



# CAT<sup>®</sup> COMPACTION CONTROL TECHNOLOGIES

*For Asphalt and Soil*

**BUILT FOR IT.™**



# QUALITY. UNIFORMITY. CONFIDENCE.

*Compaction technologies from Caterpillar enhance work site efficiency and ensure high quality work.*

**Cat® Compaction Control is a suite of technologies that empower the compactor operator by providing data that can improve performance, leading to better quality and greater efficiency.** These technologies, including measurement, positioning and analysis systems, build upon each other and are the foundational components of what Caterpillar defines as an “intelligent compaction” system.

Traditionally, compaction has been an inexact science. Operators rely primarily on intuition and their own senses, or alternatively follow a “method specification” procedure to complete compaction work. Point-by-point testing methodology reveals areas of inadequate construction, followed by the inevitable rework to bring failed areas up to the specified quality. This process has been acceptable in the past, but

governmental agencies are demanding more accountability for the quality of road work, and greater service life from the roads that are built. As road building costs increase and the construction business becomes more competitive, contractors are also looking for ways to increase efficiency and reduce the amount of rework.

Cat Compaction Control helps compaction operators to understand job site factors that lead to quality, uniform compaction. Rather than relying on intuition and guesswork, operators use real time data from Cat Compaction Control to analyze and deduce when the compaction conforms to specification, ensuring complete coverage and efficient, uniform work, allowing them to move on to the next job when the work is complete.



**INTELLIGENT  
COMPACTION**

## **MEASURE.**

Cat Compaction Control technology allows the operator to monitor work site conditions that affect job quality and efficiency in real time.

## **DOCUMENT.**

GNSS (Global Navigation Satellite System) positioning technology allows operators, site supervisors and engineers to record and visualize the quality and uniformity of the work over the entire site.

## **ANALYZE.**

Data collected can be analyzed and used for documentation or to simply uncover hidden efficiencies.

# UNDERSTANDING COMPACTION MEASUREMENT

**Density** is the traditional measurement that agencies use to assess the capability of a compacted material to support the load placed upon it. However, compaction measurement technology available for soil and asphalt compactors measures **indications of stiffness**. *Stiffness* is the ability of a certain volume and shape of material to resist deformation and is considered a more direct reflection of load bearing strength than density.

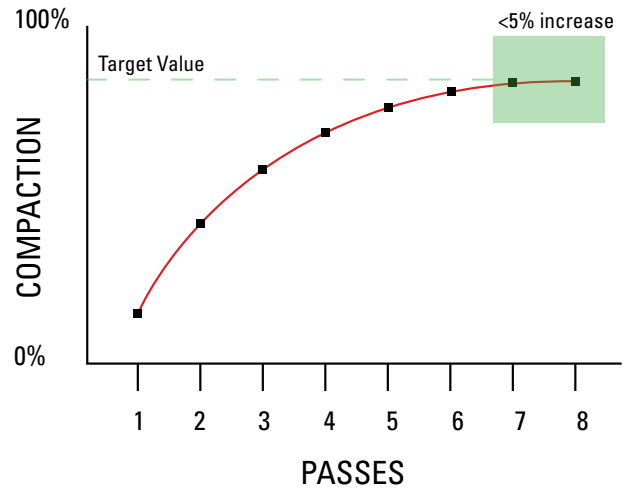
It is important to recognize that what the system on the compactor is measuring is not the same as the measurement used by agencies to determine if the work meets specifications, and they can be difficult to correlate. Despite this, the different measurements are able to reach the same goal of quality compaction using different methodologies. In the case of the compactor-borne system, it can guide the operator to ensure that compaction will meet specification.

When the compactor makes a measurement, the value is the product of a vast number of variables: soil composition, the effect of moisture, the weight of the compactor, environmental factors, temperature. These variables are constantly changing as the compactor works, and thus the measurements can change as well. Two identical compactors would likely produce different results on the same area of material. For that reason, the measurements are considered to be relative values rather than absolute values—relative to all factors at the time of measurement. In other words, indications.

The systems measure a volume of material at depths that vary depending on the machine used, the material type and other factors. This volume will encompass all layers to the full depth of measurement, providing a composite value. It is important to realize this when you are compacting multiple lifts, thin lifts or asphalt pavement layers. The measurement is essentially an average of all materials to the depth of measurement influence.

