Acceleration and GPS data monitor truck-haulage jolts

Accelerometers and pressure transducers, mounted in suspension components, can be used to monitor the ride of haulage trucks. Presently, it is difficult to tell what caused a jolt to the truck using either pressure or acceleration data alone.

When information from a global positioning system (GPS) is recorded at the same time as shock pressures or acceleration data, the exact location of an event can be determined. Mine management can then determine what caused the jolt to the truck.

This research is part of a National Institute for Occupational Safety and Health (NIOSH) project called "Engineering controls for reduction of jolting/jarring injuries in surface mines." NIOSH is investigating how the work environment of haulage truck drivers can be improved.

The US Mine Safety and Health Administration (MSHA) notes that, between 1986 and 1995, 60% of the back injuries were to haulage truck drivers in metal/nonmetal surface mining. Personnel from Phelps Dodge suggested that combining acceleration data with information obtained from a GPS could generate results with a variety of uses.

Therefore, researchers at the Spokane Research Laboratory (SRL) began investigating how to tie acceleration and GPS data together. It was originally thought that this tool would be used primarily for road and truck maintenance. However, as research progressed, it became apparent that it would also be useful in providing feedback about equipment operations and identifying unusual causes of jolting.

Experimental approach

Available components that function well by themselves were linked for the purpose of proof of concept. Using a Modular Mining Systems (MMS) product called Vital Signs, SRL researchers took an Aero-Marine Products (AMP) acceleration recorder and hardwired it to MMS Dispatch equipment already installed on a truck. AMP is one of several manufacturers of acceleration recorders frequently used to monitor freight during shipping. MMS Dispatch is used for production accounting and truck dispatching and uses GPS tracking.

Through Vital Signs, an analog or digital alarm signal can be recorded. Steve Rhoades, of MMS, wrote unique code that links the Vitals Signs data and GPS location and stores this data in an ASCII log file. SRL researchers installed the equipment in a Caterpillar 793 haul truck. The result was a working prototype. Figures 1 and 2 show the instrument installation in the truck.

Discussion

From 8:30 pm on Sept. 14, 1998 until 6:50 am on Sept. 15 1998, 899 jolts above a threshold of 2 g (1 g is the acceleration of gravity. It is either 9.81 m/s^2 or 32.17 ft/s^2.) were measured on the test truck. Some sections of the haulage road produced most of the events, while

FIG. 1.

View of "buddy seat" where an acceleration recorder was installed.

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many others produced no jolts at all (Fig. 3). 2 g is a relatively low threshold for jolts (Fig. 4). When plotting the data, the movements of the truck on some sections of the haulage road can be seen. Watching the acceleration signature of the truck is comparable to watching the thermal signature of a moving object with an infrared camera.

The data has many uses. For example, it can be used to:

- Determine if, how often and of what intensity are severe jolts that could pose a health concern.
- Monitor driving style and skill.
- Gather baseline data on truck performance to compare with future truck performance.
- Monitor road conditions.

As with any tool, proper use is the key to getting the most benefit. Some applications would require a very low threshold setting and would require large data storage and/or fast radio systems. To determine the location of potholes, for example, an event would have to be picked. Then all other events within a given radius of that selected event would need to be located. If a significant number of events occurred around a specific location, then it could be assumed that a pothole exists in the haulage road at that location.

The emphasis at any specific mine would dictate threshold levels and sampling rates. A simple use of the tool is to set the acceleration threshold at a high level, beyond what normal operation should produce. Therefore, when an event is produced, it is rare and more attention is paid to finding out its cause. Examples of root causes for high acceleration events include:

- Extreme speed for road conditions.
- Truck striking a berm or other object.
- Shovel striking the side of a truck bed.

A pertinent question concerns how this data would affect production. Would it cause drivers to slow down or act tentatively? The key is how the data is managed. Future research will focus on determining positive and negative effects. Costs per truck to install this system are not yet available and depend on how many functions would be built into it. As noted earlier, the possibilities for powerful diagnostic software are numerous. The AMP shock recorder operates on batteries and has built-in data storage. The next generation prototype is simplified and taps into the truck's system for electricity. It consists of an analog, triaxial accelerometer

FIG. 2.

AMP acceleration recorder in upper right corner.

Table 1

Specifications of the AMP recorder.

