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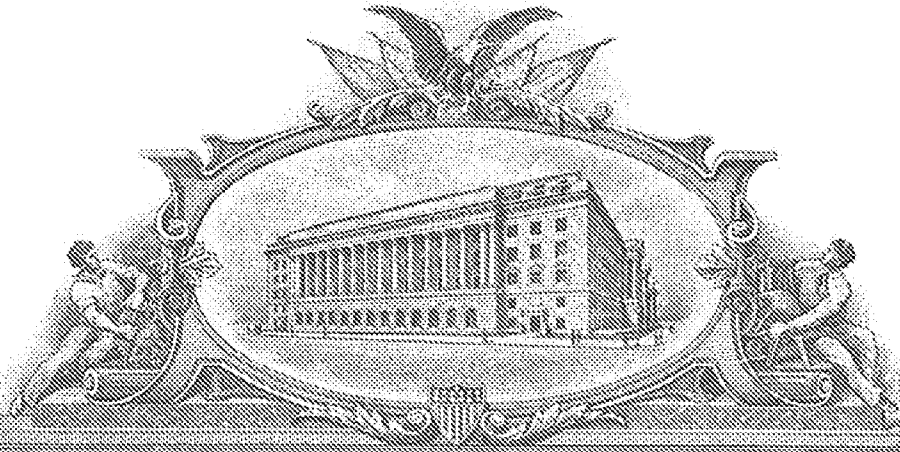
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Additional inventors are being named on the _____ separately numbered sheets attached hereto.			
TITLE OF THE INVENTION (500 characters max):			
SYSTEMS AND METHODS FOR OPERATING AND SERVICING VEHICLE CORNER MODULE			
CORRESPONDENCE ADDRESS			
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<input checked="" type="checkbox"/> The address corresponding to Customer Number: 49443			
OR			
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ENCLOSED APPLICATION PARTS (check all that apply)			
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SIGNATURE /DEVORAH LIVNEH/Date 2 January 2020TYPED or PRINTED NAME Devorah N. LivnehREGISTRATION NO. (if appropriate) 71,347TELEPHONE 646-878-0800Docket Number: P-592244-USP**USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT**

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SYSTEMS AND METHODS FOR OPERATING AND SERVICING VEHICLE CORNER MODULE

BACKGROUND OF THE INVENTION

[001] A large variety of vehicle models and specific vehicle platforms and a large number of vehicle performance profiles and vehicle wheels result in the need in a large number of specific designs and manufacturing of mechanical and electrical systems of a vehicles, which in turn result in increase in vehicle and vehicle parts manufacture and maintenance costs.

[002] A vehicle corner module (VCM) system is disclosed comprising a sub-frame of interfacing between the VCM and a vehicle platform, a wheel interface for coupling a wheel to the VCM, one or more of VCM modules, which include mechanical assemblies and electrical units for operating a wheel when assembled on the vehicle and one or more electrical interfaces for exchanging signals and data between the VCM modules and the vehicle platform.

[003] In some embodiments the VCM further comprises one or more sensors for measuring operational data of the one or more VCM modules and a VCM controller in electrical connection with the one or more electrical interfaces and the one or more electrical units of the VCM modules.

[004] In some embodiments the VCM further comprises one or more of: a suspension module, a wheel driving module, a steering module, and a control module and the wheel driving module comprises one or more of: an electric motor unit, a transmission unit, and a braking unit.

[005] In some embodiments one or more of the VCM modules are located between the wheel interface and the sub-frame.

[006] In some embodiments the one or more of the electrical units comprise a VCM module controller and the VCM module controller comprises integrated circuits having hardware and software that control two or more VCM modules.

[007] A vehicle is disclosed having one or more of the vehicle corner module described above.

[008] In some embodiments the vehicle comprising a VCMs control unit (CSCU); and a platform-VCM bus for communication between the vehicle and one or more of electrical circuits located in the VCMs.

[009] In some embodiments of the vehicle the VCMs are in direct electrical communication, such that data can be exchanged between the VCMs bypassing the CSCU.

[0010] A method of activating a vehicle corner module (VCM) is disclosed comprising mounting the VCM on a vehicle platform, setting a VCM operational profile, and activating the VCM to be operational with the VCM operational profile.

[0011] In some embodiments the method further comprising matching between operational profiles of the VCM and the vehicle platform and setting of a VCM operational profile is to a matching operational profile of the VCM.

[0012] In some embodiments the method further comprising matching between operational profiles of the VCM and the operational profiles of other VCMs coupled to the vehicle platform and setting the operational profile of one or more of the VCMs coupled to the vehicle platform in accordance to the matching between operational profiles of the one or more of the VCMs.

[0013] In some embodiments the method further comprising receiving an operational plan defined for the VCM and setting VCM operational profile according to the operational plan.

[0014] A method of servicing a vehicle having one or more vehicle corner modules (VCMs) is disclosed comprising receiving an indication that servicing of a system located in the VCM is required, halting the operation of the vehicle, de-coupling the VCM from the vehicle, mounting a substituting VCM to the vehicle and resuming the operation of the vehicle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The subject matter regarded as the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of operation, together with objects, features, and advantages thereof, may best be understood by reference to the following detailed description when read with the accompanying drawings in which:

[0016] Figs. 1A-1D depict schematic illustrations of various communication schemes between parties associated with a vehicle equipped with VCM, according to embodiments of the invention;

[0017] Figs. 2A-2C depict various embodiments of communication between a vehicle platform and one or more VCMs, according to embodiments of the present invention;

[0018] Fig. 2D is a schematic block diagram illustration presenting high-level topology of control units in a VCM-based vehicle, according to embodiments of the invention;

[0019] Fig. 2E is a schematic block diagram of software (SW) high-level scheme 240, according to embodiments of the invention.

[0020] Figs. 3A-3G depict various mechanical-electrical configurations of VCMs according to embodiments of the invention;

[0021] Fig. 4A depicts a schematic 3D illustration of an embodiment of a VCM according to embodiments of the invention;

[0022] Fig. 4B depicts a schematic 3D illustration of an embodiment of a VCM according to embodiments of the invention;

[0023] Fig. 4C is a schematic block diagram of a storage unit for storing a VCM according to embodiments of the invention;

[0024] Fig. 5 is a schematic flow diagram depicting steps involved in plugging a new VCM to a vehicle platform, according to embodiments of the present invention;

[0025] Fig. 6 is a chart detailing which elements of a system that comprises one or more VCMs, are involved in the performance of each of certain operations that may take place during operation and maintenance of a vehicle having VCMs, according to embodiments of the invention;

[0026] Figs. 7A and 7B are a schematic flow diagrams depicting processes of matching a newly installed VCM with a vehicle platform and with other VCMs, and optional additional process, respectively, according to embodiments of the present invention;

[0027] Fig. 8 is a schematic flow diagram depicting processes of calibrating a newly installed VCM, according to embodiments of the present invention;

[0028] Fig. 9 is a schematic flow diagram depicting a process of calculating operational parameters for a newly installed VCM, according to embodiments of the present invention;

[0029] Fig. 10 is a schematic flow diagram depicting process for adapting actual operational parameters based on predictive operational parameters, according to embodiments of the present invention;

[0030] Fig. 11 is a flow diagram depicting process for replacing a malfunctioning VCM, according to embodiments of the invention;

[0031] Figs. 12A – 12C are schematic block diagrams depicting communication and control flows between units of a vehicle in some exemplary situations according to embodiments of the invention; and

[0032] Fig. 13 is a schematic flow diagram depicting process for operating VCM and communicating operational data, according to embodiments of the present invention.

[0033] It will be appreciated that for simplicity and clarity of illustration, elements shown in the figures have not necessarily been drawn to scale. For example, the dimensions of some of the elements may be exaggerated relative to other elements for clarity. Further, where considered appropriate, reference numerals may be repeated among the figures to indicate corresponding or analogous elements.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

[0034] In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the invention. However, it will be understood by those skilled in the art that the present invention may be practiced without these specific details. In other instances, well-known methods, procedures, and components have not been described in detail so as not to obscure the present invention.

[0035] A vehicle corner module (VCM) is disclosed in accordance with embodiments of the present invention. A VCM may be adapted to connect a vehicle's wheel to a vehicle's platform, for providing to the wheel one or more from the following capabilities: rotational power, braking, steering and suspension.

[0036] A VCM may operate driving systems of a vehicle by communicating operational data related to driving systems located at the VCM between the VCM and the vehicle platform. The VCM may include a sub-frame for connecting the VCM to the vehicle platform. A wheel interface for mounting a vehicle wheel to the VCM, mechanical and electrical driving systems for driving the vehicle platform, sensors for measuring operational data of the VCM and for reflecting that operational data to the VCM controller and optionally to the vehicle controller and transmit/receive unit to enable exchange of the data with the vehicle controller.

[0037] Control of the driving system of a VCM may be carried out by a control unit connected to one or more of the driving systems. The control unit can be associated with each of the systems. In some embodiments, control units of two or more of the VCM systems may be embodied in a common control unit, which may be associated with multiple driving systems. Thus, a single controller can be associated with multiple VCMs thereby integrating units as opposed to distributed units)

[0038] The VCM may comprise one or more modules from a list comprising a suspension module, a wheel driving module, a steering module and a control module. A driving module may comprise one or more units from an electric motor unit, transmission unit and braking unit. A steering unit may comprise local steering actuator or mechanical steering connectors adapted to receive steering control from outside of the VCM, and optionally steering transmission unit. A control module may be adapted to control all operational aspects of the VCM, such as wheel powering parameters (moment, speed, direction etc.), suspension dampening dynamics, braking operation, steering operation, and the like.

[0039] According to embodiments of the present invention a VCM may be adapted to interface with a vehicle mechanically and electrically and to interface with control signals of the vehicle. For example, the VCM may be adapted to be connected to the vehicle's platform and optionally to mechanically interface with steering controls provided by modules on the vehicle's platform. According to some embodiments the VCM may further be coupled mechanically with rotational power provided by modules on the vehicle's platform.

[0040] In some embodiments the VCM may be adapted to receive electrical power provided by electrical modules on the vehicle's platform and to translate the electrical power to

rotational power provided to a wheel by, for example, an electrical motor comprised in the VCM. The provided electrical power may further be utilized to produce steering control to the VCM, for example using an electrical steering module such as an electrical motor, with or without steering transmission, an electrical linear motor, and the like.

[0041] In some embodiments the VCM may be adapted to engage with a vehicle's control module disposed on the vehicle's platform, for exchanging data and control commands, for controlling the wheel's rotation, braking, steering and / or suspension. In some embodiments a VCM may be configurable so as to match connecting to a given type of vehicle merely by data interaction between the vehicle controller and the VCM controller, at least with respect to control of momentary required driving power, braking profile, dampening profile and the like. According to some embodiments the plugging of a VCM to a vehicle, or its unplugging from the vehicle may be communicated to an external control unit.

[0042] A VCM module may be coupled to a vehicle's platform by mechanical means, electrical power means and control means. The coupling may be configured to operate by plug-in / plug-out means, in order to enable quick yet accurate installing / removing a VCM unit. Mounting of a VCM unit to a vehicle causes one or more of the results: coupling a wheel transmission to the vehicle platform; coupling a braking system to the vehicle's platform; coupling a suspension system to the vehicle's platform; coupling a steering system to the vehicle's platform; and coupling a wheel motor to the vehicle's platform.

[0043] According to embodiments of the invention mounting of a VCM onto a vehicle platform yields placing the vehicle and the VCM in a mechanical and electrical operational state, including required tunings and adaptations, such as adapting the dynamics of the just installed VCM (momentary driving moment, aligned steering, coordinated suspension, and the like) to the vehicle's other VCMs and vehicle platform. In some embodiments the VCM own performance parameters may be transmitted to the vehicle platform in order to enable bringing the installed VCM to full coordination with the vehicle other systems.

[0044] During installation of a VCM to a the VCM may perform a hand-shake process with a controller of the vehicle platform. In some embodiments, the handshake process includes data exchange with other VCMs of the vehicle. In some embodiments, the handshake may include communication with an external computing unit located away of the vehicle (e.g. external computer, connection to remote computing unit via cloud service, etc.).

[0045] Once installation is completed, a control system of the vehicle platform is in communication with the connected corner module and can communicate data and/or power to and from the corner modules to operate the corners by systems such as steer-by-wire, torque vectoring, brake-by-wire, yaw stability control systems (such as ESP systems).

[0046] Data exchanged between computing units on the vehicle platform and a VCM can include data representative of health monitoring and associated with preventative maintenance.

[0047] Data exchanged between computing units on the vehicle platform and a VCM can include VCM module identity number (ID) to uniquely identify the VCM, VCM model, VCM systems, and VCM capabilities/specifications. The exchanged data may further comprise vital sensor readings (errors, current lifetime status of components such as bearings, seals, oil levels, brake pads, air pressure, etc.).

[0048] An aspect of the invention relates to calibration of a VCM. Calibration can be performed after mounting the VCM on the vehicle platform. Calibration can be performed as a scheduled process. Calibration may further be performed in accordance to updated operational parameters of the vehicle and/or the VCM and/or VCMs. Calibration may include measuring, diagnosing and updating one or more of the following parameters of the VCM: orientation of wheel mounted on the VCM (caber, caster, toe angle), braking performance in response to a given breaking input value, and vibrations of one or more of the assemblies of the VCM.

[0049] According to embodiments of the invention operation of a VCM may be performed adaptively based on VCM lifecycle, on data received from the VCM and based on operator's settings.

[0050] In some embodiments the actuators included in a VCM may be electrical and/or hydraulic actuators. One or more electrical motors powering the driving systems in the wheel may be located at a VCM. Power source can be located in the VCM or outside the VCM. When a hydraulic power source is located outside the VCM, the VCM may include hydraulic control/power actuators/transmission to operate the driving systems and/or the steering systems. When a hydraulic power source is located inside the VCM located inside the wheel, driving transmission may be smaller or not required at all.

[0051] In some embodiments computing load associated with a vehicle having installed thereon at least one VCM may be separated between computing units of the vehicle platform and computing units included in the VCM unit (when the VCM is installed with computing unit(s)), as the case may be, so as to ensure that the aggregated computing capability is sufficient. A minimal computing duty for a computing unit in the VCM may be collecting and pre-processing sensors' data from the various sensors in the VCM and providing the pre-processed data to computing unit of the vehicle platform and further receiving flow of control signals provided by the computing unit of the vehicle platform and distributing the signals to various actuators.

[0052] In some embodiments following the connection (or assembly of) a VCM to the vehicle platform, a data connection may be established between the parties and autonomously the newly installed VCM may be recognized and may be placed in an operational state, without the need of a human involvement. Embodiments involving relatively high computing power at the VCM side enable high capability of upgrading the VCM operational features without overloading the vehicle platform computing unit. In some embodiments the operational profile of the vehicle may be administered by the computing unit of the VCM. Further, high computing capabilities of the computing unit of the VCM enables production of VCMs without affecting production of the vehicle platform.

[0053] In some embodiments a VCM may be in active communication not only with the vehicle platform but also with at least one other VCM. Such state is referred to as inter-connected VCMs. VCM of a vehicle may be all of the same type, or may differ having same type at the front and having another type at the rear of the vehicle. In some other embodiments VCMs of one side may be of the same type and VCMs of the other side may be of a different type. For example, in a specific type of vehicle the front VCMs may be steerable and motorized while the rear VCMs may lack steering and motorizing capabilities. In another example, the VCMs may differ from each other by the sensors they are equipped with. In such embodiments VCMs that have more sensors may communicate relevant data to VCMs lacking these sensors.

[0054] In some embodiments the vehicle may be fully controlled through all aspects of the vehicle operation where all computing work is carried out by one or more of the computing

units of the VCMs, with no computing unit on the vehicle platform. In some embodiments the vehicle may be controlled remotely, fully or partially, e.g. an autonomous vehicle.

[0055] A VCM – based vehicle may reduce routine or breakdown servicing time and costs by replacing traditional maintenance routine involving maintenance by the sub-module (brakes, steering, etc.) with replacement of the VCM in which one (or more) functions are malfunctioning with a fully functional VCM that may be selected to fit the type of vehicle mechanically while all other aspects of its operation may be tuned to fit the vehicle using data exchange between the newly installed VCM and the entire vehicle and their VCMs. This process may take from few seconds to up to few minutes, thereby keeping the in-garage down time of the vehicle to minimum, while the malfunctioning VCM may be maintained after the vehicle leaves the garage. The simplicity associated with the dismantling or assembling a VCM from/to a vehicle platform enables use of robotic equipment for carrying out the job, thereby expediting the process even more and reducing the man-labor hours. According to this embodiment maintenance may require less training and proficiency and even may be carried out by the operator of the vehicle at his/her own home garage. Further, a vehicle may be upgraded by upgrading its VCMs, without needing to change the vehicle platform. In addition, insurance of the vehicle may be changed from whole-vehicle model to VCM-based model of insurance.

