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The ROI of Readi FMIS

Fatigue Management Information System

Discover how 2 mines each achieved a **$6M annual benefit** in productivity and safety improvements using Readi FMIS

FATIGUE SCIENCE

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Introduction

Readi FMIS, the Fatigue Management Information System from Fatigue Science, is rapidly growing in use by major mining firms worldwide. In this whitepaper, we explore how two North American mines are each achieving a projected **$6M financial benefit** from their use of Readi to manage fatigue.

These gains include projected increases in **productivity** as well as **safety cost reductions.**

With substantial results like these, it's no surprise that worker fatigue optimization is emerging as a **C-level strategic priority** for the world's leading firms in mining and heavy industry.

Fatigue's Impact on Heavy Industry

Throughout mining and other heavy industry sectors, worker fatigue is recognized as a costly and deadly problem – affecting both employers and employees alike.

Most commonly, worker fatigue is associated with major accidents and fatalities, and the notion of an operator "falling asleep at the controls" is an ever-present concern in 24/7 operations.

But while catastrophic losses are certainly the most recognizable effect of fatigue, data increasingly reveals that fatigue's impact on operations is **far more pervasive.** It's now possible to quantify fatigue's impacts not only on safety, but also on productivity.

Predictive fatigue data, like those provided by Readi FMIS, is the key to calculating fatigue's full impacts. And fortunately, Readi FMIS enables employers not only to measure fatigue's impact, but also to prevent some of those losses and make significant gains in operational productivity.

In this whitepaper, we explore **large data sets** from two leading mine sites who have been using Readi FMIS in daily operations for over a year. From these data, we quantify the benefits to productivity and safety attributable to the use of Readi. Ultimately, we calculate an ROI for a representative mine site and present next steps on how your mine or industrial operation can achieve the same.

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What is Predictive Fatigue Management?

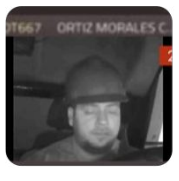
Fatigue management is a broad term encompassing both technological and non-technological methods to manage the impacts of operator fatigue. Best practices recommend a "layered approach" to fatigue management, where multiple strategies are deployed together for maximal impact. In this context, "**predictive**" fatigue management opens up powerful new avenues to achieve benefits beyond what is possible with the use "reactive" technology alone.

REACTIVE TECH

Reactive fatigue technologies emerged in the early 2000s. Typically, they involve in-cab cameras that attempt to detect an operator falling asleep shortly before an accident is imminent (a "micro-sleep"). By raising alarms in these critical moments, reactive technologies act as a "**last resort**" and are intentionally disruptive to operations. Stopping a vehicle and shaking a driver's seat, for instance, involves temporarily pausing short-term productivity in an attempt to avert catastrophe.

Cameras

PVT Tests



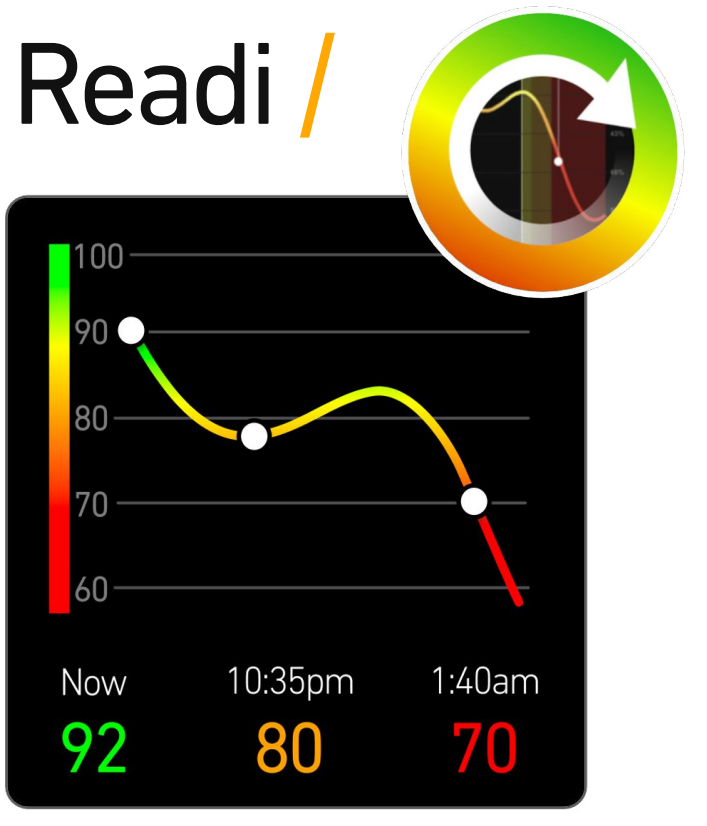
Seat Vibrators

Glasses

Hats

PREDICTIVE TECH

By contrast, predictive fatigue technologies act as a "**first resort**" – improving safety and productivity, hand-in-hand. Predictive technologies generate data long before critical fatigue events are imminent. These data enable proactive decisions at different times and by different roles within an organization – including by supervisors, dispatchers, management teams, and operators themselves.



