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(54) **AUTONOMOUS VEHICLE OPERATING STATUS ASSESSMENT**

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(58) **Field of Classification Search**
None
See application file for complete search history.

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(57) **ABSTRACT**

Methods and systems for monitoring use, determining risk, and pricing insurance policies for a vehicle having one or more autonomous or semi-autonomous operation features are provided. According to certain aspects, the operating status and/or configuration of autonomous operation fea-

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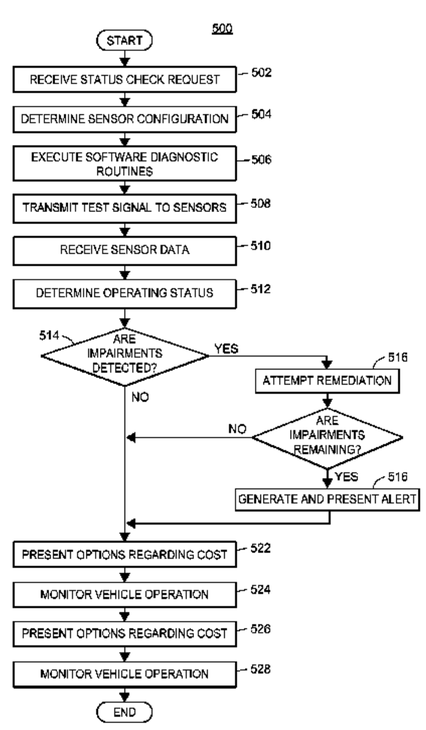

tures of an autonomous or semi-autonomous vehicle may be determined, such as via an on-board computer system or mobile device, and/or then directly or indirectly wirelessly communicated via data transmission from the vehicle computer system or mobile device to a remote server. An adjustment to one or more risk levels associated with operation of the autonomous or semi-autonomous vehicle may also be determined, and an auto insurance policy, premium, or discount may be adjusted based upon the adjustment to the risk levels and presented to the customer for their review and approval. As a result, insurance cost savings may be passed onto risk averse customers that opt into to a rewards program.

16 Claims, 14 Drawing Sheets

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Young et al., "Cooperative Collision Warning Based Highway Vehicle Accident Reconstruction", Eighth International Conference on Intelligent Systems Design and Applications, Nov. 26-28, 2008, pp. 561-565.

* cited by examiner

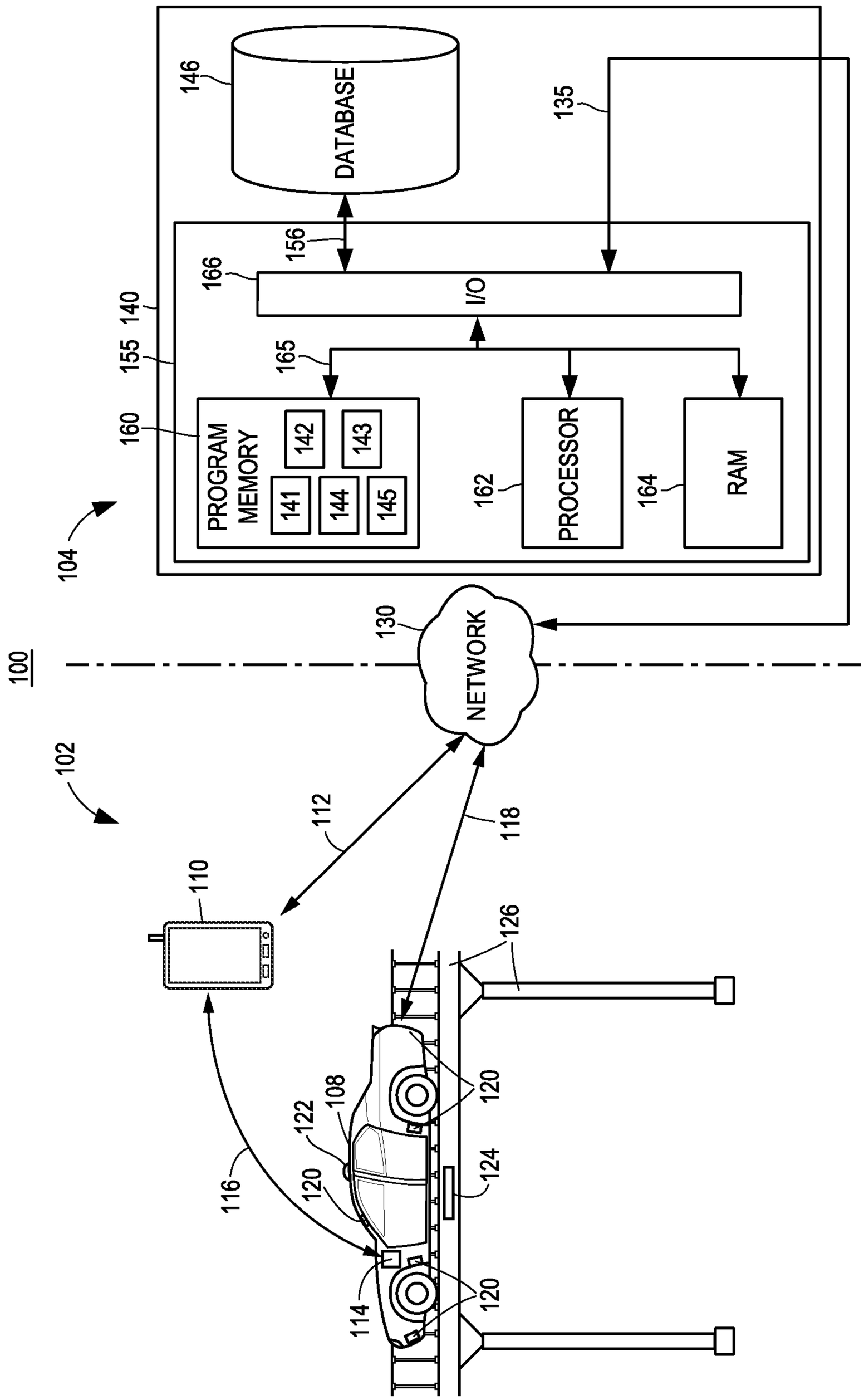

100
102
104
DATABASE
146
135
156
166
I/O
140
155
165
160
PROGRAM MEMORY
141
142
143
144
145
162
PROCESSOR
164
RAM
130
NETWORK
112
118
110
126
120
108
122
124
116
114

FIG. 1

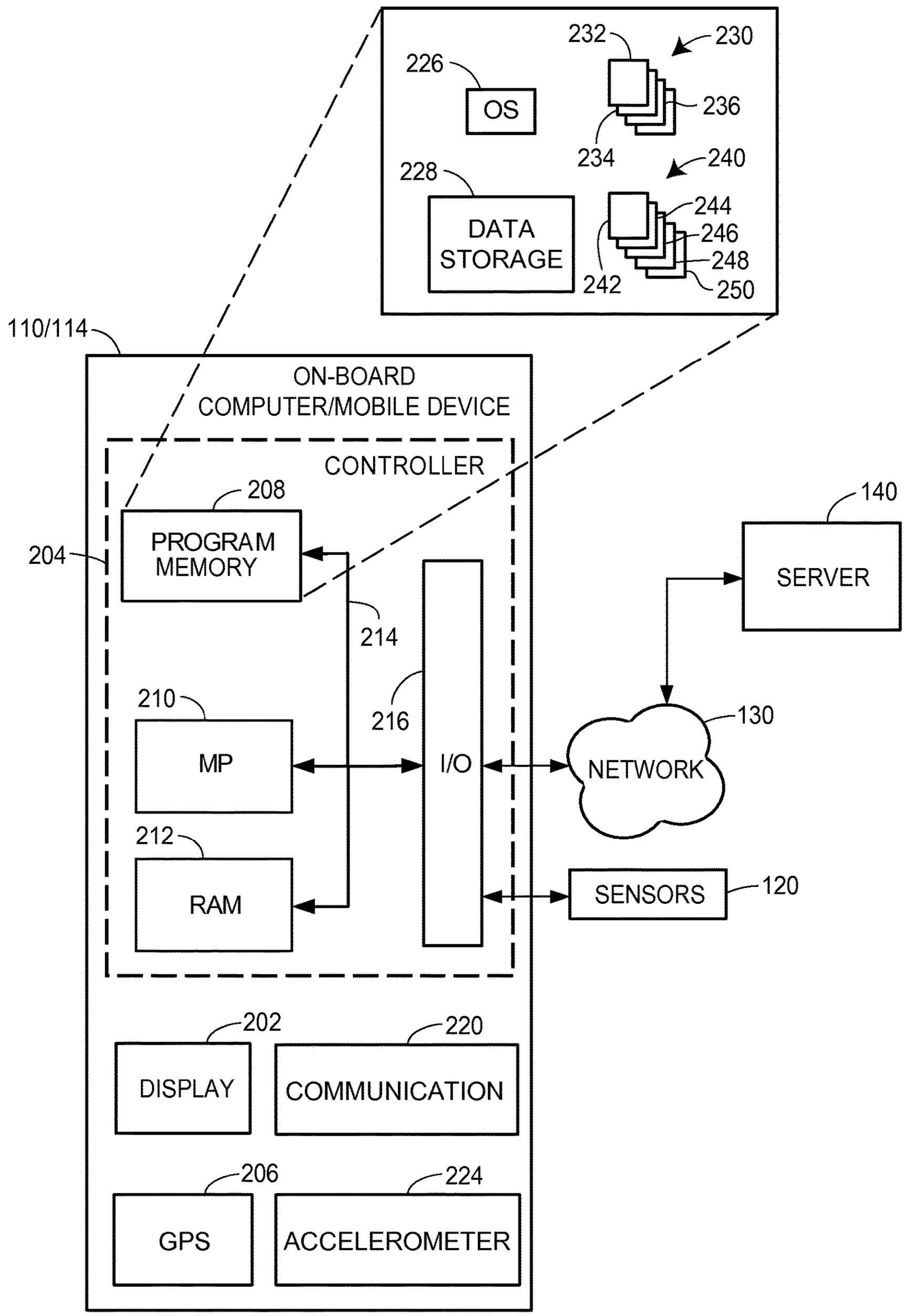

232
230
226
OS
236
234
240
228
DATA STORAGE
244
246
248
242
250
110/114
ON-BOARD COMPUTER/MOBILE DEVICE
CONTROLLER
208
PROGRAM MEMORY
204
140
SERVER
214
210
216
130
MP
I/O
NETWORK
212
RAM
SENSORS
120
202
220
DISPLAY
COMMUNICATION
206
224
GPS
ACCELEROMETER

FIG. 2

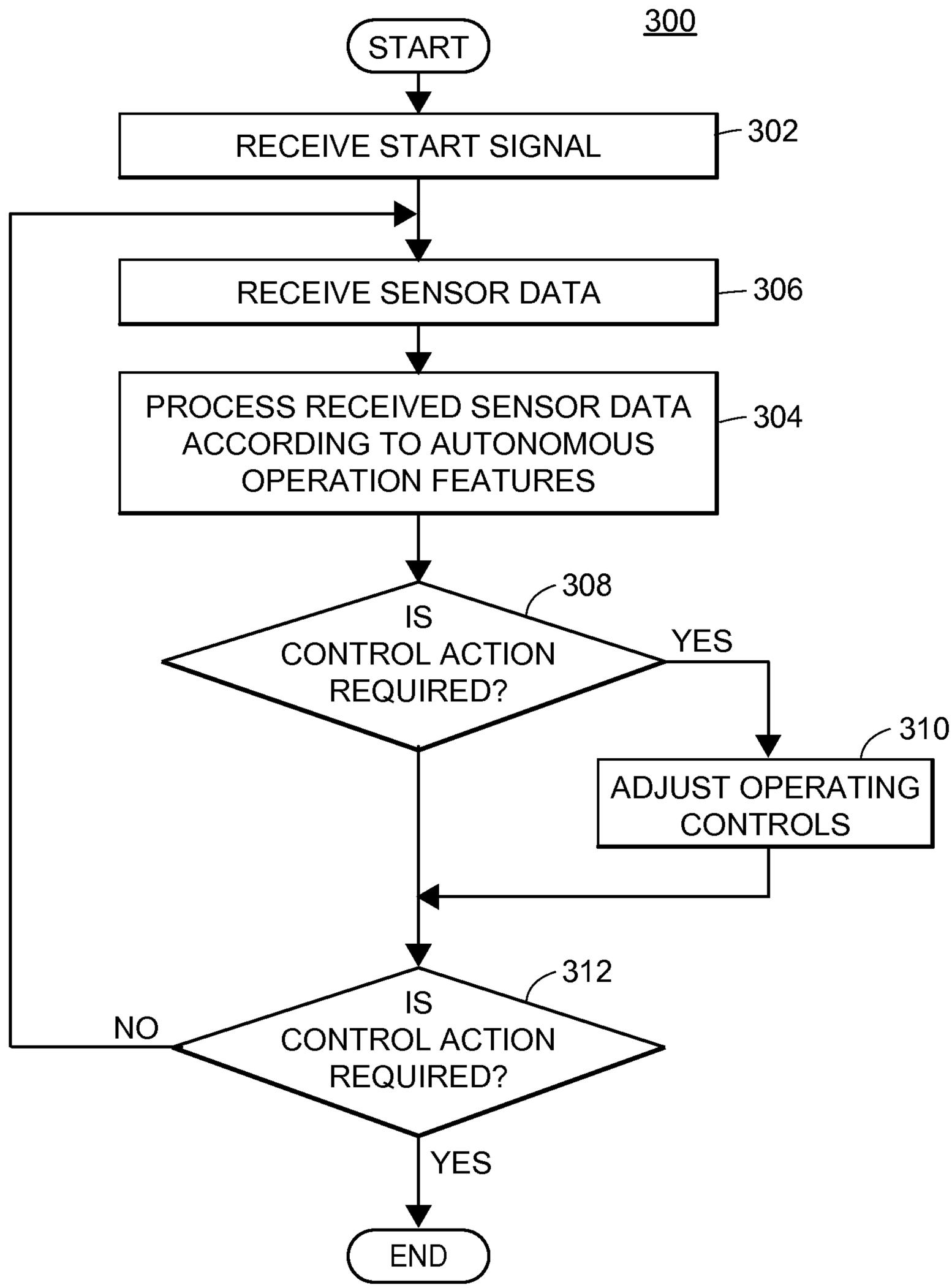

300
START
RECEIVE START SIGNAL
302
RECEIVE SENSOR DATA
306
PROCESS RECEIVED SENSOR DATA ACCORDING TO AUTONOMOUS OPERATION FEATURES
304
IS CONTROL ACTION REQUIRED?
308
YES
ADJUST OPERATING CONTROLS
310
IS CONTROL ACTION REQUIRED?
312
NO
YES
END

FIG. 3

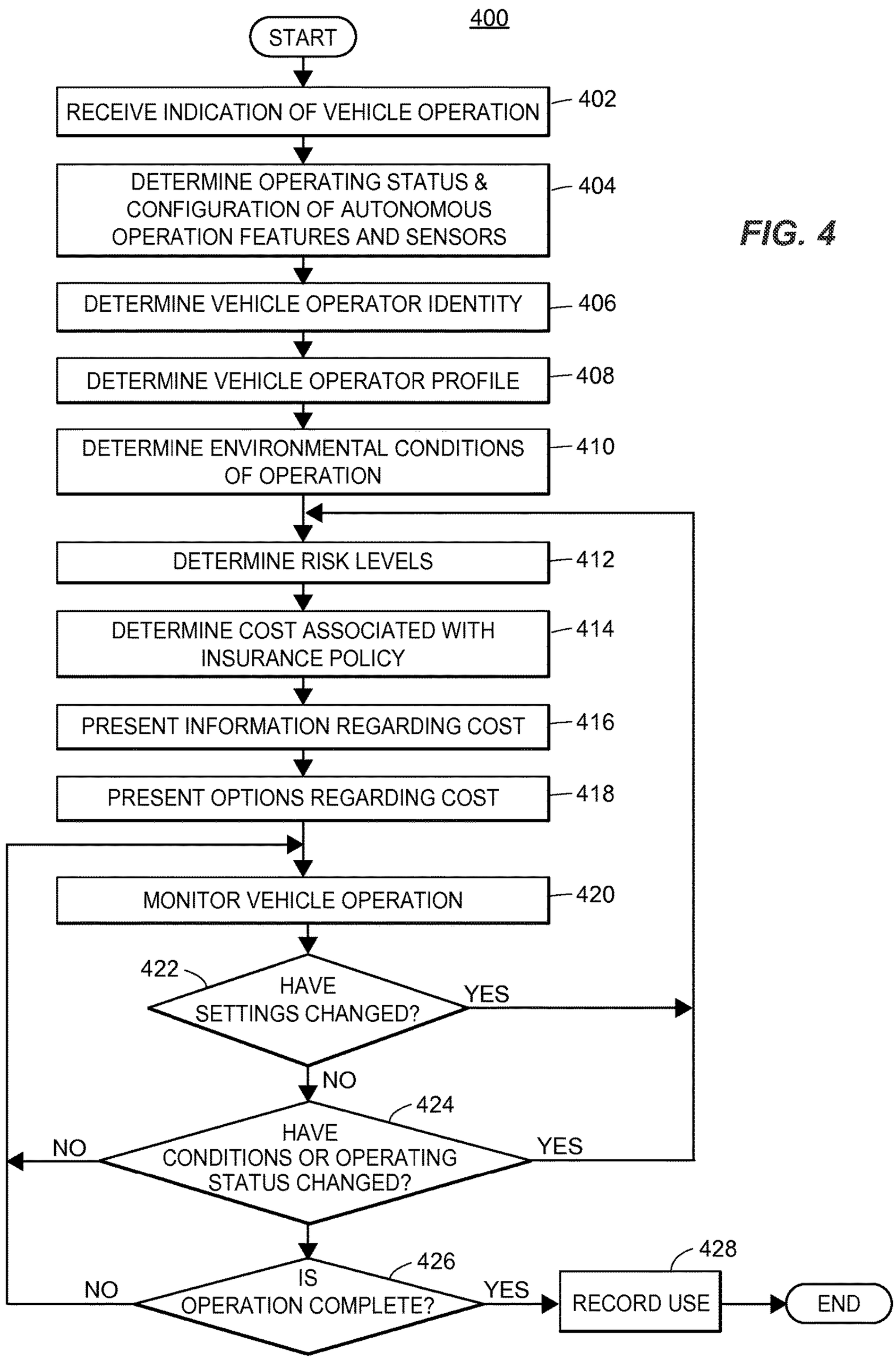

400
START
RECEIVE INDICATION OF VEHICLE OPERATION
402
DETERMINE OPERATING STATUS & CONFIGURATION OF AUTONOMOUS OPERATION FEATURES AND SENSORS
404
DETERMINE VEHICLE OPERATOR IDENTITY
406
DETERMINE VEHICLE OPERATOR PROFILE
408
DETERMINE ENVIRONMENTAL CONDITIONS OF OPERATION
410
DETERMINE RISK LEVELS
412
DETERMINE COST ASSOCIATED WITH INSURANCE POLICY
414
PRESENT INFORMATION REGARDING COST
416
PRESENT OPTIONS REGARDING COST
418
MONITOR VEHICLE OPERATION
420
422
HAVE SETTINGS CHANGED?
YES
NO
424
HAVE CONDITIONS OR OPERATING STATUS CHANGED?
NO
YES
426
IS OPERATION COMPLETE?
NO
YES
428
RECORD USE
END

FIG. 4

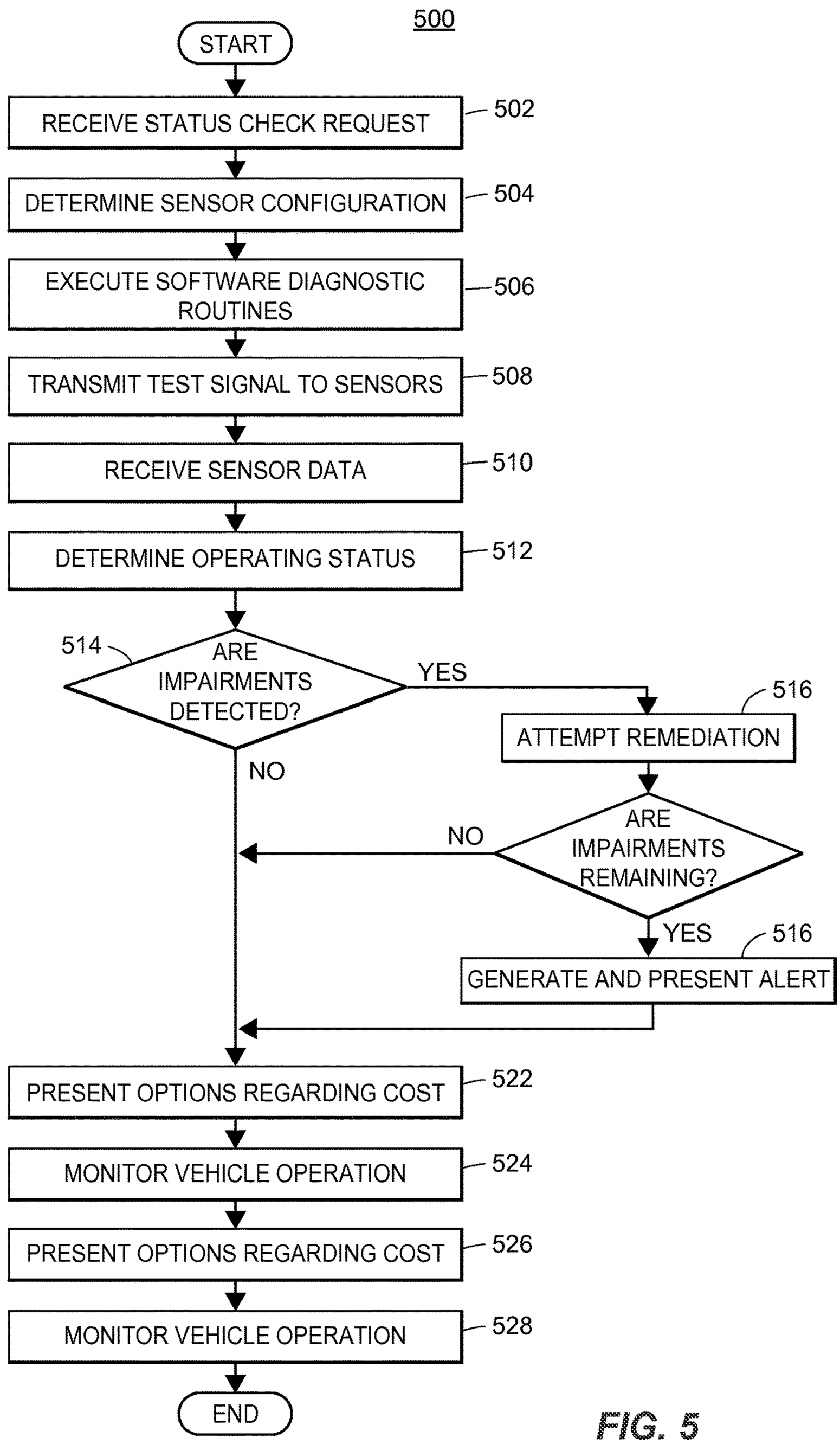

500
START
RECEIVE STATUS CHECK REQUEST
502
DETERMINE SENSOR CONFIGURATION
504
EXECUTE SOFTWARE DIAGNOSTIC ROUTINES
506
TRANSMIT TEST SIGNAL TO SENSORS
508
RECEIVE SENSOR DATA
510
DETERMINE OPERATING STATUS
512
514
ARE IMPAIRMENTS DETECTED?
YES
NO
516
ATTEMPT REMEDIATION
ARE IMPAIRMENTS REMAINING?
NO
YES
516
GENERATE AND PRESENT ALERT
PRESENT OPTIONS REGARDING COST
522
MONITOR VEHICLE OPERATION
524
PRESENT OPTIONS REGARDING COST
526
MONITOR VEHICLE OPERATION
528
END

