CASE STUDY

TOTALTRACK MONITORING

L.B. Foster Rockfall Monitoring

Safer and More Cost-Effective than Traditional Slide Fences

Rockfall hazards pose significant safety and operational challenges for railway networks. Traditional slide fences, while widely used, suffer from high false alarm rates, missed detections, and maintenance inefficiencies. L.B. Foster's Rockfall Monitoring system offers a revolutionary alternative by leveraging advanced LiDAR technology, centralized processing, and streamlined system design. This white paper traces the development of the Rockfall Monitoring system from its pilot phase to large-scale deployments with leading railway operators. The system's direct track monitoring approach addresses key safety gaps posed by slide fences, significantly reducing missed detections while enhancing operational efficiency. Real-world trial data demonstrates Rockfall Monitoring's superiority, with all valid rockfall events successfully detected, compared to only one-third detected by the slide fence. Additionally, operational cost savings are achieved through reduced maintenance callouts and minimized train slow order time. This paper establishes L.B. Foster's Rockfall Monitoring system as a transformative advancement in railway safety and service efficiency.

Rockfall hazards along railway tracks pose significant safety risks and operational challenges to railroads, commuter lines and industry. Historically, slide fences have been the primary defense mechanism for rockfall detection, but they suffer from reliability issues, leading to false activations, a large labor overhead, and dangerous missed detections. These limitations have prompted L. B. Foster to look for innovation in monitoring solutions. L. B. Foster's Rockfall Monitoring represents a new era in railway safety technology, leveraging advanced LiDAR and robust system integration to deliver enhanced detection accuracy, operational efficiency, and cost savings.

This white paper examines the evolution of the Rockfall Monitoring system, from its conceptual origins to its current production-ready form, its operational principles, and its transformative impact on railway safety and service.

Rockfall Monitoring - Development History

The Initial Plot - US Class 1- Washington State (2018)

The journey began with a pilot project with a US Class 1 in the Pacific Northwest 2018. This marked the first implementation of a LiDAR-based system as a potential replacement for traditional slide fences.

- **Purpose:** the pilot aimed to test the feasibility of LiDAR technology for rockfall detection, serving as a basic proof of concept.
- **Configuration:** 10 LiDAR units were installed to monitor a defined track section. Each unit operated independently and did not combine data from adjacent sensors. The unit's primary task was to detect obstructions and provide a relay output of a potential obstacle.
- **Key Insights:** While the pilot successfully demonstrated the feasibility of a LiDAR based rockfall detection system, the system lacked the robustness for widespread deployment. The prototype design required extensive wiring, had little to no customer interface tools and did not combine data from adjacent sensors. This limited detection redundancy and operational flexibility, which prompted the development of next generation systems.

Rockfall Monitoring First Generation - Class 1 Trial Customer - Canada (2022)

The insights from our pilot installation informed the development of a production-ready version of Rockfall Monitoring deployed at a trial customer in 2022. This system was designed to be more user friendly. The system now has a centralized controller that did not require custom integration for each site, and software that brought more functionality to Rockfall Monitoring. This included an integrated camera validation system, a web portal interface, automated email alarms, and relay outputs for local signal control. The system was deployed at a highly active rockface, through 4 active slide zones separated by tunnel segments.

- **Configuration:** Rockfall Monitoring was a developed to address insights from the pilot program. The new system integrated multiple LiDAR outputs into a centralized processor, addressing the redundancy issues identified during the pilot. This redundancy allowed for advanced detection algorithms to be implemented to reduce false alarms from environmental conditions such as fog, rain, and wildlife.
- **Performance Results:** The trial customer's deployment established the system's feasibility for real-world applications, paving the way for broader adoption. As of December 2024, the trial customer has accepted the performance of the trial period and has integrated the system into local control. The results of the trial period will be analyzed in greater detail later in this paper.

