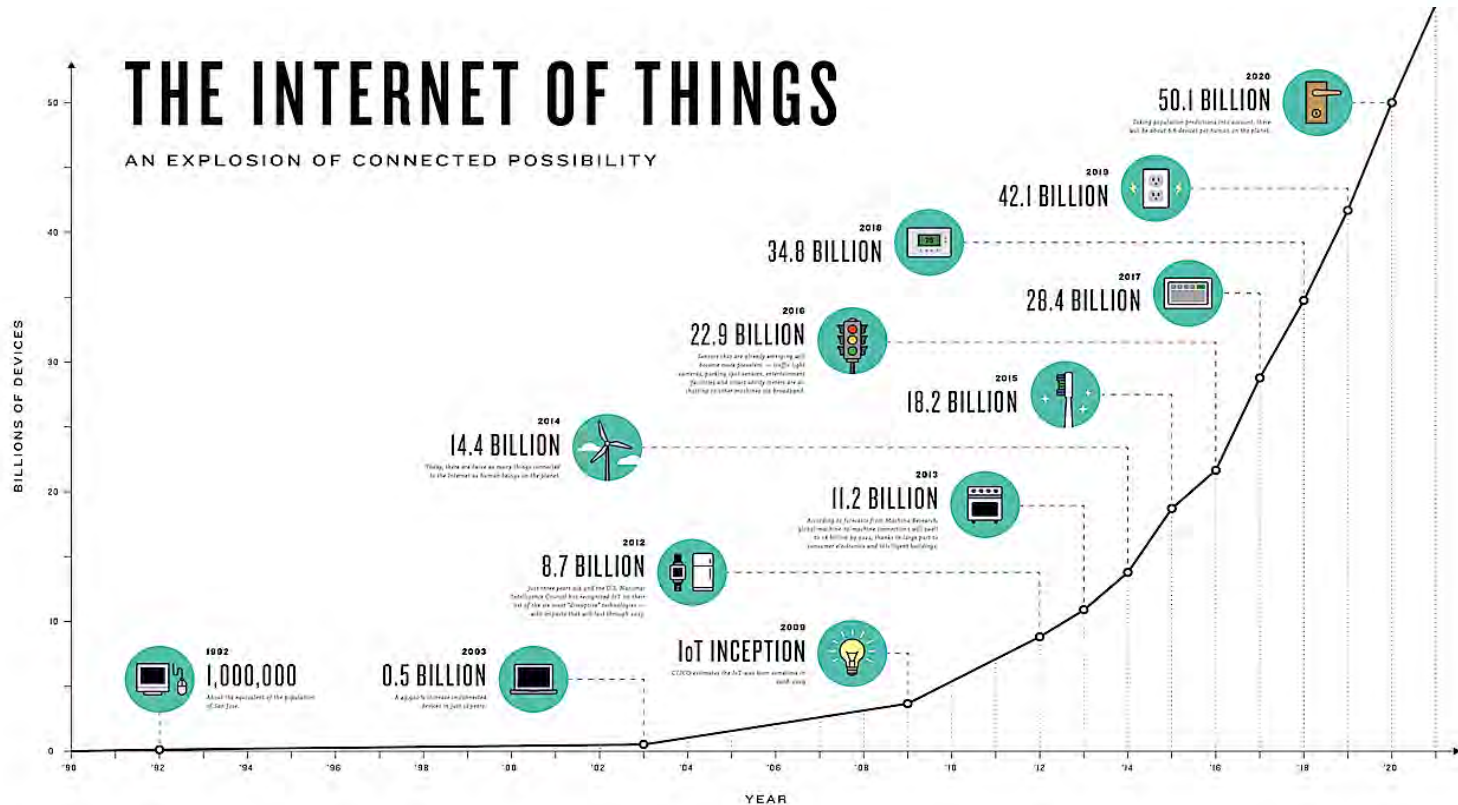




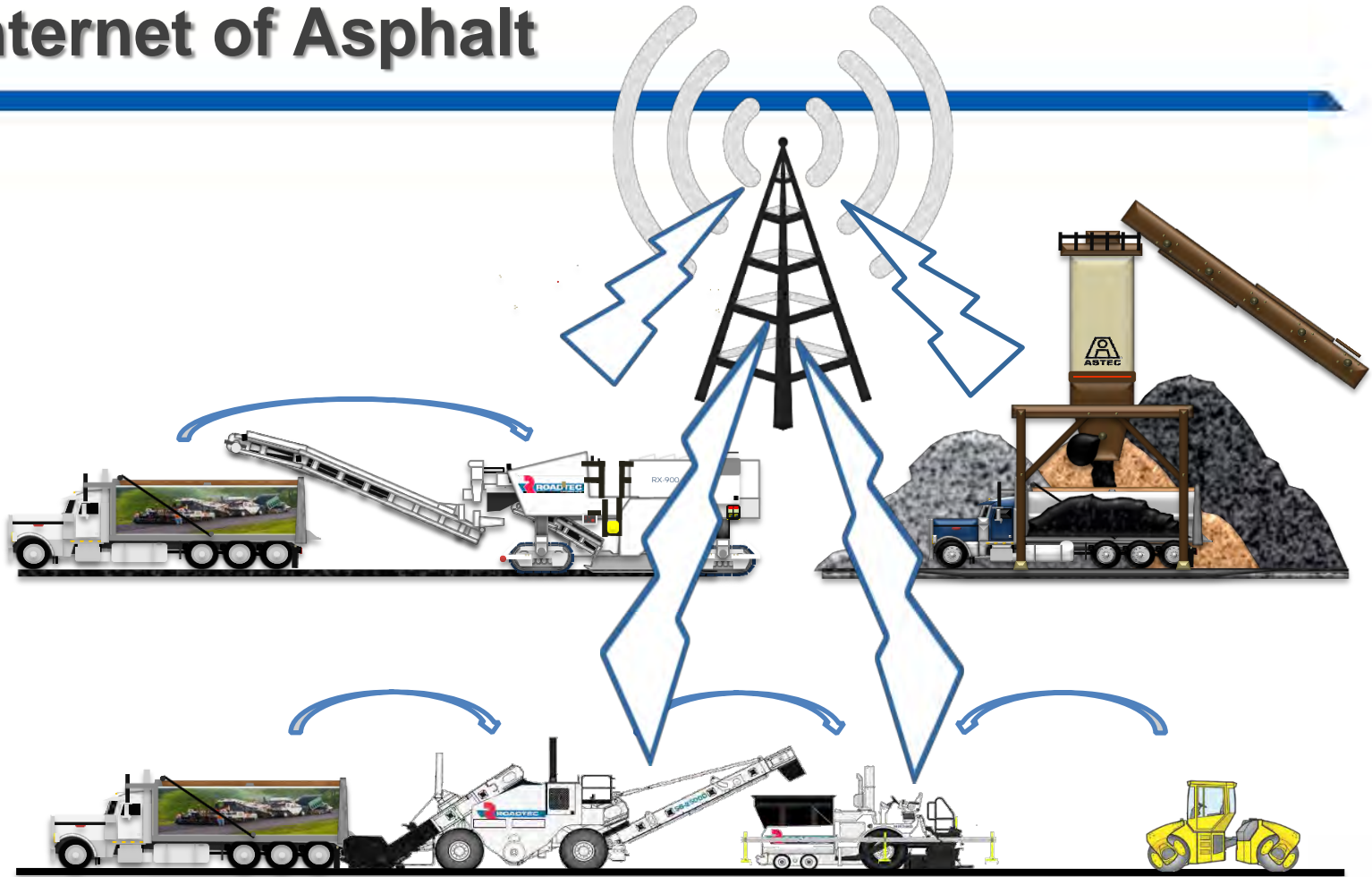
Guardian

| Max Peters

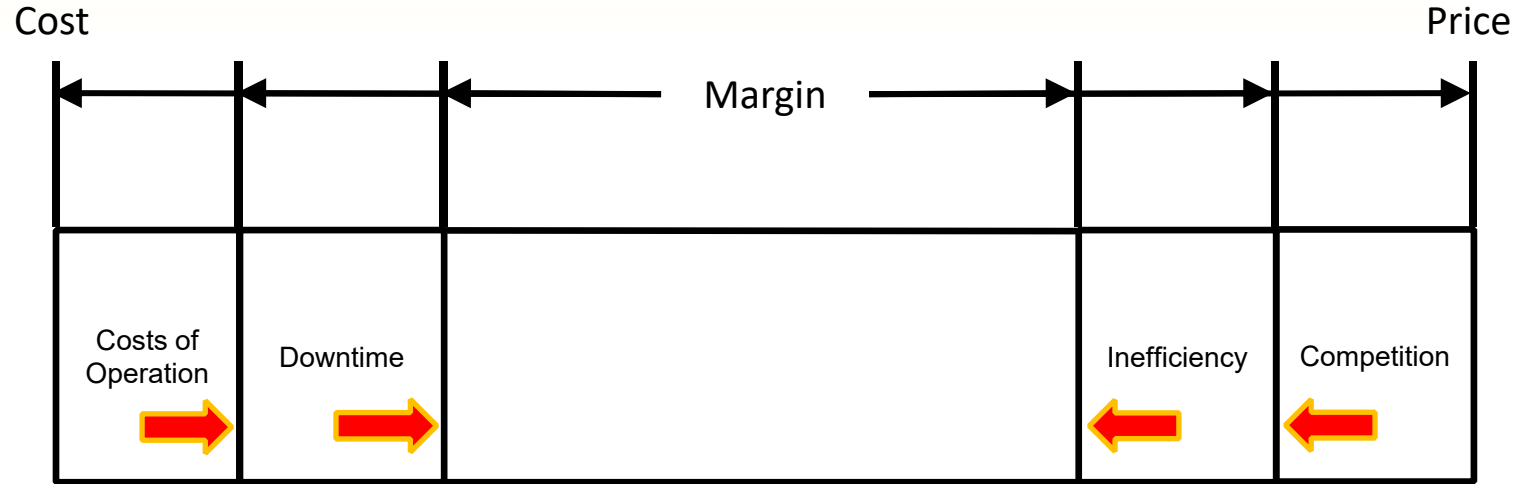
The Internet of Things



Internet of Asphalt



Burning the Candle from Both Ends



Costs of Operation

- Fuel
- Consumables

Downtime

- Equipment failures
- Waiting for service
- Reactive vs. Proactive

Inefficiency

- Quality Issues
- Production
- Trucking

Competition

- What sets you apart?
- Bidding accuracy

Engine

The screenshot displays the Guardian Roadtec Telematics System interface for an FX-600e machine. The interface is divided into several sections:

