The Technology and Use of Intelligent Compaction Equipment

Caterpillar Paving Products

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Why is compaction important?

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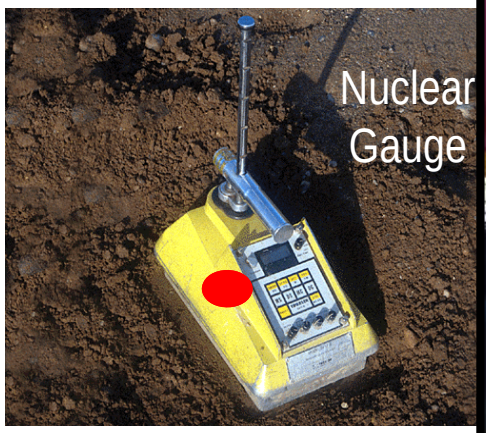
With the conventional compaction measurement, what percentage of the surface is actually tested?
Less than 1%

Conventional Measurement Methods



Intelligent Compaction

Make Every Pass Count

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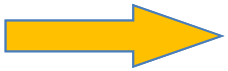
What does it take to compact asphalt?

Asphalt compaction – temperature of the asphalt layer

- Stiffness of asphalt

Machine – static and dynamic forces

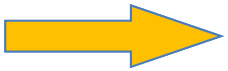
- Machine mass - static forces PLI
- Vibratory systems – dynamic forces
  - flexible amplitude range and frequencies



Machine Setup for Optimized Performance

Operator – performs the rolling pattern

- Where did I stop on the previous pass?
- Did I go back far enough on the return pass?
- Did I provide enough overlap on the previous pass?
- Is the mat temperature too hot, too cold?
- Night working?



Process Control and Measurement

What are the top 2 contributors to the inability to achieve density/stiffness on asphalt or soil?

1. Proper machine usage to ensure the highest amount of energy is applied to the asphalt or soil layer to create stiffness and load carrying capacity.

2. Consistent compaction coverage of the asphalt / soil layer at a temperature / moisture where compaction can take place.

Process Control and Measurement

The answer… Cat Compaction Control

Auto-Adjustable Compaction System

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Auto-Adjustable Compaction System

Auto Adjustable Compaction

Why it's superior…..

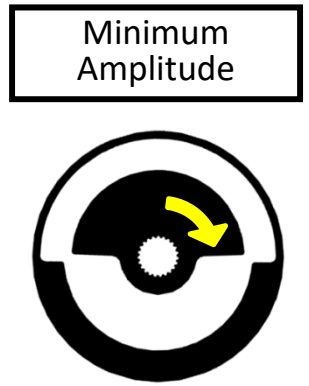
Automatic Smart drum | Automatic Smart drum

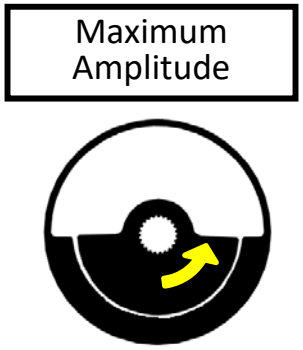
- Dual adjustable Drums - Consistent compaction
  - Intelligent Drum Technology on both drums
    - Leading drum always has optimized amplitude – no matter the direction to ensure superior compaction.
    - Dedicated accelerometer and ECM controls the each drum to deliver the highest performance
    - Industry leading response for min to max amplitude

  - Simple operation at the operators finger tip
    - Allows the operator for focus on the correct pattern
  - Automatic control feature
    - Manual available for highly experienced operators

How it functions…..

- The Automatic System
  - Independently on each drum, the eccentric weight generates vibration then transmits this energy via the drum into the asphalt mat. The asphalt mat responds with feedback energy, this energy is measured by an accelerometer.
  - The Automatic Adjustable system then changes the amplitude, by phasing an internal and external eccentric mass, to a near decoupling state.
    - This state represents the highest compaction force the mat is willing to accept on each pass.
    - Maximizing the compaction forces will deliver the quickest density/stiffness growth possible.
  - Automatic amplitude adjustment is performed by phasing an inner to outer eccentric weight with relationship to each other.
  - Industry leading response time min to max amplitude
    - Ensures uniform compaction without damage from over compaction