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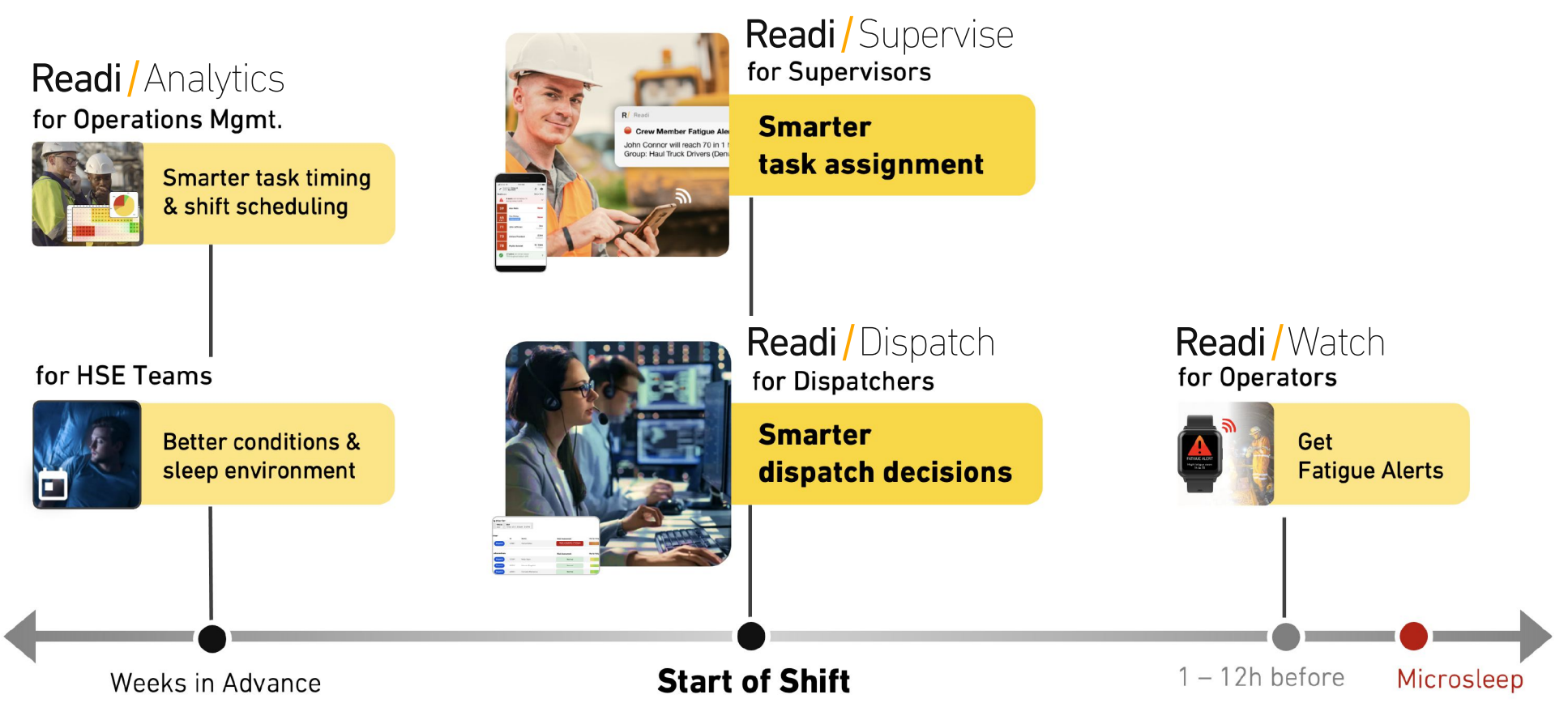
World's Leading Predictive Fatigue Technology

Readi FMIS is the world's leading predictive fatigue technology, designed specifically for mining and heavy industry. As a **Fatigue Management Information System** (FMIS), Readi not only generates validated predictive fatigue data, but also makes these data available to the relevant parties at the right moments to enable proactive decision-making.



Most prominently, **supervisors** and **dispatchers** receive Readi's predictive fatigue data at the start of each shift. With these data, they optimize daily task assignments for operators under their purview.

Supervisors may **re-allocate the most challenging tasks** to less fatigued operators, and they ensure that the most complex tasks are **performed by the right worker at the right time** of day. In rare cases, a supervisor may ask a critically fatigued operator to rest (non-punitively) if no suitable low-risk tasks can be substituted.

Separately, individual operators have a role to play in using predictive fatigue data to reduce risk. Each day, operators receive sleep data and personalized fatigue predictions for their shift ahead.

Data are displayed on their wrists, via ReadiWatch, Fitbit, or Garmin device, and optionally on their smartphone. Through daily exposure to personal sleep and fatigue patterns, operators have been shown to gradually improve their sleep habits, which in turn **reduces aggregate fatigue levels** for an organization.

Scientific Background:
How does Readi predict fatigue?

Readi generates **daily, personalized fatigue predictions** for participating operators by analyzing their trailing 10 days of sleep data in combination with circadian factors.

Analysis is performed automatically via a validated biomathematical model known as **SAFTE™**. SAFTE was developed by researchers at the US Army's Walter Reed Army Institute of Research and has been validated independently by the **US Department of Transportation, US Federal Aviation Administration**, and in 13 published independent papers. The model is exclusively available from Readi FMIS and is widely considered the world's leading fatigue model.

