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## Provisional Application for Patent Cover Sheet

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c)

### Inventor(s)

Inventor 1 — Remove

| Given Name | Middle Name | Family Name | City | State | Country |
|---|---|---|---|---|---|
| David | L. | Armitage | Golden | CO | US |

Inventor 2 — Remove

| Given Name | Middle Name | Family Name | City | State | Country |
|---|---|---|---|---|---|
| Mark | A. | Mason | Thornton | CO | US |

Inventor 3 — Remove

| Given Name | Middle Name | Family Name | City | State | Country |
|---|---|---|---|---|---|
| Gregory | F. | Kushnir | Denver | CO | US |

All Inventors Must Be Listed – Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. — Add

| | |
|---|---|
| **Title of Invention** | MOBILE RAILWAY CAR SENSOR SYSTEM |
| Attorney Docket Number (if applicable) | 479.0002P |

### Correspondence Address

Direct all correspondence to (select one):

| | |
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| (•) The address corresponding to Customer Number | ( ) Firm or Individual Name |
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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

(•) No.

( ) Yes, the name of the U.S. Government agency and the Government contract number are:



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## Entity Status

Applicant claims small entity status under 37 CFR 1.27

- (•) Yes, applicant qualifies for small entity status under 37 CFR 1.27
- ( ) No

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| | | | | | |
|---|---|---|---|---|---|
| Signature | /David J. Bovitz/ | | | Date (YYYY-MM-DD) | 2010-05-11 |
| First Name | David | Last Name | Bovitz | Registration Number (If appropriate) | 61911 |

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# MOBILE RAILWAY CAR SENSOR SYSTEM

## TECHNICAL BACKGROUND

**[0001]** Railway cars, such as those found in freight trains and passenger trains, include undercarriage portions to roll the railway car and an associated payload across railroad tracks. The undercarriage portion typically includes wheels and related equipment, such as axles, bearings, journals, gears, and other moving parts, which can experience harsh conditions while in use. These harsh conditions can include elevated temperatures while under heavy loads and during start/stop conditions. Stationary equipment, such as thermal imaging inspection equipment, or 'hotbox' detectors can be positioned at various points along a railroad track to take a snapshot of railway car bearing status. Stationary impact detectors can also be installed in the rails and used to detect wheel damage.

## OVERVIEW

**[0002]** What is disclosed is a mobile railway car monitoring system. The mobile railway car monitoring system includes a plurality of sensor nodes coupled to an undercarriage portion of a railway car, and a control node coupled to the railway car. Each of the plurality of sensor nodes is configured to monitor the undercarriage portion of the railway car when in motion and transmit information about the undercarriage portion to the control node. The control node is configured to receive the information about the undercarriage portion, process the information to determine a fault condition for the undercarriage portion, and wirelessly report the fault condition to a collection system.



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## BRIEF DESCRIPTION OF THE DRAWINGS

**[0003]** Many aspects of the disclosure can be better understood with reference to the following drawings. The components in the drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the present disclosure. Moreover, in the drawings, like reference numerals designate corresponding parts throughout the several views. While several embodiments are described in connection with these drawings, the disclosure is not limited to the embodiments disclosed herein. On the contrary, the intent is to cover all alternatives, modifications, and equivalents.

**[0004]** Figure 1 is a system diagram illustrating a railway car monitoring system.

**[0005]** Figure 2 is a block diagram illustrating a control node.

**[0006]** Figure 3 is a block diagram illustrating a sensor node.

## DETAILED DESCRIPTION

**[0007]** Figure 1 is a system diagram illustrating railway car monitoring system 100. System 100 includes railway car 110, undercarriage elements 111-114 of railway car 110, sensor nodes 121-124, control node 130, communication network 140, and collection node 150. Control node 130 and each of sensor nodes 121-124 communicate over links 161-164, respectively. Control node 130 and communication network 140 communicate over wireless link 165. Communication network 130 and collection node 150 communicate over link 166. In this example, sensor node 121 is coupled to undercarriage element 111, sensor node 122 is



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coupled to undercarriage element 112, sensor node 123 is coupled to undercarriage element 113, and sensor node 124 is coupled to undercarriage element 114. It should be understood that although four sensor nodes and undercarriage elements are shown in Figure 1, a different number of sensor nodes or undercarriage elements could be included.

**[0008]** Railway car 110 comprises a vehicle used on a rail transport system, such as a freight car, truck, wagon, coach, or passenger car. Railway car 110 could be used to carry freight, cargo, passengers, or other items. Railway car 110 includes undercarriage portions, shown as undercarriage elements 111-114 in Figure 1. Undercarriage elements 111-114 each are an element or portion of the undercarriage of railway car 110. Undercarriage elements 111-114 typically each comprise equipment related to the rolling motion of railway car 110, such as a wheel, axle, gearbox, bearing, bearing box, journal box, or other equipment.

**[0009]** Sensor nodes 121-124 each include equipment to sense and report information about undercarriage elements of a railway car. Each of sensor nodes 121-124 includes a sensor portion, and the sensor portion could include thermometers, thermocouples, thermistors, thermopiles, infrared (IR) emitters/detectors, microphones, ultrasonic emitters/detectors, accelerometers, strain gauges, flow gauges, chemical sensors, micro-electromechanical system (MEMS) sensors, electrical sensors, among other sensing equipment and circuitry. Each of sensor nodes 121-124 also includes a transceiver portion for communication with control node 130. In some examples, the transceiver portion includes a wireline transceiver for communicating with control node 130 over a wire, optical fiber, or other medium. In other examples, the transceiver portion includes a wireless transceiver and antenna for wirelessly communicating with control node 130. Each of sensor nodes 121-124 could also include a processing portion for receiving the sensor information, amplifying, scaling, modifying,



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adjusting, digitizing, or converting the sensor information, as well as controlling the transceiver portion and sensor portions. Each of sensor nodes 121-124 could also comprise a power system, such as a battery or solar cell.

**[0010]** Sensor nodes 121-124 are each attached or coupled to the associated undercarriage element of railway car 110. In some examples, sensor nodes 121-124 are fastened to the associated undercarriage element with a mechanical fastener, such as a screw, rivet, wire, harness, weld, latch, or tie. In other examples, sensor nodes 121-124 are each coupled to the associated undercarriage element with an adhesive, such as glue, tape, Velcro, suction, or other adhesive or adhesive method. In yet further examples, sensor nodes 121-124 are each coupled to the associated undercarriage element with a magnet, such as an electromagnet, permanent magnet, rare-earth magnet, ceramic magnet, or other magnetic attachment device. Sensor nodes 121-124 could each be encased in a weatherproof or sealed enclosure, or may have openings for air circulation.

