CAT® MINESTAR™

COMMAND FOR HAULING

AUTONOMOUS HAULAGE SYSTEM FOR MINING

CAT®

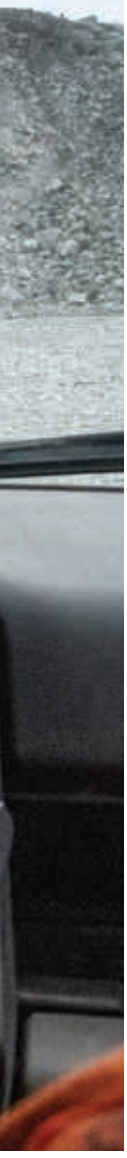
CAT MINESTAR COMMAND FOR HAULING

ADDRESSING YOUR TOUGHEST OPERATIONAL CHALLENGES

Safer sites. Fewer labor challenges. More consistent operations. Greater utilization of assets with OEM-Integrated Autonomy.

These are just a few of the outcomes you can expect when implementing autonomous haulage into your mining operation. However, not all autonomous haulage systems are the same. To get these benefits — and many more — the ideal solution is Cat® MineStar™ Command for hauling.

Caterpillar combines a proven technology solution, decades of implementation experience, deep system integration with Cat machines and the global support of the Cat dealer network to deliver a solution that can take your operation to the next level of efficiency, consistency, safety and availability — delivering maximized outputs and reduced costs.



ENHANCED SAFETY

- Proven safety record: 419+ million kilometers traveled with no injuries
- Multiple layers of safety
- Proprietary perception system that detects obstacles in the harshest mining environments
- Supports safe interactions between staffed and autonomous machines

PROVEN IMPLEMENTATION PROCESS

- Prepares people and site processes to effectively transition to autonomy

GREATER UTILIZATION OF ASSETS

- Increased productive time with consistent haul cycle times
- Real-time machine tracking, dynamic assignment and productivity management
- Active health monitoring and Cat support enable high uptime

OEM-INTEGRATED AUTONOMY

- Ensures compatibility, performance and reliability between base machine and autonomy technology

HOW DOES IT WORK?

MOVE EFFICIENCY & CONSISTENCY FORWARD WITH AUTONOMOUS HAULAGE

Command for hauling trucks operate safely around other equipment, light vehicles and personnel. Fully driverless trucks respond to calls to the loading tool, move into position, haul to dump points and report to the park-up location.

Command trucks are fitted with advanced braking and steering systems and cutting-edge electronics that are fully integrated with the base machine. This also includes perception and positioning systems, which enable precise navigation and site awareness of staffed vehicles.

Command for hauling:

+ Leverages virtual zones to define the specific area where automated operations occur and controlled access is needed.
+ Manages safe interactions between Command trucks and staffed mine support vehicles. Loading tool operators set spot points for trucks, while operators of staffed vehicles can view nearby machines on their in-cab display.
+ Provides the ability to define load, dump, fueling, ready-line, and avoidance areas.
+ Integrates with the crusher to signal to the truck when to dump and allows for trucks to dump simultaneously.
+ Through dynamic assignments, optimizes operations by routing trucks to avoid longer queues, sending the nearest available truck to a specific controlled area and managing intersections to keep traffic moving smoothly.
+ Enables Command trucks to obey speed limits and queuing protocol, signaling and executing predetermined intersection priorities.
+ Maintains truck stability by controlling steering, braking and traction. The braking and steering systems are designed with redundancies.
+ Allows the truck to operate and adjust travel speeds in dust, rain, fog and snow by using the truck perception system, which leverages advanced LiDAR and radar sensors. The trucks survey load and dump areas while traveling, uploading this data into a repository that can be used to update the virtual mine model.
+ Chooses the most efficient path to travel within the load and dump areas, minimizing required user input.
+ Notifies site personnel of any exceptions requiring attention, such as when a Command truck detects an obstacle or experiences a machine health event.
+ Provides a mode-change procedure to switch to staffed mode for service and maintenance. Each truck is equipped with mode lights that indicate its operating status.

