INTRODUCTION

In Cat machines you’ll discover a unique combination of iron and electronics. Powerful, productive — equipped with the latest in proven information technology. A full line of systems that will work harder, last longer, and help you move more material at a lower cost.

At Caterpillar, we’ve applied technologies selectively — incorporating only those that deliver intelligent solutions. So if it doesn’t improve performance, increase productivity, extend component life, help the operator, reduce service time, lower operating costs, enhance resale value, address an environmental challenge, or make your time more efficient, you won’t find it on our machines. Utilizing these technologies provides the most advanced systems available to keep your site running at peak efficiency and productivity, at the lowest possible owning and operating costs.

Grade, paving and compaction control systems are centered around robust position awareness technologies and rugged on-board systems, revolutionizing the movement of material. Guidance products provide real-time job progress with centimeter-level accuracy to the operator, eliminating guesswork that leads to rework or constant surveying, slowing progress and driving up costs. Control products take this technology a step further by integrating position awareness to automatically adjust the work tool. This results in accurately meeting the design plan while reducing the number of passes needed.

- AccuGrade™ Grade Control System (GCS)
- AccuGrade Paving Control System (PCS)
- AccuGrade Compaction Control System (CCS)
- Computer Aided Earthmoving System (CAES) for Landfill
### Technology Products | Introduction

#### Sustainability:
- **Reduce electronic component waste** — For all displays and GPS receivers utilized in Caterpillar’s mining technology products, Caterpillar offers repair services and remanufactured components. This reduces the number of electronic components in landfills and ensures any unrepairable components are disposed of properly.
- **Productivity gains** — Each mining technology solution improves mine productivity ranging from 10–25%. By increasing productivity, mines can achieve higher productivity without increasing the number of machines which translates to more tons with fewer overall emissions.
- **Increased utilization of natural resources while lowering processing costs** — Cat mining technology products help mines ensure ore and waste materials are properly identified and routed. This means that less ore is wasted by misdirected loads. Cat products also minimize processing costs and chemicals by reducing the amount of waste material sent to the processing plant.

**Mining Technology Products** continue to have a positive impact on mining operations around the world. Caterpillar offers a complete suite of technology products purpose built for the harsh mining environment. Our products combine the latest GNSS positioning technology with sophisticated electronic control modules and software to help miners increase productivity, monitor fleet health and lower operating costs.

- MineStar™ FleetCommander
- MineStar™ Health
- AQUILA™ Drill System
- AQUILA™ Dragline System
- CAESultra for Mining
- Cat® Integrated Object Detection System™
- Cat® Integrated Remote Control
- MINEGEM™ Underground Mining Automation System
- Work Area Vision System (WAVS)
- VIMS™ System

#### Fleet Management products and services provide data and information about multiple aspects of equipment, such as machine location, hours and health, to help customers more effectively manage down-time and plan maintenance. Offerings in this category are:
- **Product Link**
  For more information on these and other Cat technology products, visit [www.cat.com/pl](http://www.cat.com/pl).
## Product vs. Application chart

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>APPLICATIONS</th>
<th>MACHINES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Link</td>
<td>Product Link enables remote monitoring of your equipment to help keep your jobs on schedule, maintain machine health and reduce the costs of owning and operating your fleet. The system provides information via satellite or cellular connection to simplify fleet management, track equipment, maximize uptime, monitor machine usage and link your entire fleet.</td>
<td>Product Link comes standard on many Cat machines, and is available for retrofit on Cat and other brands of equipment.</td>
</tr>
<tr>
<td>AccuGrade™ GCS 600</td>
<td>Automatic cross slope system to control one end of the Motor Grader blade to correlate manually controlled slope of the other end. For finish grading, automatic elevation control (Sonic or Laser) can be added to reference string line/curb or laser transmitter. Additionally, this system can be upgraded to AccuGrade GCS 900.</td>
<td>Motor Graders</td>
</tr>
<tr>
<td>AccuGrade GCS 900</td>
<td>Automatic machine control system with positioning information via the Global Navigation Satellite System (GNSS) or Universal Tracking Sensor (UTS) for complex contours, bulk earthworks and design files.</td>
<td>Motor Graders, Track-Type Tractors</td>
</tr>
<tr>
<td>AccuGrade PCS 900</td>
<td>The 3D system is an extension to the 2D AccuGrade Grade and Slope for Asphalt Paver system. It allows paving without a reference surface or string line. Contractors can switch from 2D to 3D depending on job requirements.</td>
<td>Asphalt Pavers</td>
</tr>
<tr>
<td>AccuGrade PCS 400</td>
<td>System to remove irregularities from paved surfaces and control mat thickness. Features text based display with dual mode which can control both sides of the screed.</td>
<td>Asphalt Pavers</td>
</tr>
<tr>
<td>AccuGrade CCS 900</td>
<td>Measures Cat Compaction Value and when combined with a base station, provides finished grade information. Used to determine when compaction is complete and document results over entire job site.</td>
<td>Soil Compactors</td>
</tr>
<tr>
<td>AccuGrade™ PCS 900</td>
<td>AccuGrade PCS 900</td>
<td></td>
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</tbody>
</table>
## Technology Products

