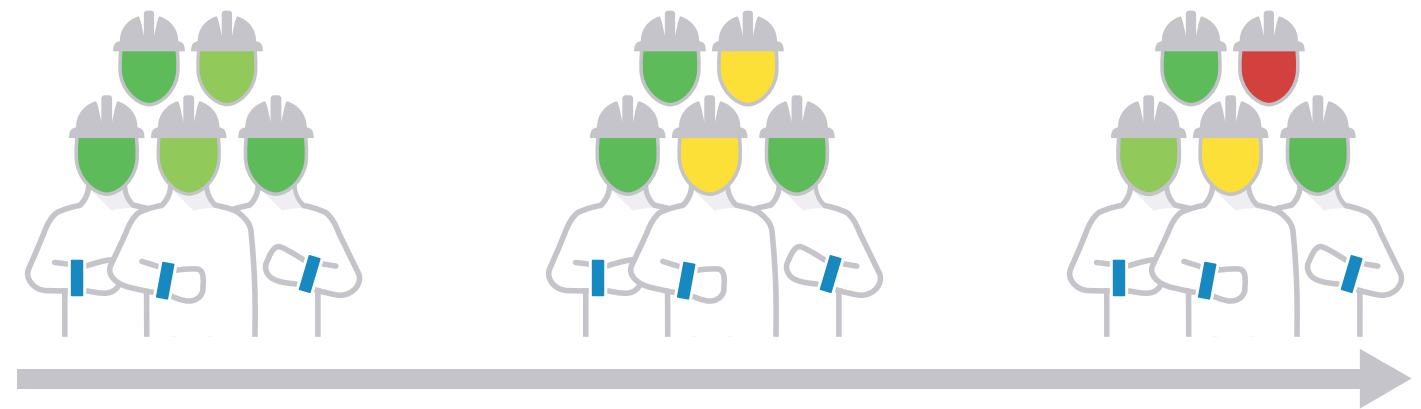
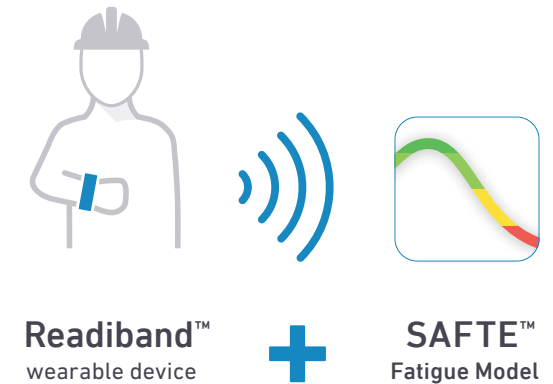
Predictive technology analyzes sleep and circadian rhythms to project if and when fatigue will occur, providing many hours of advance notice to plan for both critical interventions and root-cause treatments.

### Validated algorithms applied to wearable-based sleep data

Predictive fatigue management begins by capturing high-resolution sleep data with a validated wrist-worn wearable device, offering accuracy far beyond what is available from consumer sleep trackers.

Then, it applies a validated biomathematical model to those sleep data to generate an accurate fatigue prediction for each worker's day ahead.

These predictions are made available in an easy-to-use manager's dashboard, providing a bird's eye view of all upcoming fatigue risks.



**7:00 am**  
Start of shift  
Most workers appear non-fatigued

**1:00 pm**  
Middle of shift  
Some workers will face fatigue onset

**5:00 pm**  
Near end of shift  
A few workers will face critical fatigue

# The SAFTE™ Fatigue Model



The SAFTE Fatigue Model (Sleep, Activity, Fatigue, and Task Effectiveness) is the world's leading biomathematical fatigue model — developed by the US Army Research Lab, with over 25 years and \$37 million in research.

It has been extensively validated by the US Department of Transportation, Federal Aviation Administration, and numerous other governmental and industry organizations.

