

CAT® MINESTAR™

ENHANCING SAFETY



WHAT SAFETY CONCERNS
KEEP YOU UP AT NIGHT?



FLEET



TERRAIN



DETECT



HEALTH



COMMAND



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ENHANCING SAFETY

Safety is the top priority at every level in the mining industry because every mine site faces safety concerns and challenges. Ensuring that operators and on-site personnel make it home safely every day is more important than any other facet of an operation. We asked our customers to tell us their biggest safety concerns, and the most common answers were:

- » Collisions and equipment damage
- » Operator fatigue and distraction
- » Hazardous Conditions
- » Operator skills
- » Incident Response

In this paper, we'll look at these concerns and show how Cat® MineStar™ can help alleviate or even eliminate them.

ACCIDENTS HAPPEN



Every mine has to deal with unsafe conditions and situations. We can help mitigate the impact of these situations and reduce their frequency by answering one important question: Why do incidents occur?

Understanding the source of an incident is critical if a site wants to change policies and procedures to prevent it from happening again. Most accidents can be traced back to two causes: Uncertain or unsafe operating conditions and risky operating behaviors.

Surprisingly, only 10 percent of incidents are caused by unsafe conditions. The remaining 90 percent can be traced back to a risky behavior by a machine operator or other on-site personnel. Learning what these behaviors are and how to eliminate them can have a significant, lasting impact on any mine's safety and productivity.

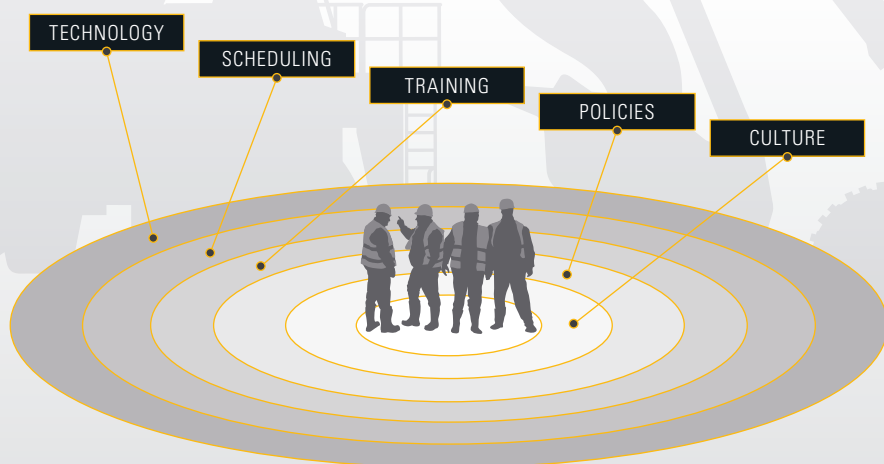
The best way to combat these behaviors is to establish multiple layers of protection. The first layer of protection is formed by a site's culture. A culture that emphasizes safety and policies that enforce it will help keep operators thinking about safety first and foremost.

The second layer solidifies a culture of safety, and that is site policy. Management adherence to safety rules trickles down to every person on site. When everyone on site is accountable for the same rules and is subject to the same punishments when they aren't followed, policy strengthens culture.

The next layer of protection is training. Operators who are fully skilled in the procedures, equipment, and technology they use every day are less likely to cause an incident through inexperience or uncertainty.

Proper scheduling forms another layer of protection. Ensuring that employees are not fatigued and that there is a balance between experienced and inexperienced operators working at any given time can be the difference between a smooth, productive shift and a dangerous or costly incident.

The final layer of defense is technology. Systems like Cat MineStar offer everything from object detection and visibility to remote operation and full autonomy—all of which can increase safety on a mine site. These technologies should be the last line of defense, not the entire safety system of a mine. A culture of safety and a well-trained workforce are the keys to a safe and productive mining operation.