### Product vs. Application chart

| PRODUCT                                                        | APPLICATIONS                                                                 | MACHINES                                                                 |
|                                                               |                                                                             |                                                                          |
| Computer Aided Earthmoving System (CAES) for Mining           | Surface Control, Machine Guidance and Ore Control. Uses high precision GNSS plus on- and off-board software to minimize machine productivity and ore extraction. | Track-Type Tractors, Wheel Dozers, Wheel Tractor-Scrapers, Wheel Loaders, Shovels and Excavators |
| Computer Aided Earthmoving System (CAES) for Landfill         | Uses high precision GNSS plus on- and off-board software to maximize landfill airspace and machine productivity. Ideal for landfill planning, engineering, surveying, grade control, and production monitoring applications in dump areas. | Landfill Compactors, Track-Type Tractors, Wheel Tractor-Scrapers, and Motor Graders |
| AQUILA™ Drill System                                           | For mining customers that value machine and operator performance reports, precise placement and depth of blast holes, and detailed strata information on each drill hole. Requires radio network and ability to receive GNSS signals. | Blast hole drills |
| AQUILA Dragline System                                        | Monitor performance and improve machine productivity. Uses a pair of high precision GNSS receivers for accurate bucket positioning. | Draglines |
| MineStar™ FleetCommander                                       | A modern decision-support tool based on industry standard open systems allowing mines to understand, test, and capture events in their mine. Features an advanced truck assignment system, alarm definition, charting and reporting, field machine communication, machine control, productivity, and machine and materials tracking. | Entire mining fleet (Cat and other brands) |
| MineStar Health                                                | Provides machine health data and reports.                                     | Mining machines equipped with VIMS™                                      |
### Technology Products

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<th>PRODUCT</th>
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<tr>
<td>MINEGEM™ Underground Automation System</td>
<td>This automation system removes the operator from the dangerous situations and allows them to work in a more comfortable, ergonomic environment. Using technology to automate and enhance operations, the system provides safety and productivity benefits for underground mines.</td>
<td>Available as an attachment to all Underground Loaders: R1300G, R1600G, R1700G, R2900G, R2900G XTRA</td>
</tr>
<tr>
<td>Cat® Integrated Object Detection System™</td>
<td>Combines cameras, radar, and alarms to notify the operator when something is close to the machine but not within an immediate viewing range. The system is configured with zones around the equipment and objects in those zones trigger various levels of alarms.</td>
<td>785, 789, 793, and 797 Off Highway Trucks</td>
</tr>
<tr>
<td>Cat Integrated Remote Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work Area Vision System (WAVS)</td>
<td>One, two, or three camera system providing operator in machine with optimal viewing angles all around equipment.</td>
<td>Entire fleet (Cat and other brands)</td>
</tr>
</tbody>
</table>
Product Link is a fleet management system that allows remote monitoring of equipment with features and capabilities that will improve overall fleet-management effectiveness. Product Link is available for all Cat machines, and included as standard equipment on approximately 75 Cat models delivered to customers in over 50 countries around the world.

Product Link is deeply integrated into the machine interacting with engine, transmission and implement control systems. Events and diagnostic codes as well as hours, fuel, idle time and other detailed information is transmitted and displayed in a secure web based application, known as VisionLink™.

The VisionLink application includes powerful tools and features used to process and convey information to users and dealers. The application also includes essential tools to manage your entire fleet of equipment include mapping, working and idle time, fuel level and more.

Hardware options provide the ability to transmit information from (and to) your equipment via cellular network (GSM) or Low-Earth-Orbit satellites. The family of enabling hardware provides you the ability to select the right fit option for the location for which your fleet operates.
### Cat® Product Link

#### Technology Products

**Features**

<table>
<thead>
<tr>
<th>Essentials</th>
<th>PL522</th>
<th>PL321</th>
<th>PL121</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic asset management features allow for location monitoring, working vs. idle time and fuel level. Machine, job site or fleet views make it easy to manage all equipment, at all sites, all the time.</td>
<td>Runtime with Idle*</td>
<td>Runtime with Idle*</td>
<td>Runtime</td>
</tr>
<tr>
<td>Expected Runtime</td>
<td>Expected Runtime</td>
<td>Location</td>
<td></td>
</tr>
<tr>
<td>Asset On/Off Notification</td>
<td>Start/Stop Times</td>
<td>Location</td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td>Geo Zones (radius)</td>
<td>Geo Zones (radius)</td>
<td></td>
</tr>
<tr>
<td>Geo Sites (polygon)</td>
<td>Fuel Level*</td>
<td>Fuel Level*</td>
<td></td>
</tr>
<tr>
<td>Fuel Level*</td>
<td>S<em>O</em>S™ Notifications*</td>
<td>S<em>O</em>S™ Notifications*</td>
<td></td>
</tr>
</tbody>
</table>

**Cat Maintenance**

Apply an effective and efficient planned maintenance program with this service plan. Know when your machine is due for service and what parts are required with detailed checklists and on-line parts ordering. Manage and document other maintenance events such as inspections, backlogs and planned component services.

<table>
<thead>
<tr>
<th>Cat Maintenance</th>
<th>PL522</th>
<th>PL321</th>
<th>PL121</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM Service intervals*</td>
<td>PM Service intervals*</td>
<td>PM Service Intervals*</td>
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<tr>
<td>Service Meter Hours</td>
<td>Service Meter Hours</td>
<td>Service Meter Hours</td>
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<tr>
<td>Checklists*</td>
<td>Checklists*</td>
<td>Checklists*</td>
<td></td>
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<tr>
<td>Parts lists</td>
<td>Parts lists*</td>
<td>Parts lists*</td>
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<tr>
<td>Partstore Integration*</td>
<td>Partstore Integration*</td>
<td>Partstore Integration*</td>
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</table>

**Cat Health**

Cat Health features provide insight to the condition of your equipment as well as timely notification of issues as they occur. Temperature and pressure warnings, operator driven events like overspeed or abuse warnings, fluid analysis reports and more.

