

New Equipment Technologies

for Mining, Construction & Paving Industries



62nd Annual Asphalt Conference



Collaboration with CAT Paving for presentation....

- Todd Mansell
Product Application Specialist

- Bryan Downing
Global Sales Support Consultant

- Dave Gerding
Global Sales Consultant – Soil Compactors

Members of Caterpillar Paving Dealer Advisory Council

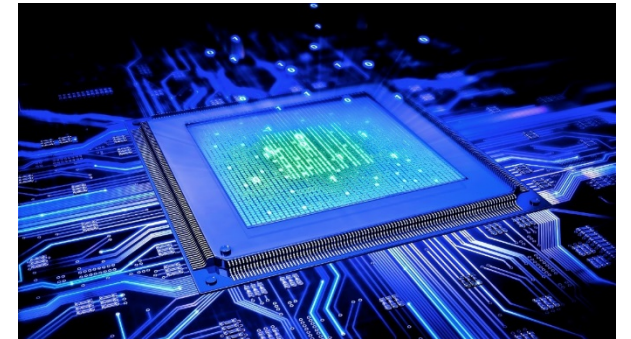
What is driving the need for Technology?

Definition:

***“the use of science in industry, engineering, etc.,
to invent useful things or to solve problems”***

- Emissions
- Safety
- Efficiency
- Productivity
- Workforce “gap”

“Meet Required Specs”



Technology & Innovation: More than just iron



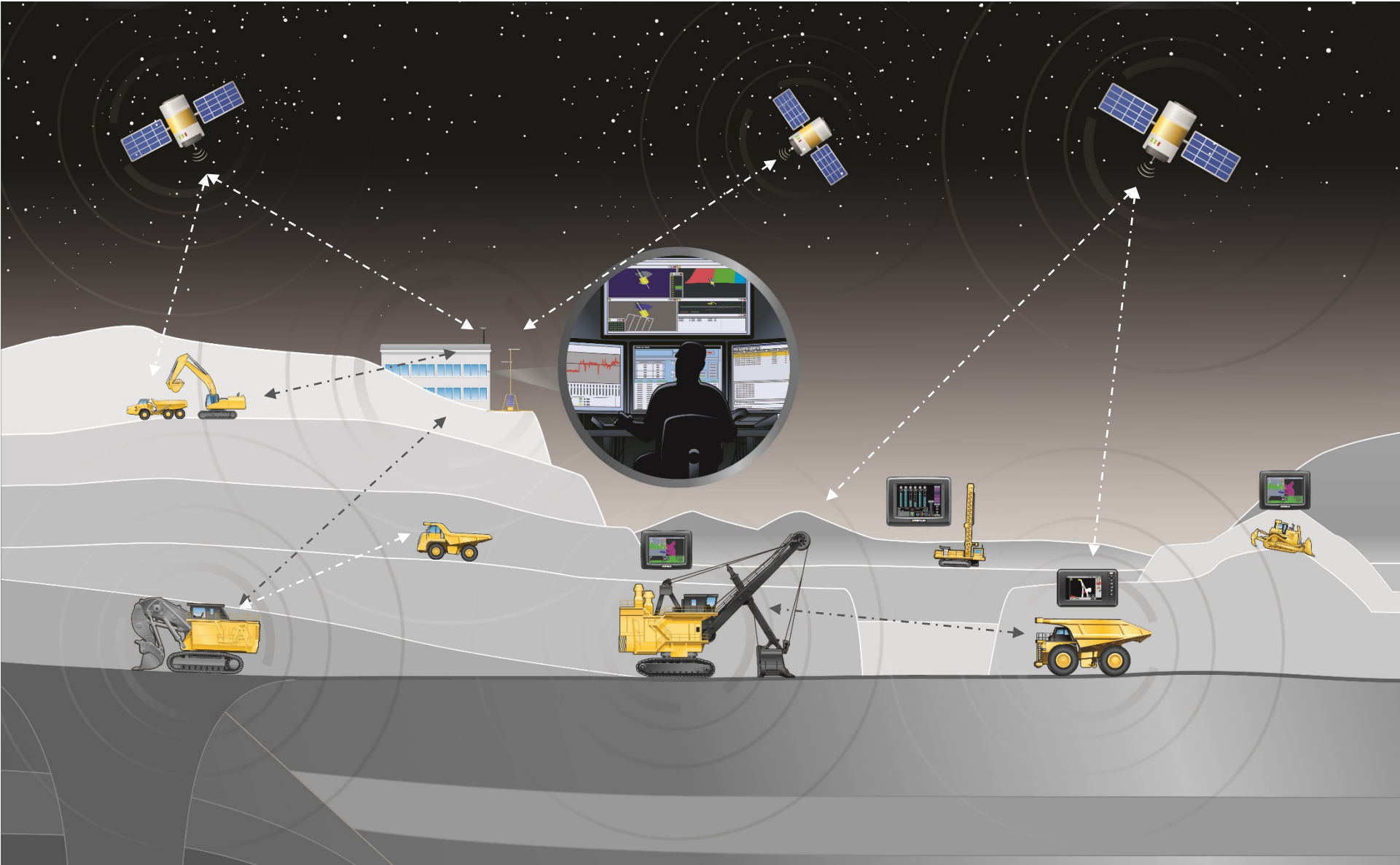
- Real-time information
- Telematics
 - Monitor all facets of equipment
- Better information = better decisions
- Faster information = faster decisions
- Faster decisions results in improvements in
 - Quality
 - Efficiency/profit
 - Value for owner