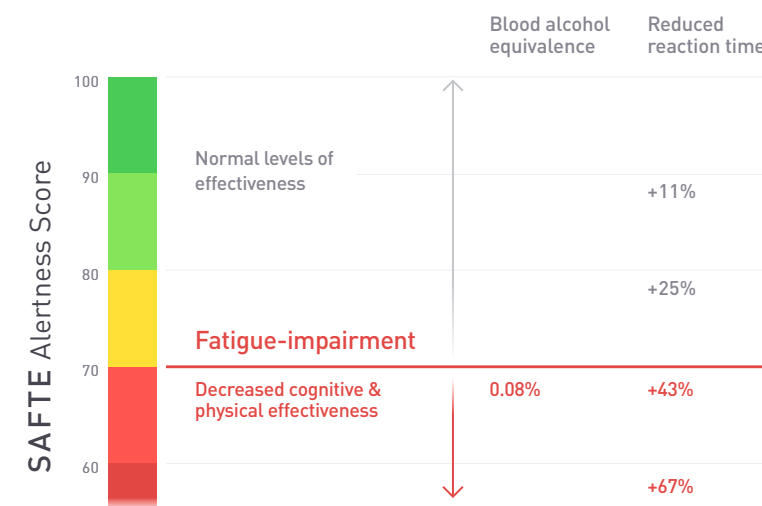
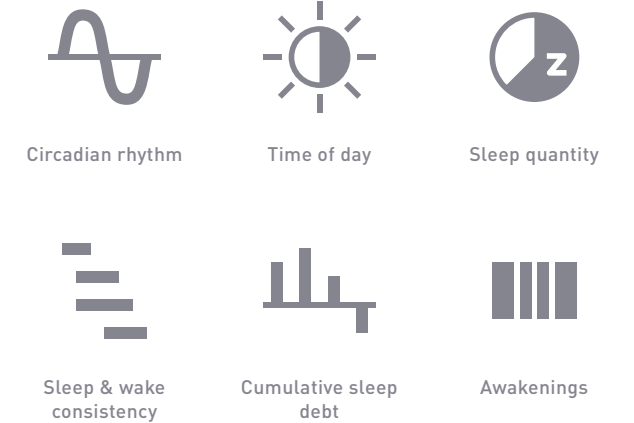
The SAFTE Fatigue Model analyzes detailed sleep data in order to predictively quantify fatigue levels, hour-by-hour, for the day ahead.

The SAFTE Fatigue Model is available exclusively from Fatigue Science and its distributors.



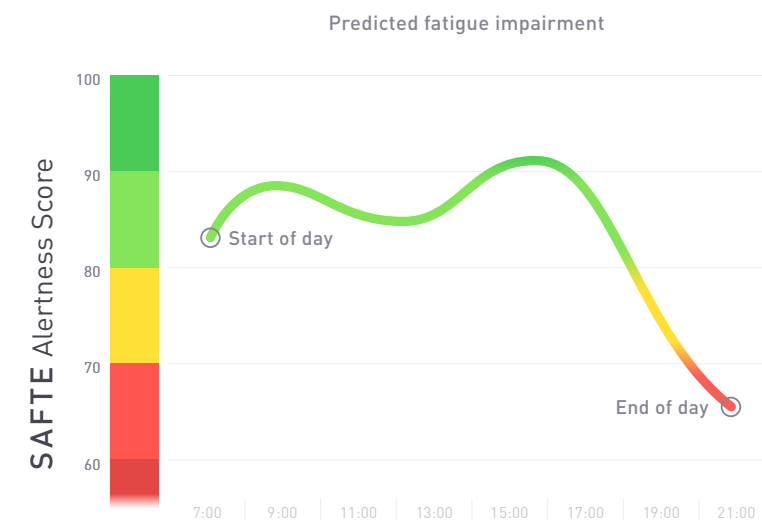
## The SAFTE Fatigue Model applies scientific research to evaluate sleep and predict fatigue

The Model analyzes a complex array of sleep factors that collectively define a “good night’s sleep.” These factors go beyond a simple count of hours slept, and they even account for factors like seasonal light exposure—a major driver of circadian rhythm.



### It quantifies fatigue and makes it easy to compare with other physiological impairments

The SAFTE Fatigue Model quantifies fatigue on an easy-to-visualize 0-100 scale—the SAFTE Alertness Score. It can reliably indicate the effects of fatigue as they compare to reaction time, lapse likelihood, and cognitive effectiveness. At a score of 70, fatigue has as similar impact as a blood alcohol concentration of 0.08.