- Header:** Includes the Guardian logo, version 5.0.0.6 (Up to date), and a status bar indicating "CONNECTED TO DEVICE WITH DATA".
- Navigation:** A menu bar with tabs for various machine systems: Cutter, Water, Conv, Propel, Tract Cont, Load Cont, Steer, Housing, Elevation, Hyd, Engine (selected), Moba, GPS, PID, and Production.
- Engine Metrics:** A grid of 12 data points:
 - Fuel PSI: N/A
 - Turbo Boost PSI: 31.32
 - Engine % Load: 87
 - Travel Speed FPM: 16
 - Fuel Temp: N/A
 - Coolant Temp: 190
 - Inlet Air Temp: 150
 - Fuel Tank Level: 27
 - Battery Voltage: 27.35
 - Oil PSI: 41.8
 - Fuel Usage GPH: 26.1
 - Total Fuel Used: 2413.9
 - Engine Speed: 1861.6
 - Engine Hours: 238.1
 - Engine % Soot: 0
- DEF Fluid:** A section for DEF Fluid with a gauge and a "TIER 4 FINAL ONLY" label. It shows "Hours Until Service" as 11.9, with buttons for "FORCE REGEN" and "INHIBIT REGEN".
- Fault Codes:** Two sections for "Active Engine Fault Codes" and "Previously Active Engine Fault Codes", each with a table for Fault Code, FMI, and Count.
- Buttons:** "Request Previously Active Fault Codes" and "Clear Fault Codes".
- Footer:** A note stating: "Active engine fault codes are displayed automatically and are not requested. You may request previously active fault codes (if not cleared) using the request button." The Windows taskbar at the bottom shows the time as 3:29 PM on 6/30/2015.

Real Time Alerts

From: Guardian@Roadtec.com

Sent: Friday, February 26, 2016 11:04:22 AM (UTC-05:00) Eastern Time (US & Canada)

To: Roadtec Diagnostics

Subject: Fault Notification RX-300e S/N-117

Dear Roadtec,

Machine Model: RX-300e

Serial No: 117

The machine/engine faults for the RX-300e S/N-117 are listed below.

Return filter 1 pressure is high. 340 PSI @ 13.5 Hrs.



Real Time Alerts

From: Guardian@Roadtec.com
Sent: Friday, February 26, 2016 1:26:45 PM (UTC-05:00) Eastern Time (US & Canada)
To: Roadtec Diagnostics
Subject: Machine Reporting Summary RX-700e S/N-2066

Dear Roadtec,

Report Date: 2/26/2016 1:26:43 PM
Machine Model: RX-700e
Serial No: 2066
Engine Hours: 104.5

The Machine Reporting Summary for the RX-700e S/N-2066 is below.

Total fuel used to date: 630.6 gallons

Total fuel used this reporting period: 207.50 gallons

Machine was last serviced at 0 hours

Machine is due for service in 145.5 hours

Current DPF Soot Load is: 0

LOGGED ENGINE FAULTS:

No logged engine faults this reporting interval.

LOGGED MACHINE FAULTS:

No logged machine faults this reporting interval.



Real Time Alerts

From: Guardian@Roadtec.com
Sent: Friday, February 26, 2016 9:38:43 AM (UTC-05:00) Eastern Time (US & Canada)
To: Roadtec Diagnostics
Subject: Fault Notification RX-600e S/N-2071

Dear Roadtec,

Machine Model: RX-600e
Serial No: 2071

The machine/engine faults for the RX-600e S/N-2071 are listed below.

2/26/2016 9:38:41 AM @ 1904.9 Hrs.

SPN: 110 Engine Coolant Temperature Sensor

FMI: 18 Data valid but below normal operational range-moderately severe level

Occ: 3

2/25/2016 3:28:05 PM @ 1903.7 Hrs.