[0056] In this type of embodiments, replacement of a VCM may involve the following steps: unfastening the VCM from the vehicle platform, disconnecting the electrical/communication connection(s) if any, positioning the replacement VCM and fastening it to the vehicle platform, re-connecting the electrical/communication connection(s) and allowing the newly installed VCM to autonomously complete its fitting-in process, carried by connecting to other VCMs and/or to the vehicle platform computing unit. This replacement process may be carried out by any one of a servicing professional, an untrained operator, or a robotic system.

[0057] VCMs that are stored on shelves waiting to be used in a vehicle may be tested for proper operational state periodically or by demand. The in-store VCM may be connected to a testing facility that may imitate full connection of the tested VCM to an operative vehicle and may inject test signals to the tested VCM and monitor the received signals, received wither from in-VCM sensors or external sensors being part of the testing facility. The test

procedure may end with go/no-go of the tested VCM or may also add test brief that may be provided to the operator and also be saved in the computing unit of the tested VCM, thereby making the tuning of the VCM after it was installed on the vehicle faster and more accurate.

[0058] The testing procedure may be adapted to perform one or more of the following test protocols: testing a single system of the VCM, testing multiple systems of the VCM, testing two or more of the VCM systems in an operational scenario involving combined operations of the systems (e.g. steering while changing speed), repetition of the test for a number of times and/or in a changing rate, and testing the VCM according to given driving profile.

[0059] Cost of usage of a VCM may serve for business transactions such as rental of vehicle, rental of corner modules, service plans, subscription services. Some examples of operational parameters are: distance traveled, hours used, accelerations (max, frequency) - data that can correlate with VCM wear rates. Operational data may be compared to operational planned values. Planned values may be part of a business plan defined for the VCM and/or vehicle, e.g. during purchasing the VCM, renting the VCM, purchasing/subscribing to service plan for the VCM. Financial data may relate to information used in insurance plan. Insurance plan can be of a corner module and/or vehicle. Insurance plan cost may be based on historical data of the VCM. According to some embodiments, operation of the VCM may be controlled according to financial data. In some embodiments, performance (operational profile) of the VCM is selected as a dependency of selected plan. In some embodiments, performance (operational profile) of the VCM is selected as a dependency of actual VCM data with respect to preceding plan. Operational profile may be set to be reduced/increased.

[0060] Some embodiments of a VCM, VCM uses, VCM as part of a vehicle and the like are described herein below with regard to the following drawings.

[0061] Reference is made now to **Figs. 1A-1D**, that depict schematic illustrations of various communication schemes between parties associated with a vehicle equipped with VCM, according to embodiments of the invention. Fig. 1A depicts a basic communication scheme 100 between a VCM 104 and a vehicle platform 102, which enable exchanging power and signals associated with the operation of the VCM motor, steering, braking, suspension and VCM computing unit. Signals may comprise control signals and data signals. Fig. 1B depicts a basic communication scheme 110 between a VCM 104, a vehicle platform 102 and an

external computing unit 106. Signals and power that may be exchanged between the vehicle platform 102 and the VCM 104 may be the same as described above with respect to Fig. 1A. Additionally VCM 104 and vehicle platform 102 may exchange data with external computing unit 106, for example for storing data for later use, or for receiving stored data, or for enjoying added computing power.

[0062] Fig. 1C depicts a basic communication scheme 120 between a VCM 104, a vehicle platform 102, an external computing unit 106 and one or more additional VCMs 108. Signals and power that may be exchanged between the vehicle platform 102, VCM 104 and external computing unit 106 may be the same as described above with respect to Fig. 1B. Additionally, one or more other VCMs 108 that are in active communication with vehicle platform 102, as is VCM 102, may optionally be in communication with VCM 102 (i.e. inter-VCM communication) and/or with external computing unit 106.

[0063] Fig. 1D depicts a basic communication scheme 130 between a VCM 104, a vehicle platform 102, an external computing unit 106 and service station 110. Signals and power that may be exchanged between the vehicle platform 102 and VCMs 104 may be the same as described above with respect to Fig. 1A. Additionally, a service station may establish active communication with either one of vehicle platform 102, VCMs 104 and/or external computing unit 106. Signals exchanged between the service station 110 and either one of vehicle platform 102, VCMs 104 and external computing unit 106 may comprise VCM related data, vehicle related data and other type of data associated with the vehicle platform, and the VCMs. Such data may be useful for servicing a malfunctioning VCM, for updating health record of a serviced VCM, for efficient tuning a VCM to a specific vehicle and the like.

[0064] **Figs. 2A-2C** depict various embodiments of communication between a vehicle platform and one or more VCMs, according to embodiments of the present invention.

[0065] Reference is made to Fig. 2A, which depicts a schematic electrical diagram 200 of connections between units on the vehicle platform 202 and a VCM 204. A power source 202A may be located on the vehicle platform, adapted to provide power to consumers on the platform 202 and/or in the VCM 204. A VCMs control unit (CSCU) 202B may be located on the platform 202 and may comprise a VCMs data processor 202B1 and a VCMs controller 202B2. VCM 204 may comprise one or more control units from the group 204A

that may comprise a suspension control unit (SCU) 202A1, a braking control unit (BCU) 202A2, a transmission control unit (TCU) 202A3 and a steering control unit (STU) 204A4. VCM 204 may further comprise a VCM controller 204C that is adapted to communicate with all other VCM sub-system control units and with VCM sensors 204B. VCM controller 204C may be in active communication with VCM systems control unit 202B. This scheme enables flow of control and data between the vehicle platform 202 and a VCM 204.

[0066] According to some embodiments, one or more of the control units 204A are designed to have merged components and functionality. In some embodiments, merging control units is by sharing processing algorithms having shared operational parameters (e.g. rotational speed). In some embodiments, merged control units share power source. In some embodiments, merged control units receive input from a common set of sensors (e.g. sensors included in 204B). In some embodiments, merged control units are accommodated within a common mechanical compartment. In some embodiments, merging control units reduces the size of control units located within VCM 204.

[0067] According to some embodiments, one or more of control units 204A are positioned with VCM 204 by using potting technique, such as the control unit does not require external housing besides of being supported at the mechanical structure of system on VCM 204.

[0068] Reference is made to Fig. 2B, which depicts a schematic electrical diagram 210 of connections between units on the vehicle platform 202 and more than one VCM 204. On the vehicle platform 202 power source 202A may be identical or similar to that of Fig. 2A. VCMs control unit (CSCU) 212B may comprise, additional to processor 212B1, that may be identical to processor 202B1 of Fig. 2A, also I/O unit 212B3 and data storage 212B4. I/O unit 202B3 may be adapted to communicate over a platform-VCM bus 213. Each of VCM units 204 may comprise, in addition to controller (CCU) 204C and sensors unit 204B – both may function similar to controller 204C and sensors unit 204B of Fig. 2A. additionally, VCM 204 may comprise data storage 204D. This scheme enables flow of control and data between the vehicle platform 202 and a two or more VCMs 204 and further enables flow of control and data between VCMs directly. According to some embodiments, two or more of the control units in each VCM 204 may be embodied in a single computing unit.

[0069] Reference is made to Fig. 2C, which depicts a schematic electrical diagram 210 of connections between units on the vehicle platform 202 and more than one VCM 204 using

separated communication buses 213 and 223. The control units on vehicle platform 202 may be identical to the corresponding units of Fig. 2B. the control units in each VCM 204 may be identical to the respective control units of VCM 204 of Fig. 2B. In contrast to the communication scheme of Fig. 2B, here another communication bus is in use – VCM-VCM bus 223 that enables direct communication between two or more VCMs with no involvement of CSCU 212B of the platform. Each of the VCMs may be connected to the platform-VCM bus 213 and to the VCM-VCM bus 223 via connector 214E. This scheme enables flow of control and data between the vehicle platform 202 and a two or more VCMs 204 and further enables flow of control and data between VCMs 204 directly.

[0070] Reference is made now to **Fig. 2D**, which is a schematic block diagram illustration presenting high-level topology of control units in a VCM-based vehicle 230, according to embodiments of the invention. Vehicle 230 may comprise four VCMs installed to its vehicle platform, namely VCMs L1 and L2 on the left side and VCMs R1 and R2 on the right side. Each of the VCMs may be in active communication with central electronic control unit (ECU) 231. ECU 231 may be a VCMs control unit (CSCU) described elsewhere herein. The communication between each of the VCMs and ECU 231 may be adapted to exchanged data, control signals, and reflect errors occurring during the operations phases of the VCM and status of the VCM.

[0071] According to some embodiments the vehicle in Fig. 2D may be an autonomous vehicle. In this embodiment, a Main Autonomy Computer 233 is installed on the vehicle and is in active communication with central ECU 231, adapted to exchange control, error and status signals. In some embodiments, vehicle may be human driven, and a Main Autonomy Computer 233 may be included as driver assistance system.

[0072] The configuration depicted in Fig. 2D does not show direct communication between the VCMs. A potential advantage of having VCMs that don't communicate with each other, is that control is done via Central ECU 231. In some cases, this simplifies the prevention of sending conflicting signals, for example conflicting steering angles.

[0073] Yet, in some embodiments a VCM-to-VCM bus (such as bus 223 of Fig. 2C) may be provided, to enable faster data exchange, improved level of redundancy, and/or distributing computing overload between processors.

[0074] Reference is made now to **Fig. 2E**, which is a schematic block diagram of software (SW) high-level scheme 240, according to embodiments of the invention. SW scheme 240 depicts division of SW assignments between SW modules of a vehicle equipped with one or more physical modules where at least one of these modules is controlled by a dedicated SW module. In SW scheme 240 each of physical modules: steering module, power module, powertrain module, thermal cooling module and brake module has an associated SW module, adapted to provide control signals to control the operation of the associated physical module, and to receive from the module reading of sensors monitoring the operation of the physical module. Accordingly, steering SW module 241, power SW module 242, powertrain SW module 243, suspension SW module 244, thermal cooling SW module 245 and brake SW module 246 are adapted to provide control signals, each to its respective physical module and to receive from its respective physical module sensors signals reflecting the operation of the associated physical module.

[0075] Each of the SW modules may be in active communication with central SW module 248, which is adapted to receive control, status and error data from each of the SW modules, to store it and optionally to process the received data according to program lines stored thereon in a non-volatile memory (not shown). Central SW module 248 may be in active communication with vehicle control unit (not shown), for example according to one or more of the control schemes described elsewhere herein. Central SW module 248 is adapted to receive control signals from an external control entity (not shown), such as Autonomous Control unit (not shown). In some embodiments each of the SW modules may be operated on a dedicated computing device (not shown) that may be disposed on, or in close proximity to the physical module it is adapted to control. This way, the respective HW/SW module is capable of full replacement ability simply by the removal of the associated module and replacing it with another such module. In other embodiments two or more of the SW modules may be embodied on a single HW platform, e.g. that is disposed on the vehicle platform. In some embodiments the HW modules of the physical modules may be identical to each other and may vary only by the SW package loaded to the HW module. This arrangement may save costs, may lower the number of on-the-shelf spare modules and may shorten the time needed for removal, installation and SW load-and-tune time.

[0076] **Figs. 3A-3G** depict various mechanical-electrical configurations of VCMs according to embodiments of the invention. In the following examples various partial combinations of units of a VCM are shown.

[0077] Reference is made now to Fig. 3A, which schematically depicts an isometric drawing of as-installed with a wheel VCM 300. VCM 300 comprises electrical motor 300A driving a suspension unit with drivetrain unit 304B, which are adapted to rotate the wheel. Additionally, in this embodiment rotation sensor 306 may be installed at the wheel bearing to reflect the rotational speed of the wheel. Electrical motor 304A may be connected to electrical power source via power connection 304A1.

[0078] Reference is made now to Fig. 3B, which schematically depicts an isometric drawing of as-installed within a wheel VCM 310. VCM 310 comprises steering assembly 310A, suspension assembly 310B, and braking assembly 310C enclosed at least partially within a rim of a wheel. Steering assembly 310A may comprise, according to embodiments, steering rod 310A1, steering motor 310A2 and steering control unit 310A3. Steering assembly 310A is adapted to receive steering control signals from steering control unit 310A3. In some embodiments, steering control unit 310A3 receives steering control signals from a central controller on a vehicle platform or from a VCM. Suspension system 310B is depicted as system enabling movement of the wheel with respect to a vehicle platform. Suspension assembly 310B may comprise sub-frame 310B2 in which rail 310B1 is moveable. Suspension assembly 310B may further comprise a sensor (not shown) that is adapted to measure suspension expansion/compression.

[0079] Figs. 3C and 3D are face view and side cross section view of the VCM embodiment of Fig. 3B, respectively. In Fig. 3C some detail of braking assembly 310C are shown, comprising braking actuator 310C1 and braking control interface 310C2. Fig. 3D depicts another view of sub frame 310B2 and rail 310B1 of suspension assembly 310B.

[0080] Reference is made to Fig. 3E showing a top cross section view of VCM 320 installed at least partially within a rim of a wheel, according to embodiments of the invention. VCM 320 may comprise motor 320A with control unit 320A1 and motor electrical connection 320A2 to receive power supply from a vehicle platform. VCM 320 further comprises power transmission 320D to provide rotational drive to the wheel interface 320C and steering assembly 320B. The wheel interface may comprise rotation sensor (not shown), to provide

data indicative of the rotational speed. Electrical and communication cable 320A2 may provide the required connections to the vehicle platform and/or to other VCMs. In some embodiments VCM control unit 320E may be installed as part of VCM 320 systems. Electrical and control connections of steering assembly 320B may be connected to control unit 320E.

[0081] Reference is made to Fig. 3F showing schematic side cross section view of VCM 330 at least partially installed within a rim of a wheel, according to embodiments of the invention. Fig. 3F depict an embodiment of VCM 330 comprising a combined drivetrain and suspension 330B adapted to rotate the wheel via driving shaft 330B1. Electrical and communication cable 330D may provide the required connections to the vehicle platform and/or to other VCMs. In some embodiments control unit 330C may be installed as part of VCM 330 systems. In case when the embodiment comprises steering capability (not shown) its electrical and control cables may be connected to control unit 330C. Reference is made to Fig. 3G showing schematic side view illustration of VCM 340 installed at least partially within the rim of a wheel according to embodiments of the invention. VCM 340 may comprise a motor 340A, a suspension assembly 340B, a VCM control unit 340C, a brake actuator 340D connected via connection 340D1 to VCM control unit 340C and rotation sensor 340E that may be disposed at the wheel bearing. VCM 340 may be connected mechanically to vehicle platform via an interface module 342. Any one of motor 340A, rotation sensor 340E, brake actuator 340D, and suspension assembly 340B may be connected and controlled by VCM control unit 340C. In some embodiments, any one of motor 340A, rotation sensor 340E, brake actuator 340D, and suspension assembly 340B is connected to a designated control unit connected and controlled by VCM control unit 340C.

[0082] Reference is made now to **Fig. 4A**, which depicts a schematic 3D illustration of an embodiment of VCM 400 according to embodiments of the invention. VCM 400 comprises motor and motor control unit 400A, power train 400B, suspension assembly 400C, steering control unit and steering actuator collectively numbered 400D, braking unit 400c and wheel interface 400F. at least part of VCM 400 is adapted to be comprised within the rim of vehicle when it is installed on wheel interface 400F. Any one of a rotation motor unit 400A, sensor (not shown), brake unit 400E, and suspension assembly 400C may be connected and controlled by a VCM control unit (not shown). In some embodiments, any one of the motor,

the brake, and suspension assembly may be connected to a designated control unit which may be connected and controlled by the VCM control unit (not shown).

[0083] Reference is made now to **Fig. 4B**, which depicts a schematic 3D illustration of an embodiment of VCM 410 according to embodiments of the invention. VCM 410 depicts an in-wheel unit for attaching to two wheels. VCM 410 comprises motor and motor electrical connections 410A adapted to drive two wheel interfaces 410D via drivetrains 410C. VCM 410 further comprises suspension assembly 410B which may comprise suspension control unit 410B1, suspension movement sensor 410B2, and suspension spring-and-damper 410B3. VCM 410 may be connected to wheels via wheel interfaces 410D and may be mechanically connected to a vehicle platform via interface 412. VCM 410 may be controlled by VCM control unit 411. Any one of motor 410A and suspension assembly 410B may be connected and controlled by VCM control unit 411. In some embodiments, any one of motor 3410A and suspension assembly 410B is connected to a designated control unit (such as suspension control unit 410B1) connected and controlled by VCM control unit 411.