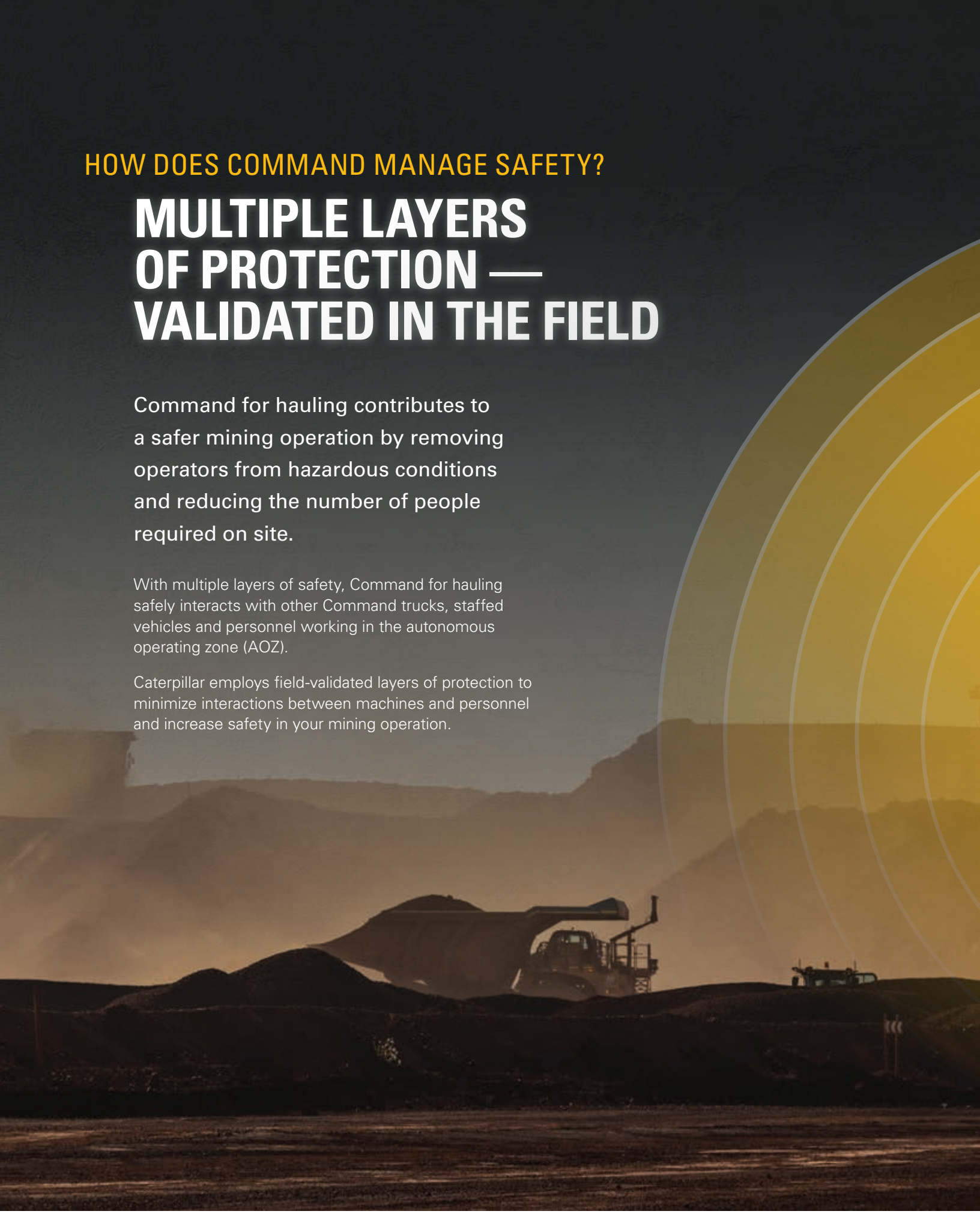
HOW DOES COMMAND MANAGE SAFETY?