SPN: 3597 ECU Power Supply Output No. 1

FMI: 18 Data valid but below normal operational range-moderately severe level

Occ: 2



Hydraulics

The screenshot displays the Guardian Roadtec Telematics System interface for an RX-600e machine. The interface is titled "Diagnostics" and includes a "Setup Menu" button. The software version is 5.0.0.6, which is up to date. A green status bar indicates the system is "CONNECTED TO DEVICE WITH DATA". The machine's serial number is 2075. The main menu includes tabs for Power, Alarms, Start, Cutter, Water, Conv, Propel, Tract Cont, Load Cont, Steer, Housing, Elevation, Hyd, Engine, Moba, GPS, and PID. The "Hyd" tab is selected, showing the following data:

Propel System		Hydraulic Oil Temp
Propel Charge PSI	Propel System PSI	Hydraulic Oil Degrees F
351	686	132

Auxiliary & Return Pressures		
Return Filter No. 1 PSI	Return Filter No. 2 PSI	Auxiliary PSI
1	0	2803
<small>RX700 & RX900 ONLY</small>		

Conveyor System		
Primary Conveyor Charge PSI	Secondary Conveyor Charge PSI	Conveyor System PSI
361	343	851

The Windows taskbar at the bottom shows the system time as 3:14 PM on 6/30/2015.



MOBA

ROADTEC Diagnostics

GUARDIAN Roadtec Telematics System
5.0.0.6 Up to date
CONNECTED TO DEVICE WITH DATA
RX-600e Machine Serial No. 2075

Power Alarms Start Cutter Water Conv Propel Tract Cont Load Cont Steer Housing Elevation Hyd Engine Moba GPS PID

LEFT Grade Controller

1.8	SE	CHANGE
100	POS	CHANGE
Inches	CAL	CHANGE
Wire Rope	S-S	CHANGE
7.8	W-W	CHANGE
1	TYPE	CHANGE
0.23	MIN Current UP	
0.30	MAX Current UP	
0.20	MIN Current DN	
0.28	MAX Current DN	

RIGHT Grade Controller

3.6	SE	CHANGE
100	POS	CHANGE
Inches	CAL	CHANGE
Wire Rope	S-S	CHANGE
OFF	W-W	CHANGE
1	TYPE	CHANGE
0.24	MIN Current UP	
0.32	MAX Current UP	
0.24	MIN Current DN	
0.32	MAX Current DN	

SET ROADTEC DEFAULTS CHANGE CURRENTS SET ROADTEC DEFAULTS CHANGE CURRENTS

Rear Sens: None Center Sens: None Front Sens: None **BLOCK OUTPUTS** Rear Sens: None Center Sens: None Front Sens: None

Pressing BLOCK OUTPUTS will put both controllers in HALF AUTO

3:17 PM 6/30/2015

Water

ROADTEC Diagnostics

Setup Menu

5.0.0.6
Up to date

CONNECTED TO DEVICE WITH DATA

RX-600e Machine Serial No. 2075

Power Alarms Start Cutter Water Conv Propel Tract Cont Load Cont Steer Housing Elevation Hyd Engine Moba GPS PID

INPUTS

- Water Manual ON
- Water Auto ON
- Water OFF

INTERLOCKS

- Machine Forward Motion
- Tank Float Switch

OUTPUTS

- Water ON

760.2	Actual mA
1014.4	Desired mA

3:08 PM
6/30/2015

Conveyors

ROADTEC Diagnostics

GUARDIAN Roadtec Telematics System

5.0.0.6 Up to date

CONNECTED TO DEVICE WITH DATA

RX-600e Machine Serial No. 2075

Power Alarms Start Cutter Water Conv Propel Tract Cont Load Cont Steer Housing Elevation Hyd Engine Moba GPS PID

INPUTS

Left JS Conv FWD ON/OFF

Right JS Conv FWD ON/OFF

Left Side Conv ON/OFF

Right Side Conv ON/OFF

Left JS Conv REV ON/OFF

Right JS Conv REV ON/OFF

INTERLOCKS

Engine Speed >500

OUTPUTS

Lower Conv Forward Output ON	44.6	Actual mA	44.6	Desired mA
Upper Conv Forward Output ON	47.3	Actual mA	48.3	Desired mA
Lower Conv Reverse Output ON	0	Actual mA	0	Desired mA
Upper Conv Reverse Output ON	4.6	Actual mA	0	Desired mA

INPUTS

Conv Speed Increase

Conv Speed Decrease

Conv Boost

Horn Switch ON

OUTPUTS

Horn Output ON

0 50 100

57 Value

Conveyor Speed Potentiometer

Left Front Remote Panel

Left Remote Conv Raise

Left Remote Conv Lower

Left Remote Swing Left

Left Remote Swing Right

Left Remote Conv Extend

Left Remote Conv Fold

Right Front Remote Panel

Right Remote Conv Raise

Right Remote Conv Lower

Right Remote Swing Left

Right Remote Swing Right

Right Remote Conv Extend

Right Remote Conv Fold

Act mA	0	Des mA	0
Act mA	0	Des mA	0
Act mA	0	Des mA	0
Act mA	0	Des mA	0

Folding Conveyor Outputs (optional)

Upper Conv Extend Output ON	0	Act mA	0	Des mA
Upper Conv Fold	0	Act mA	0	Des mA

LEFT JS

0

Conveyor Lower Input

Swing Left Input

Swing Right Input

Conveyor Raise Input

RIGHT JS

0

Conveyor Lower Input

Swing Left Input

Swing Right Input

Conveyor Raise Input

3:08 PM 6/30/2015

Propel

ROADTEC Diagnostics

GUARDIAN
Roadtec Telematics System

5.0.0.6
Up to date

CONNECTED TO DEVICE WITH DATA

RX-600e Machine Serial No. 2075

Power Alarms Start Cutter Water Conv Propel Tract Cont Load Cont Steer Housing Elevation Hyd Engine Moba GPS PID

