bluewake™

MINING CASE STUDY

Improve Safety and Productivity with Bluewake Fatigue Mitigation

IMPROVE SAFETY & PRODUCTIVITY

Bluewake Fatigue Mitigation

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This case study reflects the results of a real-world deployment of the Bluewake solution within an active mining operation. For confidentiality reasons, the company name and site locations have been withheld and replaced with the term "MineCo." All data, observations, and outcomes remain representative of actual field conditions and operational use.

1 Executive Summary

MineCo operates some of the world's most demanding mining operations, ten mines spread across four countries and employing more than 16,000 workers and contractors . Haul-truck drivers and equipment operators often work 12-hour shifts, moving massive volumes of ore through Arctic darkness or deep underground. Fatigue is always a significant risk factor that threatens safety and productivity.

Bluewake offers a science-based fatigue mitigation and alertness solution to this problem. The cab-mounted or dash-mounted alertness device (which can also be used on a desk for office workers or control room operators) emits a 70 Hz pulsed blue-light stimulus that activates photosensitive retinal ganglion cells (ipRGCs) that engage the hypothalamic arousal circuits, providing a rapid alertness boost within approximately 15 minutes without caffeine or drugs. In MineCo's initial deployment at the Site #1 complex, operators used Bluewake primarily during high-risk fatigue windows (13:00–16:00 and 02:00–05:00) and many continued to use it throughout their shift to stay alert. Preliminary results indicated reduced drowsiness episodes, improved focus, and positive operator acceptance; Bluewake reports that 85% of drivers experienced reduced drowsiness and 94% reported better daytime sleep .

The next step is to scale the technology through structured pilots across multiple mine sites and equipment groups. With its non-pharmacological design and ability to be mounted in vehicle cabs, on dashboards, or on desks, Bluewake has the potential to integrate seamlessly into MineCo's Risk Management & Monitoring System (RMMS), supporting the company's commitment to a safe, injury-free workplace .

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2 Background & Challenge

2.1 MineCo's Operating Environment

MineCo is a senior gold producer with decades long track record and a global footprint encompassing major mines in North America, Europe, and Australia. Key operations include:

- **Site #1 complex** – one of the largest gold mining operations in the world, now transitioning from open-pit to underground mining at the Site #1 mine.
- **Site #2 mine** – the company's second Arctic operation is both an underground and open-pit mine.
- **Site #3 complex:** MineCo's first Arctic operation, where the life of the mine has been extended through a smaller nearby supply site (Site #2.1). Ore is hauled long distances to the Site #3 mill.

These sites operate 24/7. Shifts often extend to 12 hours, with operators working through night-time darkness or the monotony of underground tunnels. Operators routinely face:

• Extended shifts that increase sleep debt and circadian disruption.
• Night operations where natural light cues are absent.
• High cognitive load: hauling hundreds of tonnes, navigating haul roads, avoiding equipment or human collisions.
• Isolation and monotony which can accelerate drowsiness.
• Arctic conditions with shortened daylight hours and prolonged low-light environments, reducing natural circadian cues and contributing to increased fatigue risk.

MineCo's Sustainable Development Policy and **Risk Management & Monitoring System** (RMMS) emphasize the company's commitment to injury- and fatality-free operations and require proactive risk controls for everyone on site. The company also promotes physical and mental well-being through wellness initiatives. Nonetheless, fatigue remains a persistent exposure. Traditional countermeasures such as caffeine, radio chatter, and frequent breaks have limitations; managers looked for a scientifically grounded, operator-friendly solution that could be deployed quickly across diverse operating environments.

2.2 Evidence of Fatigue Risk

During the initial field evaluation, operators noted that fatigue peaks typically occur between **13:00–16:00** and **02:00–05:00**, the so-called **"zombie zones"**, when the circadian rhythm naturally promote sleep. Operators also reported drowsiness during monotony at other times.

These insights highlight the need for tools that intervene **before microsleeps** and performance degradations occur.

2.3 Relationship to Detection Systems (e.g., Caterpillar DSS)

Across the broader mining industry, many fleets have invested in camera-based fatigue and distraction detection systems such as Caterpillar's Driver Safety System (DSS). These systems continuously monitor the operator's face, eyes, and head position to detect microsleeps or inattention and trigger an alert when a fatigue event is detected.

Bluewake operates at a different level in the fatigue control hierarchy, mitigation rather than detection. While detection systems identify fatigue after it emerges, Bluewake is designed to help reduce the likelihood and depth of fatigue by improving alertness during known high-risk periods and monotonous tasks.