**[0011]** In operation, each of sensor nodes 121-124 sense and monitor equipment associated with railway car 110. The information monitored could include undercarriage element temperature, ambient temperature, vibration, noise, among other information. In typical examples, sensor nodes 121-124 will sense and monitor the equipment while railway car 110 is in motion, such as when rolling. Each of sensor nodes 121-124 is also configured to transmit the monitored information about the undercarriage portion to control node 130 over the associated link 161-164. In some examples, each of sensor nodes 121-124 is configured to wirelessly transmit the monitored information about the undercarriage portion to control node 130. Each of sensor nodes 121-124 could also process the sensor information, which may include amplifying, scaling, modifying, adjusting, digitizing, or converting the sensor information, and transfer the



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processed sensor information to control node 130. Each of sensor nodes 121-124 could also report other information to control node 130, such as position, time, battery life, sensor status, inoperative sensors, serial numbers, sensor identifiers, among other information.

**[0012]** Control node 130 includes circuitry and equipment to exchange communications with each of sensor nodes 121-124 over links 161-164, respectively. In many examples, control node 130 also includes circuitry and equipment to exchange communications with a base station of a wireless communication network, such as a cellular communication device, satellite communication device, mobile phone circuitry, satellite phone, mobile network device, or other equipment. Control node 130 may also include user interface systems, memory devices, computer-readable storage mediums, software, processing circuitry, or some other components. In some examples, control node 130 includes a positioning system, such as a global positioning system (GPS) receiver, to receive and interpret signals from positioning satellites to determine geographic coordinates of control node 130. Control node 130 could also comprise a power system, such as a battery or solar cell.

**[0013]** Control node 130 is attached or coupled to railway car 110. In some examples, control node 130 is fastened to railway car 110 with a mechanical fastener, such as a screw, rivet, wire, harness, weld, latch, or tie. In other examples, control node 130 is coupled to railway car 110 with an adhesive, such as glue, tape, Velcro, suction, or other adhesive or adhesive method. In yet further examples, control node 130 is coupled to railway car 110 with a magnet, such as an electromagnet, permanent magnet, rare-earth magnet, ceramic magnet, or other magnetic attachment device. Control node 130 could be coupled to railway car 110 internally or externally, on a side or end portion, among other locations. Control node 130 could be encased in a weatherproof or sealed enclosure, or may have openings for air circulation.



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**[0014]** In operation, control node 130 receives sensor information, or modified sensor information, from each of sensors 121-124 over wireline or wireless links. Control node 130 processes the sensor information to determine fault conditions, or other conditions such as hotbox conditions, dragging equipment, wheel impact or sliding wheel conditions, high car or shifted load conditions, hot wheel conditions, door opening, tank level, humidity, temperature, shock, bearing temperature, vibration signatures, truck tracking deviations, among other conditions. A hotbox condition includes where an equipment box, shroud, enclosure, or other equipment container, experiences an elevated temperature. A hotbox condition is typically caused by a fault with the equipment contained within the box, such as a loss of lubricant or coolant in the box, damage, or from ambient conditions around the box, among other causes, including combinations thereof. Control node 130 then reports fault conditions to collection node 150. In the example shown in Figure 1, collection node 150 communicates with control node 130 through communication network 140, although other configurations could be employed. Control node 130 could also report other information to collection node 150, such as position, time, battery life, sensor status, inoperative sensors, serial numbers, network addresses, railway car identifiers, among other information.

**[0015]** In some examples, to determine the fault condition, control node 130 is configured to process the information received from each of sensor nodes 121-124 over a period of time to determine a threshold for reporting the fault condition. In many examples, sensor information can be affected by ambient temperature, motion, time-dependent effects, noise, or other phenomena. Control node 130 could process the sensor information to determine anomalies from an average, such as an anomaly from a running average of the temperature of all wheels on railway car 110. In other examples, a dynamic threshold is determined. The dynamic threshold

could be adjusted *in situ* as railway car conditions change, such as during motion, acceleration, ascent/descent, cornering, during weather events, time of day, position, or due to other conditions. For example, while railway car 110 is cornering, a different temperature may be sensed for wheels on the outside portion of the turn than for wheels on the inside portion of the turn. Control node 130 could take this cornering into account when determining if an anomaly exists before reporting a fault condition to collection node 150. In other examples, the ambient temperature or weather conditions could be evaluated to determine an anomaly of an undercarriage element.

**[0016]** Some examples describe a dynamic normalization, where the application of a sensor network on each railway car is employed to dynamically define norms of operation for each of the critical mechanical components. Data is streamed from an array of sensors to a Data Correlation Unit (DCU) installed on each railway car. Analysis in both the temporal and sensor domains are used to define a dynamic set of norms for the operating conditions of each mechanical component. Any significant deviation from these measurements is indicative of failure or projected failure. The population of sensors on each railway car, and the collection of measurements over a period of time, provides a baseline which is independent of railway car loading, weather, grade, track condition, component wear, and other environmental conditions. The degree to which any specific sensor deviates from this population is indicative of the severity of the mechanical condition of the component. When a deviation is detected, a satellite transmitter installed adjacent to the DCU is activated and an alert is generated. For example, when a sensor exhibits 'significant' deviation from the normal conditions, an event is generated by the DCU. Each event could be ranked by severity and status could be provided periodically, such as twice daily, to provide railcar location and system status. The event ranking could



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include a 'yellow' condition which indicates that a railway car requires service, and a 'red' condition which indicates that a sensor has detected a serious deviation from normal operations that requires immediate service. In some examples, each railway car sensor array reports every 'n' seconds to the DCU, and the DCU aggregates and continuously analyzes the datastream from the sensors. The analysis is designed to be 'agnostic' to the specific sensor. Trend modeling identifies specific sensor telemetry that lies outside norms, where 'normal' can be defined dynamically by assessing the set of sensors on each railway car. Realtime, continuous monitoring of all critical railway car components can be monitored and predictive analytics performed for wheels, bearings and trucks which is dynamically adjusted to operating conditions. Rapid detection of handbrake sets can also be performed. A railway car health 'scorecard' could be provided to a user, presented via email, text message, web page, or discrete software interfaces.

**[0017]** Communication network 140 could include base stations, base station control systems, Internet access nodes, telephony service nodes, wireless data access points, routers, gateways, or other wireless communication systems, including combinations thereof. Communication network 140 may also comprise optical networks, asynchronous transfer mode (ATM) networks, packet networks, metropolitan-area networks (MAN), or other network topologies, equipment, or systems, including combinations thereof. In typical examples, communication network 140 includes many base stations and associated equipment for providing communication services to many wireless and mobile devices across a geographic region.