### It predicts how one's fatigue will evolve over the day ahead

When a worker's sleep is analyzed, the SAFTE Fatigue Model outputs a time-series of fatigue scores for their day ahead, based on the predicted progression of the worker's circadian rhythm. This projection makes it easy to pinpoint, at the start of the day, the moment if and when the worker will reach dangerous fatigue levels.

# Sleep science validated in safety-critical environments around the world

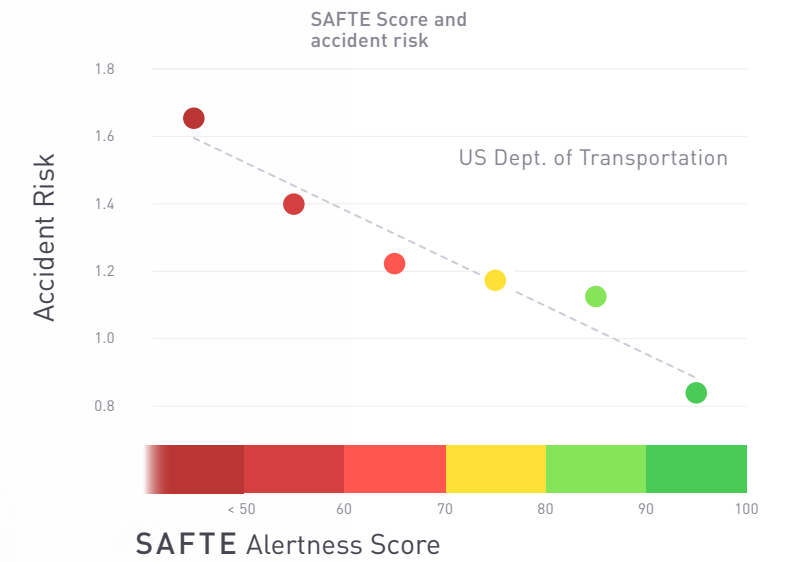


The SAFTE Fatigue Model has been studied by numerous agencies and research bodies, including the US Department of Transportation and Federal Aviation Administration.

These studies reveal a close correlation between a worker's SAFTE Alertness Score and their risk of causing a costly safety incident.

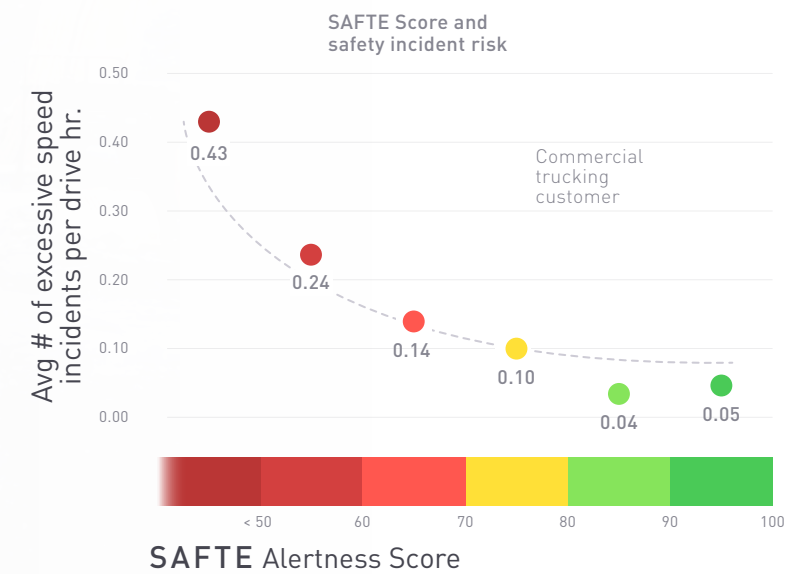
## SAFTE Alertness Score and safety incident risk

An extensive study from the US Dept. of Transportation found that fatigue accident risk in real-world locomotive environments steadily increased as SAFTE Alertness Scores became more severe. The incident risk doubled at a Score of 50, as compared to a non-fatigued state.