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<tr>
<th>Cat Health</th>
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<th>PL121</th>
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<tbody>
<tr>
<td>Continuous Reporting*</td>
<td>Continuous Reporting*</td>
<td>Continuous Reporting*</td>
<td></td>
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<tr>
<td>Event Codes*</td>
<td>Event Codes*</td>
<td>Event Codes*</td>
<td></td>
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<tr>
<td>Diagnostic Codes*</td>
<td>Diagnostic Codes*</td>
<td>Diagnostic Codes*</td>
<td></td>
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<tr>
<td>Single Sign on to SIS*</td>
<td>Single Sign on to SIS*</td>
<td>Single Sign on to SIS*</td>
<td></td>
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<tr>
<td>Links to Troubleshooting*</td>
<td>Links to Troubleshooting*</td>
<td>Links to Troubleshooting*</td>
<td></td>
</tr>
</tbody>
</table>

**Cat Utilization**

Identify when your equipment is working compared to expected runtime hours. Monitor efficiency with working vs. idle utilization details for both hours and fuel. Easy graphical views allow comparison between equipment, job sites or other groupings of equipment.

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</thead>
<tbody>
<tr>
<td>Fuel Used While Working*</td>
<td>Fuel Used While Working*</td>
<td>Fuel Used While Working*</td>
<td></td>
</tr>
<tr>
<td>Fuel Used While Idling*</td>
<td>Fuel Used While Idling*</td>
<td>Fuel Used While Idling*</td>
<td></td>
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<tr>
<td>Fuel Burn*</td>
<td>Fuel Burn*</td>
<td>Fuel Burn*</td>
<td></td>
</tr>
<tr>
<td>One hour updates</td>
<td>Daily updates</td>
<td>4 Switch Inputs</td>
<td></td>
</tr>
<tr>
<td>4 Switch Inputs</td>
<td>4 Switch Inputs</td>
<td>4 Switch Inputs</td>
<td></td>
</tr>
</tbody>
</table>

**Digital Inputs**

Enables notification from a switch as events occur. For example, connect to a lubrication system to know when the reservoir needs to be refilled or to an evacuation pump so you know when oil is drained.

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<thead>
<tr>
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<tr>
<td>4 Switch Inputs</td>
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<td>4 Switch Inputs</td>
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</tr>
</tbody>
</table>

**Rapid Reporting**

Track and trace equipment movement with one minute location updates. Display movement history in multiple map views including street, satellite or terrain.

<table>
<thead>
<tr>
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<th>PL321</th>
<th>PL121</th>
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<tr>
<td>One minute updates</td>
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<td>One minute updates</td>
<td></td>
</tr>
<tr>
<td>Service Meter Hours</td>
<td>Service Meter Hours</td>
<td>Service Meter Hours</td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td>Location</td>
<td>Location</td>
<td></td>
</tr>
</tbody>
</table>

*Special features are enabled by integration into Cat equipment electronic systems and related applications. Similar features are available for other makes of equipment or Cat machines with mechanical systems.

For more information about Product Link, customers can contact their local Cat dealer or visit www.cat.com/pl.
ACCUGRADE™
GRADE CONTROL SYSTEM (GCS)

The GCS systems reduce guesswork and costly rework by moving material right the first time, reduces survey costs and increases material utilization. The systems improve operator skills, which reduce labor requirements, aids operators in maintaining a consistent depth, grade and slope across the work site and reduce material cost. GCS Systems compute the location of the machine implement and compare the position to the desired design location and give the operator real-time cut/fill information to achieve grade (indicate-only) or signal the machine hydraulics to move the implement to the desired design automatically (on applicable systems). GCS systems offer these advantages and cost-savings:

- Fuel savings of up to 40%
- Increase productivity by up to 50%
- Reduce guesswork and costly rework by moving material right the first time
- Reduce survey costs up to 90%
- Increase material utilization
- Reduce operator costs
- Reduce labor requirements and costs
- Reduce the need for staking, string lines and grade-checkers
- Extend the work day
- Finish jobs faster

AccuGrade GCS 600

Cross slope

Cross slope systems are the foundation system for motor graders and control one blade tip without any off-board infrastructure. It can be combined with sonic, laser, GNSS or UTS technologies to make fine grading more efficient and productive. Cross slope systems are indicate-only or automatic grade control systems designed to control surface cross slope. Machine mounted sensors are used to calculate necessary blade slope positioning to achieve desired cross slope of the surface. The system makes automatic adjustments to the left or right lift cylinder, typically performed by the operator. The in-cab display delivers all of the cross slope information the operator needs to quickly and easily spread or cut material at the correct cross slope. The operator can select which side of the blade to control automatically and swap direction on the return pass without readjusting the settings. Elevation is controlled manually by matching grade or automatically by adding an elevation control device (sonic or laser).