**[0018]** Collection node 150 comprises equipment for receiving fault conditions, sensor information, location information, or other information from control node 130 through communication network 140. Collection node 150 also includes a computer system,



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microprocessor, circuitry, or some other processing device or software system, and may be distributed among multiple processing devices. Examples of collection node 150 may also include software such as an operating system, logs, utilities, drivers, networking software, and other software stored on a computer-readable medium. Collection node 150 could also include application servers, application service provider systems, database systems, logistics systems, web servers, or other systems.

**[0019]** In the example shown in Figure 1, collection node 150 communicates with control node 130 through communication network 140, although other configurations could be employed. Collection node 150 could collect fault conditions and other information from many control nodes. For example, on a train where many railway cars are connected in series, a control node could be coupled to each railway car along with associated sensor nodes. Collection node 150 could receive information from each control node of the train, and thus monitor the entire train. In some examples, control nodes include a GPS receiver, and could also provide positioning information to collection node 150. Collection node 150 could determine a position of a train based upon this information, as well as differentiate railway cars from each other within the train. Fault conditions could be isolated to a particular railway car. In further examples, the information received from multiple control nodes could be used to determine an order of railway cars in a train.

**[0020]** Communication links 161-164 each use various communication media, such as air, space, metal, optical fiber, or some other signal propagation path, including combinations thereof. Communication links 161-164 could each use various communication protocols, such as Internet Protocol (IP), Ethernet, Wireless Fidelity (WiFi), Bluetooth, Controller Area Network (CAN) bus, Inter-Integrated Circuit (I2C), 1-Wire, Radio Frequency Identification (RFID),



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optical, circuit-switched, communication signaling, or some other communication format, including combinations, improvements, or variations thereof. Communication links 161-164 could each be direct links or may include intermediate networks, systems, or devices. In some examples, communication links 161-164 each operate using wireless protocols as described for wireless link 165.

**[0021]** Wireless link 165 uses the air or space as the transport media. Wireless link 165 may use various protocols, such as Code Division Multiple Access (CDMA), Evolution-Data Optimized (EV-DO), single-carrier radio transmission technology link (1xRTT), Worldwide Interoperability for Microwave Access (WIMAX), Global System for Mobile Communication (GSM), Universal Mobile Telecommunications System (UMTS), Long Term Evolution (LTE), Wireless Fidelity (WiFi), High Speed Packet Access (HSPA), Radio Link Protocol (RLP), satellite phone communications, or some other wireless communication format, including combinations, improvements, or variations thereof.

**[0022]** Communication link 166 uses various communication media, such as air, space, metal, optical fiber, or some other signal propagation path, including combinations thereof. Communication link 166 could use various communication protocols, such as Time Division Multiplex (TDM), asynchronous transfer mode (ATM), Internet Protocol (IP), Ethernet, Wireless Fidelity (WiFi), synchronous optical networking (SONET), circuit-switched, communication signaling, or some other communication format, including combinations, improvements, or variations thereof. Communication link 166 could be a direct links or may include intermediate networks, systems, or devices. In some examples, communication link 166 operates using wireless protocols as described for wireless link 165.



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**[0023]** Links 161-166 may each include many different signals sharing the same link – as represented by the associated lines in Figure 1 – comprising access channels, forward links, reverse links, user communications, communication sessions, overhead communications, frequencies, other channels, carriers, timeslots, spreading codes, transportation ports, logical transportation links, network sockets, packets, or communication directions.

**[0024]** Figure 2 is a block diagram illustrating control node 200, as an example of control node 130 found in Figure 1, although control node 130 could use other configurations. Control node 200 includes wireless transceiver 210, processing system 220, sensor interface 230, and power system 240. Wireless transceiver 210, processing system 220, sensor interface 230, and power system 240 communicate over bus 250. Control node 200 may be distributed among multiple devices that together form elements 210, 220-222, 230, 240, 250, and 260-261.

**[0025]** Wireless transceiver 210 comprises a communication interface for communicating with a wireless access node, such as a terrestrial base station or satellite station. Wireless transceiver 210 could include transceiver equipment and antenna elements for wirelessly exchanging fault conditions, sensor information, or other information, with a collection node, omitted for clarity, over wireless link 260. Wireless transceiver 210 also receives command and control information and instructions from processing system 220. Wireless transceiver 210 could use various protocols or communication formats as described herein for wireless links 162, including combinations, variations, or improvements thereof.

**[0026]** Processing system 220 includes storage system 221. Processing system 220 retrieves and executes software 222 from storage system 221. In some examples, processing system 220 is located within the same equipment in which wireless transceiver 210, sensor interface 230, or power system 240 are located. In further examples, processing system 220



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comprises specialized circuitry, and software 222 or storage system 221 could be included in the specialized circuitry to operate processing system 220 as described herein. Storage system 221 could include a computer-readable medium such as a disk, tape, integrated circuit, server, or some other memory device, and also may be distributed among multiple memory devices. Software 222 may include an operating system, logs, utilities, drivers, networking software, and other software typically loaded onto a computer system. Software 222 could contain an application program, firmware, or some other form of computer-readable processing instructions. When executed by processing system 220, software 222 directs processing system 220 to operate as described herein, such as receive information from sensor nodes, process the information to determine fault conditions, and report the fault conditions to a collection node.

**[0027]** Sensor interface 230 comprises communication interfaces for communicating with sensor nodes. Sensor interface 230 could include transceiver equipment or antenna elements for exchanging sensor information, omitted for clarity, over the associated links 261. In some examples, two or more of the associated links 261 are used to communicate with a single sensor node. Sensor interface 230 also receives command and control information and instructions from processing system 220 or wireless transceiver 210.

**[0028]** Power system 240 includes circuitry and a power source to provide power to the elements of control node 200. The power source could include a battery, solar cell, spring, flywheel, capacitor, thermoelectric generator, nuclear power source, chemical power source, dynamo, or other power source. In some examples, power system 240 receives power from an external source, such as a railway car. Power system 240 also includes circuitry to condition, monitor, and distribute electrical power to the elements of control node 200.



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**[0029]** Bus 250 comprises a physical, logical, or virtual communication and power link, capable of communicating data, control signals, power, and other communications. In some examples, bus 250 is encapsulated within the elements of wireless transceiver 210, processing system 220, sensor interface 230, or power system 240, and may include a software or logical link. In other examples, bus 250 uses various communication media, such as air, space, metal, optical fiber, or some other signal propagation path, including combinations thereof. Bus 250 could be a direct link or might include various equipment, intermediate components, systems, and networks.