FIG. 5

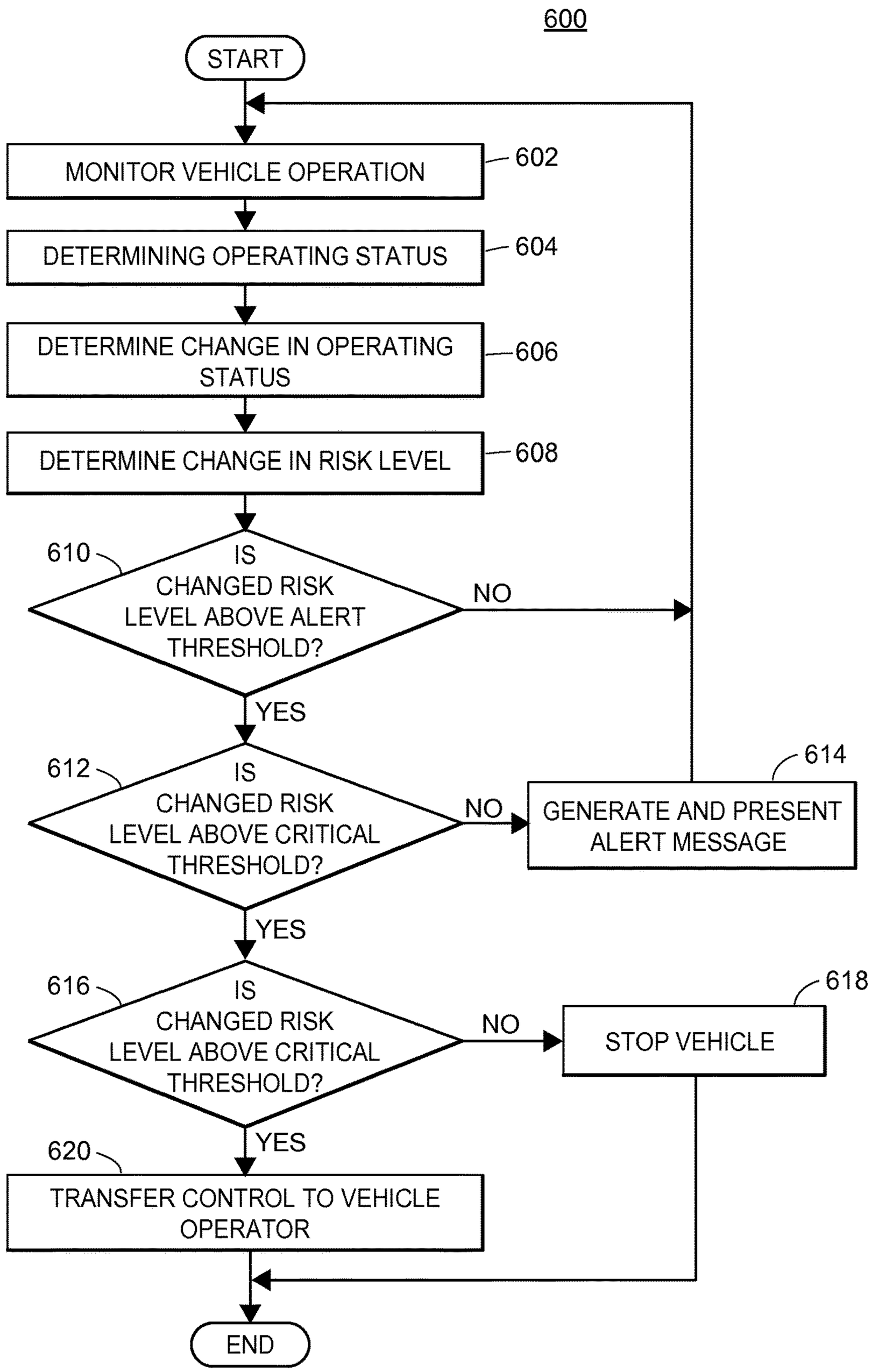

600
START
MONITOR VEHICLE OPERATION
602
DETERMINING OPERATING STATUS
604
DETERMINE CHANGE IN OPERATING STATUS
606
DETERMINE CHANGE IN RISK LEVEL
608
610
IS CHANGED RISK LEVEL ABOVE ALERT THRESHOLD?
NO
YES
612
IS CHANGED RISK LEVEL ABOVE CRITICAL THRESHOLD?
NO
614
GENERATE AND PRESENT ALERT MESSAGE
YES
616
IS CHANGED RISK LEVEL ABOVE CRITICAL THRESHOLD?
NO
618
STOP VEHICLE
YES
620
TRANSFER CONTROL TO VEHICLE OPERATOR
END

FIG. 6

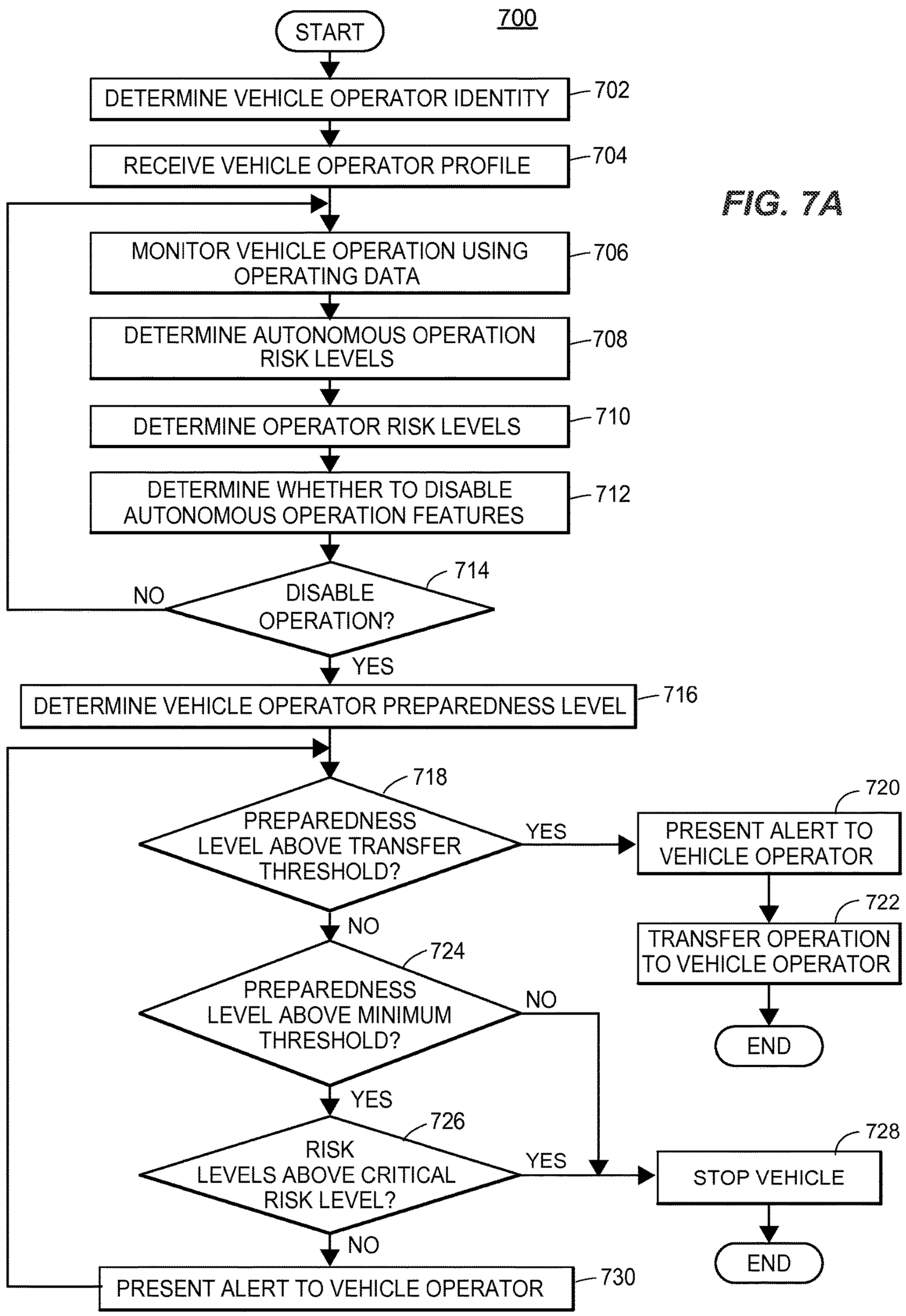
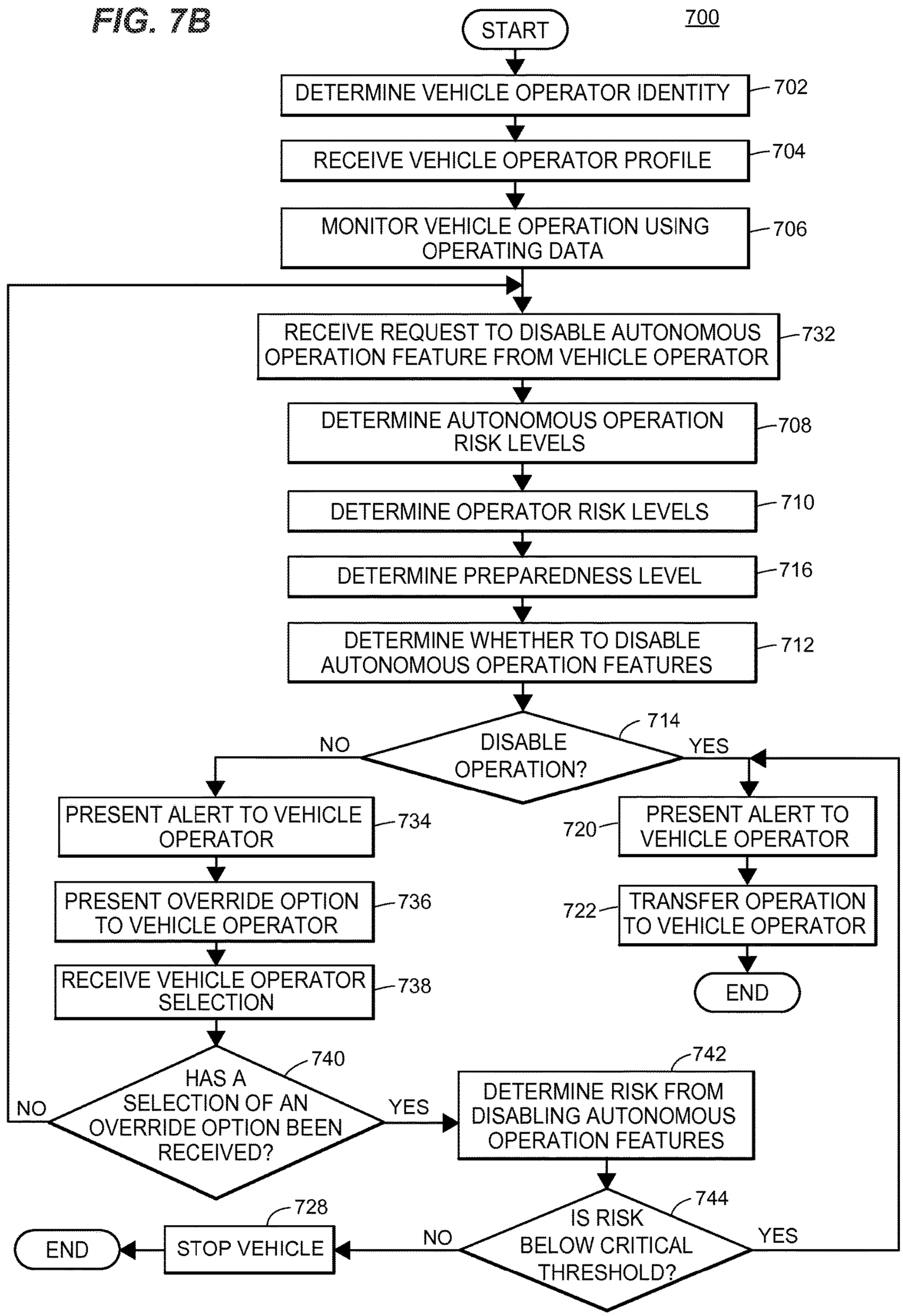

700
START
DETERMINE VEHICLE OPERATOR IDENTITY
702
RECEIVE VEHICLE OPERATOR PROFILE
704
MONITOR VEHICLE OPERATION USING OPERATING DATA
706
DETERMINE AUTONOMOUS OPERATION RISK LEVELS
708
DETERMINE OPERATOR RISK LEVELS
710
DETERMINE WHETHER TO DISABLE AUTONOMOUS OPERATION FEATURES
712
DISABLE OPERATION?
714
NO
YES
DETERMINE VEHICLE OPERATOR PREPAREDNESS LEVEL
716
PREPAREDNESS LEVEL ABOVE TRANSFER THRESHOLD?
718
YES
PRESENT ALERT TO VEHICLE OPERATOR
720
TRANSFER OPERATION TO VEHICLE OPERATOR
722
END
NO
PREPAREDNESS LEVEL ABOVE MINIMUM THRESHOLD?
724
NO
YES
RISK LEVELS ABOVE CRITICAL RISK LEVEL?
726
YES
STOP VEHICLE
728
END
NO
PRESENT ALERT TO VEHICLE OPERATOR
730

FIG. 7A

FIG. 7B


700
START
DETERMINE VEHICLE OPERATOR IDENTITY
702
RECEIVE VEHICLE OPERATOR PROFILE
704
MONITOR VEHICLE OPERATION USING OPERATING DATA
706
RECEIVE REQUEST TO DISABLE AUTONOMOUS OPERATION FEATURE FROM VEHICLE OPERATOR
732
DETERMINE AUTONOMOUS OPERATION RISK LEVELS
708
DETERMINE OPERATOR RISK LEVELS
710
DETERMINE PREPAREDNESS LEVEL
716
DETERMINE WHETHER TO DISABLE AUTONOMOUS OPERATION FEATURES
712
DISABLE OPERATION?
714
NO
YES
PRESENT ALERT TO VEHICLE OPERATOR
734
PRESENT OVERRIDE OPTION TO VEHICLE OPERATOR
736
RECEIVE VEHICLE OPERATOR SELECTION
738
720
PRESENT ALERT TO VEHICLE OPERATOR
722
TRANSFER OPERATION TO VEHICLE OPERATOR
END
HAS A SELECTION OF AN OVERRIDE OPTION BEEN RECEIVED?
740
NO
YES
DETERMINE RISK FROM DISABLING AUTONOMOUS OPERATION FEATURES
742
IS RISK BELOW CRITICAL THRESHOLD?
744
NO
YES
STOP VEHICLE
728
END

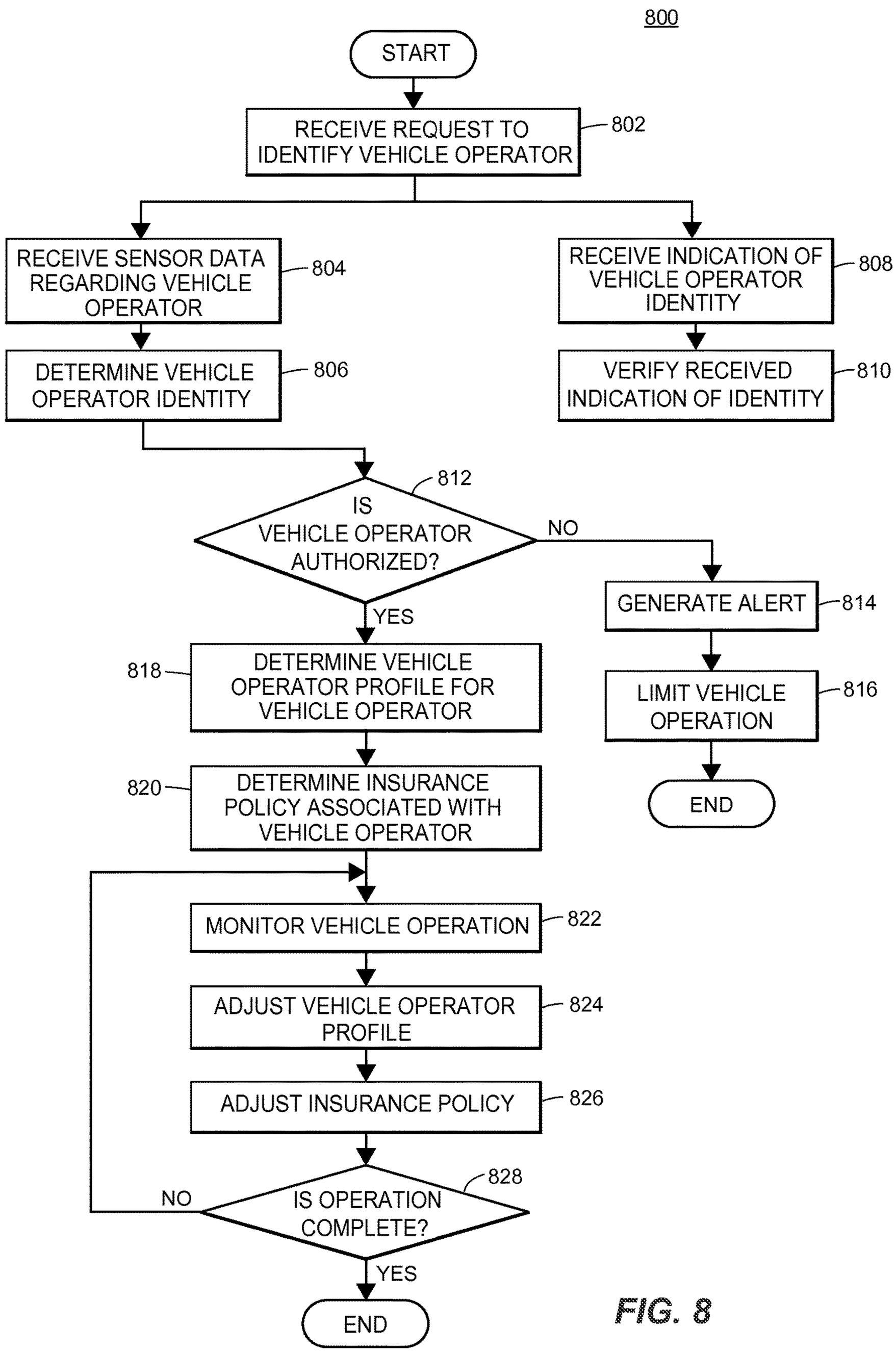

800
START
RECEIVE REQUEST TO IDENTIFY VEHICLE OPERATOR
802
RECEIVE SENSOR DATA REGARDING VEHICLE OPERATOR
804
DETERMINE VEHICLE OPERATOR IDENTITY
806
RECEIVE INDICATION OF VEHICLE OPERATOR IDENTITY
808
VERIFY RECEIVED INDICATION OF IDENTITY
810
IS VEHICLE OPERATOR AUTHORIZED?
812
NO
YES
GENERATE ALERT
814
LIMIT VEHICLE OPERATION
816
END
DETERMINE VEHICLE OPERATOR PROFILE FOR VEHICLE OPERATOR
818
DETERMINE INSURANCE POLICY ASSOCIATED WITH VEHICLE OPERATOR
820
MONITOR VEHICLE OPERATION
822
ADJUST VEHICLE OPERATOR PROFILE
824
ADJUST INSURANCE POLICY
826
IS OPERATION COMPLETE?
828
NO
YES
END

FIG. 8

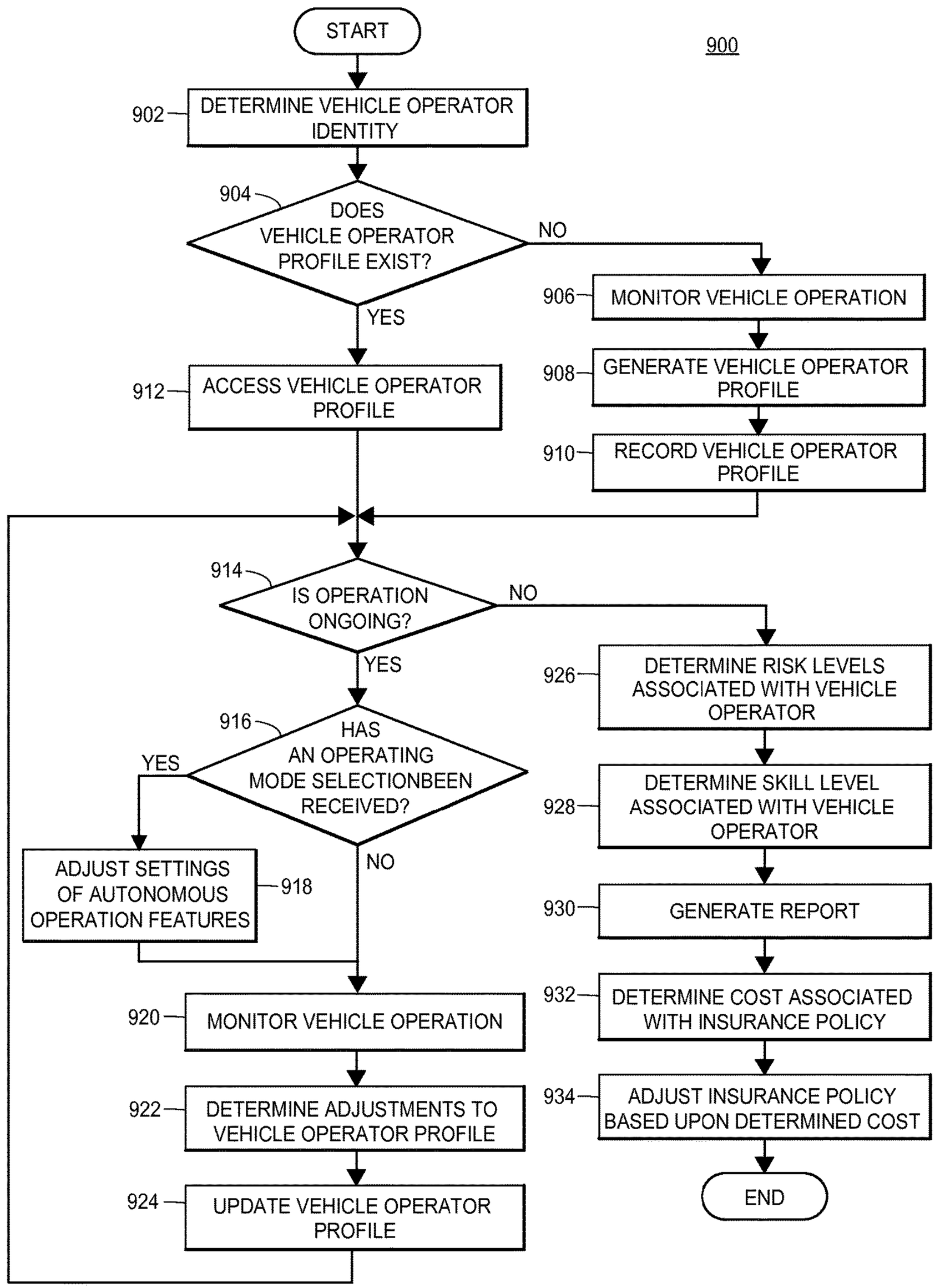

900
START
902
DETERMINE VEHICLE OPERATOR IDENTITY
904
DOES VEHICLE OPERATOR PROFILE EXIST?
NO
YES
906
MONITOR VEHICLE OPERATION
908
GENERATE VEHICLE OPERATOR PROFILE
910
RECORD VEHICLE OPERATOR PROFILE
912
ACCESS VEHICLE OPERATOR PROFILE
914
IS OPERATION ONGOING?
NO
YES
916
HAS AN OPERATING MODE SELECTIONBEEN RECEIVED?
YES
NO
ADJUST SETTINGS OF AUTONOMOUS OPERATION FEATURES
918
920
MONITOR VEHICLE OPERATION
922
DETERMINE ADJUSTMENTS TO VEHICLE OPERATOR PROFILE
924
UPDATE VEHICLE OPERATOR PROFILE
926
DETERMINE RISK LEVELS ASSOCIATED WITH VEHICLE OPERATOR
928
DETERMINE SKILL LEVEL ASSOCIATED WITH VEHICLE OPERATOR
930
GENERATE REPORT
932
DETERMINE COST ASSOCIATED WITH INSURANCE POLICY
934
ADJUST INSURANCE POLICY BASED UPON DETERMINED COST
END

FIG. 9

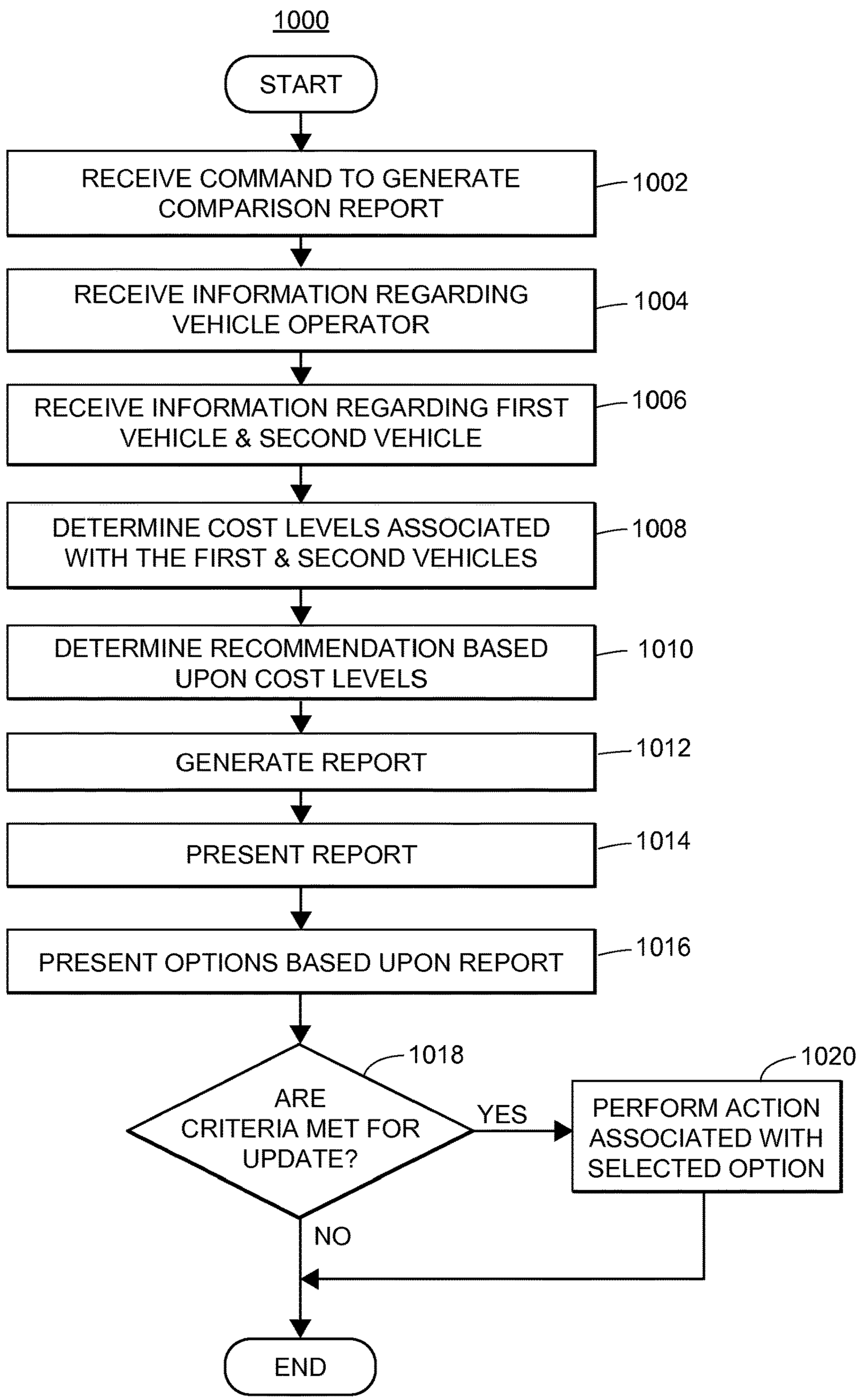

1000
START
RECEIVE COMMAND TO GENERATE COMPARISON REPORT
1002
RECEIVE INFORMATION REGARDING VEHICLE OPERATOR
1004
RECEIVE INFORMATION REGARDING FIRST VEHICLE & SECOND VEHICLE
1006
DETERMINE COST LEVELS ASSOCIATED WITH THE FIRST & SECOND VEHICLES
1008
DETERMINE RECOMMENDATION BASED UPON COST LEVELS
1010
GENERATE REPORT
1012
PRESENT REPORT
1014
PRESENT OPTIONS BASED UPON REPORT
1016
ARE CRITERIA MET FOR UPDATE?
1018
YES
PERFORM ACTION ASSOCIATED WITH SELECTED OPTION
1020
NO
END