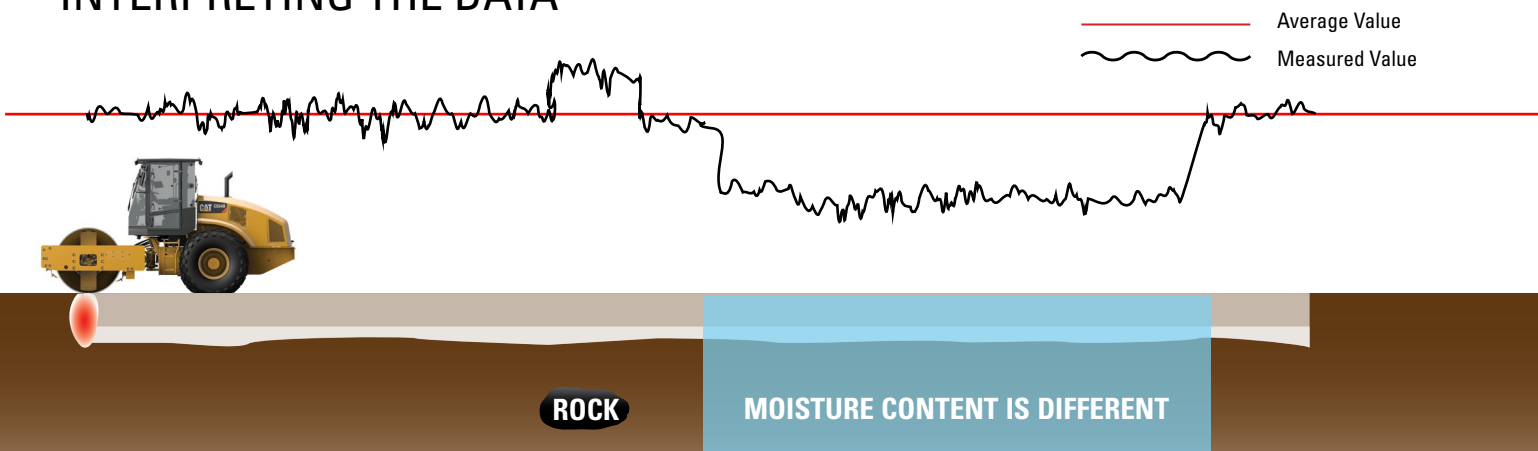


As a compactor works, the operator monitors the measurement values. With each pass, the values increase as the material becomes more compact. Correspondingly, the rate of change between one pass and the next decreases. When this rate reaches a pre-determined range, typically less than 5% change (or what is the equivalent of a few points of value), the operator can be reasonably assured that the material is very near full compaction. At this point the operator can call for the testing crews and move on to the next area. A successful test will allow the operator to establish the **target value**, a benchmark or compaction value goal for that area that indicates compaction likely meets the specification.



*With each subsequent pass, compaction increases and the rate of increase becomes less. When the percent of increase diminishes to less than 5%, the Target Value can be established.*

## INTERPRETING THE DATA



The many variables found on any compaction job have a great effect on the measurements. When conditions lack uniformity or are not consistent, the measurement values can vary.

**Variability** is regarded as an indication of the reliability of a measurement. Simply put, the more the measurements vary over a patch of ground, the less reliable they are. It is normal for the measurements to vary a small amount— however, the greater the degree of variability, the less reliable the measurement. When variability is high, it indicates that something is preventing accuracy. This can be a change in soil composition, a change in soil moisture or other factors.

For example, accelerometer based measurement systems (like CMV) use a vibrating drum to strike the ground, and then measure the ground reaction. Clayey soils are highly elastic

and have a muting effect on the vibrations, which make the measurements vary widely. Granular soils transmit the vibrations well, so the measurements vary less. This is the reason that CMV is recommended for use on granular soil but not on clays.

However, values can suddenly increase or decrease during a period of low variability. This can be an indication of a problem in the materials: the presence of a boulder, a clay ball or a buried tree trunk, for example. If the general range of the values changes it can indicate a change in the moisture content or the composition of the material. The data can indicate when further investigation is necessary.