**[0030]** Figure 3 is a block diagram illustrating sensor node 300, as an example of sensor nodes 121-124 found in Figure 1, although sensor nodes 121-124 could use other configurations. Sensor node 300 includes transceiver 310, processing system 320, sensor 330, and power system 340. Transceiver 310, processing system 320, sensor 330, and power system 340 communicate over bus 350. Sensor node 300 may be distributed among multiple devices that together form elements 310, 320-322, 330, 340, 350, and 360.

**[0031]** Transceiver 310 comprises a communication interface for communicating with a control node, such as control node 130. Transceiver 310 could include transceiver equipment and antenna elements for exchanging sensor information, data, or other information, with a control node, omitted for clarity, over link 360. Transceiver 310 also receives command and control information and instructions from processing system 320. Transceiver 310 could use various protocols or communication formats as described herein for links 161-162, including combinations, variations, or improvements thereof.

**[0032]** Processing system 320 includes storage system 321. Processing system 320 retrieves and executes software 322 from storage system 321. In some examples, processing



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system 320 is located within the same equipment in which transceiver 310, sensor 330, or power system 340 are located. In further examples, processing system 320 comprises specialized circuitry, and software 322 or storage system 321 could be included in the specialized circuitry to operate processing system 320 as described herein. Storage system 321 could include a computer-readable medium such as a disk, tape, integrated circuit, server, or some other memory device, and also may be distributed among multiple memory devices. Software 322 may include an operating system, logs, utilities, drivers, networking software, and other software typically loaded onto a computer system. Software 322 could contain an application program, firmware, or some other form of computer-readable processing instructions. When executed by processing system 320, software 322 directs processing system 320 to operate as described herein, such as monitor sensor 330, process the sensor information, and transfer sensor information or data.

**[0033]** Sensor 330 comprises a sensor or sensors for monitoring an undercarriage element of a railway car. Sensor 330 could include sensor circuitry, amplifiers, analog-to-digital converters, microcontrollers, among other circuitry. The sensor circuitry could include, for example, thermometers, thermocouples, thermopiles, infrared (IR) emitters/detectors, microphones, ultrasonic emitters/detectors, accelerometers, strain gauges, flow gauges, chemical sensors, micro-electromechanical system (MEMS) sensors, electrical sensors, among other sensing equipment and circuitry.

**[0034]** Power system 340 includes circuitry and a power source to provide power to the elements of sensor node 300. The power source could include a battery, solar cell, spring, flywheel, capacitor, thermoelectric generator, nuclear power source, chemical power source, dynamo, or other power source. In some examples, power system 340 receives power from an

external source, such as a railway car or control node. Power system 340 also includes circuitry to condition, monitor, and distribute electrical power to the elements of sensor node 300.

**[0035]** Bus 350 comprises a physical, logical, or virtual communication and power link, capable of communicating data, control signals, power, and other communications. In some examples, bus 350 is encapsulated within the elements of transceiver 310, processing system 320, sensor 330, or power system 340, and may include a software or logical link. In other examples, bus 350 uses various communication media, such as air, space, metal, optical fiber, or some other signal propagation path, including combinations thereof. Bus 350 could be a direct link or might include various equipment, intermediate components, systems, and networks.

**[0036]** Further embodiments are described in attached Exhibit A.

**[0037]** Figures 1-3 and the previous descriptions depict specific embodiments to teach those skilled in the art how to make and use the best mode. For the purpose of teaching inventive principles, some conventional aspects have been simplified or omitted. Those skilled in the art will appreciate variations from these embodiments that fall within the scope of the invention. Those skilled in the art will also appreciate that the features described above can be combined in various ways to form multiple embodiments. As a result, the invention is not limited to the specific embodiments described above, but only by the claims and their equivalents.

CLAIMS:

What is claimed is:

1. A mobile railway car monitoring system, comprising:

a plurality of sensor nodes coupled to an undercarriage portion of a railway car;

a control node coupled to the railway car;

wherein each of the plurality of sensor nodes is configured to monitor the undercarriage portion of the railway car when in motion and transmit information about the undercarriage portion to the control node; and

wherein the control node is configured to receive the information about the undercarriage portion, process the information to determine a fault condition for the undercarriage portion, and wirelessly report the fault condition to a collection system.

2. The mobile railway car monitoring system of claim 1, wherein each of the plurality of sensor nodes is configured to wirelessly transmit the information about the undercarriage portion to the control node.

3. The mobile railway car monitoring system of claim 1, wherein each of the plurality of sensor nodes is magnetically coupled to the undercarriage portion of the railway car.



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4. The mobile railway car monitoring system of claim 1, wherein the control node is configured to process the information received from each of the plurality of sensor nodes over a period of time to determine a threshold for reporting the fault condition.

5. The mobile railway car monitoring system of claim 1, wherein the control node is configured to wirelessly report the fault condition over a wireless phone network.