INPUTS

Automatics Standby Switch ON

Horn Switch ON

Go To Neutral Switch ON

Speed Selected In Murphy Display

Left Panel Cruise Cont Set/Resume

Right Panel Cruise Cont Set/Resume

Brake Switch

OUTPUTS

Joystick Enabled Half-Auto

Horn Output ON

Forward

Neutral

Reverse

Hi Speed

Mid Speed

Low Speed

Enabled Running

Enabled Idle

Brake Valve

Propel Joystick Input Raw Values 0 - 1000

0	0
Machine Travel FWD Input	Machine Travel FWD Input
Machine Travel REV Input	Machine Travel REV Input
0	0

Brake Switch

Propel Control Output in mA

0.9	Actual mA
0	Desired mA
Machine Travel FWD Output	
Machine Travel REV Output	
51.6	Desired mA
51.7	Actual mA

Windows Taskbar: 3:09 PM 6/30/2015

Production Reporting



Production Reporting



Production Reporting

The screenshot displays the Guardian Roadtec Telematics System interface. At the top, the logo features a red 'R' and the word 'GUARDIAN' in a stylized font, with 'Roadtec Telematics System' underneath. The version '5.0.0.6' and 'Up to date' are shown, along with a green status bar indicating 'CONNECTED TO DEVICE WITH DATA'. The machine model 'FX-600e' and 'Machine Serial No. 2080' are also visible. A navigation bar includes tabs for 'Cutter', 'Water', 'Conv', 'Propel', 'Tract Cont', 'Load Cont', 'Steer', 'Housing', 'Elevation', 'Hyd', 'Engine', 'Moba', 'GPS', 'PID', and 'Production'. The 'Production' tab is active, showing three main sections: 'Production Data', 'Daily Totals', and 'Setup And Calibration'. 'Production Data' includes metrics like 'Material Discharge Display' (0.0), 'Time Elapsed Loading Truck' (00:00), and 'Width of Milling Cut' (6.58). 'Daily Totals' shows cumulative production figures such as 'Total Tons' (509.8) and 'Total Work Time' (02:30). 'Setup And Calibration' allows for adjusting parameters like 'Calibration Tons/Cubic Yard' (2.00) and 'Change Width of Milling Cut' (6.58). A 'Machine Totals' section at the bottom right provides long-term performance metrics, including 'Total Tons' (9366.1) and 'Total Work Time' (67:38). The Windows taskbar at the bottom shows the system time as 3:36 PM on 6/30/2015.

Production Data	
Material Discharge Display	0.0
Time Elapsed Loading Truck	00:00
Width of Milling Cut	6.58
Depth Of Cut (Left)	-11.4
Depth Of Cut (Right)	-1.3
Depth Measurement Mode	Automatic
Select Full Pass Width	Full Pass
Reset Discharge Display	Reset Zero

Daily Totals	
Total Tons	509.8
Total Square Yards	1499.5
Total Cubic Yards	254.9
Total Trucks Loaded	35
Total Linear Feet	2051
Total Fuel Burn	78.3
Total Work Time (HH:MM)	02:30
Average Truck Loading Time	03:56
Estimated Time Of Completion	0
Teeth Changed	0

Setup And Calibration	
Calibration Tons/Cubic Yard	2.00
Change Width of Milling Cut	6.58
Set Fixed Depth of Cut	12.60
Select Depth Measurement Mode	Automatic
Select Operation Mode	Automatic
Enter No. Teeth Changed	0

Machine Totals	
Total Tons	9366.1
Total Square Yards	83552.8
Total Cubic Yards	4683.0
Total Trucks Loaded	268
Total Linear Feet	114282
Total Fuel Burn	2416.9
Total Work Time (HH:MM)	67:38
Average Truck Loading Time	03:53
Total Teeth Used	0