FIG. 10

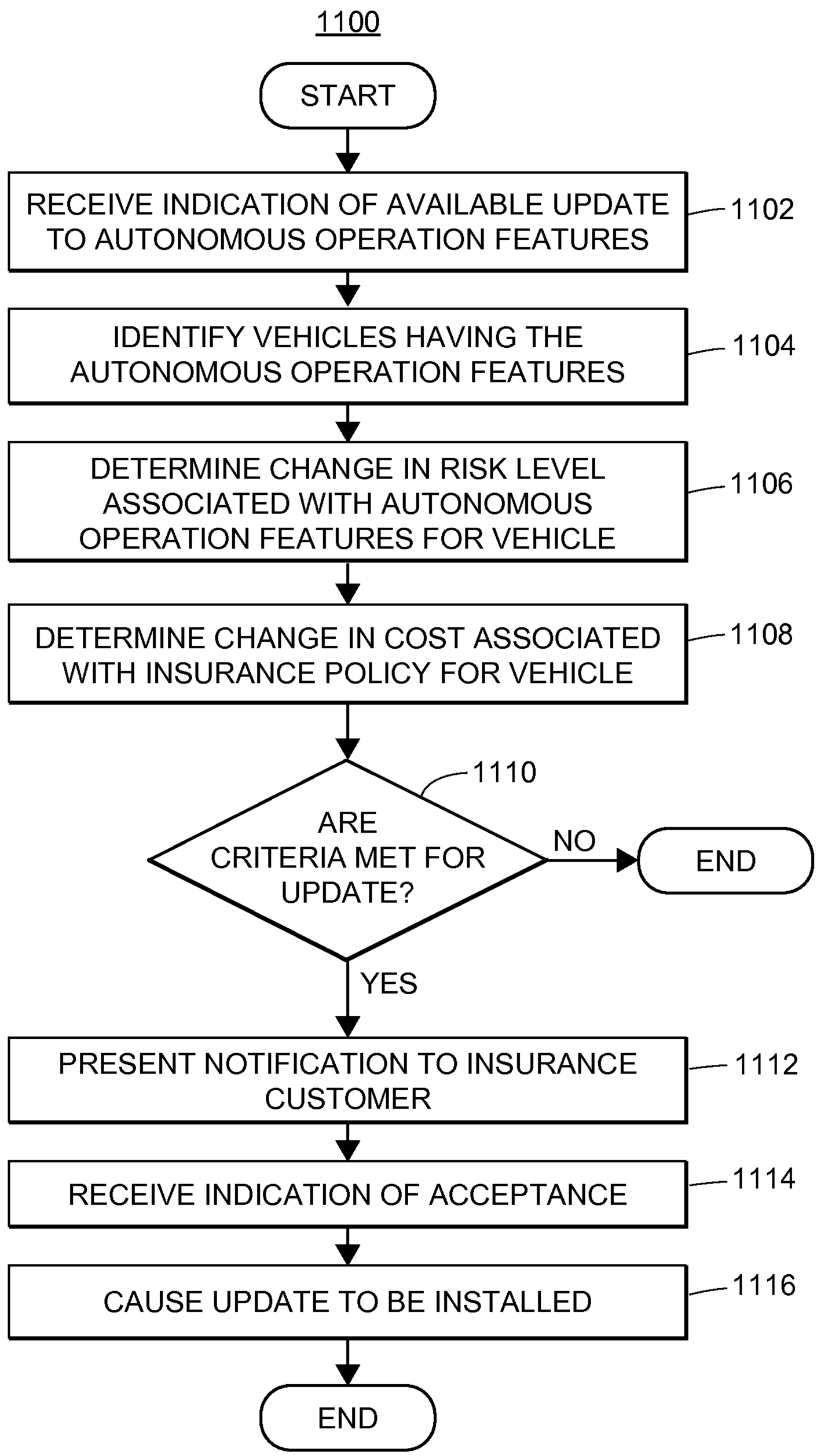

1100
START
RECEIVE INDICATION OF AVAILABLE UPDATE TO AUTONOMOUS OPERATION FEATURES
1102
IDENTIFY VEHICLES HAVING THE AUTONOMOUS OPERATION FEATURES
1104
DETERMINE CHANGE IN RISK LEVEL ASSOCIATED WITH AUTONOMOUS OPERATION FEATURES FOR VEHICLE
1106
DETERMINE CHANGE IN COST ASSOCIATED WITH INSURANCE POLICY FOR VEHICLE
1108
1110
ARE CRITERIA MET FOR UPDATE?
NO
END
YES
PRESENT NOTIFICATION TO INSURANCE CUSTOMER
1112
RECEIVE INDICATION OF ACCEPTANCE
1114
CAUSE UPDATE TO BE INSTALLED
1116
END

FIG. 11

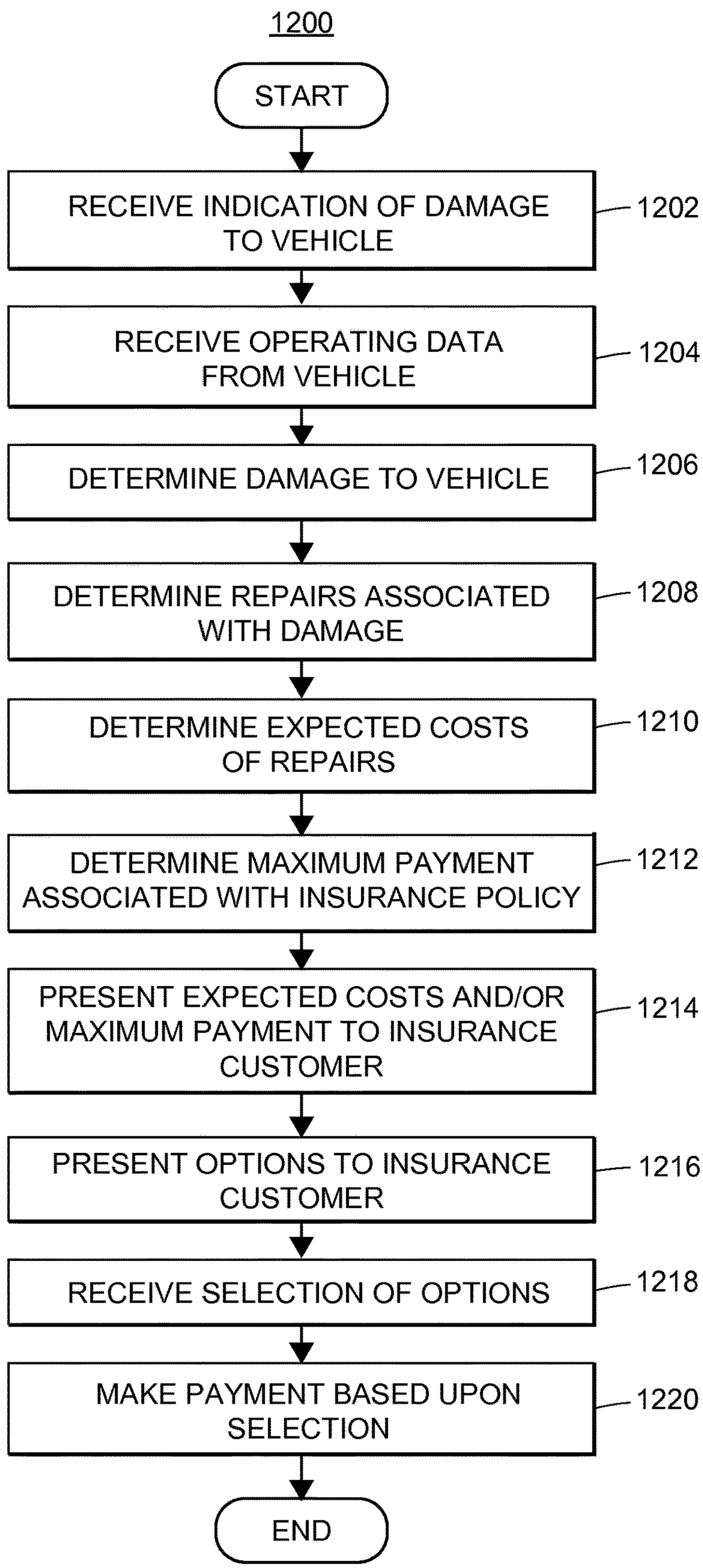

1200
START
RECEIVE INDICATION OF DAMAGE TO VEHICLE
1202
RECEIVE OPERATING DATA FROM VEHICLE
1204
DETERMINE DAMAGE TO VEHICLE
1206
DETERMINE REPAIRS ASSOCIATED WITH DAMAGE
1208
DETERMINE EXPECTED COSTS OF REPAIRS
1210
DETERMINE MAXIMUM PAYMENT ASSOCIATED WITH INSURANCE POLICY
1212
PRESENT EXPECTED COSTS AND/OR MAXIMUM PAYMENT TO INSURANCE CUSTOMER
1214
PRESENT OPTIONS TO INSURANCE CUSTOMER
1216
RECEIVE SELECTION OF OPTIONS
1218
MAKE PAYMENT BASED UPON SELECTION
1220
END

FIG. 12

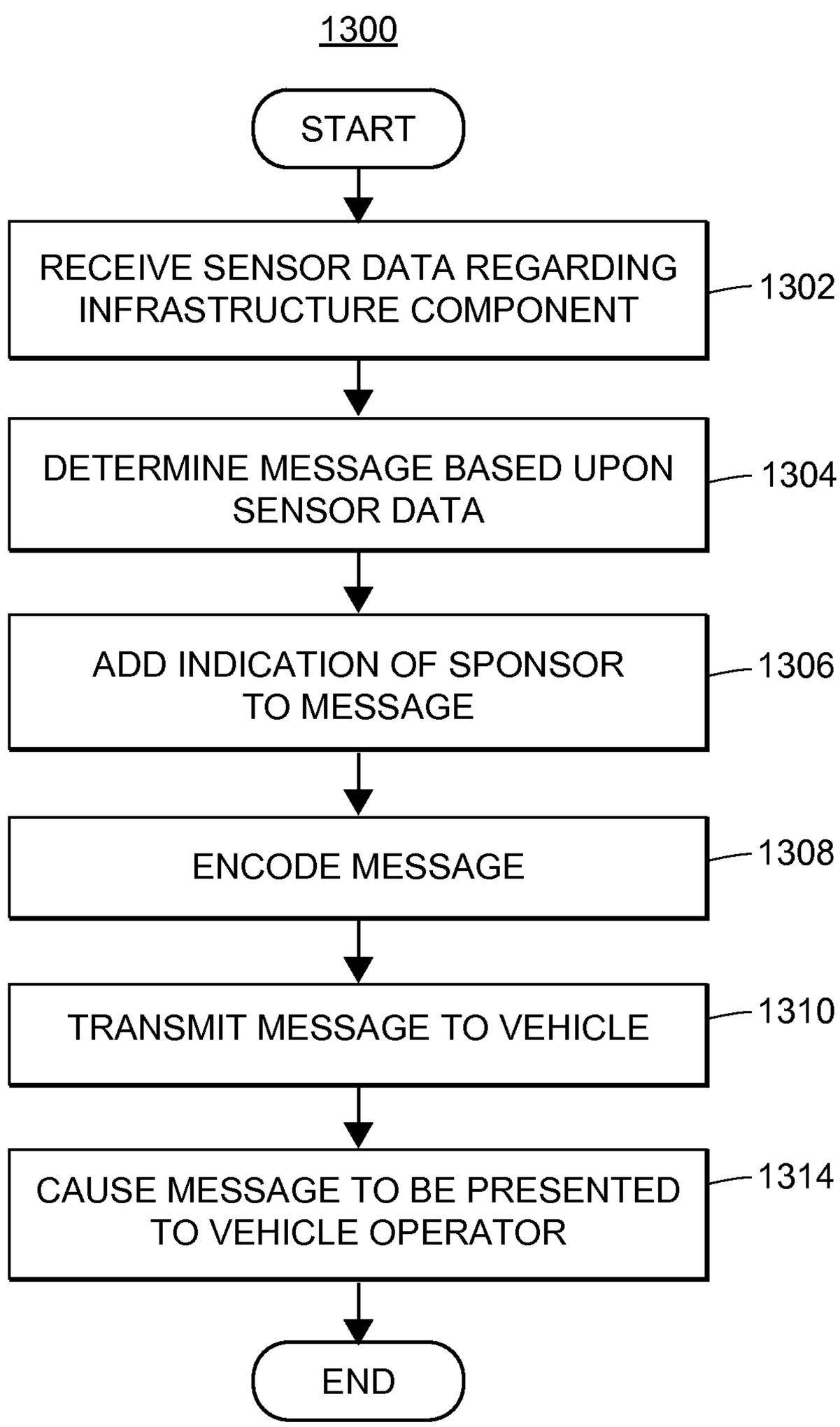

1300
START
RECEIVE SENSOR DATA REGARDING INFRASTRUCTURE COMPONENT
1302
DETERMINE MESSAGE BASED UPON SENSOR DATA
1304
ADD INDICATION OF SPONSOR TO MESSAGE
1306
ENCODE MESSAGE
1308
TRANSMIT MESSAGE TO VEHICLE
1310
CAUSE MESSAGE TO BE PRESENTED TO VEHICLE OPERATOR
1314
END

FIG. 13

AUTONOMOUS VEHICLE OPERATING STATUS ASSESSMENT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 62/079,533 (filed Nov. 13, 2014); U.S. Provisional Application No. 62/103,831 (filed Jan. 15, 2015); U.S. Provisional Application No. 62/103,836 (filed Jan. 15, 2015); U.S. Provisional Application No. 62/103,838 (filed Jan. 15, 2015); U.S. Provisional Application No. 62/103,840 (filed Jan. 15, 2015); U.S. Provisional Application No. 62/103,855 (filed Jan. 15, 2015); U.S. Provisional Application No. 62/103,856 (filed Jan. 15, 2015); U.S. Provisional Application No. 62/103,891 (filed Jan. 15, 2015); U.S. Provisional Application No. 62/103,893 (filed Jan. 15, 2015); U.S. Provisional Application No. 62/103,895 (filed Jan. 15, 2015); U.S. Provisional Application No. 62/103,907 (filed Jan. 15, 2015); U.S. Provisional Application No. 62/103,911 (filed Jan. 15, 2015); and U.S. Provisional Application No. 62/103,914 (filed Jan. 15, 2015). The entirety of each of the foregoing provisional applications is incorporated by reference herein.

Additionally, the present application is related to co-pending U.S. patent application Ser. No. 14/934,333 (filed Nov. 6, 2015); co-pending U.S. patent application Ser. No. 14/931,339 (filed Nov. 6, 2015); co-pending U.S. patent application Ser. No. 14/934,343 (filed Nov. 6, 2015); co-pending U.S. patent application Ser. No. 14/934,345 (filed Nov. 6, 2015); co-pending U.S. patent application Ser. No. 14/934,347 (filed Nov. 6, 2015); co-pending U.S. patent application Ser. No. 14/934,352 (filed Nov. 6, 2015); co-pending U.S. patent application Ser. No. 14/934,355 (filed Nov. 6, 2015); co-pending U.S. patent application Ser. No. 14/934,357 (filed Nov. 6, 2015); co-pending U.S. patent application Ser. No. 14/934,361 (filed Nov. 6, 2015); co-pending U.S. patent application Ser. No. 14/934,371 (filed Nov. 6, 2015); co-pending U.S. patent application Ser. No. 14/934,381 (filed Nov. 6, 2015); co-pending U.S. patent application Ser. No. 14/934,385 (filed Nov. 6, 2015); co-pending U.S. patent application Ser. No. 14/934,388 (filed Nov. 6, 2015); co-pending U.S. patent application Ser. No. 14/934,393 (filed Nov. 6, 2015); co-pending U.S. patent application Ser. No. 14/934,400 (filed Nov. 6, 2015); and co-pending U.S. patent application Ser. No. 14/934,405 (filed Nov. 6, 2015).

FIELD

The present disclosure generally relates to systems and methods for operating, monitoring, assessing, or insuring autonomous or semi-autonomous vehicles.

BACKGROUND

Vehicles are typically operated by a human vehicle operator who controls both steering and motive controls. Operator error, inattention, inexperience, misuse, or distraction leads to many vehicle accidents each year, resulting in injury and damage. Autonomous or semi-autonomous vehicles augment vehicle operators' information or replace vehicle operators' control commands to operate the vehicle in whole or part with computer systems based upon information from sensors within the vehicle.

Vehicle or automobile insurance exists to provide financial protection against physical damage and/or bodily injury

resulting from traffic accidents and against liability that could arise therefrom. Typically, a customer purchases a vehicle insurance policy for a policy rate having a specified term. In exchange for payments from the insured customer, the insurer pays for damages to the insured which are caused by covered perils, acts, or events as specified by the language of the insurance policy. The payments from the insured are generally referred to as "premiums," and typically are paid on behalf of the insured over time at periodic intervals. An insurance policy may remain "in-force" while premium payments are made during the term or length of coverage of the policy as indicated in the policy. An insurance policy may "lapse" (or have a status or state of "lapsed"), for example, when premium payments are not being paid or if the insured or the insurer cancels the policy.

Premiums may be typically determined based upon a selected level of insurance coverage, location of vehicle operation, vehicle model, and characteristics or demographics of the vehicle operator. The characteristics of a vehicle operator that affect premiums may include age, years operating vehicles of the same class, prior incidents involving vehicle operation, and losses reported by the vehicle operator to the insurer or a previous insurer. Past and current premium determination methods do not, however, account for use of autonomous vehicle operating features. The present embodiments may, inter alia, alleviate this and/or other drawbacks associated with conventional techniques.

BRIEF SUMMARY

The present embodiments may be related to autonomous or semi-autonomous vehicle functionality, including driverless operation, accident avoidance, or collision warning systems. These autonomous vehicle operation features may either assist the vehicle operator to more safely or efficiently operate a vehicle or may take full control of vehicle operation under some or all circumstances. The present embodiments may also facilitate risk assessment and premium determination for vehicle insurance policies covering vehicles with autonomous operation features. For instance, a consumer may opt-in to a rewards program that rewards them, such as in the form of insurance discounts, for sharing data related to their vehicles and/or autonomous features with an insurance provider.

In accordance with the described embodiments, the disclosure herein generally addresses systems and methods for determining the status of autonomous operation features of an autonomous or semi-autonomous vehicle, which may include one or more sensors. A computer associated with the vehicle (such as an on-board computer, mobile device, or server communicatively connected to the vehicle) may (1) receive a signal indicating a request to determine an operating status of one or more autonomous operation features of the autonomous or semi-autonomous vehicle; (2) determine a configuration of the one or more autonomous operation features; (3) present or send a test signal to the one or more autonomous operation features; (4) receive one or more response signals from the one or more autonomous operation features (or associated processors); (5) determine the operating status of the one or more autonomous operation features based upon the received one or more response signals; (6) generate an operating status report or electronic message indicating the operating status of the one or more autonomous operation features, which may include a certification of the operating status of the one or more autonomous operation features; (7) store the operating status report in memory for subsequent use; and/or (8) present the oper-

ating status report to an insured or vehicle operator/owner. In some embodiments, the computer may further (9) transmit the generated operating status report to a server, such as via wireless communication or data transmission, whereupon the server may further receive one or more indications of maintenance performed on the autonomous or semi-autonomous vehicle, determine an adjustment to one or more risk levels associated with operation of the autonomous or semi-autonomous vehicle, determine an adjustment to a cost associated with an insurance policy associated with the autonomous or semi-autonomous vehicle based upon the determined adjustment to the one or more risk levels and/or based upon the received one or more indications of maintenance, and/or cause the adjustment to the cost associated with the insurance policy to be implemented. The cost associated with the insurance policy may include one or more of the following: a premium, a discount, a surcharge, a rate level, a cost based upon a distance traveled, a cost based upon a vehicle trip, and/or a cost based upon a duration of vehicle operation.

In some embodiments, the signal indicating the request to determine the operating status of the one or more autonomous operation features may be automatically generated upon the occurrence of an event, including one or more of the following: receipt of a command to start the vehicle, receipt of a command to shut off the vehicle, receipt of an indication of a collision involving the vehicle, or receipt of an indication of damage to the vehicle. The signal may be received from a mobile device or from a special-purpose computing device communicatively connected to the autonomous or semi-autonomous vehicle.

In further embodiments, the computer may attempt to diagnose and/or correct problems with autonomous operation features. When the operation of one or more sensors disposed within the vehicle are determined to be impaired by environmental factors (including snow, ice, rain, dirt, mud, or condensation), a remediation module may generate a remediation signal, which may be presented to one or more remediation components disposed within the vehicle. The remediation components may be configured to remediate impairments of the one or more sensors by environmental factors. A system status module may likewise diagnose one or more errors with at least one autonomous operation feature based upon the received one or more response signals from the one or more autonomous operation features, in order to correct the diagnosed one or more errors with the at least one autonomous operation feature. Correcting the diagnosed one or more errors with the at least one autonomous operation feature may include calibrating at least one sensor disposed within the vehicle based upon the received one or more response signals from the one or more autonomous operation features.

In accordance with the described embodiments, the disclosure herein further generally addresses systems and methods for real-time (or near real-time) determination of the status of autonomous operation features of an autonomous or semi-autonomous vehicle, which may include one or more sensors. A computer (such as an on-board computer, mobile device, or server communicatively connected to the vehicle) associated with the vehicle may (1) monitor the operation of the autonomous or semi-autonomous vehicle to obtain operating data from one or more autonomous operation features; (2) determine an operating status of the one or more autonomous operation features of the autonomous or semi-autonomous vehicle based upon the operating data; (3) determine a change in the operating status of the one or more autonomous operation features based upon the determined operating status; (4) generate a report containing information regarding the change in the operating status of the one or more autonomous operation features; (5) store the operating status report in memory for subsequent use, such as the uses discussed herein, as well as directly below, and/or (6) present the operating status report or information based upon the operating status report to an insured or vehicle operator/owner.

In some embodiments, the computer may further determine an adjustment to a cost associated with an insurance policy associated with the autonomous or semi-autonomous vehicle based upon the determined change in the operating status of the one or more autonomous operation features, and/or cause the adjustment to the cost associated with the insurance policy to be implemented. Determining the adjustment to the cost associated with the insurance policy may include determining an adjustment to a risk associated with operation of the autonomous or semi-autonomous vehicle based upon the determined change in the operating status of the one or more autonomous operation features. The cost associated with the insurance policy may include one or more of the following: a premium, a discount, a surcharge, a rate level, a cost based upon a distance traveled, a cost based upon a vehicle trip, and/or a cost based upon a duration of vehicle operation.

In further embodiments, the computer may determine that the change in operating status of the one or more autonomous operation features may cause the operating status of the one or more autonomous operation features to pass an alert threshold, in which case an alert indicating an impairment of the operation of the one or more autonomous operation features may be generated and presented to a person associated with the autonomous or semi-autonomous vehicle. Additionally, or alternatively, the computer may determine that the change in operating status of the one or more autonomous operation features may cause the operating status of the one or more autonomous operation features to pass a critical threshold, in which case control of the autonomous or semi-autonomous vehicle may be transferred to a vehicle operator. If the computer further determines that control of the autonomous or semi-autonomous vehicle cannot safely be transferred to a vehicle operator, however, the autonomous or semi-autonomous vehicle may stop and discontinue operation.