The cross slope systems are ideal for maintaining accurate cross slope over long distances without the need for infrastructure.
**Site/laser reference**

Site reference systems are the foundation system for excavators and can be combined with laser, GNSS or UTS technologies to make excavating more efficient and productive. The site reference system is an indicate-only system that provides the operator with precise real-time bucket positioning relative to the desired grade. Using a combination of front linkage (stick, boom and bucket) sensors, the system calculates bucket tip position relative to a grade/survey stake or benchmark. When combined with the site reference system, the optional laser receiver allows the machine to move after obtaining a reference benchmark. The laser receiver attachment references a rotating laser to calculate the desired grade for elevation changes over large work sites, significantly increasing productivity.

The site/laser reference systems are ideal for building pads, trenches, and general utility applications.

**Laser**

Laser systems are elevation control systems designed for precise grade control with tight tolerances using a laser transmitter and receiver(s). A laser transmitter is set up on the work site and creates a constant grade reference over the work area. A digital laser receiver is mounted on the machine and senses the laser signal as the machine moves across the work site.

When combined with cross slope on a motor grader, the single laser system provides automatic blade adjustments to one side of the blade for automatic control of elevation and cross slope.

When combined with a Level Best boxblade on C Series Skid-Steer Loaders, Multi-Terrain Loaders and Compact Track Loaders, the machine electro-hydraulic controls create an automated grading system capable of extreme accuracy. Unlike conventional laser grading systems for SSL-type machines, the laser system requires no additional externally mounted hydraulic valves or displays, nor any additional in-cab levers, switches, control boxes or cables. The integrated system allows use of the loaders existing controls, keeping the operator securely in the seat and protected by built-in safety features.

The laser systems are ideal for the elevation control on fine grading applications and sites with flat, single or dual slope surfaces, such as industrial, commercial or residential building sites.

**Sonic**

Sonic systems are elevation control systems designed to control surface elevation. The sonic system uses an ultrasonic sensor to maintain the blade at the same relative vertical distance to an external reference such as a string line or a curb and gutter. The system makes automatic elevation adjustments, typically performed by the operator. The operator simply steers the machine to maintain the sensor over the external reference. When combined with cross slope, the single sonic system provides automatic blade adjustments to one side of the blade for automatic control of elevation and cross slope.

The sonic systems are ideal for the elevation control on fine grading applications on sites using existing curb and gutter or string line references.
AccuGrade™ Grade Control System (GCS)

**AccuGrade™ GCS 900**

GCS 900 systems use 3D design files that are stored on the in-cab display and are ideal for all applications including finishing slopes, excavating and truck loading, complex trenches, site with 3D designs such as super elevations, retention ponds, and golf courses.

**GNSS**

Global Navigation Satellite Systems (GNSS) use satellite technology to deliver precise blade positioning information to the operator in the cab. Using machine-mounted components, an off-board GNSS base station and Real Time Kinematic (RTK) positioning, GNSS provides the information necessary for the system to accurately determine blade positioning with centimeter level accuracy. GNSS systems compute the positioning information on the machine compares the position of the blade relative to the design plane and delivers the information to the operator via an in-cab display. Information such as:

- Blade elevation
- Level of cut/fill necessary to achieve grade
- Visual indication of blade position on design surface
- Graphical view of design plane with machine location

GNSS systems put all the information the operator needs to complete a job in the cab, resulting in a greater level of control. Vertical and horizontal guidance tools visually guide the operator to the desired grade. Automated features allow the hydraulics system to automatically control blade adjustments to move the blade to grade. The operator simply uses the light bars to steer the machine for consistent, accurate grades and slopes resulting in higher productivity with less fatigue.

**UTS**

UTS systems are high-accuracy, dynamic tracking systems that utilize Universal Total Station (UTS) technology on the work site to track a target, which is mounted on the blade of the machine to determine precise 3D positioning. Active target technology allows the system to reliably lock onto and track the intended target. This ensures the correct machine is being tracked and eliminates false lock-ons to other active machine targets, survey crews or reflective surfaces. The UTS instrument continuously measures the targets position and transmits real-time positioning data to the operator via the in-cab display, which shows the exact position of the blade in relation to the design. The system combines the position of the target with the known position of the instrument, machine measurements and sensor outputs to calculate precise positioning of the blade tips. The system uses the positioning data to calculate desired elevation and cross slope. Cut and fill values are computed by comparing the positioning of the blade with the design file. The system makes automatic blade adjustments typically performed by the operator and provides automatic blade control to one or both cutting edge types.
ACCUGRADE™
PAVING CONTROL SYSTEM (PCS)

AccuGrade PCS 400
Cat Grade and Slope
The two dimensional (2D) Grade and Slope system allows contractors to place precise amounts of asphalt mix on the surface being paved by controlling the screed. The system accepts input from sonic sensors, contacting sensors or grade sensors.

The LSD display can provide control for both sides of the screed. Sealed to withstand both moisture and dust contamination, it alerts the operator with an audible alarm whenever a diagnostic message occurs or when a sensor measures an off-grade condition.

AccuGrade PCS 900
The AccuGrade PCS 900 system utilizes Universal Total Station (UTS) technology and is an extension of the PCS 400 system. It allows paving without a reference surface or string line. Contractors can switch from 2D to 3D depending on requirements. The system accepts input from contacting sensors, sonic sensors, a slope sensor, sonic averaging beam, 3D slope or 3D elevation controls. An SPS Series UTS is required to use the 3D controls.

The AutoAdjust Feature monitors the trailing edge of the screed and automatically corrects for errors to achieve higher accuracy and mat smoothness.

The 3D system will allow contractors to better pave more complex designs such as transitions, highly elevated curves and frequently changing cross slopes.

