Project designed to reduce risk to miners

by Andrew Young, BSc

In Canada, underground mining is kept safe through constant vigilance and intensive training; any accident or fatality is one too many. Mining automation can help increase safety by moving workers away from the worksite.

As a mining engineer you've done everything you can to make the underground workplace as safe as possible and you've trained the workforce to be extremely safety conscious, but you're always looking for more ways to keep your people safe. In the future, new forms of mining automation will help increase safety and reduce risk through additional opportunities to move workers into controlled environments. ELAP, the Emulsion Loading Automation Project, is performing the research needed to learn how to automate the underground loading of explosives and thereby help increase worker safety.

In simple terms, underground mining involves:

- drilling blast holes;
- pumping explosives into these holes;
- inserting primers and detonators;
- blasting the ring;
- mucking out or removing the broken rock;
- repeating this process until the work plan or project is completed.

Automation, in various forms, is being developed for many of these process steps. Tamrock Sweden, for instance, has shown multi-shift unattended operation on their underground drilling equipment and Caterpillar USA, through their Elphinstone division in Australia, is beginning to offer autonomous operation for loading blasted material.

Loading explosives into a ring of production holes is still a manual process, however. Depending on the mining method, blast holes can be up to 150 metres long with more than 20 holes in a ring. An emulsion loader, for this type of operation, will hold up to 4000 kg of explosives.

Ontario has an excellent mining safety record, but accidents can happen. Removing miners from the worksite during the explosives loading process will significantly increase safety.

With drilling and mucking becoming more automated, MacLean Engineering and a number of partners decided to work together to develop automation techniques for loading explosives (see sidebar).

Workers at Brunswick Mining and Smelting manually load explosives into production holes, using a Maclean emulsion loader. Maclean and several partners are working on a project to automate this dangerous process.

The ELAP Project

An emulsion loader is a vehicle that can be driven from a service bay to the worksite. The vehicle holds an emulsion tank, a hose reel with enough hose to reach the end of a blast hole, a sophisticated pumping system capable of changing the density of the emulsion as it is being placed in the hole, a local operator control console, and as a number of other computer and support systems including fire suppression.

Removing people from the explosive loading worksite can be achieved by moving the operator's control console down the drift or mine tunnel once the vehicle is in place or by allowing the emulsion loader to be controlled by an operator on the surface. Another possibility is to develop an intelligent system capable of acting like a human operator and autonomously controlling the emulsion loading process. In ELAP, all three control methods will be developed and implemented.

The remote, line-of-sight or around-the-corner control console will have all the capabilities of the on-board local console. This remote console will use in-air 802.11, an ethernet standard. Ethernet communications provide full motion video, and will allow operators to find and load all blast holes. The emulsion loader vehicle will still need to be driven to the worksite but the operator will be able to immediately move to a safe location to control the emulsion loading process. Both MacLean and AMS have technology that can be adapted for this remote terminal.

AMS has implemented surface-based teleoperation control of load-haul-dump (LHD) units for removing muck. This type of technology has been demonstrated in a number of Inco mines and is now being used extensively at the Kali and Salz mines in Germany. For an LHD, the teleoperator console has all the capability of an on-board operator's control console. In the ELAP application, this technology will be modified to allow the teleoperator to tram the emulsion loader from the underground service bay to the worksite as well as to control the emulsion loading process. Using this technology, the operator would not need to visit the worksite at all and would, therefore, be completely safe.

The third possibility, an intelligent autonomous emulsion loader, offers the opportunity of increasing safety for the underground remote operator, as well as improving the overall efficiency and productivity of both the remote operator and the surface-based teleoperator.

Intelligent System

A human operator understands how to load blast holes, what to do if the emulsion hose gets stuck, the best retraction rate for the hose under specific conditions, when to start and stop pumping emulsion, how to move the hose efficiently from hole to hole, etc. The human is an expert in the complete emulsion loading process but sometimes needs assistance and asks another miner to help complete the task. The ELAP intelligent system being designed by C-CORE, called the Loading Process Supervisor (LPS), will act like a human operator even to the extent of calling for help when it encounters an unknown situation.

The LPS developers have built up a complete diagram of the emulsion loading process and are now converting the diagram into Java. Just as a human operator does, the LPS will be able to "look for" and "see" blast holes by using the robotic boom developed by ISE and MacLean and a vision system developed by Orica and C-CORE. The LPS will then determine if the holes are in the right place using an as-drilled map and test the holes for correct length by inserting the emulsion hose. Once the blast holes have been located and the length verified, the LPS will control the Orica emulsion pumping system to fill the holes with emulsion. The LPS will repeat the hole-filling process until all the holes in the ring are filled.

There is no question that ELAP is an extremely ambitious collaborative research project. Modifying existing technology to create the remote and teleoperator consoles is not trivial, but the LPS is an intelligent system that has never been produced before. Mining, however, is an extremely harsh environment and testing new systems under "real" conditions is absolutely critical. ELAP will not be an exception to this rule. After system integration is completed in September 2002, ELAP will be tested at Inco's 175 Research Mine and, if these tests are successful, there is a possibility that ELAP could be tested in a production mine.

Even though the remote operator is protected by operating the emulsion loader at a distance, using the LPS to automatically load emulsion into a production ring will significantly decrease the need for the operator to go back or check out a hole that needs to be filled. In addition, for both the remote and teleoperator, since there is an automatic system filling the holes, they can increase mining productivity by doing other tasks related to the job at hand.

There is no question that, through the use of intelligent systems and the adaptation of some existing technologies, ELAP has the potential to significantly increase safety for underground workers loading explosives.

However, the Loading Process Supervisor is an intelligent piece of software on a computer system acting like a human operator. The ELAP team will need to do a control HazOp review on the LPS to ensure that it will not be able to harm the workers it is intended to help and protect.

ELAP: a collaborative process

ELAP is a collaborative project managed under the auspices of Precarn, an Ottawa-based, not-for-profit R&D industrial consortium that funds collaborative projects in intelligent systems. None of the project participants could accomplish the project outcomes by themselves. Each has strengths and capabilities essential to the success of the project:

- Automated Mining Systems (AMS) of Aurora, Ont., supplies products and services for teleoperation and control of underground infrastructure control systems and mobile equipment.
- C-CORE, St John's, Nfld., is an applied research and development organization with a strong focus on intelligent systems for harsh environments and resource industries.
- DYI Technologies, Ottawa, manages high-tech automation projects.
- International Submarine Engineering (ISE) is a Vancouver, BC-based company that develops and implements harsh environment robotics for underwater, surface and space applications.
- Inco Limited of Sudbury, is one of the world's premier mining and metals companies and the world's second largest producer of nickel.
- MacLean Engineering of Collingwood, Ont., supplies advanced technology, equipment and solutions to the mining industry around the world.
- Orica a global Australian company is a leading supplier of commercial explosives, blasting technology and related services.

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