Case Study

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Microseismic Railway Monitoring System Successfully Detects Rockfall Events

Working in partnership with Alstom Signaling, ESG installed a microseismic monitoring system along 250 feet of railway track, near the Dalles, Oregon. Analysis of data from a rockfall event enabled ESG to successfully calibrate the microseismic system so that real-time rockfall detection may be enabled, helping to reduce risk to oncoming trains.

Fig. 1: Location of the seismic sensors (approximately in line with the hydro poles) in relation to the railway tracks and rock face

In regions with rugged terrain, railways are commonly located in environments where steep natural rock slopes or cliffs pose a risk of rockfall hazard. Rockfall risk management is critical along railway lines to minimize the risk of train derailment and ensure efficient service with minimal disruptions.

Existing rockfall detection systems typically consist of electrical fences or netting to warn of rockfall events. However, these systems require personnel to investigate events and repair or reset systems in the event of a rockfall, posing risk to works and slowing transportation along the route. The increasing use of microseismic systems to detect rockfall events is appealing due to their ability to reset automatically and allow normal transportation to resume more quickly. Microseismic systems are designed to automatically distinguish between a true rockfall event and other sources of noise based on specific seismic source characteristics.

ESG Solutions
20 Hyperion Court, Kingston, ON, Canada K7K 7K2
Tel: +1.613.548.8287 Fax: +1.613.548.8917
www.esgsolutions.com sales@esgsolutions.com

Background

ESG installed a permanent microseismic railway monitoring system (MRMS) in September 2008 along a 250 foot length of railway track near the Dalles, Oregon that was prone to rockfall events. The system consists of 12 uniaxial sensors installed at a distance of 3-6 feet from the edge of the railway track (Fig. 1) and continues to operate in full capacity. The sensor cables connect to a small sensor splice box and a trunk cable running parallel to the tracks (Fig. 2). Microseismic data is digitized by two Paladin™ data acquisition units, operating at a sampling rate of 5000Hz and 24-bit resolution.

A known rockfall event occurred on December 17, 2010. The main rock involved in the rockfall appears to have fallen from a cliff face at a height of about 50 ft (Fig 3). A segment of the continuous microseismic data collected at the site consisting of a period of 7 days and including the rockfall event yielded a total of 1915 event triggers (Fig 4a). Closer examination of the source characteristics of the rockfall event enabled ESG to fine tune the triggering methods to isolate the rockfall event from all other events so that the system may be used in real time to warn oncoming trains of potential hazards.

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Upon closer inspection of the data, it was determined that the microseismic event triggers could be separated into five event types (passing train, car on tracks, electrical noise, small seismic event, rockfall event) based on the specific seismic characteristics of each event type. By optimizing the triggering logic and implementing an event rejection function, ESG was able to filter all event triggers with the exception of the single rockfall event (Fig 4B).

This study provides evidence that a microseismic railway monitoring system can be successfully used for rockfall detection along critical portions of railway line with steep rock slopes.

Fig. 2: Standard MRMS sensor installed near a railway track

Fig. 3: Cliff face located above the train tracks where the rockfall originated

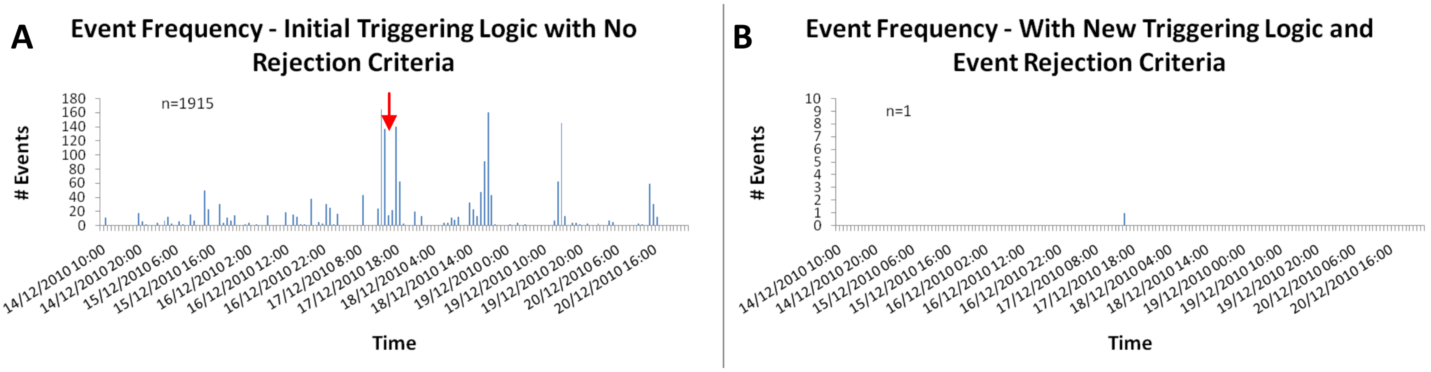

Fig. 4: Event-time histograms with 1-hour windows using A) initial triggering parameters and B) new triggering logic and event rejection criteria. The time of the rockfall is marked with an arrow in A

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