Cat Grade and Slope for Cold Planers
The two dimensional (2D) Grade and Slope system controls rotor depth and cross slope to a preset cutting depth. The system accepts input from contacting wire rope sensors, non-contacting sonic sensors, a sonic averaging ski or a cross slope sensor.

The display can provide control for both sides of the cutting drum. Sealed to withstand both moisture and dust contamination, it alerts the operator with an audible alarm whenever a diagnostic message occurs or when a sensor measures an off-grade condition.
Technology Products | AccuGrade™ Compaction Control System (CCS)

ACCUGRADE™ COMPACTION CONTROL SYSTEM (CCS)

AccuGrade CCS 900
AccuGrade™ Compaction and Temperature Mapping for asphalt compactors helps contractors increase efficiency and productivity while recording data for quality control documentation and future planning. The system provides a real-time visual reference of the pass-count and asphalt mat temperature. Utilizing AccuGrade Compaction can lead to better mat quality and higher bonus payments.

Pass-count mapping helps achieve target density and increase roller efficiency. With proper pre-project planning, including machine selection, vibratory selection, and speed control, the operator can execute the rolling pattern in the most efficient manner possible. Incomplete pass coverage can result in lower mat densities, premature road failure, as well as penalties for failure to meet specification requirements.

Temperature mapping helps operators determine when the asphalt is acceptable to compaction.

The display provides real-time pass-count mapping and temperature readings. This enables the operator to visualize where the machine is on the mat and how many passes have been made.

Better process control during construction will result in longer periods without required maintenance on asphalt roads. This reduces material needs and minimizes traffic delays for construction.

AccuGrade CCS 900
AccuGrade Compaction on a soil compactor senses compaction as the machine works and correlates the data with machine position. These capabilities improve work quality while lowering owning and operating costs. Reducing the amount of manpower required enhances sustainability and the number of compaction passes used to finish the job.

The level of compaction is determined based on drum movement measured by an accelerometer (used to predict soil stiffness). The system provides project owners with complete project documentation of the number of passes and stiffness values of the soil.

Elevation mapping is also provided which alerts an operator to inaccuracies in grade elevation.

The display provides the operator with compaction levels compared to target and site coverage information.
COMPUTER AIDED EARTHMOVING SYSTEM (CAES)

The Right Material in the Right Place for Maximum Machine Productivity

CAESultra uses high precision GNSS technology to help customers maximize machine productivity and job efficiency. Traditionally, an engineer working in the office creates a site plan on a computer. This information is then transferred to paper, and the surveyor goes out and stakes the area to identify elevation, grade, slope, or material type. Once the machine operator has completed the job, the surveyor resurveys the area and updates the office plan. This process is labor intensive and is prone to a check, rework, recheck approach. CAES revolutionizes this process. Its high precision GNSS system allows the machines to act as surveyors. Changes to a digital terrain model (the engineering design file) are recorded as it occurs. The engineer can work with the updated design and modify it further without stopping the machine. It also provides machine operators and site managers information to eliminate rework, reduce field surveying and more accurately complete the earthmoving plan. CAES combines centimeter-level accuracy with Real Time Kinematic (RTK) initialization times for fast and accurate positioning.
High Precision Positioning using Global Navigation Satellite System (GNSS)

Site Requirements
- Line of sight to multiple satellites that are part of the GPS or GLONASS constellations. These transmit signals that are used to determine position.
- Base Station with a GNSS receiver and radio. The base station compares its known (or surveyed) position to the position calculated from the GNSS signals. The difference is used to produce a Compact Measuring Record (CMR).
- A radio network to relay the CMRs to machines equipped with CAESultra system.

On-board Requirements
- Antenna to receive low-precision signals from the GNSS constellation.
- Radio to receive the CMR corrections from the base station.
- Receiver that combines the GNSS signals and CMR corrections to calculate the vehicle position with centimeter accuracy.
- Display running software that provides real-time feedback on job progress and design plan to the operator.

CAESultra On-board
CAESultra on-board components keep the operator informed with real-time information, which provides greater control and empowerment. Caterpillar has designed the on-board components to meet harsh environmental demands of equipment in mining applications. Easy-to-use software provides the operator with critical information required to get the job done quickly and safely. The on-board system also monitors and logs specific parameters that can be used to determine site productivity as well as individual operator and machine performance.

CAESultra for Landfill
CAESultra helps the landfill industry conserve airspace. For a landfill compactor, each time the wheel travels over a surface, the CAESultra screen changes color to acknowledge the compaction pass. CAESultra indicates finished areas. The operator achieves maximum effective compaction, by making only the necessary number of passes. Track-type tractors in landfills benefit from CAESultra because it indicates lift thickness of cover material and trash.

Additionally, CAES permits the recording of site-specific storage areas such as hazardous waste, medical, industrial, organic, and other materials which require special handling or a record of placement. All of this information is monitored and managed in the landfill office with CAESultra Office Software.

CAESultra for Mining
CAESultra moves the material identification file and survey system into the machine, eliminating the need for survey stakes or pin flags. A touch screen monitor displays the location of pit boundaries, material type, bench height, and design grade, eliminating operator guesswork. With material types and locations displayed, ore identification and recovery are optimized.