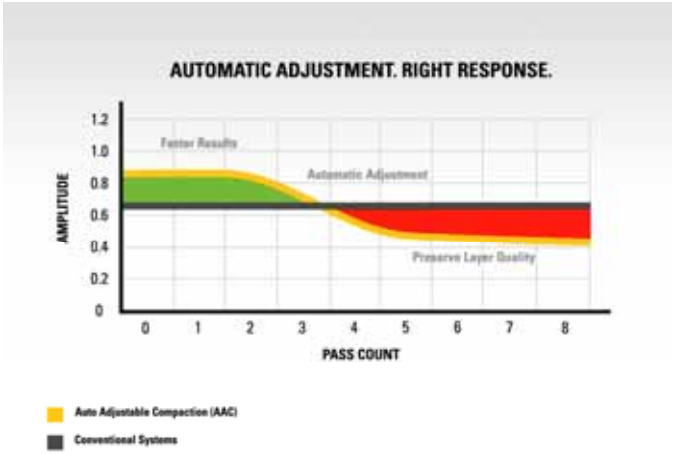
Operation Simplicity…..

- Fully Automatic System
  - Select Frequency set points
    - 42 Hz (2,520 vpm) and 53 Hz (3,180 vpm)
  - Press automatic
    - Automatic – system optimizes compaction efforts for the best results
    - Manual – operator controls the system for customized results
  - Wide Amplitude ranges – used only in manual

Superior Value – Simple, Efficient with Quality Results

Operational Simplicity - Automatic control

- Ensures the amplitude is optimized
- Easy to use for all operators – Simple operation
- Operators see the system value immediately
- Ensures inexperienced operators do not damage the asphalt.

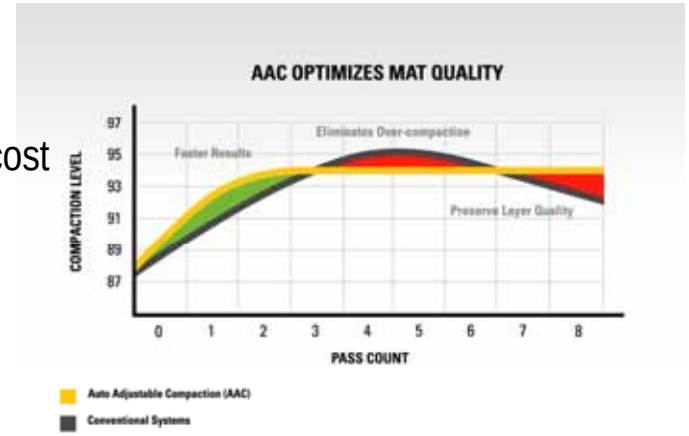


Increased Productivity - Do More

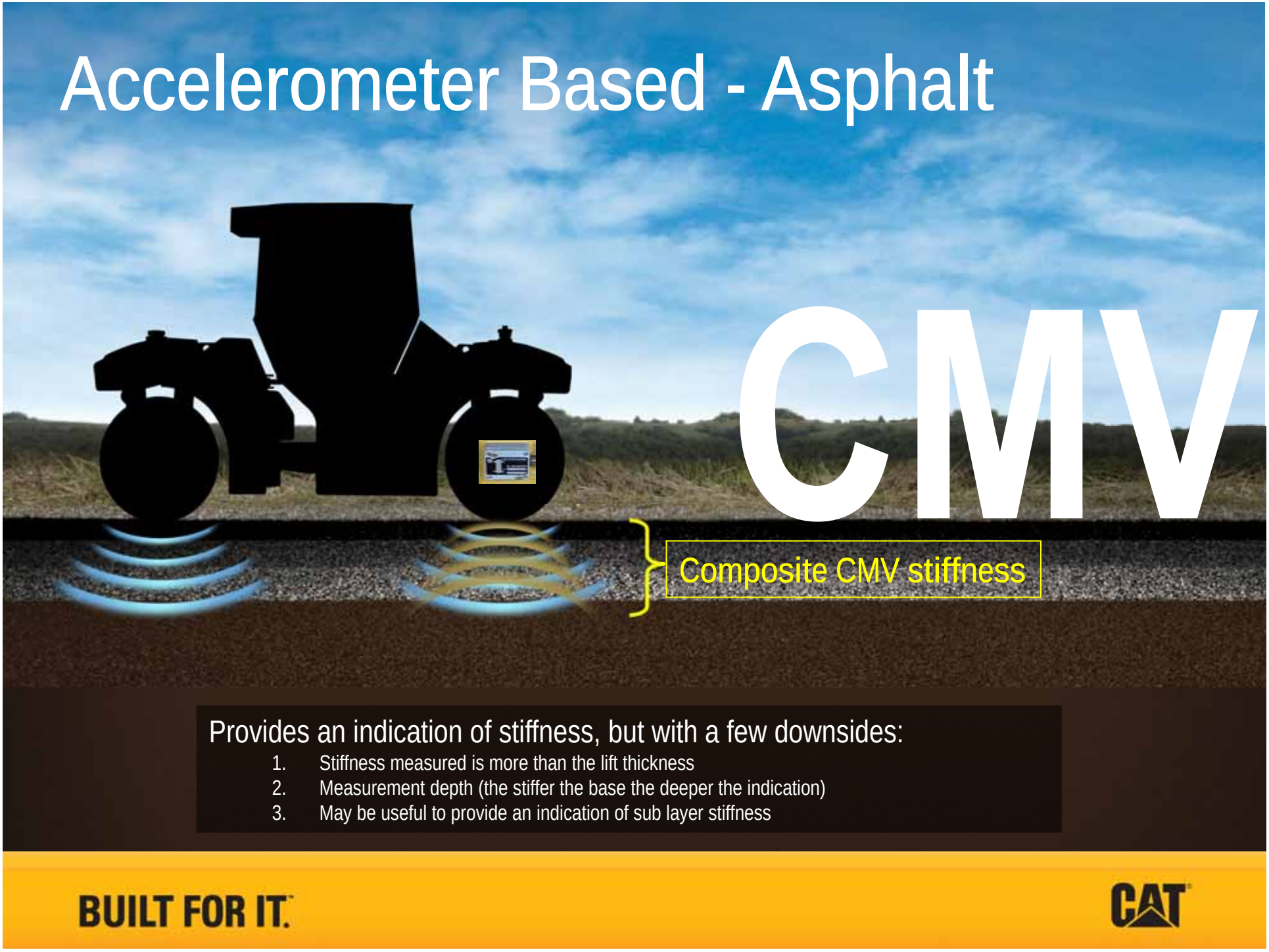
- Intelligent compaction next to sensitive structures
- The system prevents decoupling / damage to asphalt
- Sensitivity customized for different bitumen stiffness.