Part number	1005083-1
Sensor type	3-axes piezoelectric accelerometer
Dynamic range	+/-2 to +/-200 g in each axis
Cross axis	5% typical
Digitization	10 bits
Sampling frequency	User programmable from once every 1 to 50 msec.
Lower frequency limit	1.5 Hz
Upper frequency limit	90 Hz
Trigger threshold	User programmable 2 to 50 g
Accuracy of acceleration	Better than 4% full-scale over temperature
Accuracy of peak	Better than 5% full-scale over temperature
Pretrigger	1 sample

FIG. 3.

GPS data points for acceleration events (Frankel, Spokane Research Laboratory).

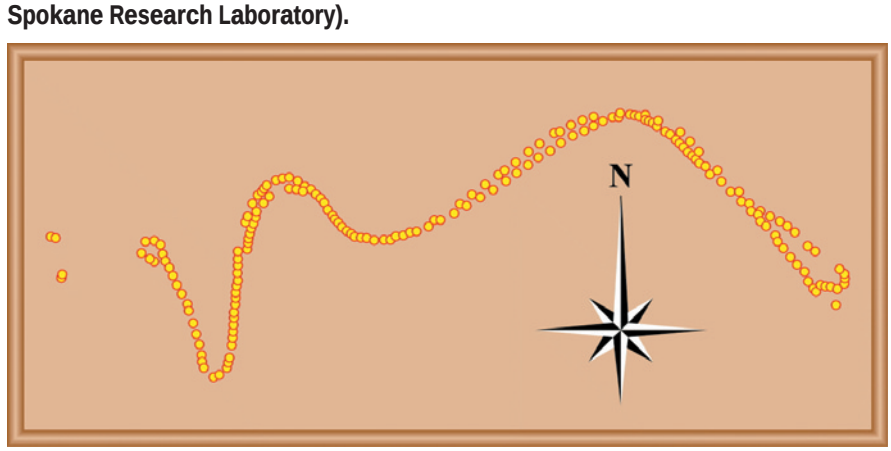
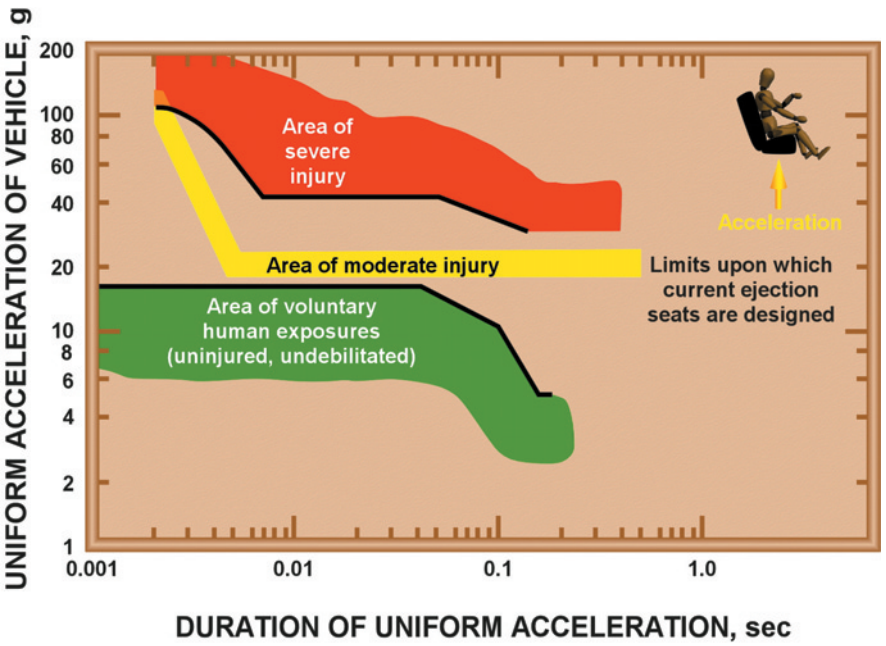


FIG. 4.

Effect of uniform acceleration on humans (Eiband, NASA Memo 5-10-59E).



connected to a digital component. The digital component monitors all three axes and sends out an alarm signal when a preset threshold is exceeded.The specifications of the AMP recorder used are given in Table 1.

Conclusions

A data collection system that ties acceleration and GPS location data has been successfully demonstrated at a cooperating mine. A variety of applications are possible. Using plotting software, the person reviewing the data produced can see the acceleration history of the truck, much like an infrared camera can display the thermal signature of a moving object.

Sophisticated hardware and software monitors very low-level accelerations and increases functionality. Severe jolts can be monitored by using inexpensive hardware and software. ■