The CAESultra for Mining system is an ideal tool for mine planning, engineering, surveying, grade control and production monitoring applications. For example, the CAES system can be used for:
- Haul road and bench construction and maintenance
- Production dozing
- Leach pad construction and maintenance
- Reclamation
- Task List Management
- Ore grade control and material identification
- Coal load out terminals

The system can be used on scrapers, loaders, dozers, shovels, motor graders, hydraulic excavators and track-type tractors.
AQUILA™ DRILL SYSTEM

Production, Strata Recognition and Guidance

AQUILA Drill Systems are designed for installation on electric and hydraulic rotary blasthole drills. It provides production and performance monitoring, strata recognition and GNSS guidance. Provided as a field retrofit to machines already operating at mine sites, the AQUILA Drill System uses on-board computing integrated with sensors to monitor critical machine performance characteristics. System modules help the operator and site managers enhance drill performance and improve the drilling and blasting operation.

The **Production** module offers a graphical user interface to provide the operator with immediate feedback on drilling productivity and performance. The product minimizes operator input by an array of sensing hardware to detect:

- hole depth
- reaching target depth
- steel changes

The **Strata Recognition** module analyzes the monitored drilling variables in real-time, determining variability in the hole geology. The different strata horizons are presented on the display. The system provides useful and concise information from the start of drilling — not large amounts of raw data that typify traditional drill monitoring systems. A Blastability Index is determined by the Strata Module and approximates the hardness of the ground. The hole-loading requirements and ore grindability predictions are then based on measured rock hardness enabling improved blending and optimized mill throughput rates.

Combining the **Production** module with the **Strata Recognition** module logs:

- bit rotary speed
- penetration rate
- depth
- rotary torque or pressure
- pulldown pressure
- bailing air pressure

Drilling practice, efficiency and productivity can then be analyzed and assessed.

The **GNSS Guidance** module adds high precision GPS to help precisely position a drill on a blast pattern without the need for surveying or staking. The Guidance module uses a moving map display that shows the 3D (Northing, Easting and Elevation) of the drill and drill bit relative to the designed position of the blastholes. Once the drill is positioned and leveled over a hole, the system automatically determines collar elevation and then calculates the designed target depth. Guidance improves the drill’s production and utilization, and the operator’s ability to drill to the plan. This leads to better rock fragmentation for easier loading. Since holes are drilled to the correct elevation leading to a flatter post-blast surface, the result is smoother pit floors. This helps eliminate rework, enhances the mobile equipment’s performance and reduces its wear and tear.

**AQUILA™ Drill Office Software**

**AQUILA™** Office Software integrates planning and design operations. Engineers can transmit designs to the machine’s on-board computer, which show the machine location relative to the design area, current surface, final design surface, and material map (for loading machines). The software package allows you to create customized reports on productivity data, cycle times, volume and material type.
AQUILA™ DRAGLINE SYSTEM

The AQUILA Dragline System provides real-time monitoring and reporting of dragline operations. By combining Global Navigation Satellite System (GNSS) and production monitoring data, the system empowers the mining office to plan and control operations. It records the complete, detailed data associated with each load cycle.

The AQUILA Dragline System gives the operator the design plan and real-time position of the dragline relative to the plan in 3D. It also monitors, displays, and logs various parameters from the machine and site.

The dragline system is packaged with Cat Office Software, providing access to the data collected by the on-board components. This enables office personnel to track production and monitor operator performance.
MINESTAR™ FLEETCOMMANDER

MineStar FleetCommander is the Cat fleet management system developed to maximize mining process productivity while simultaneously maximizing equipment and fleet productivity.

FleetCommander is a modern decision-support tool enabling mines to manage and administer installation, user interface, configuration, security, system administration, database administration, disaster recovery, logging and diagnostics, software updates, calendars, charting and reporting, alarming and scheduled jobs.

The MineStar platform communicates to the mine and integrated process entities with PitLink, the component which manages field communications with machines and fixed plant as well as operators. It also ensures the delivery of the latest on-board software files to all MineStar equipment.

The key office components that are built into the MineStar office to suit the host mine’s complexity and needs are:

- **Machine Tracking** provides position analysis of MineStar equipment as it is moved around the travel network.
- **Material Tracking** uses the mine’s mining block model for equipment assignment and for loading material according to local blending and production requirements.
- **Operator Management** manages and monitors site personnel for machine licenses, pre-start checklists, scheduled breaks and shift change optimization.
- **Production** monitors site activities, delays, cycles, payload monitoring, Key Performance Indicator (KPI) summaries, fluids and tire management as well as Service Meter Unit (SMU) interpolation.
- **Assignment** applies FleetCommander’s assignment engine to provide the best allocation solution when all trucks are considered so that every assignment provided to each truck is always computed considering the most relevant, current information.

FleetCommander provides a proven solution suite based on a single trusted set of data for real-time KPI and for standard and ad-hoc reports. It provides the mine with information to:

- Identify and quantify performance improvement opportunities (within and post shift)
- Develop strategies to capture performance improvement initiatives
- Support engineer and operator performance
- Assign equipment and fleets for maximized fleet production or achievement of material management goals. Capability scales from simple assignment to full truck assignment with linear programming to ensure maximal flexible loader, truck and material capacity utilization
- Blend materials in order to meet preparation plant quality, tonnage and timing requirements
- Track machines and materials to ensure correct delivery of materials from sources to planned sinks and to monitor equipment routing
- Manage operators (licensing, shift allocation and rostering)
- Manage equipment fluids and tires
- Track equipment productivity capability, consumption and variance
- Monitor equipment health including alarms and sensor channel monitoring, pre-start checklists
- Determine “what if” impacts of making specific changes to the product plan

Cost reduction of 10% and greater can be achieved and sustained using MineStar FleetCommander. Cost reductions are typically realized through reduced equipment, manning, lower fuel and service requirements, while achieving the same levels of productivity.
MINESTAR™ HEALTH

Equipment failures, excessive wear rates, over-temperatures, overloading and degrading operating conditions are all examples of machine health information that when correctly acquired, managed and analyzed can improve a mine's efficiency and lower operating costs.