QuickCheck

GUARDIAN
Roadtec Telematics System

Select Application: QuickCheck

PRODUCTS USED SUPPORT TRAINING MEDIA

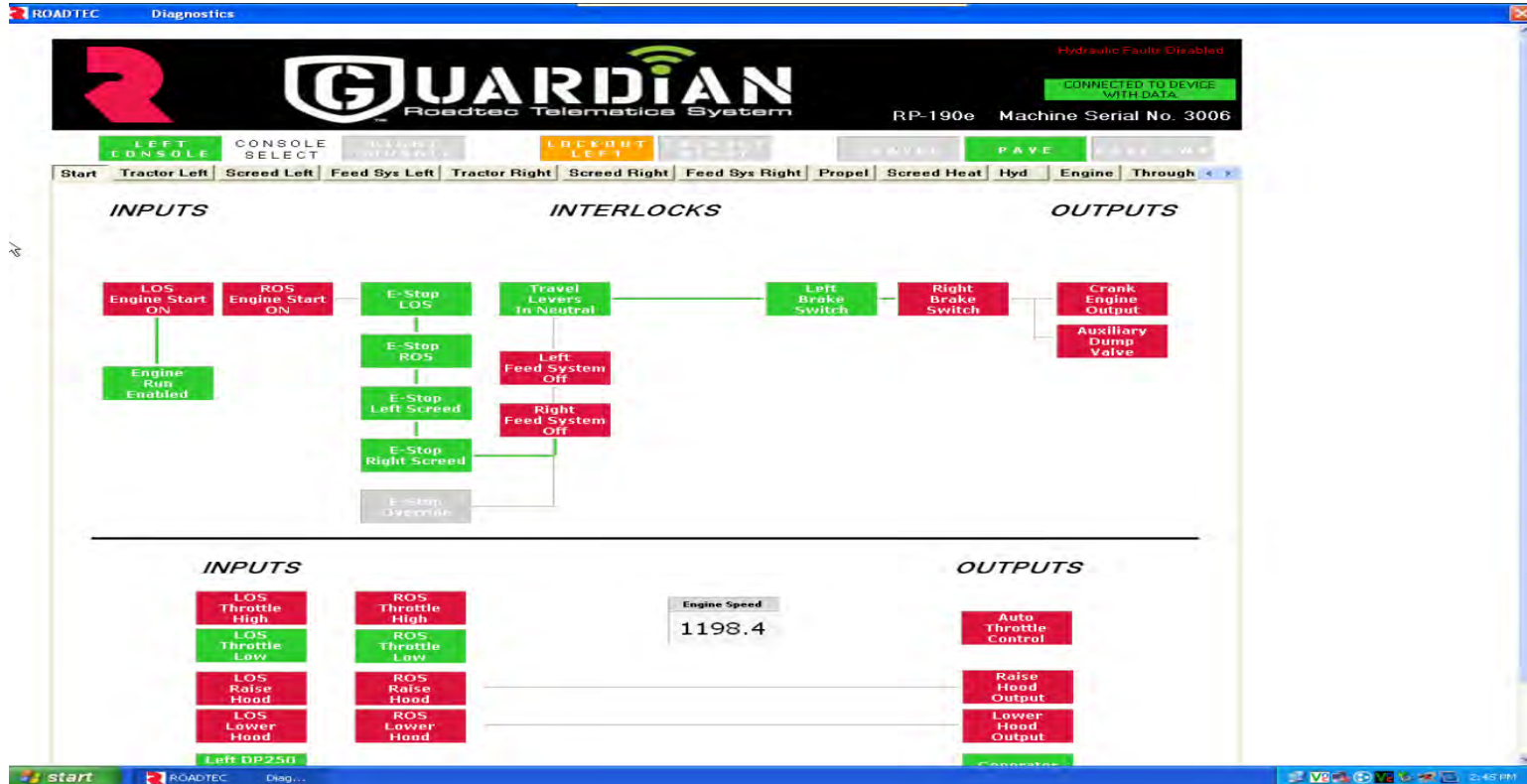
<input checked="" type="checkbox"/> RX-600 4007 4007 Foot/Minute: 0 Idle Time: 0:00:00 Fuel Level: 70% Engine Hours: 460 Hours Until Service: 187.6
<input checked="" type="checkbox"/> RP-190 4010 4010 Foot/Minute: 0 Idle Time: 0:00:00 Fuel Level: 0% Engine Hours: 375 Hours Until Service: -124.6
<input checked="" type="checkbox"/> RP-190 4013 4013 Foot/Minute: 0 Idle Time: 0:00:00 Fuel Level: N/A% Engine Hours: 242 Hours Until Service: 7.7
<input checked="" type="checkbox"/> RP-190 4026 4026 Foot/Minute: 0 Idle Time: 0:00:00 Fuel Level: 0% Engine Hours: 254 Hours Until Service: -3.6
<input checked="" type="checkbox"/> RP-190 4028 4028 Foot/Minute: 0 Idle Time: 0:00:00

Map showing vehicle locations in Texas and surrounding states (Oklahoma, Arkansas, Louisiana, Mississippi, Alabama, Tennessee). Callouts for units 4026, 4010, 4013, and 4028 are visible.