Simultaneous Deployment - Regional Transit, NM (2022)

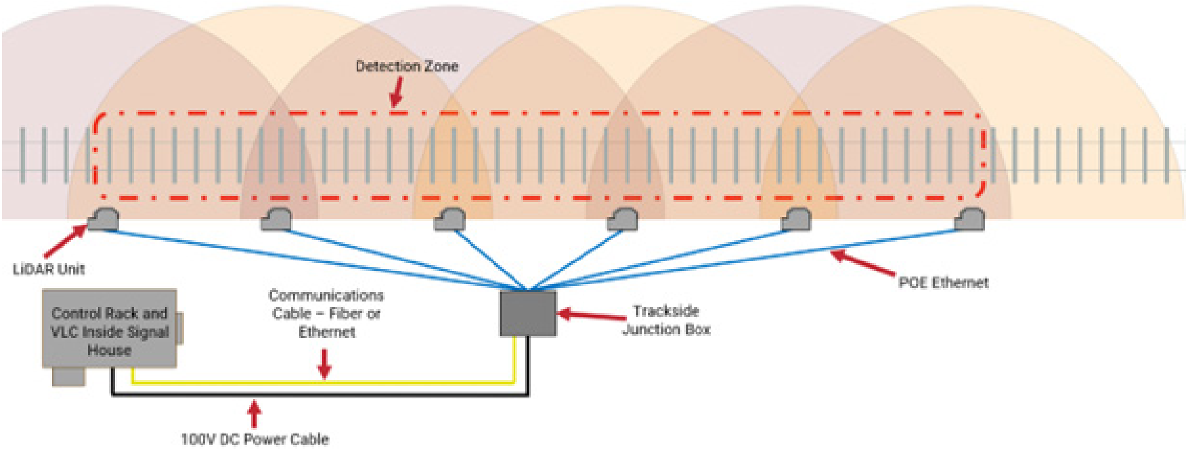
In the same year, Herzog Rail adopted the production version, reinforcing the technology's credibility.

- **Dual Deployments:** The concurrent installations at the trial customer and regional transit highlighted the system's scalability and adaptability to varying railway environments. Devil's Throne is a rockface that is deep in the New Mexico desert, a stark contrast in environment to the trial customer's installation in British Columbia, Canada. These two installations were highlighted to show the capability of the system in the toughest of environmental conditions.

The Current Generation - Class 1 Railroad, California (2024)

By 2024, L.B. Foster introduced significant enhancements to the system, tailored to further meet the needs of our customer. The system redesign was aimed at making system operation and installation as user friendly as possible. Taking feedback from the first production systems, the following improvements were made:

- **Local System Configuration:** The addition of an HMI screen within the control rack was made to allow for on-site system information. This includes system status, needed maintenance activities, alarm logging and alarm mapping.
- **Power Architecture:** Based on customer feedback, we moved to transition the power to DC at a safe voltage. This shift was aimed to reduce installation costs and simplified hardware requirements. Additionally this made power backup much simpler, and electrical work on the system much safer for maintainers.
- **Cost Efficiency:** Finally the feedback that we received from our customers routinely highlighted a high installation cost. With this feedback in mind, the system was redesigned to require less hardware to be installed. Notably, each LiDAR on previous systems required a junction box. This was reduced to 1 junction box for up to 8 LiDAR units. Additionally, from the junction boxes, the system wiring scheme was improved to utilize POE ethernet with the aim to lower installation costs. These advancements made the system more accessible for rail operators, with reduced installation complexity and lower maintenance demands.