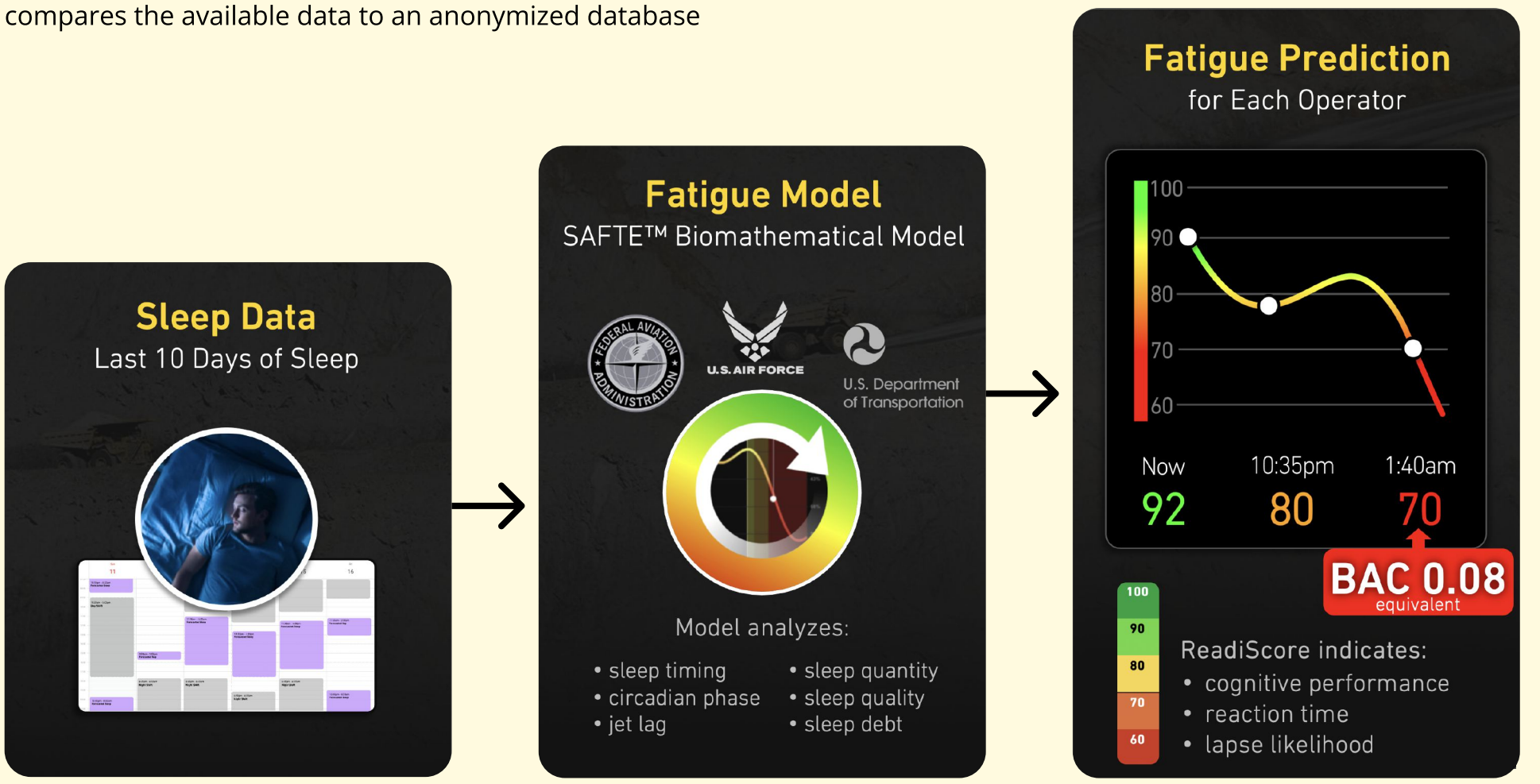
SAFTE analyzes a **wide array of factors** to predict fatigue, including cumulative historical sleep duration, quality, and timing, as well as circadian factors like sunrise/sunset times, night shifts, and time zone travel. These factors are considered not just for the prior 24 hours, but for the past 10 days, as indicated by the science.

Sleep data is either captured from validated wearable devices (e.g. ReadiWatch, Fitbit, or Garmin) or it can be estimated as needed. Such estimations are made by Readi's Machine Learning engine, which analyzes an operator's personal work hours from the **past 10 days**, combined with any past sleep history the operator may have recorded and any demographic data. Readi then compares the available data to an anonymized database of millions of industrial sleeps labelled with similar data in order to predict the operator's trailing 10 days of sleep, or to fill any gaps in the operator's sleep history. With 10 days of real or estimated sleep, SAFTE generates a **daily, personalized fatigue prediction for the operator**, for each of the 18 hours subsequent to an operator's wake. These fatigue predictions are known as the "ReadiScores."

The **ReadiScore** quantifies fatigue on a scale of 1 to 100, predicting **cognitive effectiveness, reaction time** and **lapse likelihood.** A lapse is a measure of attention deficit closely related to the tendency for a microsleep, or "nodding off at the controls". At a ReadiScore of 70, the impact on those 3 factors is roughly equivalent to that of having a **Blood Alcohol Concentration of 0.08.**

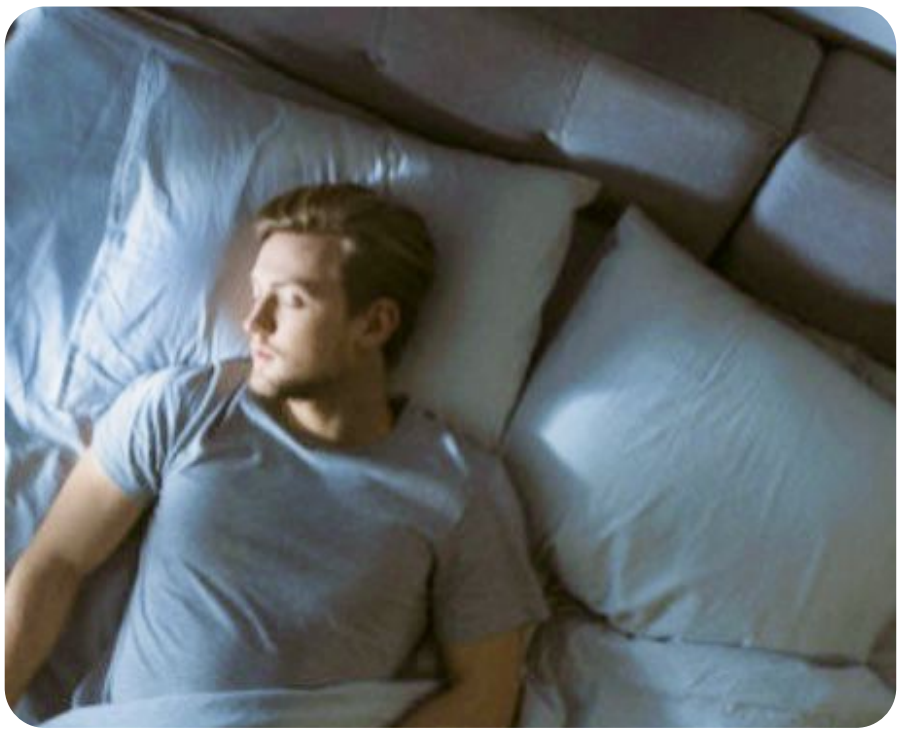
Additionally, the ReadiScore has been observed to have a direct relationship to **real-world operator performance** in mining environments and other areas of heavy industry. Key productivity metrics, such as Dig Rate and Spot Time, and safety data, such as video-captured microsleeps, were correlated with operators' ReadiScores. These metrics are used in calculating ROI in this whitepaper.

For more information on the SAFTE Model or how Readi works, visit www.fatiguescience.com.



