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TYING ACCELERATION AND GPS LOCATION INFORMATION TOGETHER TO CREATE A MINE MANAGEMENT TOOL

R.E. Miller
NIOSH
Spokane, WA

P. Boman
J. Walden
Phelps Dodge Morenci, Inc.
Morenci, AZ

S. Rhoades
Modular Mining System, Inc.
Tucson, AZ

R. Gibbs
Phelps Dodge Tyrone, Inc.
Tyrone, NM

ABSTRACT

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 is recorded at the same time as shock pressures or acceleration data, then the exact location of an event can be determined. Mine management can then determine what caused the jolt to the truck.

INTRODUCTION

This research is part of a National Institute for Occupational Safety and Health (NIOSH) project called AEngineering Controls for Reduction of Jolting/Jarring Injuries in Surface Mines.@ Phelps Dodge Morenci, Inc. (PDMI), and NIOSH are working together to investigate how the work environment of haulage truck drivers can be improved. The Mine Safety and Health Administration (MSHA) notes that 60 pct of the back injuries were to haulage truck drivers; in metal/nonmetal surface mining between 1986 and 1995. It was suggested by mine personnel that combining acceleration data with information obtained from a Global Positioning System (GPS) could generate results with a variety of uses. Therefore, Spokane Research Laboratory (SRL) researchers 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, but 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

Readily available components that function well by themselves were linked for the purpose of proof of concept. Utilizing a Modular Mining Systems, Incorporated (MMS) product called Vital Signs, SRL researchers took an AMP acceleration recorder and hardwired it to MMS Dispatch equipment already installed on the 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 utilizes GPS tracking. Through Vital Signs, an analog or digital alarm signal can be recorded. Steve Rhoades, MMS, wrote unique code that links the Vitals Signs data and GPS location and stores these data in an ASCII log file. SRL researchers and Jeff Walden of PDMI worked together to install the equipment in a Caterpillar 793 haulage truck. The result was a successful, working prototype.

Figures 1 and 2 show the instrument installation in the truck.

Figure 1. — View of "buddy seat" where acceleration recorder was installed.

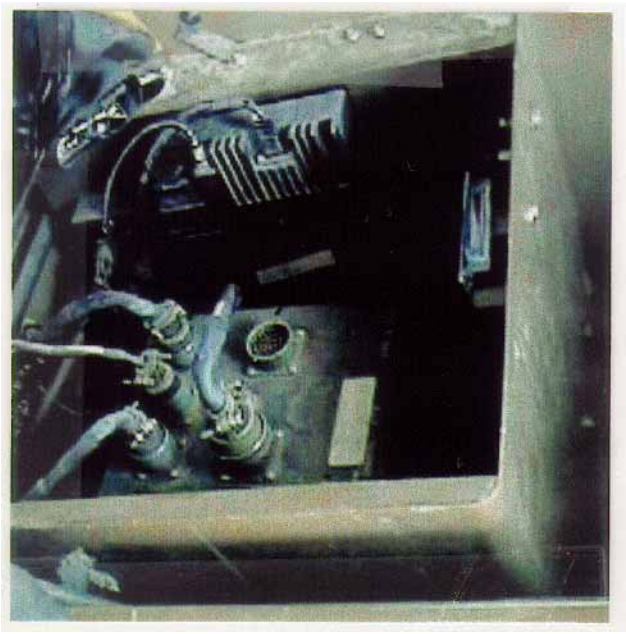

Figure 2.—AMP acceleration recorder in upper right corner

DISCUSSION

From 8:30 p.m. September 14th until 6:50 a.m. September 15th, 899 jolts above a threshold of 2 g were measured on the test truck. As figure 3 illustrates, some sections of the haulage road produced most of the events, while many others produced no jolts at all. As figure 4 illustrates, 2 g is a relatively low threshold for jolts. Because the threshold is low, when plotting the data, the movements of the truck in some sections of 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.

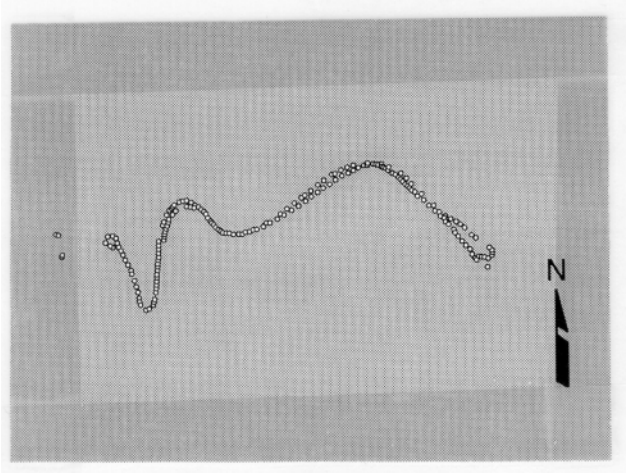

Figure 3. — GPS data points for acceleration events *(Garth Frankel, Spokane Research Laboratory)*