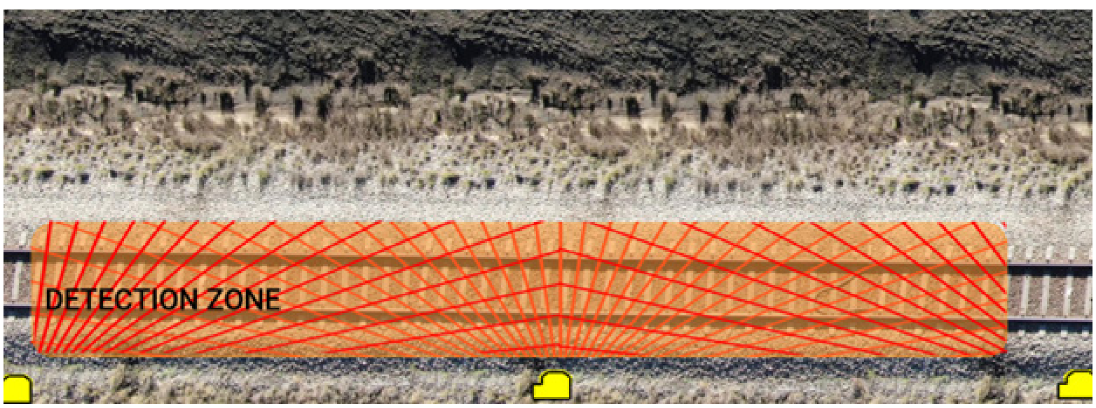


System Operation

The Rockfall Monitoring system utilizes advanced LiDAR technology and intelligent data processing to ensure reliable track monitoring. Its design principles and operational mechanisms are as follows:

Detention Principles

- **LiDAR Scanner Network:**
  - 2D LiDAR scanners are strategically placed every 87 feet along the track.
    - This spacing allows for redundant coverage of the track, and any obstacle is seen by at least 2 LiDAR from 2 angles.
  - The dection zone spans 6 feet from the track center, ensuring comprehensive coverage of the track.
- **Obstacle Detection:** If an object is identified within this zone, the system triggers an alarm to signal potential obstructions.



Data Integration and Processing

- **Centralized Processing Unit:**
  - Data from all LiDAR scanners are fed into an on-site safety-critical processor.
  - The processor integrates and analyzes inputs to determine track status (clear or occupied).
- **Relay Outputs:** Based on the analysis, the processor generates a clear or obstructed track condition. This decision is fed to relay outputs to control local signaling, enabling or restricting train movements through the monitored zone.

System Design and Advantages

- **Redundancy:** The integration of multiple LiDAR perspectives ensures safer operation, minimizing the risk of missed detections.
- **Customizability:** The system's HMI screen allows operators to view local system status such as alarm logs, component health, and detected obstacle position. Additionally, an engineer tool can be used to configure local parameters, such as obstacle detection zone size, enhancing operational flexibility.
- **Stability:** Advanced algorithms and hardware design ensure stable operation across varied environmental conditions.

Safety - Slide-Fences and Rockfall Monitoring

In the rail industry, the rock slide-fence is the most common method of rockfall detection. Traditional slide fences, while widely used, are prone to false activations, averaging around a 96% false detection rate. Despite this high false alarm rate, slide fences are still widely utilized as they are viewed as the only current viable solution. Furthermore, slide fences are seen as safe because even though only 4% of alarms are valid, the consensus is that they are unlikely to miss a true detection event. LB Foster wanted to challenge the belief that slide fences were the only viable option for safe operation through rockfall prone regions and entered into a head-to-head trial in 2024.

Our trial site was carefully selected a rockface along the Thompson River in British Columbia. This rockface was known for being very active throughout the spring and fall freeze thaw cycle due to a loose rockface composition. LB Foster Rockfall Monitoring was installed side by side the existing slide fence, with the purpose of collecting side by side data between both the Rockfall Monitoring system and the slide fence. During this trial, data such as false activations, missed detections, true rockfall events and labor callouts were collected.

Real-World Performance - Trial Site Head-to-Head Trial

During the trial period, three true rockfall events were recorded. A true rockfall event is a rockfall that causes a rock of at least 16 inches tall and 16 inches wide, to land within the 6 feet of track center, posing a potential hazard to train traffic. Any obstacle of this size or greater could pose a hazard to train traffic and therefore must be detected. Two events that were captured by Rockfall Monitoring but missed by the slide fence are detailed below:

> **Qualifying Event 1: A rock of approximately 16” x 22”**

Fig. 1. Qualifying Rockfall Event Captured by Rockfall Monitoring, Missed by Slide Fence

A qualifying rock of approximately 16” X 22” fell within the detection zone at 7:18am on September 27th 2024. Upon video review of the event, this rock bounced through the slide fence wires without tripping the fence. Being of the minimum size that the rockfall system is set to alarm upon (Greater than 16X16), and being within the detection zone, Rockfall Monitoring went into alarm. This alarm set the local relay from clear to obstructed, and sent out an alarm email 45 seconds after the event took place to the customer’s personnel.