In operations where both technologies are deployed, Bluewake supports proactive alertness while detection systems provide continuous monitoring as a secondary safeguard. This layered approach allows Bluewake to integrate into existing Fatigue Risk Management (FRM) programs while strengthening overall fatigue risk controls rather than replacing them.

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3 Objectives of the Evaluation

MineCo and Bluewake defined clear objectives for the pilot at the Canadian Site #1 complex:

1. **Assess real-world impact on early-fatigue episodes** – determine whether Bluewake reduces drowsiness indicators during high-risk windows.
2. **Evaluate user acceptance and ease of use** – gauge how willing operators are to adopt the technology and integrate it into their routine.
3. **Understand in-cab usability** – ensure the device's mounting and one-button operation are practical in haul-truck cabins.
4. **Gather subjective feedback** – collect operator reports on alertness, focus, comfort, and any adverse effects.
5. **Assess integration with existing Fatigue Risk Management (FRM) practices** – evaluate how Bluewake complements scheduling, breaks, and caffeine policies.
6. **Identify equipment groups and roles that gain the most from the device** (e.g., haul-truck drivers, maintenance staff, loaders).
7. **Explore logistical feasibility** – examine power requirements, device durability, and mounting solutions to understand scalability across remote sites.

By clearly defining these objectives, MineCo ensured that the pilot would yield actionable insights for decision-makers.

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4 The Bluewake Solution

4.1 Technology Overview

Bluewake is a compact alertness device that projects a pulsed blue light at 70 Hz. It targets **intrinsically photosensitive retinal ganglion cells (ipRGCs),** which play a key role in regulating circadian rhythms and alertness. When activated, these cells relay light

information to the brain's circadian and arousal centers, helping promote wakefulness, sharpen reaction time, and support sustained attention.

Scientific studies, including independent research performed at **NASA and Harvard University**, demonstrate the effectiveness of short-wavelength blue light in reducing sleepiness and enhancing cognitive performance. The device can also be used on desks for office workers or control room operators.

4.2 Key Benefits

• **Rapid alertness boost:** Operators typically experience a noticeable improvement in wakefulness, alertness and productivity within approximately 15 minutes of exposure.
• **Non-pharmacological:** Bluewake uses light, not stimulants, avoiding caffeine crashes or drug side effects.
• **Maintains healthy sleep:** During exposure, the light stimulus promotes alertness. When discontinued, melatonin secretion is no longer suppressed, allowing normal nighttime physiology to return and supporting recovery sleep.
• **Operator-controlled and flexible placement:** It mounts easily in vehicle cabs or on dashboards, and can also be used on desks for office or control room personnel; operators decide when they need it and can use external battery packs to power it on the go.

4.3 Safety & Certification

Bluewake complies with the **IEC 62471 photobiological safety standard**. Independent testing at **Laval University** confirmed that its radiance remains below recommended exposure limits, meaning it is safe for prolonged use. It emits 10x less light intensity than a computer screen and 2x less light intensity than a mobile phone screen.

The device is also:

• **FCC-certified** in the United States
• **CE-certified** in the European Union

This confirms compliance with major electronic safety and electromagnetic compatibility requirements.

Bluewake is patented and is currently used by major clients in the mining industry.

5 Deployment & Methodology

5.1 Site # 1 Pilot Scope

• **Participants:** 30–40 haul-truck operators at the Site #1 complex. Operators were drawn from day and night shifts.
• **Devices deployed:** 30 devices distributed, ensuring one per operator during peak usage periods.
• **Duration:** 2–4 week evaluation period.
• **Operation pattern:** Devices remained installed in the haul-truck cabs and were in use around the clock, rotating between operators working consecutive 12-hour shifts.
• **Training:** Operators received a brief explanation of the science behind blue light, instructions on when to activate the device, and safety guidelines. Supervisors reminded operators to prioritize safe operation and to report any discomfort.

Data Collection:
• *Operator surveys:* Anonymous questionnaires captured subjective perceptions of alertness, focus, ease of use, comfort, and comparison to caffeine.
• *Supervisor observations:* Foremen noted visible signs of fatigue (e.g., yawning, slower reaction to instructions) before and after operators activated Bluewake.
• *Cloud-based data collection*: A centralized software platform captured device usage data (e.g., activation times, duration, and intensity levels), enabling aggregation and further analysis of alertness patterns, usage trends, and correlations with operational performance metrics.

5.2 Site #3 Deployment

Following the Site #1 pilot, **devices were deployed** at the Site #3 complex. Operators at Site #3 work in extreme Arctic conditions, including polar night and long-haul roads.