[0084] Reference is made now to **Fig. 4C**, which is a schematic block diagram 450 of storage unit 452 for storing VCM 454, according to embodiments of the invention. VCM 454 may be similar to any one of the VCM described above, for example, VCM 204 that was described in Fig. 2A, having VCM controller 454C that may be in active communication with sensors unit 454A and with the following active systems: suspension control unit (SCU) 454B1, braking control unit (BCU) 454B2 and steering control unit (STU) 454B3 and wheel driving control unit 454B4.

[0085] VCM 454 may be adapted to be mounted in storage unit 452 via one or more mechanical mounts 452A and at least one electrical and control connector 452B. Any one of mounts 452A may be adapted to support the weight of VCM 454 within storage unit 452. In some embodiments, one or more of mounts 452A contain electrical circuit.

[0086] According to some embodiments, storage unit 452 may be provided with controller and control programs (not shown) adapted to perform health tests to the VCM 454 when stored within storage unit 452, as explained herein above. Storage unit 452 may further comprise local output unit 452C (e.g. display, wireless transmitter/receiver, etc.) that may provide VCM test results and enable control of test parameters. One or more mounts 452A may include or comprise one or more from the following sensors: vibration sensor,

mechanical load sensor, mechanical moment sensor, and the like. Tests may be performed by activation one or more of the VCM systems according to the test scheme. The testing results may be recorded by the VCM sensors 454A and/or by sensors included in mounts 452A.

[0087] Storage unit 452 may be a container having a plurality of walls 450a, 450b, 450c, 450d. Storage unit 452 may be shaped to fit a VCM 454 or may be designed to be adjustable (e.g. by adjustable mounts 452A) to fit a plurality of VCM types. Storage unit 452 may be shaped and sized to accommodate a plurality of VCMs 454 as once. Storage unit 452 may be stationary or may be adapted to be mobile.

[0088] Reference is made now to **Fig. 5**, which is a schematic flow diagram depicting steps involved in plugging a VCM to a vehicle platform, according to embodiments of the present invention. A VCM may be plugged to the vehicle platform in step 502. In some embodiments, plugging step 502 is of a new VCM, not mounted earlier to the vehicle platform. In some embodiments, plugging step 502 is of a VCM, which has been installed on the vehicle platform in the past. According to some embodiments, plugging is by a human operator (e.g. technician, driver, fleet professional). In some embodiments, plugging is by a robotic system. The VCMs operational profile data is received by the platform in step 504.

[0089] The VCM version is checked in step 506. If VCM validation fails, a notice is issued in step 506a. Failure notice may be provided to an operator and may be visual or by sound. Failure notice may be an output transmitted to another device. Failure notice may be provided by the VCM and/or by the vehicle platform, and/or a device connected to the VCM. In some embodiments, if the VCM version needs to be updated an update takes place at step 506b.

[0090] The VCM profile and the platform profile are matched in step 508 and if matching fails this is reported in step 508a. In some embodiments, reporting 508a is followed by unplugging of VCM and terminating the plugging a VCM to a vehicle platform process. Reporting 508a may be to an operator and may be visual or by sound. Reporting 508a may be an output transmitted to another device. Reporting 508a may be provided by the VCM and/or by the vehicle platform, and/or a device connected to the VCM.

[0091] At step 510 the newly installed VCM is activated using a profile that matches the vehicle's profile. According to some embodiments, a profile is selected from profiles

database stored at the VCM. In some embodiments, profiles database is stored at the vehicle platform. In some embodiments, profiles database is stored at a remote storage unit (device, computer, cloud). According to some embodiments, selected operational profile includes activating/deactivating of system related to steering and/or braking and/or driving of the VCM. According to some embodiments, profile includes operational parameters that fit the performance of the vehicle. In some embodiments, profile includes operational parameters that fit a driver profile. In some embodiments, profile includes predictive operational parameters according to planned operation of the vehicle (e.g. time, distances, speed, weather, road conditions).

[0092] The VCM historical data may optionally be loaded at step 512. In some embodiments, historical data may be operational data of the vehicle platform. In some embodiments, historical data may be operational data of the VCM. In some embodiments, historical data may be of planned operation of the vehicle. In some embodiments, loading historical data 512 is followed by analyzing 513 the historical data. In some embodiments, a warning is provided when analyzing 513 results in conflicting with expected operation of the VCM and/or the vehicle platform (e.g. time to maintenance is short to allow predictive operation).

[0093] After the VCM has been activated, its profile is matched with those of other VCMs of the vehicle at step 514. According to some embodiments, if a mismatch is found it is reported in step 514a (reporting method can be similar to those listed above).

[0094] At step 516 the profile of the new VCM is adjusted to those of the other VCMs of the vehicle.

[0095] At step 518 the profiles of the other VCMs are adjusted to that of the new VCM, thereby creating closed loop, until a required adjustment has been achieved. When adjustment of all VCMs has successfully finished the activation of the newly installed VCM becomes operational at step 520.

[0096] Reference is made now to **Fig. 6**, which is a chart detailing which elements of a system that comprises one or more VCMs, are involved in the performance of each of certain operations that may take place during operation and maintenance of a vehicle having VCMs, according to embodiments of the invention.

[0097] Reference is made now to **Figs. 7A and 7B**, which are a schematic flow diagrams depicting processes of matching a newly installed VCM with a vehicle platform and with other VCMs, and optional additional process, respectively, according to embodiments of the present invention. A new VCM is plugged to vehicle platform in step 702 and a controlling unit at the VCM is activated in step 704. The VCM may be validated by one of a remote/external computer, by the vehicle platform controller or by a remote, in-cloud service in step 706. The VCM's information is transmitted to the vehicle platform controller in step 708 and then it is transmitted to other VCMs of the vehicle in step 710, to finish the process.

[0098] The following steps (712 – 716) are optional: in step 712 data from the other VCMs may be received and in step 714 the operational profile of the newly installed VCM may be set based on data from the other VCMs. If historical info of the new VCM is required it may be loaded in step 714a, in order to optimize the results achieved in step 714. Finally, in step 716 operational parameters of the VCMs are calibrated to match operation with the vehicle systems.

[0099] Reference is made now to **Fig. 8**, which is a schematic flow diagram depicting processes of updating operational VCM installed on the vehicle platform, according to embodiments of the present invention. When a VCM is installed and activated, the operational parameters of the vehicle may be updated (step 802). Updating step 802 may be during the operation of the vehicle, e.g. changing speed and or steering, while driving. Updating may be as part of servicing procedure.

[00100] Updating 802 is followed by identifying (step 804) one or more of the systems of the one or more VCMs that may support the required updated operational parameters of the vehicle.

[00101] Updated parameters are now computed for the identified VCM systems (step 806). The computing may be done by computing units on the vehicle platform or at the VCM as the case may be. Following the computing step 806 operational parameters for actuating one or more of the systems in one or more VCMS are updated (step 808). After the update step 808, the VCM systems are actuated (step 810) and approval of successful actuation of systems of the VCM is provided to the vehicle platform and/or the other VCMs (step 812).

[00102] One or more of the steps of identifying 804, updating 808, actuating 810, and approving 812, may include data exchange between VCM and VCM systems control unit are described elsewhere above.

[00103] Reference is made now to **Fig. 9**, which is a schematic flow diagram depicting a process of updating operational parameters for an installed VCM, according to embodiments of the present invention.

[00104] Target operational profile set is received from the vehicle operator (step 902). Target operational profile may be provided during one or more of the operations of the vehicle, a servicing procedure, and an initial activation.

[00105] Setting target profile (902) is followed by receiving (904) of current operational profile of the vehicle from the vehicle platform controller and/or from the one or more controlling units of the one or more VCMs.

[00106] Based on the above target VCM operational parameters and current operational profiles, target operational profile parameters may be calculated (step 906). Calculating 906 can be by computing units located at the vehicle platform, the VCM, and/or a remote computing unit.

[00107] The calculated operational parameters may be distributed (step 908) to one or more control units in one or more VCMs control units may transmit updated actuation signals to the systems in the VCMs in accordance to the target parameters values.

[00108] Reference is made now to **Fig. 10**, which is a schematic flow diagram depicting process for adapting actual operational parameters based on predictive operational parameters, according to embodiments of the present invention. The process may begin by receiving data indicative of the VCM required performance (step 1002) and continues with estimating of the predictive operational performance of the VCM (step 1004).

[00109] Next, based on the previous steps it is determined whether the VCM is able to achieve the predicted performance (step 1006). At this step updated operational parameters may be calculated in order to achieve the predictive data (step 1006a) and optionally the predictive data is update accordingly (step 1006b).

[00110] Activation instructions that may be based on the calculated updated predictive data may now be sent to the one or more VCMs (step 1008) and be determined

again, in closed loop, in step 1006. In case calculating 1006a results in a failure of providing updated operational parameters, failure is provided. One or more of the steps of determining 1006 and calculating 1006a can be by the computing units located at the one or more of vehicle platform, the VCM, and/or a remote computing unit.

[00111] Reference is made now to **Fig. 11**, which is a flow diagram depicting process for replacing a VCM, according to embodiments of the invention.

[00112] A VCM may be identified as requiring replacement, for example in one of the following paths: a mismatch has been detected between the target operational parameters of the VCM, and the actual operational parameters, that exceeds a pre-determined threshold (step 1102A), in case the expiration of the VCM has been detected (step 1102B) or in case a change in the planned service program has been detected (step 1102C).

[00113] If it was determined that the VCM need to be replaced a signal expressing “replacement is required” will be issued (step 1104) and the operation mode of the vehicle will be set to service mode (step 1106).

[00114] The malfunctioning VCM is removed from the vehicle platform (step 1108) and according to its actual state it may be discarded (step 1110A) or be serviced (step 1110B).

[00115] Regardless of the actual state of the removed VCM, a replacement VCM may be mounted to the vehicle platform and is activated (step 1112) and the replacement operation resumes (step 1114).

[00116] Reference is made now to **Figs. 12A-12C**, which are schematic block diagrams depicting communication and control flows between units of a vehicle in some exemplary situations according to embodiments of the invention. In all three examples a vehicle platform may be equipped at least with power source and VCM system controller where the system controller may be disconnected from other units, as the case may be in the examples below. Each the VCM modules in the examples below may be equipped at least with one or more from the list comprising motor unit, steering unit, braking unit, suspension unit and a VCM controller – per the following examples. In all of the following examples the communication between the vehicle platform controller and the VCM control unit may be disconnected. Other communication lines may also be disconnected. In the examples below a disconnected communication line is marked with a red cross on it.

[00117] Fig. 12A depicts a basic communication arrangement of a platform vehicle communicating with a VCM via an external or remote computer to bypass the disconnected direct line between them.

[00118] Fig. 12B depicts a configuration including a vehicle platform with more than one VCM and an external / remote computer, where the direct communication lines between a single VCM and the platform and between the platform and several VCMs are disconnected. This configuration exemplifies how the communication of all VCMs with the platform is performed via the remote/external computer, and communication between the VCMs may strengthen it.

[00119] Fig. 12C depicts a scenario in which in a vehicle the vehicle platform is disconnected from direct communication with a VCM but has communication line with a remote/external computer and with a service station. A communication line is also active between the remote/external computer and the service station. As seen here the communication between the platform and the VCM may be performed via two alternative paths – via the service station and/or via the remote/external computer.

[00120] Reference is made now to Fig. 13, which is a flow diagram depicting process for operating VCM and communicating VCM data with other systems, according to embodiments of the invention.

[00121] The operation of a VCM may be associated with systems and processes that contribute to the operational parameters and the selection of operational profile. The operation of a VCM may also be associated with systems and databases used for financial purpose and business transactions. Cost of usage may serve for business transactions such as rental of vehicle, rental of VCMs, service plans, subscription services. Some examples of operational parameters that can be communicated with other systems may be: distance traveled, hours operated, accelerations (max, frequency), all of these provide data that can correlate with VCM wear rates. Operational data may be compared to planned values. Planned values may be part of a business plan defined for the VCM and/or the vehicle, e.g. during purchasing the VCM, renting the VCM, purchasing/subscribing to service plan for the VCM (e.g. VCM-as a service), and purchasing usage plan. Financial data may relate to information used in insurance plan. Insurance plan can be of a VCM and/or a vehicle. Insurance plan cost may be based on historical data of the VCM. According to some

embodiments, operation of the VCM may be controlled according to financial data and financial considerations. In some embodiments, performance (operational profile) of the VCM is selected as a dependency of selected plan. In some embodiments, performance (operational profile) of the VCM is selected as a dependency of actual VCM data with respect to a preceding plan. As shown in Fig. 13, operation of the VCM may include the following elements: receiving corner module (1302), receiving (1302) may be according to a plan set for the vehicle platform, for operator profile, etc. As described elsewhere above, the VCM is coupled (1304) to a vehicle platform. Prior to activating (1308) of the VCM there may be a step of receiving (1306) information about operational plan set for the VCM. Setting of the VCM profile (1310) may be in according to a plan.

[00122] Operational data of the VCM may be recorded (1312) to be used by other systems after outputting (1314) the recorded operation data of the VCM. Other systems, which may be financial system, may receive (1316) the operational data. Received data, can be used for analyzing (1318) usage of data of the VCM, and calculating (1320) financial charges according to the analyzed data. Financial charges may be outputted (1322) to VCM holder. In some embodiments, analyzed data may be outputted for updating (1324) the operational plan of the VCM.

[00123] As shown in steps 1330 to 1336, the plan can be based on a business plan set for the VCM. The operational plan of the VCM may be set (1332), stored (1334) in a database, and outputted (1336) as required to another device (e.g. external computer, cloud, vehicle platform computing unit, and corner module computing unit).

[00124] While certain features of the invention have been illustrated and described herein, many modifications, substitutions, changes, and equivalents will now occur to those of ordinary skill in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention.

CLAIMS

What is claimed is:

1. A vehicle corner module (VCM) system, comprising:
 - a sub-frame of interfacing between the VCM and a vehicle platform;
 - a wheel interface for coupling a wheel to the VCM;
 - one or more of VCM modules, which include mechanical assemblies and electrical units for operating a wheel when assembled on the vehicle;
 - and
 - one or more electrical interfaces for exchanging signals and data between the VCM modules and the vehicle platform.
2. A vehicle corner module (VCM) system according to claim 1, comprising:
 - one or more sensors for measuring operational data of the one or more VCM modules;
 - a VCM controller in electrical connection with the one or more electrical interfaces and the one or more electrical units of the VCM modules.
3. A vehicle corner module (VCM) system according to any one of claims 1 to 2, wherein the VCM modules comprise one or more of:
 - a suspension module, a wheel driving module, a steering module, and a control module; and
 - the wheel driving module comprises one or more of: an electric motor unit, a transmission unit, and a braking unit.
4. A vehicle corner module (VCM) system according to any one of claims 1 to 3, wherein one or more of the VCM modules are located between the wheel interface and the sub-frame.
5. A vehicle corner module (VCM) system according to any one of claims 1 to 4, wherein:
 - the one or more of the electrical units comprise a VCM module controller; and
 - the VCM module controller comprises integrated circuits having hardware and software that control two or more VCM modules.

6. A vehicle having one or more of the vehicle corner module (VCM) of claims 1 to 5.
7. A vehicle according to claim 6, comprising a VCMs control unit (CSCU); and a platform-VCM bus for communication between the vehicle and one or more of electrical circuits located in the VCMs.
8. A vehicle according to claim 7, wherein the VCMs are in direct electrical communication, such that data can be exchanged between the VCMs bypassing the CSCU.
9. A method of activating a vehicle corner module (VCM), comprising:
 - mounting the VCM on a vehicle platform;
 - setting a VCM operational profile;
 - activating the VCM to be operational with the VCM operational profile.
10. A method according to claim 9, comprising matching between operational profiles of the VCM and the vehicle platform; and
 - the setting of a VCM operational profile is to a matching operational profile of the VCM.
11. A method according to any one of claims 9 to 10, comprising:
 - matching between operational profiles of the VCM and the operational profiles of other VCMs coupled to the vehicle platform;
 - setting the operational profile of one or more of the VCMs coupled to the vehicle platform in accordance to the matching between operational profiles of the one or more of the VCMs.
12. A method according to any one of claims 9 to 11, comprising:
 - receiving an operational plan defined for the VCM; and
 - setting VCM operational profile according to the operational plan.
13. A method according to any one of claims 9 to 12, comprising:
 - recording operational data of the VCM;
 - outputting operational data to a computing system external to the VCM.
14. A method of servicing a vehicle having one or more vehicle corner modules (VCMs), comprising:

receiving an indication that servicing of a system located in the VCM is required;
halting the operation of the vehicle;
de-coupling the VCM from the vehicle;
mounting a substituting VCM to the vehicle;
resuming the operation of the vehicle.