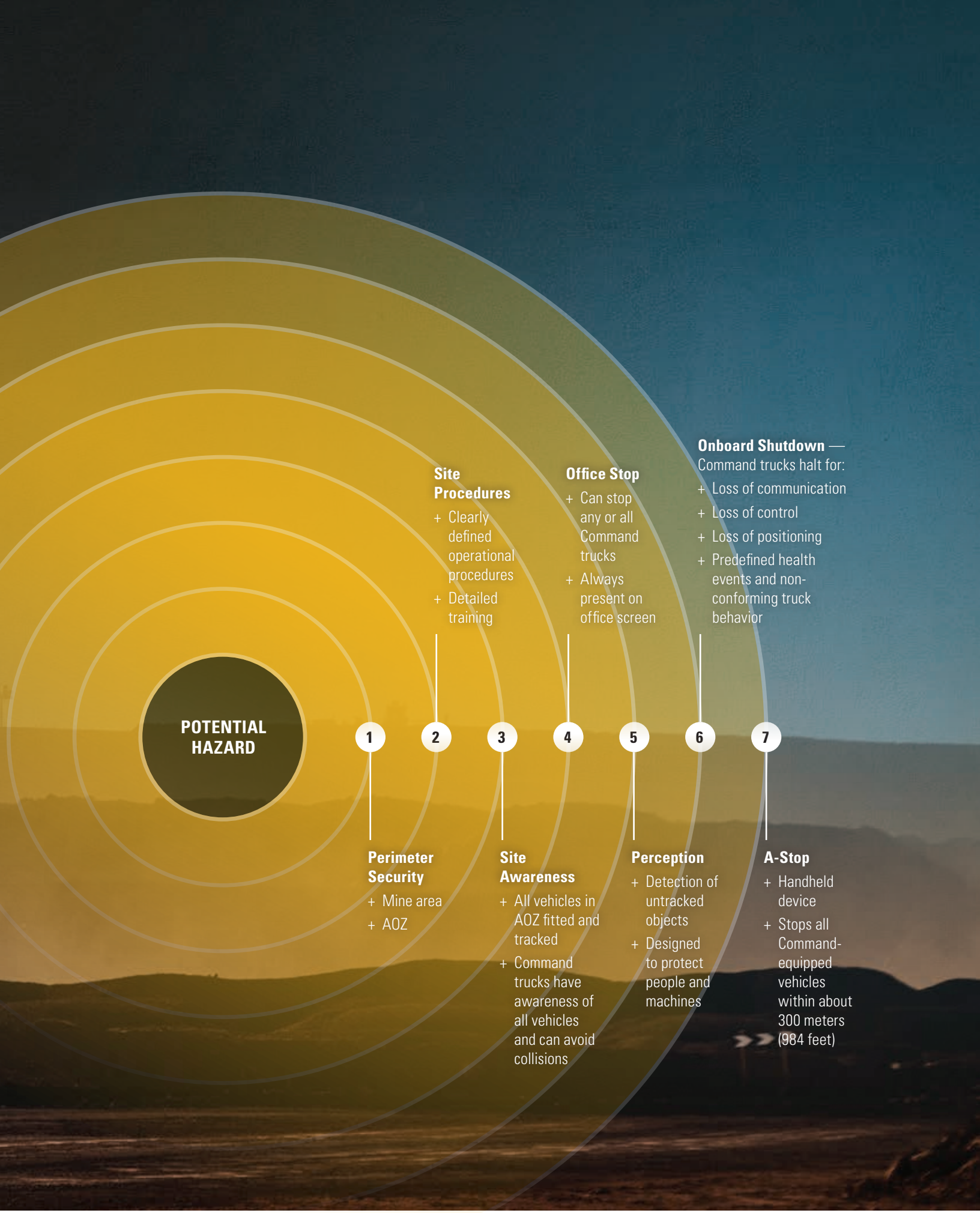
MULTIPLE LAYERS OF PROTECTION — VALIDATED IN THE FIELD

Command for hauling contributes to a safer mining operation by removing operators from hazardous conditions and reducing the number of people required on site.