Early feedback was positive, leading management to order **additional units** to expand usage across more haul trucks and roles.

This phased approach provided additional insights into logistical considerations such as:

• Power provisioning
• Device rotation
• In-cab mounting adjustments

5.3 Site #2 Planning

The Site #2 mine has not yet commenced its trial due to competing operational priorities, but the evaluation is scheduled. Lessons from Site #1 and Site #3 will inform device allocation and training at Site #2, where automated **underground operations** and a **remote workforce** in a central operations center may present different fatigue patterns.

6 Key Findings

1. **Early activation improves alertness:** Operators reported that turning on Bluewake at the onset of fatigue helped restore wakefulness and prevent deeper drowsiness.
2. **Sustained use enhances focus:** Many operators kept Bluewake on during long, monotonous hauls. They noted smoother concentration compared to relying solely on caffeine.
3. **High user acceptance:** Over **90%** of operators reported that the device was comfortable and easy to use; they appreciated the non-chemical nature of the intervention. Both experienced drivers and newer hires embraced it.
4. **Preference over caffeinated alternatives:** Operators felt that caffeine provided a temporary jolt followed by a crash, whereas Bluewake delivered a more stable state of alertness without jitteriness.
5. **Reduced visible fatigue markers:** Supervisors observed fewer yawns, less head-nodding, and improved responsiveness during Bluewake sessions. At Site #1, Bluewake's internal summary recorded that **85% of drivers experienced reduced drowsiness** and **94% reported better daytime sleep**.
6. **Minimal disruptions:** No complaints were recorded regarding eye strain or headaches.

7 Quantitative & Qualitative Feedback

Metric / Theme	Evidence & Observations
Usage timing	Peak usage occurred between **13:00–16:00 and 02:00–05:00**; many operators extended use through the entire 12-hour shift.
Perceived alertness	Operators consistently reported feeling more alert during known fatigue windows; **85% experienced reduced drowsiness and 94% reported better daytime sleep**.

Metric / Theme	Evidence & Observations
Focus & accuracy	Drivers described smoother focus during repetitive haul cycles, and supervisors informally noted more consistent reaction times and fewer missed radio communications.
Comfort & ease of use	Operators generally found the device comfortable and simple to operate after initial familiarization; no significant complaints were recorded.
Desire to continue	Operators expressed willingness to continue using Bluewake; some indicated interest in having consistent access to a unit in their assigned vehicle.

8 Impact on Fatigue Risk Management (FRM)

MineCo's RMMS mandates global health and safety standards and calls for a comprehensive set of requirements to manage health and safety across the organization. Bluewake aligns with FRM in the following ways:

- **Proactive intervention:** The device helps operators combat fatigue *before* microsleeps occur, complementing scheduling, breaks, and operator training.
- **Standardization:** By providing a consistent, evidence-based alertness tool, Bluewake reduces reliance on inconsistent strategies such as energy drinks, coffee or ad-hoc radio conversations.
- **Integration with metrics:** Usage logs can be combined with haul-truck telematics to track alertness interventions alongside speed, cycle time, and incident reports.
- **Compliance with policy:** Bluewake's non-pharmacological approach supports MineCo's commitment to health and wellness while aligning with international fatigue-management best practices advocated by organizations such as the ICMM.

In essence, Bluewake provides a **Level-2 preventive control**, something operators can deploy themselves, augmenting existing FRM protocols that focus on scheduling, sleep education, and fitness-for-duty assessments.

8.1 Complementing Detection Technologies (e.g., CAT DSS)

MineCo use camera-based fatigue and distraction detection systems such as **Caterpillar's Driver Safety System (DSS),** Bluewake was deployed as a complementary physiological mitigation layer.

Detection systems like DSS are designed to recognize when an operator is **already drowsy or entering a microsleep**, triggering an immediate in-cab alert.

Bluewake, by contrast, is designed to **reduce the likelihood that such fatigue events occur in the first place** by improving alertness during known high-risk windows (13:00–16:00, 02:00–05:00) and during monotonous tasks.

This creates a **dual-layer fatigue control model**:

• **Mitigation:** Operators use Bluewake proactively to maintain alertness and reduce the onset of drowsiness.
• **Detection:** DSS monitors continuously in the background and intervenes only if a microsleep still occurs.

Several Bluewake clients deploy both technologies in parallel, describing this configuration as a **"belt and suspenders" solution,** supporting the operator's physiology while retaining automated monitoring for residual risk.