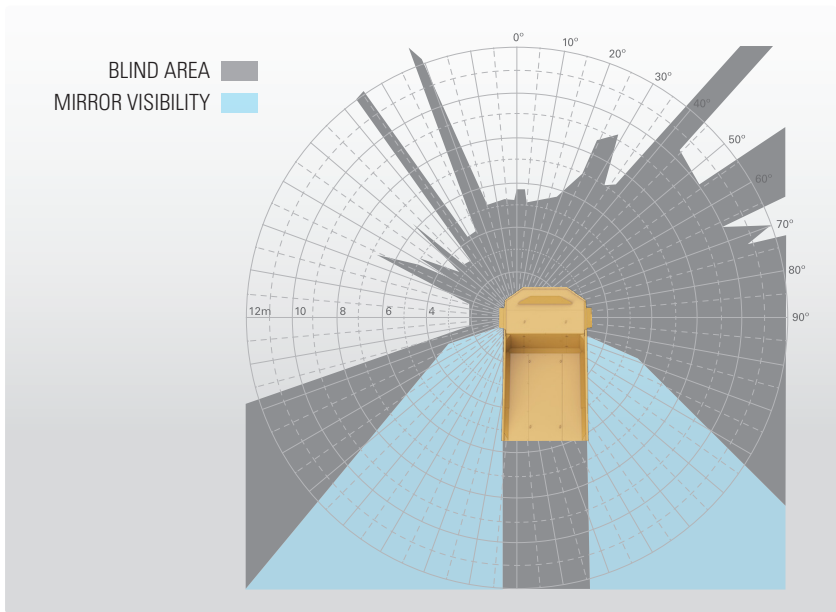
COLLISIONS & EQUIPMENT DAMAGE

REDUCING DOWNTIME & REPAIR COSTS

Operator visibility is a one of the biggest concerns for most mining companies.

Haul truck operators in particular have limited visibility, especially on the right and to the rear. Since they are in constant motion, their lack of visibility can result in collisions if they aren't careful. These cause injuries or even fatalities, as well as unscheduled repair time and lost productivity due to downtime and investigations.

Even the most experienced operators can experience collisions. No one is immune, whether they have two years of experience or twenty.



How can Cat MineStar help?

MineStar offers a number of technologies that can significantly reduce the risk of a collision. Detect features Object Detection, which increases operators' situational awareness at slow speeds and during startup—the highest-risk time for a collision.

Fleet and Proximity Awareness include Position Awareness, which tracks all equipment on site. This gives operators increased awareness of other vehicles even if the operator can't see them.

Terrain allows for the creation and management of avoidance zones—areas where a machine shouldn't operate. Machines entering these zones will warn the operator or even shut down, preventing operation in an unsafe area.

Command has the ability to completely shut down all autonomous vehicles whenever an incident is predicted to occur.

OPERATOR FATIGUE/ DISTRACTION

MAINTAINING FOCUS

In recent years, the United States has seen the number of highway collisions caused by fatigue and distraction surpass the number caused by driving while intoxicated. The instructors of Mine Safety & Health Association (MSHA) classes have long talked about how home and personal behavior carries over on the mine site, and fatigued or distracted driving is no exception. A driver who runs stop signs occasionally or drives through severe fatigue on personal time will likely do the same thing at the wheel of a haul truck.

Fatigue and distraction have become a major concern for mining companies. For years, they have been searching for the invisible threat that was creating incidents with no apparent cause.

Caterpillar's Dr. Dave Edwards began investigating the cause of these incidents. Suspecting that drivers were fatigued or distracted during these events, Dr. Edwards investigated emerging technologies for a solution. He found a technology used for detecting microsleep events in motorists, the Driver Safety System (DSS).

While the company behind DSS was focused on research and application in the automotive field, Dr. Edwards saw potential for its adaptation to the mining industry. As a result, Caterpillar now offers a system that helps its users monitor and even prevent fatigue and distraction related events.

DSS tracks operator's facial and eye movements that characterize fatigue or distraction events. While fatigue is self-explanatory, DSS users have found a surprising number of sources for distraction. Typical distractions include the machine's dashboard, other vehicles or points of interest outside the cab, cell phones, and even books or magazines.

Once an event is detected, DSS can alert the operator by shaking the seat or playing a tone, as well as alerting management that the event occurred. By logging these events, it allows users to actively manage change and train operators, resulting in up to an 80 percent reduction in fatigue and distraction events.