With multiple layers of safety, Command for hauling safely interacts with other Command trucks, staffed vehicles and personnel working in the autonomous operating zone (AOZ).

Caterpillar employs field-validated layers of protection to minimize interactions between machines and personnel and increase safety in your mining operation.




POTENTIAL HAZARD
1
2
3
4
5
6
7
Perimeter Security
+ Mine area
+ AOZ
Site Procedures
+ Clearly defined operational procedures
+ Detailed training
Site Awareness
+ All vehicles in AOZ fitted and tracked
+ Command trucks have awareness of all vehicles and can avoid collisions
Office Stop
+ Can stop any or all Command trucks
+ Always present on office screen
Perception
+ Detection of untracked objects
+ Designed to protect people and machines
Onboard Shutdown — Command trucks halt for:
+ Loss of communication
+ Loss of control
+ Loss of positioning
+ Predefined health events and non-conforming truck behavior
A-Stop
+ Handheld device
+ Stops all Command-equipped vehicles within about 300 meters (984 feet)

ZERO
REPORTED LOST TIME INJURIES

We take immense pride not only in our advanced haulage solution, but also in our commitment to protecting people and operations. At our largest autonomous site, more than 450 staffed vehicles are equipped with site aware technology to safely operate alongside autonomous trucks. To date, Command trucks have safely traveled over 419 million kilometers with no reported injuries.

419+
MILLION KILOMETERS TRAVELED
WITH NO REPORTED INJURIES


7F
220
2134

WHY SHOULD WE CONSIDER IT?

WHAT MAKES COMMAND FOR HAULING RIGHT FOR MY OPERATION?

Command for hauling has forever changed how mines move material, delivering unprecedented gains in safety, efficiency, consistency and uptime.

Command takes advantage of the most innovative technologies available to deliver a haulage solution that provides benefits across the operation.

+ **Enhances safety** — removing operators from harm's way, reducing the number of people required in the pit and ensuring safe interactions between staffed and autonomous machines.
+ **Reduces labor challenges** — helping to address labor shortages by attracting new employees, broadening the skills and improving retention of current employees and reducing overall costs.
+ **Improves operational consistency** — reducing the variability of haulage operations from shift to shift.
+ **Reduces operational delays** — providing near-continuous operation.
+ **Increases utilization of availability** — keeping trucks moving and optimally meeting production plans.
+ **Improves machine uptime** — Keeping trucks operating within design parameters and monitoring machine health by onboard sensors and Cat Condition Monitoring.

EVALUATING THE NEED

Are you ready for Command for hauling? We can help you find out. We'll spend time on your site learning about your business, understanding priorities, identifying challenges, evaluating processes, getting to know your people and their roles, and reviewing current operations and changes required for a successful autonomous operation.

We follow a measured approach — evaluating the risks and rewards and collaborating to determine if Command is the right solution to help you achieve your goals. Then we work together to find the right way to implement it at your operation. We look for ways to work more efficiently, lower costs and utilize existing resources. We simplify systems and tailor training to suit your application.

WHY CATERPILLAR?