# SOLUTIONS

	Vibratory Soil Smooth Single Drum	Vibratory Soil Padfoot Single Drum	Vibratory Asphalt Double Drum	Pneumatic Tire
Machine Drive Power (MDP)	✓	✓		
Compaction Meter Value (CMV)	✓		✓	
MDP and CMV	✓			
Temperature			✓	✓
GNSS Mapping	✓	✓	✓	✓
Auto Adjustable Compaction (AAC)			✓	
Machine-to-Machine	✓	✓	✓	✓

## SOIL TECHNOLOGIES

### COMPACTION METER VALUE (CMV)

- Accelerometer-based
- Provides an indication of soil stiffness at depths between 1-1.2 m (3-5 feet) depending on machine size and soil conditions
- Smooth drum machines on granular soil

### MACHINE DRIVE POWER (MDP)

- Energy-based
- Provides an indication of soil stiffness at depths between 30-60 cm (1-2 feet) depending on machine size and soil conditions
- Smooth or padfoot drum machines on granular or cohesive soil
- Measures with vibration on or off

## ASPHALT TECHNOLOGIES

### COMPACTION METER VALUE (CMV)

- Accelerometer-based
- Provides an indication of the stiffness of the road, represented as a composite value of the asphalt layers as well as a portion of the base conditions underlying
- Tandem drum vibratory compactors

### TEMPERATURE

- Infrared sensors
- Provides real time measurements of mat temperatures
- Allows the operator to efficiently compact the mat and keep up with the paver
- Tandem drum vibratory compactors and pneumatic tire compactors

### AUTO ADJUSTABLE COMPACTION (AAC)

- Ensures the machine applies the optimal amount of compaction force into the asphalt without the direct command of the operator

## POSITIONING TECHNOLOGIES

### GNSS MAPPING

- Utilizes global navigational satellite constellations to map and record the position of measurements made
- Allows the operator to visualize the progress of work as well as enabling the documentation of work quality for the purpose of analysis
- Several correction options are available depending on the degree of accuracy desired, including autonomous, SBAS and RTK

### MACHINE-TO-MACHINE COMMUNICATION

- Allows operators to see the progress of their machines as well as the progress of machines working the same area, helping to ensure maximum efficiency, full coverage and uniform quality

# GRANULAR OR COHESIVE SOIL

*Note: smooth drum machines can also use MDP technology.*



cm	in
30	— 12
60	— 24
90	— 36
120	— 48



**MDP**

Depth of measurement influence

# GRANULAR SOIL



cm	in
30	— 12
60	— 24
90	— 36
120	— 48



**CMV**

Depth of measurement influence

# ASPHALT AND BASE LAYERS



cm	in
30	— 12
60	— 24
90	— 36
120	— 48



The measurements are a composite value of all layers to the full depth of compaction influence— this can include multiple asphalt and/or soil layers

**CMV**

Depth of measurement influence

# SOIL TECHNOLOGIES

## TWO MEASUREMENT TECHNOLOGIES AVAILABLE

- Provide indications of soil stiffness
- Technologies suitable for wide range of applications
- Technologies complement each other; each provide unique capabilities
- Smooth drum (CS) soil compactors can have both technologies on one machine, providing widest application range and maximum versatility

### CMV - COMPACTION METER VALUE

- Measures only when vibratory system is active
- Provides indications of soil stiffness
- CMV (Compaction Meter Value) is accelerometer-based
- For use on smooth drum (CS) machines only
- Suitable for granular applications
- Measures deep: 1 to 1.2 m (3.3 to 4 ft), depending on materials

### MDP - MACHINE DRIVE POWER

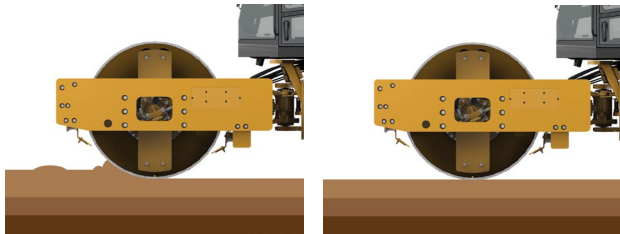
- Provides indications of soil stiffness
- Energy-based measurement correlates compaction with rolling resistance; does not require vibration
- For use on all Cat compactors over 10 metric tons: smooth drum (CS) or padfoot (CP), or smooth drum models with padfoot shell kits
- Suitable for granular and cohesive soil applications
- Measures to the depth of an average lift: 30-60 cm (12-24 in)
- Measures with the vibratory system active or inactive



# MACHINE DRIVE POWER (MDP)

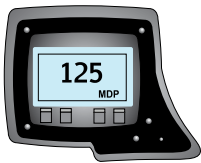
## HOW DOES IT WORK?

MDP measures the **energy necessary to overcome rolling resistance**, a more tangible and direct indication of **soil stiffness**, converting it to an estimated unitless value.