The Impact of Fatigue and Distraction

In 2011, The US Department of Transportation did a study investigating operator effectiveness and the economic impact of rail incidents. Using data gathered by the Federal Railroad Administration between 2003 and 2005, the study analyzed 1,300 reportable incidents, 350 had a human factor root cause.

The study found that people who were operating at 70 percent effectiveness or below had a 62 percent increased accident risk. The economic risk impact of these tired or distracted operators was increased by 400 percent. Conversely, those operators working at 90 percent effectiveness or more saw their accident risk drop by 30 percent, with an accompanying 400 percent decrease in economic risk.

Mining companies have found similar results with their own studies. At a 140-million tonne per year mine in Africa, owners suspected that 60 to 70 percent of the incidents involving their fleet of 72 trucks were caused by or related to fatigue and distraction.

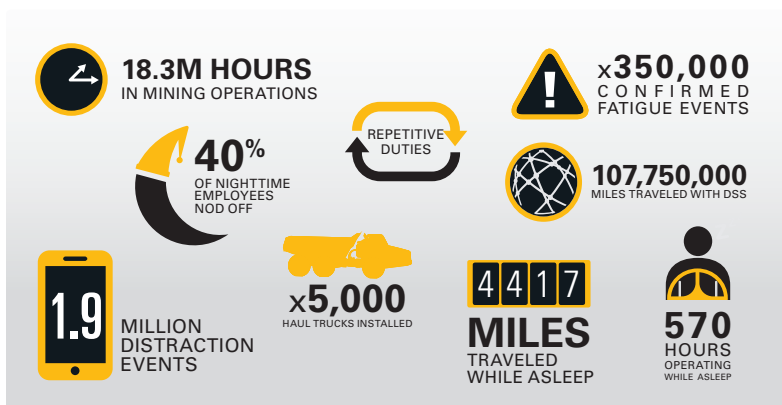
In 2011, the company attributed around US\$ 2.4 million in accident costs to fatigue and distraction. They began rolling out in-cab technologies in 2012 and reduced those costs by US\$ 1.4 million. Full deployment was achieved in 2013, resulting in an additional US\$ 985,000 reduction for an overall reduction of US\$ 2.38 million—90 percent of 2011's costs.

Fatigue and distraction don't just affect operators on-site or at the wheel of their haul trucks, either. A recent story in the Australia Mining Journal covered an operator who sued a mine for an injury sustained due to fatigue off-site. The operator was forced out of lodging at the mine site after only a partial night of sleep and was, subsequently, injured on the way home.

The human brain can't run all the time. It needs rest. People with a level of effectiveness below 70 percent react and behave the same way as someone with a Blood Alcohol Content of .08 percent—legally drunk by the standards of the United States. If an operator came in to work drunk, he or she would be sent home. On the other hand, an operator who shows up to work tired is encouraged to “power through” and get to work.

Driver Safety System by the Numbers

The Driver Safety System is currently installed on 5,000 trucks. It has logged 18.3 million hours of mining operations and nearly 108 million miles traveled. Over that time, it has also logged 350,000 fatigue events and 1.9 million distraction events. It has noted that 40 percent of nighttime employees nod off at least once, for a total of 4,417 miles and 570 hours of travel asleep at the wheel.



According to a mine manager in Australia that makes use of the DSS, “Effectively controlling fatigue and distraction forms the biggest single opportunity to reduce serious incidents, injuries and fatalities in mobile fleets at our sites.”

Tim Cuestas, Director of Health and Safety at Freeport McMoRan, said, “We’ve gone from 100 per shift to less than a dozen. I would bet we are saving money by reducing fatigue-related incidents—like wear on tires from hitting berms and rocks.”

How can Cat MineStar help?

Obviously, the Driver Safety System is the biggest way Cat MineStar can help manage fatigue and distraction, but there are other technology solutions that can help.

Fleet can help with crew management and scheduling, helping a mine better plan its shifts to keep fatigued operators off the road.

Through the use of avoidance zones, Terrain and Proximity Awareness can help prevent operators from traveling off the road or into unsafe areas while fatigued or distracted.