In each of the embodiments or aspects described above, the methods may be provided in corresponding computer systems including at least one or more processors and a non-transitory program memory coupled to the one or more processors and storing executable instructions. The computer systems may further include or be communicatively connected to one or more sensors, communication components or devices, or other equipment as described herein. In yet another aspect, a tangible, non-transitory computer-readable medium storing instructions corresponding to each of the embodiments or aspects described above may be provided. Each of the methods or executable instructions of the computer systems or computer-readable media may include additional, fewer, or alternate actions, including those discussed elsewhere herein.

Methods and systems for monitoring use, determining risk, and pricing insurance policies for a vehicle having one or more autonomous or semi-autonomous operation features are provided. According to certain aspects, the operating status and/or configuration of autonomous operation features of an autonomous or semi-autonomous vehicle may be determined, such as via an on-board computer system or mobile device, and/or then wirelessly communicated via

data transmission from the vehicle computer system or mobile device to a remote server. An adjustment to one or more risk levels associated with operation of the autonomous or semi-autonomous vehicle may also be determined, and an auto insurance policy, premium, or discount may be adjusted based upon the determined adjustment to the one or more risk levels and presented to the customer for their review and approval. In some embodiments, insurance cost savings may be passed onto risk averse customers that opt-in to a rewards or other insurance-based program.

BRIEF DESCRIPTION OF THE DRAWINGS

Advantages will become more apparent to those skilled in the art from the following description of the preferred embodiments which have been shown and described by way of illustration. As will be realized, the present embodiments may be capable of other and different embodiments, and their details are capable of modification in various respects. Accordingly, the drawings and description are to be regarded as illustrative in nature and not as restrictive.

The figures described below depict various aspects of the applications, methods, and systems disclosed herein. It should be understood that each figure depicts an embodiment of a particular aspect of the disclosed applications, systems and methods, and that each of the figures is intended to accord with a possible embodiment thereof. Furthermore, wherever possible, the following description refers to the reference numerals included in the following figures, in which features depicted in multiple figures are designated with consistent reference numerals.

FIG. **1** illustrates a block diagram of an exemplary computer network, a computer server, a mobile device, and an on-board computer for implementing autonomous vehicle operation, monitoring, evaluation, and insurance processes in accordance with the described embodiments;

FIG. **2** illustrates a block diagram of an exemplary on-board computer or mobile device;

FIG. **3** illustrates a flow diagram of an exemplary autonomous vehicle operation method in accordance with the presently described embodiments;

FIG. **4** illustrates a flow diagram of an exemplary monitoring method during vehicle operation in accordance with the presently described embodiments;

FIG. **5** illustrates a flow diagram of an exemplary operating status assessment method in accordance with the presently described embodiments;

FIG. **6** illustrates a flow diagram of an exemplary operating status monitoring method in accordance with the presently described embodiments;

FIGS. **7**A-B illustrate flow diagrams depicting exemplary vehicle operation hand-off methods in accordance with the presently described embodiments;

FIG. **8** illustrates a flow diagram depicting an exemplary vehicle operator identification method in accordance with the presently described embodiments;

FIG. **9** illustrates a flow diagram depicting an exemplary vehicle operator use monitoring and evaluation method in accordance with the presently described embodiments;

FIG. **10** illustrates a flow diagram depicting an exemplary cost comparison method in accordance with the presently described embodiments; and

FIG. **11** illustrates a flow diagram depicting an exemplary autonomous operation feature update method in accordance with the presently described embodiments;

FIG. **12** illustrates a flow diagram depicting an exemplary autonomous vehicle repair method in accordance with the presently described embodiments; and

FIG. **13** illustrates a flow diagram depicting an exemplary infrastructure communication method in accordance with the presently described embodiments.

DETAILED DESCRIPTION

The systems and methods disclosed herein generally relate to evaluating, monitoring, and managing risks related to the operation of autonomous or semi-autonomous vehicles having autonomous (or semi-autonomous) operation features. The systems and methods further relate to pricing and processing vehicle insurance policies for autonomous or semi-autonomous vehicles. The autonomous operation features may take full control of the vehicle under certain conditions, viz. fully autonomous operation, or the autonomous operation features may assist the vehicle operator in operating the vehicle, viz. partially autonomous operation. Fully autonomous operation features may include systems within the vehicle that pilot the vehicle to a destination with or without a vehicle operator present (e.g., an operating system for a driverless car). Partially autonomous operation features may assist the vehicle operator in limited ways (e.g., automatic braking or collision avoidance systems).

The type and quality of the autonomous operation features may affect the risks related to operating a vehicle, both individually and/or in combination. In addition, configurations and settings of the autonomous operation features may further impact the risks. To account for the effects on such risks, some embodiments evaluate the quality of each autonomous operation feature and/or combination of features. Additional embodiments evaluate the risks associated with the vehicle operator interacting with the autonomous operation features. Further embodiments address the relative risks associated with control of some aspects of vehicle control by the autonomous operation features or by the vehicle operator. Still further embodiments address use of information received or generated by the autonomous operation features to manage risk and/or damage.

Some autonomous operation features may be adapted for use under particular conditions, such as city driving or highway driving. Additionally, the vehicle operator may be able to configure settings relating to the features or may enable or disable the features individually or in groups. For example, the vehicle operator may select a mode of operation for the autonomous or semi-autonomous vehicle, which may adjust settings for one or more autonomous operation features. Therefore, some embodiments monitor use of the autonomous operation features, which may include the settings or levels of feature use during vehicle operation, as well as the selection of features or settings of the autonomous operation features chosen by the vehicle operator.

Information obtained by monitoring feature usage may be used to determine risk levels associated with vehicle operation, either generally or in relation to a vehicle operator. In such situations, total risk may be determined by a weighted combination of the risk levels associated with operation while autonomous operation features are enabled (with relevant settings) and the risk levels associated with operation while autonomous operation features are disabled. For fully autonomous vehicles, settings or configurations relating to vehicle operation may be monitored and used in determining vehicle operating risk.

In addition to use in controlling the vehicle, information regarding the risks associated with vehicle operation with and without the autonomous operation features may then be used to determine risk categories or premiums for a vehicle insurance policy covering a vehicle with autonomous operation features. Risk category or price may be determined based upon factors relating to the evaluated effectiveness of the autonomous vehicle features. The risk or price determination may also include traditional factors, such as location, vehicle type, and level of vehicle use. For fully autonomous vehicles, factors relating to vehicle operators may be excluded entirely. For partially autonomous vehicles, factors relating to vehicle operators may be reduced in proportion to the evaluated effectiveness and monitored usage levels of the autonomous operation features. For vehicles with autonomous communication features that obtain information from external sources (e.g., other vehicles or infrastructure), the risk level and/or price determination may also include an assessment of the availability of external sources of information. Location and/or timing of vehicle use may thus be monitored and/or weighted to determine the risk associated with operation of the vehicle.

Autonomous Automobile Insurance

The present embodiments may relate to assessing and pricing insurance based upon autonomous (or semi-autonomous) functionality of a vehicle, utilization of the autonomous (or semi-autonomous) functionality of the vehicle, and/or operation of the vehicle by a human operator. In some embodiments, the vehicle operator may not control the operations of the vehicle directly, in which case the assessment, rating, and pricing of insurance may exclude consideration of the vehicle operator. A smart vehicle may maneuver itself without human intervention and/or include sensors, processors, computer instructions, and/or other components that may perform or direct certain actions conventionally performed by a human operator.

An analysis of how artificial intelligence facilitates avoiding accidents and/or mitigates the severity of accidents may be used to build a database and/or model of risk assessment. After which, automobile insurance risk and/or premiums (as well as insurance discounts, rewards, and/or points) may be adjusted based upon autonomous or semi-autonomous vehicle functionality, such as by groups of autonomous or semi-autonomous functionality or individual features. In one aspect, an evaluation may be performed on how artificial intelligence, and the usage thereof, impacts automobile accidents and/or automobile insurance claims.

The types of autonomous or semi-autonomous vehicle-related functionality or technology that may be used with the present embodiments to replace human driver actions may include and/or be related to the following types of functionality: (a) fully autonomous (driverless); (b) limited driver control; (c) vehicle-to-vehicle (V2V) wireless communication; (d) vehicle-to-infrastructure (and/or vice versa) wireless communication; (e) automatic or semi-automatic steering; (f) automatic or semi-automatic acceleration; (g) automatic or semi-automatic braking; (h) automatic or semi-automatic blind spot monitoring; (i) automatic or semi-automatic collision warning; (j) adaptive cruise control; (k) automatic or semi-automatic parking/parking assistance; (l) automatic or semi-automatic collision preparation (windows roll up, seat adjusts upright, brakes pre-charge, etc.); (m) driver acuity/alertness monitoring; (n) pedestrian detection; (o) autonomous or semi-autonomous backup systems; (p) road mapping systems; (q) software security and anti-hacking measures; (r) theft prevention/automatic return; (s) automatic or semi-automatic driving without occupants; and/or other functionality. Additionally or alternatively, the autonomous or semi-autonomous functionality or technology may include and/or may be related to: (t) driver alertness or responsive monitoring; (u) pedestrian detection; (v) artificial intelligence and/or back-up systems; (w) navigation or GPS-related systems; (x) security and/or anti-hacking measures; and/or (y) theft prevention systems.

The adjustments to automobile insurance rates or premiums based upon the autonomous or semi-autonomous vehicle-related functionality or technology may take into account the impact of such functionality or technology on the likelihood of a vehicle accident or collision occurring. For instance, a processor may analyze historical accident information and/or test data involving vehicles having autonomous or semi-autonomous functionality. Factors that may be analyzed and/or accounted for that are related to insurance risk, accident information, or test data may include (1) point of impact; (2) type of road; (3) time of day; (4) weather conditions; (5) road construction; (6) type/length of trip; (7) vehicle style; (8) level of pedestrian traffic; (9) level of vehicle congestion; (10) atypical situations (such as manual traffic signaling); (11) availability of internet connection for the vehicle; and/or other factors. These types of factors may also be weighted according to historical accident information, predicted accidents, vehicle trends, test data, and/or other considerations.

In one aspect, the benefit of one or more autonomous or semi-autonomous functionalities or capabilities may be determined, weighted, and/or otherwise characterized. For instance, the benefit of certain autonomous or semi-autonomous functionality may be substantially greater in city or congested traffic, as compared to open road or country driving traffic. Additionally or alternatively, certain autonomous or semi-autonomous functionality may only work effectively below a certain speed, e.g., during city driving or driving in congestion. Other autonomous or semi-autonomous functionality may operate more effectively on the highway and away from city traffic, such as cruise control. Further individual autonomous or semi-autonomous functionality may be impacted by weather, such as rain or snow, and/or time of day (day light versus night). As an example, fully automatic or semi-automatic lane detection warnings may be impacted by rain, snow, ice, and/or the amount of sunlight (all of which may impact the imaging or visibility of lane markings painted onto a road surface, and/or road markers or street signs).

Automobile insurance premiums, rates, discounts, rewards, refunds, points, or other costs may be adjusted based upon the percentage of time or vehicle usage that the vehicle is the driver, i.e., the amount of time a specific driver uses each type of autonomous (or even semi-autonomous) vehicle functionality. Such premiums, rates, discounts, rewards, refunds, points, or other costs may further be adjusted based upon the extent of use of the autonomous operation features, including settings or modes impacting the operation of the autonomous operation features. Moreover, information regarding the vehicle environment during use (e.g., weather, traffic, time of day, etc.) may be included in insurance adjustment determinations, as may traditional information regarding one or more vehicle operators (and the extent to which each vehicle operator uses the vehicle).

Such usage information for a particular vehicle may be gathered over time and/or via remote wireless communication with the vehicle. One embodiment may involve a processor on the vehicle, such as within a vehicle control system or dashboard, monitoring in real-time the vehicle operator and/or the use of autonomous operation features

while the vehicle is operating. Other types of monitoring may be remotely performed, such as via wireless communication between the vehicle and a remote server, or wireless communication between a vehicle-mounted dedicated device (that is configured to gather autonomous or semi-autonomous functionality usage information) and a remote server.

Additionally, in some embodiments, the vehicle may transmit and/or receive communications to or from external sources, such as other vehicles (V2V), infrastructure (e.g., a bridge, traffic light, railroad crossing, toll both, marker, sign, or other equipment along the side of a road or highway), pedestrians, databases, or other information sources external to the vehicle. Such communication may allow the vehicle to obtain information regarding other vehicles, obstacles, road conditions, or environmental conditions that could not be detected by sensors disposed within the vehicle. For example, V2V communication may allow a vehicle to identify other vehicles approaching an intersection even when the direct line between the vehicle and the other vehicles is obscured by buildings. As another example, the V2V wireless communication from a first vehicle to a second vehicle (following the first vehicle) may indicate that the first vehicle is braking, which may include the degree to which the vehicle is braking. In response, the second vehicle may automatically or autonomously brake in advance of detecting the deceleration of the first vehicle based upon sensor data.

Insurance premiums, rates, ratings, discounts, rewards, special offers, points, programs, refunds, claims, claim amounts, or other costs associated with an insurance policy may be adjusted for, or may otherwise take into account, the foregoing functionality and/or the other functionality described herein. For instance, insurance policies may be updated based upon installed autonomous operation features, the extent of use of the autonomous operation features, V2V wireless communication, and/or vehicle-to-infrastructure or infrastructure-to-vehicle wireless communication. The present embodiments may assess and price insurance risks at least in part based upon autonomous operation features that replace some actions of the vehicle operator in controlling the vehicle, including settings and operating status of the autonomous operation features.

Exemplary Autonomous Vehicle Operation System

FIG. **1** illustrates a block diagram of an exemplary autonomous vehicle insurance system **100** on which the exemplary methods described herein may be implemented. The high-level architecture includes both hardware and software applications, as well as various data communications channels for communicating data between the various hardware and software components. The autonomous vehicle insurance system **100** may be roughly divided into front-end components **102** and back-end components **104**. The front-end components **102** may obtain information regarding a vehicle **108** (e.g., a car, truck, motorcycle, etc.) and the surrounding environment. An on-board computer **114** may utilize this information to operate the vehicle **108** according to an autonomous operation feature or to assist the vehicle operator in operating the vehicle **108**. To monitor the vehicle **108**, the front-end components **102** may include one or more sensors **120** installed within the vehicle **108** that may communicate with the on-board computer **114**. The front-end components **102** may further process the sensor data using the on-board computer **114** or a mobile device **110** (e.g., a smart phone, a tablet computer, a special purpose computing device, etc.) to determine when the vehicle is in operation and information regarding the vehicle. In some embodiments of the system **100**, the front-end components **102** may communicate with the back-end components **104** via a network **130**. Either the on-board computer **114** or the mobile device **110** may communicate with the back-end components **104** via the network **130** to allow the back-end components **104** to record information regarding vehicle usage. The back-end components **104** may use one or more servers **140** to receive data from the front-end components **102**, determine use and effectiveness of autonomous operation features, determine risk levels or premium price, and/or facilitate purchase or renewal of an autonomous vehicle insurance policy.

The front-end components **102** may be disposed within or communicatively connected to one or more on-board computers **114**, which may be permanently or removably installed in the vehicle **108**. The on-board computer **114** may interface with the one or more sensors **120** within the vehicle **108** (e.g., an ignition sensor, an odometer, a system clock, a speedometer, a tachometer, an accelerometer, a gyroscope, a compass, a geolocation unit, a camera, a distance sensor, etc.), which sensors may also be incorporated within or connected to the on-board computer **114**. The front-end components **102** may further include a communication component **122** to transmit information to and receive information from external sources, including other vehicles, infrastructure, or the back-end components **104**. In some embodiments, the mobile device **110** may supplement the functions performed by the on-board computer **114** described herein by, for example, sending or receiving information to and from the mobile server **140** via the network **130**. In other embodiments, the on-board computer **114** may perform all of the functions of the mobile device **110** described herein, in which case no mobile device **110** may be present in the system **100**. Either or both of the mobile device **110** or on-board computer **114** may communicate with the network **130** over links **112** and **118**, respectively. Additionally, the mobile device **110** and on-board computer **114** may communicate with one another directly over link **116**.

The mobile device **110** may be either a general-use personal computer, cellular phone, smart phone, tablet computer, phablet, wearable electronics, PDA (personal digital assistant), smart glasses, smart watches, smart bracelet, pager, computing device configured for wired or wireless RF (radio frequency) communication, a dedicated vehicle use monitoring device, and/or other mobile computing device. Although only one mobile device **110** is illustrated, it should be understood that a plurality of mobile devices **110** may be used in some embodiments. The on-board computer **114** may be a general-use on-board computer capable of performing many functions relating to vehicle operation or a dedicated computer for autonomous vehicle operation. Further, the on-board computer **114** may be installed by the manufacturer of the vehicle **108** or as an aftermarket modification or addition to the vehicle **108**. In some embodiments or under certain conditions, the mobile device **110** or on-board computer **114** may function as thin-client devices that outsource some or most of the processing to the server **140**.

The sensors **120** may be removably or fixedly installed within the vehicle **108** and may be disposed in various arrangements to provide information to the autonomous operation features. Among the sensors **120** may be included one or more of a GPS (Global Positioning System) unit, other satellite-based navigation unit, a radar unit, a LIDAR (Light Detection and Ranging) unit, an ultrasonic sensor, an infrared sensor, a camera, an accelerometer, a tachometer, and/or a speedometer. Some of the sensors **120** (e.g., radar,

LIDAR, or camera units) may actively or passively scan the vehicle environment for obstacles (e.g., other vehicles, buildings, pedestrians, etc.), lane markings, or signs or signals. Other sensors **120** (e.g., GPS, accelerometer, or tachometer units) may provide data for determining the location or movement of the vehicle **108**. Other sensors **120** may be directed to the interior or passenger compartment of the vehicle **108**, such as cameras, microphones, pressure sensors, thermometers, or similar sensors to monitor the vehicle operator and/or passengers within the vehicle **108**. Information generated or received by the sensors **120** may be communicated to the on-board computer **114** or the mobile device **110** for use in autonomous vehicle operation.

In some embodiments, the communication component **122** may receive information from external sources, such as other vehicles or infrastructure. The communication component **122** may also send information regarding the vehicle **108** to external sources. To send and receive information, the communication component **122** may include a transmitter and a receiver designed to operate according to predetermined specifications, such as the dedicated short-range communication (DSRC) channel, wireless telephony, Wi-Fi, or other existing or later-developed communications protocols. The received information may supplement the data received from the sensors **120** to implement the autonomous operation features. For example, the communication component **122** may receive information that an autonomous vehicle ahead of the vehicle **108** is reducing speed, allowing the adjustments in the autonomous operation of the vehicle **108**.

In further embodiments, the front-end components may include an infrastructure communication device **124** for monitoring the status of one or more infrastructure components **126**. The infrastructure communication device **124** may include or be communicatively connected to one or more sensors (not shown) for detecting information relating to the condition of the infrastructure component **126**. The sensors (not shown) may generate data relating to weather conditions, traffic conditions, or operating status of the infrastructure component **126**. The infrastructure communication device **124** may be configured to receive the sensor data generated and determine a condition of the infrastructure component **126**, such as weather conditions, road integrity, construction, traffic, available parking spaces, etc. The infrastructure communication device **124** may further be configured to communicate information to vehicles **108** via the communication component **122**. In some embodiments, the infrastructure communication device **124** may receive information from the vehicles **108**, while, in other embodiments, the infrastructure communication device **124** may only transmit information to the vehicles **108**.

In addition to receiving information from the sensors **120**, the on-board computer **114** may directly or indirectly control the operation of the vehicle **108** according to various autonomous operation features. The autonomous operation features may include software applications or routines implemented by the on-board computer **114** to control the steering, braking, or throttle of the vehicle **108**. To facilitate such control, the on-board computer **114** may be communicatively connected to the controls or components of the vehicle **108** by various electrical or electromechanical control components (not shown). In embodiments involving fully autonomous vehicles, the vehicle **108** may be operable only through such control components (not shown). In other embodiments, the control components may be disposed within or supplement other vehicle operator control components (not shown), such as steering wheels, accelerator or brake pedals, or ignition switches.

In some embodiments, the front-end components **102** may communicate with the back-end components **104** via the network **130**. The network **130** may be a proprietary network, a secure public internet, a virtual private network or some other type of network, such as dedicated access lines, plain ordinary telephone lines, satellite links, cellular data networks, combinations of these. Where the network **130** comprises the Internet, data communications may take place over the network **130** via an Internet communication protocol.

The back-end components **104** may include one or more servers **140**. Each server **140** may include one or more computer processors adapted and configured to execute various software applications and components of the autonomous vehicle insurance system **100**, in addition to other software applications. The server **140** may further include a database **146**, which may be adapted to store data related to the operation of the vehicle **108** and its autonomous operation features. Such data might include, for example, dates and times of vehicle use, duration of vehicle use, use and settings of autonomous operation features, speed of the vehicle **108**, RPM or other tachometer readings of the vehicle **108**, lateral and longitudinal acceleration of the vehicle **108**, incidents or near collisions of the vehicle **108**, communication between the autonomous operation features and external sources, environmental conditions of vehicle operation (e.g., weather, traffic, road condition, etc.), errors or failures of autonomous operation features, or other data relating to use of the vehicle **108** and the autonomous operation features, which may be uploaded to the server **140** via the network **130**. The server **140** may access data stored in the database **146** when executing various functions and tasks associated with the evaluating feature effectiveness or assessing risk relating to an autonomous vehicle.

Although the autonomous vehicle insurance system **100** is shown to include one vehicle **108**, one mobile device **110**, one on-board computer **114**, and one server **140**, it should be understood that different numbers of vehicles **108**, mobile devices **110**, on-board computers **114**, and/or servers **140** may be utilized. For example, the system **100** may include a plurality of servers **140** and hundreds of mobile devices **110** or on-board computers **114**, all of which may be interconnected via the network **130**. Furthermore, the database storage or processing performed by the one or more servers **140** may be distributed among a plurality of servers **140** in an arrangement known as "cloud computing." This configuration may provide various advantages, such as enabling near real-time uploads and downloads of information as well as periodic uploads and downloads of information. This may in turn support a thin-client embodiment of the mobile device **110** or on-board computer **114** discussed herein.

The server **140** may have a controller **155** that is operatively connected to the database **146** via a link **156**. It should be noted that, while not shown, additional databases may be linked to the controller **155** in a known manner. For example, separate databases may be used for autonomous operation feature information, vehicle insurance policy information, and vehicle use information. The controller **155** may include a program memory **160**, a processor **162** (which may be called a microcontroller or a microprocessor), a random-access memory (RAM) **164**, and an input/output (I/O) circuit **166**, all of which may be interconnected via an address/data bus **165**. It should be appreciated that although only one microprocessor **162** is shown, the controller **155**

may include multiple microprocessors **162**. Similarly, the memory of the controller **155** may include multiple RAMs **164** and multiple program memories **160**. Although the I/O circuit **166** is shown as a single block, it should be appreciated that the I/O circuit **166** may include a number of different types of I/O circuits. The RAM **164** and program memories **160** may be implemented as semiconductor memories, magnetically readable memories, or optically readable memories, for example. The controller **155** may also be operatively connected to the network **130** via a link **135**.

The server **140** may further include a number of software applications stored in a program memory **160**. The various software applications on the server **140** may include an autonomous operation information monitoring application **141** for receiving information regarding the vehicle **108** and its autonomous operation features, a feature evaluation application **142** for determining the effectiveness of autonomous operation features under various conditions, a compatibility evaluation application **143** for determining the effectiveness of combinations of autonomous operation features, a risk assessment application **144** for determining a risk category associated with an insurance policy covering an autonomous vehicle, and an autonomous vehicle insurance policy purchase application **145** for offering and facilitating purchase or renewal of an insurance policy covering an autonomous vehicle. The various software applications may be executed on the same computer processor or on different computer processors.

The various software applications may include various software routines stored in the program memory **160** to implement various modules using the process **162**. Additionally, or alternatively, the software applications or routines may interact with various hardware modules that may be installed within or connected to the server **140**. Such modules may implement part of all of the various exemplary methods discussed herein or other related embodiments. Such modules may include a vehicle control module for determining and implementing control decisions to operate the vehicle **108**, a system status module for determining the operating status of autonomous operation features, a monitoring module for monitoring the operation of the vehicle **108**, a remediation module for correcting abnormal operating states of autonomous operation features, an insurance module for determining risks and costs associated with operation of the vehicle **108**, an alert module for generating and presenting alerts regarding the vehicle **108** or the vehicle operator, a risk assessment module for determining risks associated with operation of the vehicle **108** by the autonomous operation features or by the vehicle operator, an identification module for identifying or verifying the identity of the vehicle operator, an information module for obtaining information regarding a vehicle operator or vehicle **108**, a use cost module for determining costs associated with operation of the vehicle **108**, a comparison module for comparing one or more costs associated with owning or operating the vehicle **108**, an update module for updating an autonomous operation feature of the vehicle **108**, or other modules.

Exemplary Mobile Device or on-Board Computer

FIG. **2** illustrates a block diagram of an exemplary mobile device **110** and/or an exemplary on-board computer **114** consistent with the system **100**. The mobile device **110** and/or on-board computer **114** may include a display **202**, a GPS unit **206**, a communication unit **220**, an accelerometer **224**, one or more additional sensors (not shown), a user-input device (not shown), and/or, like the server **140**, a controller **204**. In some embodiments, the mobile device **110** and on-board computer **114** may be integrated into a single device, or either may perform the functions of both. The on-board computer **114** (or mobile device **110**) may interface with the sensors **120** to receive information regarding the vehicle **108** and its environment, which information may be used by the autonomous operation features to operate the vehicle **108**.