Quantifying the Benefits of Readi FMIS

This whitepaper will focus on quantifying the financial and safety benefits of each of the two primary methods by which Readi FMIS generates value, namely:



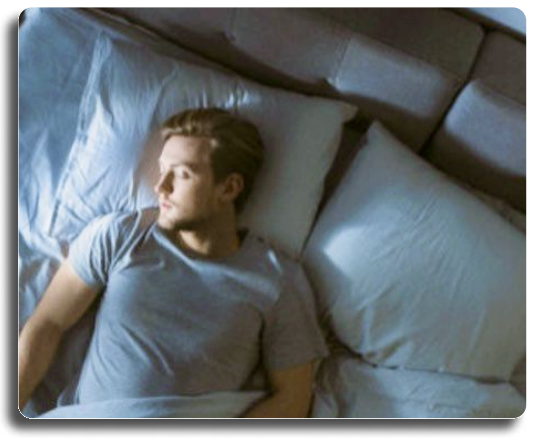
1. Fatigue Reduction

Aggregate reduction in on-duty fatigue levels across the operation as operators, supervisors, and management benefit from Readi FMIS's daily fatigue insights

2. Task Assignment Optimization

Supervisors using Readi FMIS to make daily decisions at the start of shift to assign tasks to workers in consideration of personalized fatigue predictions

Calculating the Benefits:
Fatigue Reduction



We begin our ROI Calculation by calculating the benefits of **Fatigue Reduction** brought about by customers' use of Readi FMIS.

This calculation involves **4 major steps:**

1. Determine an operation's Fatigue Risk Profile in baseline and subsequent periods
2. Link productivity metrics to the Fatigue Risk Profiles
3. Link safety metrics to the Fatigue Risk Profiles
4. Calculate the projected change in productivity and safety vs. the baseline scenario

The results of this analysis are summarized below.

Scenario 1 represents the typical annual output and Fatigue Related Lost-Time Incidents (FR-LTIs) for a mine in our analysis under baseline conditions, **without Readi FMIS.**

Scenario 2 represents the same metrics, but for the period of months 9 to 12, **after ongoing use of Readi FMIS** for Fatigue Reduction.

In Scenario 2, the mine's Fatigue Risk Profile **has improved as a result of using Readi FMIS.** Fewer hours were worked in the "high" and "severe" fatigue ReadiScore Zones (0 - 70).

Metrics used for **per-hour** output and FR-LTIs **remain constant within each ReadiScore Zone**, with the change in overall results being driven by the change in Fatigue Risk Profile.

Comparing the scenarios, we project the following **benefits attributable to Fatigue Reduction** from Readi FMIS, per site annually:

- **Increase of $3.26M** in output
- **Decrease of 0.23** LTI's
- **Decrease of $210K** in LTI costs

For a full discussion of the methodology used here, including the definition of terms and the basis for inputs, go to the **Appendix (page 14)**.

Scenario 1 (Baseline)

ReadiScore Zone	Hours Worked	Implied Output ($M)	Implied FR-LTIs
90 – 100	198,000	$ 101.14	0.02
80 – 90	522,000	$ 263.41	0.28
70 – 80	522,000	$ 260.83	0.39
60 – 70	270,000	$ 133.57	0.41
0 – 60	288,000	$ 141.05	0.50
Overall	1,800,000	**$ 900.00**	**1.60**

Scenario 2 (Fatigue Reduction)

ReadiScore Zone	Hours Worked	Implied Output ($M)	Implied FR-LTIs
90 – 100	369,000	$ 188.48	0.04
80 – 90	583,200	$ 294.29	0.31
70 – 80	409,320	$ 204.52	0.31
60 – 70	243,000	$ 120.22	0.37
0 – 60	195,480	$ 95.74	0.34
Overall	1,800,000	**$ 903.26**	**1.37**

Improvement vs. Scenario 1	**$ 3.26**	**(0.23)**

	FR-LTI	FR-LTI Cost
Scenario 1 (Baseline)	1.60	$ 1,440,000
Scenario 2	1.37	$ 1,229,568
Difference	**(0.23)**	**$ (210,432)**
	−15%	

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Calculating the Benefits:
Task Assignment Optimization

Having calculated the benefits of Readi's **Fatigue Reduction**, we now calculate the additional benefits provided by Readi's **Task Assignment Optimization**.

This calculation involves **2 major steps:**

1. Determine how the operation's Fatigue Risk Profile changes on account of Task Assignment Optimization
2. Calculate the projected change in productivity and safety vs. the previous scenario

The results of this analysis are summarized below.

Scenario 3 represents the impact of Task Assignment Optimization, in addition to the benefits of Fatigue Reduction from Scenario 2.

In Scenario 3, the Fatigue Risk Profile of **safety-sensitive** work hours has been **further improved**, as a result of using Readi FMIS. Less time is spent in the "high" and "severe" fatigue ReadiScore Zones, as fatigued operators are re-assigned to non-safety-senstiive tasks.

As with the previous analysis, **per-hour** output and FR-LTIs remain constant within each ReadiScore Zone, with the change in overall results being driven by the change in Fatigue Risk Profile.

Compared to the previous scenario, we project the following **benefits attributable to Task Assignment Optimization** from Readi FMIS, per site annually:

- **Increase of $2.27M** in output
- **Decrease of 0.19** LTI's
- **Decrease of $168K** in LTI costs

For a full discussion of the methodology used here, go to the **Appendix (page 18).**

Scenario 3 (Fatigue Reduction + Task Optimization)

ReadiScore Zone	Hours Worked	Implied Output ($M)	Implied FR-LTIs
90 – 100	410,000	$ 209.43	0.04
80 – 90	648,000	$ 326.99	0.35
70 – 80	454,800	$ 227.25	0.34
60 – 70	243,000	$ 120.22	0.37
0 – 60	44,200	$ 21.65	0.08
Overall	1,800,000	$ 905.53	1.18
Improvement vs. Scenario 2		$ 2.27	(0.19)

	FR-LTI	FR-LTI Cost
Scenario 2	1.37	$ 1,229,568
Scenario 3	1.18	$ 1,061,120
Difference	**(0.19)**	**$ (168,448)**
	–14%	