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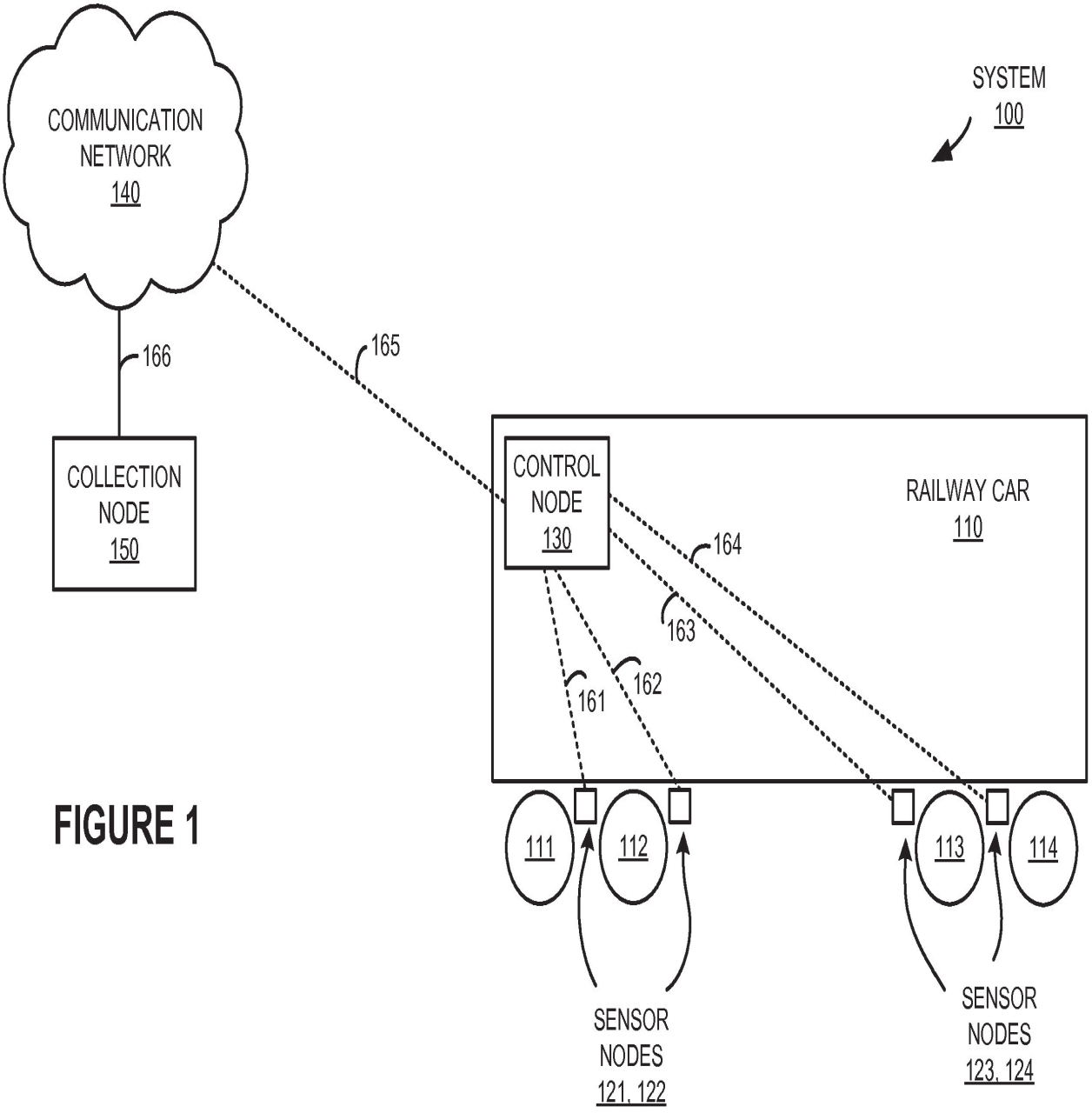

COMMUNICATION NETWORK 140
SYSTEM 100
166
165
COLLECTION NODE 150
CONTROL NODE 130
RAILWAY CAR 110
164
163
162
161
111
112
113
114
SENSOR NODES 121, 122
SENSOR NODES 123, 124

FIGURE 1

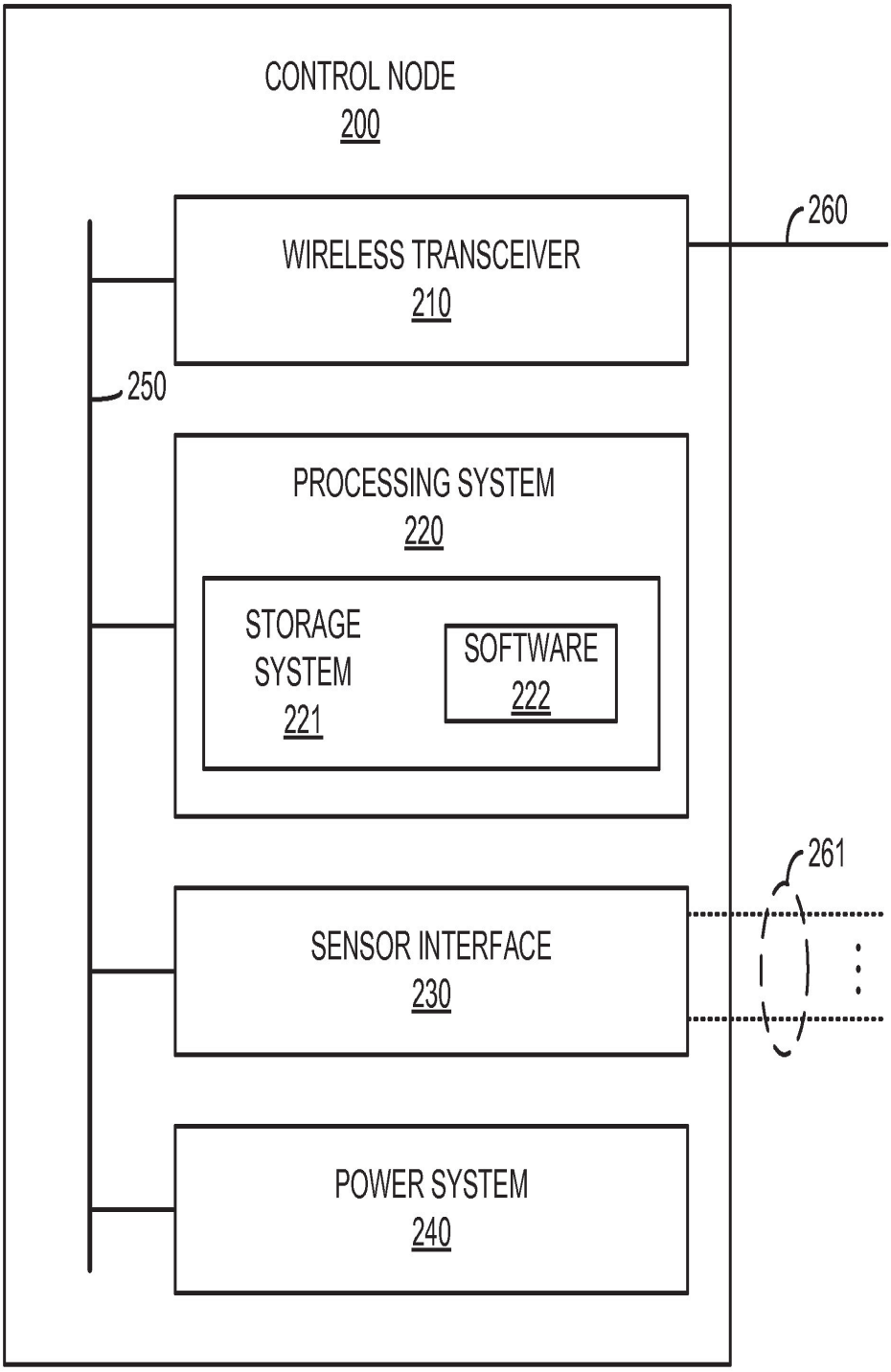

CONTROL NODE
200
WIRELESS TRANSCEIVER
210
260
250
PROCESSING SYSTEM
220
STORAGE
SYSTEM
221
SOFTWARE
222
261
SENSOR INTERFACE
230
POWER SYSTEM
240

