Proximity detection

Dr-Ing. Andree Röttig and Cristian Ramírez, Modular Mining Systems, US,

introduce a proximity warning system designed to prevent accidents between shovels and dozers.

When a shovel swings and a dozer takes a hit it may seem an impossible scenario. However, there may well be a good safety procedure already in place. But this exact scenario happens more often than one would think. Operators are human and unfortunately, humans are not perfect. They can become distracted or lose concentration for a variety of valid reasons. In the light of this, Modular Mining Systems Inc. was asked by a mine in South America to develop a proximity warning system. This article presents the circumstances surrounding the accident scenarios, the implemented solution and the achieved results.

The scenario

In this particular mine, shovels are the central piece of equipment for the mining operation. Wheel and track dozers act as auxiliary equipment that cleans the access to the shovel for trucks, or more importantly in this case, removes material that has fallen off the face. The normal procedure is for the dozer operator to announce by radio to the shovel operator that he or she will be working in the same area. The shovel then has two options: to stop work completely or to load only from one side. As noted, humans are not perfect. Dozer operators can forget to announce their presence and shovel operators can forget that a dozer is working within its swing radius. On several separate instances, near the end of the shift, when operators were tired, a dozer was rammed. Luckily there were no severe consequences. For good reasons the mine decided to mitigate this situation and look for a solution that would lower the probability of these accidents occuring.

The basic idea was to use existing technology to automate the announcement procedure and give constant feedback of the operational situation around each piece of equipment.

Existing technology onsite

Mine management systems in use at the site include Modular's Dispatch® and ProVision® systems. The communication architecture consists of an 802.11 wireless network technology product, also from Modular, known as the MasterLink® system. This system allows 802.11 standard compatible devices to communicate via a wireless network and provides a reliable high speed data backbone across the entire mining operation. Full coverage is achieved even in very difficult areas by strategic deployment of access points (APs) and the system's self-configuring heuristic, which incorporates alternative routing paths between APs to maintain optimal coverage. A big advantage for this site is that with the MasterLink network, shovels can also act as APs. Full and reliable coverage plays a vital role in the implementation of any proximity detection subsystem.

The system plays a key role in managing the mining fleet by providing supervisors and management with real-time awareness of the location of all equipment. The position determination for the mine equipment is provided by standard precision GPS, while selected equipment systems are equipped with high-precision GPS. This high-precision GPS information is used for machine guidance applications. Shovels are enabled for selective digging and elevation control. Dozers and graders are guided to work towards or maintain a certain design surface. Drills with these applications navigate to designed holes and calculate hole depth on the fly. Moreover, they provide feedback on the actual drilled holes for further use in the blast management process. This suite of machine guidance systems is called the ProVision system.

Unfortunately, these systems were limited in their ability to display other equipment on the graphics console (GC) due to the lack of topical position data for the mobile equipment. Position data is stored on the central computer, but in order to be meaningful for a proximity warning system, the position exchange

between the equipment must be in real-time.

Taking machine guidance a step further

The mine wanted to replace its existing error prone, manual communication procedure between equipment operators with an automatic system utilising functionality similar to that of a radio based system. The main requirements were as follows:

- Three configurable warning levels each representing the presence of other equipment within a hazardous distance.
- Different warnings and alarms sent to the operator for each system level.
- Display of neighbouring equipment on each of their navigation screens.
- Configurable dispatcher notification of events and logging of all messages.
- Minimal delay for position update of equipment entering shovel work zone.
- No major additional hardware investment.
- No degradation in the performance of the radio communication network.
- Reliability information display on the operator console when the system is not reliable.
- Historical reports of warning and alarm messages.
- Possibility to disable the system on selected equipment.

Taking into consideration the capabilities of the ProVision systems that have already been deployed, basic hardware and software prerequisites were given to avoid additional investments. These were as follows:

- Precise position data in centimetre range.
- Central application to collect position data of all equipment in near real-time.
- Navigation screen for shovels, dozers, and drills (Figure 1).