Technology advancements in use in mining



Autonomous for Hauling – Surface Mining

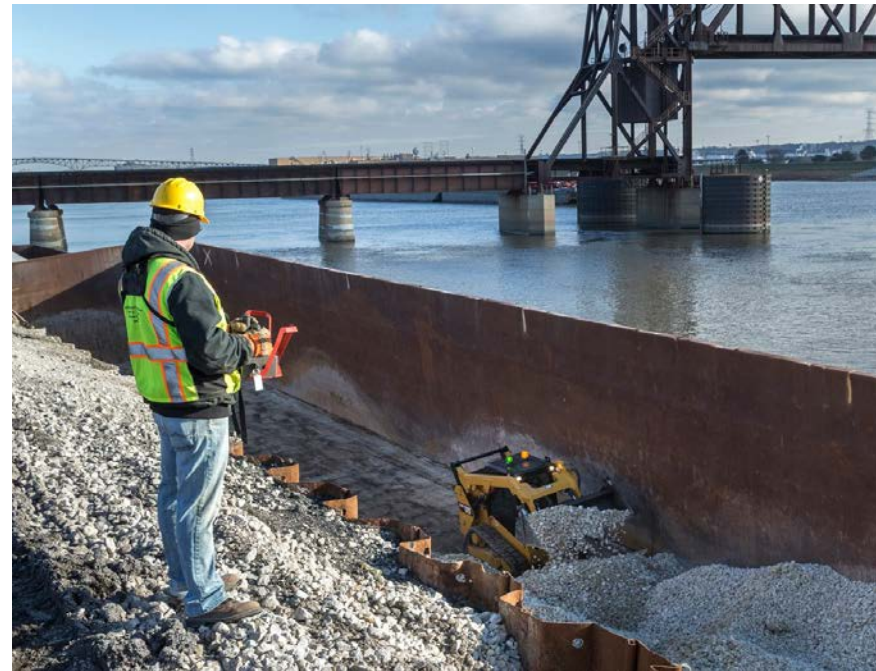
- Requires a full integration with proprietary office software
- Delivers multiple layers of safety with redundant systems
- Requires significant pre-planning, infrastructure development and change management upon implementation
- Focused on Large Hauling Vehicles (793D, 793F and 797F)
- Two sites running in Western Australia



Remote Control in Construction



- No operator, remote operator
 - *“Line of Sight”*
- Already exists in mining



Use of Advanced Sensors in Excavators

Allows operators to set up for protection in all directions.....



E-WALL SWING

E-WALL FORWARD

E-WALL CAB PROTECTION

E-WALL CEILING

E-WALL FLOOR

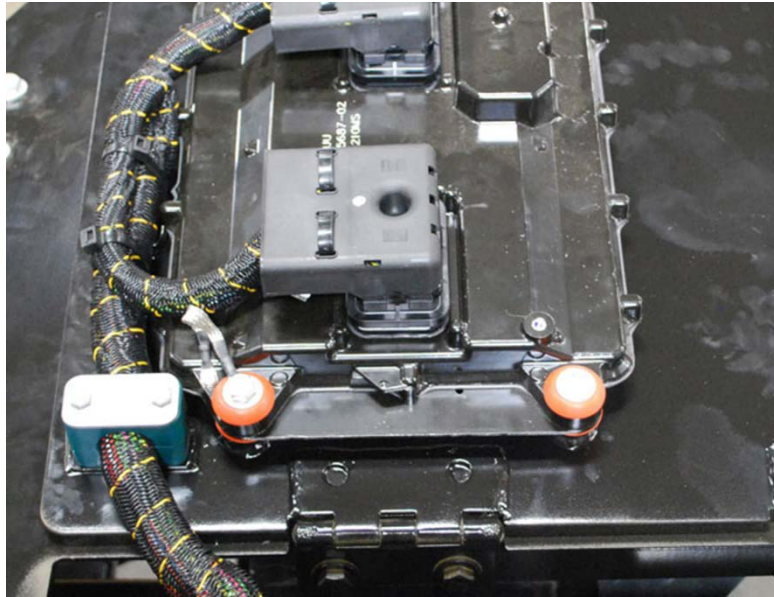
In addition to 2D, 3D or Payload options.....

Automated Machine Guidance & Control (AMG/AMC)



- GPS based or UTS
- Precise grading to elevation
- Precise material quantities
- Stakeless surveys
 - Efficiency
 - Safety
- In use since the mid 90's

What allows this new age of information?



- Advancement in Positioning systems
 - (GPS) & Robotics
- Computing speeds/capacity
- CANbus technology
- Wireless data transmission



Conventional Soil Compaction



Semi-Autonomous Soil Compaction (in Beta Testing)



COMMAND FOR COMPACTION BASIC OPERATION

1. Define work area
2. Set compaction parameters
3. Initiate Auto Mode

SET-UP SEQUENCE

Soil Compaction

Compaction Meter Value (CMV) Options

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

INDUSTRY-STANDARD TECHNOLOGY

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

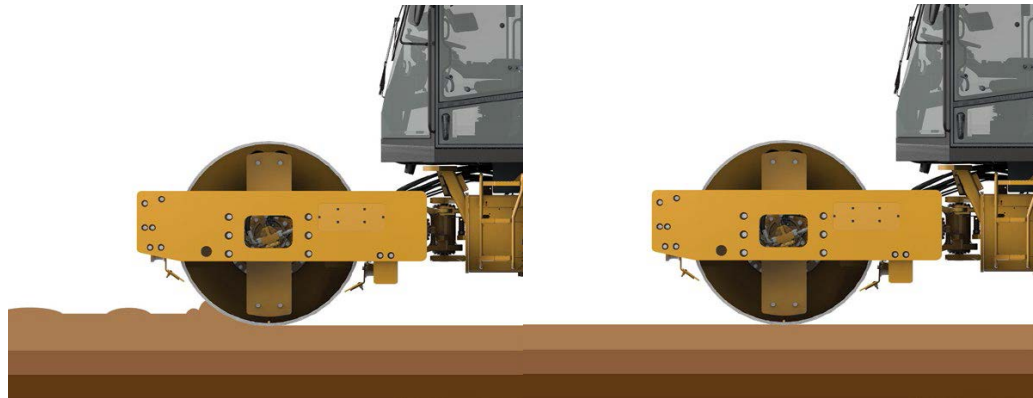
MEASURES DEEP

- 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

Soil Compaction Machine Drive Power Options

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

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

Automatic Grade & Slope Control



- Existed since the 1950s
- New features
 - Cross coupling
 - Easier interface
 - Sonic systems most popular today



Asphalt Paver Innovations - Today



- Integrated G&S control
- Pre-set paving speed
- Telematics
- Auto-fill
- 3D screed control