PROVEN SOLUTIONS BACKED BY EXPERTISE & SUPPORT

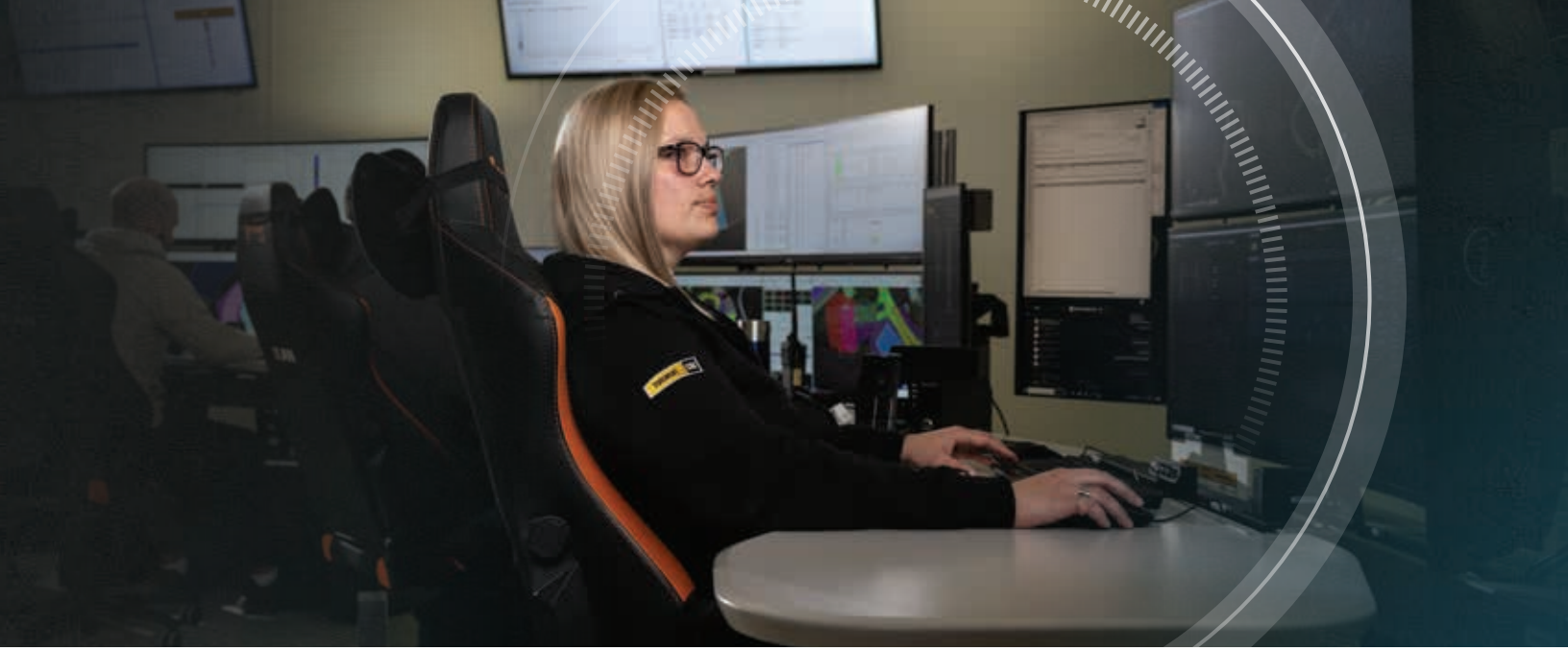
MINESTAR: A PROVEN SOLUTION

+ Robust testing and validation process
+ Designed for challenging environments
+ Validated across multiple applications

WORLD-CLASS SUPPORT FROM CATERPILLAR AND CAT DEALERS

Support options include online and remote support delivered by Caterpillar, on-the-ground support from Cat dealers, and consultation services provided by both Caterpillar and Cat dealer experts.

+ Realize the full potential of your investment
+ Achieve critical availability of your MineStar technologies
+ Sustain operational gains through continuous improvement



IMPLEMENTATION EXPERTISE

We're uniquely qualified to integrate our products into your environment and provide guidance for long-term success.

Installation and Deployment

We work with local Cat dealers to install, deploy and integrate MineStar software and hardware into your environment, and then ensure a smooth transition to your own team.

Training

Our comprehensive suite of training opportunities allows users to build skills through web-based, instructor-led, virtual reality and on-the-job courses.

Change Enablement

Caterpillar experts support initiatives to help your personnel prepare for the transition to technology.

Processes and Procedures

We work with site leaders to develop the operational processes and procedures that are essential to success.