Similar to the controller **155**, the controller **204** may include a program memory **208**, one or more microcontrollers or microprocessors (MP) **210**, a RAM **212**, and an I/O circuit **216**, all of which are interconnected via an address/data bus **214**. The program memory **208** may include an operating system **226**, a data storage **228**, a plurality of software applications **230**, and/or a plurality of software routines **240**. The operating system **226**, for example, may include one of a plurality of general purpose or mobile platforms, such as the Android™, iOS®, or Windows® systems, developed by Google Inc., Apple Inc., and Microsoft Corporation, respectively. Alternatively, the operating system **226** may be a custom operating system designed for autonomous vehicle operation using the on-board computer **114**. The data storage **228** may include data such as user profiles and preferences, application data for the plurality of applications **230**, routine data for the plurality of routines **240**, and other data related to the autonomous operation features. In some embodiments, the controller **204** may also include, or otherwise be communicatively connected to, other data storage mechanisms (e.g., one or more hard disk drives, optical storage drives, solid state storage devices, etc.) that reside within the vehicle **108**.

As discussed with reference to the controller **155**, it should be appreciated that although FIG. **2** depicts only one microprocessor **210**, the controller **204** may include multiple microprocessors **210**. Similarly, the memory of the controller **204** may include multiple RAMs **212** and multiple program memories **208**. Although FIG. **2** depicts the I/O circuit **216** as a single block, the I/O circuit **216** may include a number of different types of I/O circuits. The controller **204** may implement the RAMs **212** and the program memories **208** as semiconductor memories, magnetically readable memories, or optically readable memories, for example.

The one or more processors **210** may be adapted and configured to execute any of one or more of the plurality of software applications **230** or any one or more of the plurality of software routines **240** residing in the program memory **204**, in addition to other software applications. One of the plurality of applications **230** may be an autonomous vehicle operation application **232** that may be implemented as a series of machine-readable instructions for performing the various tasks associated with implementing one or more of the autonomous operation features according to the autonomous vehicle operation method **300**. Another of the plurality of applications **230** may be an autonomous communication application **234** that may be implemented as a series of machine-readable instructions for transmitting and receiving autonomous operation information to or from external sources via the communication unit **220**. Still another application of the plurality of applications **230** may include an autonomous operation monitoring application **236** that may be implemented as a series of machine-readable instructions for sending information regarding autonomous operation of the vehicle to the server **140** via the network **130**.

The plurality of software applications **230** may call various of the plurality of software routines **240** to perform functions relating to autonomous vehicle operation, monitoring, or communication. In some embodiments, the plu-

rality of software routines may further assess risk levels or determine insurance policy costs and adjustments. One of the plurality of software routines **240** may be a configuration routine **242** to receive settings from the vehicle operator to configure the operating parameters of an autonomous operation feature. Another of the plurality of software routines **240** may be a sensor control routine **244** to transmit instructions to a sensor **120** and receive data from the sensor **120**. Still another of the plurality of software routines **240** may be an autonomous control routine **246** that performs a type of autonomous control, such as collision avoidance, lane centering, and/or speed control. In some embodiments, the autonomous vehicle operation application **232** may cause a plurality of autonomous control routines **246** to determine control actions required for autonomous vehicle operation. Similarly, one of the plurality of software routines **240** may be a monitoring and reporting routine **248** that monitors and transmits information regarding autonomous vehicle operation to the server **140** via the network **130**. Yet another of the plurality of software routines **240** may be an autonomous communication routine **250** for receiving and transmitting information between the vehicle **108** and external sources to improve the effectiveness of the autonomous operation features.

Any of the plurality of software routines **240** may be designed to operate independently of the software applications **230** or in conjunction with the software applications **230** to implement modules associated with the methods discussed herein using the microprocessor **210** of the controller **204**. Additionally, or alternatively, the software applications **230** or software routines **240** may interact with various hardware modules that may be installed within or connected to the mobile device **110** or the on-board computer **114**. Such modules may implement part of all of the various exemplary methods discussed herein or other related embodiments.

For instance, such modules may include a vehicle control module for determining and implementing control decisions to operate the vehicle **108**, a system status module for determining the operating status of autonomous operation features, a monitoring module for monitoring the operation of the vehicle **108**, a remediation module for correcting abnormal operating states of autonomous operation features, an insurance module for determining risks and costs associated with operation of the vehicle **108**, an alert module for generating and presenting alerts regarding the vehicle **108** or the vehicle operator, a risk assessment module for determining risks associated with operation of the vehicle **108** by the autonomous operation features or by the vehicle operator, an identification module for identifying or verifying the identity of the vehicle operator, an information module for obtaining information regarding a vehicle operator or vehicle **108**, a use cost module for determining costs associated with operation of the vehicle **108**, a comparison module for comparing one or more costs associated with owning or operating the vehicle **108**, an update module for updating an autonomous operation feature of the vehicle **108**, and/or other modules.

When implementing the exemplary autonomous vehicle operation method **300**, the controller **204** of the on-board computer **114** may implement a vehicle control module by the autonomous vehicle operation application **232** to communicate with the sensors **120** to receive information regarding the vehicle **108** and its environment and process that information for autonomous operation of the vehicle **108**. In some embodiments, including external source communication via the communication component **122** or the communication unit **220**, the controller **204** may further implement a communication module based upon the autonomous communication application **234** to receive information for external sources, such as other autonomous vehicles, smart infrastructure (e.g., electronically communicating roadways, traffic signals, or parking structures), or other sources of relevant information (e.g., weather, traffic, local amenities). Some external sources of information may be connected to the controller **204** via the network **130**, such as the server **140** or internet-connected third-party databases (not shown). Although the autonomous vehicle operation application **232** and the autonomous communication application **234** are shown as two separate applications, it should be understood that the functions of the autonomous operation features may be combined or separated into any number of the software applications **230** or the software routines **240**.

In some embodiments, the controller **204** may further implement a monitoring module by the autonomous operation monitoring application **236** to communicate with the server **140** to provide information regarding autonomous vehicle operation. This may include information regarding settings or configurations of autonomous operation features, data from the sensors **120** regarding the vehicle environment, data from the sensors **120** regarding the response of the vehicle **108** to its environment, communications sent or received using the communication component **122** or the communication unit **220**, operating status of the autonomous vehicle operation application **232** and the autonomous communication application **234**, and/or commands sent from the on-board computer **114** to the control components (not shown) to operate the vehicle **108**. The information may be received and stored by the server **140** implementing the autonomous operation information monitoring application **141**, and the server **140** may then determine the effectiveness of autonomous operation under various conditions by implementing the feature evaluation application **142** and the compatibility evaluation application **143**. The effectiveness of autonomous operation features and the extent of their use may be further used to determine risk associated with operation of the autonomous vehicle by the server **140** implementing a risk assessment module or insurance module associated with the risk assessment application **144**.

In addition to connections to the sensors **120**, the mobile device **110** or the on-board computer **114** may include additional sensors, such as the GPS unit **206** or the accelerometer **224**, which may provide information regarding the vehicle **108** for autonomous operation and other purposes. Furthermore, the communication unit **220** may communicate with other autonomous vehicles, infrastructure, or other external sources of information to transmit and receive information relating to autonomous vehicle operation. The communication unit **220** may communicate with the external sources via the network **130** or via any suitable wireless communication protocol network, such as wireless telephony (e.g., GSM, CDMA, LTE, etc.), Wi-Fi (802.11 standards), WiMAX, Bluetooth, infrared or radio frequency communication, etc. Furthermore, the communication unit **220** may provide input signals to the controller **204** via the I/O circuit **216**. The communication unit **220** may also transmit sensor data, device status information, control signals, and/or other output from the controller **204** to one or more external sensors within the vehicle **108**, mobile devices **110**, on-board computers **114**, and/or servers **140**.

The mobile device **110** and/or the on-board computer **114** may include a user-input device (not shown) for receiving instructions or information from the vehicle operator, such as settings relating to an autonomous operation feature. The

user-input device (not shown) may include a "soft" keyboard that is displayed on the display **202**, an external hardware keyboard communicating via a wired or a wireless connection (e.g., a Bluetooth keyboard), an external mouse, a microphone, or any other suitable user-input device. The user-input device (not shown) may also include a microphone capable of receiving user voice input.

Exemplary Autonomous Vehicle Operation Method

FIG. **3** illustrates a flow diagram of an exemplary autonomous vehicle operation method **300**, which may be implemented by the autonomous vehicle insurance system **100**. The method **300** may begin at block **302** when the controller **204** receives a start signal. The start signal may be a command from the vehicle operator through the user-input device to enable or engage one or more autonomous operation features of the vehicle **108**. In some embodiments, the vehicle operator **108** may further specify settings or configuration details for the autonomous operation features. For fully autonomous vehicles, the settings may relate to one or more destinations, route preferences, fuel efficiency preferences, speed preferences, and/or other configurable settings relating to the operation of the vehicle **108**. In some embodiments, fully autonomous vehicles may include additional features or settings permitting them to operate without passengers or vehicle operators within the vehicle. For example, a fully autonomous vehicle may receive an instruction to find a parking space within the general vicinity, which the vehicle may do without the vehicle operator. The vehicle may then be returned to a selected location by a request from the vehicle operator via a mobile device **110** or otherwise. This feature may further be adapted to return a fully autonomous vehicle if lost or stolen.

For other autonomous vehicles, the settings may include enabling or disabling particular autonomous operation features, specifying thresholds for autonomous operation, specifying warnings or other information to be presented to the vehicle operator, specifying autonomous communication types to send or receive, specifying conditions under which to enable or disable autonomous operation features, and/or specifying other constraints on feature operation. For example, a vehicle operator may set the maximum speed for an adaptive cruise control feature with automatic lane centering. In some embodiments, the settings may further include a specification of whether the vehicle **108** should be operating as a fully or partially autonomous vehicle. In embodiments where only one autonomous operation feature is enabled, the start signal may consist of a request to perform a particular task (e.g., autonomous parking) and/or to enable a particular feature (e.g., autonomous braking for collision avoidance). In other embodiments, the start signal may be generated automatically by the controller **204** based upon predetermined settings (e.g., when the vehicle **108** exceeds a certain speed and/or is operating in low-light conditions). In some embodiments, the controller **204** may generate a start signal when communication from an external source is received (e.g., when the vehicle **108** is on a smart highway or near another autonomous vehicle).

After receiving the start signal at block **302**, the controller **204** may receive sensor data from the sensors **120** during vehicle operation at block **304**. In some embodiments, the controller **204** may also receive information from external sources through the communication component **122** and/or the communication unit **220**. The sensor data may be stored in the RAM **212** for use by the autonomous vehicle operation application **232**. In some embodiments, the sensor data may be recorded in the data storage **228** and/or transmitted to the server **140** via the network **130**. The sensor data may alternately either be received by the controller **204** as raw data measurements from one of the sensors **120** and/or may be preprocessed by the sensor **120** prior to being received by the controller **204**. For example, a tachometer reading may be received as raw data and/or may be preprocessed to indicate vehicle movement or position. As another example, a sensor **120** comprising a radar and/or LIDAR unit may include a processor to preprocess the measured signals and send data representing detected objects in 3-dimensional space to the controller **204**.

The autonomous vehicle operation application **232**, other applications **230**, and/or routines **240** may cause the controller **204** to process the received sensor data at block **306** in accordance with the autonomous operation features. The controller **204** may process the sensor data to determine whether an autonomous control action is required and/or to determine adjustments to the controls of the vehicle **108**. For example, the controller **204** may receive sensor data indicating a decreasing distance to a nearby object in the vehicle's path and process the received sensor data to determine whether to begin braking (and, if so, how abruptly to slow the vehicle **108**). As another example, the controller **204** may process the sensor data to determine whether the vehicle **108** is remaining with its intended path (e.g., within lanes on a roadway). If the vehicle **108** is beginning to drift or slide (e.g., as on ice or water), the controller **204** may determine appropriate adjustments to the controls of the vehicle to maintain the desired bearing. If the vehicle **108** is moving within the desired path, the controller **204** may nonetheless determine whether adjustments are required to continue following the desired route (e.g., following a winding road). Under some conditions, the controller **204** may determine to maintain the controls based upon the sensor data (e.g., when holding a steady speed on a straight road).

When the controller **204** determines an autonomous control action is required at block **308**, the controller **204** may cause the control components of the vehicle **108** to adjust the operating controls of the vehicle to achieve desired operation at block **310**. For example, the controller **204** may send a signal to open or close the throttle of the vehicle **108** to achieve a desired speed. Alternatively, the controller **204** may control the steering of the vehicle **108** to adjust the direction of movement. In some embodiments, the vehicle **108** may transmit a message or indication of a change in velocity or position using the communication component **122** and/or the communication unit **220**, which signal may be used by other autonomous vehicles to adjust their controls. As discussed further below, the controller **204** may also log or transmit the autonomous control actions to the server **140** via the network **130** for analysis.

The controller **204** may continue to receive and process sensor data at blocks **304** and **306** until an end signal is received by the controller **204** at block **312**. The end signal may be automatically generated by the controller **204** upon the occurrence of certain criteria (e.g., the destination is reached or environmental conditions require manual operation of the vehicle **108** by the vehicle operator). Additionally, or alternatively, the vehicle operator may pause, terminate, and/or disable the autonomous operation feature or features using the user-input device or by manually operating the vehicle's controls, such as by depressing a pedal or turning a steering instrument. When the autonomous operation features are disabled or terminated, the controller **204** may either continue vehicle operation without the autonomous features or may shut off the vehicle **108**, depending upon the circumstances.

Where control of the vehicle **108** must be returned to the vehicle operator, the controller **204** may alert the vehicle operator in advance of returning to manual operation. The alert may include a visual, audio, and/or other indication to obtain the attention of the vehicle operator. In some embodiments, the controller **204** may further determine whether the vehicle operator is capable of resuming manual operation before terminating autonomous operation. If the vehicle operator is determined not be capable of resuming operation, the controller **204** may cause the vehicle to stop and/or take other appropriate action.

Exemplary Monitoring Method During Operation

FIG. **4** illustrates a flow diagram depicting an exemplary monitoring method **400** during vehicle operation, which may be implemented by the autonomous vehicle insurance system **100**. The method **400** may monitor the operation of the vehicle **108** and adjust risk levels and rates based upon vehicle use. Although the exemplary embodiment is described as primarily performed by the on-board computer **114**, the method **400** may be implemented by the mobile device **110**, the on-board computer **114**, the server **140**, or a combination thereof. Upon receiving an indication of vehicle operation at block **402**, the on-board computer **114** may determine the configuration and operating status of the autonomous operation features (including the sensors **120** and the communication component **122**) at block **404**. The identity of the vehicle operator may be determined and/or verified at block **406**, which identity may be used to determine or receive a vehicle operator profile at block **408**. The vehicle operator profile may contain information regarding the vehicle operator's ability to manually operate the vehicle and/or past use of autonomous operation features by the vehicle operator. Information from the sensors **120** and/or external data from the communication component **122** may be used at block **410** to determine environmental conditions in which the vehicle **108** is operating. Together, this information determined at blocks **404-410** may be used at block **412** to determine one or more risk levels associated with operation of the vehicle, from which may be determined a costs associated with an insurance policy at block **414**. In some embodiments, information regarding the determined cost may be presented to the vehicle operator or other insurance customer associated with the vehicle **108** at block **416**. In still further embodiments, the vehicle operator and/or insurance customer may be presented with recommendations or options regarding the cost associated with the insurance policy at block **418**. Presentation of options may assist the vehicle operator and/or insurance customer in reducing the cost by allowing the vehicle operator and/or insurance customer to select a lower-cost option (e.g., by adjusting the settings associated with the autonomous operation features). In some embodiments, the vehicle operator and/or insurance customer may be able to select one or more of the options to effect an adjustment in the risk levels and/or insurance cost.

The method **400** may continue monitoring operation of the vehicle **108** at block **420**, and adjustments may be made to the risk levels and insurance costs. If the settings associated with the autonomous operation features are determined to have changed at block **422** (e.g., as a result of the vehicle operator taking manual operation of additional controls), the one or more risk levels may be determined based upon the new settings at block **412**, in which case the blocks **414-422** may be repeated. When no changes have been made to the settings, the method **400** may further check for changes to the environmental conditions and/or operating status of the autonomous operation features at block **424**. If changes are determined to have occurred at block **424**, the one or more risk levels may be determined based upon the new settings at block **412**, as at block **422**. When no changes have occurred, the method **400** may determine whether vehicle operations are ongoing or whether operation is complete at block **426**. When vehicle operation is ongoing, the method **400** may continue to monitor vehicle operation at block **420**. When vehicle operation is complete, information regarding operation of the vehicle may be recorded at block **428**, at which point the method **400** may terminate.

At block **402**, the on-board computer **114** may receive an indication of vehicle operation. This indication may be received from the vehicle operator (either directly or through the mobile device **110**), and/or it may be generated automatically. For example, the on-board computer **114** or the mobile device **110** may automatically generate an indication of vehicle operation when the vehicle starts operation (e.g., upon engine ignition, system power-up, movement of the vehicle **108**, etc.). Upon receiving the indication of vehicle operation, the on-board computer **114** may initiate a system check and/or begin recording information regarding operation of the vehicle **108**.

At block **404**, the on-board computer **114** may determine the configuration and operating status of one or more autonomous operation features of the vehicle **108**. This may include determining the configuration, settings, and/or operating status of one or more hardware or software modules for controlling part or all of the vehicle operation, aftermarket components disposed within the vehicle to provide information regarding vehicle operation, and/or sensors **120** disposed within the vehicle. In some embodiments, a software version, model version, and/or other identification of the feature or sensor may be determined. In further embodiments, the autonomous operation feature may be tested to assess proper functioning, which may be accomplished using a test routine or other means. Additionally, the sensors **120** or the communication component **122** may be assessed to determine their operating status (e.g., quality of communication connections, signal quality, noise, responsiveness, accuracy, etc.). In some embodiments, test signals may be sent to one or more of the sensors **120**, responses to which may be received and/or assessed by the on-board computer to determine operating status. In further embodiments, signals received from a plurality of sensors may be compared to determine whether any of the sensors are malfunctioning. Additionally, signals received from the sensors may be used, in some embodiments, to calibrate the sensors.

At block **406**, the on-board computer **114** may determine the identity of the vehicle operator. To determine the identity of the vehicle operator, the on-board computer **114** may receive and process information regarding the vehicle operator. In some embodiments, the received information may include sensor data from one or more sensors **120** configured to monitor the interior of the vehicle. For example, a camera or other photographic sensor may provide photographic information regarding the vehicle operator, which may be processed and compared with other photographic data for a plurality of persons to determine the identity of the vehicle operator. In further embodiments, the on-board computer may receive information from a mobile computing device associated with the vehicle operator, such as a mobile phone or wearable computing device. For example, a mobile phone may connect to the on-board computer **114**, which may identify the vehicle operator. Additional steps may be taken to verify the identity of the vehicle operator, such as comparing a weight sensed on a seat or use of voice recognition algorithms.

At block **408**, the on-board computer **114** may determine and/or access a vehicle operator profile based upon the identity of the vehicle operator determined at block **406**. The vehicle operator profile may include information regarding the vehicle operator's style of operating the vehicle, including information regarding past operation of one or more vehicles by the vehicle operator. This information may further contain past vehicle operator selections of settings for one or more autonomous operation features. In some embodiments, the on-board computer **114** may request or access the vehicle operator profiled based upon the determined identity. In other embodiments, the on-board computer **114** may generate the vehicle operator profile from information associated with the identified vehicle operator. The vehicle operator profile may include information relating to one or more risks associated with operation of the vehicle by the vehicle operator. For example, the vehicle operator profile for a driver may include information relating to risk levels based upon past driving patters or habits in a variety of relevant environments, which may include risk levels associated with manual operation of the vehicle by the driver. In some embodiments, the vehicle operator profile may include information regarding default settings used by the vehicle operator for the autonomous operation features.

At block **410**, the on-board computer **114** may determine environmental conditions within which the vehicle **108** is or is likely to be operating. Such environmental conditions may include weather, traffic, road conditions, time of day, location of operation, type of road, and/or other information relevant to operation of the vehicle. The environmental conditions may be determined based upon signals received from the sensors **120**, from external data received through the communication component **122**, and/or from a combination of sources. The environmental conditions may then be used in determining risk levels associated with operation of the vehicle **108**.

At block **412**, the on-board computer may determine one or more risk levels associated with operation of the vehicle **108**. The risk levels may be determined based upon a combination of risk factors relating to the autonomous operation features and/or risk factors relating to the vehicle operation. Risks associated with the autonomous operation features may be determined based upon the configuration and/or operating status of the autonomous operation features, the settings of the autonomous operation features, and the vehicle environment. Risks associated with the vehicle operation may be determined based upon the autonomous operation features settings (i.e., the extent to which the vehicle operator will be controlling vehicle operations) and/or the vehicle operator profile. The combined risk may account for the likelihood of the autonomous operation features and/or the vehicle operator controlling vehicle operations with respect to relevant functions of the vehicle **108**.

At block **414**, the on-board computer **114** may determine a cost associated with an insurance policy based upon the one or more risks. In some embodiments, the server **140** may receive information regarding the vehicle operator and the autonomous operation features and/or may determine the cost associated with the insurance policy based upon the risks. The cost may be based upon risk levels associated with separate autonomous operation features, interaction between autonomous operation features, the design and capabilities of the vehicle **108**, the past operating history of the vehicle operator as included in the vehicle operator profile, and/or other information regarding the probability of an accident, collision, and/or other loss event involving the vehicle **108**. Each of the separate risks may depend upon the environmental conditions, and the risks may be weighted based upon the likelihood of each situation. In some embodiments, a total risk may be determined relating to operation of the vehicle under foreseeable conditions with specific settings and configurations of autonomous operation features by a specific vehicle operator. The total risk may be used to determine one or more costs associated with the insurance policy, such as a premium and/or discount.

In some embodiments, information regarding the cost associated with the insurance policy may be presented to the vehicle operator or insurance customer at block **416**. The information may be presented by a display, such as the display **202** of the on-board computer **114** or the mobile device **110**. The information may be presented either for informational purposes or to receive acceptance of the vehicle operator or insurance customer. The insurance cost information may include an indication of one or more of a premium, rate, rating, discount, reward, special offer, points level, program, refund, and/or other costs associated with one or more insurance policies. Additionally, or alternatively, summary information may be presented regarding insurance costs, including a risk level (e.g., high risk, low risk, a risk/cost level on a spectrum, etc.). In some embodiments, presentation of insurance cost information may be suppressed or delayed (e.g., cost information may be presented in summary form on a periodic billing statement).

In further embodiments, options or recommendations regarding the cost associated with the insurance policy may be presented to the vehicle operator or insurance customer at block **418**. The options or recommendations may likewise be presented by a display, such as the display **202** of the on-board computer **114** and/or the mobile device **110**. The options or recommendations may include information regarding costs associated with other settings or configurations of the autonomous operation features (e.g., enabling additional features, selecting an operating mode with lower risks under the determined environmental conditions, etc.). In some embodiments, the recommendations or options may be presented for informational purposes only, requiring the vehicle operator or insurance customer to make any adjustments separately (e.g., through a settings module or other means of adjusting settings for the autonomous operation features). In other embodiments, the vehicle operator or insurance customer may select one or more of the options, whereby adjustments to the configuration or settings of the autonomous operation features may be caused to be implemented by the on-board computer **114** or other controlling device. In some embodiments, the options or recommendations may include options or recommendations to update the software version of one or more autonomous operation features, in which case information regarding a cost associated with updating the features (if applicable) may be presented. Once the information and/or options or recommendations regarding insurance costs have been presented at blocks **416-418** (including, in some embodiments, while such presentation is occurring), the on-board computer **114** may monitor operation of the vehicle **108**.

At block **420**, the on-board computer **114** may monitor operation of the vehicle **108**, including autonomous operation feature control decisions, signals from the sensors **120**, external data from the communication component **122**, and/or control decisions of the vehicle operator. Monitoring vehicle operation may include monitoring data received directly from the features, sensors, and/or other components, as well as summary information regarding the condition, movement, and/or environment of the vehicle **108**. The

on-board computer **114** and/or mobile device **110** may cause the operating data to be stored or recorded, either locally in the data storage **228** and/or via server **140** in the program memory **160** and/or the database **146**. Monitoring may continue until vehicle operation is complete (e.g., the vehicle has reached its destination and shut down), including during any updates or adjustments.

At block **422**, the on-board computer **114** may determine whether any changes have been made to the settings or configuration of the autonomous operation features. If such changes or adjustments have been made, the on-board computer **114** may proceed to determine new risk levels and insurance costs at blocks **412-414** and/or present the information to the vehicle operator or insurance customer at blocks **416-418**, as discussed above. In some embodiments, minor changes below a minimum change threshold may be ignored when determining whether any changes have been made. In further embodiments, the cumulate effect of a plurality of such minor changes below the minimum change threshold may be considered as a change at block **422** when the cumulative effect of the minor changes reaches and/or exceeds the minimum change threshold. When no changes to the settings or configuration of the autonomous operation features are determined to have been made at block **422**, the on-board computer **114** may further determine whether any changes in the environmental conditions and/or operating status of the autonomous operation features or sensors have occurred. Although these steps are illustrated separately for clarity, it should be understood that they may be further divided or combined in various embodiments.

