CAT® MINESTAR™

CONTROLLING COSTS

WHAT'S DRIVING INCREASING COSTS IN YOUR MINING OPERATION?

FLEET

TERRAIN

DETECT

HEALTH

COMMAND

CAT®

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Mining is an expensive business. The costs of equipment, fuel, payroll and maintenance add up quickly, and every dime spent detracts from the mine's profits. You want to get the most out of your mining operation, so it's in your best interest to make sure all aspects of your operation are performing as cost-effectively as possible.

Caterpillar understands this challenge, and we have the expertise and technology to help you meet it. We asked our customers to identify their biggest sources of increased costs, and many of them gave us the same five answers: process variability, unscheduled repairs, fuel costs, collisions and shift change.

In this paper, we've gathered brief explanations of each of these challenges and offered our advice on how you can measure and respond to them. In addition, we've included information on how Cat® technologies can help you get the lowest possible cost per ton from your mining operation.

PROCESS VARIABILITY

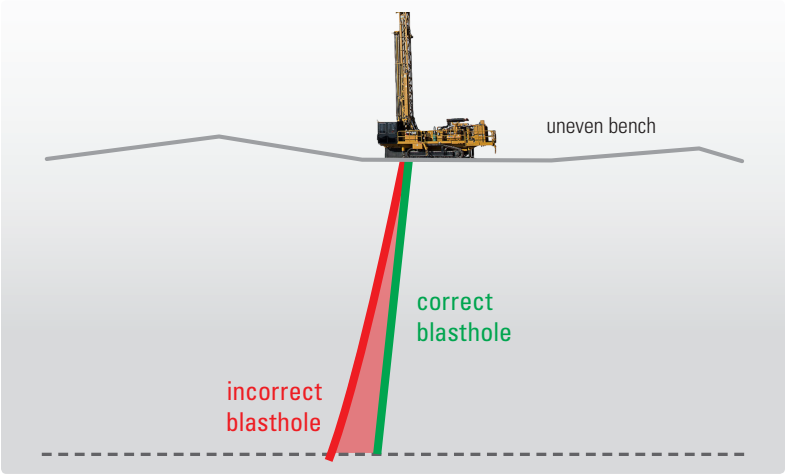
IMPROVING EFFICIENCY THROUGH CONSISTENCY

Process variability can be a big contributor to costs, but it's a difficult topic to quantify. Variability can be present in almost every area of your operation. Instead of trying to come up with an all-encompassing definition for process variability, it's easier to examine your operation's processes one by one and determine where unpredictable results are increasing your costs.

Operator Performance—This is one of the most common examples of process variability. Obviously, not all operators are equal in every way. You will always have operators who are tired from a restless night or distracted by other matters during their shifts, as well as some who consistently outperform their peers.

Inconsistent Cycle Times—Cycle times are affected by the performance of both loaders and trucks. Loading tool cycle times may be inconsistent, resulting in inefficient loading that negatively impacts the entire fleet. Trucks may be traveling at suboptimal speeds or taking longer routes than necessary, which also increases cycle times—thereby increasing fuel costs, wear and tear, and overall cost per ton.

Drilling Variability—One of the easiest places to measure the impact of process variability is in drilling. Incorrect hole placement and depth can have a negative impact on costs throughout the entire value chain. Improper pattern spacing creates significant waste of both drill consumables and explosives, and can even create a need to re-drill holes entirely. Poorly blasted material is difficult to load and haul efficiently, increasing costs in this phase of the operation, and it can also reduce the mine's total throughput if rock must be broken up before it can be placed in the crusher.



Overdrilling & Underdrilling—Drilling holes to an improper depth can also contribute to high costs. If holes are too shallow, blasting may leave behind unexploded rock, which can create challenging digging conditions, cause damage to loading tools, and increase truck loading time. Uneven floor conditions can cause pitching, racking and rolling that damages the truck's frame and tires. Even auxiliary equipment experiences increased wear, because it is much more difficult to maintain grade on an improperly blasted bench.

