

Improving shovel safety using SAFEmine's situational awareness technology

Marco de Werk^a, Todd Ruff^b

^a Engineering, Aecon Mining, Fort McMurray, Canada

^b Product Development, Hexagon Mining, Tucson, United States

ABSTRACT

Mining operations involve risks that can be controlled through engineering and process control. The human factor however, is extremely difficult to quantify and control. Best practices, proper rest, and a good work/life balance contribute to safer operating conditions, but there is no way of predicting when an employee has had a bad day. Impacts of external stressors that are beyond the control of the employer can be minimized by implementing safety technology such as Hexagon Mining's SAFEmine collision avoidance system. Technology is another layer of protection, but it does not give the desired outcome without proper implementation, business processes, and continuous effort to improve. Aecon has successfully completed a pilot project with the SAFEmine system and has committed to operating a 5500 shovel and supporting dozer with the system. This paper aims to outline the process and results obtained during the pilot project.

KEYWORDS: Collision avoidance; shovel pit safety; equipment safety; safety equipment

1. OBJECTIVE FOR INSTALLING SAFEMINE

Safety first is Aecon's #1 core value and a recent metal-to-metal contact incident has been driving changes to mine pit safety. In a mining operation the pit involves the largest number of variables in generally the smallest physical space. A shovel, dozer, trucks, and light duty vehicles all interact in a congested, but organized fashion. The cleanup dozer is exposed to the highest risk factors in the pit, as it works in close proximity to a large shovel that has numerous blind spots. Operator situational awareness plays a crucial role in pit safety, yet situational awareness is greatly impacted by the operator's state of mind. External stressors that cannot always be controlled or monitored by the employer are impacting pit safety directly. Using technology to enhance the operator's awareness and provide an additional layer of protection can help mitigate many of these risks. There are three main areas of risk that were looked at to be reduced by using a collision avoidance system:

1. Shovel and dozer interaction
2. Shovel and pit feature interaction
3. Light vehicle and shovel interaction

Proper business process controls can help define safe movement of the dozer in relationship to the shovel; however, the human factor can sometimes interfere with the business process. Reduced focus or constant repetition of the same scenario can put the shovel

operator at risk of moving the shovel towards the dozer when business process prohibits this movement. At the same time, the dozer operator can enter the swing radius of the shovel without following the established business process. If both the shovel operator and dozer operator could be made aware when such an event occurs it could prevent a metal-to-metal contact.

The second risk is impact between the mining face and the shovel body. Generally, every precaution is taken to allow for sufficient room, but some situations are challenging due to design constraints or the sinking of a new bench. An experienced operator will be aware of the swing radius, but the mining face might contain ground water or frost that can cause small collapses during regular operating of the shovel. If such collapse occurs during the swing motion of the shovel, it is nearly impossible for the operator to recognize this. A system that can detect objects and alert the operator about the changes in his/her surroundings increases situational awareness, reduces possible contact between equipment and surroundings, and thereby increases pit safety and production.

Light vehicles enter the pit throughout the day for surveying operations, shovel inspections and servicing. Light vehicles can easily be overlooked compared to the size of the equipment around them in a mining operation. The shovel operator controls the pit and the access to the pit, however the shovel operator cannot always see all the traffic that is moving in the pit. If the shovel operator were to

know, at all times, where all light vehicles are that enter the pit, this would help ensure that no light vehicles are in the operating area of the shovel when it starts moving after service, inspection, or a break. The situational awareness gives the shovel operator an additional layer or “last line” of defense.

The SAFEmine configuration selected by Aecon does not require the complete fleet to be outfitted with a SAFEmine system. While the focus was mainly on the three scenarios described above, other vehicles, such as haul trucks, were also detected by the system on the shovel. The radar portion of the system provides information on proximity at which the trucks spot relative to the shovel. Once the shovel swings towards the face, the radar on the near side of the shovel will pick up if the truck is spotted too close. This was a benefit of the system, but it was not part of the scope of the evaluation.

2. SAFEMINE CAS SYSTEM

Hexagon Mining’s SAFEmine Collision Avoidance and Traffic Awareness System (CAS) provides vehicle and equipment operators with information concerning the location of nearby vehicles and provides an audible alarm if an approaching vehicle is on a collision course.