HAZARDOUS CONDITIONS

KEEPING OPERATORS OUT OF HARM'S WAY

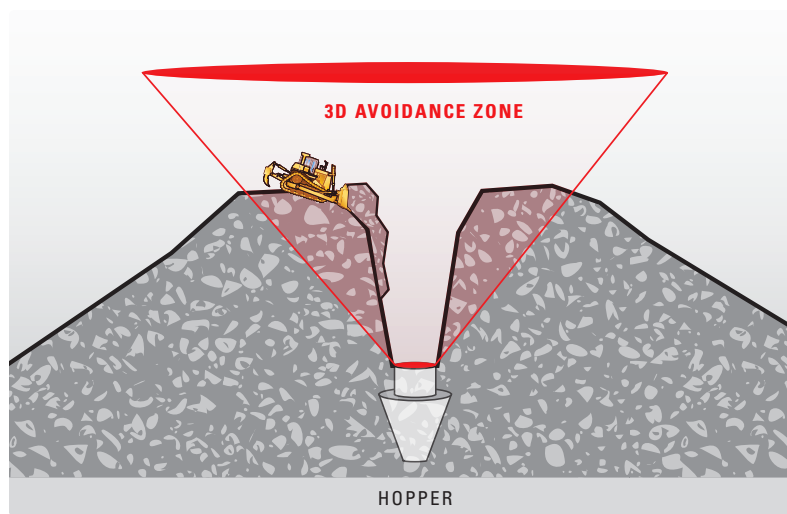
Hazardous conditions—unstable terrain, slides, and excessive dust and noise—exist on even the safest mine sites. Stockpiles, where dozers are pushing material into a crusher or hopper, have their own unique hazards.

When a dozer is pushing material into the hopper, operators can get too close and cause the dozer to fall in. This can lead to operator injury and damage to both the hopper and the machine—shutting down the mine until the operator and machine can be retrieved and a safety investigation can be carried out.

Terrain creates 3D avoidance zones. Mining engineers can place a cone-shaped avoidance zone around a hazardous areas, like a hopper. As a dozer operator is pushing material, if they get too close to an avoidance cone, the onboard system will alert him. If he enters the cone area, the system will alert him a second time.

At this point, there are two things that could happen. The operator can choose to ignore the warnings from the system or they may need to enter the avoidance zone to complete the task. If the material piles up, they have to break it loose somehow, so they'll go into that hazardous

zone anyway. If the material breaks free during the push, the dozer and operator could fall into the hopper.



What if the operator wasn't on the dozer? Using remote control technology, an operator can run the dozer out of harm's way. Even if the material piles up, they can safely operate the machine into the hazardous area to break it loose. In case the dozer actually does fall in, then the mine may only shut down for as long as it takes to get the dozer out. Nobody is going to get hurt, and they can avoid a safety investigation that can shut a mine down for days.

How can Cat MineStar help?

In addition to the safety measures provided by Terrain and Command, Proximity Awareness, a Detect capability, can give operators the increased awareness they need to avoid hazardous areas and risky behavior.

Fleet can further increase an operator's positional awareness by tracking nearby equipment.

OPERATOR SKILLS

TRAINING & EXPERIENCE

A skilled operator is less likely to have an incident. Training can be the difference between an inexperienced workforce and one with the experience and confidence to avoid incidents.

For an example of the impact training can have on operator safety, we turn to Kiewit's Buckskin Mine in the United States.

Kiewit established a goal to improve operational safety, efficiency and productivity through operator training in accident avoidance, project discipline, site safety procedures and situational awareness.

"Since implementation of MineStar and targeted training with the Immersive Technologies simulator in late summer of 2011, we have realized a **15%** improvement of **shovel productivity**, a **21%** improvement in **truck payloads** resulting in a **5%** improvement in **operating cost**. Also **operator induced errors** have been reduced by **97%** resulting in annual equipment maintenance **savings of over a million dollars.**"

—Stephen Mullaney, Area Manager, Kiewit Mining Group

After a month, Kiewit saw their operators' starting to return to their old habits. The company then implemented rules and procedures to monitor training and application of these techniques, and were able to correct this relapse and continue improving safety.