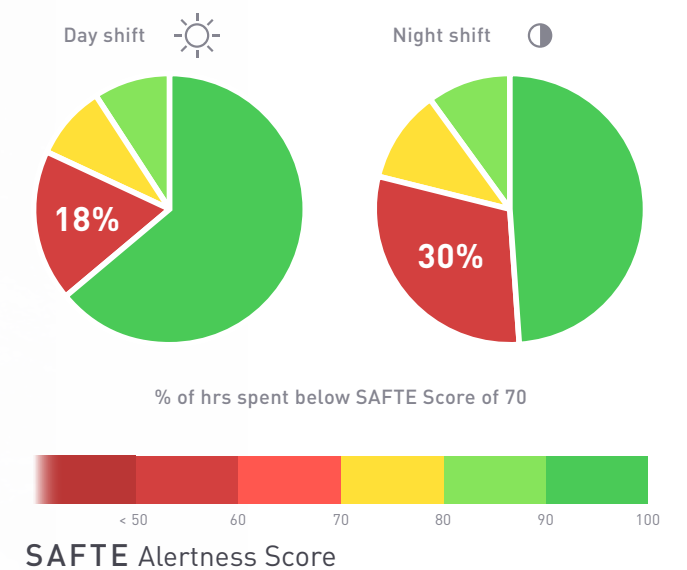
## SAFTE Alertness Score and driver behavior

An analysis we performed on a commercial trucking customer's sleep and telematics data found that drivers with SAFTE Alertness Scores below 50 were 8.5 times more likely to exhibit instances of excessive speed, with similar findings for the incidence of harsh braking.

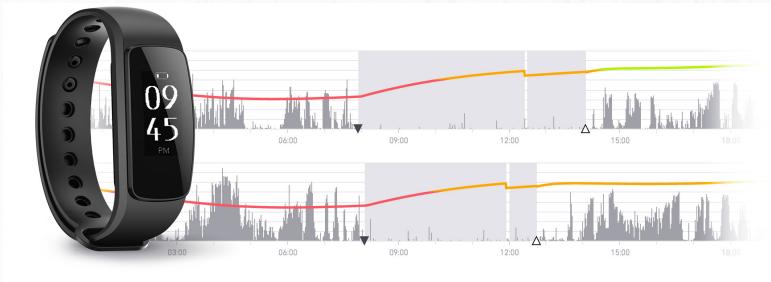


## Benchmarking your operation's overall fatigue exposure

Every organization wonders about their own level of fatigue risk exposure. An added benefit of quantifying fatigue for each and every shift hour is that you can finally obtain an objective benchmark of your workforce's fatigue exposure – and track improvements in this risk profile over time.



# Using predictive fatigue management in your mining operation



Bluetooth®



Water resistant



No location tracking

## The Readiband™ wearable device

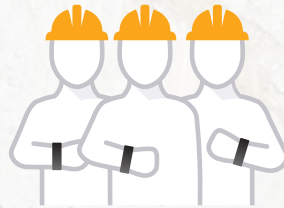
The wrist-worn Fatigue Science Readiband captures high-resolution sleep data with validated 92% accuracy, as compared with a clinical polysomnography sleep lab.

With the Readiband's 30-day battery life, it's easy to "wear it and forget it," and workers' bands sync automatically when arriving for duty.

1

## RECORD

Readibands capture sleep data in high-resolution, with validated accuracy.



2

## SYNC

When workers arrive for duty, their Readibands automatically sync via a secure iPad stationed on-site. No user action is required.