Propelling over soft ground requires more energy

Propelling over stiff ground requires less energy



Cat® Compaction Control - MDP Gauge on Standard LCD Display



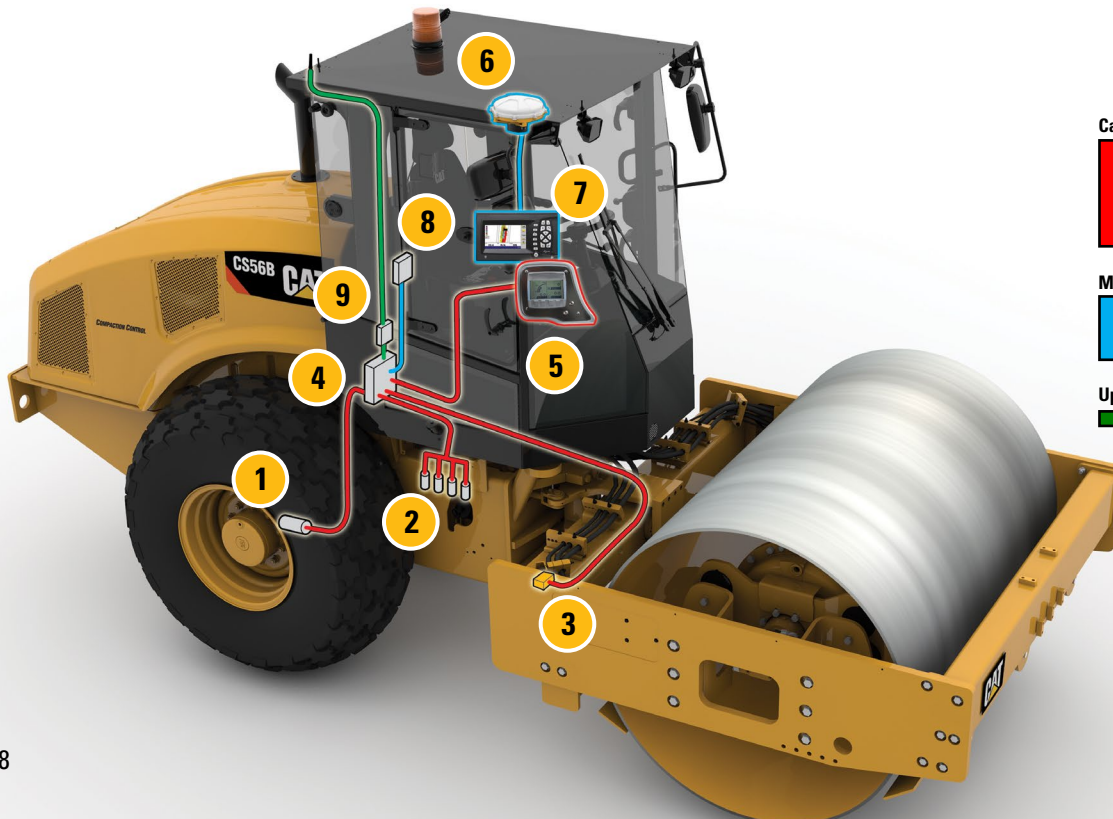
Mapping Color Display

## WIDE APPLICATION RANGE

- MDP compatible with all soil types: fines, granular and cohesive
- MDP compatible with smooth drums, padfoot drums or smooth drums equipped with padfoot shell kits
- MDP measures with the vibratory system on or off, allowing operators to measure during working passes and shut the vibratory system off for proofing passes
- System is scalable, flexible with wide range of target potential

## MORE CONFIDENCE IN THE MEASUREMENT

- MDP closer to the depth that the machine is able to compact, closer to the thickness of the lift
- MDP measurements are more easily correlated to portable measuring devices that testing personnel utilize (plate load test, for example)
- Intuitive system:
  - Loose materials require more energy to propel through
  - Stiff materials require less energy to propel through
- MDP measurements are less affected by the dampening effect of cohesive soils; you can trust the measurement
- Less variability compared to other compaction measurement technologies available on the market makes measurement more trustworthy



### Cat Compaction Control - MDP

- 1. Speed Sensor
- 2. Pressure Sensors
- 3. Angle Sensor
- 4. Controller
- 5. LCD Display