At block **424**, the on-board computer **114** may determine whether any changes have occurred to the environmental conditions of the vehicle **108** and/or the operating status of the autonomous operation features, sensors **120**, or communication component **122**. Such changes may occur when weather or traffic conditions change, when sensors **120** malfunction or become blocked by debris, and/or when the vehicle **108** leaves an area where external data is available via the communication component **122**. When such changes occur, the risk levels associated with control of the vehicle **108** by the vehicle operator and the autonomous operation features may likewise change. Therefore, it may be advantageous to adjust the use of the autonomous operation features to account for such changes. Thus, the on-board computer **114** may proceed to determine new risk levels and insurance costs at blocks **412-414** and/or present the information to the vehicle operator or insurance customer at blocks **416-418**, as discussed above, when such changes are determined to have occurred at block **424**. Similar to the determination at block **422**, minor changes below a minimum change threshold may be ignored at block **424**, unless the cumulative effect of the changes reaches or exceeds the minimum change threshold. When no changes are determined to have occurred at block **424**, the method **400** may continue to monitor the operation of the vehicle **108** until vehicle operation is determined to have ended.

At block **426**, the on-board computer **114** may determine whether vehicle operations are complete. This may include determining whether a command to shut down the vehicle **108** has been received, whether the vehicle **108** has remained idle at a destination for a predetermined period of time, and/or whether the vehicle operator has exited the vehicle **108**. Until operation is determined at block **426** to be complete (i.e., when the vehicle trip has concluded), the on-board computer **114** may continue to monitor vehicle operation at block **420**, as discussed above. When operation is determined to be complete at block **426**, the on-board computer **114** may further cause a record of the operation of the vehicle **108** to be made or stored. Such records may include operating data (in full or summary form) and may be used for assessing risks associated with one or more autonomous operation features or the vehicle operator. As noted above, in some embodiments, records of operating data may be generated and stored continually during operation. In some embodiments, the partial or completed records may be transmitted to the server **140** to be stored in the database **146**. After completion and recordation of the vehicle operation, the method **400** may terminate.

Exemplary Methods for Determining Operating Status

FIG. **5** illustrates a flow diagram depicting an exemplary operating status assessment method **500** that may be used to determine operation status of the autonomous operation features, sensors **120**, and/or communication component **122**, as indicated in blocks **404** and **424** above. The method **500** may evaluate the autonomous operation features of the vehicle **108** (including sensors **120**) and determine whether they are operating correctly, are malfunctioning, and/or are operating with impaired or degraded quality. Such determinations may be particularly important as the vehicle **108** ages or in environments that may block or damage sensors **120**. In such cases, the original effectiveness of the autonomous operation features may be reduced as sensors become less accurate or processing of the sensor data is slowed (such as by software version updates that improve accuracy but require greater computational resources). The exemplary method **500** may be implemented regularly to ensure appropriate risk assessment, as well as periodically to certify the operating status level of the vehicle for roadworthiness or insurance rate adjustment. In some embodiments, periodic evaluation may be performed using special purpose computing devices and/or by licensed or authorized third parties. Periodic evaluation may further include more thorough testing and analysis of the vehicle **108**, which may include testing at a test environment. Although the exemplary embodiment is described as primarily performed by the on-board computer **114**, the method **500** may be implemented by the mobile device **110**, the on-board computer **114**, the server **140**, or a combination thereof.

Upon receiving a request to determine the operating status of the autonomous operation features of the vehicle **108** at block **502**, the configuration of the sensors **120** may be determined at block **504**. The functioning of autonomous operation feature software routines may further be determined at block **506**. A test signal may be transmitted to the sensors **120** at block **508**, and/or sensor data may be received at block **510**. The sensor data may include a response to the test signal, as well as other signals from the sensors based upon the vehicle environment or operation of the vehicle **108**. Based upon the received information, the operating status of the autonomous operation features and components may be determined at block **512**. If any impairments are detected at block **514**, the method **500** may attempt to remediate the impairments at block **516**. If impairments are detected to remain at block **518** after the remediation attempt, an alert may be generated and presented to the vehicle operator or an insurance customer at block **520**. When no impairments are detected or after presentation of the alert, a report indicating the operational status of the autonomous operation features may be generated at block **522**. In some embodiments, the report may be transmitted to an insurer at block **524**, and/or a cost associated with an insurance policy associated with the vehicle **108** may be determined at block **526**. The determined cost may be presented with the report at block **528** to the vehicle operator

or insurance customer. Once the report has been presented, the exemplary method may end.

At block **502**, the on-board computer **114** may receive an indication of a request to check the operating status of the autonomous operation features of the vehicle **108**. In some embodiments, the request may be generated in response to a user interaction with the mobile device **110** or a special-purpose computing device communicatively connected to the vehicle **108**. For example, an application running on the mobile device **110** may allow the user of the mobile device **110** to request an evaluation of the autonomous operation features. Similarly, a special-purpose computing device may be connected to the vehicle **108** (wirelessly or via a communication port) to evaluate the operating status of the autonomous operation features. In other embodiments, the request may be automatically generated by the on-board computer **114** in response to the occurrence of an event, such as receipt of a command to start the vehicle, receipt of a command to shut off the vehicle, receipt of an indication of a collision involving the vehicle, and/or receipt of an indication of damage to the vehicle.

In yet further embodiments, the request may be generated by the server **140** and transmitted to the on-board computer **114** to determine the operating status of the autonomous operation features. Such server-generated requests may be used for insurance rating, and may be generated periodically.

In some embodiments, the request may further include information regarding the extent of the evaluation of the operating status of the autonomous operation features. For example, the request may indicate that only software or sensors are to be evaluated, and/or the request may indicate one or more tolerances within which the system components may be determined to be operating properly.

At block **504**, the on-board computer **114** may determine the configuration of the sensors **120** disposed within or communicatively connected to the vehicle **108**. This may include determining any of the number, type, location, technical specifications, and/or characteristics of the sensors **120**. In further embodiments, the on-board computer **114** may determine normal functioning characteristics and/or output ranges for the sensors **120**, which may be used in determining whether the sensors **120** are functioning normally. Determining normal functioning characteristics may include requesting such information from the server **140** and/or accessing such information stored within the data storage **228**. In some embodiments, the configuration of one or more communication components **122** may also be determined at block **504**.

At block **506**, the on-board computer **114** may execute one or more software diagnostic routines to evaluate the operation of the software components of the autonomous operation features. In some embodiments, a special-purpose computing device and/or mobile device **110** may execute the routines or receive the output of the routines. The software diagnostic routines may cause test inputs to be presented to the autonomous operation features and receive responses based upon the test inputs. For example, the software diagnostic routines may simulate sensor inputs corresponding to a situation in which the autonomous operation features should cause the vehicle to brake, then record the control signals generated by the autonomous operation features. Of course, the control signals output from the autonomous operation feature software may be disconnected from the operating controls of the vehicle **108** and/or suppressed during evaluation to prevent the vehicle **108** from physically responding to the test inputs.

At block **508**, in some embodiments, the on-board computer **114** may generate and transmit one or more test signals to the sensors **120**. The test signals may cause the sensors **120** to respond with status information, such as verification of the communicative connection, signal quality, a predetermined set of response signals, and/or other information regarding the sensors. In some embodiments, the test signals may cause the sensors **120** to enter a test mode or execute a calibration routine, in which case information regarding the operating status of the sensors **120** may be generated at the sensors **120** and transmitted to the on-board computer **114**. In further embodiments, the on-board computer **114** may further generate and transmit test signals to the communication component **122**.

At block **510**, the on-board computer **114** may receive sensor data from the sensors **120** or communication components **122**. The received sensor data may include responses to test signals. The received sensor data may, in some embodiments, also or alternatively include sensor data generated in the ordinary course of operation of the sensors. For example, the received sensor data may include data indicating sensor readings of obstacles within sensor range of the vehicle **108**. Such ordinary course sensor data may be combined and compared to determine the operating status of each of a plurality of sensors connected to the vehicle **108**.

At block **512**, the on-board computer **114** may determine the operating status of the autonomous operation features, including the sensors **120** and/or the communication component **122**, based upon the received information at blocks **506** and/or **510**. This may include determining the signal quality or accuracy of the sensor data and/or the accuracy or response time of the autonomous operation feature software. In some embodiments, determining the operating status of a sensor **120** may include determining an expected sensor output signal based upon information received from other sensors **120** and comparing the actual output signal from the sensor to the expected output signal. To avoid minor deviations from expected sensor or software operation from being interpreted as a malfunction, a range of values indicating a normal operating status may be allowed for the sensors and software. Thus, a sensor signal within the normal range may be treated as indicating a normal operating status even if the value is slightly different from the expected value. Additionally, sensors **120** from which no signal is received may be determined to be missing, malfunctioning, and/or damaged. Some sensors **120** may further be determined to be blocked based upon the received sensor data.

At block **514**, the on-board computer **114** may determine whether any of the autonomous operation features, sensors **120**, and/or communication components **122** have an impaired operating status. If all are operating normally, then the on-board computer **114** may proceed to generate a report at block **522**. If any impairments are detected at block **514**, however, the on-board computer **114** may attempt to remediate the impairment at block **516**. Remediation attempts may be determined based upon the type of feature or component, as well as the type of impairment. For example, a remediation attempt for autonomous operation feature software errors may include rebooting or reinstalling a portion of the software. As another example, a signal error in a sensor **120** may be remediated by calibration of the sensor **120** based upon available sensor data. Some vehicles **108** may include remediation components (not shown) for certain types of common impairments of some or all sensors **120**. For example, sensors **120** may become blocked by snow or ice in cold climates, so heating elements may be disposed within the vehicle **108** to melt accumulated snow

or ice from an area around the sensors **120**. Other types of blockages, such as by snow, ice, rain, dirt, mud, condensation, and/or other blockages, may be addressed with other remediation components.

If remediation is determined at block **518** to successfully address all impairments, a report may be generated at block **522**. If one or more impairments remain, then an alert may be generated and presented to the vehicle operator or insurance customer at block **520**. The alert may include information regarding the type of autonomous operation feature or sensor impairment, the severity of the impairment, an impact on risks associated with autonomous operation, whether some autonomous operation features must be disabled, and/or recommendations regarding autonomous operation features use and settings. In addition to the alert generated and presented at block **520**, the on-board computer **114** may generate a report at block **522**.

At block **522**, the on-board computer **114** may generate a report indicating the operating status of the autonomous operation features and components based upon the information received at blocks **506** and **510**. If remediation of one or more impairments has been attempted, the report may so indicate and/or may be adjusted based upon the results determined at block **518**. In some embodiments, the report may include information regarding impaired features or sensors, while in other embodiments the report may include information all features and sensors regarding. In further embodiments, the report may include recommendations regarding autonomous operation feature use or settings, as well as recommendation maintenance or updates. In some embodiments, the report may include a certification of the operating status of the autonomous operation features, sensors, and/or other components. In further embodiments, the report may include information regarding maintenance performed on the vehicle **108**, which may be recorded in the data storage **228**. Where the evaluation is performed by an authorized or licensed third party, information regarding the third party may be included in the report.

At block **524**, the report may be transmitted to a server **140** associated with an insurer for determination of costs or adjustments to one or more insurance policies. At block **526**, the server **140** may determine one or more costs associated with the one or more insurance policies based upon the report. The one or more costs may include one or more of the following: a premium, a discount, a surcharge, a rate level, a cost based upon a distance traveled, a cost based upon a vehicle trip, and/or a cost based upon a duration of vehicle operation. In some embodiments, the server **140** may first determine one or more adjustments to risk levels based upon the information in the report. For example, a risk level associated with an autonomous operation feature may be increased if one or more sensors used by the feature are impaired. The risk levels may be further used to determine costs based upon expected loss rates for the vehicle **108** and/or the vehicle operator.

At block **528**, the report may be presented to the vehicle operator and/or insurance customer by a display, such as display **202**. The report may be presented in full or may be summarized for ease of use. In some embodiments, the one or more costs associated with the insurance policy determined at block **526** may also be presented. If the report includes a certification of the status of the autonomous operation features and components, the certification may also be presented to the vehicle operator and/or insurance customer. In some embodiments, the certification may be further transmitted to an account associated with the vehicle operator and/or insurance customer and/or may be transmitted to a third party, such as a government agency. In some embodiments, the vehicle operator and/or insurance customer may be presented with an option to save, record, print, and/or transmit the report.

FIG. **6** illustrates a flow diagram of an exemplary operating status monitoring method **600** that may be used to determine operation status of the autonomous operation features, sensors **120**, and/or communication component **122**, in addition to or alternatively to the exemplary method **500** above. The method **600** may be implemented while the vehicle **108** is in operation to monitor the operating status of the autonomous operation features and components. The method **600** may monitor the vehicle operating data at block **602** to determine operating status of the autonomous operation features and components at block **604**. When a change in operating status is detected at block **606**, one or more corresponding changes in risk levels may be determined at block **608**. If the changes in risk levels are determined to cause the risk levels to exceed an alert threshold but not a critical threshold at blocks **610** and **612**, respectively, an alert is generated and presented to the vehicle operator at block **614**. If the risk levels are determined to exceed the critical threshold at block **612**, the method **600** may determine whether control of the vehicle **108** can be safely transferred to the vehicle operator at block **616**. If the vehicle operator is prepared and able to assume control of the vehicle **108**, then vehicle operation may be transferred to the vehicle operator at block **620**. If control cannot be safely transferred, the vehicle **108** may cease operations and shut down at block **618**. Once the vehicle **108** is no longer operating, the method **600** may terminate. Although the exemplary embodiment is described as primarily performed by the on-board computer **114**, the method **600** may be implemented by the mobile device **110**, the on-board computer **114**, the server **140**, or a combination thereof.

At block **602**, the on-board computer **114** may monitor the operations of the vehicle **108** to obtain data regarding the autonomous operation features and components. In some embodiments, this may include receiving and recording operating data from the autonomous operation features, sensors **120**, and/or communication component **122**. This vehicle operating data may be processed by the on-board computer **114** at block **604** to determine the operation status of the autonomous operation features (including sensors **120** and/or communication component **122**), as discussed above.

At block **606**, the on-board computer **114** may compare the operating status information determined at block **604** with previously determined operating status information. When no previous operating status information is available from the current or previous vehicle trip, the determined operating status information may be compared with baseline and/or expected operating status information. In some embodiments, minor changes to operating status may be disregarded at block **606**, unless the cumulative effect of the changes exceeds a minimum threshold. The method **600** may continue with monitoring the vehicle operation until a change in operating status is determined at block **606**. When a change is determined, the change in operating status may then be translated into a change in risk levels.

At block **608**, the on-board computer **114** may determine one or more changes in risk levels associated with operation of the vehicle **108** by the autonomous operation features based upon the determined changes in operating status. As discussed above, the changes in operating status of the autonomous operation features, sensors **120**, and/or communication components **122** may cause risks associated with vehicle operation to increase or decrease. For example, if a

sensor **120** malfunctions, the change in operating status of the sensor from operating normally to malfunctioning may increase the risks associated with vehicle operation by limiting the sensor data available to one or more autonomous operation features, thereby diminishing their effectiveness. If the malfunctioning sensor **120** were to later resume normal operation (e.g., as a result of jostling or remediation), the additional sensor data may decrease the risks associated with vehicle operation. In some embodiments, the on-board computer **114** and/or the server **140** may further determine an adjustment to a cost associated with an insurance policy covering the vehicle based upon the changes in operating status (e.g., adjustments to a premium, a discount, a surcharge, a rate level, a cost based upon a distance traveled, a cost based upon a vehicle trip, or a cost based upon a duration of vehicle operation.). In addition to changes in risk levels, the on-board computer **114** and/or server **140** may further determine risk levels associated with operation of the vehicle based upon the operating status and operating data.

At block **610**, the on-board computer **114** may determine whether the changes in one or more risk levels cause the total risk level or risk levels for one or more autonomous operation features to exceed the alert threshold. If the alert threshold is not exceeded, the on-board computer **114** may continue to monitor the operating data at block **602** for changes to operating status that may cause one or more risk levels to exceed the alert threshold. If the alert threshold is exceeded, the on-board computer **114** may further determine whether the critical threshold for operation is exceeded at block **612**. If the critical threshold is exceeded, one or more autonomous operation features may no longer be able to safely control the vehicle **108** in the existing environmental conditions. If the critical threshold is not exceeded, the autonomous operation features may continue to control the vehicle **108**, but with lower effectiveness.

If the critical threshold is determined not to be exceeded at block **612**, the on-board computer **114** may generate and present to the vehicle operator and/or insurance customer an alert indicating the impairment of the one or more autonomous operation features at block **614**. The alert may include information regarding the impairment, recommended actions to remediate or ameliorate the impairment (e.g., unblocking sensors, adjusting settings, etc.), relative risk levels, and/or other information regarding the heightened risk associated with vehicle operation. In some embodiments, the alert may further include information regarding a change to a cost associated with an insurance policy based upon the changes in operating status, which may be determined by the on-board computer **114** or the server **140**. In some embodiments, the alert may further include one or more options the vehicle operator may select to automatically adjust the settings of the autonomous operation features and/or attempt to remediate the impairment.

If the critical threshold is exceeded, the on-board computer **114** may determine whether the vehicle operator is able and prepared to assume control of one or more aspects of operation of the vehicle **108** from one or more of the autonomous operation features at block **616**. Determining whether the vehicle operator is able and prepared to safely accept a transfer of control may include determining one or more of risk levels associated with manual operation by the vehicle operator under the environmental conditions, the physical or mental state of the vehicle operator, the attentiveness or alertness of the vehicle operator, and/or the time available to transfer control of the vehicle **108**, as described in further detail below. If the vehicle operator is not prepared to accept a transfer of vehicle operation from the one or more autonomous operation features, the on-board computer **114** may cause the vehicle **108** to safely stop at block **618**. This may include causing the vehicle **108** to maneuver out of traffic and/or into a position normally occupied by stationary vehicles. In some embodiments, the on-board computer **114** may further shut down the engine or locomotive components of the vehicle **108** and/or apply parking or locking devices to secure the vehicle **108** (e.g., a parking brake). If the vehicle operator is prepared to accept a transfer of vehicle operation from the one or more autonomous operation features, control of the one or more aspects of vehicle operation may be transferred to the vehicle operator at block **620**. In some embodiments, the transfer may involve an alert or warning in advance of the transfer of control, in order to provide the vehicle operator sufficient time to prepare to assume control of the vehicle **108**. In some embodiments, the warning period may depend upon the vehicle operating status, the environmental conditions, and/or the preparation level of the vehicle operator.

Thus, according to certain aspects, the operating status and/or configuration of autonomous operation features of an autonomous or semi-autonomous vehicle may be determined, such as via an on-board computer system or mobile device, and/or then directly or indirectly wirelessly communicated via data transmission from the vehicle computer system or mobile device to a remote server. An adjustment to one or more risk levels associated with operation of the autonomous or semi-autonomous vehicle may also be determined, and an auto insurance policy, premium, or discount may be adjusted based upon the adjustment to the risk levels and presented to the customer for their review and approval. As a result, insurance cost savings may be passed onto risk averse customers that opt into to a rewards program.

With the foregoing, a customer may opt into a rewards or other type of program, and willingly share their vehicle data with an insurance provider. In return, risk averse drivers and vehicle owners may receive discounts or insurance cost savings related to auto and other types of insurance from the insurance provider.

Diagnostic Checks

A. Abnormal Operating Condition

In one aspect, a computer-implemented method of enhancing vehicle operation may be provided. The method may include (1) determining, via one or more processors, that an autonomous or semi-autonomous functionality or technology of a vehicle is not operating correctly or optimally, and/or otherwise is unsafe (or in an unsafe operating condition); (2) generating, via the one or more processors, a warning to a driver of the vehicle indicating that the autonomous or semi-autonomous functionality or technology is not operating correctly or optimally, and/or otherwise is unsafe; and/or (3) preventing, via the one or more processors, the driver of the vehicle from engaging or switching on the autonomous or semi-autonomous functionality or technology that is not operating correctly or optimally, and/or otherwise is unsafe. The method may include additional, fewer, or alternate actions, including those discussed elsewhere herein.

For instance, the method may include (a) generating, via the one or more processors, a wireless communication indicating that the autonomous or semi-autonomous functionality or technology is not operating correctly or optimally, and/or otherwise is unsafe; (b) transmitting, via the one or more processors, the wireless communication to an insurance provider remote processor or server; and/or (c) adjusting or updating, at or via the insurance provider

remote processor or server, an insurance policy, premium, rate, rewards or points program, and/or discount for the vehicle based upon the autonomous or semi-autonomous functionality or technology not operating correctly or optimally, and/or otherwise being unsafe.

The method may include (i) receiving, at or via the insurance provider remote processor or server, via wireless communication from a mobile device of an insured that the autonomous or semi-autonomous functionality or technology that was not operating correctly or optimally was repaired and/or received maintenance, and/or is now operating correctly or optimally, and/or otherwise safely; and/or (ii) adjusting or updating, at or via the insurance provider remote processor or server, an insurance policy, premium, rate, rewards or points program, and/or discount for the vehicle based upon the autonomous or semi-autonomous functionality or technology operating correctly or optimally, and/or otherwise safely.

Determining, via the one or more processors, that the autonomous or semi-autonomous functionality or technology of the vehicle is not operating correctly or optimally may be based upon one or more pedestrians or traffic policeman being identified or recognized as being within a vicinity of the vehicle. Additionally or alternatively, via the one or more processors, that the autonomous or semi-autonomous functionality or technology of the vehicle is not operating correctly or optimally may be based upon a traffic light being identified or recognized within a vicinity of the vehicle as not working or operating correctly.

Determining, via the one or more processors, that the autonomous or semi-autonomous functionality or technology of the vehicle is not operating correctly or optimally may be based upon detecting a vehicle accident ahead or road construction ahead. Additionally or alternatively, determining, via the one or more processors, that the autonomous or semi-autonomous functionality or technology of the vehicle is not operating correctly or optimally may be done through, or via, an electric charging station and the vehicle may be an electric car or hybrid vehicle that has rechargeable batteries.

Determining, via the one or more processors, that the autonomous or semi-autonomous functionality or technology of the vehicle is not operating correctly or optimally may be based upon one or more diagnostic checks performed by the one or more processors. Additionally or alternatively, determining, via the one or more processors, that the autonomous or semi-autonomous functionality or technology of the vehicle is not operating correctly or optimally may be based upon one or more diagnostic checks performed by an electric charging station (such as for an electric or hybrid vehicle).

Determining, via the one or more processors, that the autonomous or semi-autonomous functionality or technology of the vehicle is not operating correctly or optimally may be based upon one or more diagnostic checks performed by a gas station or smart fuel pump. Additionally or alternatively, determining, via the one or more processors, that the autonomous or semi-autonomous functionality or technology of the vehicle is not operating correctly or optimally may be based upon determining or detecting that one or more vehicle-mounted sensors (such as on an exterior of the vehicle) are covered by snow, ice, mud, touch-up or new paint, dust, and/or dirt. Further, determining, via the one or more processors, that the autonomous or semi-autonomous functionality or technology of the vehicle is not operating correctly or optimally may also be based upon determining or detecting that software associated with the autonomous or semi-autonomous functionality or technology has been corrupted, infected with a virus, needs updating to a newer software version, and/or has been hacked into by a third party and/or has another security issue.

The method may further include (a) determining, at or via the insurance provider remote processor or server, that the insured or owner of the vehicle (and/or a computing device associated with the insured or owner) may not be configured to perform diagnostic checking (and/or does not have an automated means for diagnostic checking) of the vehicle's autonomous or semi-autonomous functionality or technology; (b) adjusting or generating, at or via the insurance provider remote processor or server, an insurance policy, premium, rate rewards or points program, and/or discount for the vehicle based upon the lack of diagnostic checking capabilities (and/or the lack of the automated means for diagnostic checking) of the vehicle's autonomous or semi-autonomous functionality or technology; (c) communicating, at or via the insurance provider remote processor or server, a message or wireless communication to the insured of updated or adjusted insurance policy, premium, rate rewards or points program, and/or discount for the vehicle based upon the lack of diagnostic checking capabilities (and/or the lack of the automated means for diagnostic checking) of the vehicle's autonomous or semi-autonomous functionality or technology; (d) generating, at or via the insurance provider remote processor or server, a recommendation to the insured or vehicle owner an automated means (and/or other means or functionality) for diagnostic checking of the vehicle's autonomous or semi-autonomous functionality or technology, and/or an associated insurance-related cost savings associated with implementing the recommendation; and/or (e) transmitting, via the insurance provider remote processor or server, the recommendation, such as via wireless communication, to a mobile device of the insured or vehicle owner to facilitate automated diagnostic checking of the vehicle's autonomous or semi-autonomous functionality or technology being implemented by the insured or vehicle owner.