Quality Compaction

- Homogeneous, uniform compaction creates compaction with less cost
- Reduced risk of over-compaction



Accelerometer Based - Asphalt



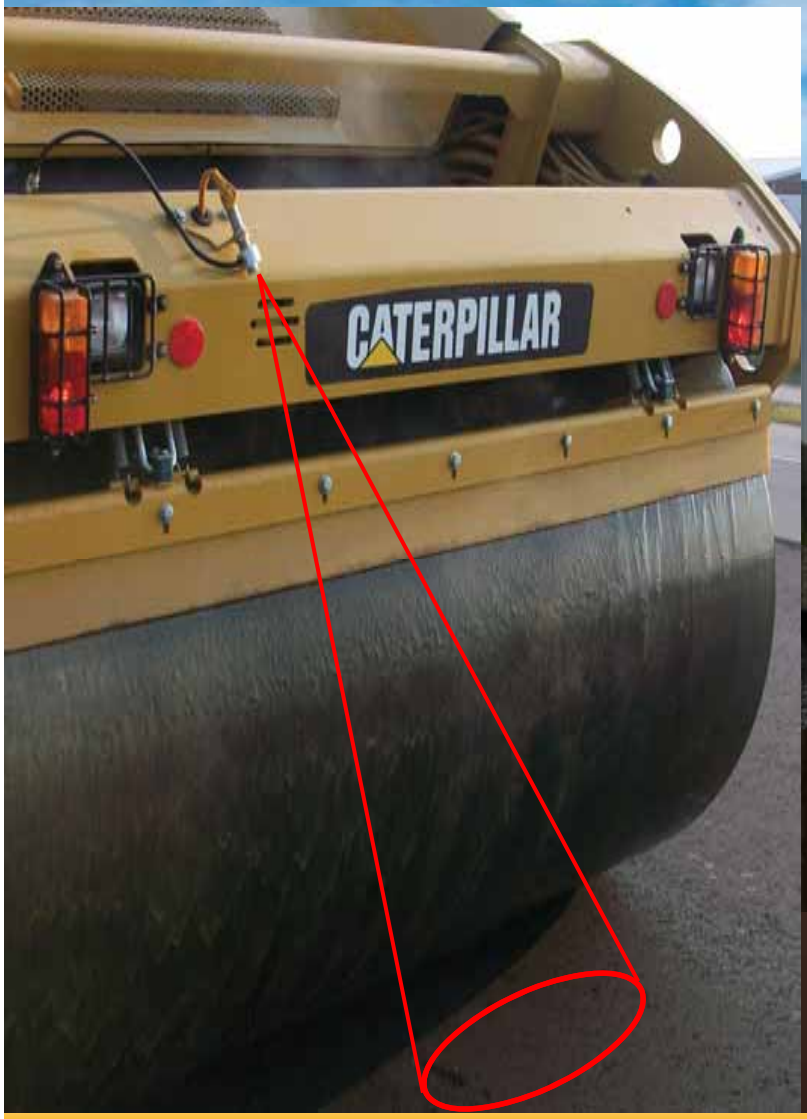
Provides an indication of stiffness, but with a few downsides:

1. Stiffness measured is more than the lift thickness
2. Measurement depth (the stiffer the base the deeper the indication)
3. May be useful to provide an indication of sub layer stiffness

Things to understand about CMV…

- CMV values are influenced by sub-surface conditions
  - Depths may be as deep as 4 feet below the layer of compaction
- CMV is an indicator of material stiffness, NOT a measure of density
- Other devices measure density, shear strength, resilient moduli and bearing strength of the soil
- Correlation between CMV and conventional measurement methods is difficult to achieve
- The IC compactor is its own measuring device and CMV values are not comparable between machines
- CMV values on asphalt must be interpreted as a composite value

Temperature Based - Asphalt



Not a direct measure of compaction, rather, important data for compaction process control on asphalt

- Dual infra-red sensors mounted on the front and rear of machine deliver real-time readings
- *Keep operator informed* of when to begin rolling and when to stop
- *Help avoid tender-zones*
  - often occur in the 104º to 110º C (219º to 230º F) temperature range
- Eliminates hand-held devices

Positioning Data

via GNSS Mapping Capability

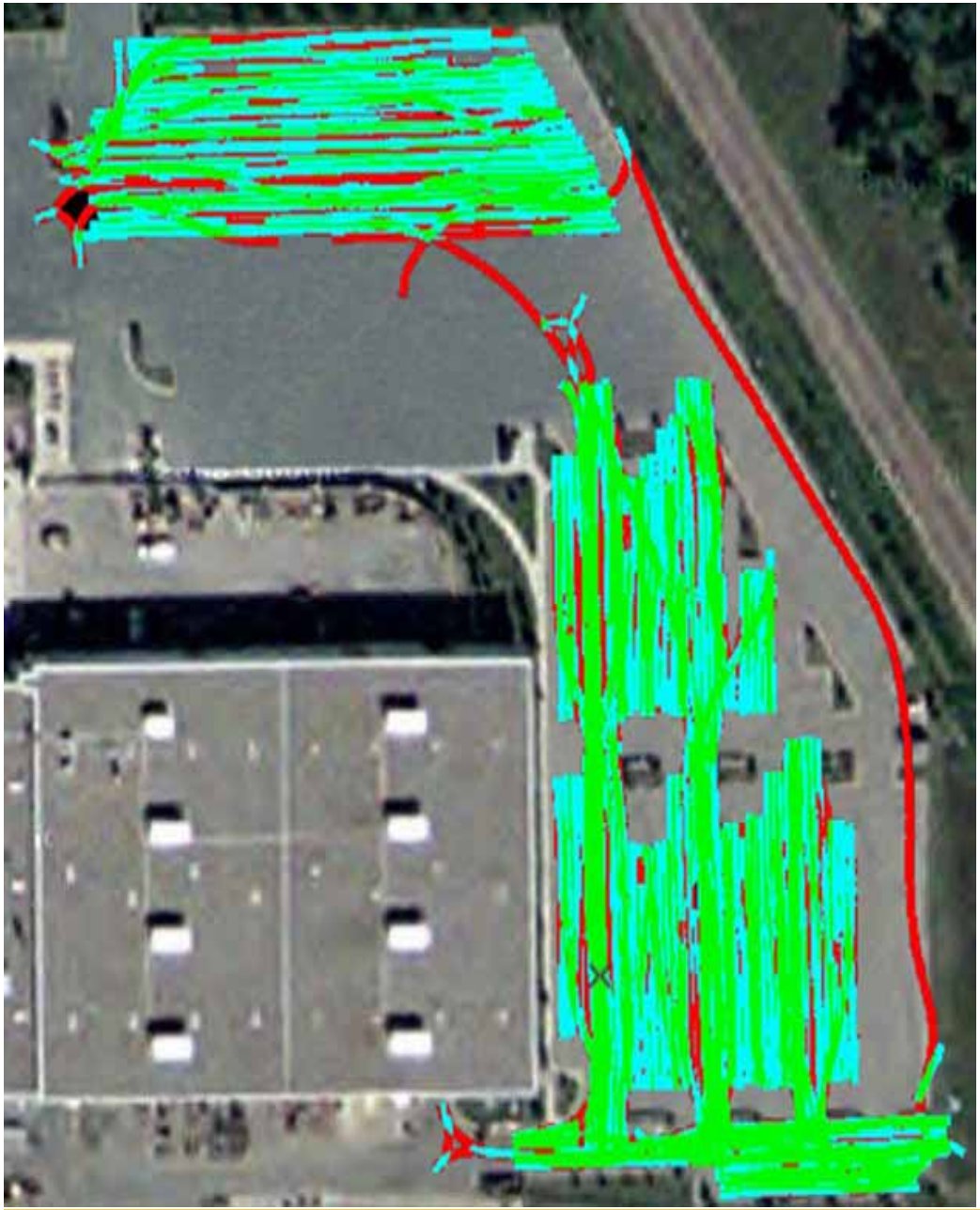
- Utilizes Global Navigation Satellite System (GNSS)
  - GPS, GLONASS
- Correlates measurements to a location
  - Compaction, frequency, pass count, temperature, etc.
  - Documents work
  - Can provide picture of overall compaction consistency
- Choice of accuracy
  - SBAS: provides accuracy to 1 meter; this is the standard package
  - RTK – provides millimeter accuracy; this is an upgrade to standard package