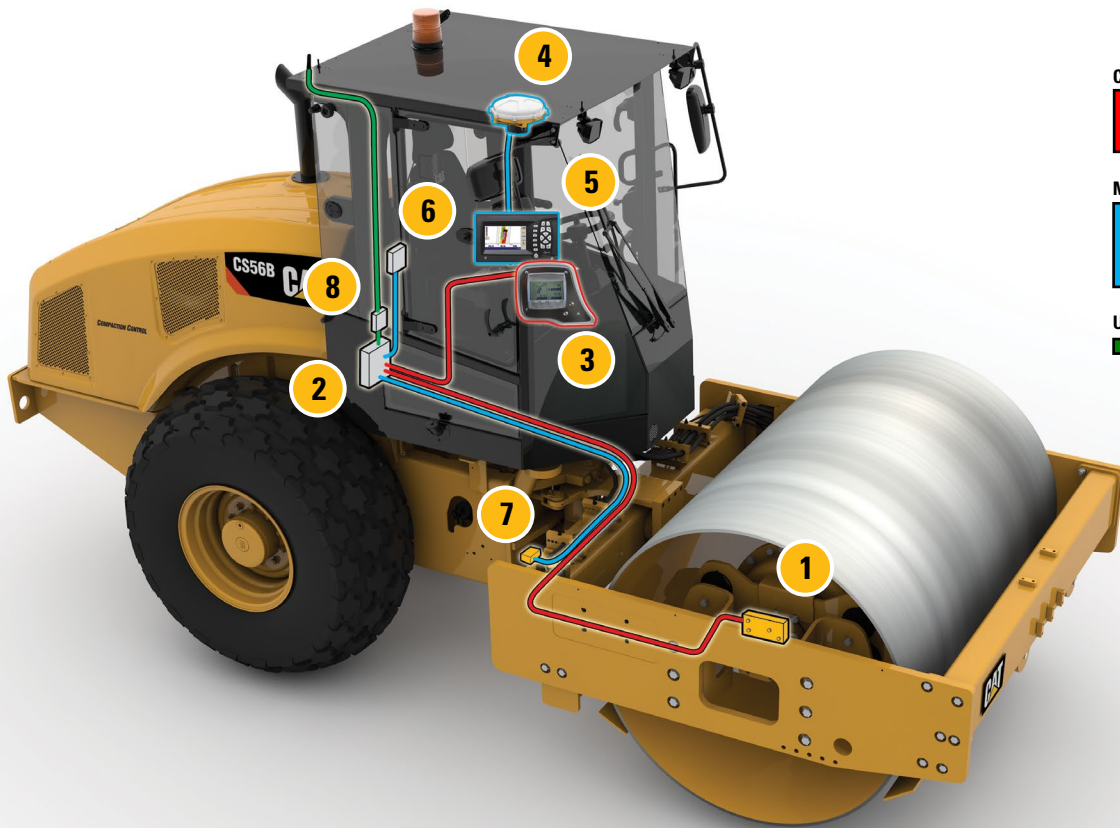
### Mapping, SBAS

- 6. GNSS Antenna
- 7. Color Display
- 8. GNSS Receiver

### Upgrade to RTK

- 9. Radio Kit





**Cat Compaction Control - CMV**

- 1. Accelerometer
- 2. Controller
- 3. LCD Display

**Mapping, SBAS**

- 4. GNSS Antenna
- 5. Color Display
- 6. GNSS Receiver
- 7. Angle Sensor (optional)

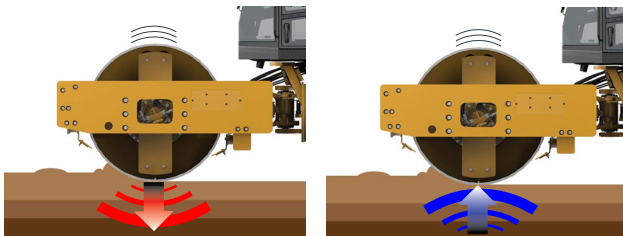
**Upgrade to RTK**

- 8. Radio Kit

# COMPACTION METER VALUE (CMV)

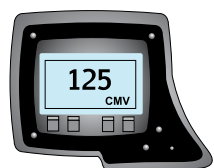
## CMV – HOW DOES IT WORK?

CMV calculates an **indication** of **soil stiffness**, converting it to an estimated unitless value.



Vibratory energy is imparted on the soil by the vibrating drum

The material vibrates in response, which is detected and measured by the accelerometer



Cat Compaction Control - CMV Gauge on Standard LCD Display



Mapping Color Display

## INDUSTRY-STANDARD TECHNOLOGY

- Most intelligent compaction solutions available on the market are accelerometer-based technologies

## MEASURES DEEP

- CMV measures 1 to 1.2 m (39 to 48 in) deep depending on the soil type, moisture and other factors
- CMV can indicate the presence of buried objects (rocks, tree trunks, clay balls) that could affect the quality of the base
- CMV can provide indications of soil stiffness as well as need for additional moisture to aid compaction
- CMV helps contractors find and remedy potential problems while the ground is open and the costs are lower
- Reliable solution for granular materials
- Less reliable for cohesive materials