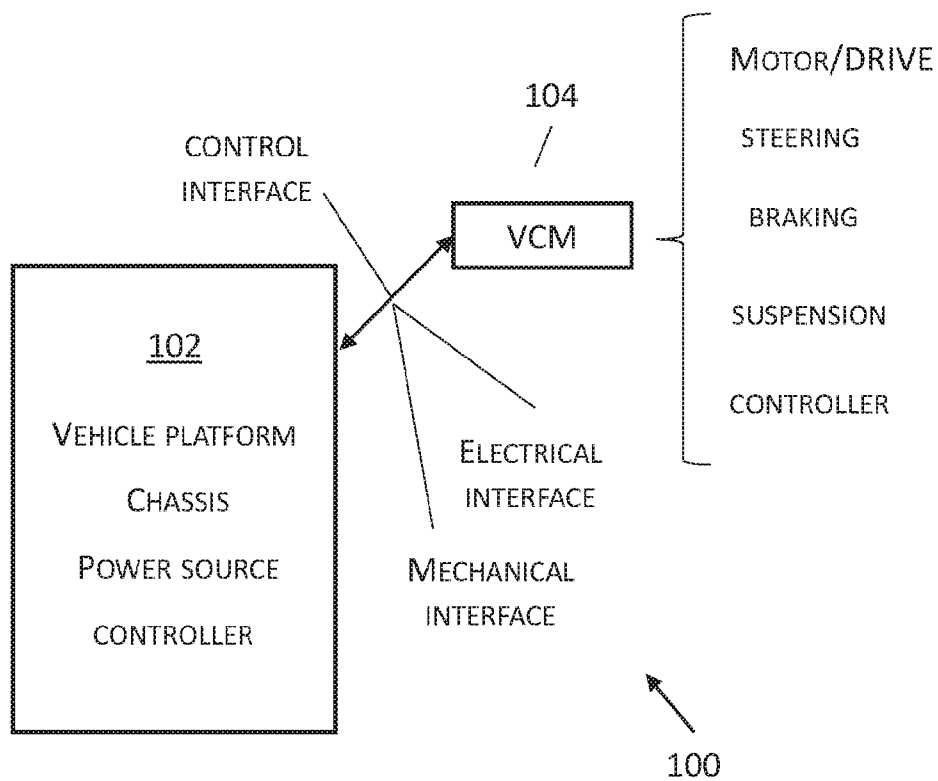


FIG. 1A

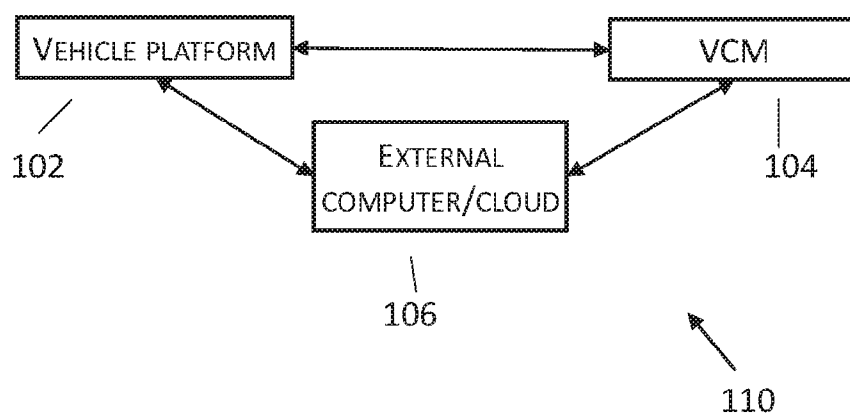
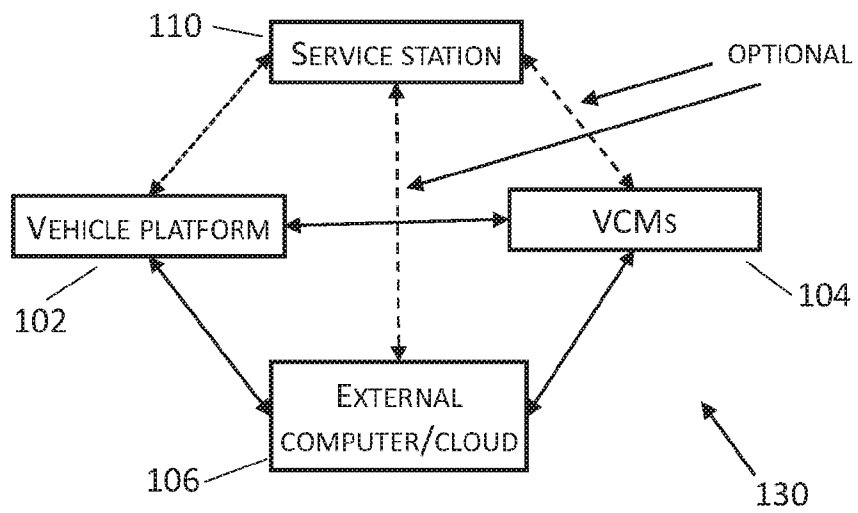
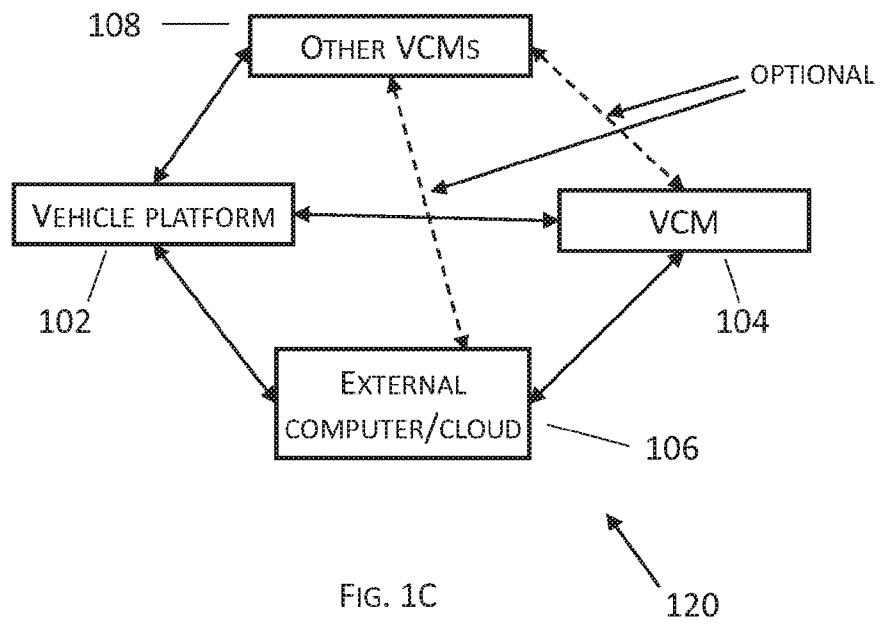