Compactor Data Collection

Data Collection - Parameters

The Compaction Control system displays and records the following:

- Machine Position (GNSS)
- Machine Pass Count
- Pass Coverage
- Compaction Width
- Asphalt Temperature
- Compaction Measurement (CMV)
- Vibratory Status (on/off/rear/both)
- Vibratory Frequency
- Machine Speed
- Direction or travel (forward, reverse)

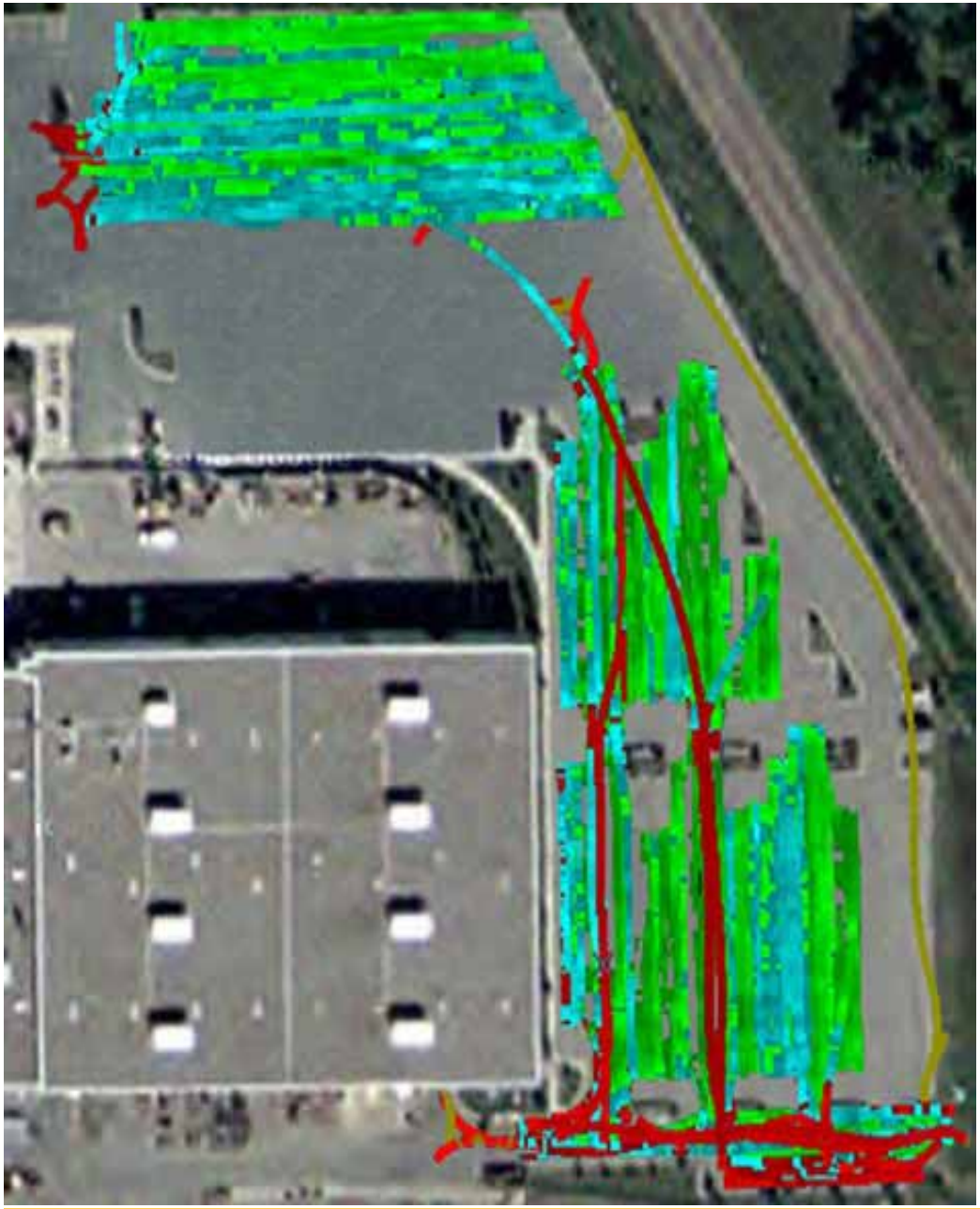


Mapping Passes

This illustration provides the pass-count mapping that occurred in the Minneapolis Cat® Paving factory parking lot. The colors signify the number of times that the drums hit a specific area.

Green – Target pass-count was met
Blue – Target pass-count not met; 1 more passes needed