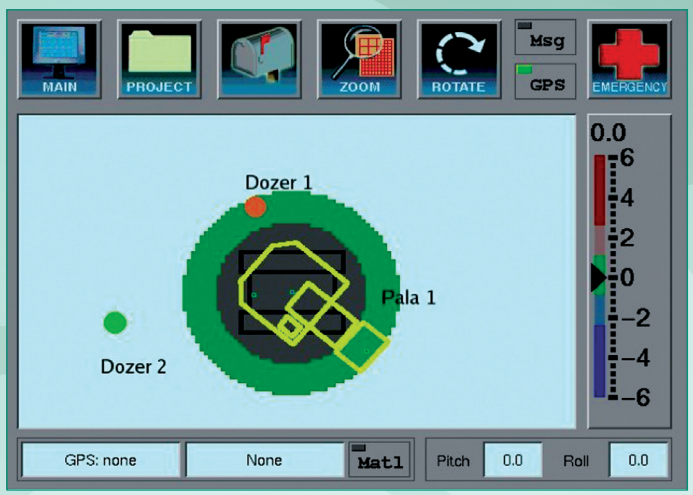

Figure 1. Navigation screen for shovels, dozers, and drills.

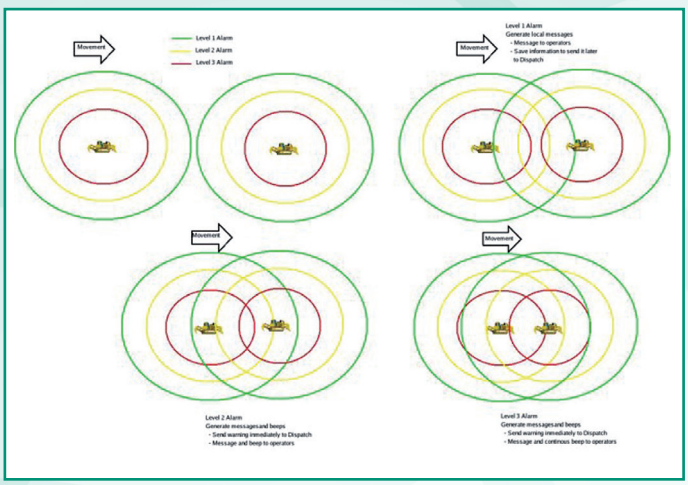

Figure 2. Illustration of how an alarm is triggered for each level.

The exchange of position data involves heavy radio traffic. Therefore, sending position data between each unit of equipment in the mine to continuously inform each operator of the current locations was ruled out. Instead, available information on the central computer was used to form local 'groups' of equipment. Position data is shared within the group, thus reducing considerably the amount of radio traffic. This avoids interference with the main applications that rely on the same communication channel, and moreover, it reduces outages of the proximity detection system. By restricting the radio traffic to a limited area, the proximity detection activity is isolated from the rest of the network.

Once two or more pieces of equipment form a group, individual position data is sent to each member of the group. Each equipment operator can see neighbouring equipment on his or her screen. Equipment entering the work zone is represented by a coloured circle (Figure 1). Each colour indicates a different level of proximity. Figure 2 illustrates how an alarm is triggered for each level. Again, the different colours represent the respective warning levels and correspond to the ones on the operator navigation screen. The actions taken for each level are completely configurable. It is possible to trigger various audible warnings, flash the entire screen, colour parts of the screen, print messages, pop-up a dialogue, send a message to the despatcher or any combination of the above. The warning level actions are managed through the company's 'Dispatch' system. In the case of the mine in question, it was decided that despatchers should receive messages immediately when a level 2 or 3 warning is needed. For a level 1 event, a text message is sent and the screen beeps shortly. A continuous sound warns in level 3 because there is an imminent danger of a collision. On the office side, the application can decide what to do with these warning messages. At the mine, the messages are logged as simple transactions in the following form:

- Equipment 1 reported that equipment 2 entered its zone 2 hazardous area.
- Equipment 2 left the zone 2 hazardous area of equipment 1.