3

## ANALYZE

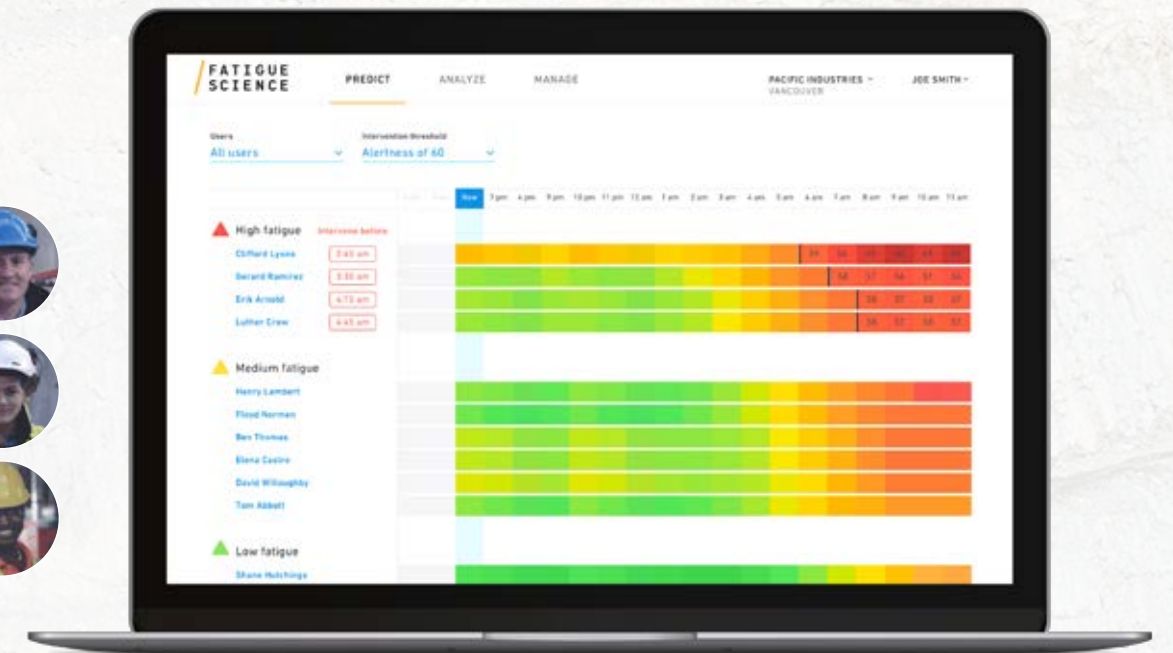
In a secure cloud environment, the SAFTE Fatigue Model analyzes workers' data and produces individual fatigue predictions for the shift ahead.



4

## PREDICT & MANAGE

The **Fatigue Science web app** gives shift supervisors and safety managers an easy, at-a-glance view of all current and upcoming fatigue risks in their on-duty workforce. With this comprehensive "bird's-eye view" of the day ahead, safety-critical interventions are now possible hours in advance.



5

## SHARE RESPONSIBILITY

With the **Readiband app**, workers can play an important role in reducing their own fatigue risk.

By illustrating the relationship between a worker's sleep habits and their resulting safety on the job, our app helps workers "connect the dots" to the concrete actions they can take to reduce their own fatigue.