FIGURE 2

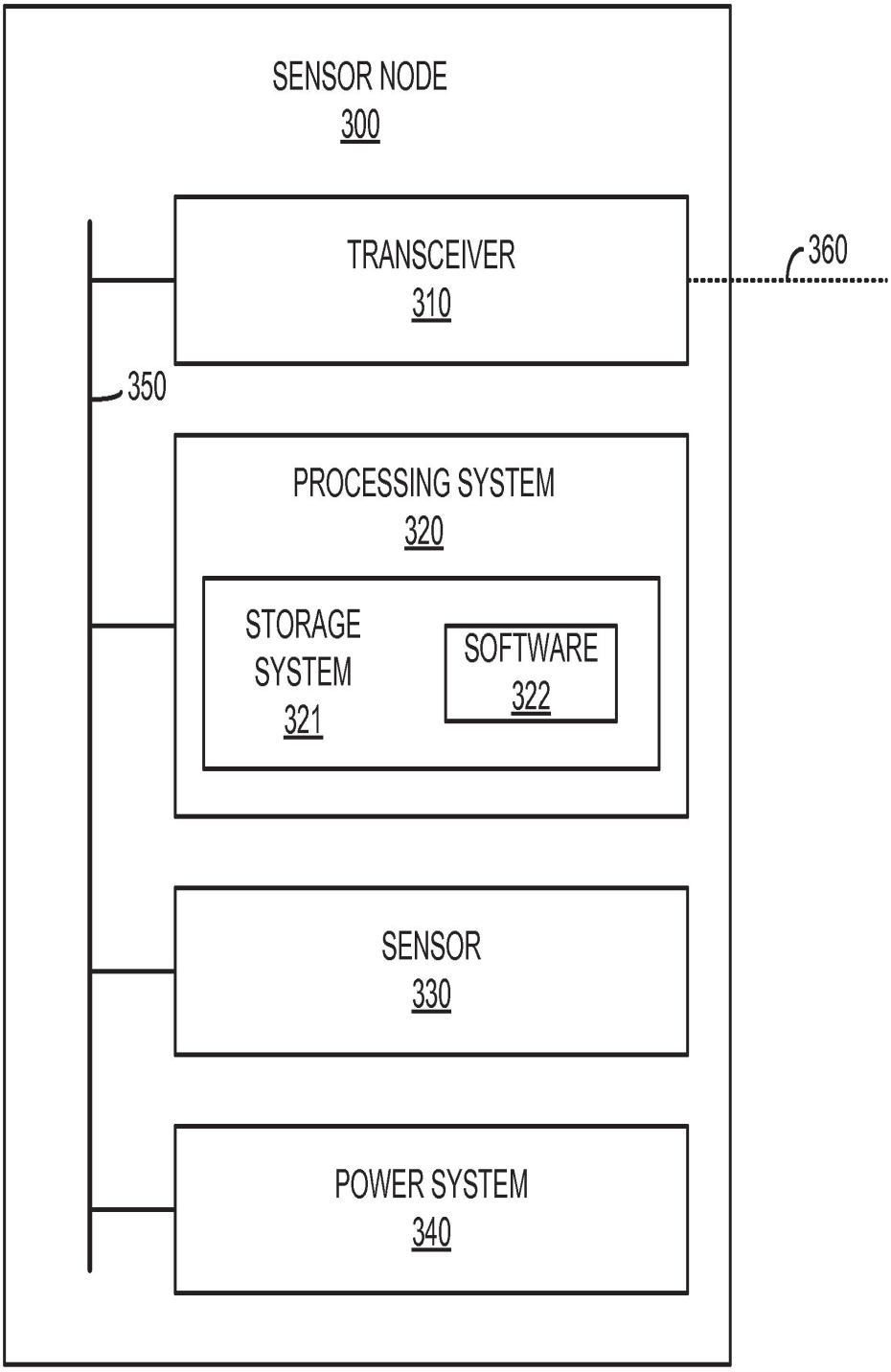

SENSOR NODE
300
TRANSCEIVER
310
360
350
PROCESSING SYSTEM
320
STORAGE
SYSTEM
321
SOFTWARE
322
SENSOR
330
POWER SYSTEM
340

FIGURE 3

# Dynamic Railcar Health Monitoring

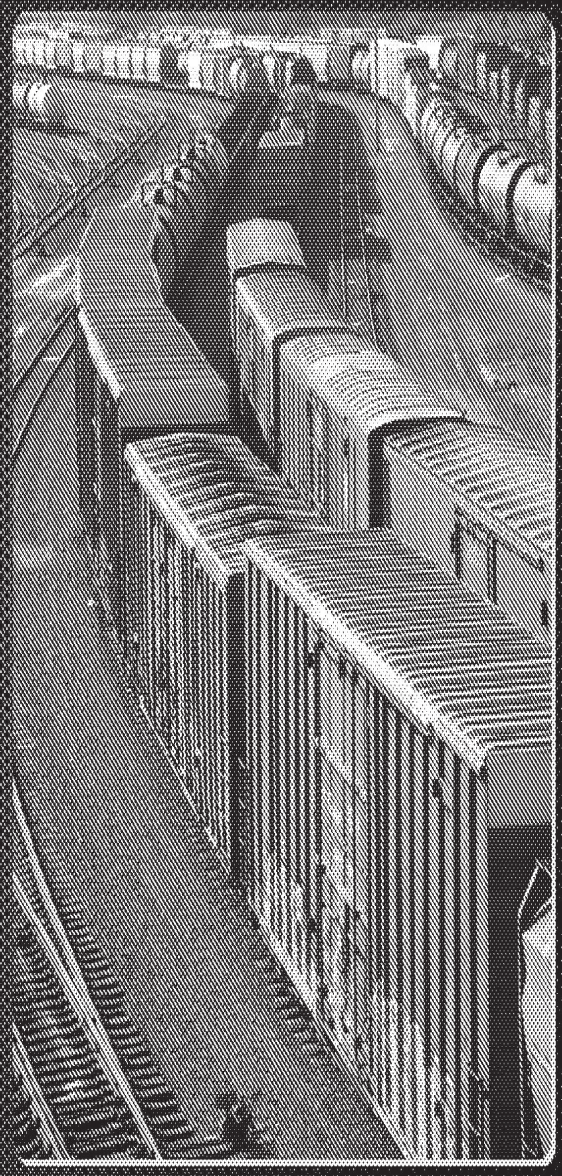
realtime operational intelligence

for the rail industry

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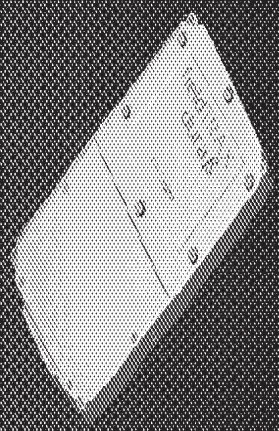
# overview