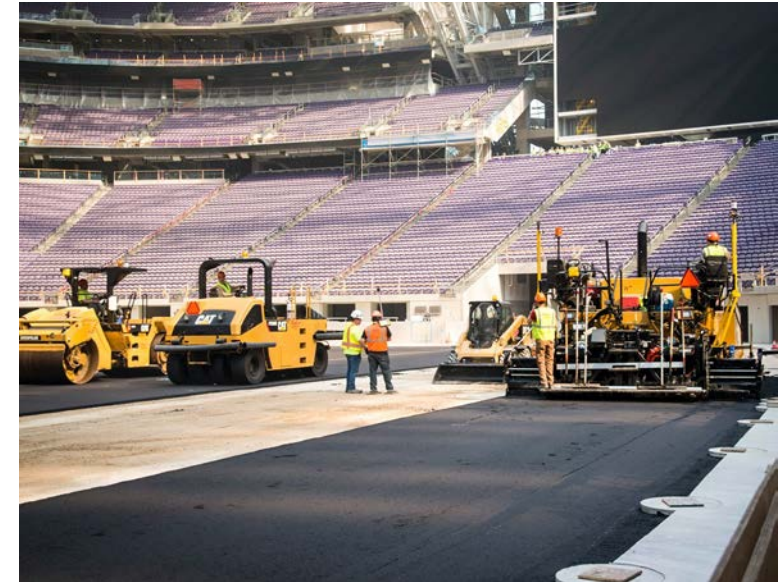
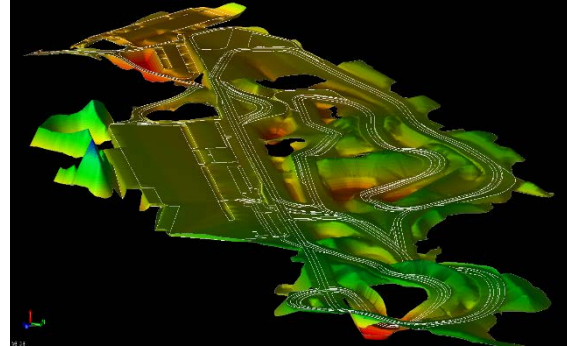
3D Paving/Milling



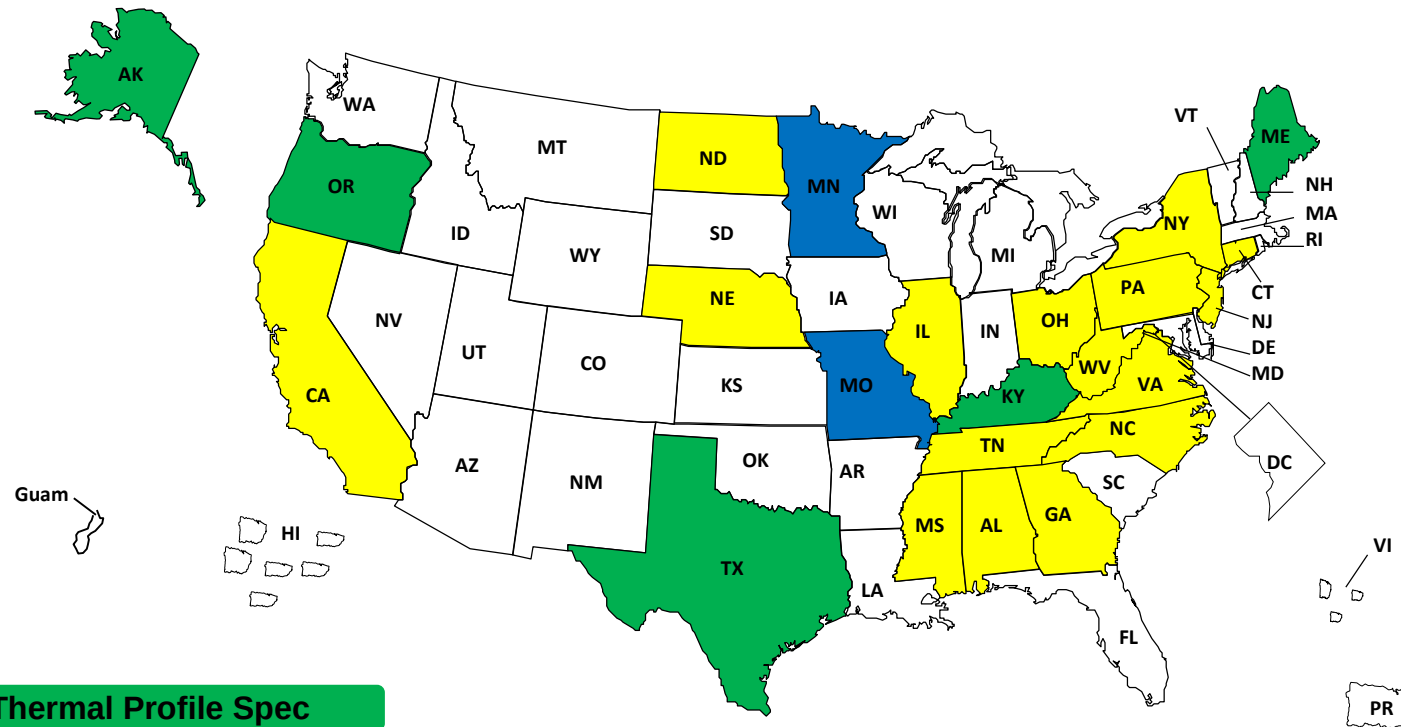
- New Android App raw GNSS data
- Power bands on receivers

3D Paving

- Precise material lay down
 - Precise control of material – material savings
 - Precise control of elevations and profile
 - Accurate within 1/24"–1/8" (1-3 mm)
 - Less chance of operator error with complex designs
 - Transitions
 - Super-elevated curves
 - Frequently changing cross slopes
- Smoothness
 - 3D equipment and controls facilitates less screed adjustments delivering the smoothest application of asphalt.
 - Maintain production rate – No stopping/starting