FIG. 1B



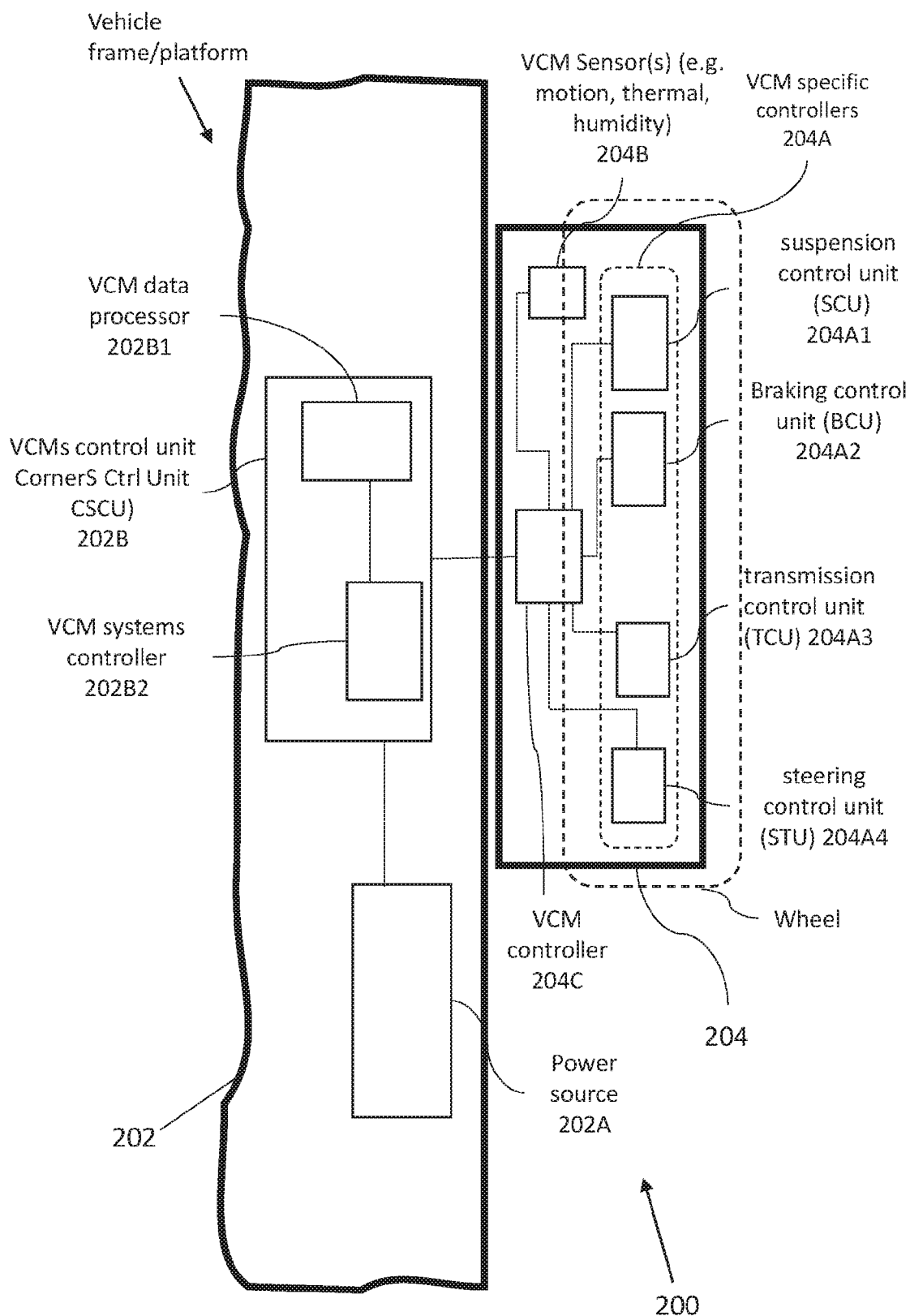


FIG. 2A

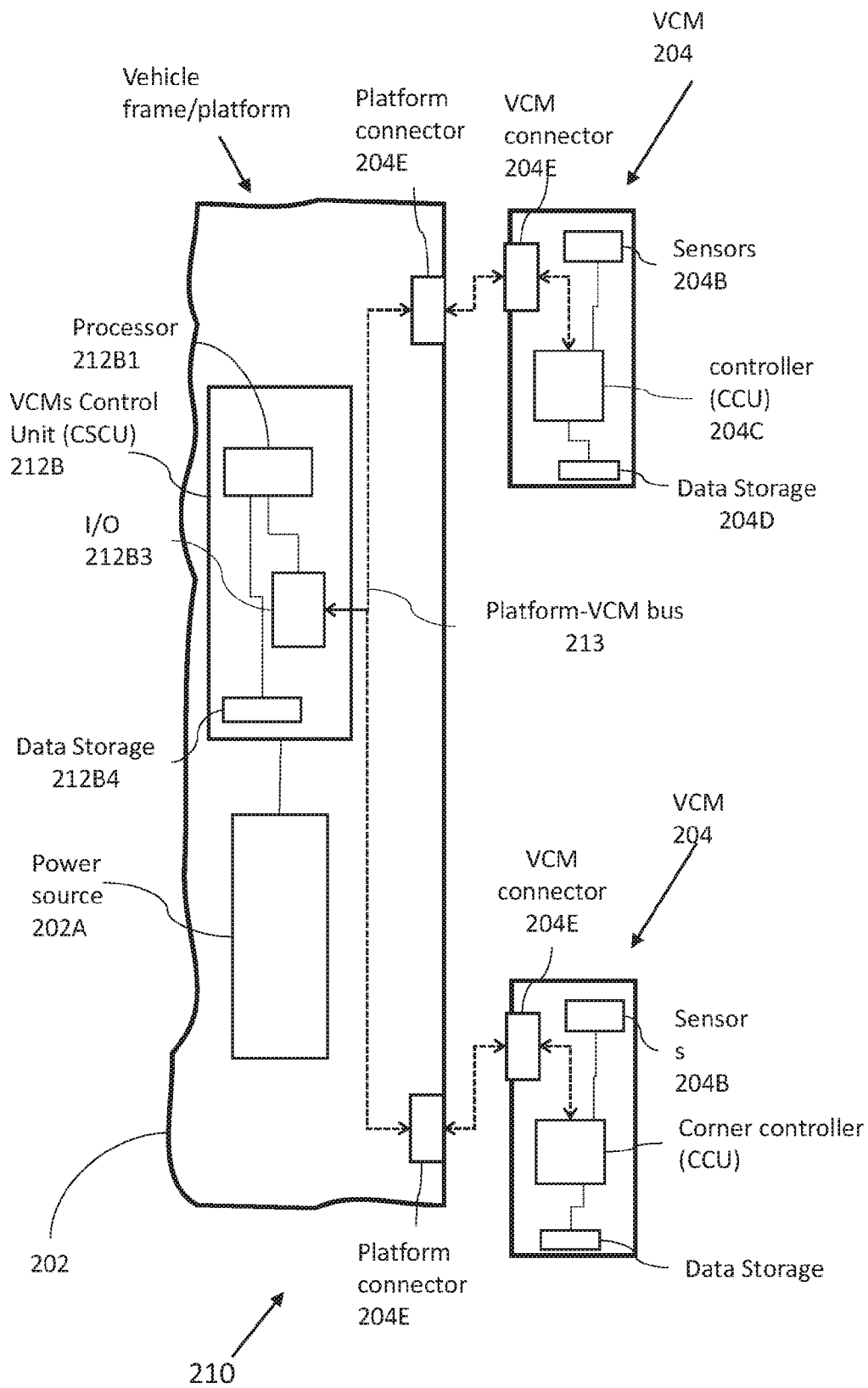


FIG. 2B

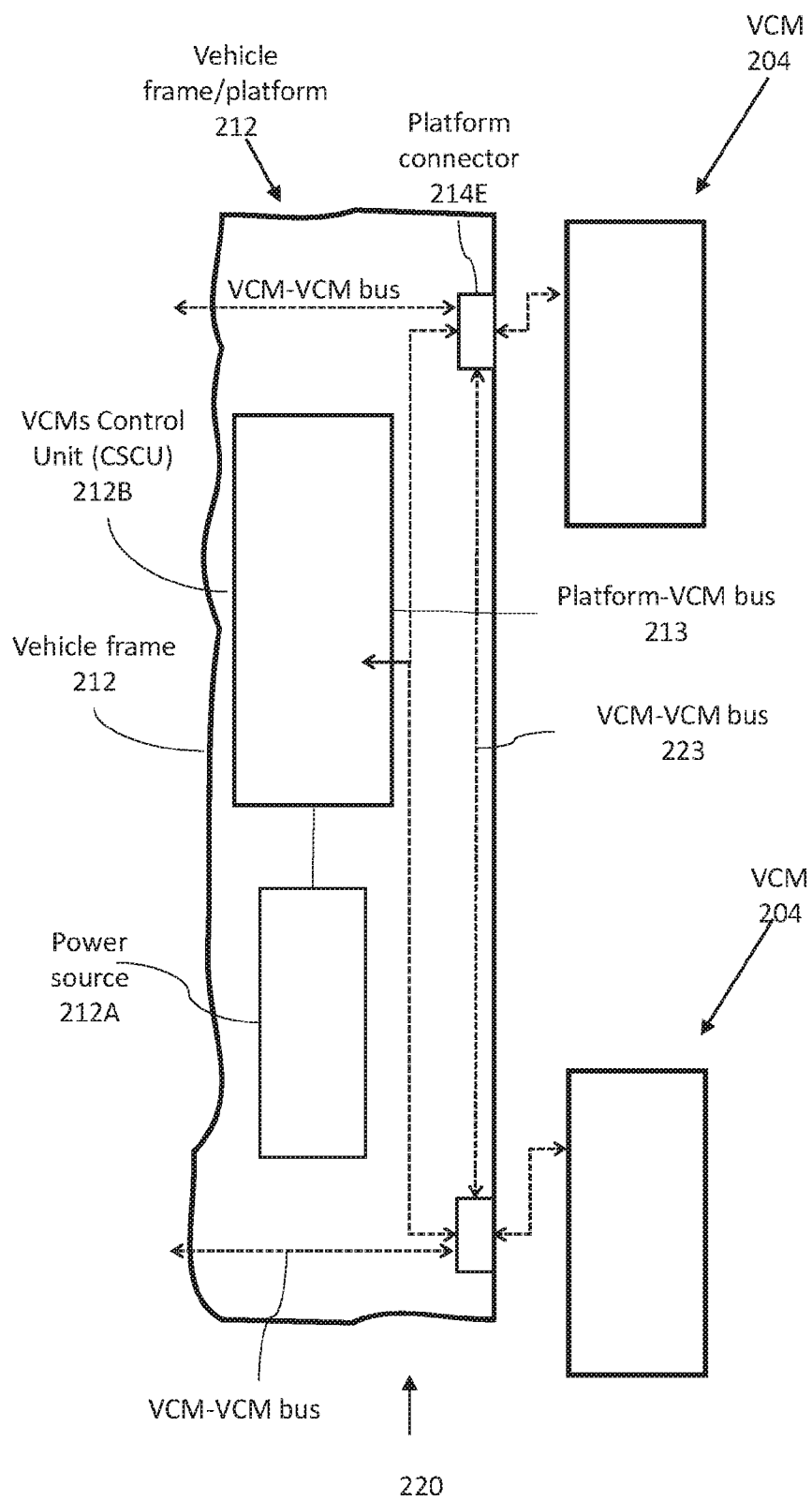


FIG. 2C

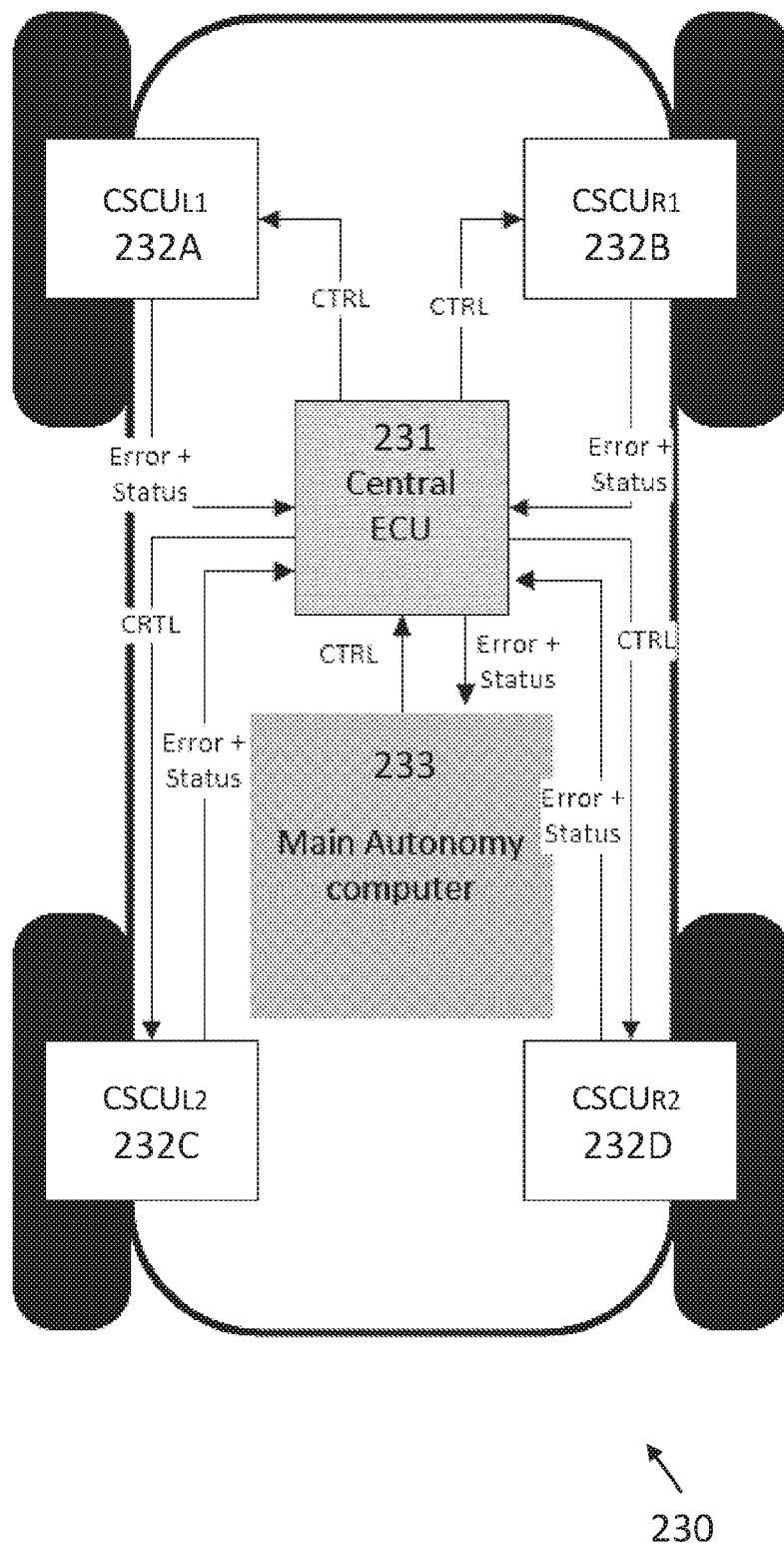


FIG. 2D