MINESTAR: AN INTEGRATED AND SCALABLE ECOSYSTEM

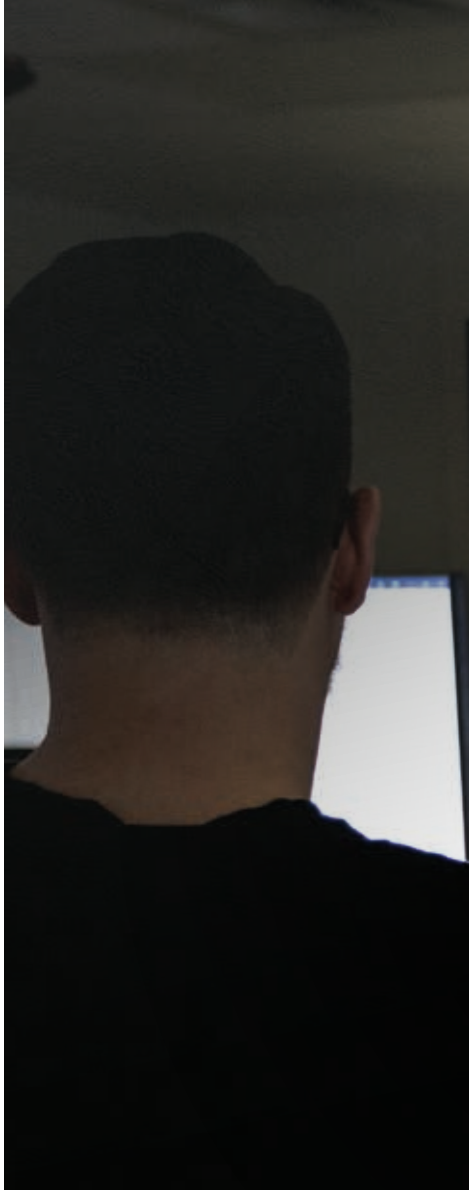
MineStar allows you to tailor your technology journey, leveraging any of the building blocks that are the foundational elements making up your site operating system. Additional building blocks for safety and surface management use key common system components, allowing for the interchange of planning, blending, survey and production data within the one system.

+ Integrates data across the operation
+ Enables operational execution by managing and optimizing all assets

MINESTAR REPORTING

This centralized data warehouse consolidates data from multiple MineStar products. Flexible, customizable reporting allows you to extract the information you want, whether you leverage Caterpillar's own purpose-built mining analytics platform or export to a third-party platform.

TRACK, MONITOR, AUTOMATE AND MANAGE YOUR ASSETS WITH CAT MINESTAR SOLUTIONS



Cat MineStar Solutions is one of the mining industry's most comprehensive and thoroughly integrated suites of technology offerings for surface and underground operations.

MineStar can track, monitor, measure, manage and optimize all types of assets — from material and people to production machines and light vehicles on site. Whether you deploy a single technology or a multi-purpose solution, you can expect a safer, more productive and more efficient operation.

MineStar capabilities include:

TERRAIN, which increases efficiency and reduces variability of drilling, dragline, grading and loading operations through the use of high-precision guidance technology.

FLEET, which is an integrated fleet monitoring and management system that helps you measure, manage and optimize the use of assets at your site. It automatically records and tracks data up and down your value chain, providing insights that help you identify what's working and fix what's not.

DETECT, which helps increase operator awareness, enhancing safety at your operation. It includes a range of capabilities designed to assist the operator, including collision awareness and fatigue risk management for mobile equipment.

HEALTH, which delivers critical event-based machine condition and operating data for your entire fleet. It includes comprehensive equipment health and asset monitoring capabilities, with a wide range of diagnostic, analytic and reporting tools.

COMMAND, which makes it possible for mines to automate a single mining process, remotely control a single machine, automate multiple types of equipment across a mixed fleet, or implement a fully driverless fleet of trucks.

ADDRESSING YOUR TOUGHEST OPERATIONAL CHALLENGES

Cat MineStar Command for hauling has forever changed how mines move material. By making it possible for trucks to operate autonomously, Command delivers unprecedented gains in safety, efficiency, consistency and uptime.

Benefits are as compared to operations without a similar technology. Actual results may vary based on application, infrastructure, network connectivity, equipment maintenance and operating procedures, among other factors.