Thermal profile specifications



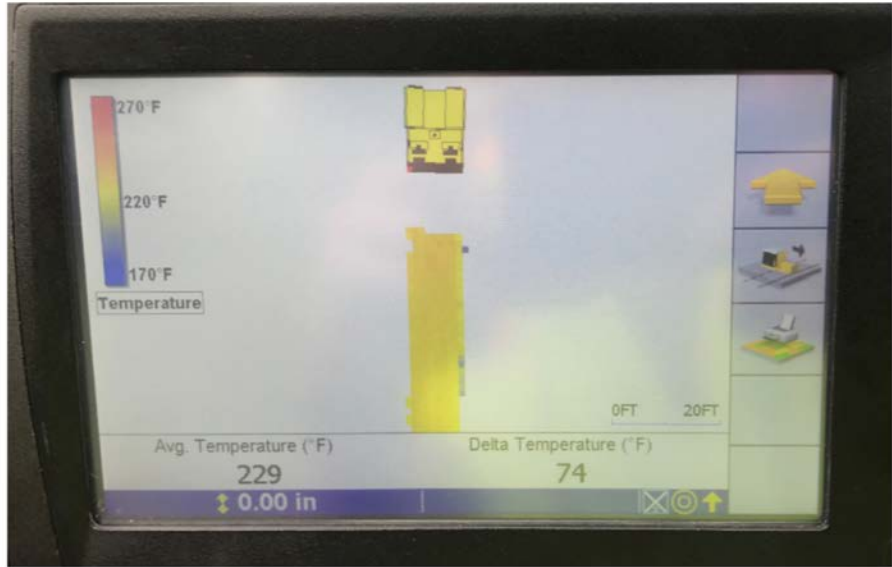
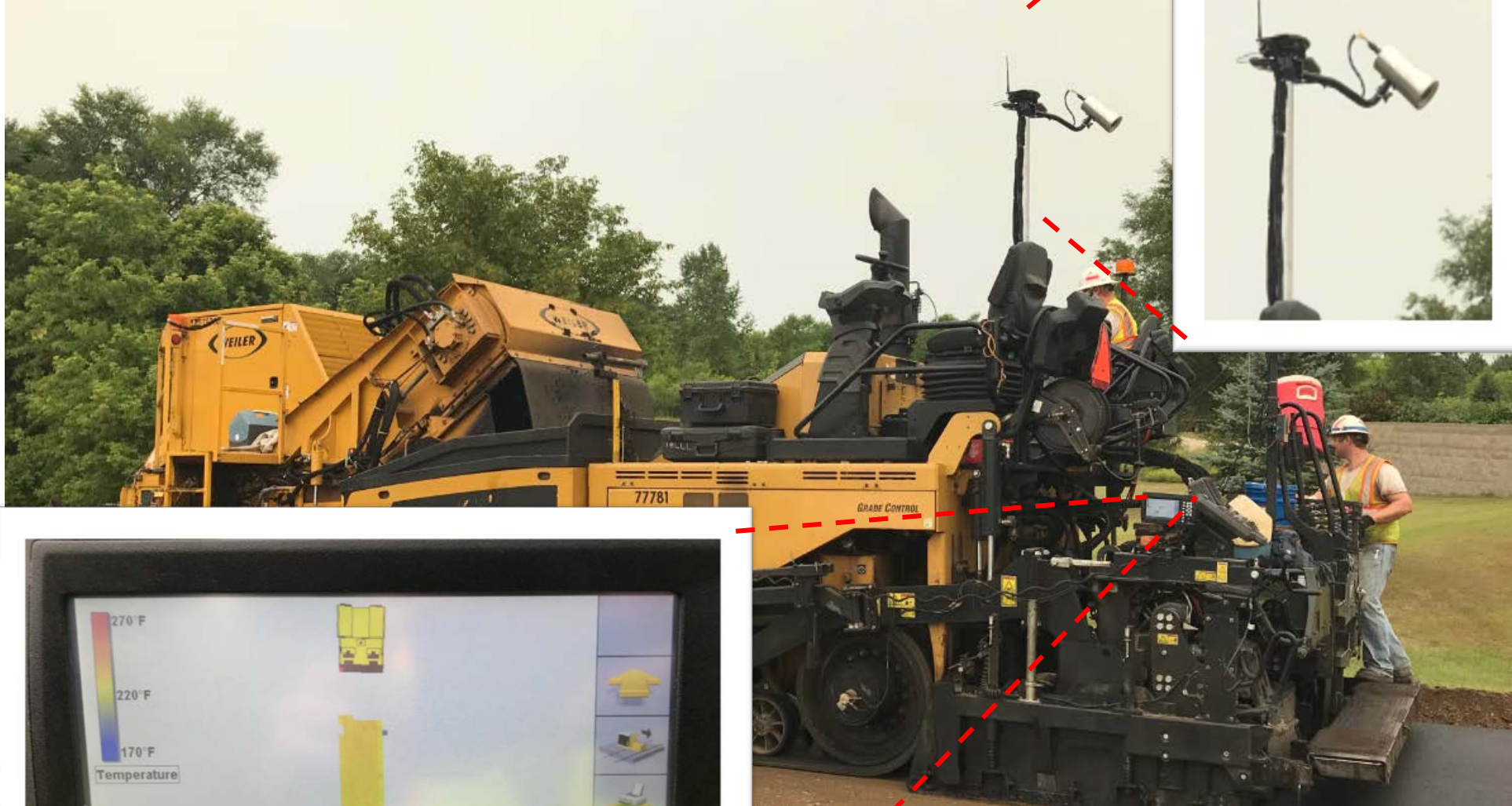
Thermal Profile Spec

Leading States

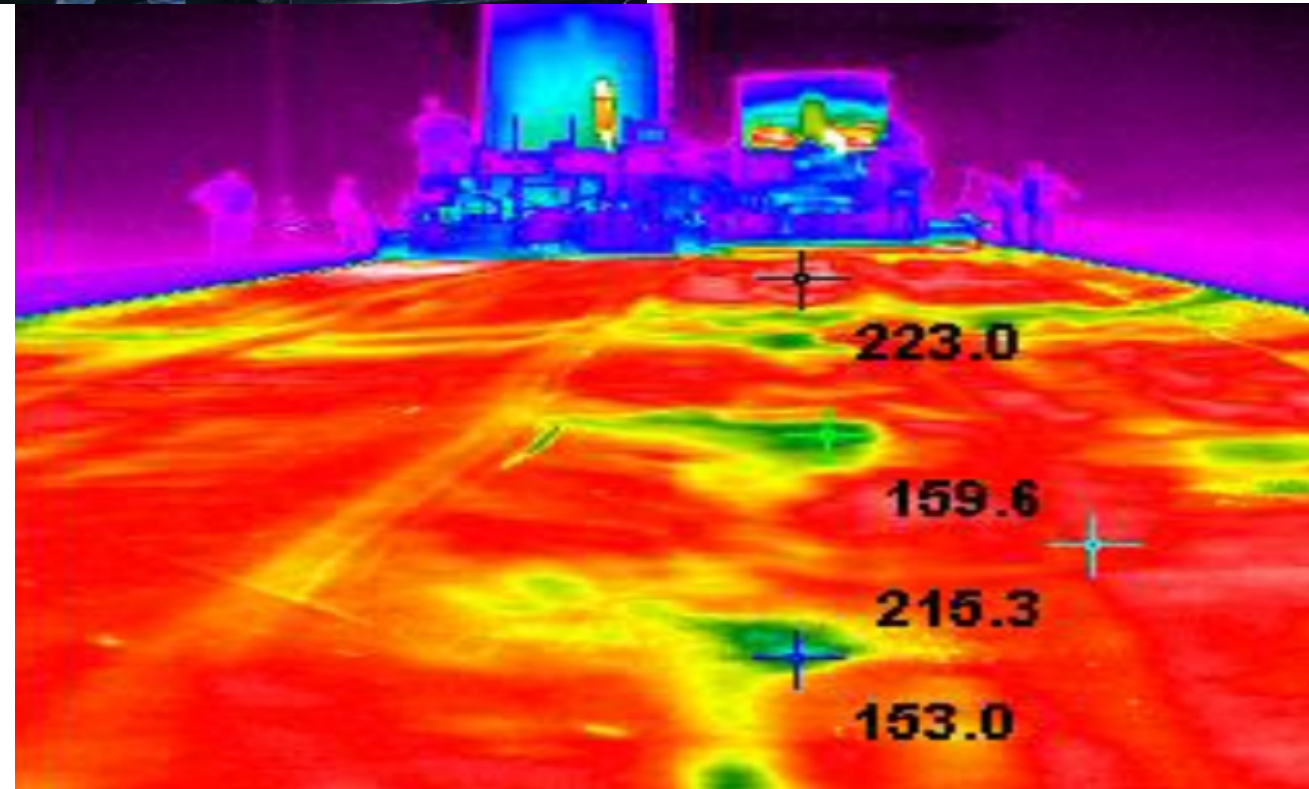
FHWA SHRP2 or TPF-5
Participating States