For MineCo, this illustrates how Bluewake can fit seamlessly into a modern FRM ecosystem that includes scheduling, education, wellness initiatives, and, where present, in-cab detection technologies.

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9 Operational Feasibility for Scaling

Successful deployment in remote and extreme environments depends on more than the device's physiological effect; logistical considerations include:

• **Power logistics:** Bluewake devices are powered via standard USB connections (vehicle power, wall adapters, or computer USB ports). Sites can also use portable battery packs to power devices when fixed power sources are not available, ensuring continuous operation through 12-hour shifts and across shift turnovers.

• **Mounting solutions:** At Site #1, a custom metal bracket was engineered to position the device at the center-right of the steering wheel, with power hardwired directly into the vehicle's electrical system. Similar cab and dash-mount solutions can be standardized across fleets, and the device can also be placed on desks for office or control room use.

• **Durability:** Devices survived dust, vibration, and significant temperature fluctuations. Tested operation between **–50°C and +50°C** indicates suitability for Arctic winter conditions and hot environments.

• **Maintenance & replacement:** Bluewake units require minimal maintenance, with sites holding spare units to ensure uninterrupted availability.

• **Fleet management:** An enterprise app is now available that allows organizations to control devices (turning them on/off and adjusting intensity), track device usage, manage inventory across sites, assign devices to specific drivers, teams or business areas, configure schedules and specialized settings, and review usage analytics to support FRM decision-making.

These findings suggest that rolling out Bluewake across additional sites is **technically feasible**.

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10 Conclusion

The Bluewake pilot at MineCo's Canadian Site #1 complex illustrates how scientific innovation can address a longstanding operational hazard. By delivering a rapid, non-chemical alertness boost within approximately 15 minutes of exposure, Bluewake empowered operators to manage fatigue proactively and maintain focus during critical tasks. Strong operator acceptance, ease of use, and preliminary reductions in drowsiness indicators show that the device is not just a novelty but a potentially transformative tool.

Expanding to the Site #3 complex and the planned evaluations at Site #2 reveal cross-site interest and operational feasibility. In aligning with MineCo's RMMS and health and wellness commitments, Bluewake represents a practical, operator-driven control that complements existing fatigue management strategies.

With a structured multi-site pilot, MineCo can validate the device's impact on safety and productivity across its global portfolio. If the results continue to be positive, Bluewake could become an integral part of the company's culture of innovation and its pursuit of an injury- and fatality-free workplace.

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11 Appendix (Scientific Background & Device Specifications)

11.1 Scientific Evidence for Blue Light and Alertness

Research has demonstrated that short-wavelength (blue) light directly influences the brain's alertness pathways. NASA and Harvard University studies cited by Bluewake show that blue light improves reaction time, vigilance, and cognitive performance.

More specifically, ipRGC stimulation relays light information through hypothalamic and thalamic pathways to brain arousal networks that support alertness, attention, and cognitive readiness. Bluewake uses a specific wavelength and pulsed-light profile optimized for biological efficiency, enabling effective alertness support at lower light intensities.

11.2 Photobiological Safety

Testing at the **Laval University Optical Engineering Research Lab** confirmed that Bluewake's radiance stays below the **10 mW/cm²·sr** limit recommended by ACGIH/ICNIRP.
The device:

- Complies with **IEC 62471** photobiological safety standards
- Is classified as **eye-safe** for prolonged industrial use
- Is **FCC-certified** in the USA
- Is **CE-certified** in the European Union

This ensures that Bluewake meets all major electronic safety and electromagnetic compatibility requirements.

11.3 Device Specifications

- **Light source:** 70 Hz pulsed blue LED
- **Power:** Powered via USB (vehicle power, wall adapter, computer USB port); compatible with external battery packs for portable use
- **Mounting:** Cab and dash-mount configurations; also suitable for placement on desks (e.g., for office workers or control room operators); custom brackets (such as those developed at Canadian Site #1) can standardize positioning in vehicle cabs
- **Controls:** One-button on/off; brightness levels
- **Operating temperature:** –50°C to +50°C

11.4 Glossary

- **MineCo:** For privacy reasons the company name and mining sites have been omitted from this case study.
- **FRM (Fatigue Risk Management):** A systematic approach to managing fatigue-related risk, often incorporating scheduling, education, monitoring, and interventions
- **Photosensitive retinal ganglion cells (ipRGCs):** a class of retinal neurons that respond directly to blue-wavelength light and relay signals to brain systems involved in circadian timing and arousal.
- **RMMS (Risk Management & Monitoring System):** MINECO's integrated system for identifying, preventing, and mitigating operational risks, including health and safety exposures.