Each operator also receives a similar message from his or her specific point of view. The navigation screen provides the operator with a constant overview. The messages serve only as a reminder and proof that he or she was notified. Moreover, if equipment enters the area with the highest accident probability (zone 3), the despatcher receives an exception screen alarm, which he or she must acknowledge. The previously mentioned server application (that joins equipment to the group) is also responsible for removing equipment from the group. If this happens, the equipment stops and broadcasts its current position to the other members of the group. Additionally, an operator may choose to disable

the warning system on his or her unit. Unlike removing the equipment from the group, in this case, the equipment is still visible to the rest of the group. The operator simply does not receive any further warning messages. A despatcher can reverse this setting from the office. With real-time overview in the office application, the despatcher can monitor the current status of each group (Figure 3). He or she also has limited access to their configuration. For reporting purposes, the system stores the following information in a database:

- Date and time of the warnings (messages).
- Type of message.
- Warning level.
- Warned equipment.
- Warned operator.
- Location name in mine.
- Equipment that caused this message.
- Exact co-ordinates when the event occurred.

The biggest challenge in this project was to ensure fast and reliable position delivery among the equipment within a group. Since Modular has control of communication implementation, it added the necessary functionality to emulate a quasi peer-to-peer data exchange without breaking the standard. If the system detects a position delivery failure, the operator is informed by a light which goes from green to red; indicating that he or she cannot fully rely on the system.

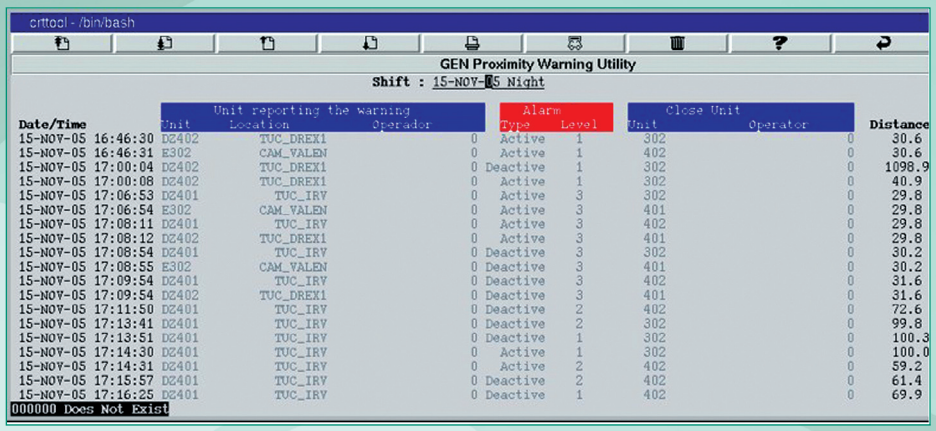

Figure 3. The current status of each group.

The proximity detection configuration takes into account that there is an inevitable delay before the position of the neighbouring equipment is displayed. The increase in the radius depends on the average speed for the dozers involved.

Proximity detection to hazards

In addition to the proximity detection to other equipment, the system can also handle the detection of hazardous objects which are static. These objects, such as power lines, water holes and dangerous areas, must be provided for real-time download by mine planning or other authorised personnel. The system treats these static objects exactly like moving equipment and also transmits messages to the office application. These objects can be areas, lines or circles. Each object is identified by a name that appears in the event reports.

Conclusion

Since the implementation of this system last year, no incidents have been recorded at the South American mine in question. The client is very satisfied with the responsiveness and verified reliability of the proximity detection system. As a major achievement, the safety of the operation improved while awareness of the dangerous environment increased. This improvement was also noted by the mine's internal auditors.

Although special attention must be paid during the configuration in order to avoid annoyances for the operator, the improvement in safety is considerable.