VETA
INTELLIGENT CONSTRUCTION

Paver Mounted Thermal Camera



Infrared temperature measurement



Customer Need – Temperature Mapping

Performance

How should I prioritize my time to do a good job in the shortest amount of time?

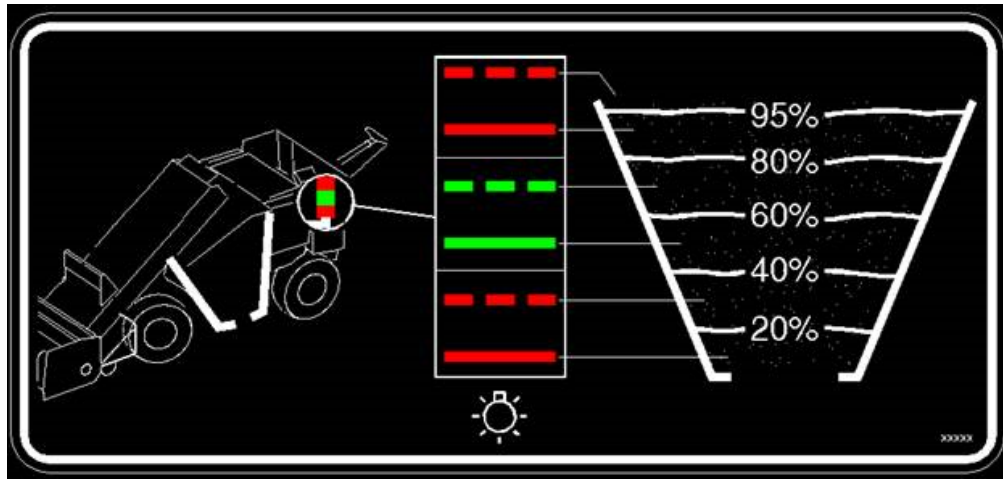
How much time do I have to compact this asphalt before it is too cold to compact?

When can I start compacting newly laid asphalt?



Storage Hopper Management System-Select MTVs

- Indicates level of material in storage hopper
- Operator sees % readout on controller



Distance Control System on MTV

- Maintains a set distance between the transfer vehicle and paver
- Engage from a stopped or moving position
- Propel lever/potentiometer controls distance
 - “Time Out” safety feature

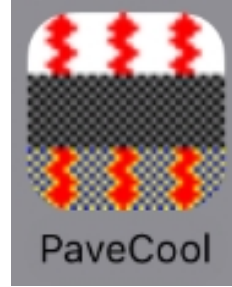


Paver Hopper Management for MTV

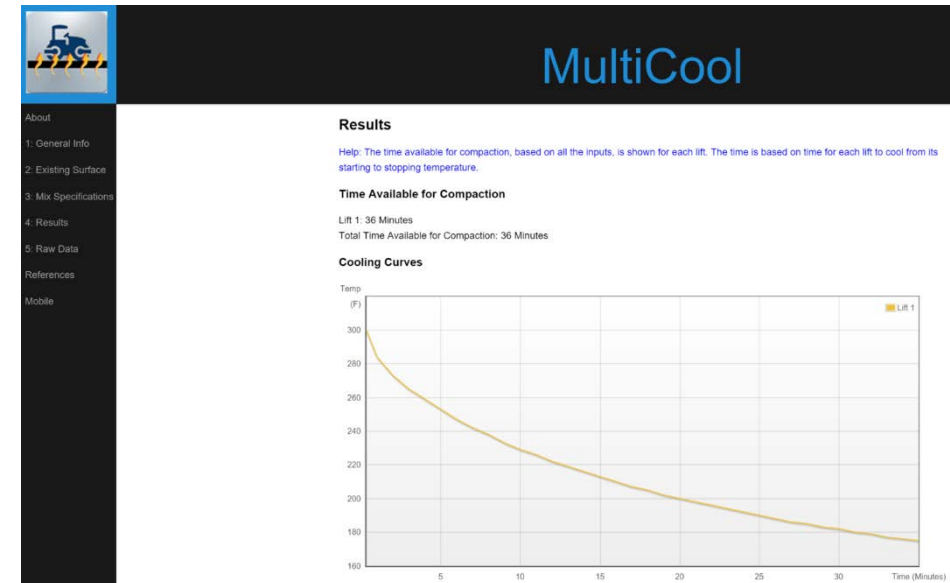
- **Manages output of elevator and conveyor via sonic sensor that reads the pile in the hopper insert**



Paving Calculators



- Provide information based on inputs
- Actual changes are still done “manually” by operators – a form of AMG
- Future – changes are automatic if desired = AMC



Asphalt Paver Innovations - Future

- Guidance systems
- Automated paving speed balanced with plant & trucking
- Full autonomy – no operator



Asphalt IC Specifications



**With the conventional compaction measurement,
what percentage of the surface is actually tested?**



Less than 1%

Asphalt Roller Innovations - Today



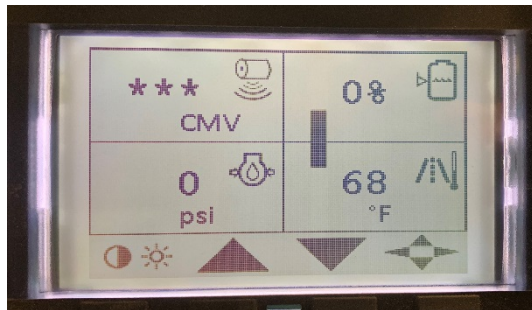
- **Intelligent Compaction**
 - Pass count mapping
 - Temperature mapping
 - Stiffness measurements
- M2M communication

Intelligent Compaction on Asphalt

Performance



- Pass count, Temperature, ICMV
- Some specs written around pass count %
- ICMV $\neq$ Density
- Experience indicates that initial breakdown temperature correlates well with final density



- Real-time information that is “actionable” – reduced rework
- Increased Operator Awareness – self training tool
- Improved Density & Smoothness – uniform passes
- Operator productivity – reduced number of passes
- Night work – knowing where you’re at!
- Documentation of 100% of job!!