Using GPS, the system determines the location, speed, and heading of the vehicle in which it is installed, and transmits this information to other nearby vehicles, along with vehicle ID, using a vehicle-to-vehicle radio network. Sophisticated algorithms constantly monitor vehicle traffic to determine if a collision is likely. An audible alarm is generated only if two or more vehicles are at high risk of collision, which greatly reduces nuisance alarms.

The system monitors the full 360° around the vehicle and vehicle locations are indicated on an LED display (Figure 1) or on a graphical display called ScopeScreen (Figure 2).



Figure 1: SAFEmine LED display showing vehicle locations and distances (e.g. green LED indicates a vehicle to the left at 100 m, red LEDs indicate vehicles behind and to the right at 50 m).



Figure 2: SAFEmine ScopeScreen showing TopView for nearby traffic information.

The standard SAFEmine system consists of: 1) an antenna unit that houses the GPS, vehicle-to-vehicle radio, and WiFi antennas (Figure 4, top); 2) the main processing unit and receiver (Fig. 4, left); and 3) the remote LED display (Figure 4, right). These are the typical components installed on light vehicles, haul trucks, and other secondary heavy equipment. For the Aecon application, light vehicles and dozers were outfitted with this system.



Figure 4: Hexagon Mining SAFEmine system components.

The system provides two main functions: traffic awareness and collision avoidance. Traffic awareness gives the operator an indication of nearby equipment, but no audible alarms are generated. This information is displayed using the LED display or ScopeScreen and is meant to improve situational awareness (Figure 5). The collision avoidance function provides audible and visual alarms when two or more vehicles are on a collision course. This is determined using Dynamic Safety Zones which extend in the vehicle’s direction of travel and are adjusted according to vehicle size, type, speed, heading, and braking distance. If two vehicles are approaching each other and their Dynamic Zones intersect, then a collision alarm is generated (Figure 6).



Figure 5: Traffic awareness function provides the operator with location and distance to nearby vehicles.



Figure 6: Collision avoidance function provides audible alarms and visual indicators when two vehicles are on a collision course as determined by their Dynamic Safety Zones.

3. CAS FOR SHOVELS

The SAFEmine ShovelCAS system installed on a shovel at Aecon differs from the standard CAS system in a few respects: a second CAS unit, called a Beacon, is installed on the rear of the shovel to provide improved heading information for machines that can rotate around a center point; radar sensors, called TrackingRadar, are installed around the perimeter of the shovel to provide precise location information of nearby equipment in the shovel's body swing radius; and the ScopeScreen is installed to show vehicle location and ID, along with radar alarms for body swing protection.

Other vehicles outfitted with the SAFEmine CAS system components, such as Aecon dozers, are shown on the shovel's ScopeScreen as an icon

representing that vehicle type, along with their ID number. Typically all vehicles in the mine are outfitted with the CAS system so collision avoidance is functional everywhere in the pit. However, Aecon's situation as a contractor is unique in that only Aecon-owned vehicles are outfitted. Other contractor or mine-owned vehicles that do not have SAFEmine installed are still detected by the TrackingRadar system if they enter the body swing radius of the shovel. An audible radar alarm warns the shovel operator of this critical encroachment (Fig. 7). This way all vehicles are protected in the loading area.

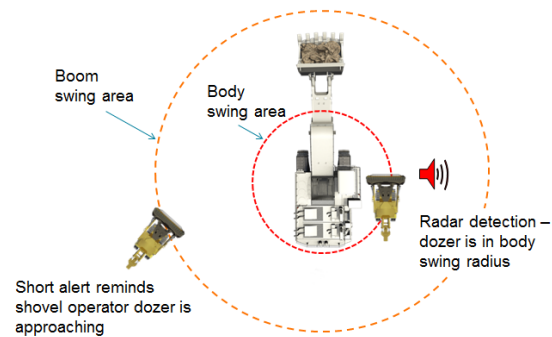


Figure 7: Example of the ShovelCAS functions for detecting a nearby dozer. Shovel operator receives short alert when dozer enters the boom swing area. A full collision alarm is generated in the shovel if the dozer is detected in the body swing radius.