- Low cost, scalable solution for monitoring the health and safety of railcars
- Operates independently of other cars, locomotives, or trackside detectors
- Accommodates wide variety of railcar operating conditions
- Enables proactive, preventative response by the car owner
- Continuous global coverage. Minimal network bandwidth requirements.
- Operating conditions may include:
  - No external power sources
  - Extreme environmental conditions
  - Extensible to a wide array of sensor types
  - Dynamically adjust to track, environment, weather, loading, and railcar mechanical conditions



# example components

- Each railcar is equipped with the following:
- Battery-powered direct satellite transmitter (duraß)
- Integrated, high precision GPS
- Local area sensor array
- Intelligent data correlation unit (DCU)



Designed for the intelligent management of powered and non-powered, fixed and movable assets, **fieldTRAX duraß** is a practical solution to improve operating efficiency and security.

The "Asset Ready" design allows it to be easily installed and field managed without the need for harnesses, antennas, or external power. The **duraß** is powered by 4 "off the shelf" AA 1.5V lithium batteries providing 3+ years of battery life and removes the need to purchase expensive proprietary batteries for replacement.

The **duraß** utilizes motion sensors, comparative GPS positions and custom configured sensors to gather and transmit asset status information. Each **duraß** is custom configured to track its asset's specific needs and provide intermediate and emergency alerts by email and/or text/cellular.

**Features**

•Quick installation using either industrial adhesives or screw mounts

•Total packaged solution requires no harnesses, no external power and no external antenna

•Change of location sensing sends alerts if asset moves outside of pre-determined range

•Messaging cost reduction mode: reduced satellite messaging if asset remains in same location

•Run time monitoring

•Hardware on/off feature allows the unit to initiate GPS re-centering functionality

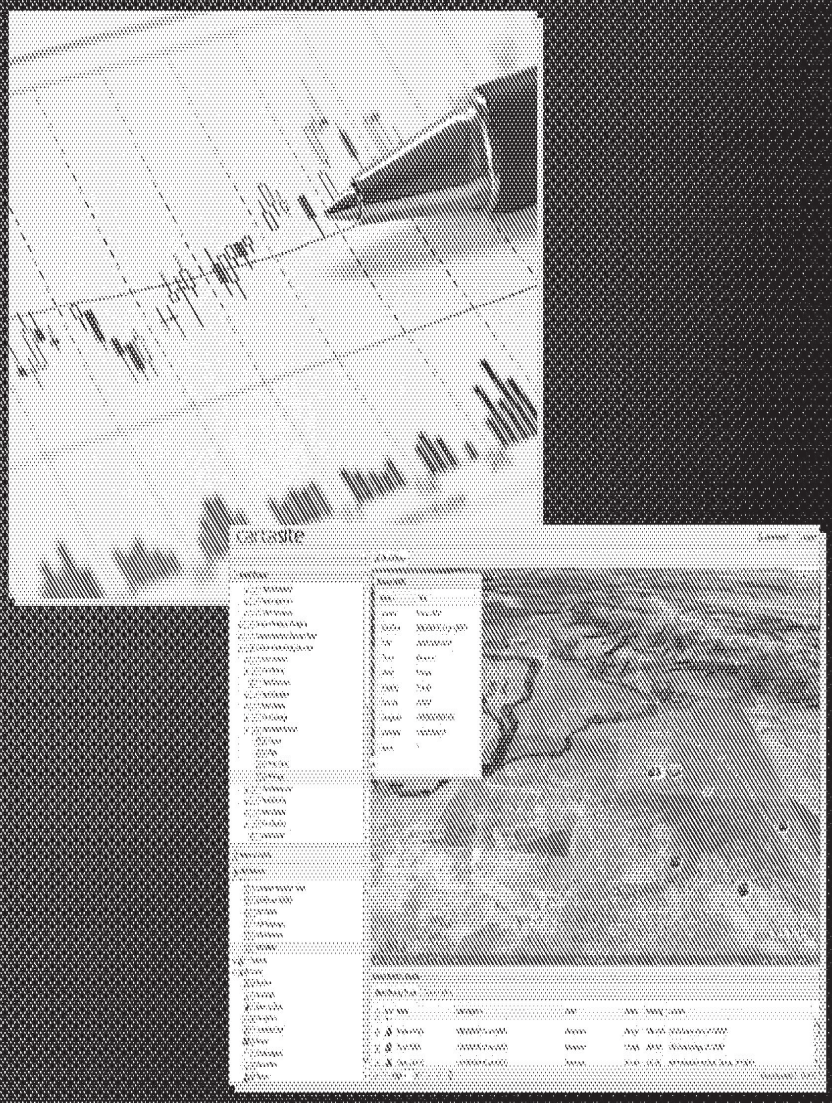
# dynamic normalization

- Each railcar sensor array reports every ‘n’ seconds
- Sensors include accelerometers, thermistors, strain gauges, etc.
- DCU aggregates and continuously analyzes datastream
- ‘Agnostic’ to the specific sensor
- Trend modeling identifies specific sensor telemetry that lies outside norms
- ‘Normal’ is defined dynamically by assessing the set of sensors on each railcar

*Some examples of the invention describe the application of a sensor network on each railcar to dynamically define norms of operation for each of the critical mechanical components. Data is streamed from an array of sensors to a Data Correlation Unit (DCU) installed on each railcar. Analysis in both the temporal and sensor domains are used to define a dynamic set of norms for the operating conditions of each mechanical component. Any significant deviation from these measurements is indicative of prospective failure. The population of sensors on each railcar, and the collection of measurements over a period of time, provides a baseline which is independent of railcar loading, weather, grade, track condition, component wear, and other environmental conditions. The degree to which any specific sensor deviates from this population is indicative of the severity of the mechanical condition of the component. When a deviation is detected, a satellite transmitter installed adjacent to the DCU is activated and an alert is generated.*