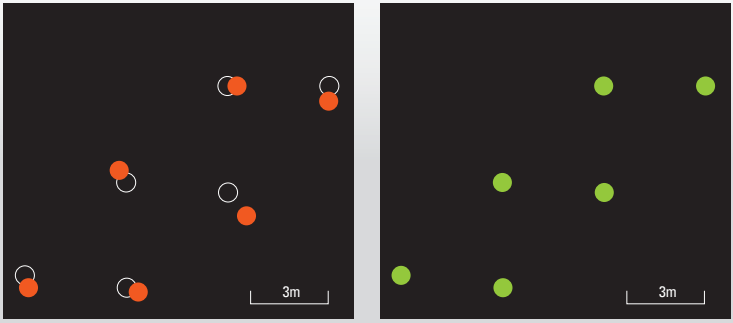
Overdrilled holes can add costs to drill consumables and maintenance, as well as contribute to lost productivity. They can also cause you to overuse explosives, which further increases costs. And just like an underdrilled hole, an overdrilled hole makes for more work when it comes to maintaining grade on the bench.

Reducing costs by improving drill accuracy

At a gold mine in Brazil, a Caterpillar customer decided to use Cat® MineStar™ Terrain for drilling to reduce process variability in its drilling operations. The result was a dramatic reduction in costs—not just in drilling, but throughout the operation.

After using Terrain for drilling for one complete drill and blast operation, the mine found that it had been overdrilling holes by an average of 1.0 meter (3.2 feet). With Terrain for drilling, the margin of error dropped to under 10 centimeters (4 inches), reducing total drilling time by 6 percent over the course of a year—a savings of more than 1,200 hours. This also resulted in more efficient use of drill consumables and explosives for a cost reduction of $200,000 USD.

The mine also improved its pattern spacing, increasing the accuracy of hole spacing and placement and resulting in more homogeneous blasted material. This translated into a 5 percent increase in rope shovel productivity, as well as reduced maintenance time and a 450-hour reduction in total excavation time. All this combined to save the customer an additional $250,000 USD.



WITHOUT TERRAIN WITH TERRAIN

Increased drilling and blasting accuracy also improved hauling cycle times, reduced planned truck maintenance times, and had a marked impact on load consistency and cycle times. Overall, equipping just four drills with Terrain for drilling saved the customer more than $2.2 million USD annually.

How can Cat MineStar help?

The Brazilian gold mine is a powerful example of how Cat MineStar can reduce process variability and costs, but Terrain for drilling is not the only capability set that can do so. Fleet can manage material movement and contribute to consistent productivity across your entire equipment fleet. Terrain for loading can manage payloads and timing, ensuring consistent, productive performance and increased efficiency. And Command, our automation capability, can deliver the most predictable, repeatable operations of all by removing the human element entirely.

UNSCHEDULED REPAIRS

INCREASING MACHINE AVAILABILITY

Maintenance and repair are a necessary part of every mining operation, and both activities result in machine downtime. But while a good, proactive maintenance strategy can keep equipment running cost-effectively, unscheduled repairs can quickly develop into significant costs and greatly impact the efficiency of operations.

There are a multitude of causes for unscheduled repairs, including:

- Failure to execute a planned maintenance strategy. Even the best of plans will fail if it is not consistently executed.
- Poor maintenance practices, including the failure to monitor the condition of components, which can allow minor problems to escalate into major ones
- Poor haul road or dump area conditions, which can cause damage not only to tires but to machines as well
- Operator abuse

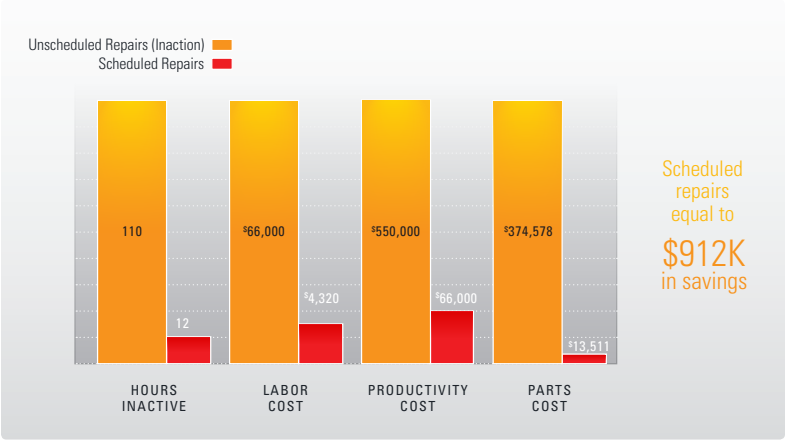
Whatever the cause, unplanned machine downtime has significant costs attached. For starters, the lost production time during an unplanned maintenance event is considerably higher than a planned procedure. It can also cost more if you factor in rush part orders and overtime paid to technicians just to make sure all the parts and people are on hand to solve the problem. Other costs include towing damaged machines, paying operators who no longer have machines to run, and contamination control activities and additional safety measures that are required during the repair.