© 2015 Microsoft Corporation © 2015 HERE



Pavers



Pavers - Tractor Left

ROADTEC Diagnostics

GUARDIAN
Roadtec Telematics System

RP-190e Machine Serial No. 3006

CONNECTED TO DEVICE WITH DATA

LEFT CONSOLE CONSOLE SELECT LOCKOUT LEFT

Start Tractor Left Screenshot Left Feed Sys Left Tractor Right Screenshot Right Feed Sys Right Propel Screenshot Heat Hyd Engine Through

Left Tractor Controls

DP250 INPUTS

INPUTS

- LRS Vibrators On
- LRS Screenshot Lift
- LRS Screenshot In Float
- LRS Screenshot Locked
- LRS Screenshot Boost/Assist
- Horn
- LRS Auger Raise
- LRS Auger Lower
- LRS Hopper Raise
- LRS Hopper Lower
- LRS Console Pivot In
- LRS Console Pivot Out
- LRS Extend Left Extension
- LRS Retract Left Extension

OUTPUTS

- Vibrators On
- Screenshot Lift
- Screenshot In Float
- Screenshot Locked
- Screenshot Boost/Assist
- Horn
- Raise Left Auger
- Raise Right Auger
- Lower Left Auger
- Lower Right Auger
- Raise Hopper
- Lower Hopper
- Truck Hitch In
- Truck Hitch Out
- Left Console Pivot In
- Left Console Pivot Out
- Left Extension Extended
- Left Extension Retracting

Machine Stopped

ROADTEC Diag... 4:38 PM

Paver - Screed Left

ROADTEC Diagnostics

GUARDIAN
Roadtec Telematics System

Hydraulic Fault Disabled

CONNECTED TO DEVICE WITH DATA

RP-190e Machine Serial No. 3006

LEFT CONSOLE CONSOLE SELECT LOCK FOOT LEFT PAVE

Start Tractor Left **Screed Left** Feed Sys Left Tractor Right Screed Right Feed Sys Right Propel Screed Heat Hyd Engine Through

INPUTS

LOCK OUT

DP250 INPUTS

- LSC Vertical Increase
- LSC Vertical Decrease
- LSC Slope Increase
- LSC Slope Decrease
- LSC Berm Increase
- LSC Berm Decrease
- LSC Towpoint Raise
- LSC Towpoint Lower
- LSC Tunnel Extend
- LSC Tunnel Retract
- L Screed Control Extend Left
- L Screed Control Retract Left
- Auger Reverse
- Horn

Left Screed Controls

- LSC E-Stop

OUTPUTS

- Vibrator On
- Crown Up
- Crown Down
- Left Vertical Increase
- Left Vertical Decrease
- Left Slope Increase
- Left Slope Decrease
- Left Berm Increase
- Left Berm Decrease
- Left Towpoint Raise
- Left Towpoint Lower
- Left Tunnel Extending
- Left Tunnel Retracting
- Left Extension Extending
- Left Extension Retracting
- Auger Rev Output
- Horn

start ROADTEC Diag... 4:47 PM

Location

The screenshot displays a web-based interface for the Guardian telematics system. At the top, the header includes the ROADTEC logo, the Guardian logo with the text "Roadtec Telematics System", and the device information "RP-190e Machine Serial No. 3006". A status bar below the header shows "Hydraulic Faults Disabled" and "CONNECTED TO DEVICE WITH DATA".

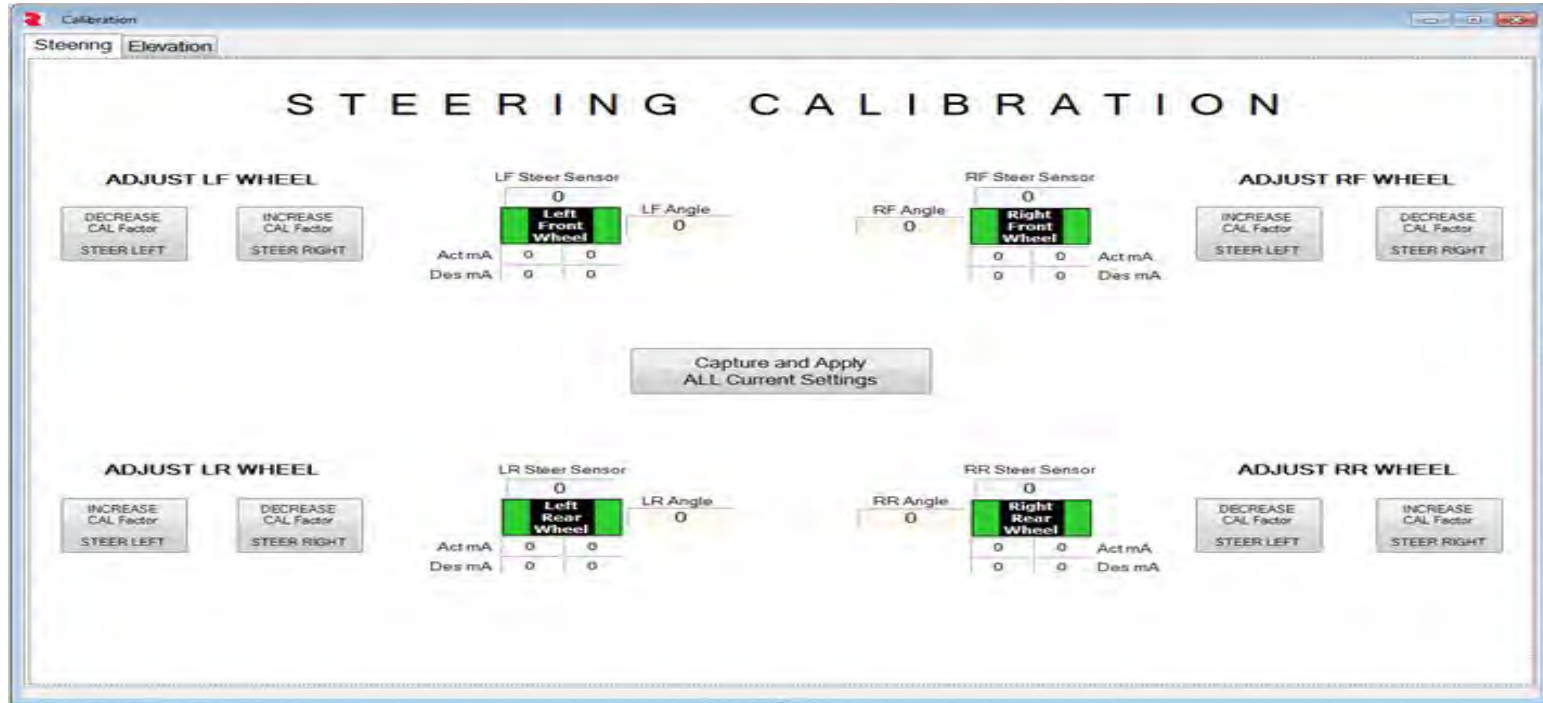
The main interface features a navigation menu with buttons for "LEFT CONSOLE", "CONSOLE SELECT", "RIGHT CONSOLE", "LOCKOUT LEFT", "LOCKOUT RIGHT", "TRAVEL", "PAUSE", and "SAVE DATA". Below this, there are tabs for "Screed Left" and "Feed Sys Left".