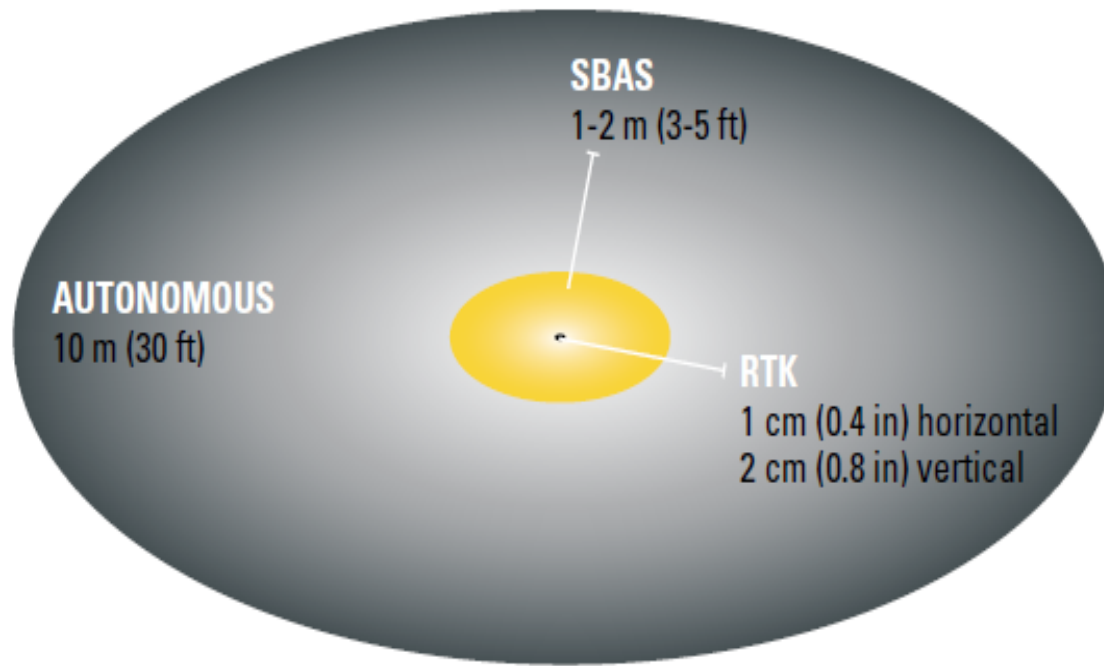
Intelligent Compaction on Asphalt

Performance

- Coverage
- Pass Count
- Temperature
- Vibe on or Off
- Frequency
- Amplitude
- Quality Control (Mapping)



GNSS Mapping Accuracies



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.

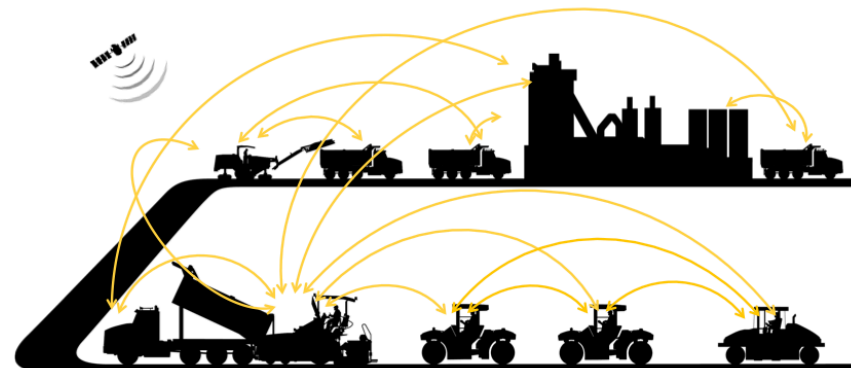
RTK: Real Time Kinematic

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.

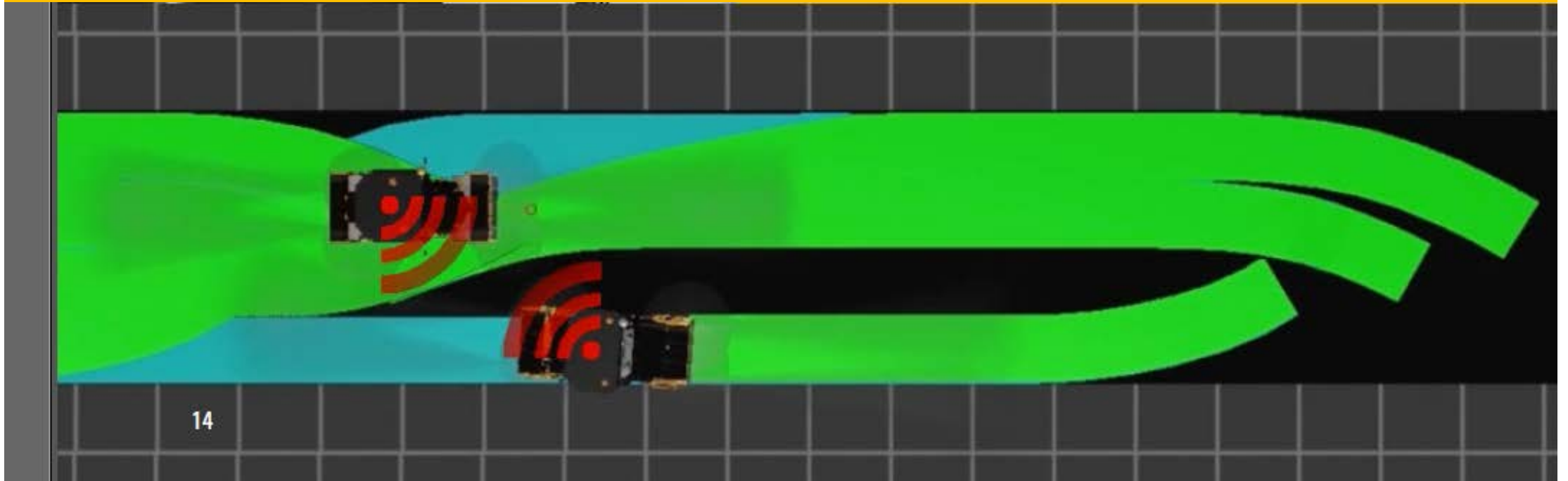
Machine-to-machine (M2M) communication

Connectivity

- Machine position and pass count allows multiple machines to perform the work as one (interactive mapping) -- echelon breakdown rolling
- Temperature can be used to start/finish compaction and to avoid tender temperature zones where damage can occur
- Complete operator understanding