Reducing costs by preventing failures

To illustrate how significant the difference between planned and unplanned repairs can be, we reference a Caterpillar customer mine in Chile. Using Cat Equipment Care Advisor (Cat ECA), a tool in the MineStar Health capability, Cat dealer Condition Monitoring personnel detected a potential high-pressure pump issue in a 795F mining truck. The team alerted the on-site dealer maintenance crew, which addressed the potential issue before a failure occurred—all within a single shift.

Even though the machine was down for only 12 hours, the issue amounted to $60,000 USD in lost productivity. The part itself cost less than $10,000 USD, and the labor to make the repair cost less than $5,000 USD. All told, this one issue cost the mine about $75,000 USD.

However, the customer validated that early detection of the issue saved them nearly $1 million USD by preventing the part failure. If the part had failed during production, the impact would have felt in a number of ways. Fuel would have become contaminated, and over time, the broken pieces of the pump would have shattered and affected other systems, resulting in a total engine failure. The dealer calculated 110 hours of downtime would have been necessary to make that repair, with around $550,000 USD in lost productivity. Add that to $375,000 USD for parts and more than $65,000 USD in labor, and the mine would've lost $990,000 USD. These costs were avoided thanks to the diligence of the condition monitoring staff and the protection provided by Cat ECA.



How can Cat MineStar help?

We've illustrated how Cat MineStar Health and its Cat ECA web-based tool can help reduce the cost of unplanned repairs. Additionally, Health provides continuous updates and monitoring, allowing you to better track your equipment's status and plan preventive maintenance procedures. Terrain monitors and manages operator performance, preventing excess wear caused by unsafe or damaging operation, and Fleet optimizes equipment usage for reduced wear and tear.

FUEL MANAGEMENT

MAXIMIZING MATERIAL MOVED PER LITER

At almost every mine in the world, the biggest annual costs aren't the result of damage to machines or the impact of inefficient operations. For most mines, the biggest cost is also one that seems unavoidable: fuel. Without fuel, nothing can happen. However, there are significant savings to be found by making sure all your machines are getting the most productivity out of every liter of fuel they consume.

Costs that can be tied to fuel go beyond its actual purchase. For example, rehandling material unnecessarily burns fuel without contributing to overall production. Fueling equipment too often results in excess downtime. Even the design of the mine itself can contribute: If trucks are taking a longer route than necessary, every cycle is burning that much extra fuel. The ultimate goal of every mine should be to move as many tons as possible with every liter of fuel burned.

Reducing costs by optimizing machine usage

An iron ore mine in Australia collaborated with a Cat dealer to find a way to decrease mean time between fueling. Initially, the mine's trucks

averaged just over 13 hours between fuelings, which meant the trucks were fueled at the beginning of or during every single shift. The dealer provided the change management and training necessary to implement the fueling module within Fleet, which helped the mine optimize equipment utilization and increase mean time between fueling. By the end of the implementation, the mine's average time between fueling was almost 22 hours—a number that has continued to increase. All told, Fleet helped the mine produce over **1 million** more tons per year using the *same* number of trucks.

At another iron ore mine in South Africa, Cat dealer Barloworld helped a customer address concerns about fuel costs and a need to bring the mine in line with strict emissions standards. Working with Caterpillar experts, Barloworld examined the mine and came up with a solution.

Since the pit is relatively shallow and the mine's 795F AC trucks travel well below their maximum speed, they were not making efficient use of their engines' horsepower. With this in mind, Caterpillar and Barloworld installed software that decreased the engine's horsepower, reducing fuel usage and emissions accordingly. This small change improved the mine's liters per ton ratio by almost 9 percent. The liters used per hour by each truck were reduced by 18.9 liters (5 gallons), saving the mine 2.35 million liters (621,000 gallons) over 36 months. It also reduced annual carbon emissions by nearly 1.7 million kilograms (3.7 million pounds), allowing the mine to claim a tax credit that further reduced operating costs. All of this was accomplished without any noticeable impact on fleet cycle times.

How can Cat MineStar help?