On the left side, there is a panel displaying the current location coordinates: "Latitude N33.40515" and "Longitude W88.84557". A "Show Map" button is located below these coordinates.

The central focus is a Google Maps window titled "Guardian Machine Location". The search bar contains the coordinates "N33.40547,W88.84543". The map shows a location in Starkville, MS, with a red pin and a thumbnail image of a road. The address "1935-1951 Louisville St, Starkville, MS 39759, 9.9 ft W" is displayed. The map includes street names such as "Longview Rd", "W Poor House Rd", "Louisville St", and "Juliana Rd". A scale bar indicates 1000 feet and 200 meters. The bottom of the map window shows "Map data ©2013 Google" and "Edit in Google Map Maker".

The Windows taskbar at the bottom shows the "start" button, several open applications including "ROADTEC Diag...", "Guardian Machin...", and system icons for network, volume, and power, along with the time "2:52 PM".

Calibration Through Guardian



Stabilizer steering calibration

Calibration Through Guardian (continued)

The screenshot displays the 'ELEVATION CALIBRATION' window with the 'Elevation' tab selected. The interface is organized into four quadrants, each representing a different cylinder: Left Front (LF), Right Front (RF), Left Rear (LR), and Right Rear (RR). Each quadrant contains the following elements:

- Actual mA** and **Desired mA** input fields, both set to 0.
- Jog Up** and **Jog Down** output buttons.
- Sensor** and **Setpoint** readouts, all showing 0.
- ADJUST [Cylinder] CYLINDER** section with **DECREASE CAL Factor** and **INCREASE CAL Factor** buttons, and **LOWER LEG** and **RAISE LEG** labels.

A central **Capture and Apply ALL Current Settings** button is located between the four adjustment sections.

Stabilizer elevation calibration



Guardian Tools

- Machines will be accessed through a web interface
- Email setup and controls
- Diagnostics
- Production Reporting
- Advanced queries
 - Machines with low fuel pressure
 - Machines with certain engine fault codes
 - Etc.
- Roadtec will still log in to update controllers, run service tool, etc.



Status Board

PAVER ALERTS

FW: Fault Notification RP-190e S/N-3055
Eric Baker 9:48 PM

FW: Machine Reporting Summary RP-195e S/ N-3011
Eric Baker 8:31 PM

FW: Machine Reporting Summary RP-190e S/ N-3055
Eric Baker 8:20 PM

FW: Machine Reporting Summary RP-190e S/ N-3060
Eric Baker 2:41 PM



MILL ALERTS

FW: Machine Reporting Summary RX-700e S/ N-2053
Eric Baker 2:58 PM

FW: Machine Reporting Summary RX-700e S/ N-2046
Eric Baker 12:41 PM

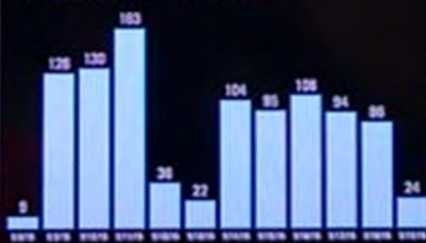
FW: Machine Reporting Summary RX-700e S/ N-2013
Eric Baker 11:58 AM

FW: Machine Reporting Summary RX-600e S/ N-2049
Eric Baker 11:58 AM

PAVER ALERTS - GRAPH BY HOUR



ALL ALERTS - GRAPH BY DAY



MILL ALERTS - GRAPH BY HOUR