Red – Target pass-count not met;
2 more passes needed

* Note: The red slivers within the paved areas indicate that there wasn't proper drum overlap



Mapping Temperature

This illustration provides asphalt temperatures as the roller passed over the fresh mat. The color pattern signifies the different temperature ranges that were present.

Green – optimum temperature met
Blue – Target temperature met, lower range than green
Red – Temperature below target

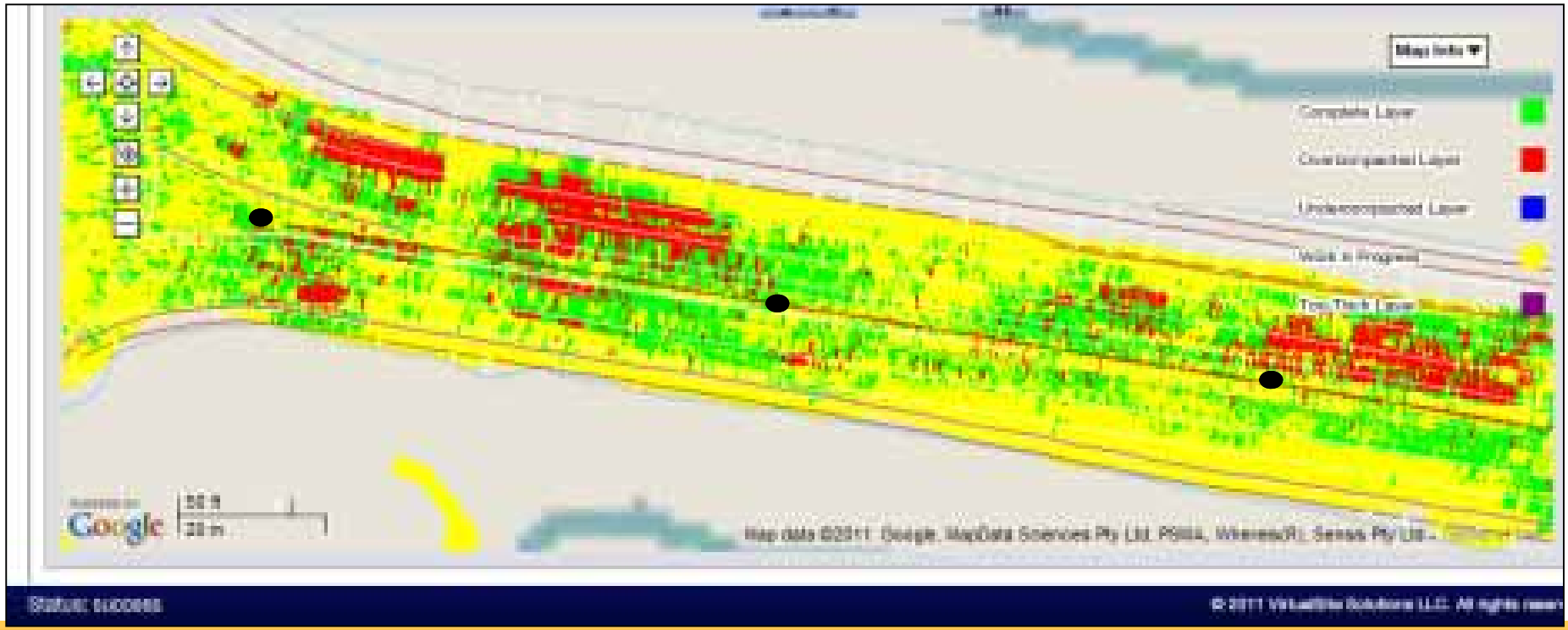
- Upper temperature limit that permits compaction is normally around 149C (300F)
- Lower limit that permits compaction is normally around 85C (185F)
- Avoid “tender zones” if one is present