# ASPHALT TECHNOLOGIES

## COMPACTION METER VALUE (CMV)

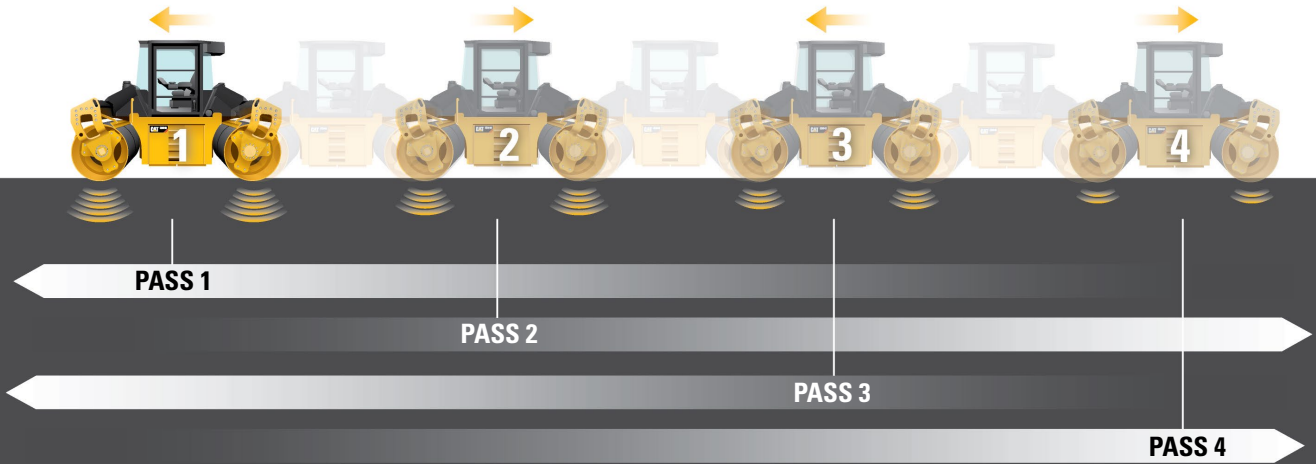
### HIGHLIGHTS

- CMV technology utilizes a drum-mounted accelerometer to measure and record composite stiffness of the material below the drum
- A unitless value calculation derived from the recorded data provides an indication of composite stiffness
- The unitless value calculation is referred to as a "composite stiffness value" that indicates stiffness of the current and supporting layers beneath the drum
- Scalable accuracy to provide the highest level of Global Navigation Satellite System positioning (GNSS)
- Mapping system is able to record compaction, frequency, and pass-count data to the specific location the measurement was taken

*Compaction Meter Value is a combined stiffness of the asphalt layer, base layer(s) and sub-base materials.*

*CMV can help indicate road structure health on "mill and fill" applications.*





# AUTO ADJUSTABLE COMPACTION

AVAILABLE ON CB54B AND CD54B ONLY

## EXCLUSIVE COMPACTION PERFORMANCE

- Front and rear drums are equipped with auto-adjusting technology
- Each drum is controlled independently
- Delivers highest level of amplitude without over-compacting
- Dedicated accelerometer and processor controls each drum

## SIMPLE OPERATION

- Automatic feature simplifies operation and optimizes compaction performance
- Controls stay with the operator when swiveling the seat

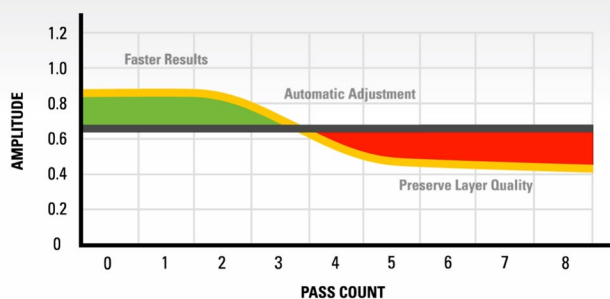
## INCREASED PRODUCTIVITY

- Optimizes performance, helpful near sensitive structures
- Full range of amplitude adjustment occurs in as little as 4 seconds
- Eliminates de-coupling and damage to asphalt
- Sensitivity adjustments for a variety of mix designs
- Meets VT2 classification for Europe