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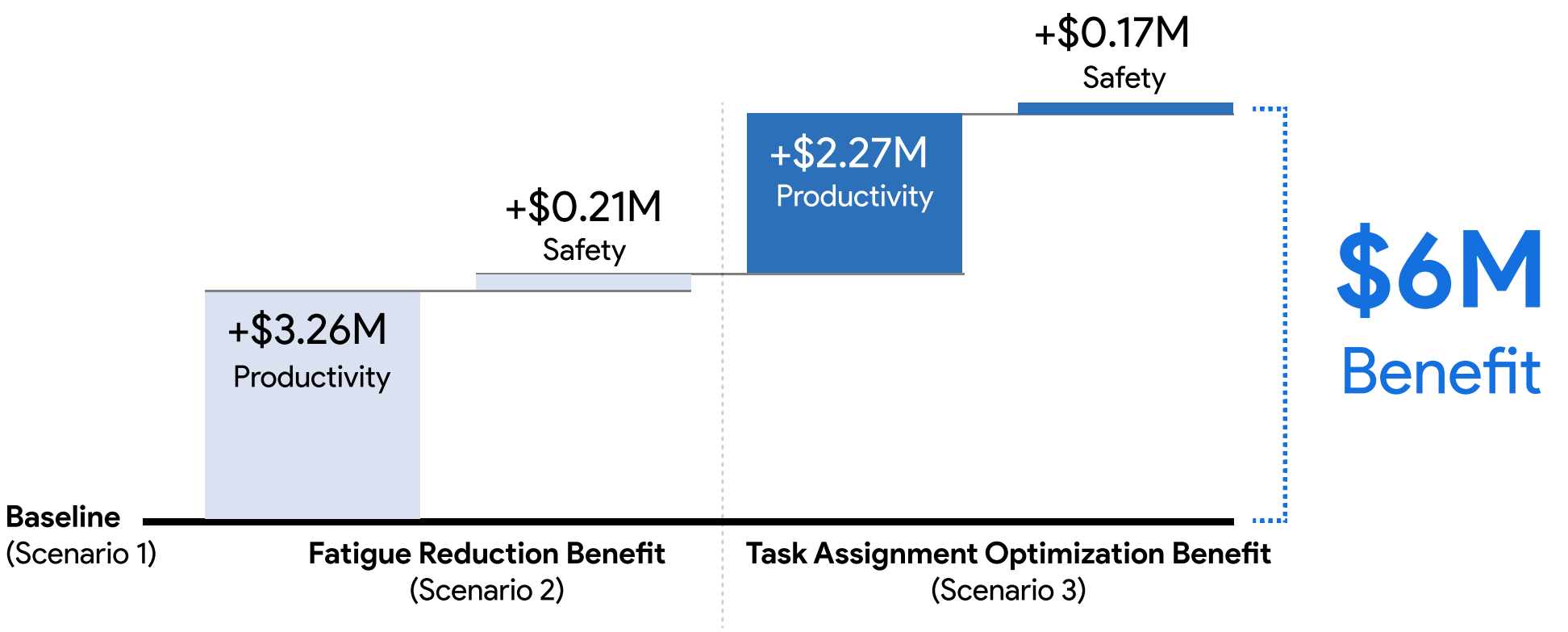
Adding It All Together

Determining Return on Investment

As we conclude our analysis, we summarize the projected **benefits of Readi FMIS**, comprised of improvements from "**Fatigue Reduction**" and from "**Task Assignment Optimization**"

Total benefits are projected at **$5.91M** per site annually, comprised primarily of productivity gains, as well as a reduction in LTIs. On average, Fatigue-Related LTIs are projected to decrease by **26%,** and consequently total LTIs are projected to decrease by **13%.** A breakout of total benefits follows:



	Productivity Improvement	LTI Cost Reduction	Total Financial Benefit
Scenario 1 (Baseline)			
Scenario 2 (F. Reduction)	$ 3,255,201	$ 210,432	$ 3,465,633
Scenario 3 (F. Reduction + Task Opt.)	$ 2,273,777	$ 168,448	$ 2,442,225
Total Improvement	**$ 5,528,978**	**$ 378,880**	**$ 5,907,858**

	Fatigue-Related LTIs / Yr.	Total LTIs / Yr.
Scenario 1 (Baseline)	1.60	3.20
Scenario 2 (F. Reduction)	1.37	2.97
Scenario 3 (F. Reduction + Task Opt.)	1.18	2.78
Total Improvement	**-26%**	**-13%**

For a full discussion of the methodology of these calculations, go to the Appendix (page 13).

The last step is computing **Return on Investment**.

To calculate the return on investment, we subtract the investment amount from the financial benefit, and divide by the investment amount. Readi FMIS technology is available on a subscription basis, with costs varying by the complexity of each site's operation. We'll use an average assumption of $288K USD per year for the representative sites in this analysis.

$$\boxed{\text{ROI}} = \frac{\text{Benefit} - \text{Investment}}{\text{Investment}} = \frac{\$5.91\text{M} - \$0.288\text{M}}{\$0.288\text{M}} = 19.51$$

Based on these projections, we project a **20x annual ROI** from the use of Readi, with an implied **"payback period" of under 3 weeks** on an annualized basis.

20x	$6M	-13%
ROI	Benefit	Total LTIs

Conclusion & Next Steps

Eager to know what financial benefit Readi FMIS can have **on your own operation**?

Our dedicated Professional Services team at Fatigue Science supports each client's Readi program through all aspects of deployment and ongoing operations, to ensure you're getting the most out of your investment and achieving ROI to its maximum potential.

Our business analysts will also generate a customized Return on Investment analysis to quantify these benefits for you, at no extra charge.

Ultimately, predictive fatigue technology is one of the few areas where worker well-being and safety truly coincide with increases in operational productivity.

It is a rare "**win-win**" for employees and employers alike. It's why mine sites and industrial operations on 96 countries are using Readi to improve operations – with adoption growing rapidly.

Reach out to our sales team to get started improving operational productivity and safety, and become a part of the predictive data revolution today.

Sales Inquiries:
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www.fatiguescience.com

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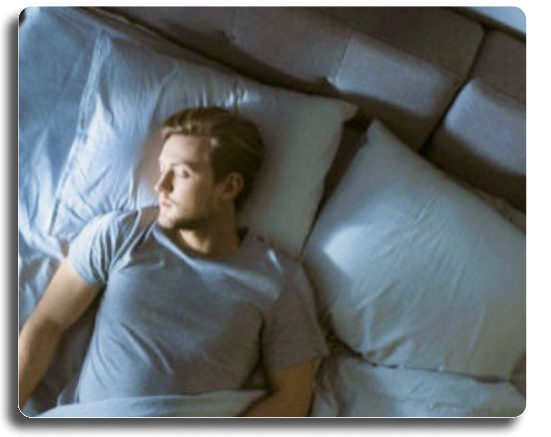
Appendix

Calculating the Benefits:
Fatigue Reduction



We begin our ROI Calculation by calculating the benefits of Fatigue Reductions brought about by customers' use of Readi FMIS.