In addition to the haul truck fuel savings available through Fleet, MineStar can be leveraged to help reduce fuel usage—and costs—for a number of machines. Terrain manages and measures utilization and practices for draglines, loading tools, grading equipment and drills, ensuring that your machines are operating as efficiently as possible. In addition, Health can provide fuel usage reporting that lets you track and assess your fuel efficiency.

COLLISIONS

REDUCING DOWNTIME & REPAIR COSTS

Vehicle collisions are an unfortunate part of any mining operation. Whether a machine is striking rocks or berms or colliding with other machines, a collision is both a safety risk and a significant cost driver. Collisions result in unscheduled repairs and machine downtime, which we have already identified as large costs. In addition, collisions require administrative time and have strict reporting requirements, especially if the collision necessitates an investigation that might keep machines—or even whole sites—down for long periods of time.

Most collisions involve haul trucks moving at slow speeds or even at startup—specifically at the beginning of shifts, immediately after fueling and when leaving the loading area. Most of these collisions can be attributed to a lack of visibility. These machines have large areas where the operator cannot see or can only see using mirrors. A single operator can't watch in every direction at once—but Cat Object Detection can help.

"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."

Tim Cuestas, Director of Health & Safety, Freeport-McMoRan

Reducing costs while improving safety

Object Detection is an effective combination of cameras and radar systems that can look in all blind spots simultaneously. It gives the operator greater visibility, and can even provide alerts when objects are within risk areas. This translates into improved safety for everyone working in and around your haul trucks, as well as reducing the costs associated with collisions.

Operator fatigue and distraction are two major causes of collisions. Tired and distracted operators do not pay full attention to the road, and they can easily lose track of their position and run into objects or other machines. The Driver Safety System (DSS) can help manage these risks. The DSS uses a dash-mounted camera that tracks the movement of an operator's head and eyes and provides a warning both in the cab and to the mine's management when a fatigue or distraction event occurs. This keeps operators focused and allows higher-level personnel to establish processes to reduce fatigue and distraction.

How can Cat MineStar help?

Object Detection and the Driver Safety System (DSS) are just two of the Cat technologies that can reduce the risk of collisions. Detect increases operator visibility for a number of machines. Fleet can increase operator awareness of other machines by providing real-time position updates. Terrain also tracks a machine's position, and allows the creation of Avoidance Zones to prevent machines from traveling into unsafe areas. And with Command, any machine entering one of these Avoidance Zones is automatically shut down, completely removing the risk of any machine operating in the area.

These systems all help manage costs, but they also create a culture of safety—a top priority of every mine.

SHIFT CHANGES

OPTIMIZING SHIFT MANAGEMENT

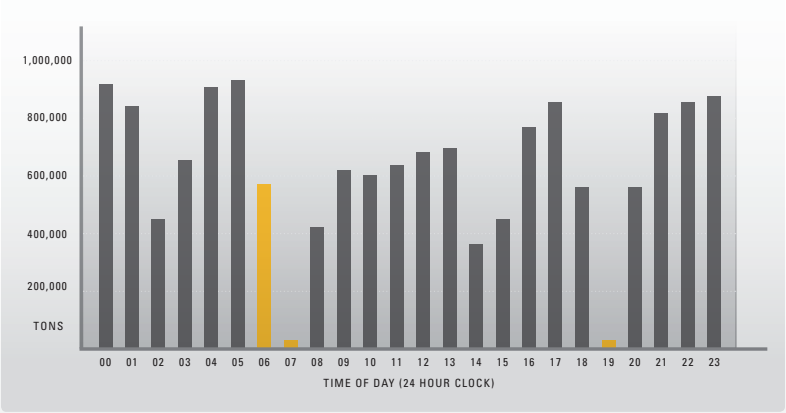
Shift change may be the most predictable delays in your operation, but that doesn't mean they can't be better managed to reduce their effect on your operating costs. Inefficient shift changes leave machines sitting idle while operators change, significantly reducing productivity during the first and last hour of every shift. One metric used to measure the efficiency of your shift change process is first- and last-hour tons.

There are a few variables that can negatively impact your shift change efficiency, such as tie-down locations that require trucks to travel long distances at the end of their shifts and unnecessarily long personnel routes that keep operators out of the cab longer. Having all trucks park in a single location also results in poor spacing during the first few hauls of the shift. This leads to shovel hangtime and inefficient loading, increasing costs. Forcing trucks to park while empty can also reduce efficiency, as trucks may not be able to carry another full load during their shift.