> **Qualifying Event 2: A rock of approximately 36” x 44”**

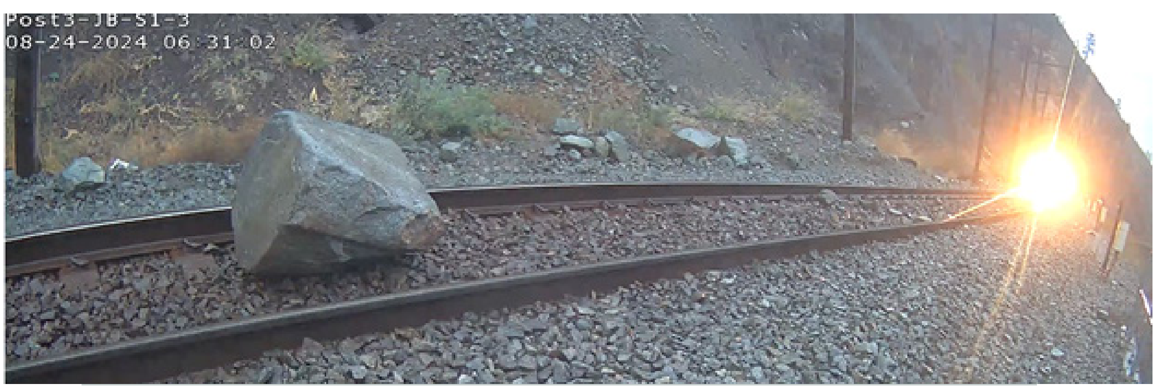


Fig. 2. Train Stopped Short of Rockfall Event Captured by Rockfall Monitoring, Missed by Slide Fence

A qualifying rock of approximately 36” X 44” fell within the detection zone at 2:50am on September 27th, 2024. Upon video review of the event, this rock bounced through the slide fence wires without tripping the fence. The below image shows the bottom wires, where the rock passed through intact. Furthermore, this missed activation was confirmed by the railroad.

Being of well above the minimum size that the rockfall system is set to alarm upon (Greater than 16X16), and in the center of the detection zone, Rockfall Monitoring went into alarm. This alarm set the local relay from clear to obstructed, and sent out an alarm email 45 seconds after the event took place to the customer's personnel. This alert was used to stop local train traffic and send maintainers out to clear the track. This detection was critical in highlighting the dangers of relying on a slide fence, rather than actively monitoring the tracks for obstructions.

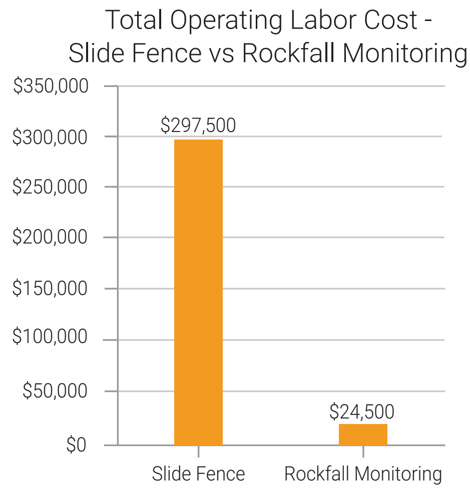
Safety Summary

Of three valid rockfall events during the trial period, Rockfall Monitoring captured all three whereas the slide fence only captured one. This highlights a critical issue with slide fences that Rockfall Monitoring aims to address. Rockfall Monitoring directly monitors the tracks as opposed to a slide fence which rely on indirectly detecting an event which may or may not impact train travel. Rockfall Monitoring actively monitoring the tracks themselves provides inherent safety benefits. By monitoring the tracks directly, the system reduces the likelihood of false alarms and more critically, missed detections. This in turn enhances reliability and ensures safer railway operations.