This calculation involves **4 major steps:**

1. Determine an operation's Fatigue Risk Profile in baseline and subsequent periods
2. Link productivity metrics to Fatigue Risk Profile
3. Link safety metrics to Fatiuge Risk Profile
4. Calculate the projected change in productivity and safety vs. the baseline scenario

Step 1

The first step is to construct Fatigue Risk Profiles for the operation's workforce. We will construct a profile for a "Baseline" period, as well as one for a subsequent period 9 months later.

What is a Fatigue Risk Profile? A Fatigue Risk Profile (FRP) segments an operation's total work hours over a given period by the fatigue level of operators. In other words, an FRP answers "**What percent of time are workers spending at high fatigue, moderate fatigue, low fatigue, etc.**?"

To generate an FRP, we pool together all the ReadiScores that Readi FMIS has generated for operators in the analysis period, for each hour that they were on duty.

To the right: a sample set of FRPs, representing months 1 – 3 ("Scenario 1") and 9 – 12 ("Scenario 2") of a customer's use of Readi. These FRPs are similar to the actual FRPs achieved by the two mines in this analysis.

(Actual FRPs are not shared for privacy reasons.)

The "Scenario 2" FRP reflects the impact of fatigue reductions from implementing **Readi FMIS**.

The impact of these improvements is noticeable in the **lower amount of time spent in the "High" and "Severe" fatigue categories**, and the higher amount of time spent in "Low" and "Moderate" fatigue categories.

		% of Work Hours	
Fatigue Level	ReadiScore Zone	**Scenario 1** (Baseline)	**Scenario 2** (Improved)
Low	90 – 100	11%	21%
Moderate	80 – 90	29%	32%
Elevated	70 – 80	29%	23%
High	60 – 70	15%	14%
Severe	0 – 60	16%	11%
Total		**100%**	**100%**

Our case studies indicate that customers using **Readi FMIS achieve an average 21% reduction** in "High" and "Severe" fatigue levels, compared to the baseline period.

Step 2

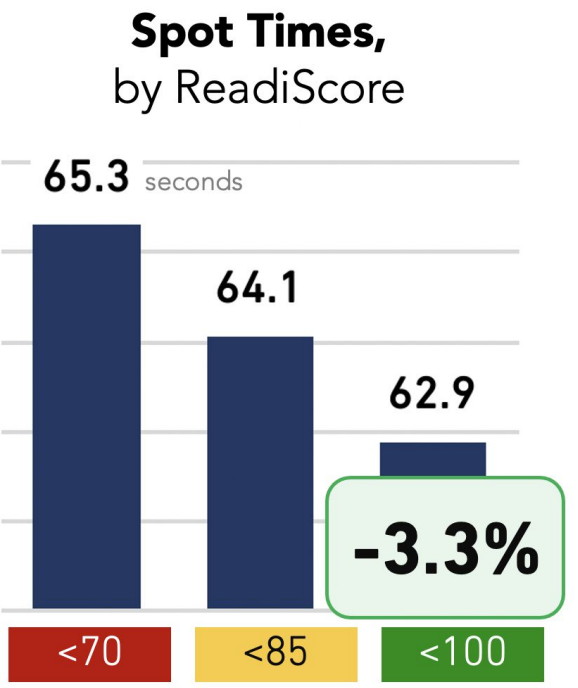
Next, we need to **link productivity metrics to fatigue metrics.**

Management leaders understand that workers operate more efficiently when they are less fatigued. Readi enables us to **quantify this connection.**

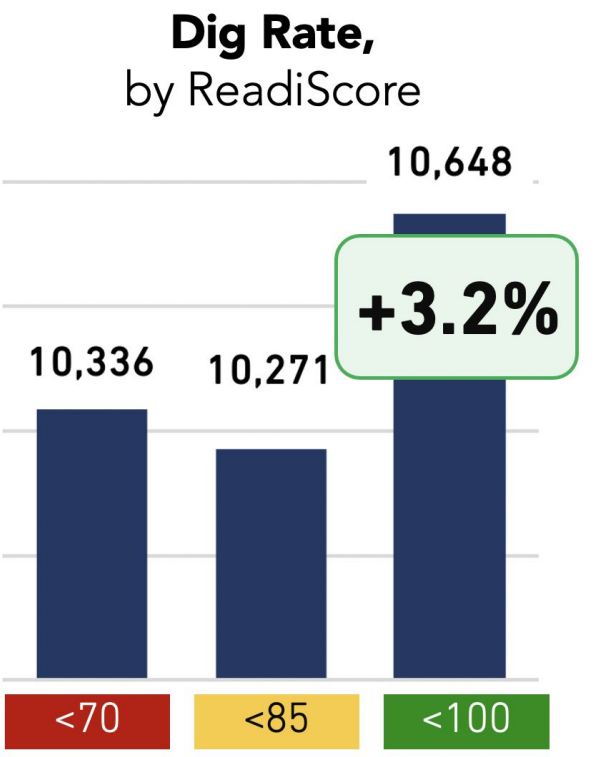
We combine ReadiScores from participating operators with **real-world data from telematics equipment** on haul trucks and shovels to quantify the impact of fatigue.

Telematics data from both participating mine sites illustrated **nearly identical relationships** between the productivity of an operator and the their fatigue level while operating equipment.

Spot Times for haul trucks were found to be **3.3% faster** when an operator had a ReadiScore indicating Low Fatigue (ReadiScore 90 - 100) vs. one indicating High or Severe Fatigue (0 - 70).



Similarly, **Dig Rates** for shovel operators were found to be **3.2% higher** when an operator had a ReadiScore indicating Low Fatigue vs. one indicating High Fatigue.



Across broader operational metrics, *The Journal of Occupational and Environmental Medicine* estimated a **4% productivity loss** attributable to operating while fatigued.[1]

Combining these 3 separate metrics, we conservatively assume a **3.25% difference** in operator efficiency when operating at Low Fatigue vs. High Fatigue across a general range of safety-sensitive tasks.