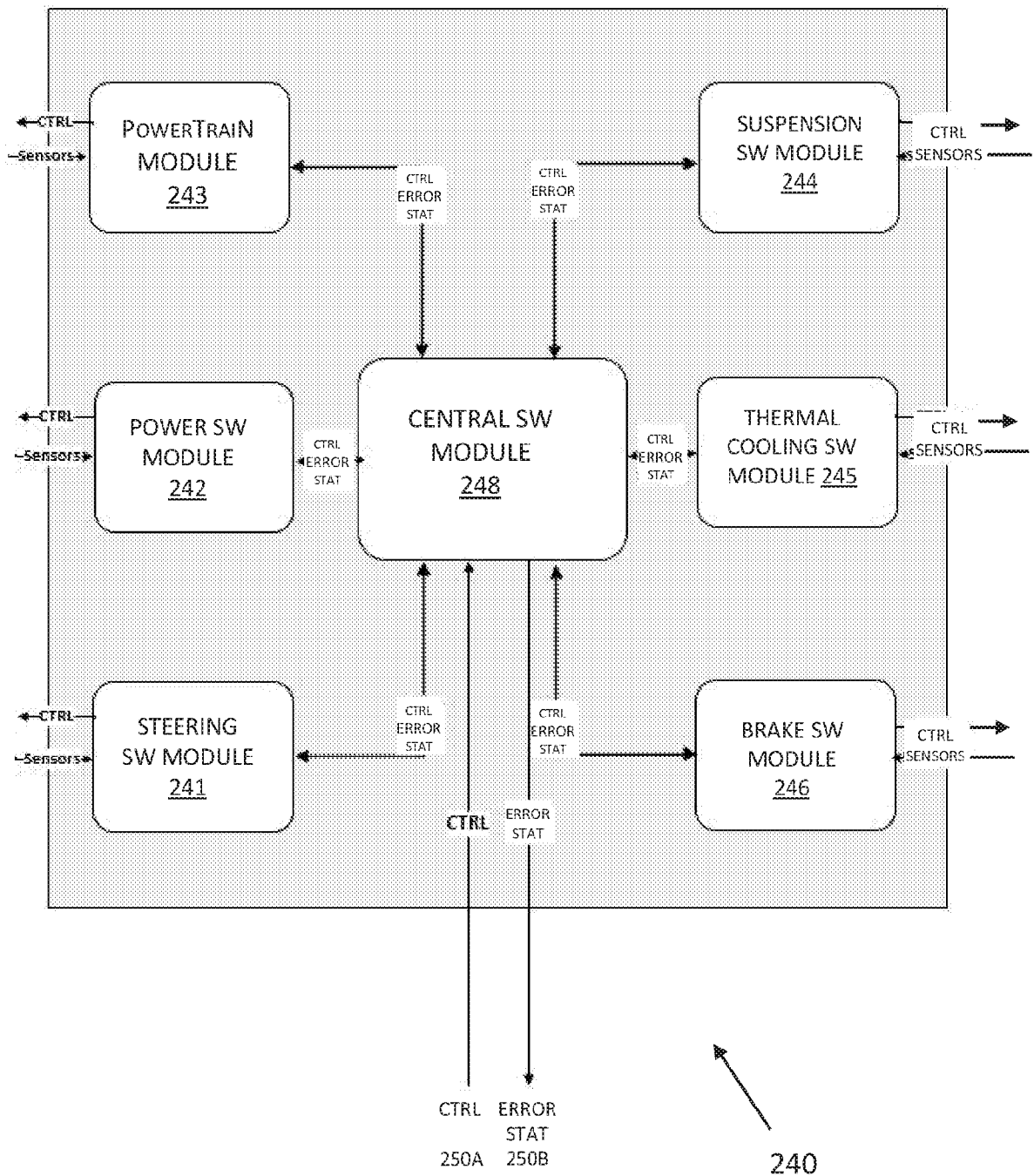


FIG. 2E

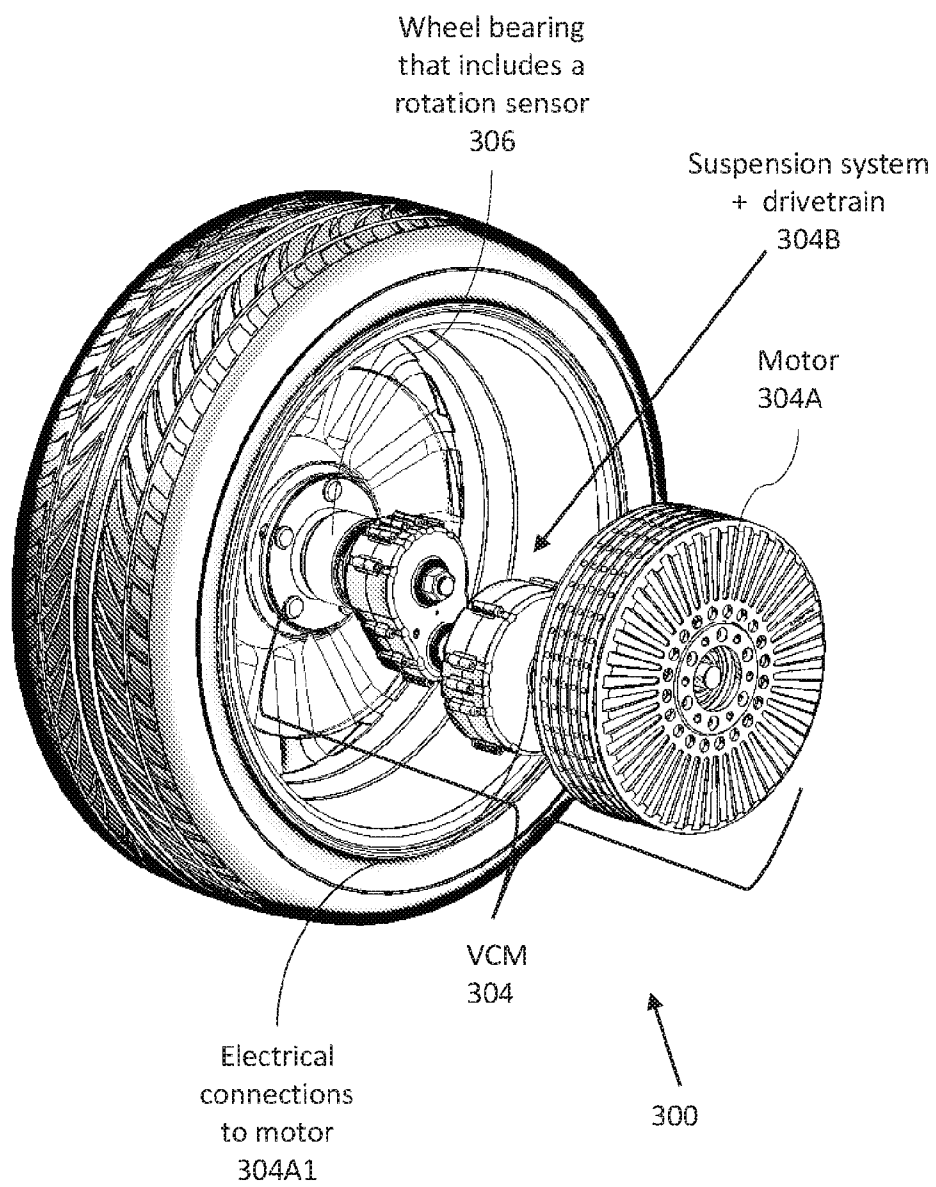
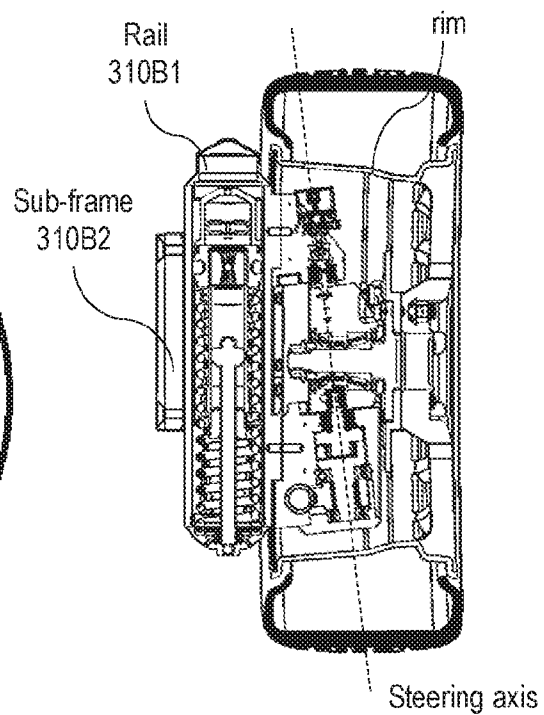
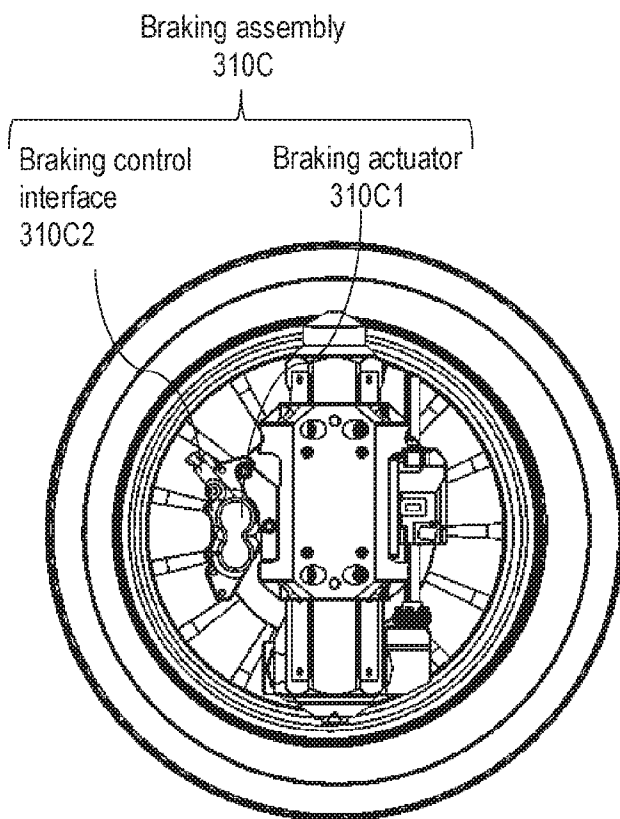
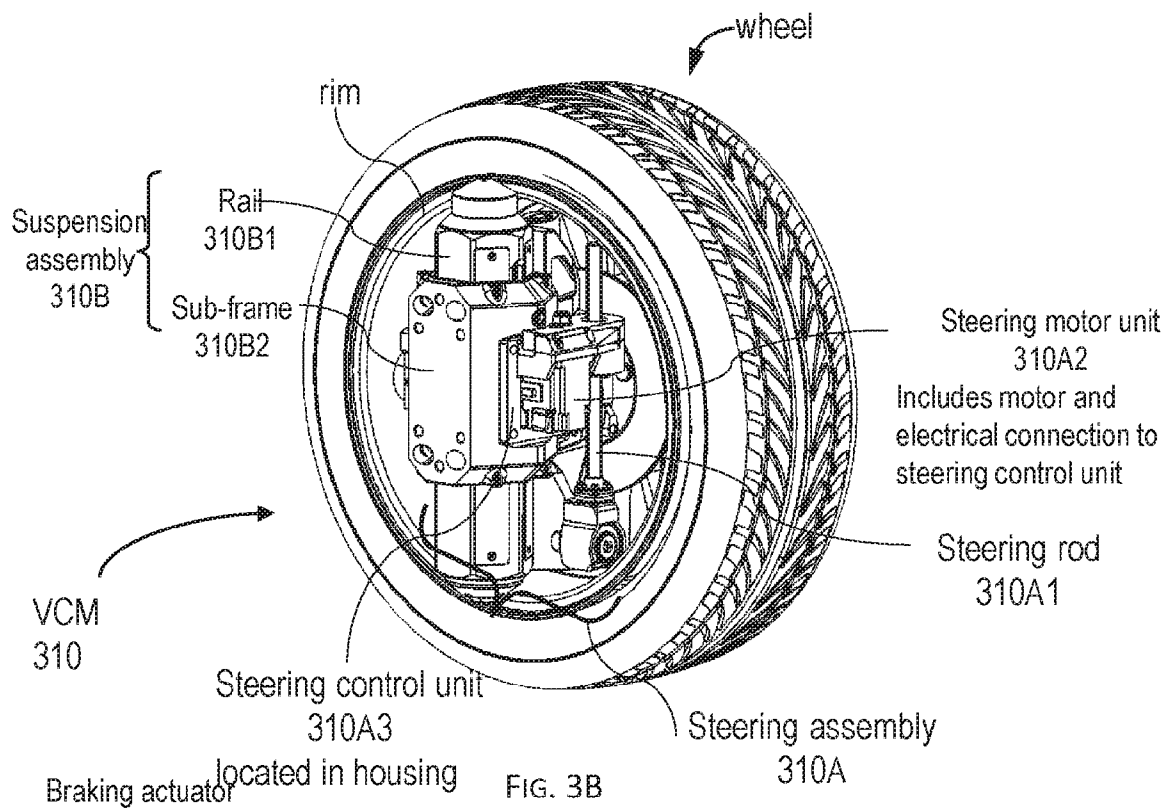


