Example 19 (2003) – An early warning system (EWS) for detecting rock falls

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>MAIN OBJECTIVE</th>
<th>MAIN BENEFIT</th>
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<td>Full scale field test</td>
<td>Develop a microseismic early warning system</td>
<td>Five year performance data obtained</td>
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BACKGROUND AND DESCRIPTION OF PROJECT
The topography of Norway consists of 75% exposed rock, primarily in the form of steep slopes or rugged mountains that are subjected to varying amounts of precipitation as well as extreme seasonal cycles of freezing and thawing. Consequently, one of the principal geohazards is the potential for rock falls or rock and ice slides. Considerable effort is being put into developing suitable warning systems to protect life and property. An example is the microseismic early warning system (EWS) installed by NGI to monitor a long section of railway line that is vulnerable to ice and rock falls.

FACTORS THAT INFLUENCED THE DESIGN OF THE MONITORING PROGRAM
A 500m long section of railway line in northern Norway is exposed to frequent ice and rock falls. This section was chosen in 2003 to be a pilot site for the developing and testing a warning system in cooperation with Jernbaneverket. A microseismic system using subterraneous geophones was chosen, with a line of geophones placed along the uphill side of the track. The geophones are vertically cast in concrete to attain good coupling to the surrounding track substrate. The warning system was in operation until 2010.

SCOPE OF INSTRUMENTATION
The main components of the acquisition system are the geophone array, a seismic data logger and an industrial PC. The geophone array is a custom-built cable with 24 geophones. The PC controls the logger and analyses incoming data sets. A wireless router allows communication and automatic SMS based warning to users.

For the first three years after installation (2004-2007), the system was used as a monitoring system only, and all events were recorded and used primarily to evaluate the performance of the system. During 2005, a test of controlled rock falls was made to gain more rock fall events. This data was used to optimise the parameters of the three slide algorithms used to evaluate whether a warning situation exists or not.

TYPICAL EVENT REGISTRATION
In a warning system such as this, there are many different events that can trigger the system. Two examples are shown below.

**REFERENCE:** Cleave, Myrvoll and Nålsund (2009)