Machine to Machine Communication



Allows for proper accounting of pass overlay when echelon rolling

Future roller technology

- Density on-the-run
- Smoothness on-the-run
- Automated machine setup
- Autonomous machine control
- More connected worksite
- Learning systems that adapt to changing conditions



Cold Planer Innovations - Today



- Ventilation systems
- Automated functions - ramp in/ramp out & jump/hold features
- Integrated 2D grade control
- 3D grade control

Cold Planer Innovations - Future



- Ventilation on all sizes moving forward
- 3D will be more common
- Object detection
- Automated setup & control features
- Measure quantities in real-time
- Monitoring wear in real-time for cost/estimating

Other emerging technologies



- Drones
 - Road condition surveys
 - Site reconnaissance
 - Stockpile management
 - Plant maintenance
 - Thermal images
 - LIDAR

Learning systems

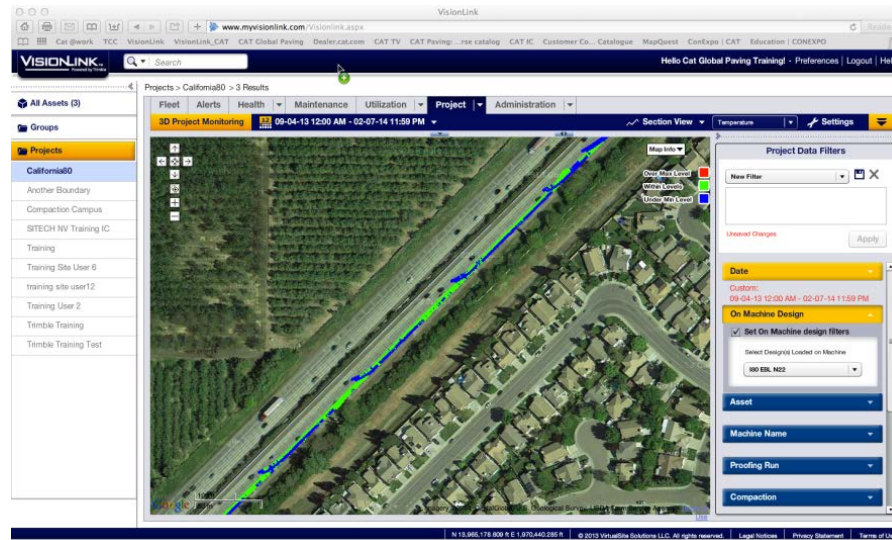
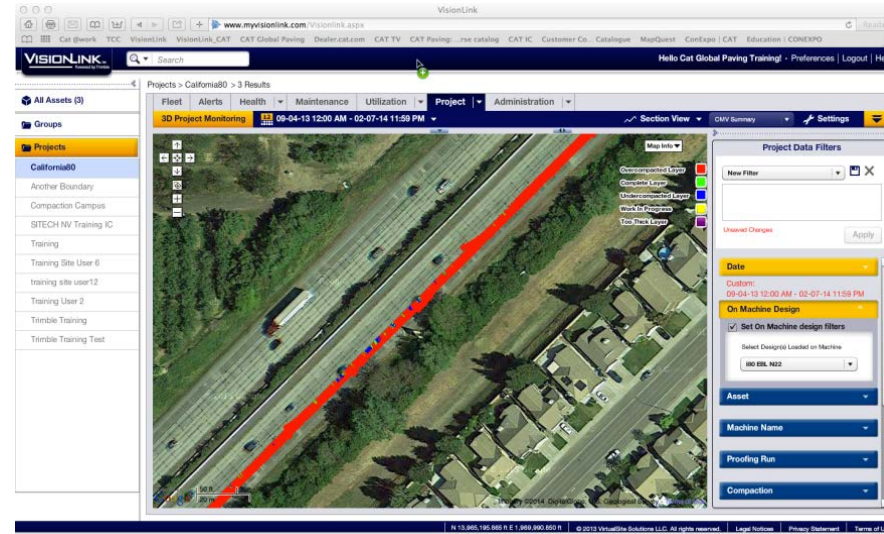
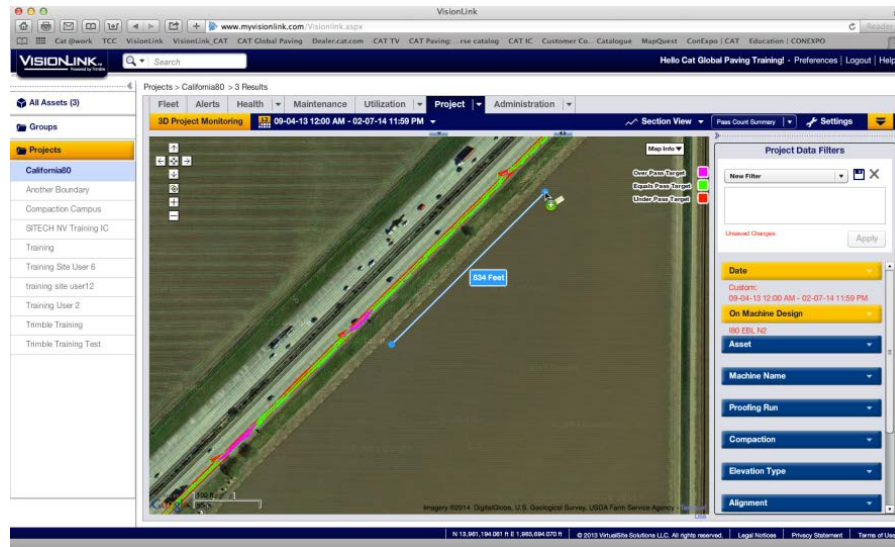