FIG. 3A



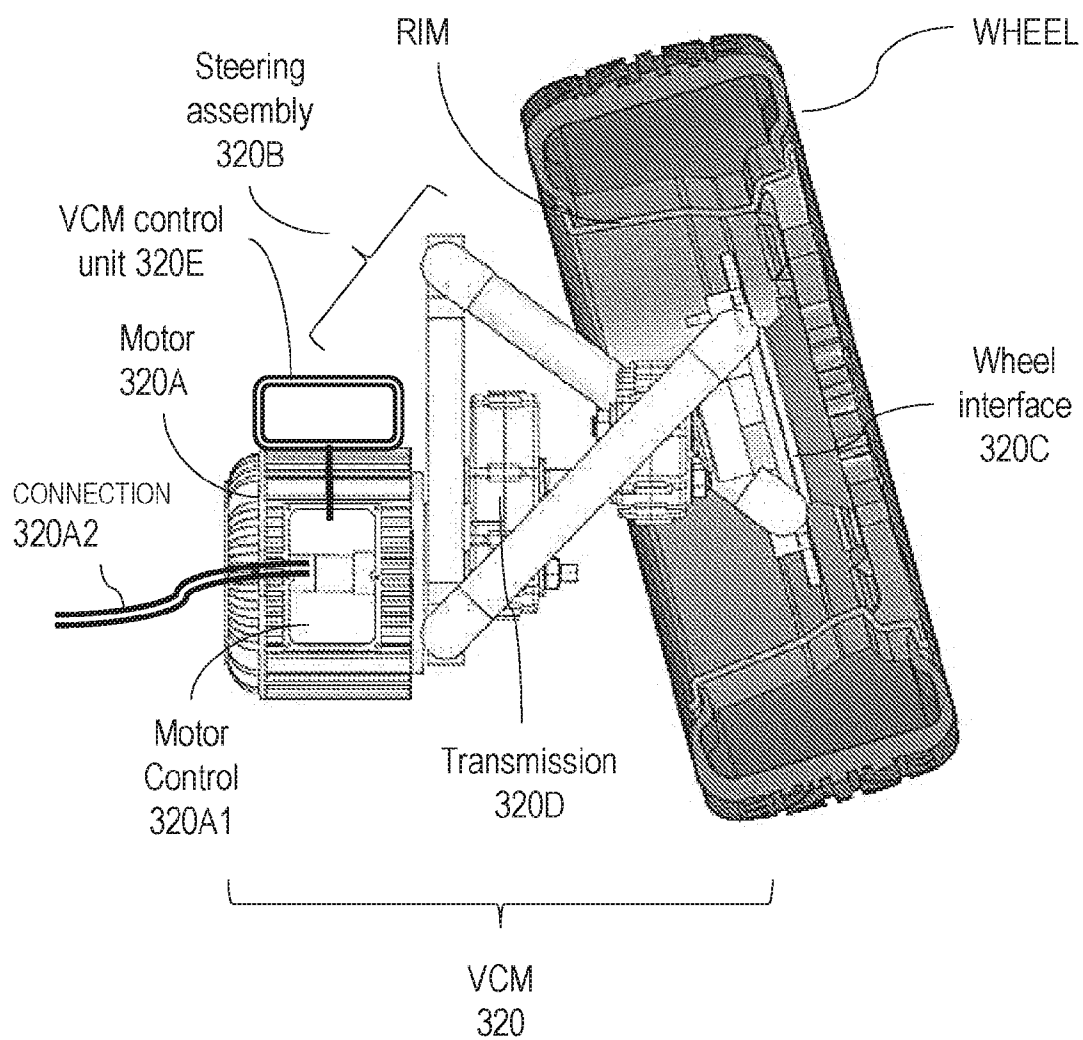


FIG. 3E

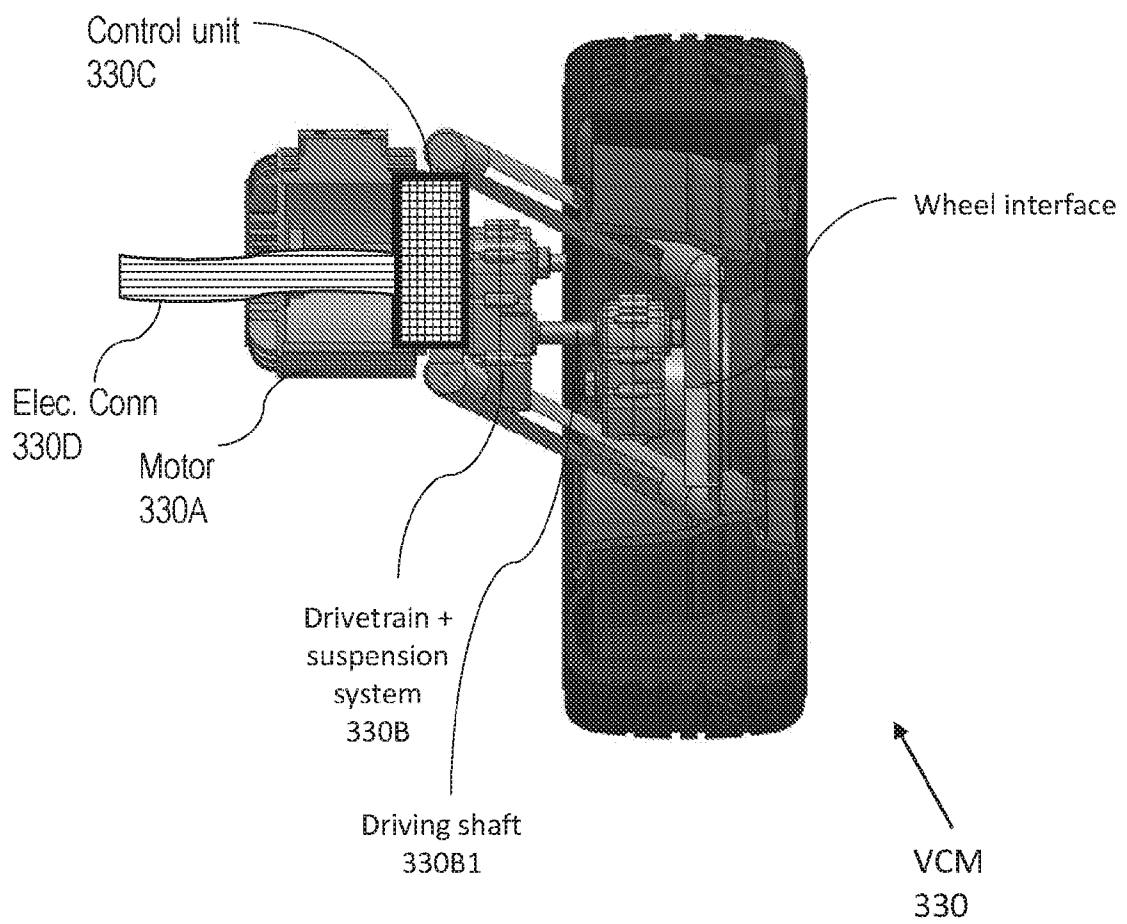


FIG. 3F

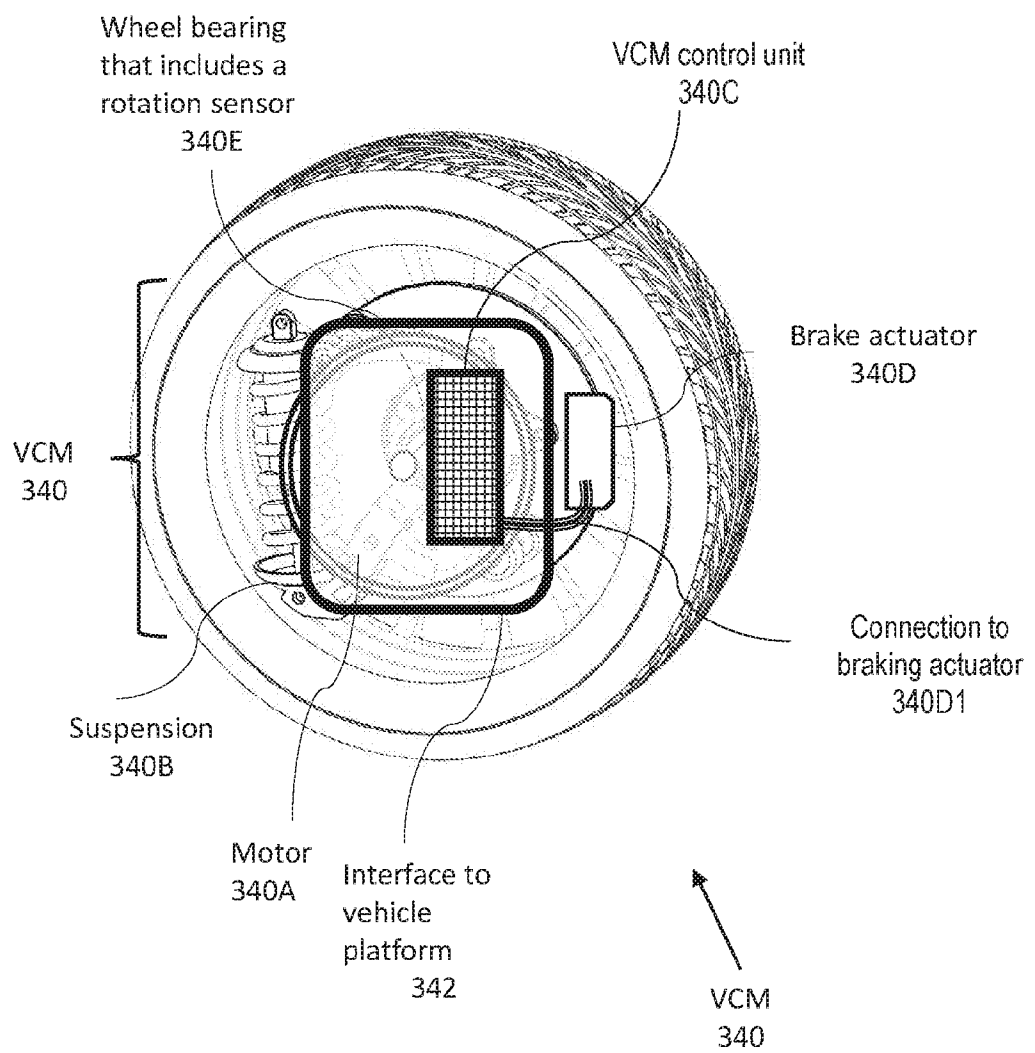


FIG. 3G

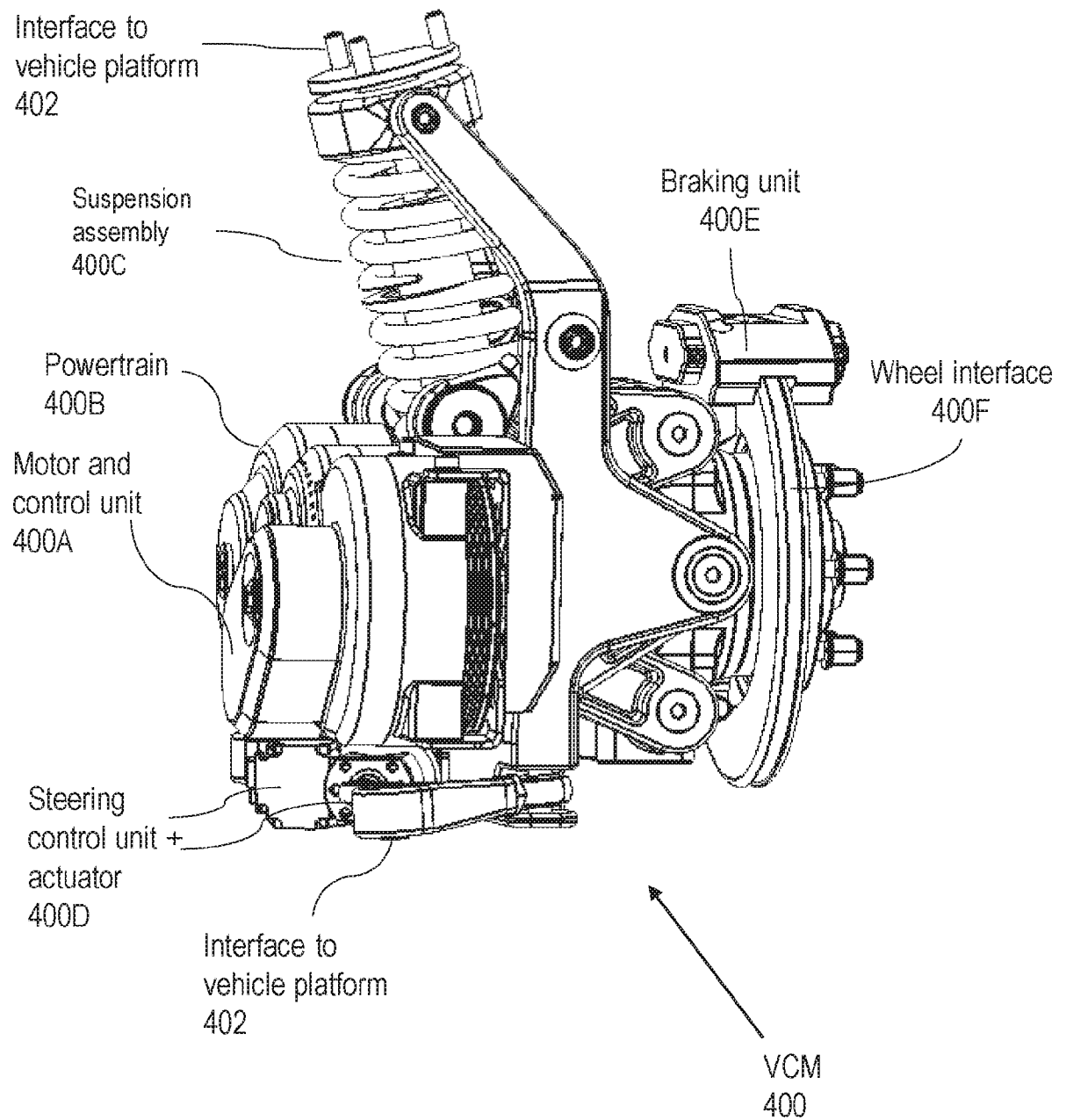


FIG. 4A

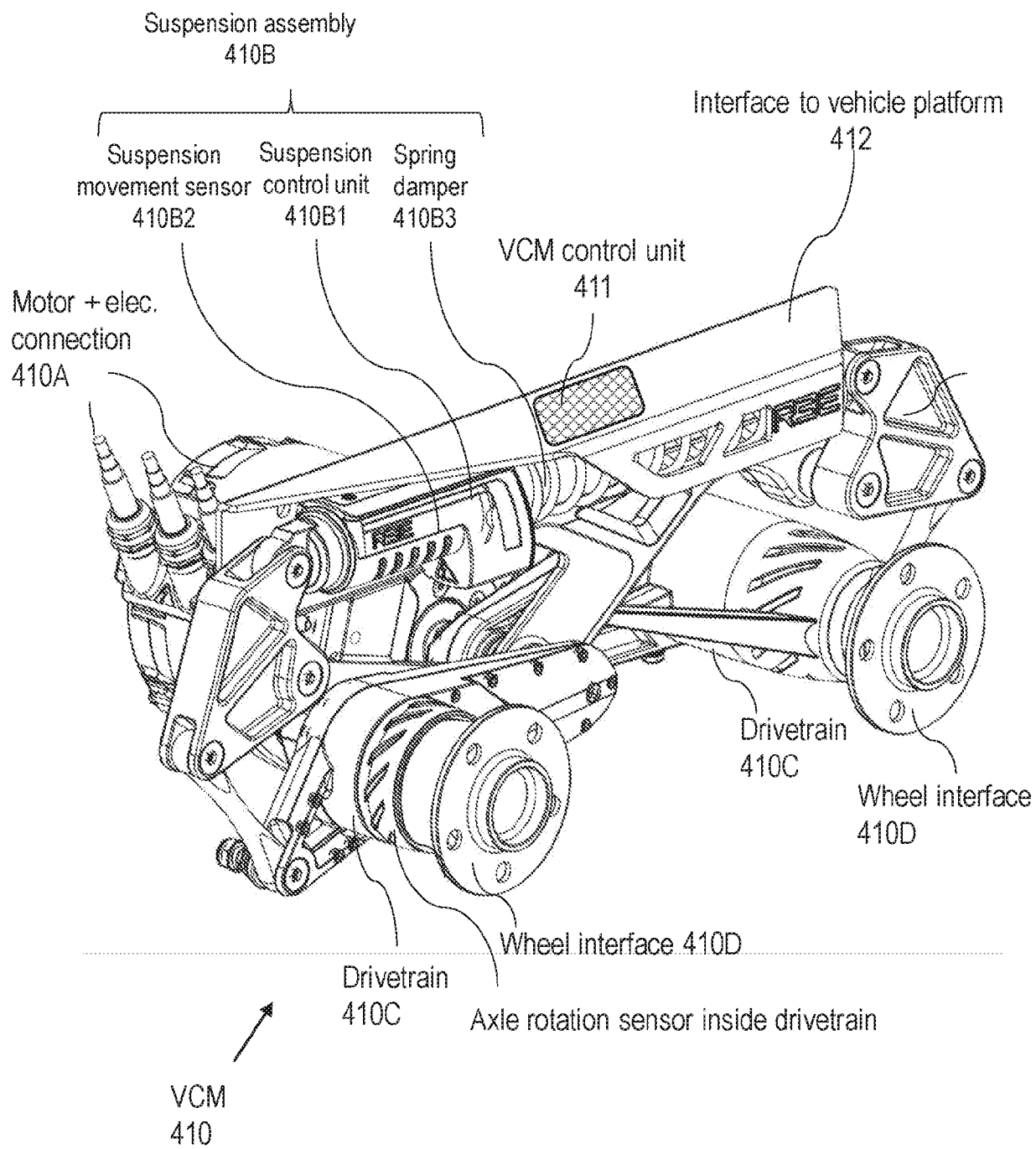


FIG. 4B

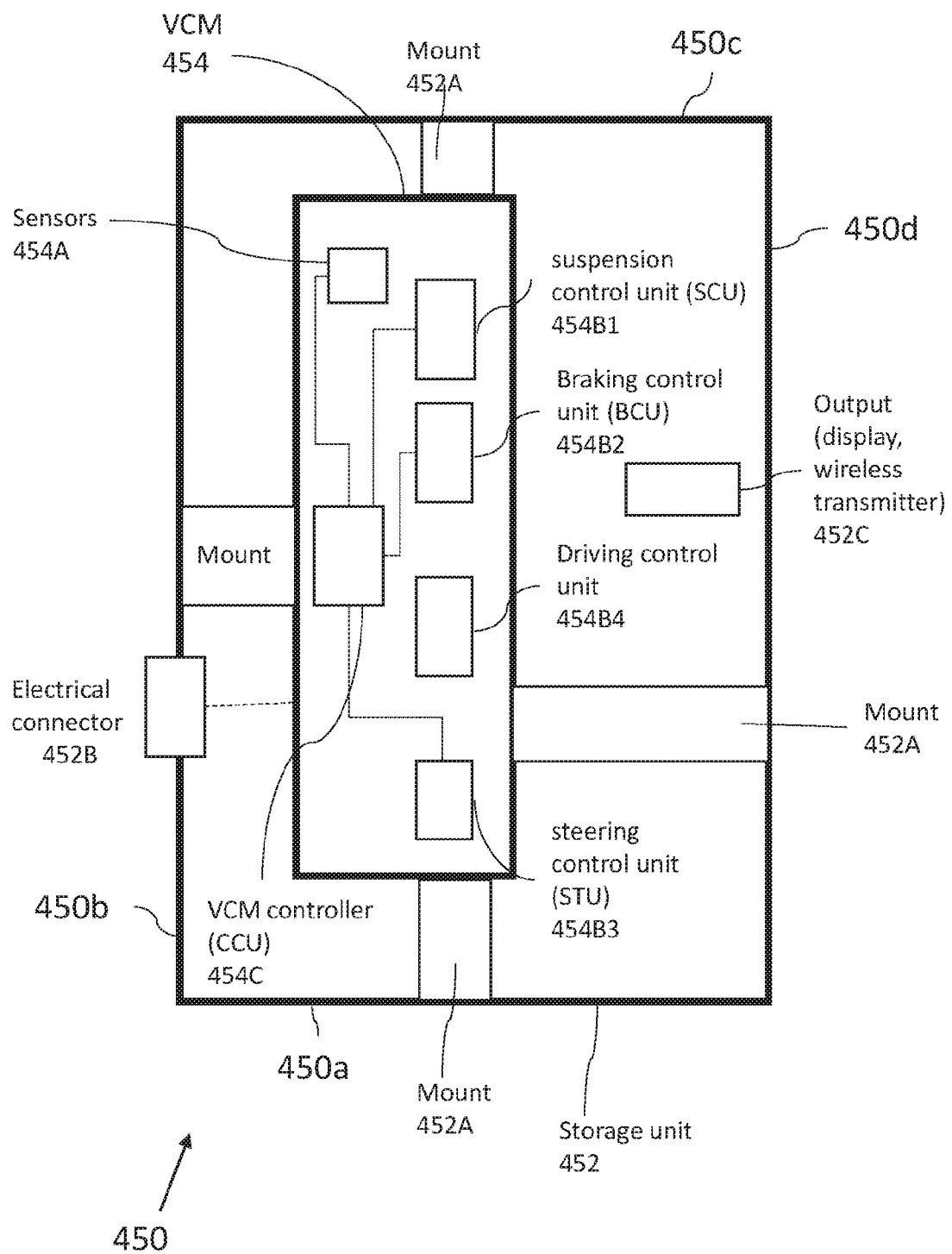


FIG. 4C

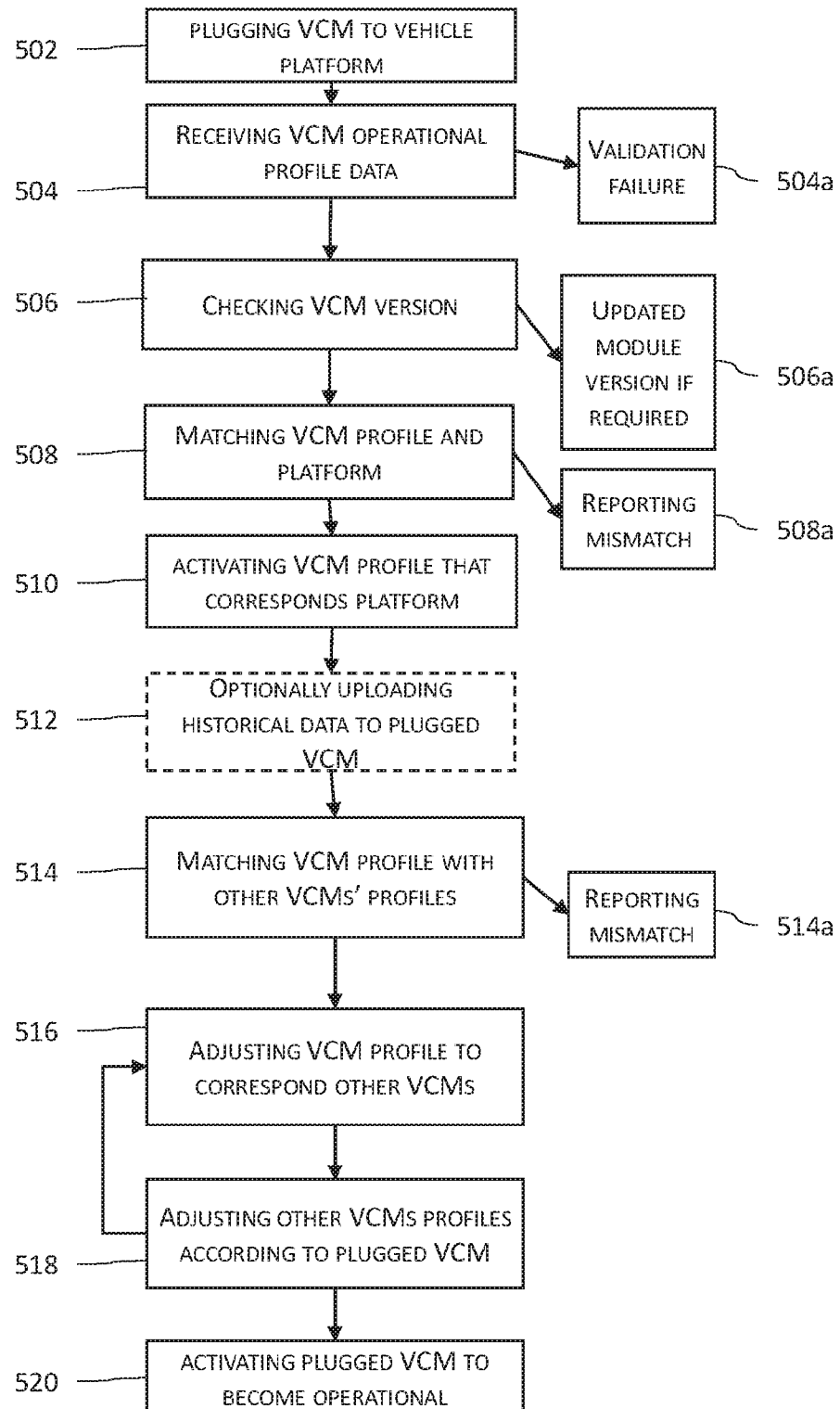


FIG. 5

	HUMAN OPERATOR	ROBOTIC SYSTEM	VEHICLE PLATFORM	VCM Other VCM	EXT. COMP
PLUGGING VCM TO VEHICLE PLATFORM	V	V			
VALIDATING VCM			V		V
RECEIVING VCM OPERATIONAL PROFILE DATA			V		
MATCHING VCM PROFILE WITH PLATFORM			V	V	
MATCHING VCM PROFILE WITH CORNERS PROFILE			V		
ACTIVATING VCM TO OPERATIONAL STATE			V	V	
UPLOADING HISTORICAL VCM INFORMATION TO CCU					V
ADJUSTING VCM PROFILE TO CORRESPOND TO PLATFORM			V	V	
ADJUSTING VCM PROFILE TO CORRESPOND OTHER VCMS			V	V	
ADJUSTING PROFILES OF OTHER VCMS				V V	