Echelon compaction – very common in breakdown compaction phase

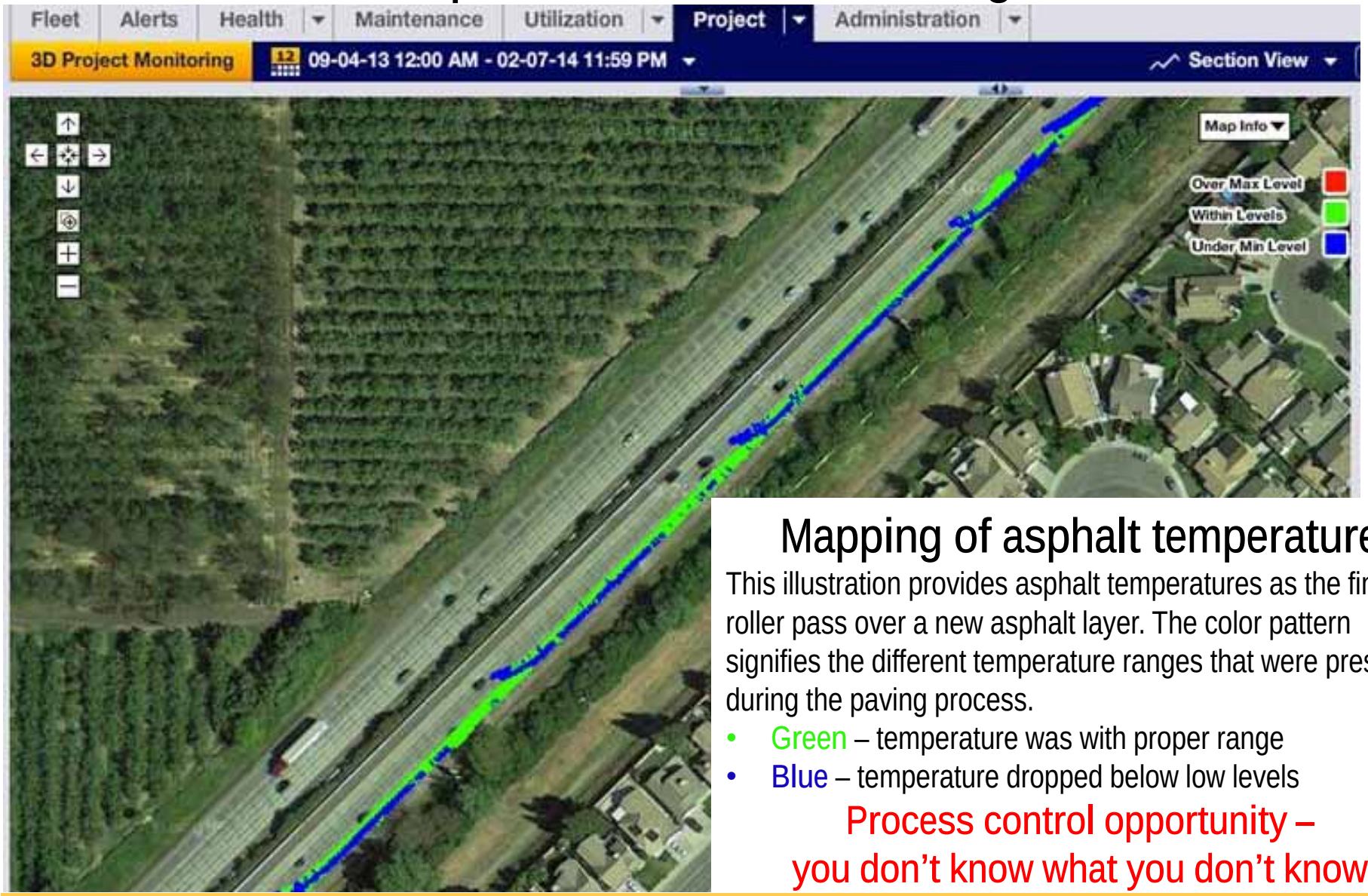
For machine compacting in tandem, machine to machine communication is critical for the highest quality compaction. Enables consistent and uniform coverage.