4. EFFECTIVE SYSTEM IMPLEMENTATION

A safety system is a risk mitigation system that will reduce the likelihood of an event occurring. It is important to establish, prior to the project, what is considered "successful mitigation". Without putting a standard in place there is no measure of success.

One of the key elements that has to be recognized with a safety system is that it is only "a system". The operational processes associated with the system are critical to a lasting change in operating safety.

Frequently, technology is seen as an answer to the complete problem, but this is rarely the case. With the SAFEmine system it is important to involve all levels of the organization with the solution and ensure that adequate checks and validations are carried out on a frequent basis. Aecon had to change its operational process by ensuring that all light vehicles that enter the pit on a regular basis were using the mobile SAFEmine units. The radars are inspected daily for damage and any damage is reported immediately to ensure the system can be repaired at the next available opportunity.

A system will only work if the operators are receptive to the solution that is being installed. Operators were made aware of the SAFEmine system prior to installation and its functionality was explained in detail. Providing a transparent and open dialogue about SAFEmine ensured that once the system was installed operators would be willing to give it a fair test. It is human nature to be opposed to change, but Aecon succeeded with open dialogue to have minimal hesitation by the operators to adopt the additional system.

The SAFEmine system installation was planned well in advance, minimizing delays during installation. During a major outage all wiring was pre-routed on the machine reducing the final installation time down to nine hours. Performing the installation in phases effectively eliminated interruption to production. The most important part of the installation is keeping in mind what repairs could be required once the system is activated and how to plan for simple replacements. Installing the radars on poles rather than welded plates for easy access has proven to be a major time saving solution (Figure 8).



Figure 8: Rear mounting locations for TrackingRadar (just below counterweight).

When running the required communication cabling, including connector locations, thought must be given to where the shovel will be disassembled for transportation - this facilitates future moves. Running wiring in locations where it will not need to be touched for regular maintenance, including component replacements, also decreases maintenance delays.

The SAFEmine system was commissioned in a phased process to ensure that operators were adequately trained and alarms were verified. The initial deployment had all alarms silenced and daily downloads were completed to check the frequency of alarms. When radar alarms were excessive, radar parameters were adjusted to bring the alarm frequency down. After two weeks of adjusting and monitoring, all alarms were activated in the shovel

and dozer. At the same time an engineer was on the shovel to coach the operator on the alarms and make any required adjustments. It is critical to ensure that the alarms are meaningful for the operator so that alarms are acknowledged. If the alarms are configured incorrectly, the operator may ignore them and lose interest in the system, resulting in no additional layer of protection.

5. RESULTS AND KEY FINDINGS

The key objective of this project was to create a safer pit operation by providing the shovel and dozer operator with improved situational awareness. The system has been very well received by the operators from the start. The inclusive implementation strategy resulted in minimal negative feedback. Minor adjustments had to be made to the alarm settings to ensure that alarms in both the shovel and the dozer were meaningful and correctly indicated risk.

Since the implementation of the SAFEmine system in January 2015, there have been no metal-to-metal contacts involving the shovel and dozer. No near misses have been reported either and no maintenance has been required on the system. Only semi-annual verification has been done on the system.

The largest impact that has been observed is the change in shovel operator behavior. When truck drivers spot the truck very close to the shovel, they say that it increases production by reducing the amount of boom travel that is required per bucket dumped. But this also increases the risk of contact. In the months post-deployment, the radar system detection range was slowly extended to allow for a safer separation distance (just beyond the counter weight swing radius); however, the observed alarm frequency was reduced. This shows that shovel operators are loading the trucks farther away from the car body to avoid alarms and thereby reducing the risk of accidental contact between the truck and shovel. This change in behavior has had no negative impact on production.

Using the GPS-based portion of the system, the shovel operators can see at all times where the cleanup dozer is located. The additional situational awareness has been described by all shovel operators as “a great tool” and “a must for all pits”.

The SAFEmine system has created a safer work environment for Aecon, however it is absolutely paramount that proper procedures are in place and adhered to. Any safety system adds a layer of protection, but it will not guarantee no metal-to-metal contact.