FIG. 6

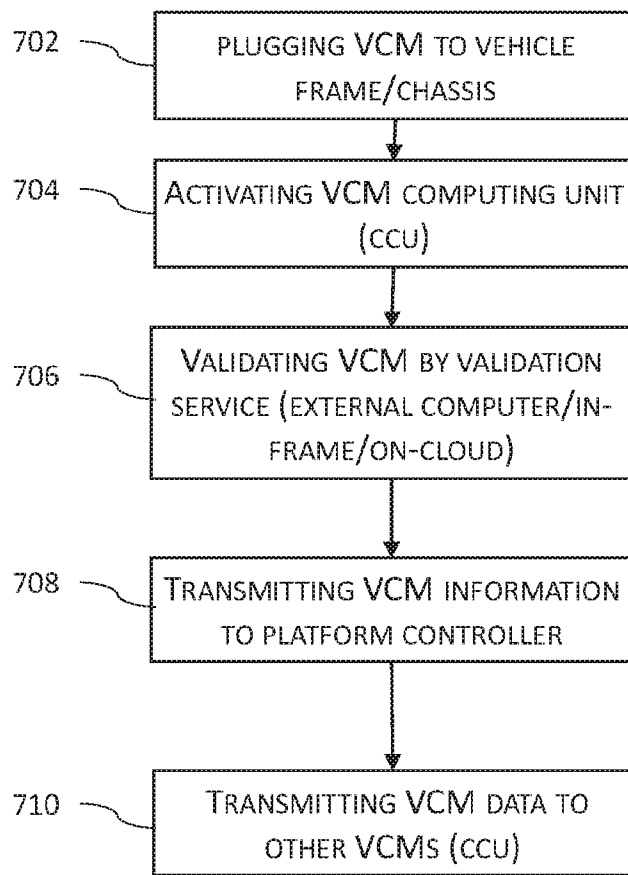


FIG. 7A

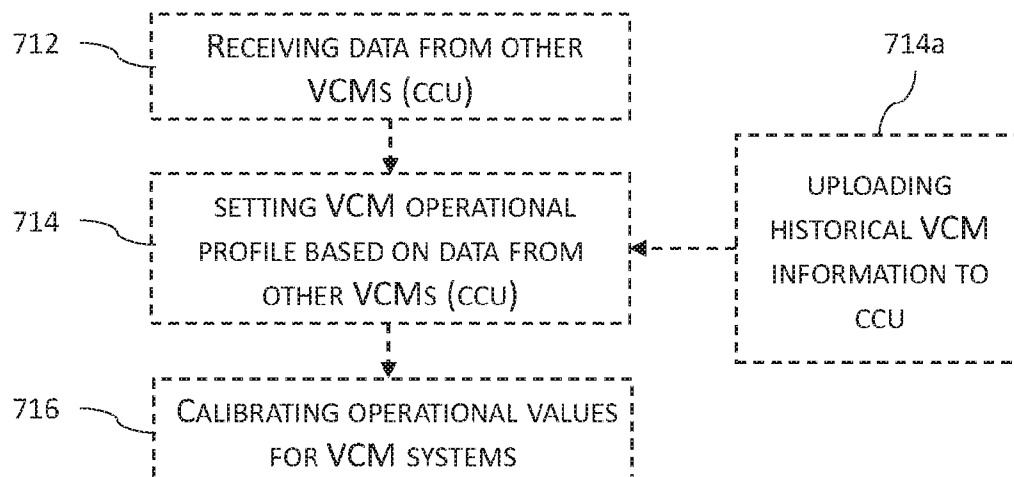


FIG. 7B

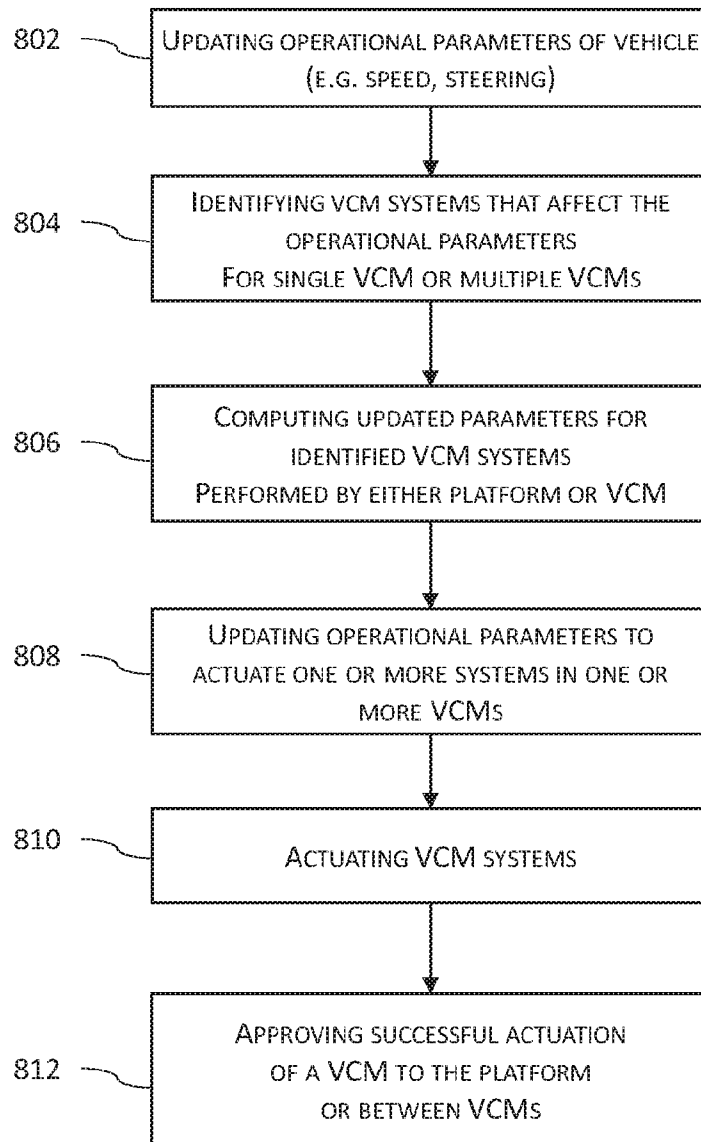


FIG. 8

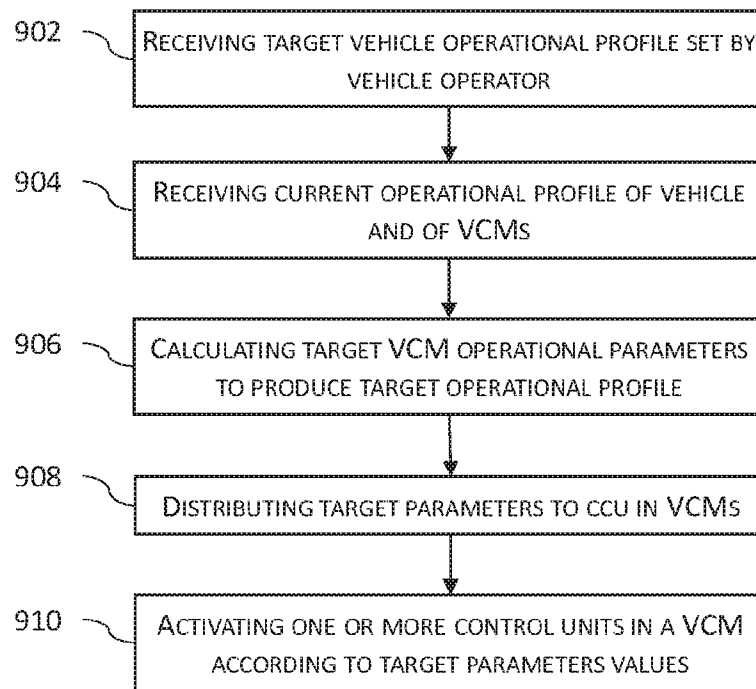


FIG. 9

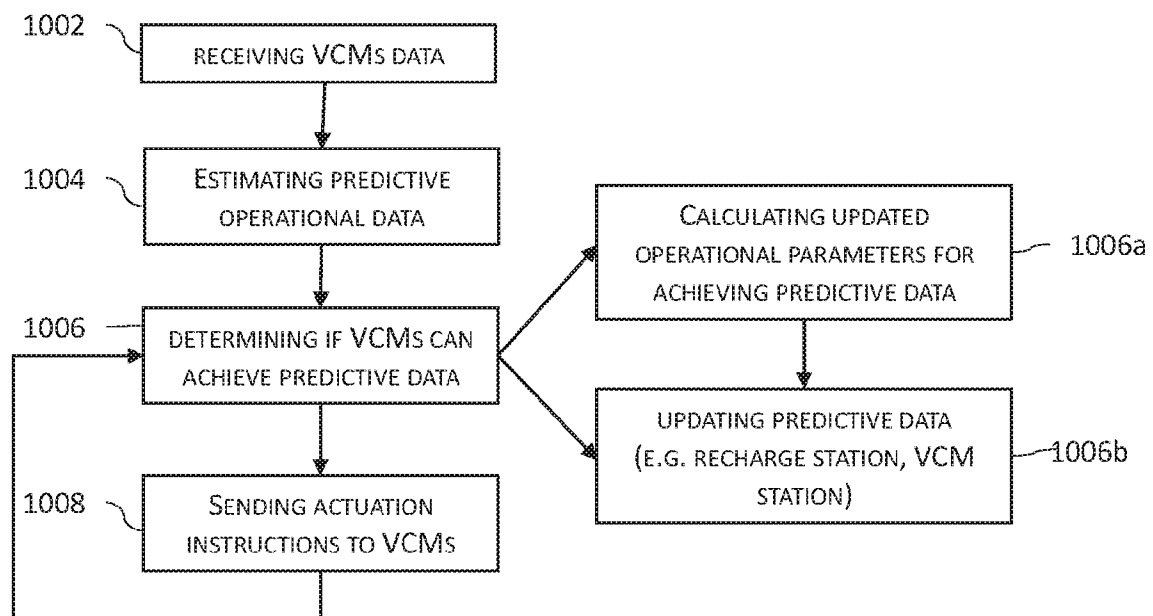


FIG. 10

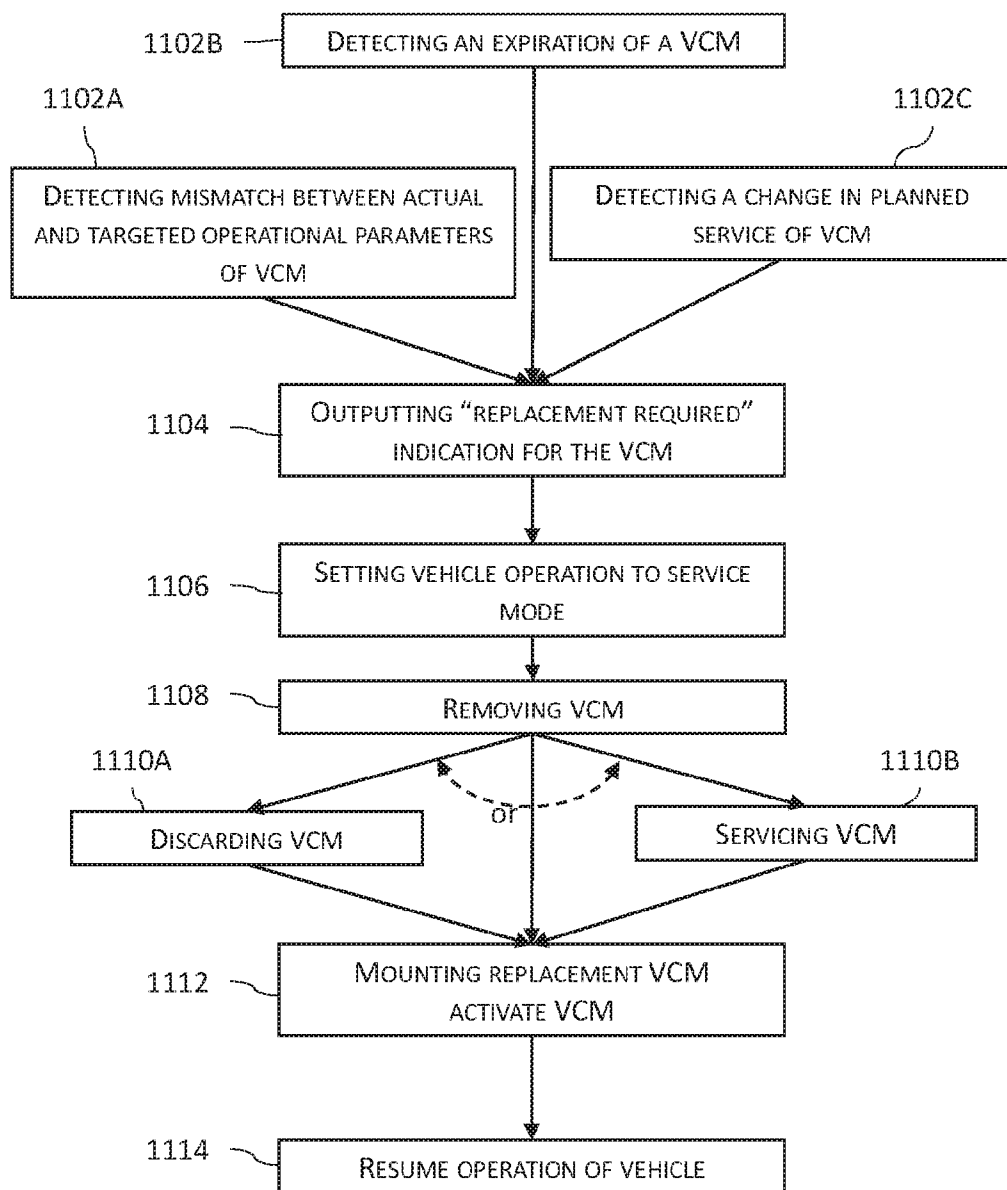


FIG. 11

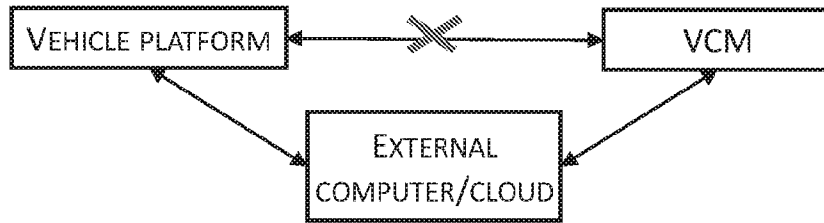


FIG. 12A

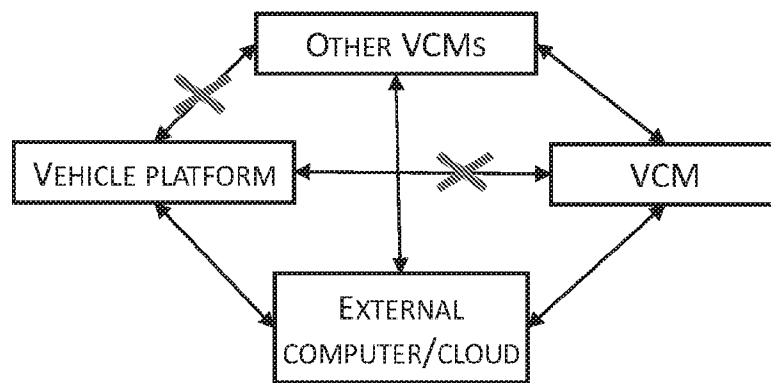


FIG. 12B

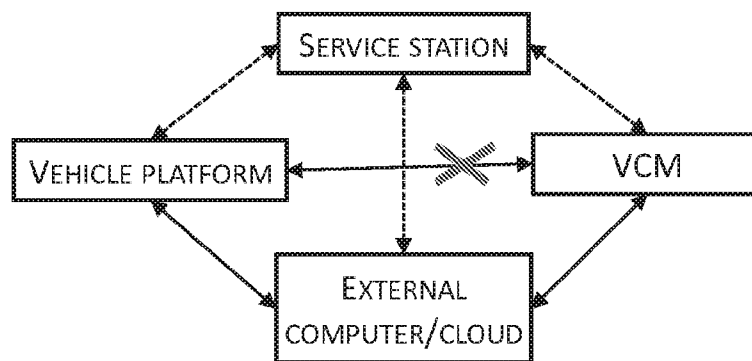


FIG. 12C

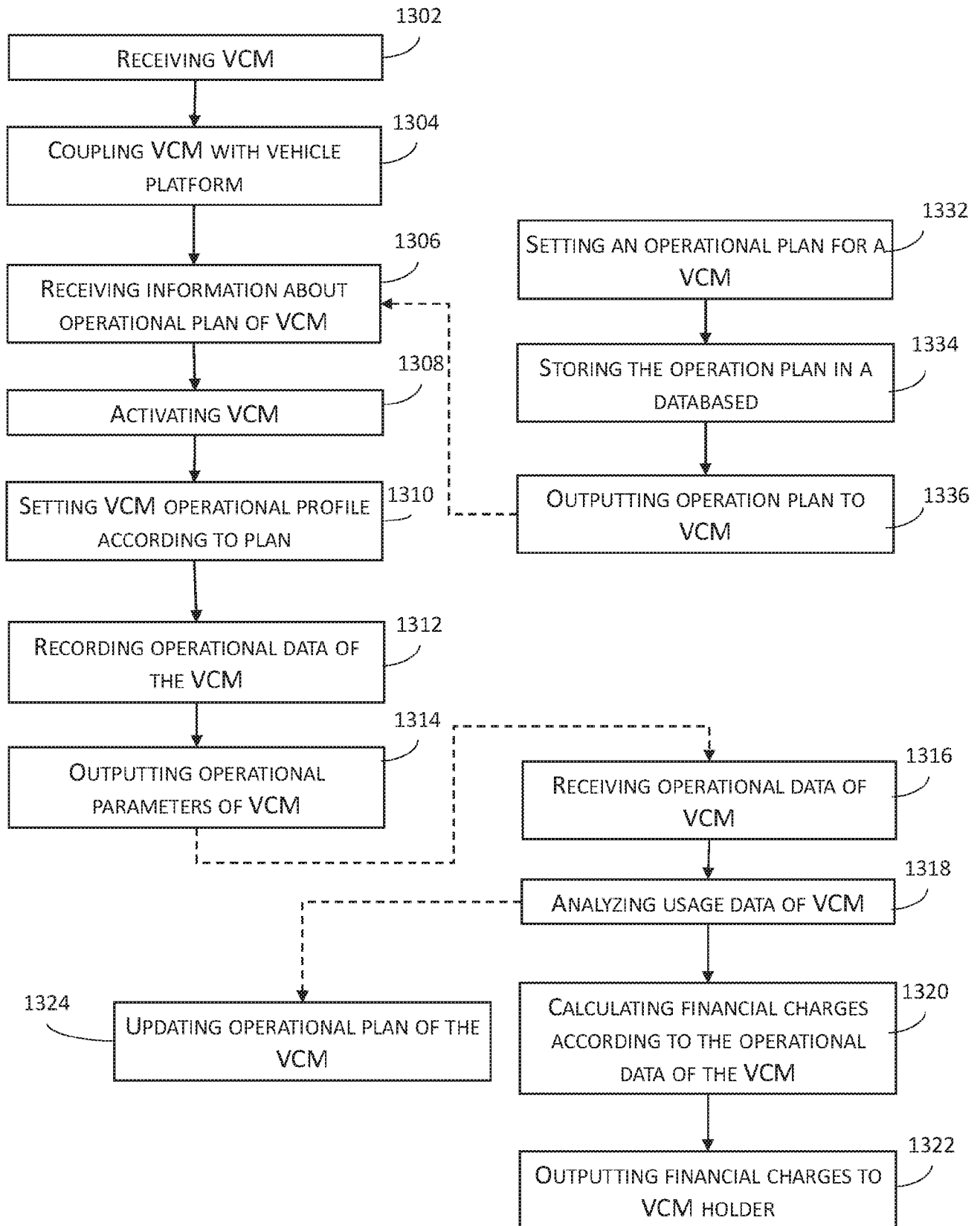


FIG. 13