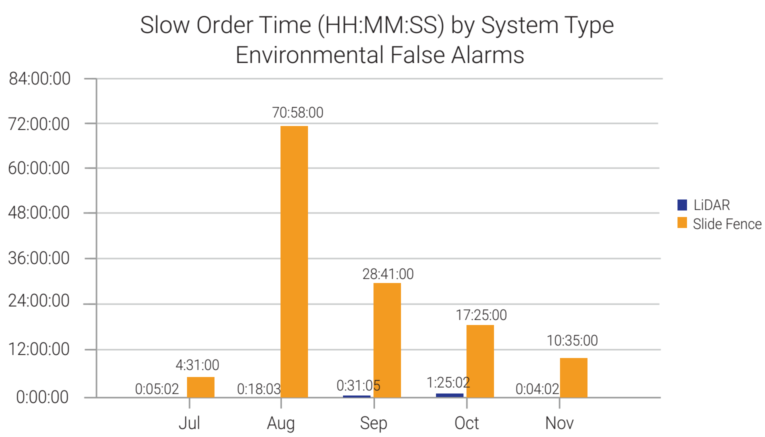
Service - Slide Impact and Cost Analysis

Beyond safety, the Rockfall Monitoring system delivers measurable benefits in terms of operational efficiency and cost savings. An analysis of slide fence activations compared to Rockfall Monitoring was conducted through the trial period to understand the service impact of operating both systems.

Cost of Slide Fence Activations (Through 2024)



When a rock slide fence is activated, the system remains in alarm until the fence is manually reset or repaired. Due to this, any activation, whether genuine or false-alarm requires a maintenance callout. Rockfall Monitoring on the other hand will automatically reset if an alarming obstacle is removed and is much less prone to false alarm than a slide fence from benign environmental conditions. During the trial period the slide fence required 85 callouts to reset the system. During the same period, Rockfall Monitoring only had 5 events for routine maintenance, and 3 valid obstacles needed to be cleared; a total of 7 callouts. For sake of comparison a callout will be assumed to cost approximately $3,500, a number determined by a 2018 case study around slide fence maintenance. These operational labor cost comparisons for labor are denoted in the chart above.



Environmental conditions cause the slide fence to routinely false alarm. These false alarms still trigger a slow order as trains need to approach the area at caution. Throughout the trial period, environmental conditions leading to false alarms, and slow orders were meticulously tracked. Through July-November, the slide fence caused 131 hours of slow order time at the site. Through this same period, Rockfall Monitoring resulted in 2 hours of slow order time, a 98.5% reduction from the slide fence.

Conclusion

The development and deployment of L.B. Foster's Rockfall Monitoring system mark a significant advancement in railway safety and operational efficiency. By leveraging the power of LiDAR technology, centralized processing, and intuitive system design, Rockfall Monitoring addresses the critical shortcomings of traditional slide fences. Unlike slide fences, which rely on indirect detection and suffer from high false alarm rates and missed detections, Rockfall Monitoring offers direct track monitoring, ensuring more accurate detection and timely response to hazardous conditions.

The system's evolution from a pilot program at to full-scale deployments underscores its scalability and adaptability to diverse railway environments. Key design improvements, such as the integration of centralized processing, enhanced HMI controls, and streamlined installation processes, have further reduced system costs and maintenance demands. The system's ability to maintain stable performance across varying environmental conditions, including fog, rain, and wildlife interference, highlights its operational robustness.

Real-world performance data from the head-to-head trial provides compelling evidence of the system's superiority. Rockfall Monitoring successfully detected all three valid rockfall events during the trial, whereas the traditional slide fence missed two of the three events. This direct track monitoring approach eliminates the dependency on indirect event detection and significantly reduces the likelihood of missed detections—a crucial safety advantage.

Moreover, Rockfall Monitoring delivers substantial operational cost savings. During the trial, the slide fence required 85 maintenance callouts, compared to just 7 for Rockfall Monitoring. With each callout costing an estimated $3,500, the potential for cost reduction is clear. Additionally, Rockfall Monitoring's lower false alarm rate resulted in significantly less train slow order time—129 fewer hours compared to the slide fence—further boosting operational efficiency and reducing service delays.

In summary, L.B. Foster's Rockfall Monitoring represents a transformative leap in railway rockfall detection technology. By providing enhanced safety, operational reliability, and cost efficiency, it establishes a new industry standard for rockfall monitoring. The system's successful deployments and proven performance make it a compelling alternative to traditional slide fences, offering a safer, smarter, and more cost-effective solution for rail operators navigating rockfall-prone regions.

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