B. Verifying Diagnostic Checking Capabilities

In one aspect, a computer-implemented method of adjusting insurance policies may be provided. The method may include (1) determining, at or via one or more processors (such as a local vehicle-mounted or home-mounted processor, and/or an insurance provider remote processor or server), that the insured or owner of the vehicle (and/or a computing device associated with the insured or owner) (i) may not be configured for diagnostic checking, (ii) may not have diagnostic checking capabilities or functionality, and/or (iii) may not have an automated means (and/or other means or functionality, i.e., not configured) for diagnostic checking of an autonomous or semi-autonomous functionality or technology of the vehicle; (2) adjusting or generating, at or via the one or more processors, an insurance policy, premium, rate rewards or points program, and/or discount for the vehicle based upon the lack of the diagnostic checking functionality or capabilities, and/or the lack of automated means (and/or other means or functionality) for diagnostic checking of the vehicle's autonomous or semi-autonomous functionality or technology; (3) communicating, at or via the one or more processors, a message or wireless communication to the insured of the updated or adjusted insurance policy, premium, rate rewards or points program, and/or discount for the vehicle based upon the lack of the diagnostic checking functionality or capabilities, and/or the lack of the automated means ((and/or other means or functionality) for diagnostic checking of the vehicle's

autonomous or semi-autonomous functionality or technology; (4) generating, at or via the one or more processors, a recommendation to the insured or vehicle owner one or more diagnostic checking systems or pieces of equipment, and/or an automated means (and/or other means or functionality) for diagnostic checking of the vehicle's autonomous or semi-autonomous functionality or technology, and/or an associated insurance-related cost savings associated with implementing the recommendation; and/or (5) transmitting, under the direction or control of the one or more processors, the recommendation, such as via wireless communication, to a mobile device of the insured or vehicle owner to facilitate automated diagnostic checking of the vehicle's autonomous or semi-autonomous functionality or technology being implemented by the insured or vehicle owner and/or providing an enticement to an insured to check performance or proper operation of autonomous or semi-autonomous technology and/or functionality. The method may include additional, fewer, or alternate actions, including those discussed elsewhere herein.

The method may include (a) receiving, at or via the insurance provider remote processor or server, via wireless communication from a mobile device of an insured that the insured or vehicle owner has acquired or implemented the automated means (and/or other means or functionality) for diagnostic checking of the vehicle's autonomous or semi-autonomous functionality or technology; and/or (b) adjusting or updating, at or via the insurance provider remote processor or server, an insurance policy, premium, rate, rewards or points program, and/or discount for the vehicle based upon the insured or vehicle owner having the diagnostic checking functionality. Determining, at or via one or more processors that the insured or owner of the vehicle does not have diagnostic checking functionality for the autonomous or semi-autonomous functionality or technology of the vehicle may be accomplished by, via, through communication with, and/or in conjunction with an electric charging station, device, and/or power cord.

C. Electric Charging Station

In one aspect, a computer-implemented method of enhancing vehicle operation may be provided. The method may include (1) determining, via an electric charging station and/or an electric charging station processor (such as for an electric or hybrid vehicle), that an autonomous or semi-autonomous functionality and/or technology of a vehicle is not operating correctly or optimally, and/or otherwise is unsafe, based upon one or more diagnostic checks performed by the electric charging station and/or the electric charging station processor; (2) generating, via the one or more processors (such as a processor associated with the vehicle or electric charging station), a warning to a driver of the vehicle indicating that the autonomous or semi-autonomous functionality and/or technology is not operating correctly or optimally, and/or otherwise is unsafe (or is in an unsafe operating condition); and/or (3) preventing, via the one or more processors (such as one or more processors associated with the vehicle and/or electric charging station), the driver of the vehicle from engaging or switching on the autonomous or semi-autonomous functionality and/or technology that is not operating correctly or optimally, and/or otherwise is unsafe, to facilitate vehicle accident prevention or safer vehicle operation. The method may include additional, fewer, or alternate actions, including those discussed elsewhere herein.

For instance, the method may further include (i) generating, via the one or more processors, a wireless communication indicating that the autonomous or semi-autonomous functionality and/or technology is not operating correctly or optimally, and/or otherwise is unsafe; (ii) transmitting, via the one or more processors, the wireless communication to an insurance provider remote processor or server; and/or (iii) adjusting or updating, at or via the insurance provider remote processor or server, an insurance policy, premium, rate, rewards or points program, and/or discount for the vehicle based upon the autonomous or semi-autonomous functionality and/or technology not operating correctly or optimally, and/or otherwise being unsafe.

The method may further include (a) receiving, at or via the insurance provider remote processor or server, via wireless communication from a mobile device of an insured that the autonomous or semi-autonomous functionality and/or technology that was not operating correctly or optimally was repaired and/or received maintenance, and/or is now operating correctly or optimally, and/or otherwise safely; and/or (b) adjusting or updating, at or via the insurance provider remote processor or server, an insurance policy, premium, rate, rewards or points program, and/or discount for the vehicle based upon the autonomous or semi-autonomous functionality and/or technology operating correctly or optimally, and/or otherwise safely.

D. Remote Processor or Server

In one aspect, a computer-implemented method of adjusting an insurance policy may be provided. The method may include (1) receiving, at or via the insurance provider remote processor or server, via wired or wireless communication an indication that an autonomous or semi-autonomous functionality and/or technology is operating correctly or optimally, and/or received periodic maintenance or a periodic safety certification; (2) generating, adjusting, or updating, at or via the insurance provider remote processor or server, an insurance policy, premium, rate, rewards or points program, and/or discount for the vehicle based upon the autonomous or semi-autonomous functionality and/or technology operating correctly or optimally, and/or receiving periodic maintenance or periodic safety certification; and/or (3) generating and transmitting, at or from the insurance provider remote processor server, to a mobile device of an insured via wireless communication a notification of the insurance policy, premium, rate, rewards or points program, and/or discount that has been generated, adjusted, or updated based upon the autonomous or semi-autonomous functionality and/or technology operating correctly or optimally, and/or receiving periodic maintenance or periodic safety certification. The method may include additional, fewer, or alternate actions, including those discussed elsewhere herein.

The method may include (i) receiving, at or via the insurance provider remote processor or server, via wired or wireless communication an indication that the autonomous or semi-autonomous functionality and/or technology is not operating correctly or optimally, and/or has not received periodic maintenance or a periodic safety certification; (ii) generating, adjusting, or updating, at or via the insurance provider remote processor or server, an insurance policy, premium, rate, rewards or points program, and/or discount for the vehicle based upon the autonomous or semi-autonomous functionality and/or technology not operating correctly or optimally, and/or not receiving periodic maintenance or periodic safety certification; and/or (iii) generating and transmitting, at or from the insurance provider remote processor server, to the mobile device of the insured via wireless communication a notification of the insurance policy, premium, rate, rewards or points program, and/or discount that has been generated, adjusted, or updated based upon the autonomous or semi-autonomous functionality

and/or technology not operating correctly or optimally, and/or not receiving periodic maintenance or periodic safety certification.

Exemplary Methods for Control Hand-Off

FIGS. **7**A-B illustrate flow diagrams depicting exemplary vehicle operation hand-off methods **700** that may be used to transfer operation of the vehicle **108** from one or more autonomous operation features to the vehicle operator. FIG. **7**A illustrates hand-off of control when determined necessary based upon heightened risk levels associated with operation by the one or more autonomous operation features under the environmental conditions. FIG. **7**B illustrates hand-off of control when requested by the vehicle operator while one or more autonomous operation features are performing vehicle control tasks. The methods **700** illustrated in FIGS. **7**A and **7**B may be combined or separately implemented in various embodiments. Although the exemplary embodiment is described as primarily performed by the on-board computer **114**, the exemplary method **700** may be implemented by the mobile device **110**, the on-board computer **114**, the server **140**, and/or a combination thereof.

Exemplary vehicle operation hand-off method **700** may be implemented at any time when one or more autonomous operation features are controlling part or all of the operation of the vehicle **108**. The method **700** may begin by identifying the vehicle operator at block **702** and receiving a vehicle operator profile for the vehicle operator at block **704**. At block **706**, the operating data (including, in some embodiments, sensor data and external data) may be received and used to monitor operation of the vehicle **108**. In some embodiments, a request to disable one or more autonomous operation features may be received from the vehicle operator at block **732**. Autonomous risk levels associated with operation of the vehicle **108** by the autonomous operation features and operator risk levels associated with operation of the vehicle **108** by the vehicle operator may be determined at block **708** and **710**, respectively. The determined risk levels may be used at block **712** to determine whether to disable one or more autonomous operation features. In some embodiments, the determination of whether to disable one or more autonomous operation features may further be based upon the preparedness level of the vehicle operator determined at block **716**.

When it is determined to disable one or more autonomous operation features at block **714**, the method **700** may transfer control to the vehicle operator. In some embodiments, this may include determining whether the vehicle operator is able to safely assume control by determining whether the vehicle operator's preparedness level is above a transfer threshold level at block **718**. If so, an alert may be presented to the vehicle operator at block **720** to notify the vehicle operator of the transfer of control from the one or more autonomous operation features before transferring operation at block **722**. If the vehicle operator's preparedness level is determined to be below the transfer threshold but above a minimum threshold at block **724**, an alert may be presented at block **730** to attempt to prepare the vehicle operator to assume control if the risk levels associated with continued operation by the autonomous operation features do not exceed a critical risk threshold at block **726**. Once the alert is presented to the vehicle operator at block **730**, the vehicle operator's preparedness level may be determined again at block **716** and evaluated at block **718**. If the risk levels exceed the critical threshold at block **726** or the vehicle operator's preparedness level is below the minimum threshold at block **724**, the vehicle **108** may discontinue operation at block **728** and the method **700** may end.

When it is determined not to disable the one or more autonomous operation features at block **714**, the method **700** may continue to monitor the operating data at block **706**. If the vehicle operator requested that one or more autonomous operation features be disabled, the method **700** may present an alert at block **734** to notify the vehicle operator that disabling the autonomous operation features is not recommended. In some embodiments, options to override the determination not to disable the autonomous operation features may be presented to the vehicle operator at block **736**, which the vehicle operator may select at block **738**. If the vehicle operator is determined at block **740** to have not selected an option to override the determination, the method **700** may continue to monitor operation data at block **706**. If the vehicle operator is determined at block **740** to have selected an option to override the determination, control of operation may be transferred from the one or more autonomous operation features to the vehicle operator. In some embodiments, one or more risk levels associated with disabling the autonomous operation features may be determined at block **742**. If the risk levels are determined to be below a critical threshold at block **744**, control may be transferred to the vehicle operator. If the risk levels meet or exceed the critical threshold at block **744**, the vehicle **108** may instead discontinue operation at block **728** and the method **700** may end.

Exemplary Methods for Vehicle Operator Identification

FIG. **8** illustrates a flow diagram depicting an exemplary vehicle operator identification method **800** that may be used to adjust an insurance policy associated with the vehicle operator or vehicle **108**. The exemplary method **800** may begin with receipt of a request to identify the vehicle operator of the vehicle at block **802**. At blocks **804-810**, the vehicle operator may be identified by sensor data or received indications of identity, such as from a mobile device **110**. Once the identity of the vehicle operator has been determined (or cannot be determined), the method **800** may further determine whether the vehicle operator is authorized to operate the vehicle **108** at block **812**. If the vehicle operator is not authorized, an alert may be generated and vehicle operations may be limited at blocks **814-816**. If the vehicle operator is authorized, a vehicle operator profile associated with the vehicle operator may be obtained at block **818**, and/or an insurance policy associated with the vehicle **108** or the vehicle operator may be identified at block **820**. During vehicle operation, operating data of the vehicle **108** may be received and used to adjust the vehicle operator profile and the insurance policy at blocks **822-826**. When vehicle operation has been determined to be complete at block **828**, the method **800** may terminate. Although the exemplary embodiment is described as primarily performed by the on-board computer **114**, the method **800** may be implemented by the mobile device **110**, the on-board computer **114**, the server **140**, and/or a combination thereof.

Exemplary Methods for Monitoring Use by Vehicle Operators

FIG. **9** illustrates a flow diagram depicting an exemplary vehicle operator use monitoring and evaluation method **900** that may be used to determine skill or risk levels associated with a vehicle operator or adjust an insurance policy. The exemplary method **900** may begin with determining the identity of the vehicle operator at block **902**. If a vehicle operator profile can be found for the vehicle operator at block **904**, the vehicle operator profile may be accessed at block **912**. If no vehicle operator profile can be found for the vehicle operator at block **904**, a vehicle operator profile may be created based upon vehicle operations and stored for

future use at blocks **906-910**. The newly created vehicle operator profile may be generated at block **908** with vehicle operating data from only a short time period or may include only information regarding configuration and/or settings of the autonomous operation features, in which case operation of the vehicle may continue after the vehicle operator profile is generated. If operation is determined to be ongoing at block **914**, vehicle operation may be monitored and the vehicle operator profile may be updated at blocks **916-924**. In some embodiments, the vehicle operator may be able to select an option of a mode for vehicle operation. If such a mode selection is detected at block **916**, the settings of the autonomous operation features may be adjusted at block **918**. Vehicle operation may be monitored at block **920** based upon received operating data, which may be used to determine adjustments to the vehicle operator profile at block **922**. The adjustments may then be used to update the vehicle operator profile at block **924**. When operation is complete, the method **900** may determine risk or skill levels associated with the vehicle operator at blocks **926-928**. These determined levels may be used at blocks **930-934** to generate a report or adjust an insurance policy. Although the exemplary embodiment is described as primarily performed by the on-board computer **114**, the method **900** may be implemented by the mobile device **110**, the on-board computer **114**, the server **140**, and/or a combination thereof.

The vehicle operator profile may include information regarding the vehicle operator, including an operating style of the vehicle operation. The operating style may include information regarding frequency with which the vehicle operator operates the vehicle manually, uses one or more autonomous operation features, selects one or more settings for the autonomous operation features, and/or takes control from the autonomous operation features under various conditions. The operating style may further include information regarding observed control decisions made by the vehicle operator, such as rate of acceleration, frequency of lane changes, use of vehicle signaling devices, distances maintained from other vehicles or pedestrians, and/or other aspects of vehicle operation. For example, vehicle operator decisions regarding how long to stop at a stop sign or when to begin accelerating from such a stop in the presence of other vehicles or pedestrians may be included in the operating style. The vehicle operator profile may further include information regarding vehicle operator skill levels, as described below. In some embodiments, the vehicle operator profile may include a risk profile or information regarding one or more risk levels associated with operation of the vehicle by the vehicle operator. Such risk levels may be associated with particular configurations or settings of autonomous operation features and/or particular conditions of the vehicle environment (e.g., time of day, traffic levels, weather, etc.).

In further embodiments, the vehicle operator profile may include information regarding attentiveness of the vehicle operator while the vehicle is being autonomously operated. For example, some vehicle operators may typically pay attention to road conditions while a vehicle is operating in a fully autonomous mode, while other vehicle operators may typically engage in other activities. In some embodiments, the vehicle operator profile may include information regarding decisions made by the vehicle operator regarding actions that would result in adjustments to costs associated with an insurance policy (e.g., accepting or rejecting recommendations to optimize autonomous operation feature use to lower insurance costs).

The vehicle operator profile or vehicle operator behavior data may indicate how well the specific vehicle operator drives in rain, snow, sleet, ice, heavy traffic, road construction, stop-and-go traffic, bumper-to-bumper traffic, country or rural traffic, and/or city or downtown street traffic. The current environment (or condition) may include or be rain, ice, snow, fog, heavy traffic, bumper-to-bumper traffic, road construction, city traffic, country or rural traffic, and/or may be associated with a type of road, such as a two-lane or four-lane highway, and/or downtown city street or other street having several traffic lights.

The operating mode may include one or more settings or configurations of autonomous operation features. For example, operating modes may include adjustments to settings that cause the autonomous operation features to control the vehicle **108** in a more or less aggressive manner with respect to speed, distance from other vehicles, distance from pedestrians, etc. As an example, the settings may cause the vehicle **108** to remain at least a minimum distance from other vehicles (which may depend upon vehicle speed or road conditions), and/or modes may set different minimum distances. Examples of modes may include a city driving mode, a highway driving mode, a rush operation mode, a smooth operation mode, a cautious mode, and/or a user-defined mode.

In some embodiments, an operating mode may be based upon the vehicle operator profile. For example, the vehicle profile may include information indicating an operating style of the vehicle operator based upon observations of control commands by the vehicle operator, which profile information may be used to generate an operation mode that mimics the style of the vehicle operator. Thus, if the vehicle operator typically stops at stop signs for a particular length of time, the operating style may mimic this length of time to provide an experience that seems normal or customary to the vehicle operator.

Exemplary Methods for Comparing Costs

FIG. **10** illustrates a flow diagram depicting an exemplary cost comparison method **1000** that may be used to compare costs associated with vehicles, some of which may include autonomous operation features. The exemplary method **1000** may begin by receiving a command to generate a comparison report between two or more alternative transportation options for an insurance customer or other user. The method **1000** may further receive information regarding one or more vehicle operators may be received at block **1004** and/or information regarding a first vehicle and a second vehicle at block **1006**. The first and second vehicles may differ in autonomous operation features or other characteristics. Cost levels associated with obtaining, operating, and insuring the first vehicle and the second vehicle may be determined at block **1008**, and/or a recommendation based upon the costs may be determined at block **1010**. A report including the costs levels, recommendation, and/or related information may be generated at block **1012** and presented to the insurance customer or other user at block **1014**. Additionally, one or more options may be presented along with the report at block **1016**, such as options to perform another comparison or present additional information. If an option is selected at block **1018**, the corresponding action may be performed at block **1020**. Although the exemplary embodiment is described as primarily performed by the server **140**, the method **1000** may be implemented by the mobile device **110**, the on-board computer **114**, the server **140**, and/or a combination thereof.

Exemplary Methods for Updating Autonomous Operation Features

FIG. **11** illustrates a flow diagram depicting an exemplary autonomous operation feature update method **1100** that may be used to identify, recommend, and/or install updates to autonomous operation features in appropriate autonomous or semi-autonomous vehicles. In some embodiments, the updates may include software version updates. The exemplary method **1100** may begin with the receipt of an indication of an available update to an autonomous operation feature at block **1102**, which may include an update to a version of autonomous operation feature software. A plurality of vehicles having the autonomous operation feature may be identified at block **1104** based upon recorded features or communication with the plurality of vehicles. A change in one or more risk levels associated with the update may be determined for some or all of the identified vehicles at block **1106**, and/or a change in a cost associated with one or more of the plurality of vehicles may be determined at block **1108**. If the determined changes in risk levels or insurance costs meet certain criteria for installing the update at block **1110**, a notification regarding the update may be presented to an insurance customer at block **1112**. The notification may further include information regarding costs associated with the update. If an indication of acceptance of the update is received at block **1114**, the update may be installed at block **1116**. Although the exemplary embodiment is described as primarily performed by the server **140**, the method **1100** may be implemented by the mobile device **110**, the on-board computer **114**, the server **140**, and/or a combination thereof.

Exemplary Methods for Repair of an Autonomous Vehicle

FIG. **12** illustrates a flow diagram depicting an exemplary autonomous vehicle repair method **1200** that may be used to determine repairs needed as a result of damage to an autonomous or semi-autonomous vehicle. The exemplary method **1200** may begin by receiving an indication of damage to the vehicle **108** at block **1202** and/or receiving operating data associated with the vehicle **108** at block **1204**. Based upon the operating data, the type and extent of damage to the vehicle **108** may be determined at block **1206**, and/or repairs needed to fix the damage may be determined at block **1208**. Additionally, one or more expected costs (or ranges of costs) for the repairs may be estimated at block **1210**. An insurance policy associated with the vehicle **108** may be identified, and/or a maximum payment for the repairs may be determined at block **1212** based upon the estimated costs and the insurance policy. Information regarding the estimated cost or costs and the maximum payment under the insurance policy may be presented to an insurance customer at block **1214**. Additionally, options associated with the repairs may be presented to the insurance customer at block **1216**, and/or a selection of one or more options may be received at block **1218**. An insurer or other party may cause a payment to be made at block **1220** to the insurance customer, beneficiary, or other relevant party based upon the estimated costs of repairing the damage and the selected option. Although the exemplary embodiment is described as primarily performed by the server **140**, the method **1200** may be implemented by the mobile device **110**, the on-board computer **114**, the server **140**, and/or a combination thereof.

Exemplary Methods for Infrastructure Communications

FIG. **13** illustrates a flow diagram depicting an exemplary infrastructure communication method **1300** that may be used to detect and communicate information regarding infrastructure components to vehicles. The exemplary method **1300** may begin with the infrastructure communication device **124** receiving information regarding the infrastructure component **126** from one or more sensors at block **1302**. The information may be used at block **1304** to determine a message regarding the infrastructure component **126**. In some embodiments, the message may be augmented at block **1306** by information associated with a sponsor or other party affiliated with the infrastructure communication device **124**. The message may then be encoded at block **1308** and transmitted at block **1310**, which may cause the message to be presented to the vehicle operator of the vehicle **108** at block **1312**. Although the exemplary embodiment describes one infrastructure communication device **124** communicating with one vehicle **108**, it should be understood than any number of infrastructure communication devices **124** may communicate with any number of vehicles **108**.

Updating Insurance Policies

In one aspect, a computer-implemented method of updating an insurance policy may be provided. The method may include (a) gathering or receiving, at or via one or more processors (such as either a local processor associated with a smart vehicle and/or a remote processor or server associated with an insurance provider), data indicative of (1) vehicle usage, and/or (2) vehicle drivers for an insured vehicle; (b) analyzing the data, via the one or more processors, to determine (i) an amount and/or (ii) type of vehicle usage for each vehicle driver; (c) based upon the amount of vehicle usage for each vehicle driver and/or the type of vehicle usage for each vehicle driver, via the one or more processors, updating or adjusting an insurance policy (such as a premium, rate, rewards or points program, discount, etc.) for the insured vehicle; (d) transmitting, under the direction or control of the one or more processors, the updated or adjusted insurance policy (or otherwise causing the updated or adjusted insurance policy to be presented or displayed to the insured) to a mobile device of the insured for their review, modification, and/or approval; and/or (e) receiving, at or via the one or more processors, from the mobile device of the insured (such as via wireless communication) an approval of the updated or adjusted insurance policy of the insured to facilitate more accurate insurance pricing and/or insurance cost savings. The method may include additional, fewer, or alternate actions, including those discussed elsewhere herein.

For instance, the amount of vehicle usage may include an amount of time and/or miles that each individual vehicle driver drives the vehicle. The type of vehicle usage may include characterizing various periods of driving and/or trips as city driving; country driving; freeway or highway driving city street driving; heavy traffic or congested traffic driving; driving in good weather; driving in hazardous weather; rush hour driving; and/or time-of-day driving.

The vehicle drivers may be identified from mobile device signature; seat pressure sensors and weight; image recognition techniques performed upon images of the driver; and/or biometric devices (such as heart beat or rate characteristics; voice print; and/or thumb or finger prints).

Biometric Device Data

In one aspect, a computer-implemented method of updating an insurance policy using biometric device data may be provided. The method may include (a) gathering or receiving, at or via one or more processors (such as either a local processor associated with a smart vehicle and/or a remote processor or server associated with an insurance provider), data from a biometric device indicative of whom is driving an insured vehicle; (b) gathering or receiving, at or via the one or more processors, data indicative of vehicle usage for a single trip and/or driving or driver behavior during the

single trip; (c) updating or adjusting, at or via the one or more processors, an insurance policy (such as a premium, rate, rewards or points program, discount, etc.) for the insured vehicle based upon (1) whom is driving the insured vehicle (and/or his or her driving profile or score), and/or (2) the data indicative of vehicle usage for the single trip and/or the driving or driver behavior exhibited during the single trip to facilitate more accurate risk assessment and/or cost savings to the insured. The method may include additional, fewer, or alternate actions, including those discussed elsewhere herein. For instance, the biometric device may verify an identity of the driver based upon heartbeat, facial recognition techniques, and/or mood.

In another aspect, a computer-implemented method of updating an insurance policy may be provided. The method may include (1) gathering or receiving, at or via one or more processors (such as either a local processor associated with a smart vehicle and/or a remote processor or server associated with an insurance provider), data from a biometric device identifying a driver of an insured vehicle; (2) gathering or receiving, at or via the one or more processors, data indicative of driving or driver behavior for the driver identified from the biometric device data; (3) generating, at or via the one or more processors, a usage-based insurance policy for the insured vehicle based upon (i) the identity of the driver determined from the biometric device data, and/or (ii) the data indicative of driving or driver behavior exhibited by the driver to facilitate more accurate risk assessment and/or provide cost savings to the insured. The method may include additional, fewer, or alternate actions, including those discussed elsewhere herein.

Software Versions

In one aspect, a computer-implemented method of updating an insurance policy may be provided. The method may include (1) gathering or receiving, at or via one or more processors (such as either a local processor associated with a smart vehicle and/or a remote processor or server associated with an insurance provider), data indicative of a software version installed on or in an insured vehicle that is associated with an autonomous or semi-autonomous functionality; (2) determining, at or via the one or more processors, that the software version is out of date or a (safer or less risky) new software version exists and/or is available for download; (3) generating, at or via the one or more processors, a recommendation to an insured to update or upgrade to the new software version, and transmitting that recommendation under the direction or control of the one or more processors to a mobile device or insured vehicle controller (such as via wireless communication or data transmission); (4) determining, at or via the one or more processors, (or receiving an indication) that the insured has updated or upgraded to the new software version associated with the autonomous or semi-autonomous functionality; and/or (5) updating or adjusting, at or via the one or more processors, an insurance policy (such as a premium, rate, rewards or points program, discount, etc.) for the insured vehicle based upon the insured updating or upgrading to the new software version associated with an autonomous or semi-autonomous functionality to facilitate providing cost savings to the insured and/or enticing drivers to update vehicle software to most recent versions and/or versions that perform better. The method may include additional, fewer, or alternate actions, including those discussed elsewhere herein.