Solutions to these situations are not complicated. For example, allowing all machines to tie down near their current location maintains appropriate spacing, and a single vehicle can carry crew to each truck instead of having all trucks carry their operators to a single tie-down point. Allowing trucks to stop where they are regardless of their load makes shift changes faster and more efficient. Pre-shift safety inspections can be moved to fueling times, when you know that machines are empty and immobile, unless local regulations prohibit it.

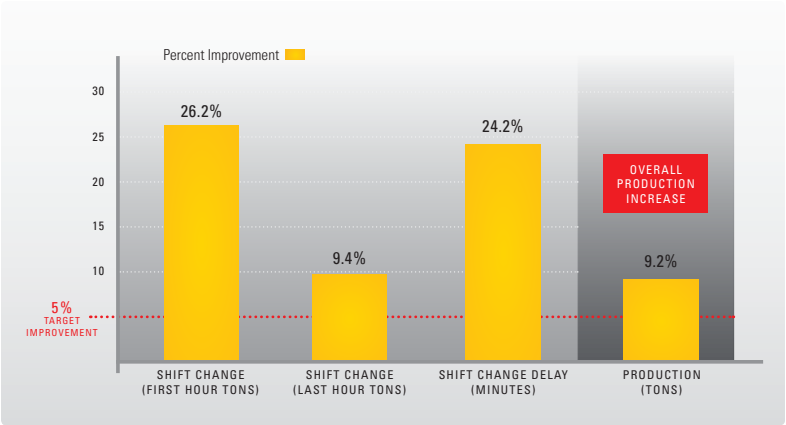
Reducing costs by improving shift change efficiency

To see some of the benefits to be gained from improved shift changes, we'll look at an iron ore mine in Australia. The mine's owners partnered with Caterpillar to solve a common problem—their first- and last-hour tons were low and it was affecting the mine's profitability. By implementing the shift change component of Fleet, the mine saw more than a 25 percent improvement in first- and last-hour tons.



Another site, Robinson mine in Nevada, wanted to improve its shift change efficiency, so the owners asked Caterpillar if it was possible to do a trial of Fleet prior to purchasing the technology. In order to ensure that all parties were aware of the goal, we agreed to use a 5 percent improvement in prime tons moved, and began breaking down the problem to decide where we should focus.

After settling on first- and last-hour tons and mean time to complete shift changes as our target areas, we began training and change management to implement Fleet. The end result was a 26.2 percent increase in first-hour tons, a 9.4 percent increase in last-hour tons and a 24.2 percent improvement in shift change delay. While we set our initial goal at a 5 percent increase in prime tons, the change resulted in a 9.2 percent increase. The customer is now on its third generation of Fleet upgrades.



How can Cat MineStar help?

Fleet has a shift-change module and tracks first- and last-hour tons, helping optimize shift changes to reduce costs. But there are other ways MineStar can help make shift changes more efficient. Terrain tracks operators and delays, allowing you to make sure machines are in the proper position and all operators are getting back to work quickly. By removing operators from the process, Command removes the need for shift changes entirely.

CONTROLLING COSTS WITH CAT MINESTAR

No matter what you mine, where you mine or how you mine, finding ways to control your overall operating costs is a top priority. And Caterpillar and Cat dealers are committed to helping you in this effort.

There are hundreds of costs drivers in every operation—such as process variability, unplanned maintenance, fuel, shift changes and collisions—and the Cat MineStar suite of capabilities is one of the greatest tools we have to significantly impact nearly every one of them.

» **Health,** which provides continuous updates and monitoring, fuel usage reports and sophisticated analytics so you can better manage fuel costs, track equipment health and plan preventive maintenance procedures—avoiding costly failures.

» **Terrain,** which can monitor and manage operator performance, measure utilization, and track machine position—reducing the costs of downtime caused by operator abuse, inefficient operation, poor equipment utilization and accidents.

- **Fleet,** which helps you optimize equipment utilization for reduced wear and tear, increase mean time between fueling, and optimize shift changes to reduce costs of fuel, accidents and inefficient operation.
- **Detect,** which improves operator visibility and helps you manage fatigue and distraction—reducing the risk of accidents and their associated costs.
- **Command,** which removes operators completely from harm's way, eliminating the costs of accidents or injuries; and improves the consistency of operations to reduce the costs associated with inefficiencies.

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 lower your costs and improve your profitability.

CAT® MINESTAR™

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.™

CAT®