## LOWER COST COMPACTION

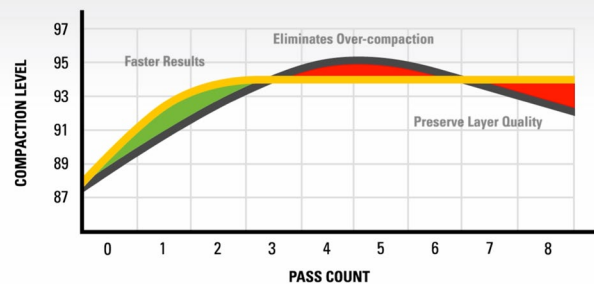
- Uniform compaction helps meet quality standards
- Minimal training required for inexperienced operators

**AUTOMATIC ADJUSTMENT. RIGHT RESPONSE.**



Auto Adjustable Compaction (AAC)  
Conventional Systems

**AAC OPTIMIZES MAT QUALITY**



Auto Adjustable Compaction (AAC)  
Conventional Systems



# PASS-COUNT AND TEMPERATURE MAPPING

## PASS-COUNT MAPPING

- Achieve target density and increase roller efficiency
- Record and monitor pass pattern to ensure consistent coverage
- Optimize drum overlap to help keep pace with the paver
- Simplify nighttime operation
- Prevent incomplete passes
- Prevent overcompaction by overworking areas

## TEMPERATURE MAPPING

- Provides a visual readout of mat temperature to keep the machine in the proper temperature range
- Records and monitors temperature for future analysis of the proper temperature range

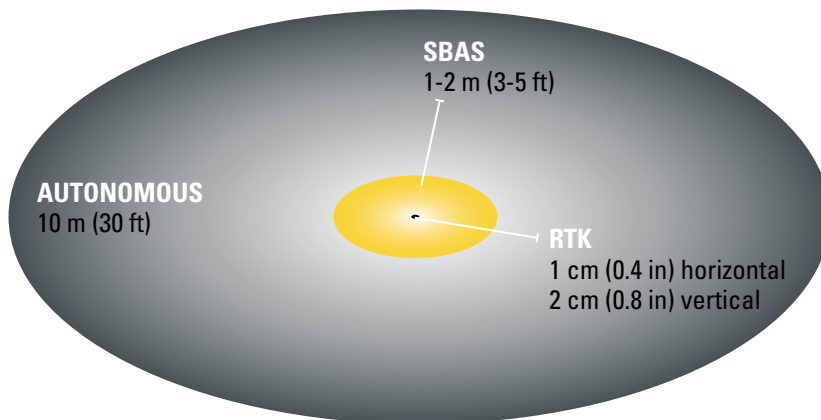
## TEMPERATURE SENSORS

- Dual infrared (IR) sensors mounted on the front and rear of the machine deliver real-time temperature readings
- Air-purged IR sensor minimizes inaccurate readings caused by debris on sensor
- Keep operator informed of when to begin rolling and when to stop
- Help avoid tender-zones that often occur in the 104°-110° C (219°-230° F) temperature range
- Optimal mat temperatures for compaction
  - Upper limit is around 149° C (300° F)
  - Lower limit is around 85° C (185° F)
- Eliminates hand-held devices; sensor readouts are integrated into standard machine display



# POSITIONING TECHNOLOGIES

FOR SOIL OR ASPHALT APPLICATIONS



**MAPPING ACCURACY**  
(day-to-day float)

## **Autonomous**

The uncorrected satellite positioning signal. Not typically used for construction purposes.

## **SBAS: Satellite Based Augmentation System**

System triangulates to multiple ground-based "anchor" points to provide a correction measurement for the satellite signal.

## **RTK: Real Time Kinematic**

Utilizes local radio base stations (UTS - Universal Total Stations) or cell/modem based technologies (VRS - Virtual Reference Stations) to provide the highest degree of correction of the satellite signal. Can provide elevation data in addition to ground positioning.

## **GNSS MAPPING TECHNOLOGY**

- Ties compaction or temperature measurements to the location they were taken
- Keeps track of pass counts and coverage to ensure uniform work
- Provides real time maps of compaction work
- Allows operators, managers and agencies to visualize and monitor work as it happens
- Provides documentation for quality
- Versatile options whether accuracy or value is paramount: SBAS, RTK
- Initial investment can be scaled up to meet job-specific needs