"MineStar does more than reduce inefficiencies, it provides awareness and ensures individual operator accountability."

—George Leupold, MineStar Manager, Kiewit Mining Group

How can Cat MineStar help?

While operator skill will always come down to each individual employee, MineStar can help manage efforts to improve it.

Fleet ensures all operators have the proper training and licensing for their machines.

Terrain helps deliver consistent results and provides feedback to help operators improve.

Detect reduces unsafe practices and behaviors by increasing awareness.

As Kiewit found, Immersive simulators can provide realistic operator training with no risk to an actual machine.

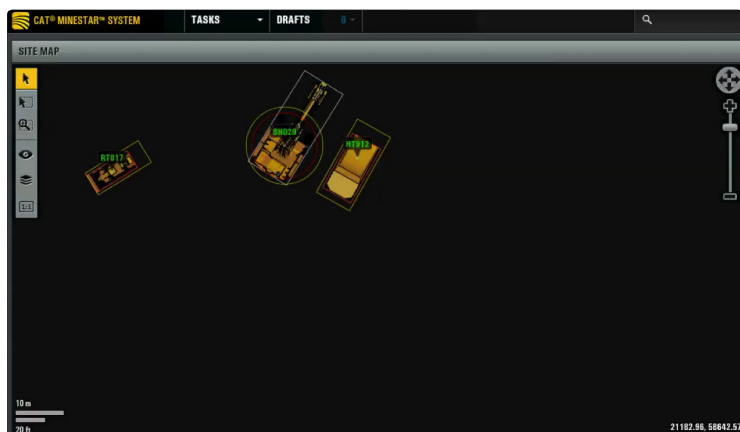
INCIDENT RESPONSE

PLANNING FOR UNPLANNED OCCURRENCES

Preventing incidents will always be a top priority for mine sites, but no operation can remove them entirely. It's important to be ready to deal with incidents when they do occur.

Technology can track equipment and personnel so that operations can respond quickly and effectively to any incidents. MineStar provides open lines of communication—even when radio lines are down or unreliable—through the Mayday functionality available on all capability sets. Detect also offers incident playback with Proximity Awareness.

Playback allows management to review the incident and assess the situation to determine whether any changes need to be made to policy or equipment.



How can Cat MineStar help?

All MineStar capability sets offer the Mayday functionality that can be critical when responding to an incident.

Detect offers incident playback to support incident investigations.

Fleet can provide machine and personnel locations to establish an even clearer picture of an incident.



ENHANCING SAFETY WITH CAT MINESTAR

No matter what you mine, where you mine or how you mine, the safety of the people working on-site is your top priority. Caterpillar and Cat dealers share that priority, and we're committed to keeping your operation running safely and productively.

Every operation faces risks—collisions, fatigue, distraction, hazardous conditions and lack of operator skill, to name a few. Some of these risks can be fought with policy and culture changes or increased operator training. As a first line of defense, the Cat MineStar suite of capabilities can mitigate or even remove some of these risks.

Terrain can monitor and provide feedback on operator performance, allowing you to track patterns of unsafe behavior and correct them through training or crew changes. It also allows you to create avoidance zones that warn operators when they enter unsafe areas.

Fleet provides position information on every piece of equipment on-site, giving operators enhanced situational awareness.

Detect increases operator visibility and awareness, significantly reducing the risk of a collision during startup and slow-speed operations.

Command eliminates the need for an operator to enter the machine at all, removing the risk of injury when operating in unsteady or unsafe conditions.

We combine these state-of-the-art technology offerings with Caterpillar and Cat dealer expertise, and implement them along with services like site assessments, change management and training initiatives, continuous improvement projects, and more. This combination of technology and support makes it possible for you to make the improvements you need to bring everyone home safe every day.

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The industry's broadest suite of integrated mine operations and mobile equipment management technologies configurable to suit your needs. It lets you integrate products, processes and people like never before, meeting the needs of mining operations of any size, type or complexity.

BUILT FOR IT.™

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