We can then translate these **relative** differences into a specific **productivity-per-work-hour** metric for each ReadiScore range. The numbers below are rounded for privacy, but are illustrative of the two mines in this study.

ReadiScore Zone	Hours Worked	Relative Output / Work Hour	Output ($M)	Output / Work Hour
90 – 100	198,000	1.033	$ 101	$ 511
80 – 90	522,000	1.020	$ 263	$ 505
70 – 80	522,000	1.010	$ 261	$ 500
60 – 70	270,000	1.000	$ 134	$ 495
0 – 60	288,000	0.990	$ 141	$ 490
Overall	1,800,000		$ 900	**$ 500**

Our table assumes a mine with ~$1B USD in annual revenue, 1,000 operators, and 90% of hours & revenue attributable to safety-sensitive tasks.

[4] "The Cost of Poor Sleep: Workplace Productivity Loss and Associated Costs", Journal of Occupational and Environmental Medicine, Jan 2010

Note: we assume the remaining 10% of tasks are Non-Safety-Sensitive, low-complexity tasks, for which output does not vary as meaningfully by fatigue level.

Step 3

Now, let's **link safety metrics to fatigue metrics.**

Similar to our approach in Step 2, we can use telematics data from mine sites to **determine the relative risk of a Lost-Time Incident (LTI)** for an hour worked in a given ReadiScore range.

Here we use **video-verified microsleep data** as a proxy for the risk of critical events at a given fatigue level. These data were provided by a Hexagon OAS camera system installed in participating haul trucks. The data revealed a **14x higher incidence of critical microsleeps** in hours when an operator's ReadiScore indicated High Fatigue vs. Low Fatigue.

Microsleeps per Hour,
by ReadiScore

We can then translate this relative difference into a specific estimate of **Fatigue-Related-LTI's-per-hour** for time spent in each ReadiScore range.

We begin with industry data on total incidence of LTI's-per-hour. In 2021, major mines experienced **0.32 LTIs per 200,000 hours worked**.[2]

How many of these total LTI's were attributable to fatigue? A study by Caterpillar Global Mining found that **65% of all haul truck accidents** were related to fatigue.[3] To be conservative, we will only assume 50% of LTI's are fatigue-related.

With these assumptions, the table below illustrates that a typical mine in a baseline scenario can expect an average of **1.60 Fatigue Related LTI's (FR-LTI's) per year.**

LTI / 200,000 Hours	0.32
Work Hrs / Yr.	2,000,000
Safety-Sens. Work Hrs / Yr.	1,800,000
LTI / Year	3.20
% of LTIs Fatigue-Related	50%
Fatigue-Related LTI / Year	**1.60**

Finally, we combine the **1.60 FR-LTI** figure above with the relative risk per hour in each ReadiScore range. We arrive at an average **FR-LTI's-per-hour worked in each ReadiScore range**, as shown in the table below.

ReadiScore Zone	Hours Worked	Relative FR-LTI's per Hour	FR-LTI per 200K Hours
90 – 100	198,000	1	0.022
80 – 90	522,000	5	0.108
70 – 80	522,000	7	0.151
60 – 70	270,000	14	0.302
0 – 60	288,000	16	0.345
Overall	1,800,000		**0.178**

(Note: We assume that "Safety-Sensitive" tasks are, by definition, the ones with a risk of LTIs. Therefore, the figures in the green column indicate the FR-LTI rate per 200K "Safety-Sensitive" work hours).

[2]Survey of sustainability reports for top mining firms, 2021
[3]Caterpillar Global Mining, 2007

Step 4

With metrics linking both productivity and safety to operator fatigue levels, we can now **calculate the projected benefits** of the observed reduction in an operation's fatigue levels.

To do this, we multiply the number of Safety-Sensitive work hours in each ReadiScore range by the corresponding "per-hour" metrics for productivity and LTI's.

Below are results for **Scenario 1** (Baseline).

Scenario 1 (Baseline)

ReadiScore Zone	Hours Worked	Implied Output ($M)	Implied FR-LTIs
90 – 100	198,000	$ 101.14	0.02
80 – 90	522,000	$ 263.41	0.28
70 – 80	522,000	$ 260.83	0.39
60 – 70	270,000	$ 133.57	0.41
0 – 60	288,000	$ 141.05	0.50
Overall	1,800,000	**$ 900.00**	**1.60**

And below are results for the **Scenario 2**.

Scenario 2 (Fatigue Reduction)

ReadiScore Zone	Hours Worked	Implied Output ($M)	Implied FR-LTIs
90 – 100	369,000	$ 188.48	0.04
80 – 90	583,200	$ 294.29	0.31
70 – 80	409,320	$ 204.52	0.31
60 – 70	243,000	$ 120.22	0.37
0 – 60	195,480	$ 95.74	0.34
Overall	1,800,000	**$ 903.26**	**1.37**
Improvement vs. Scenario 1		**$ 3.26**	**(0.23)**

Comparing the scenarios, we project the following benefits attributable to Readi's Fatigue Reductions, per site annually:

- **Increase of $3.26M** in output
- **Decrease of 0.23** LTI's

Lastly, we estimate the financial benefit of this **decrease in LTI's**, based on the average cost of a Fatigue-Related LTI in the mining industry. Costs will vary by operation, but it's important to consider both direct costs and indirect costs.

> **Direct costs:** workers compensation payouts, medical costs, and equipment damage
>
> **Indirect costs:** factors such as work stoppage, re-training, HR replacement, crisis management time, legal fees, reputational damage, and general resource use

We estimate the full cost of a Fatigue-Related LTI in mining to be $900,000 USD.[4]

Average Cost of LTI in Mining

	Any Cause	Fatigue Related	Non-Fatigue Related
Direct	$ 100,000	$ 150,000	$ 50,000
Indirect	$ 500,000	$ 750,000	$ 250,000
Total	$600,000	**$900,000**	$300,000

Using this figure, we can quantify a **$210K avg. annual LTI cost reduction** attributable to Readi FMIS's Fatigue Reduction at the mine site.