Caterpillar’s MineStar Health system constantly records information on critical machine parameters fleet-wide. Linked with on-board monitoring systems like VIMS, MineStar Health provides wireless or wired transfer of this critical data to the service center for processing and review. It uses VIMS data to remotely monitor events and alarms, allowing focused channel polling to log condition-based event tracking and Application Severity Analysis calculations. It allows service personnel and maintenance planners to track health changes on a large array of on-board components while completing mine duty cycles. Some of the data collected by MineStar Health includes: system voltages, component performance overloading and load/dump/travel/delay times.

MineStar Health is designed to work seamlessly with MineStar FleetCommander or is available as a stand alone health reporting system from your Cat dealer. It can also be integrated into a production database for expanded analysis.

Key benefits of MineStar Health include:

- Saved component failures
- Extended component life
- Reduced phantom breakdowns
- Full fleet health monitoring
- Efficient data analysis
- Improved maintenance practices
VIMS™ System

VIMS™ is an advanced diagnostic and equipment management tool. By continuously monitoring a wide range of vital machine functions, this high-tech electronic monitoring system improves machine availability, component life, and productivity while reducing both repair costs and risk of catastrophic failure.

By integrating numerous machine sensors into each machine design, VIMS monitors over 250 machine functions and health statistics. Essential machine functions are displayed for the operator via the message center. If a parameter falls outside of the specification, VIMS sends a warning message to the operator and depending on the severity of the event recommends an appropriate course of action. VIMS not only provides important machine and system information to the operator, it also stores a large amount of data about the machine for proactive health and production management.

The third generation of the VIMS System — VIMS 3G — is now available for select Cat Mining equipment, offering enhanced convenience and functionality, along with updated communications capabilities.

Analysis tools help turn data into decisions.

The software applications of the VIMS Off-Board System include a number of data analysis file types. Each file type analyzes different kinds of information and is used to produce specific results.

- **Event List** records, categorizes and stamps up to 500 system “events” that occur during machine operation.
- **Event Recorder (Snapshot)** helps technicians troubleshoot a specific event by capturing detailed data before and after the event occurs.
- **Data Logger** enables the operator to trigger recording of real-time machine data that can show service personnel exactly what is happening when an event occurs.
- **Payload** helps enhance truck and loading tool effectiveness and improve total fleet production by collecting payload, cycle-time and haul-distance data.
- **Trends, Cumulatives and Histograms** provide a variety of reporting and analysis tools for monitoring specific machine parameters.

Value of VIMS System

- For the machine operator VIMS establishes two-way communication between the operator and the machine. Real-time machine information allows the operator to make informed decisions that directly affect safety, machine availability, and ultimately the productivity of the mine.
- For maintenance VIMS provides an in-depth view of operator and machine performance. This allows maintenance managers and technicians to maximize component life, reduce catastrophic failures, minimize unscheduled downtime and improve asset management.
- For production VIMS collects the information needed to monitor equipment usage, personnel performance, and productivity levels. Payload information can be used as an accounting tool, an indicator of cycle time efficiency and truck overloading or under loading.

VIMS Wireless Interfaces

VIMS information can be transmitted wirelessly using VIMS Communicator or Health Interface Module. These units download VIMS data at user programmable intervals and send it back to the office via various telemetry systems.

VIMS Analysis Tools

VIMS information can be downloaded and viewed by VIMS pc, VIMS 3G Connect and VIMS Supervisor using a laptop at the machine or wirelessly. VIMS information is also available with MineStar Health System.
The Cat® Integrated Object Detection System™ is designed for machines ranging from large mining and quarry trucks to machines such as wheel loaders and motor graders. It is meant to reduce blind spots and increase perimeter awareness. This robust system includes both radars and a vision system providing optimal awareness around the machine. With both audible and visual indications of a detected object, the Object Detection System helps prevent work area injuries caused by limited awareness. Using a combination of short-range radars, medium-range radars, cameras, and a high-resolution touch screen display, operators can view the areas immediately surrounding their machine, helping to prevent collisions and accidents.

The Object Detection System is highly integrated with the specific machine configuration to optimize radar and camera coverage. The system has been calibrated to provide appropriate fields of view and range. Unlike basic camera systems, the Object Detection System provides operators with audible and visual types of warnings that enable the operator to make informed decisions when moving or operating the machine. When a camera system is running at all times, it's easy for the operator to overlook the screen when performing job tasks. This system alerts the operator when an object is in close proximity so they can decide if action needs to be taken to avoid it.

**Features**
- Provides coverage on up to four sides of machine.
- Robust components designed and tested to work in heavy-duty off-road applications.
- Radar detects both moving and non-moving objects.
- System uses visual and audible means to alert operator to objects.
- Cameras allow operator to identify objects detected by radar.
- On-board diagnostics monitor system health and alert operator to any issues.
- Configurations allow operator to adapt system to local conditions.