Data Management

- Web based software used for machine health / project data
- Optional packages to download compaction data for analysis and creation of reports for QC/QA, DOT approval, archives for future reference, etc.
- “Key to unlock the value” of Intelligent Compaction



Temperature Pattern Challenges



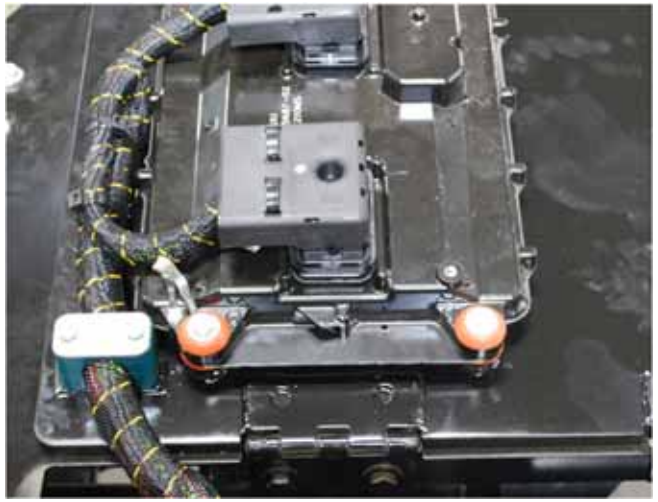
Mapping of asphalt temperature

This illustration provides asphalt temperatures as the final roller pass over a new asphalt layer. The color pattern signifies the different temperature ranges that were present during the paving process.

- Green – temperature was with proper range
- Blue – temperature dropped below low levels

Process control opportunity –
you don't know what you don't know

What allows this new age of information?



Positioning systems (GPS)

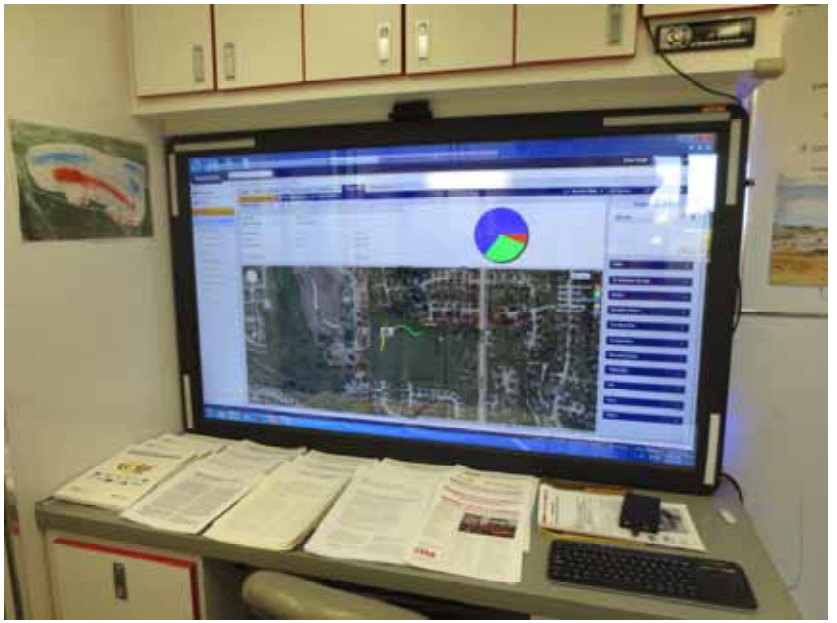
Computing speeds/capacity

CANbus technology

Wireless data transmission

Wireless data near ‘real-time’

Project Management



Courtesy: Dr. White, Iowa State University

So what? How does IC benefit us?

Quality Control & Process Control

- Increased Operator Awareness
  - Real-time compaction (soils), temperature (asphalt), pass count data, early notice of problem areas, etc.
- Improved Rolling Pattern (asphalt)
  - Optimized pass coverage; easier night-time operation
- Improved Density & Smoothness (asphalt)
  - Better understanding of mat conditions
- Lower Operating Costs
  - Maximized machine utilization with better efficiency
- Documentation
  - 100% jobsite documentation
  - Reduced in-field quality control measurement
  - Potential real time data analysis

Technology Innovations

Intelligent Compaction

Caterpillar offered

SITECH offered

- Send data to cloud - VisionLink
- Multiple machine data sharing

SNM940 - and - SNRxxx

MS952 or MT900

CB460

3rd Party Printer

Cat Compaction Control Temperature Sensor

Cat Compaction Control Temperature Sensor

Intelligent Compaction
CMV System

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SITECH CAT

Questions?