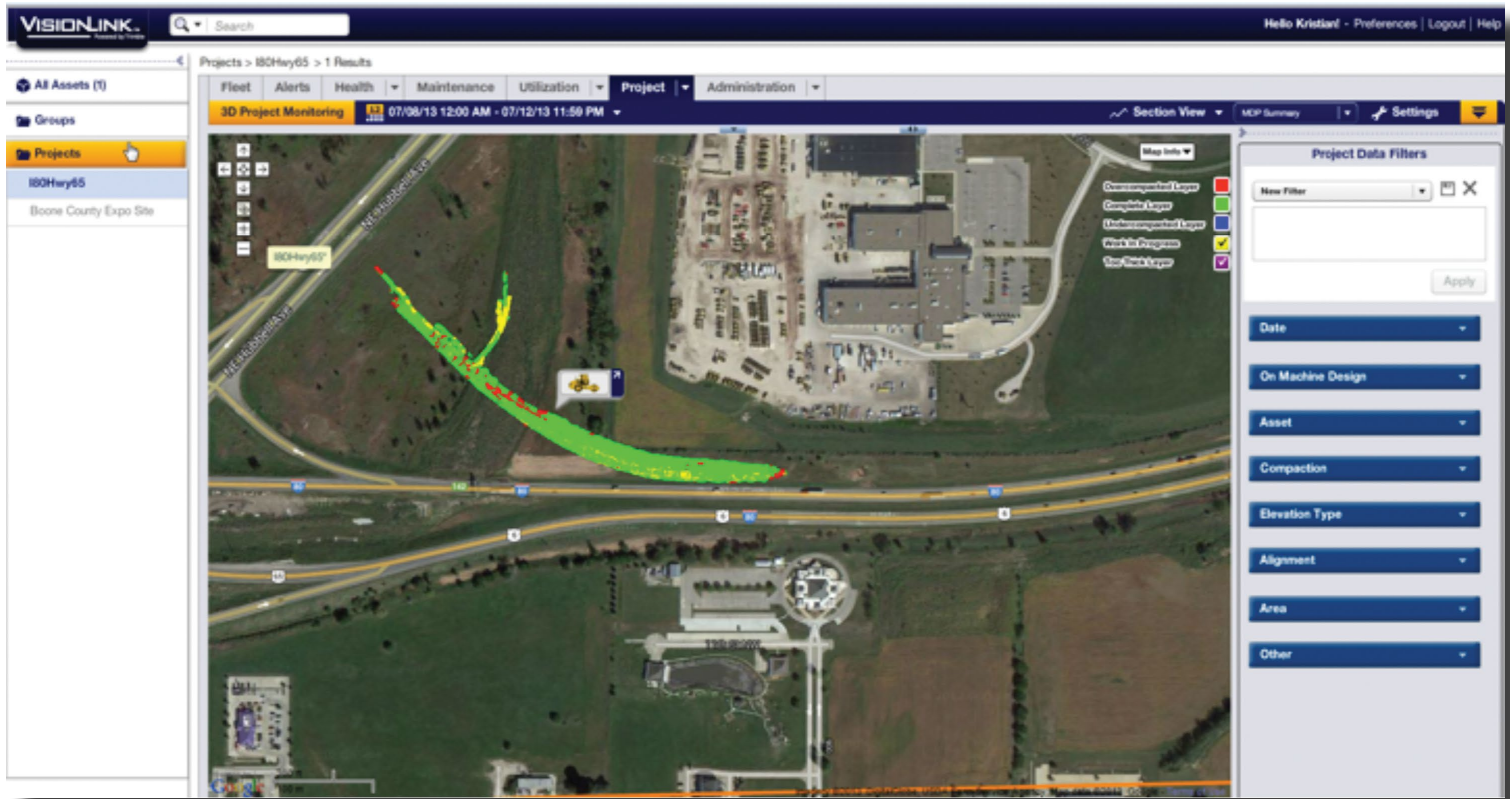
## MACHINE TO MACHINE COMMUNICATION

### IMPROVE COMPACTION RESULTS

- Shows composite real time progress of multiple machines
- Improves job site efficiency
- Easily monitor fleet patterns
- Pickup pass patterns where others left off
- Simplify nighttime operation



# DOCUMENTATION AND ANALYSIS



## DOCUMENT THE WORK WITH VISIONLINK™

- Allows managers and agencies to monitor progress of the work in real time
- Provides detailed project data for documentation
- Data can be mined to reveal hidden efficiencies that may reduce operational costs
- Make decisions for rework early, when costs are lower

Caterpillar has a legacy of introducing innovations that have changed the way the world builds roads. Technology that makes the work easier, the results more predictable and the costs lower. We partner with our customers to ensure that the equipment we provide meets their expectations and helps them to grow their business. And with each new generation of machines we introduce, more and more customers around the world make the decision to switch to Cat.

For more complete information on Cat products, dealer services, and industry solutions, visit us on the web at [www.cat.com](http://www.cat.com).

**BUILT FOR IT.™**



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