**Benefits**
- Improves site safety by enhancing operator's situational awareness.
- Reduces cost and machine downtime due to accidents.
- Does not require any off-board infrastructure.
- Easy to learn display interface.
- Minimizes nuisance audible alarms.
- Scalable solution allows user to start with camera system and later add radars.
**Cat® Integrated Remote Control™**

The Cat® Integrated Remote Control™ system enables machine operation from a safe location with the operator removed from the cab. This system enhances operator safety by limiting exposure to full body vibration, dust and sound, and slips, trips and falls from machine ingress/egress. The machine is controlled remotely through use of an Operator Console which is an over the shoulder, line of sight unit. Integrated Remote Control is ideal for use in hazardous situations such as stockpile operations, cleaning up high wall and bench failures, or working with hazardous materials. This system is integrated with engine, implement, and power train controls. Safety controls are built in which stop the machine in case of the loss of radio, transceiver, or ECM communications. The machine will also stop in the event the Operator Console is tipped. Additional protection features include the use of auto-brakes when in neutral and engine over-speed protection. Perhaps the most unique feature is the integration with the Computer Aided Earthmoving System (CAES) avoidance zone functionality which prevents the machine from entering predefined avoidance zones.

Advantages of Integrated Remote Control include:
- Improved system response (more direct control of electro hydraulic system)
- Improved reliability/serviceability (fewer parts/hardened components)
- Enhanced performance features (AutoCarry, ABA)
- Faster installation times (fewer parts)

Engine controls include:
- Engine Start
- EngineShutdown
- Engine Speed/Throttle
- Engine Deceleration

Implement controls include:
- Blade Control (raise/lower, tilt left/right, pitch forward/back, float)
- Single/Dual Tilt Blade Mode (assuming dual tilt is installed on machine)
- Auto Blade Assist Mode
- AutoCarry
- Ripper Control (raise/lower, in/out, auto stow)
- Implement Lockout

Power train controls include:
- (FNR) Direction
- Gear (1 or 2)
- Steering
- Bi-directional AutoShift
- AutoKickdown
- Service Brake
- Parking Brake

Auxiliary controls include:
- Machine Power
- Lights
- Horn
MINEGEM™ UNDERGROUND MINING AUTOMATION SYSTEM

Developed out of the need to reduce human exposure to injury, the system removes the operator from dangerous situations and allows them to work in a more comfortable, ergonomic environment. Using technology to automate and enhance operations, the Cat MINEGEM system will increase productivity and make a measurable impact on your mine’s bottom line.

MINEGEM offers 2 levels of control:
- Co-pilot: operator-assisted automatic steering
- Auto-pilot: machine is operated under its own self-guidance system

MINEGEM consists of four major sub-systems that support the functionality of the system.

Operator Station

The Operator Station allows machines to be operated from an ergonomically designed seat in a variety of locations. The operator can safely operate the machine from a mine control room or mobile office, either above or underground. This removes the operator from potentially dangerous environments in the mine drives underground. The Operator Station consists of a computer, three monitors, a seat and two joysticks; one controlling the movement of the machine, the other controlling the bucket.

Machine Automation System

The Machine Automation System consists of the on-board hardware components that make the MINEGEM system function. LADAR, cameras, lights, sensors, antennas, and control modules combine to create a system that provides safety and productivity for your underground mining operation.

Area Isolation System

Ensures that personnel cannot enter or equipment cannot leave the Operations Area while the machine is in autonomous mode. The operator has the ability to arm and disarm the system to compensate for changing business needs. A barrier control panel is located at each entry to the Operations Area. These are connected to barriers to ensure the area is secure. The status of each barrier control panel is reported to the programmable logic controller via the Local Area Radio Network (LARN). The programmable logic controller then determines whether the Operations Area should be armed.

Local Area Radio Network (LARN)

The LARN is a wireless Ethernet data network that enables communication between the machine and the operator station. The network uses the 802.11 b/g protocols and requires exclusive use of the 2.4 GHz RF spectrum.

Signals from the Machine Automation System roam between LARN antennas as the machine moves within the operations area. The signals work primarily over line-of-sight, but can reach a short distance around corners. Video images and data are sent via the LARN.
WORK AREA VISION SYSTEM (WAVS)

Cat WAVS is offered in one, two or three camera configurations for Cat machines and your entire fleet. WAVS meets Caterpillar’s rugged testing to function in tough environments and to withstand harsh climates.

Operators are finding that the use of a reliable camera system allows them to efficiently accomplish the job with minimal risk of machine incidents. Less risk on the job reduces liability and maximizes profit.

Site Assurance

Position the cameras to view blind spot locations; this reduces machine incidents due to poor visibility. Cameras will reduce the guessing of machine surroundings.

Work Efficiency

Enhanced visibility around machines increases up-time, operator efficiency and productivity.

Ergonomics/Comfort

Operator maintains forward direction as display shows machine surrounding and reduces operator’s positional motion.

WAVS improves productivity by increasing the operator’s field of visibility. The closed circuit camera system can be integrated into the machine so the camera view will be automatically prompted based on camera set-up preference. For example, when the machine is placed in reverse the rear camera is automatically displayed.

7" Color LCD Display
- Auto-sensing illumination for changes in light conditions
- 2 Camera views available
  - Panoramic 115°
  - Narrow 78°
- Splash-proof
- Adjustable mounting

Camera
- Robust design withstands 15G’s of vibration and protection from high-pressure washing
- Includes internal heater for removal of condensation, snow, and ice
- Chemically hardened glass, which prevents breakage, scratches and damage