	FR-LTI	FR-LTI Cost
Scenario 1 (Baseline)	1.60	$ 1,440,000
Scenario 2	1.37	$ 1,229,568
Difference	**(0.23)**	**$ (210,432)**
	−15%	

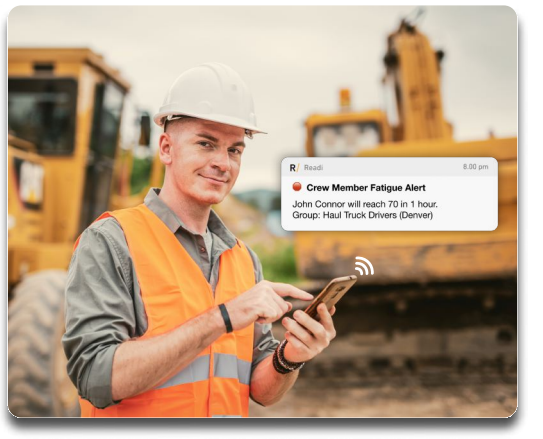
[4]**Fatigue-Related LTI cost estimation:** The average direct cost for an **any-cause LTI** in the industry mining is approximately $100,000 USD.[4] There is a typical ratio of 5:1 for indirect to direct costs, i.e. $600,000 in total costs for an any-cause mining LTI.[5] Research from the the US Dept. of Transportation indicates that Fatigue-Related accidents tend to be among the most severe accident types. Specifically, Fatigue-Related accidents were found to be 5x more costly than non-Fatigue-Related accidents.[6] To be conservative, we assume Fatigue-Related LTI's (FR-LTI) are only 3x more costly, not 5x. Consequently, we estimate the full cost of a **FR- LTI** in mining to be **$900,000 USD.**

[5]IRSST – Estimating the Costs of Occupational Injuries - A Feasibility Study in the Mining Industry, 2013, extrapolated for inflation and currency difference

[6]Hubler et al., 2012

[7]Validation and Calibration of a Fatigue Assessment Tool for Railroad Work Schedules. Hursh et al., 2004

Calculating the Benefits:
Task Assignment Optimization



Having calculated the benefits of Readi's **Fatigue Reduction**, we now calculate the additional benefits provided by Readi's **Task Assignment Optimization**.

This calculation involves **2 major steps:**

1. Determine how the operation's Fatigue Risk Profile changes on account of Task Assignment Optimization
2. Calculate the projected change in productivity and safety vs. the previous scenario

Step 1

While Readi's "Fatigue Reductions" change an operation's **overall** Fatigue Risk Profile, "Task Assignment Optimization" functions differently.

Instead of changing **overall** fatigue levels, this method improves the **allocation** of fatigue risk between Safety-Sensitive and Non-Safety-Sensitive tasks.

In other words, what changes is the **type of task** each operator may perform, based on their fatigue level. Using predictive data, a supervisor may **re-assign complex, safety-sensitive tasks** away from critically-fatigued operators.

> A supervisor may also rest an operator for an entire shift, but this is uncommon and the benefit is not modeled here.

To model the change in task assignment, we will return to our general assumption that 90% of time spent at a mine site involves "**Safety-Sensitive**" tasks, and that the remaining 10% of time involves "**Non-Safety-Sensitive**" tasks. The split will vary by operation, but we believe it is a useful general assumption.

Starting with the Fatigue Risk Profile from the previous scenario ("Scenario 1"), we model the 90/10 split in work hours as follows:

FRP: Scenario 2
(Fatigue Reduction Only)

ReadiScore Zone	All Work Hours	90% Safety-Sensitive Hours	10% Non-Safety-Sensitive Hours
90 – 100	410,000	369,000	41,000
80 – 90	648,000	583,200	64,800
70 – 80	454,800	409,320	45,480
60 – 70	270,000	243,000	27,000
0 – 60	217,200	195,480	21,720
Total	2,000,000	1,800,000	200,000

Then, we **model the task re-assignment** as an exchange of work hours across ReadiScore zones:

	Hours Diverted from Safety-Sensitive	Hours Diverted from Non-Safety Sensitive
90 – 100		(40,000)
80 – 90		(65,000)
70 – 80		(46,000)
60 – 70		
0 – 60	(151,000)	
Total	(151,000)	(151,000)

The result is a Fatigue Risk Profile for "**Scenario 3**".

Here, the overall amount of fatigue risk is the same, but the amount of **"High" and "Severe" fatigue risk is decreased in "Safety-Sensitive" work hours,** and it is increased correspondingly in "Non-Safety-Sensitive" work hours.

FRP: Scenario 3 (Fatigue Reduction + Task Optimization)			
	All Work Hours	**90%** Safety-Sensitive Hours	**10%** Non-Safety-Sensitive Hours
90 – 100	410,000	410,000	–
80 – 90	648,000	648,000	–
70 – 80	454,800	454,800	–
60 – 70	270,000	243,000	27,000
0 – 60	217,200	44,200	173,000
Total	2,000,000	1,800,000	200,000

Step 2

From there, we follow the **same method** as in the previous analysis in order to calculate the projected benefits to **productivity** and **safety.**

We multiply the number of Safety-Sensitive work hours in each ReadiScore range by the corresponding "per-hour" metrics for productivity and LTI's.

Compared to the previous scenario ("Scenario 2"), we project the following benefits attributable to Task Assignment Optimization from Readi FMIS, per site annually:

- **Increase of $2.27M** in output
- **Decrease of 0.19** LTI's
- **Decrease of $168K** in LTI costs

Scenario 3 (Fatigue Reduction + Task Optimization)				
ReadiScore Zone	**Hours Worked**		**Implied Output ($M)**	**Implied FR-LTIs**
90 – 100	410,000	$	209.43	0.04
80 – 90	648,000	$	326.99	0.35
70 – 80	454,800	$	227.25	0.34
60 – 70	243,000	$	120.22	0.37
0 – 60	44,200	$	21.65	0.08
Overall	1,800,000	$	905.53	1.18
Improvement vs. Scenario 2		$	2.27	(0.19)

	FR-LTI	**FR-LTI Cost**
Scenario 2	1.37	$ 1,229,568
Scenario 3	1.18	$ 1,061,120
Difference	**(0.19)**	**$ (168,448)**
	−14%	

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