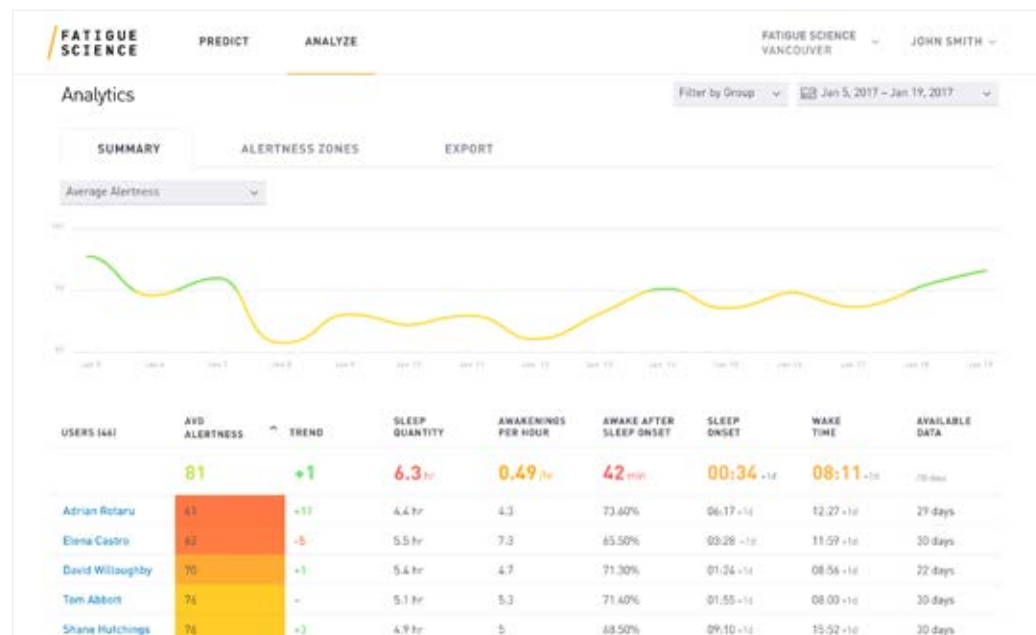


# Help chronically fatigued workers reduce their fatigue at its source

## A toolkit that empowers industrial health staff to identify and help treat chronically fatigued workers

Predicting fatigue and intervening early is your best defense against the day's fatigue risks. But what if you could also reduce the presence of fatigue to begin with? Your workers would be better rested, safer, healthier, and more productive – a win for everyone.

Using our comprehensive fatigue analytics platform — the same one used by recent winners of the Superbowl® and World Series® — authorized health staff can easily identify chronically fatigued workers and guide them with data-backed sleep advice, and even steer them toward treatment for possible sleep disorders.



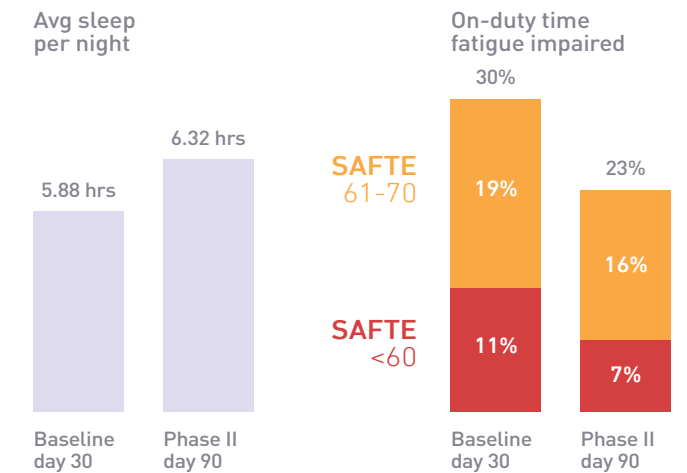
# A step-by-step approach to a successful deployment

Implementing any new workforce technology can often appear to be a daunting task, especially when it involves remote locations and extreme conditions. But it doesn't have to be.

## Pilot and fatigue assessment phase

At Fatigue Science we've implemented FRMS technologies and strategies for over 10 years. Through our experience, we've learned that the most constructive first step in implementing any risk reduction strategy is to establish a baseline risk profile of your existing operation.

We begin each deployment with a pilot project, wherein we deploy Readibands with a limited set of workers and closely analyze the data in this pilot period. With these data, we'll quantify the sources and extent of fatigue in your operation, constructing a baseline Fatigue Risk Profile unique to your operating environment.



## Implementation

Next, we'll use our findings to align closely with your management goals, including change management guidance for introducing a policy of fatigue intervention into daily use. We'll also help introduce workers to the program, including teaching them about sleep hygiene and best practices for reducing their own fatigue.

## Ongoing specialized support

Finally, you can count on us to provide expert-level support for your operation, including not only dedicated technical support and implementation guidance, but also analytical insights as we help you drive measurable improvements to your Fatigue Risk Profile.

## The New York Times: Seattle Seahawks rely on Fatigue Science for performance edge

"I always thought that sleep was overrated, and I had to kind of be knocked in the head to understand," Seahawks head coach Pete Carroll told the Times. "Like so many things, once it gets on the radar screen, it makes sense and you ask, why didn't we pay attention before?"



## BBMV construction managing fatigue on London's \$19-billion Crossrail megaproject

"People were ready to wear the Readibands because they saw positive benefit, and it worked very well for us that their sleep patterns started to improve."

John Clifton, BBMV Supervisor  
Crossrail Project, London, UK





# **FATIGUE SCIENCE**

To learn more how Fatigue Science can help reduce fatigue risk in your fleet, please contact an expert from our team for a free consultation.

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