Exemplary Autonomous Vehicle Insurance Risk and Price Determination Methods

Risk profiles or risk levels associated with one or more autonomous operation features determined above may be further used to determine risk categories or premiums for vehicle insurance policies covering autonomous vehicles. In some embodiments or under some conditions, the vehicle **108** may be a fully autonomous vehicle operating without a vehicle operator's input or presence. In other embodiments or under other conditions, the vehicle operator may control the vehicle **108** with or without the assistance of the vehicle's autonomous operation features. For example, the vehicle may be fully autonomous only above a minimum speed threshold or may require the vehicle operator to control the vehicle during periods of heavy precipitation. Alternatively, the autonomous vehicle may perform all relevant control functions using the autonomous operation features under all ordinary operating conditions. In still further embodiments, the vehicle **108** may operate in either a fully or a partially autonomous state, while receiving or transmitting autonomous communications.

Where the vehicle **108** operates only under fully autonomous control by the autonomous operation features under ordinary operating conditions or where control by a vehicle operator may be disregarded for insurance risk and price determination, the risk level or premium associated with an insurance policy covering the autonomous vehicle may be determined based upon the risks associated with the autonomous operation features, without reference to risks associated with the vehicle operator. Where the vehicle **108** may be operated manually under some conditions, the risk level or premium associated with an insurance policy covering the autonomous vehicle may be based upon risks associated with both the autonomous operation features and the vehicle operator performing manual vehicle operation. Where the vehicle **108** may be operated with the assistance of autonomous communications features, the risk level or premium associated with an insurance policy covering the autonomous vehicle may be determined based in part upon a determination of the expected use of autonomous communication features by external sources in the relevant environment of the vehicle **108** during operation of the vehicle **108**.

Data Acquisition

In one aspect, the present embodiments may relate to data acquisition. Data may be gathered via devices employing wireless communication technology, such as Bluetooth or other IEEE communication standards. In one embodiment, a Bluetooth enabled smartphone or mobile device, and/or an in-dash smart and/or communications device may collect data. The data associated with the vehicle, and/or vehicle or driver performance, that is gathered or collected at, or on, the vehicle may be wirelessly transmitted to a remote processor or server, such as a remote processor or server associated with an insurance provider. The mobile device **110** may receive the data from the on-board computer **114** or the sensors **120**, and may transmit the received data to the server **140** via the network **130**, and the data may be stored in the database **146**. In some embodiments, the transmitted data may include real-time sensor data, a summary of the sensor data, processed sensor data, operating data, environmental data, communication data, or a log such data.

Data may be generated by autonomous or semi-autonomous vehicles and/or vehicle mounted sensors (or smart sensors), and then collected by vehicle mounted equipment or processors, including Bluetooth devices, and/or an insurance provider remote processor or server. The data gathered may be used to analyze vehicle decision making. A processor may be configured to generate data on what an autonomous or semi-autonomous vehicle would have done in a given situation had the driver not taken over manual control/

driving of the vehicle or alternative control actions not taken by the autonomous or semi-autonomous operation features. This type of control decision data (related to vehicle decision making) may be useful with respect to analyzing hypothetical situations.

In one embodiment, an application, or other computer or processor instructions, may interact with a vehicle to receive and/or retrieve data from autonomous or semi-autonomous processors and sensors. The data retrieved may be related to radar, cameras, sensor output, computer instructions or application output. Other data related to a smart vehicle controller, car navigation unit information (including route history information and typical routes taken), GPS unit information, odometer and/or speedometer information, and smart equipment data may also be gathered or collected. The application and/or other computer instructions may be associated with an insurance provider remote processor or server.

The control decision data may further include information regarding control decisions generated by one or more autonomous operation features within the vehicle. The operating data and control decision data gathered, collected, and/or acquired may facilitate remote evaluation and/or analysis of what the autonomous or semi-autonomous vehicle was "trying to do" (brake, slow, turn, accelerate, etc.) during operation, as well as what the vehicle actually did do. The data may reveal decisions, and the appropriateness thereof, made by the artificial intelligence or computer instructions associated with one or more autonomous or semi-autonomous vehicle technologies, functionalities, systems, and/or pieces of equipment. The data may include information related to what the vehicle would have done in a situation if the driver had not taken over (beginning manual vehicle control). Such data may include both the control actions taken by the vehicle and control actions the autonomous or semi-autonomous operation features would have caused the vehicle to take. Thus, in some embodiments, the control decisions data may include information regarding control decisions not implemented by the autonomous operation features to control the vehicle. This may occur when an autonomous operation feature generates a control decision or associated control signal, but the control decision or signal is prevented from controlling the vehicle because the autonomous feature or function is disabled, the control decision is overridden by the vehicle operator, the control signal would conflict with another control signal generated by another autonomous operation feature, a more preferred control decision is generated, and/or an error occurs in the on-board computer **114** or the control system of the vehicle.

For example, a vehicle operator may disable or constrain the operation of some or all autonomous operation features, such as where the vehicle is operated manually or semi-autonomously. The disabled or constrained autonomous operation features may, however, continue to receive sensor data and generate control decision data that is not implemented. Similarly, one or more autonomous operation features may generate more than one control decision in a relevant period of time as alternative control decisions. Some of these alternative control decisions may not be selected by the autonomous operation feature or an autonomous operation control system to control the vehicle. For example, such alternative control decisions may be generated based upon different sets of sensor or communication data from different sensors **120** or include or excluding autonomous communication data. As another example, the alternative control decisions may be generated faster than they can be implemented by the control system of the vehicle, thus preventing all control decisions from being implemented.

In addition to control decision data, other information regarding the vehicle, the vehicle environment, or vehicle operation may be collected, generated, transmitted, received, requested, stored, and/or recorded in connection with the control decision data. Additional operating data including sensor data from the sensors **120**, autonomous communication data from the communication component **122** or the communication unit **220**, location data, environmental data, time data, settings data, configuration data, and/or other relevant data may be associated with the control decision data. In some embodiments, a database or log may store the control decision data and associated information. In further embodiments, the entries in such log or database may include a timestamp indicating the date, time, location, vehicle environment, vehicle condition, autonomous operation feature settings, and/or autonomous operation feature configuration information associated with each entry. Such data may facilitate evaluating the autonomous or semi-autonomous technology, functionality, system, and/or equipment in hypothetical situations and/or may be used to calculate risk, and in turn adjust insurance policies, premiums, discounts, etc.

Autonomous Vehicle Insurance Policies

The disclosure herein relates to insurance policies for vehicles with autonomous operation features. Accordingly, as used herein, the term "vehicle" may refer to any of a number of motorized transportation devices. A vehicle may be a car, truck, bus, train, boat, plane, motorcycle, snowmobile, other personal transport devices, etc. Also as used herein, an "autonomous operation feature" of a vehicle means a hardware or software component or system operating within the vehicle to control an aspect of vehicle operation without direct input from a vehicle operator once the autonomous operation feature is enabled or engaged. The term "autonomous vehicle" means a vehicle including at least one autonomous operation feature. A "fully autonomous vehicle" means a vehicle with one or more autonomous operation features capable of operating the vehicle in the absence of or without operating input from a vehicle operator.

Additionally, the term "insurance policy" or "vehicle insurance policy," as used herein, generally refers to a contract between an insurer and an insured. In exchange for payments from the insured, the insurer pays for damages to the insured which are caused by covered perils, acts, or events as specified by the language of the insurance policy. The payments from the insured are generally referred to as "premiums," and typically are paid by or on behalf of the insured upon purchase of the insurance policy or over time at periodic intervals. Although insurance policy premiums are typically associated with an insurance policy covering a specified period of time, they may likewise be associated with other measures of a duration of an insurance policy, such as a specified distance traveled or a specified number of trips. The amount of the damages payment is generally referred to as a "coverage amount" or a "face amount" of the insurance policy. An insurance policy may remain (or have a status or state of) "in-force" while premium payments are made during the term or length of coverage of the policy as indicated in the policy. An insurance policy may "lapse" (or have a status or state of "lapsed"), for example, when the parameters of the insurance policy have expired, when premium payments are not being paid, when a cash value of

a policy falls below an amount specified in the policy, or if the insured or the insurer cancels the policy.

The terms "insurer," "insuring party," and "insurance provider" are used interchangeably herein to generally refer to a party or entity (e.g., a business or other organizational entity) that provides insurance products, e.g., by offering and issuing insurance policies. Typically, but not necessarily, an insurance provider may be an insurance company. The terms "insured," "insured party," "policyholder," and "customer" are used interchangeably herein to refer to a person, party, or entity (e.g., a business or other organizational entity) that is covered by the insurance policy, e.g., whose insured article or entity is covered by the policy. Typically, a person or customer (or an agent of the person or customer) of an insurance provider fills out an application for an insurance policy. In some cases, the data for an application may be automatically determined or already associated with a potential customer. The application may undergo underwriting to assess the eligibility of the party and/or desired insured article or entity to be covered by the insurance policy, and, in some cases, to determine any specific terms or conditions that are to be associated with the insurance policy, e.g., amount of the premium, riders or exclusions, waivers, and the like. Upon approval by underwriting, acceptance of the applicant to the terms or conditions, and payment of the initial premium, the insurance policy may be in-force, (i.e., the policyholder is enrolled).

Although the exemplary embodiments discussed herein relate to automobile insurance policies, it should be appreciated that an insurance provider may offer or provide one or more different types of insurance policies. Other types of insurance policies may include, for example, commercial automobile insurance, inland marine and mobile property insurance, ocean marine insurance, boat insurance, motorcycle insurance, farm vehicle insurance, aircraft or aviation insurance, and other types of insurance products.

Other Matters

Although the text herein sets forth a detailed description of numerous different embodiments, it should be understood that the legal scope of the invention is defined by the words of the claims set forth at the end of this patent. The detailed description is to be construed as exemplary only and does not describe every possible embodiment, as describing every possible embodiment would be impractical, if not impossible. One could implement numerous alternate embodiments, using either current technology or technology developed after the filing date of this patent, which would still fall within the scope of the claims.

In one aspect, autonomous or semi-autonomous vehicle; telematics; interconnected home; mobile device; and/or other data, including that discussed elsewhere herein, may be collected or received by an insurance provider remote server, such as via direct or indirect wireless communication or data transmission, after a customer affirmatively consents or otherwise opts into an insurance discount, reward, or other program. The insurance provider may then analyze the data received with the customer's permission to provide benefits to the customer. As a result, risk averse customers may receive insurance discounts or other insurance cost savings based upon data that reflects low risk behavior and/or technology that mitigates or prevents risk to (i) insured assets, such as autonomous or semi-autonomous vehicles, and/or (ii) autonomous or semi-autonomous vehicle operators or passengers.

It should also be understood that, unless a term is expressly defined in this patent using the sentence "As used herein, the term ' ' is hereby defined to mean . . . " or a similar sentence, there is no intent to limit the meaning of that term, either expressly or by implication, beyond its plain or ordinary meaning, and such term should not be interpreted to be limited in scope based upon any statement made in any section of this patent (other than the language of the claims). To the extent that any term recited in the claims at the end of this disclosure is referred to in this disclosure in a manner consistent with a single meaning, that is done for sake of clarity only so as to not confuse the reader, and it is not intended that such claim term be limited, by implication or otherwise, to that single meaning. Finally, unless a claim element is defined by reciting the word "means" and a function without the recital of any structure, it is not intended that the scope of any claim element be interpreted based upon the application of 35 U.S.C. § 112(f).

Throughout this specification, plural instances may implement components, operations, or structures described as a single instance. Although individual operations of one or more methods are illustrated and described as separate operations, one or more of the individual operations may be performed concurrently, and nothing requires that the operations be performed in the order illustrated. Structures and functionality presented as separate components in example configurations may be implemented as a combined structure or component. Similarly, structures and functionality presented as a single component may be implemented as separate components. These and other variations, modifications, additions, and improvements fall within the scope of the subject matter herein.

Additionally, certain embodiments are described herein as including logic or a number of routines, subroutines, applications, or instructions. These may constitute either software (code embodied on a non-transitory, tangible machine-readable medium) or hardware. In hardware, the routines, etc., are tangible units capable of performing certain operations and may be configured or arranged in a certain manner. In example embodiments, one or more computer systems (e.g., a standalone, client or server computer system) or one or more hardware modules of a computer system (e.g., a processor or a group of processors) may be configured by software (e.g., an application or application portion) as a hardware module that operates to perform certain operations as described herein.

In various embodiments, a hardware module may be implemented mechanically or electronically. For example, a hardware module may comprise dedicated circuitry or logic that is permanently configured (e.g., as a special-purpose processor, such as a field programmable gate array (FPGA) or an application-specific integrated circuit (ASIC) to perform certain operations. A hardware module may also comprise programmable logic or circuitry (e.g., as encompassed within a general-purpose processor or other programmable processor) that is temporarily configured by software to perform certain operations. It will be appreciated that the decision to implement a hardware module mechanically, in dedicated and permanently configured circuitry, or in temporarily configured circuitry (e.g., configured by software) may be driven by cost and time considerations.

Accordingly, the term "hardware" should be understood to encompass a tangible entity, be that an entity that is physically constructed, permanently configured (e.g., hardwired), or temporarily configured (e.g., programmed) to operate in a certain manner or to perform certain operations described herein. Considering embodiments in which hardware is temporarily configured (e.g., programmed), the hardware need not be configured or instantiated at any one instance in time. Software may accordingly configure a

processor, for example, to constitute a particular hardware module at one instance of time and to constitute a different hardware module at a different instance of time. Hardware elements can provide information to, and receive information from, other hardware elements. Accordingly, the described hardware may be regarded as being communicatively coupled.

The various operations of example methods described herein may be performed, at least partially, by one or more processors that are temporarily configured (e.g., by software) or permanently configured to perform the relevant operations. Whether temporarily or permanently configured, such processors may constitute processor-implemented modules that operate to perform one or more operations or functions. The modules referred to herein may, in some example embodiments, comprise processor-implemented modules. Similarly, the methods or routines described herein may be at least partially processor-implemented. The performance of certain of the operations may be distributed among the one or more processors, not only residing within a single machine, but deployed across a number of machines. In some example embodiments, the processor or processors may be located in a single location (e.g., within a home environment, an office environment or as a server farm), while in other embodiments the processors may be distributed across a number of locations.

Unless specifically stated otherwise, discussions herein using words such as "processing," "computing," "calculating," "determining," "presenting," "displaying," or the like may refer to actions or processes of a machine (e.g., a computer) that manipulates or transforms data represented as physical (e.g., electronic, magnetic, or optical) quantities within one or more memories (e.g., volatile memory, non-volatile memory, or a combination thereof), registers, or other machine components that receive, store, transmit, or display information. As used herein any reference to "one embodiment" or "an embodiment" means that a particular element, feature, structure, or characteristic described in connection with the embodiment may be included in at least one embodiment. The appearances of the phrase "in one embodiment" in various places in the specification are not necessarily all referring to the same embodiment. Some embodiments may be described using the expression "coupled" and "connected" along with their derivatives. For example, some embodiments may be described using the term "coupled" to indicate that two or more elements are in direct physical or electrical contact. The term "coupled," however, may also mean that two or more elements are not in direct contact with each other, but yet still co-operate or interact with each other. The embodiments are not limited in this context.

As used herein, the terms "comprises," "comprising," "includes," "including," "has," "having" or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a process, method, article, or apparatus that comprises a list of elements is not necessarily limited to only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. Further, unless expressly stated to the contrary, "or" refers to an inclusive or and not to an exclusive or. In addition, use of the "a" or "an" are employed to describe elements and components of the embodiments herein. This is done merely for convenience and to give a general sense of the description. In this description, and the claims that follow, the singular also includes the plural unless it is obvious that it is meant otherwise. This detailed description is to be construed as exemplary only and does not describe every possible embodiment, as describing every possible embodiment would be impractical, if not impossible. One could implement numerous alternate embodiments, using either current technology or technology developed after the filing date of this application.

Upon reading this disclosure, those of skill in the art will appreciate still additional alternative structural and functional designs for system and a method for assigning mobile device data to a vehicle through the disclosed principles herein. Thus, while particular embodiments and applications have been illustrated and described, it is to be understood that the disclosed embodiments are not limited to the precise construction and components disclosed herein. Various modifications, changes and variations, which will be apparent to those skilled in the art, may be made in the arrangement, operation and details of the method and apparatus disclosed herein without departing from the spirit and scope defined in the appended claims.

The particular features, structures, or characteristics of any specific embodiment may be combined in any suitable manner and in any suitable combination with one or more other embodiments, including the use of selected features without corresponding use of other features. In addition, many modifications may be made to adapt a particular application, situation or material to the essential scope and spirit of the present invention. It is to be understood that other variations and modifications of the embodiments of the present invention described and illustrated herein are possible in light of the teachings herein and are to be considered part of the spirit and scope of the present invention.

What is claimed is:

1. A computer-implemented method for determining the status of autonomous operation features of an autonomous or semi-autonomous vehicle, comprising:

receiving, at one or more processors, a signal indicating a request to determine an operating status of one or more autonomous operation features of the autonomous or semi-autonomous vehicle, wherein each of the one or more autonomous operation features comprises a control module configured to generate control decisions that actuate one or more electromechanical control components of the autonomous or semi-autonomous vehicle based upon data received from a plurality of sensors associated with the one or more autonomous operation features;

determining, by the one or more processors, a configuration of the plurality of sensors comprising at least one of: a number of the plurality of sensors, a type of each of the plurality of sensors, a location of each of the plurality of sensors, and a technical specification for each of the plurality of sensors including normal functioning characteristics or output ranges;

presenting, by the one or more processors, a test signal to each of the plurality of sensors;

determining, by the one or more processors in response to the test signal, one or more of the plurality of sensors are missing, malfunctioning or damaged;

determining, by the one or more processors, the operating status of the one or more autonomous operation features associated with the one or more of the plurality of sensors that are missing, malfunctioning or damaged is impaired;

generating, by the one or more processors, an operating status report indicating the operating status of the one or more autonomous operation features, including the impaired operating status of the one or more autonomous operation features;

storing, in a computer-readable non-transitory memory, the operating status report for subsequent use;

transmitting, via a network, the generated operating status report to a server;

determining, by one or more processors of the server, an adjustment to one or more risk levels associated with operation of the autonomous or semi-autonomous vehicle based upon the impaired operating status of the one or more autonomous operation features; and

adjusting, by the one or more processors of the server, an insurance policy cost associated with the autonomous or semi-autonomous vehicle based upon the determined adjustment to the one or more risk levels.

2. The computer-implemented method of claim **1**, wherein the cost associated with the insurance policy includes at least one of the following: a premium, a discount, a surcharge, a rate level, a cost based upon a distance traveled, a cost based upon a vehicle trip, and a cost based upon a duration of vehicle operation.

3. The computer-implemented method of claim **1**, further comprising receiving, at the one or more processors of the server, one or more indications of maintenance performed on the autonomous or semi-autonomous vehicle, wherein determining the adjustment to the cost associated with the insurance policy is further based upon the received one or more indications of maintenance.

4. The computer-implemented method of claim **1**, wherein the signal indicating the request to determine the operating status of the one or more autonomous operation features is automatically generated by a processor upon the occurrence of an event.

5. The computer-implemented method of claim **4**, wherein the event includes one or more of the following: receipt of a command to start the vehicle, receipt of a command to shut off the vehicle, receipt of an indication of a collision involving the vehicle, and receipt of an indication of damage to the vehicle.

6. The computer-implemented method of claim **1**, wherein the signal indicating the request to determine the operating status of the one or more autonomous operation features is received from a mobile device communicatively connected to the autonomous or semi-autonomous vehicle.

7. The computer-implemented method of claim **1**, wherein the signal indicating the request to determine the operating status of the one or more autonomous operation features is received from a special-purpose computing device communicatively connected to the autonomous or semi-autonomous vehicle.

8. The computer-implemented method of claim **1**, further comprising:

determining, by the one or more processors, the impaired operating status of the one or more autonomous operation features is caused by a blockage of the one or more of the plurality of sensors due to environmental factors;

generating, by the one or more processors, a remediation signal to remove the blockage; and

causing one or more remediation components of the autonomous or semi-autonomous vehicle to remove the blockage by: (i) heating an area around the one or more of the plurality of sensors, or (ii) physically removing the blockage using other remediation components.

9. The computer-implemented method of claim **8**, wherein the blockage is caused by one or more of the following: snow, ice, rain, dirt, mud, and condensation.

10. The computer-implemented method of claim **1**, further comprising correcting the impaired operating status of the one or more autonomous operating features by calibrating the one or more of the plurality of sensors based upon available sensor data.

11. The computer-implemented method of claim **1**, wherein generating the operating status report includes generating a certification of the operating status of the one or more autonomous operation features.

12. The computer-implemented method of claim **1**, wherein the one or more autonomous operation features are related to at least one of the following: steering, accelerating, braking, monitoring blind spots, presenting a collision warning, adaptive cruise control, parking, driver alertness monitoring, driver responsiveness monitoring, pedestrian detection, artificial intelligence, a back-up system, a navigation system, a positioning system, a security system, an anti-hacking measure, a theft prevention system, and remote vehicle location determination.

13. A computer system for determining the status of autonomous operation features of an autonomous or semi-autonomous vehicle, comprising:

one or more processors;

a plurality of sensors associated with the one or more autonomous operation features communicatively connected to the one or more processors; and

a program memory coupled to the one or more processors and storing executable instructions that when executed by the one or more processors cause the computer system to:

receive, at the one or more processors, a signal indicating a request to determine an operating status of one or more autonomous operation features of the autonomous or semi-autonomous vehicle, wherein each of the one or more autonomous operation features comprises a control module configured to generate control decisions that actuate one or more electromechanical control components of the autonomous or semi-autonomous vehicle based upon data received from a plurality of sensors associated with the one or more autonomous operation features;

determine, by the one or more processors, a configuration of the plurality of sensors comprising at least one of: a number of the plurality of sensors, a type of each of the plurality of sensors, a location of each of the plurality of sensors, a technical specification for each of the plurality of sensors including normal functioning characteristic or output ranges;

present, by the one or more processors, a test signal to each of the plurality of sensors;

determine, by the one or more processors in response to the test signal, one or more of the plurality of sensors are missing, malfunctioning or damaged;

determine, by the one or more processors, the operating status of the one or more autonomous operation features associated with the one or more of the plurality of sensors that are missing, malfunctioning or damaged is impaired;

generate, by the one or more processors, an operating status report indicating the operating status of the one or more autonomous operation features, including the impaired operating status of the one or more autonomous operation features;

store, in a computer-readable non-transitory memory, the operating status report for subsequent use;

transmit, via a network, the generated operating status report to a server;

determine, by one or more processors of the server, an adjustment to one or more risk levels associated with

operation of the autonomous or semi-autonomous vehicle based upon the impaired operating status of the one or more autonomous operation features; and

adjust, by the one or more processors of the server, an insurance policy cost associated with the autonomous or semi-autonomous vehicle based upon the determined adjustment to the one or more risk levels.

14. The computer system of claim **13**, wherein the program memory further stores executable instructions that cause the computer system to:

determine, by the one or more processors, the impaired operating status of the one or more autonomous operation features is caused by a blockage of the one or more of the plurality of sensors due to environmental factors;

generate, by the one or more processors, a remediation signal to remove the blockage; and

cause one or more remediation components of the autonomous or semi-autonomous vehicle to remove the blockage by: (i) heating an area around the one or more of the plurality of sensors, or (ii) physically removing the blockage using other remediation components.

15. A tangible, non-transitory computer-readable medium storing instructions for determining the status of autonomous operation features of an autonomous or semi-autonomous vehicle that, when executed by at least one processor of a computer system, cause the computer system to:

receive, at one or more processors, a signal indicating a request to determine an operating status of one or more autonomous operation features of the autonomous or semi-autonomous vehicle, wherein each of the one or more autonomous operation features comprises a control module configured to generate control decisions that actuate one or more electromechanical control components of the autonomous or semi-autonomous vehicle based upon data received from a plurality of sensors associated with the one or more autonomous operation features;

determine, by the one or more processors, a configuration of the plurality of sensors comprising at least one of: a number of the plurality of sensors, a type of each of the plurality of sensors, a location of each of the plurality of sensors, a technical specification for each of the plurality of sensors including normal functioning characteristics or output ranges;

present, by the one or more processors, a test signal to each of the plurality of sensors;

determine, by the one or more processors in response to the test signal, one or more of the plurality of sensors are missing, malfunctioning or damaged;

determine, by the one or more processors, the operating status of the one or more autonomous operation features associated with the one or more of the plurality of sensors that are missing, malfunctioning or damaged is impaired;

generate, by the one or more processors, an operating status report indicating the operating status of the one or more autonomous operation features, including the impaired operating status of the one or more autonomous operation features;

store, in a computer-readable non-transitory memory, the operating status report for subsequent use;

transmit, via a network, the generated operating status report to a server;

determine, by one or more processors of the server, an adjustment to one or more risk levels associated with operation of the autonomous or semi-autonomous vehicle based upon the impaired operating status of the one or more autonomous operation features; and

adjust, by the one or more processors of the server, an insurance policy cost associated with the autonomous or semi-autonomous vehicle based upon the determined adjustment to the one or more risk levels.

16. The tangible, non-transitory computer-readable medium of claim **15**, wherein the instructions further cause the computer-system to:

determine, by the one or more processors, the impaired operating status of the one or more autonomous operation features is caused by a blockage of the one or more of the plurality of sensors due to environmental factors;

generate, by one or more processors, a remediation signal to remove the blockage; and

cause one or more remediation components of the autonomous or semi-autonomous vehicle to remove the blockage by: (i) heating an area around the one or more of the plurality of sensors, or (ii) physically removing the blockage using other remediation components.

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