# event triggers

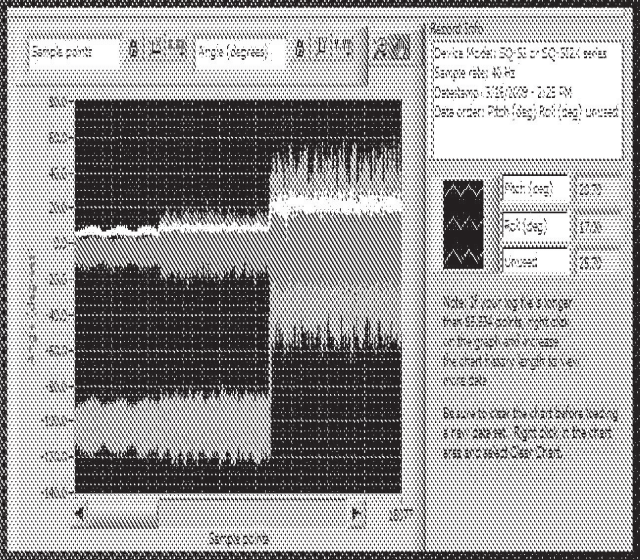
- When a sensor exhibits ‘significant’ deviation from the norm an event is generated by the DCU
- Each event is ranked by severity
  - Periodic (twice daily ?) heartbeat provides railcar location and system status
  - Condition ‘yellow’ indicates that railcar requires service
  - Condition ‘red’ indicates that sensor has detected a serious deviation from normal operations that requires immediate service
- Notification is presented via email, text message and visually on the Cartasite worldVIEW dashboard

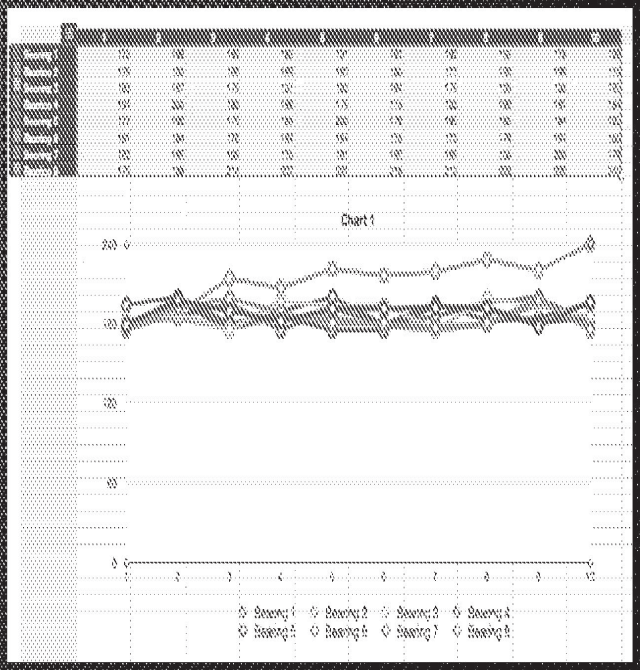



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# example features

- realtime tracking of location
- automatic and assigned geofence notification
- no wires, no antenna, small size, low cost, simplistic install, long life, Class1/Div1, rugged and durable
- local area sensor network
  - door opening, tank level, humidity, temperature, shock…
  - bearing temperature, vibration signature….
  - truck tracking deviation
- realtime, continuous monitoring of all critical car components
  - predictive analytics for wheels, bearings and trucks
  - dynamically adjusted to operating condition
  - rapid detection of handbrake sets
  - railcar health 'scorecard'



# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | |
| **Filing Date:** | |
| **Title of Invention:** | MOBILE RAILWAY CAR SENSOR SYSTEM |
| **First Named Inventor/Applicant Name:** | David L. Armitage |
| **Filer:** | David J. Bovitz/Sarah McLaughlin |
| **Attorney Docket Number:** | 479.0002P |

Filed as Small Entity

## Provisional Filing Fees

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| Provisional Application filing fee | 2005 | 1 | 110 | 110 |
| **Pages:** | | | | |
| **Claims:** | | | | |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |
| **Post-Allowance-and-Post-Issuance:** | | | | |
| **Extension-of-Time:** | | | | |

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| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Miscellaneous:** | | | | |
| | | | **Total in USD ($)** | **110** |

# Electronic Acknowledgement Receipt

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| **EFS ID:** | 7587952 |
| **Application Number:** | 61333428 |
| **International Application Number:** | |
| **Confirmation Number:** | 4561 |
| **Title of Invention:** | MOBILE RAILWAY CAR SENSOR SYSTEM |
| **First Named Inventor/Applicant Name:** | David L. Armitage |
| **Customer Number:** | 76444 |
| **Filer:** | David J. Bovitz |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | 479.0002P |
| **Receipt Date:** | 11-MAY-2010 |
| **Filing Date:** | |
| **Time Stamp:** | 14:24:03 |
| **Application Type:** | Provisional |

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| Payment Type | Credit Card |
| Payment was successfully received in RAM | $110 |
| RAM confirmation Number | 587 |
| Deposit Account | |
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| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
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|---|---|---|---|---|---|
| 1 | Provisional Cover Sheet (SB16) | ProvisionalCoverSheet.pdf | 999596<br>6af5a9fae58ab8b756362516f4c1fd348498879f | no | 3 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Specification | ProvisionalApplication.pdf | 75189<br>b79508f863c390a331e55e763d7a6e4d5ed5b59d | no | 17 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | Drawings-only black and white line drawings | ProvisionalDrawings.pdf | 27118<br>f146ecd870f4e2998321606f1ee9113bd034657e | no | 3 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 4 | Appendix to the Specification | ExhibitA.pdf | 1317216<br>7cb6148d410d72ad08fcb7eef14ac1e84c3f383e | no | 6 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 5 | Fee Worksheet (PTO-875) | fee-info.pdf | 29578<br>696f3f00ee7acd5ad2fb5286a40a0d2d02f6f129 | no | 2 |
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**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

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| APPLICATION NUMBER | FILING or 371(c) DATE | GRP ART UNIT | FIL FEE REC'D | ATTY.DOCKET.NO | TOT CLAIMS | IND CLAIMS |
|---|---|---|---|---|---|---|
| 61/333,428 | 05/11/2010 | | 110 | 479.0002P | | |

**CONFIRMATION NO. 4561**

**FILING RECEIPT**

76444
Setter Roche LLP
P.O. Box 780
Erie, CO 80516

*OC000000041812065*

Date Mailed: 05/28/2010

Receipt is acknowledged of this provisional patent application. It will not be examined for patentability and will become abandoned not later than twelve months after its filing date. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

**Applicant(s)**

David L. Armitage, Golden, CO;
Mark A. Mason, Thornton, CO;
Gregory F. Kushnir, Denver, CO;

**Power of Attorney:**
David Bovitz--61911

**If Required, Foreign Filing License Granted:** 05/26/2010
The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 61/333,428**
**Projected Publication Date:** None, application is not eligible for pre-grant publication
**Non-Publication Request:** No
**Early Publication Request:** No
** **SMALL ENTITY** **
**Title**

MOBILE RAILWAY CAR SENSOR SYSTEM

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