The data have many uses. For example, they 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 and 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 would be safe to assume 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 some high level, beyond what normal operation should produce. Therefore,

produced, it is rare and more attention is paid to finding out what caused it. 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 truck bed

A pertinent question concerns how this data would affect production. Would it cause drivers to slow down or act tentatively? The key here is how the data is managed. Future research will be focused 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. On the hardware side, the AMP shock recorder operates on batteries and has built in data storage. The next generation prototype would be simplified and tap into the truck's system for electricity. It would be an analog triaxial accelerometer connected to a digital component. The digital component would monitor all three axis and send out an alarm signal when a preset threshold is exceeded.

The present specifications of the AMP recorder are given in table 1.

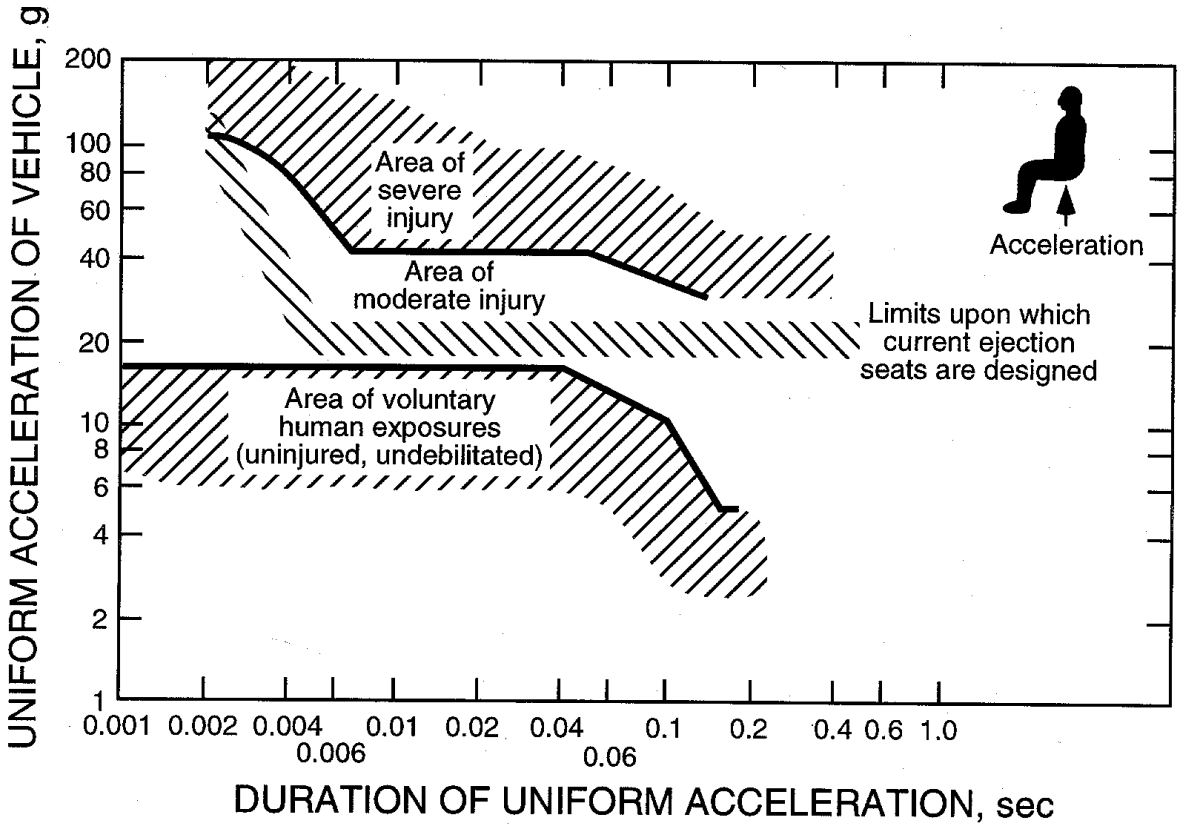

Figure 4. – Effect of uniform acceleration on humans (M. Eiband, NASA Memo 5-10-95E).

Table 1.—Specification for AMP recorders

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

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. Utilizing sophisticated hardware and software allows for monitoring very low level accelerations and results in more functionality. Using plotting software, the person reviewing the data produced can "see" the acceleration of the truck much like an infrared camera can display the thermal signature of a moving object. Utilizing inexpensive hardware and software, severe jolts can be effectively monitored.