- “Intelligent Construction” where machines can record and share information (M2M) and adapt to changing site conditions
- Example: Paver and roller speeds adjust automatically based on trucking/plant/traffic information to maximize smoothness and density bonuses, quality



Data Analysis & Management

Project Management



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	1	2013/Aug/05	14353748	64	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
2	2	2013/Aug/05	14353750	56	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
3	3	2013/Aug/05	14353751	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
4	4	2013/Aug/05	14353752	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
5	5	2013/Aug/05	14353753	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
6	6	2013/Aug/05	14353754	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
7	7	2013/Aug/05	14353755	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
8	8	2013/Aug/05	14353756	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
9	9	2013/Aug/05	14353757	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
10	10	2013/Aug/05	14353758	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
11	11	2013/Aug/05	14353759	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
12	12	2013/Aug/05	14353760	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
13	13	2013/Aug/05	14353761	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
14	14	2013/Aug/05	14353762	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
15	15	2013/Aug/05	14353763	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
16	16	2013/Aug/05	14353764	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
17	17	2013/Aug/05	14353765	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
18	18	2013/Aug/05	14353766	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
19	19	2013/Aug/05	14353767	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
20	20	2013/Aug/05	14353768	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
21	21	2013/Aug/05	14353769	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
22	22	2013/Aug/05	14353770	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
23	23	2013/Aug/05	14353771	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
24	24	2013/Aug/05	14353772	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
25	25	2013/Aug/05	14353773	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
26	26	2013/Aug/05	14353774	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
27	27	2013/Aug/05	14353775	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
28	28	2013/Aug/05	14353776	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
29	29	2013/Aug/05	14353777	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
30	30	2013/Aug/05	14353778	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
31	31	2013/Aug/05	14353779	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
32	32	2013/Aug/05	14353780	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
33	33	2013/Aug/05	14353781	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
34	34	2013/Aug/05	14353782	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
35	35	2013/Aug/05	14353783	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
36	36	2013/Aug/05	14353784	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
37	37	2013/Aug/05	14353785	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
38	38	2013/Aug/05	14353786	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
39	39	2013/Aug/05	14353787	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?
40	40	2013/Aug/05	14353788	71	1029921.853	1	0	080831TEST	6.54E+14	2.8mph	RTK Fixed	Medium (0.1)	3	1	1	35	?	?	?

Where are we now?



“Let’s hold off making a decision until we have even more information we don’t really need.”

- Technology components exist
- Starting to connect the pieces
 - Software packages
- Customer value: Cost vs. ROI
 - Costs high, but decreasing
- Technology continues to evolve
- Collecting more & more data

What's next?

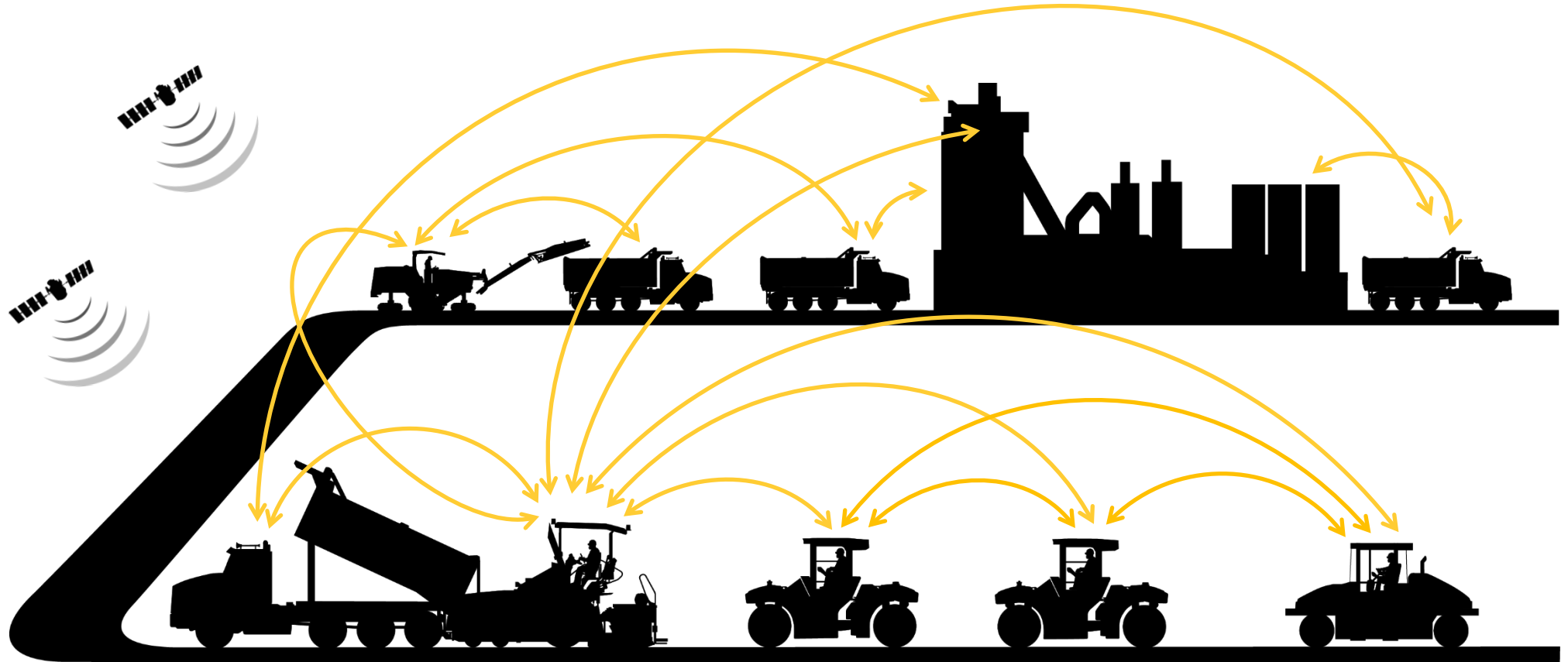
- Automated machine control & remote site management
- Connected Worksite = integration of ALL machines – beyond paving
- Integrating site inspection “e-Construction”



Paving Connected Worksite

Connectivity

Goal: Increase customer value by achieving asphalt road density, smoothness (quality, efficiency) in the shortest possible time (cost) with no waste (sustainability) through a connected worksite.



“Houston, we have a problem”



Challenges...



- Mixed fleet software solutions
- Compatibility among OEMs
- Information security
- Information overload
- Data ownership
- Data privacy



Questions??

Richard J. Costello

Manager, Paving Products & Technology

dcostello@foleyinc.com